

Training Course on Use of the Model for Evaluation of Energy Demand (MAED)

MAED Methodology and Approach for Model Application

Model for Analysis of the Energy Demand

- ⇒ Simulation model (not optimization)
- ⇒ Applicable for medium and long term
(not for short term)
- ⇒ Based on the scenario approach
(not econometric)

General Structure Of MAED Model

MODULE MAED-d:

Energy Demand Evaluation

MODULE MAED-el:

Electrical Load and Load Duration Curve

MODULE MAED-g:

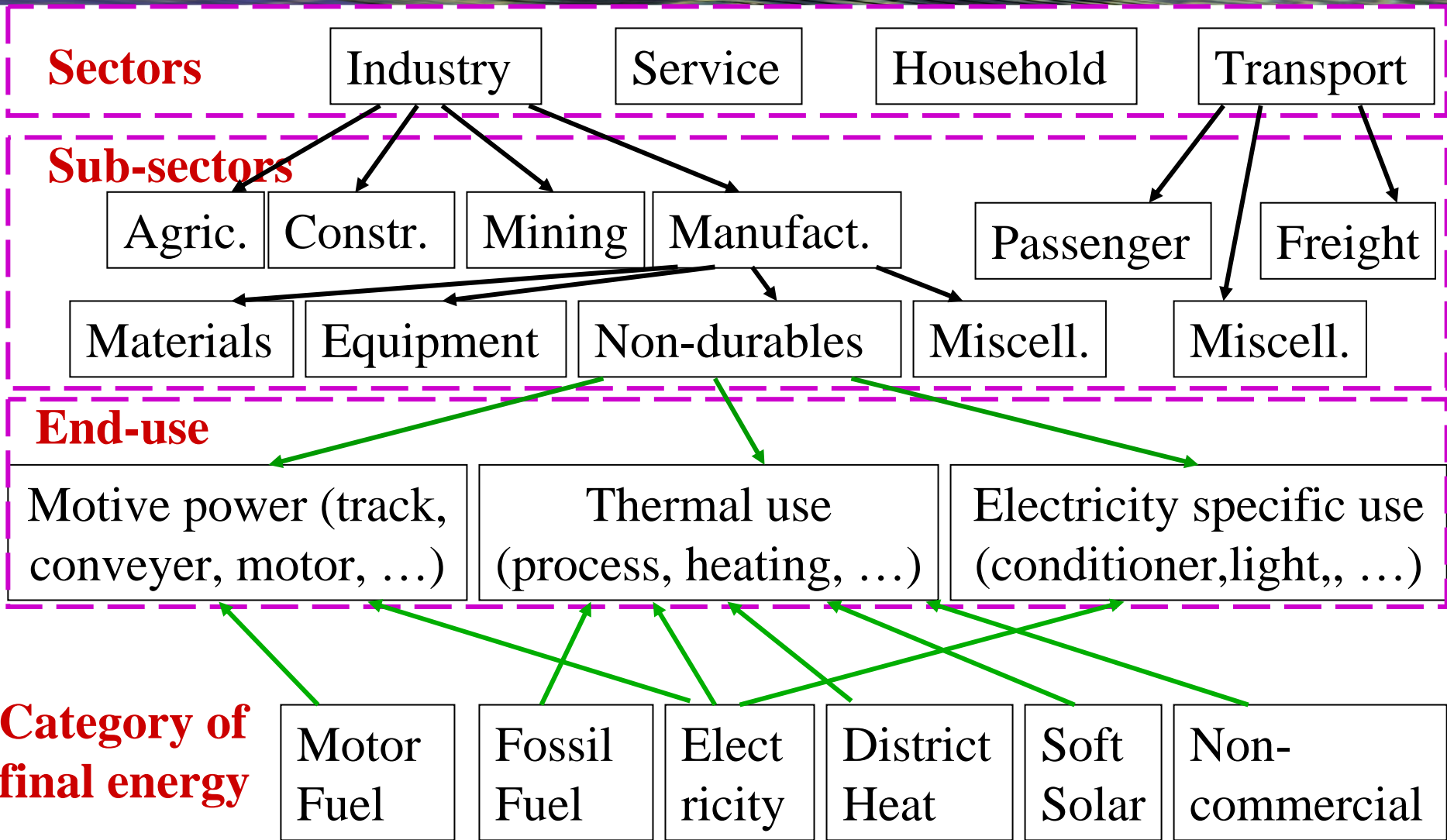
Graphs of Output Results

MAED Methodology

☞ The structure of the final energy consumption of the country is broken down in a consistent manner, subdividing the economy into major consuming sectors and sub-sectors, e.g. agriculture; residential; transportation; etc.

☞ Energy consumption in each sub-sector is disaggregated into a multitude of end-uses, e.g.: space heating (services, residential); steam (industry); cooking (residential); motor fuels (transportation); etc.

Illustration of Decomposition of Final Energy Consumption



MAED Methodology (Cont'd)

- ☞ The set of social, economic and technical factors which influence each category of end use energy demand is identified**
- ☞ The development scenarios of social, economic and technical factors are being constructed**
- ☞ Evaluation of the energy demand is performed resulting from each scenario**

Generic Equation for Calculation of Energy Demand Forecast

$$ED_{FY} = (ED/DP)_{BY} * DP_{FY} * CH_{FY}$$

**Energy Demand
in Future year**

**Driving Parameter
in Future year**

**Specific Energy Demand
per unit of Driving
Parameter in Base year**

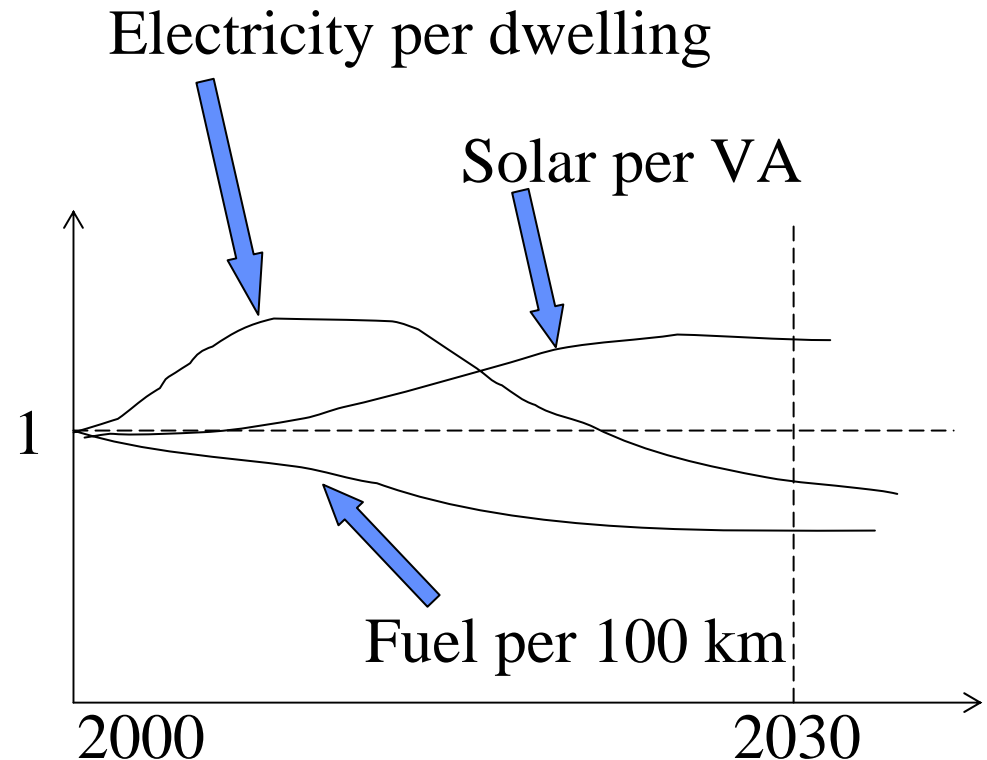
**Coefficient to reflect evolution of
Specific Energy Demand per
unit of Driving Parameter**

Generic Equation for Calculation of Energy Demand Forecast (Cont'd)

Driving Parameters:

- * VA by industry;
- * T-km transported
- * P-km transported
- * Service floor area
- * Number of dwellings

Coefficient of changes



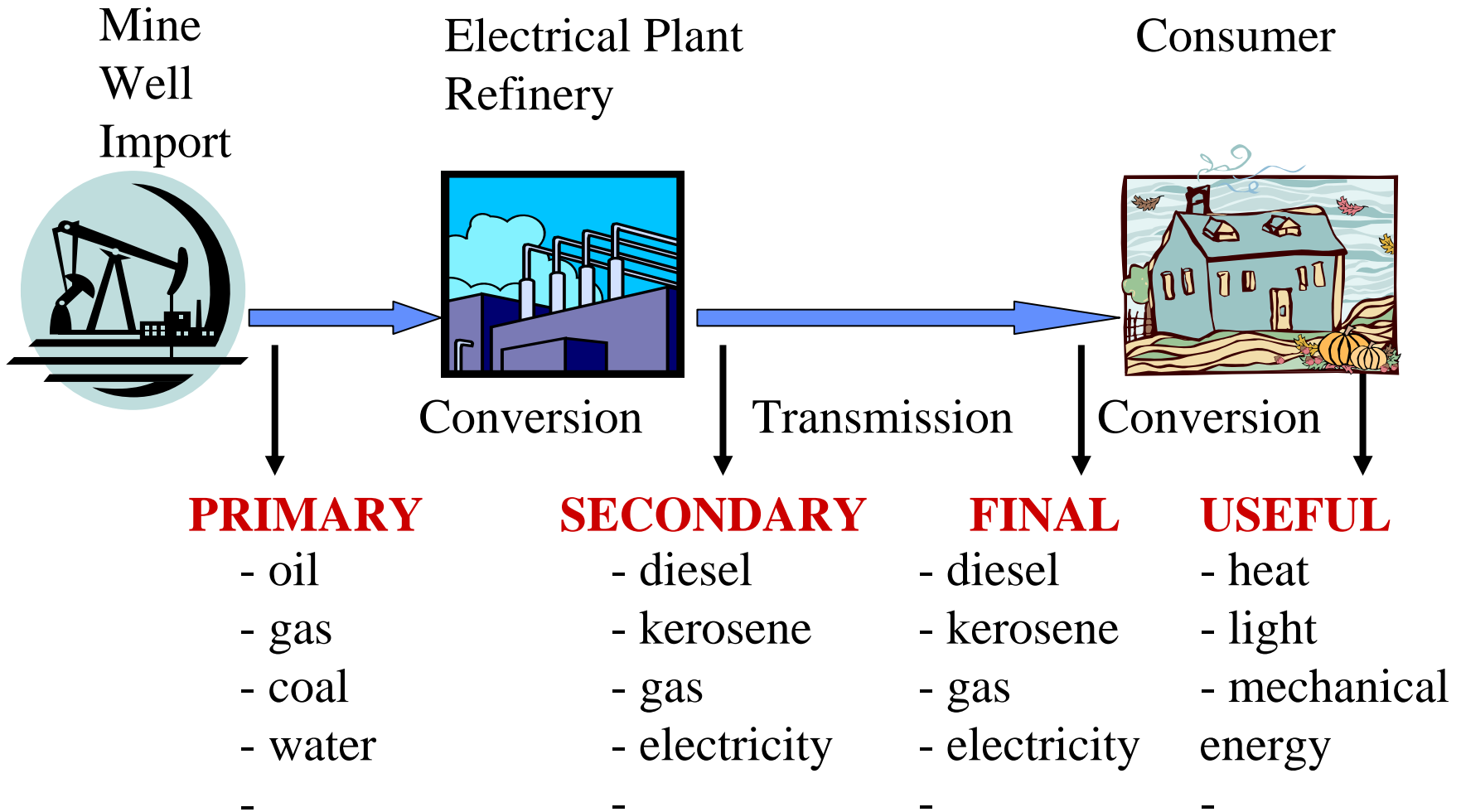
Important Aspects of the MAED Methodology

- 👉 **Price of energy forms is not explicitly considered in the MAED analysis, but to be used by the planner in establishing the development scenarios**
- 👉 **Fossil fuels consumption is not broken down into oil, gas, coal (depends on the supply system situation and the relative prices of these fuels - factors beyond model's scope)**

Important Aspects of the MAED Methodology (Cont'd)

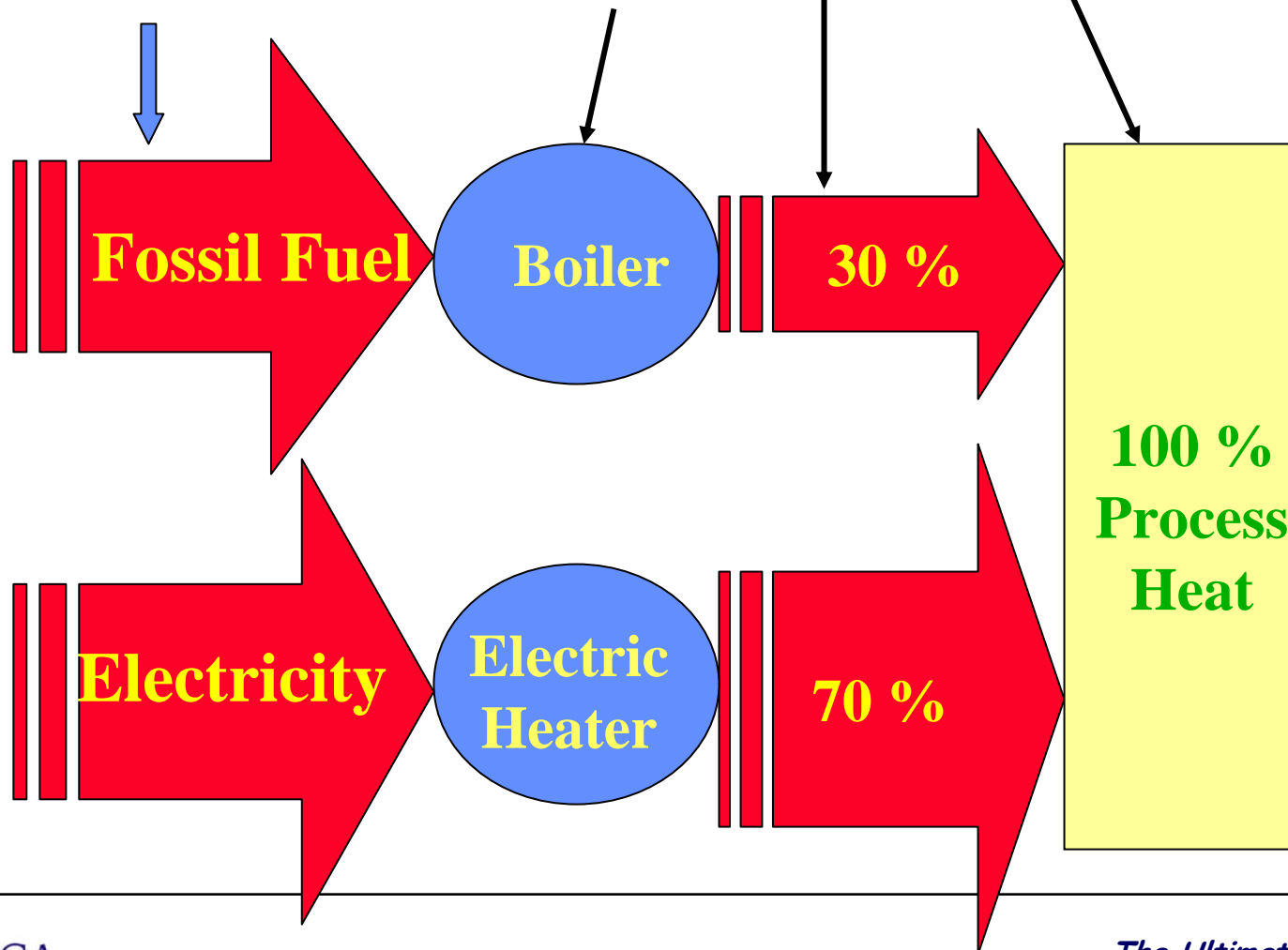
- ☞ Energy demand is as long as possible calculated in terms of useful energy to allow the study of fuel substitution

Energy Chain

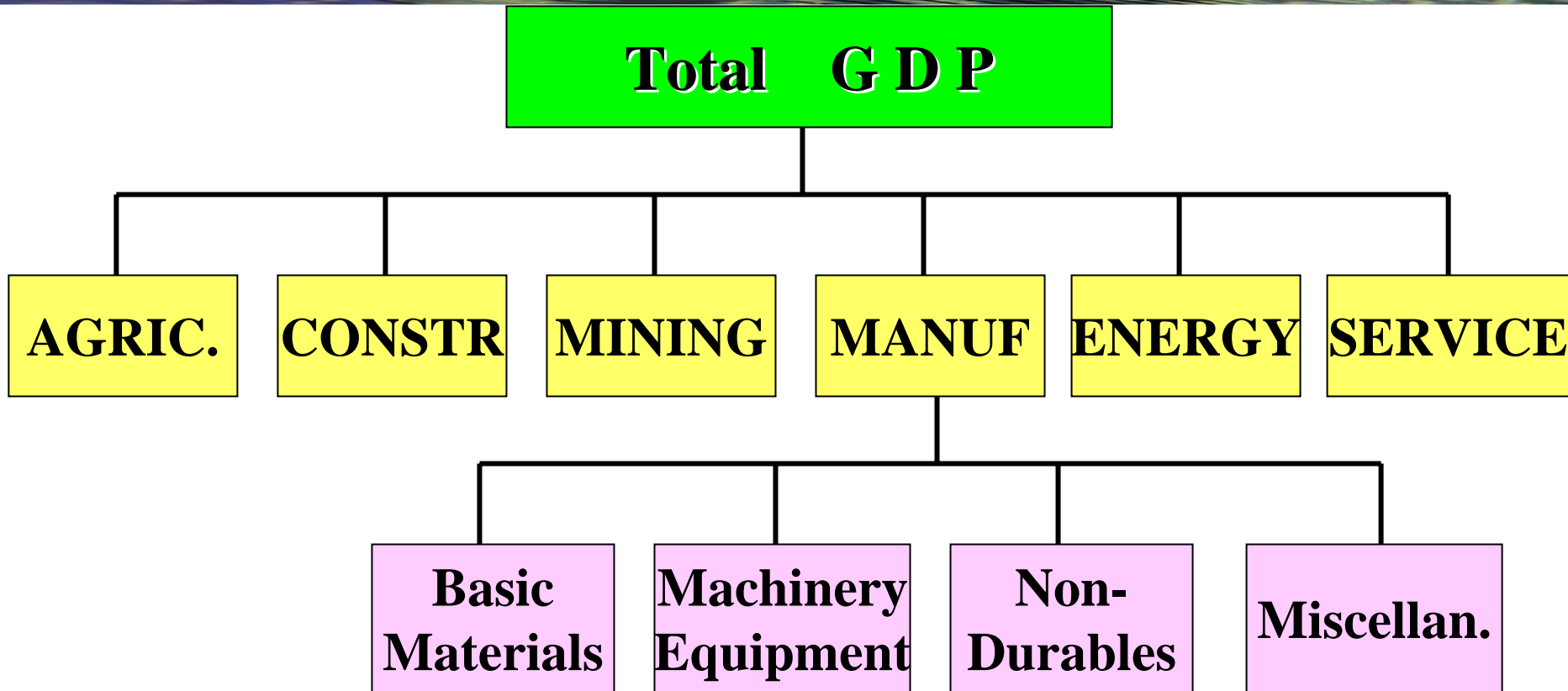


Conversion of Energy Demand in terms of Useful to Final

$$ED_{\text{Final}} = (1 / \text{Eff}) * \text{PEN} * ED_{\text{Useful}}$$



GDP Structure



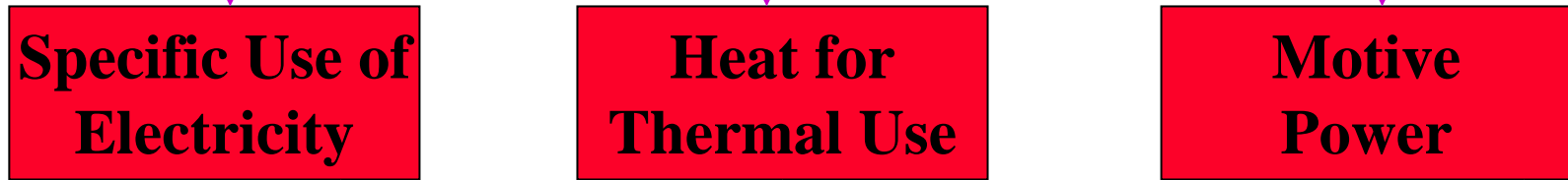
$$VA_{SEC} = GDP * FRACTION_{SEC}$$

Energy Demand by Sectors: INDUSTRY

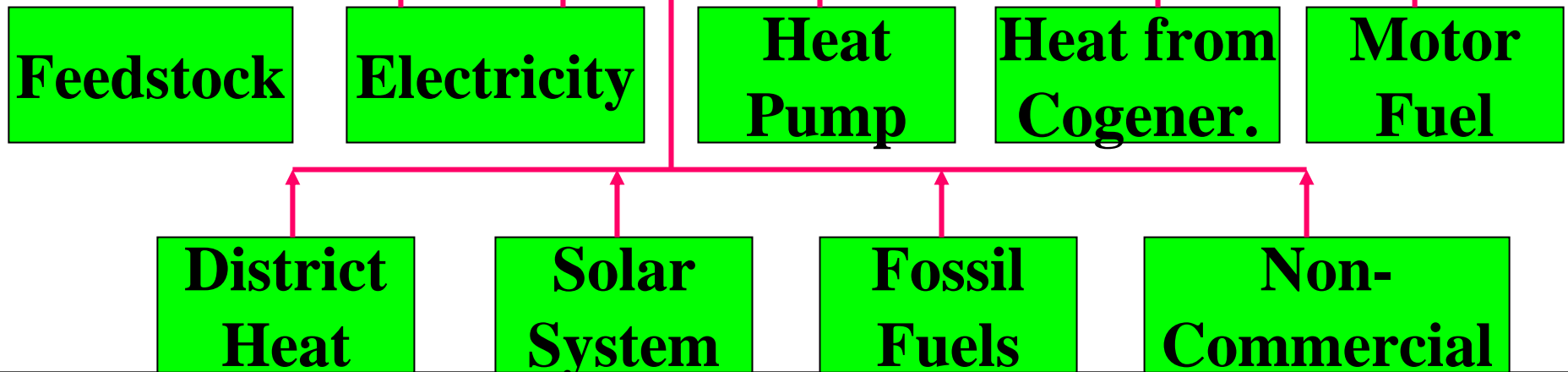
Sub-sectors



End-use



Category of Final Energy

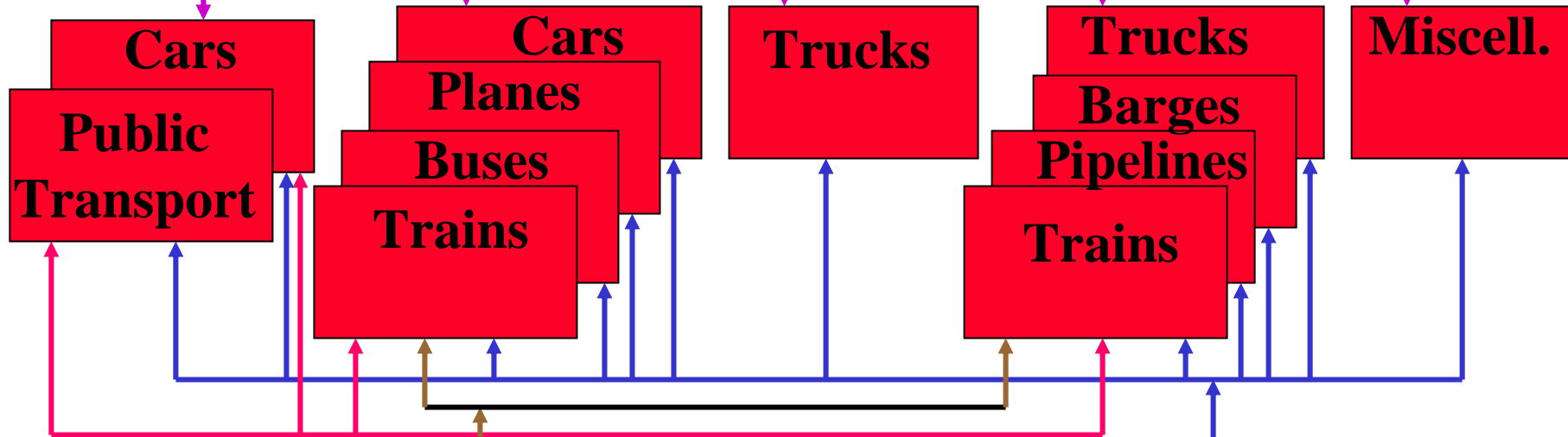


Energy Demand by Sectors: TRANSPORT

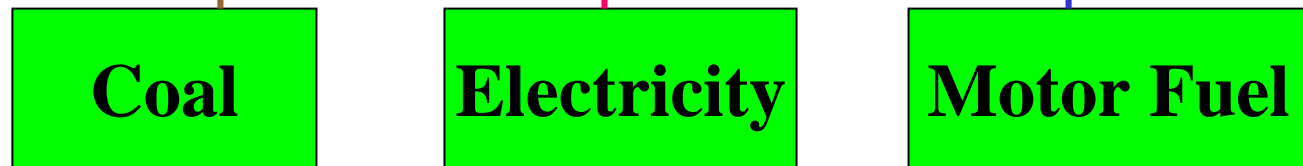
Sub-sectors



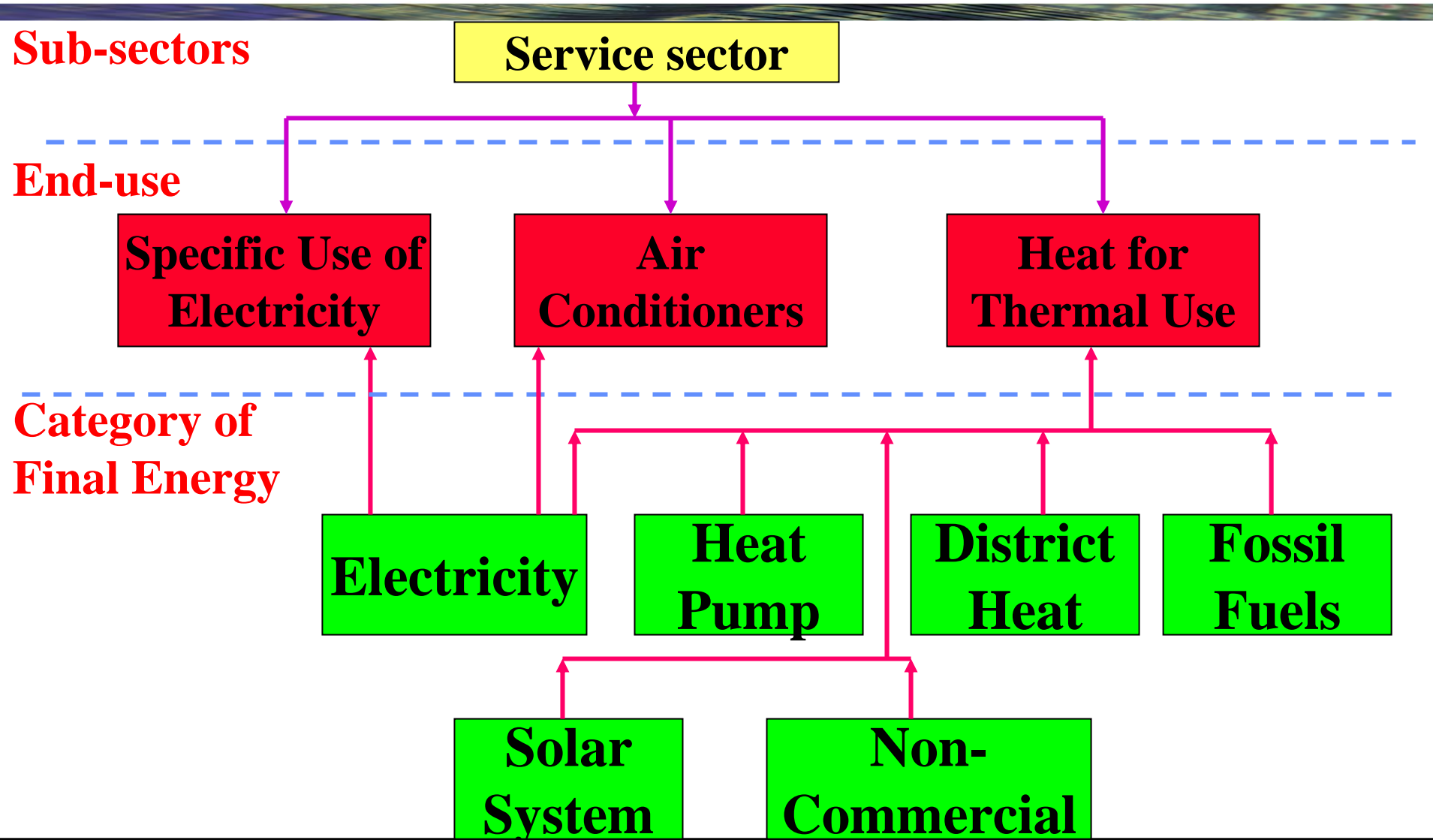
End-use



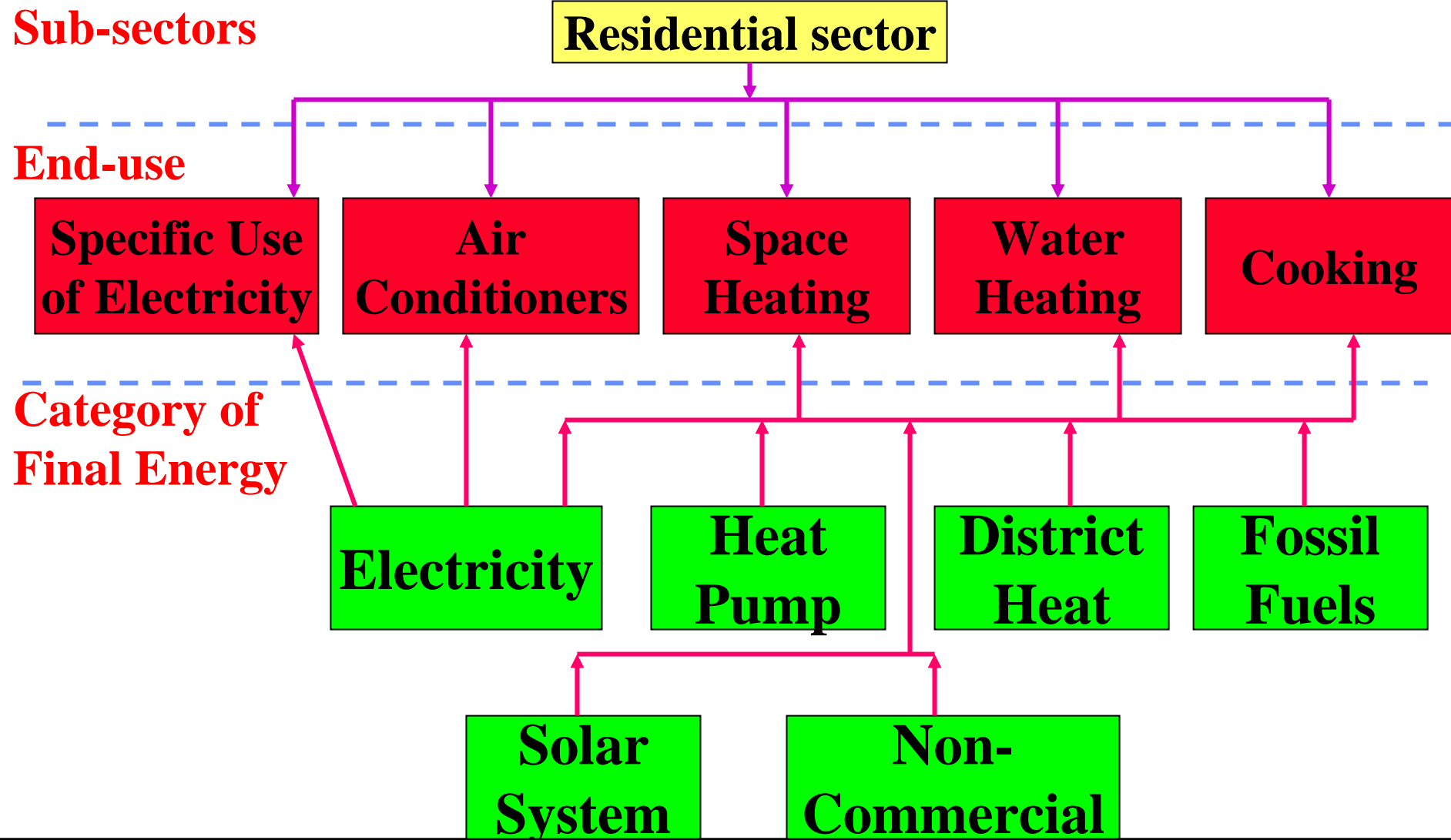
Category of Final Energy



Energy Demand by Sectors: SERVICE

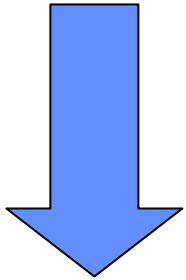


Energy Demand by Sectors: HOUSEHOLD



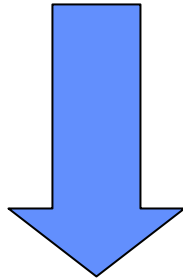
Content of Input Data

Economy



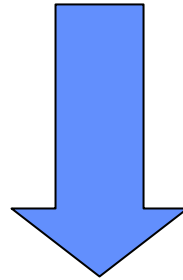
- **GDP**
- **GDP growth rate**
- **Fractions of sectors**

Demography



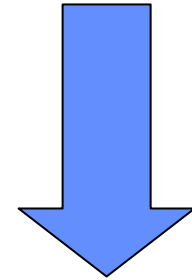
- **Population**
- **Growth rate**
- **Urbanization**
- **Labor Force**

Life Style



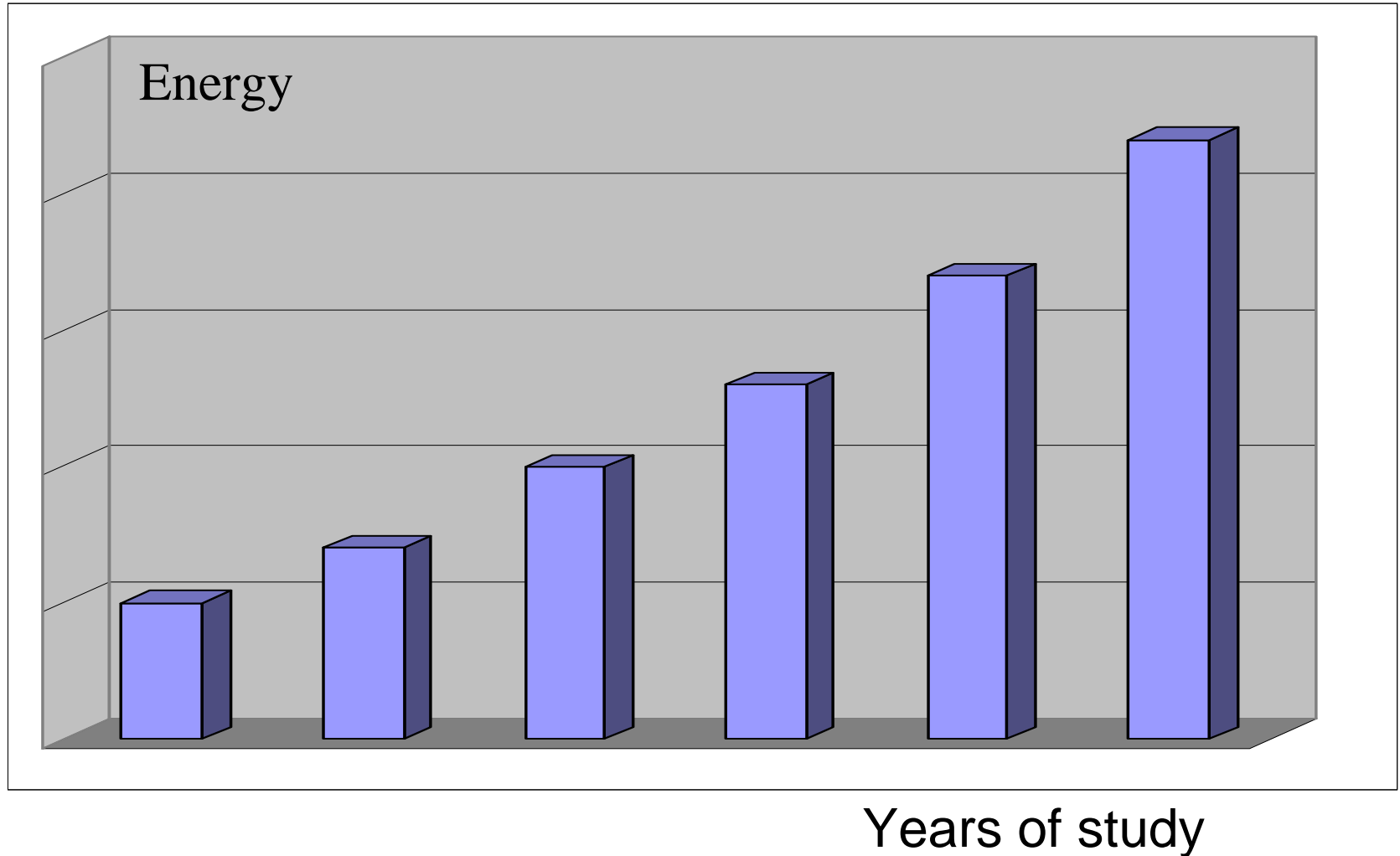
- **Household size**
- **Mobility**
- **Car ownership**
- **Electrification**
- **Transport modes**

Technology

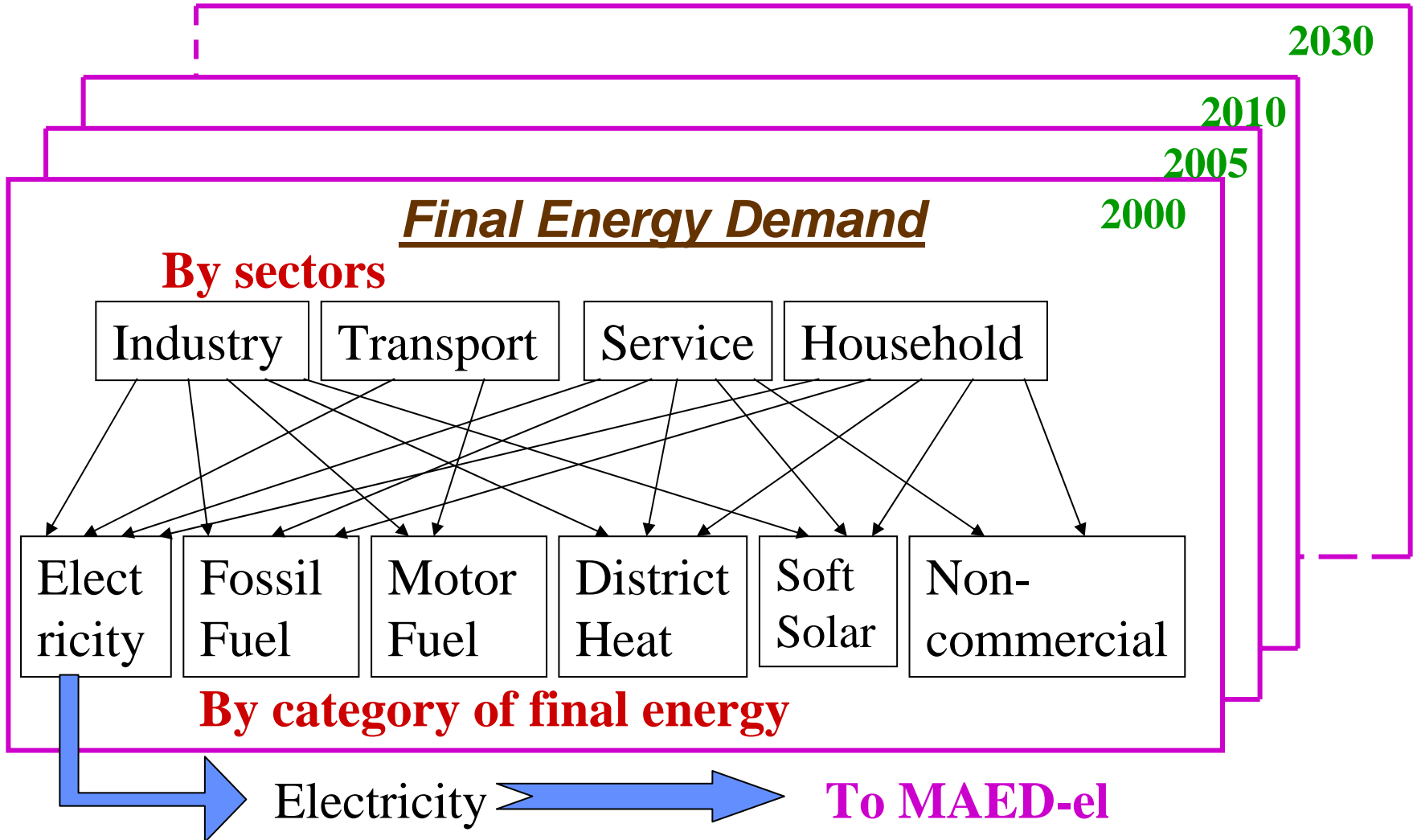


- **Energy intensity**
- **Efficiency**
- **Mileage**
- **Penetrations**

Output - Final Energy Demand



Output Results of MAED-d



MAED-el

- ★ Based on a complete definition of the behavior of electricity consumers it converts annual electricity demands of each sector (GWh) into the hour-by-hour power demand (MW) imposed on generating system**
- ★ Then it transforms the hourly load curve of power generating system to load duration curve by ranking the hourly demand in decreasing order of magnitude.**

Module MAED-el

Calculation of hourly load imposed on power grid is performed using various modulating coefficients, which characterize the changes in electricity consumption of each particular hour with respect to the average consumption.

Modulating Coefficients


☞ Trend of the average growth rate of electricity over the year (introduced in the model weekly by clients)

$$T(k) = (1 + gr)^{[(k - 26) / 52]}$$

☞ Weekly variations of electricity consumption (introduced in the model by sectors)

$$S(k)$$

Modulating Coefficients

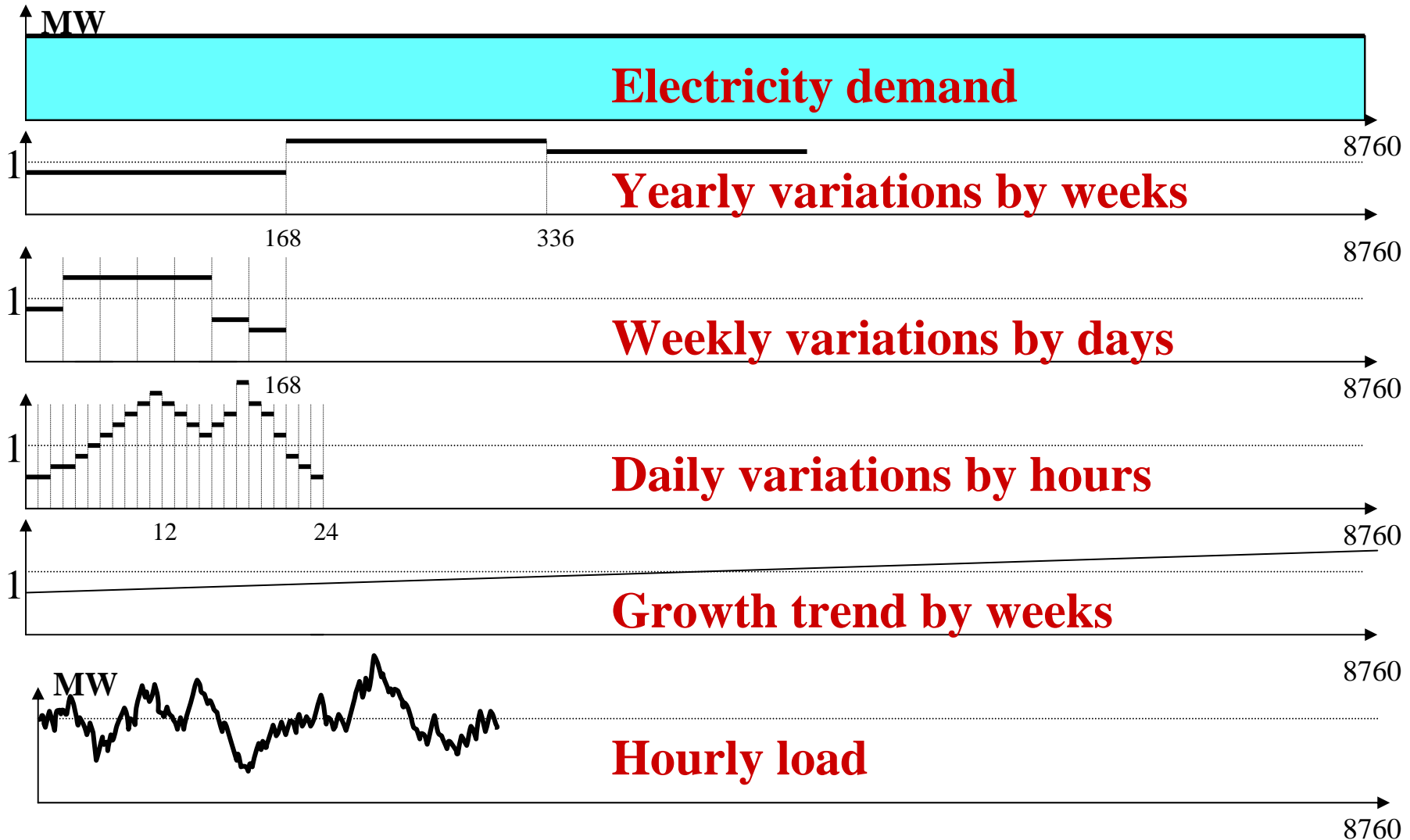
 **Impact of the type of day - working day, Saturday, etc. (introduced in the model by sectors)**

D (l,k)

 **Hourly variations in electricity consumption during each day (introduced in the model by clients for each day type during a season)**

H (j,l)

Methodology for Conversion of Yearly Consumption to Hourly Load



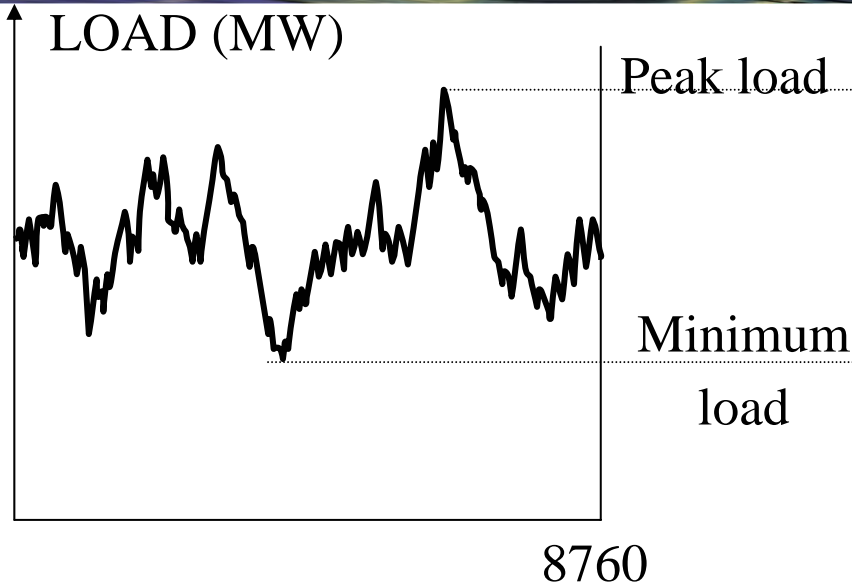
Module MAED-el

The ultimate purpose of the module is to transform the hourly load curve of the power generating system into the load duration curve information as needed for power system expansion analysis.

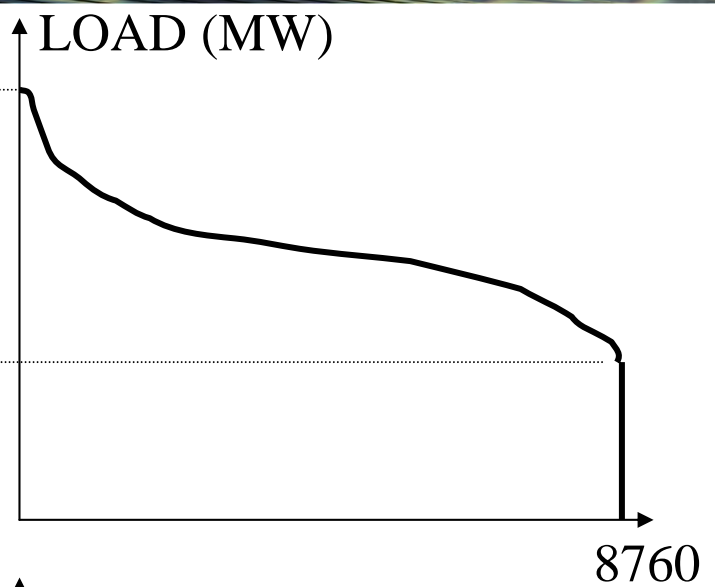
Hourly Load Curve of the Power Generating System Transformed into the Load Duration Curve

- ➔ Chronological presentation of hourly electricity demand is sorted by load
- ➔ Total duration of every load level over the period is calculated
- ➔ Function of load level depending on its duration is produced - (Load Duration Curve - LDC)
- ➔ Both load and duration are normalized
- ➔ Normalized function of load level from its duration is produced -(Normalized Load Duration Curve)

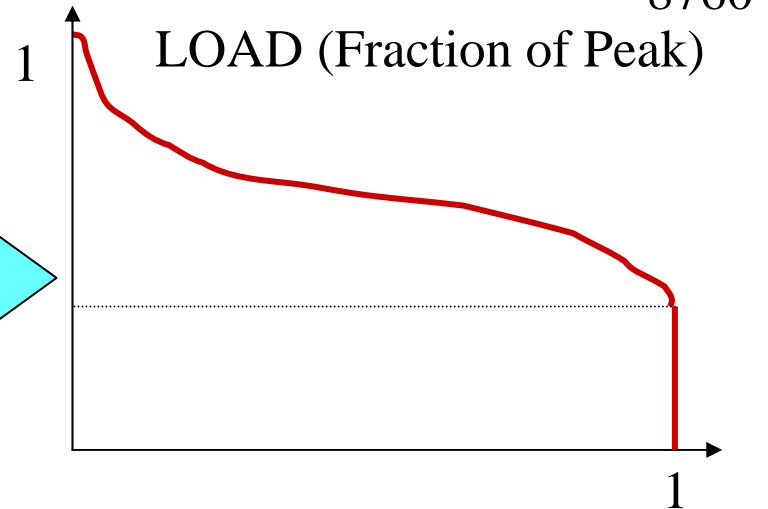
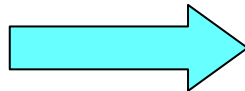
HOURLY LOAD CURVE



LOAD DURATION CURVE



NORMALIZED LOAD DURATION CURVE



Input Data

- Final electricity demand by sectors (from MAED-d)
- Fractions of final electricity consumption by clients within each sector
- Transmission and distribution (by sectors) losses
- Modulating coefficients:
 - yearly and weekly by sectors
 - daily by clients within each sector
- Calendar

Execution of MAED Study

Execution of MAED study involves the following phases:

- ⇒ **Reconstruction of the energy consumption in the base year**
 - *total energy consumption by sectors, by end-use and by fuels*
 - *electrical load (peak value and period, load factor)*
- ⇒ **Establishing scenarios of economic, social and technological development**
- ⇒ **Analysis of energy demand forecast arising from the scenarios**

Reconstruction of Energy Consumption for Base Year of the Study

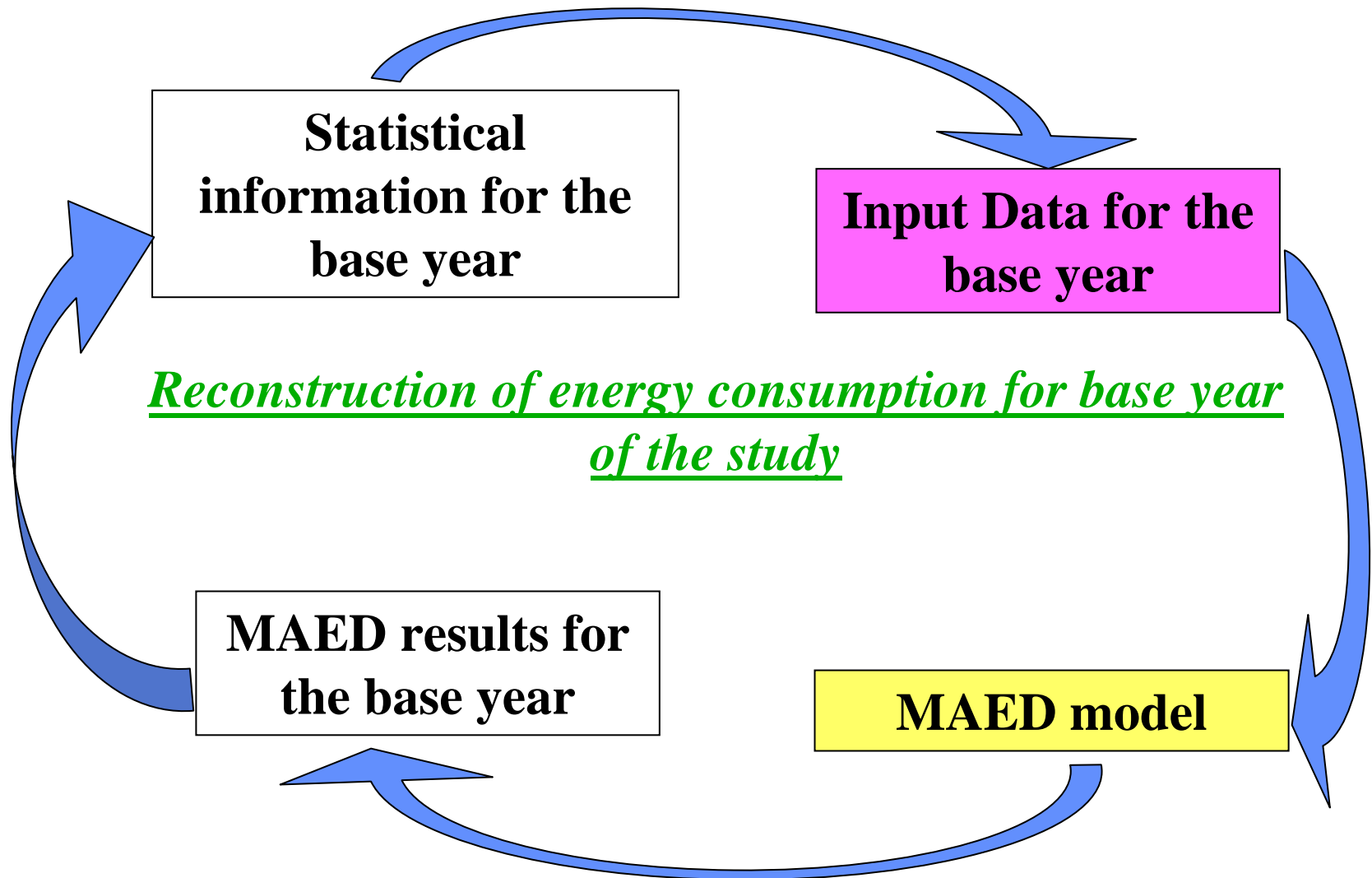
consists of a detailed application of MAED to reproduce statistical data on energy consumption for the selected base year with the objective

to validate the program for energy system of the specific country

Importance of Selection of the Base Year for MAED Analysis

- ☞ The base year must be selected from a most recent year in the past for which energy and economic statistics are reliable and consistent
- ☞ The base year should be selected to represent stable conditions of energy consumption
- ☞ Unusual situations should prevent a year from being selected

Reconstruction of Energy Consumption for Base Year of the Study



The Scenario

**A SCENARIO IS A SET OF CONSISTENT
PARAMETERS DESCRIBING POSSIBLE
LONG-TERM PATTERN OF A COUNTRY
ECONOMY, DEMOGRAPHY, SOCIAL,
AND TECHNICAL DEVELOPMENT**

Examples of Input Data for the Scenario

- **Population growth rate**
- **GDP growth rate**
- **Structural changes in economy**
- **Improvement in household size**
- **Improvement in efficiency**

General Steps in Scenario Constructing

- ➡ **CAREFULLY DEFINE OBJECTIVES OF STUDY**
- ➡ **SPECIFY TIME HORIZON AND INTERMEDIATE REFERENCE YEARS**
- ➡ **BUILT UP A HIERARCHICAL STRUCTURE OF THE SCENARIO VARIABLES**
- ➡ **WRITE A QUALITATIVE DESCRIPTION OF THE SCENARIOS**
- ➡ **QUANTIFY SCENARIO VARIABLES AND PREPARE INPUT DATA**

Execution of MAED Study

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