CHAPTER III
EXPERIMENTAL

3.1 Materials and Equipments

- Desktop PC (Pentium IV, RAM 1GB, WinXP and MS Office 2003).
- SimaPro v7.0 (professional LCA software) together with available databases (especially Ecoinvent).

3.2 Methodology

3.2.1 Preparation

- Prioritize petrochemical products according to their importance to other industries: VCM, LDPE, LLDPE, PVC, Propylene, PP, SM, Benzene, SAN/ABS, Toluene and P-Xylene.
- Survey the petrochemical industry in order to identify major manufacturers of these targeted products (Table D1).
- Contact those companies, explaining the importance and meaning of this work to them through meetings and asking for their corporations.
- Study the production processes of the targeted products.

3.2.2 Defining Goal

The study, under the National LCI Database Development for Thailand project, was commissioned by MTEC (National Metal and Materials Center of Thailand) to collect the LCI information of major petrochemical products manufactured in Thailand (namely LDPE, propylene, benzene, toluene, VCM, ABS, PVC, PP, etc.), assessing available information and identifying information gaps before integrating them into the national database. The LCA which was going to be conducted subsequently (for this research, the analysis was limited to the production of average PVC mixed from suspension and emulsion processes) aimed at providing a better understanding to both industry and the public regarding the potential environmental impacts associated with PVC production. Although it was not the study's primary goal to identify "hot spots" in the production systems or to support

an alternative method of production, the results may help manufacturers recognize the major problems caused by their products to the environment (such as climate change or ozone depletion) and provide some improvement suggestions. Later on, with greater-detailed studies into their system, limited to unit processes accounting for that specific problem, practical improvement measures will be implemented. Finally, along with other LCA research carried out recently in Thailand, this study elaborates and helps the industry realize that the procedure, as well as the applications of LCA, can be an effective analytical tool assisting them in the cause of striving for sustainable development, especially in this early stage of LCA development in Thailand.

3.2.3 Defining Scope and Functional Unit

Considering the time and budget constraints for this research, the boundary for all the product systems under investigation has been agreed upon among working group members to follow the gate-to-gate approach. This means the data regarding material consumption, fuel, utilities (water, electricity), emissions and waste from gate-to-gate (excluding capital goods) have been collected during the life-cycle of each product's production. The functional unit of this research is 1 kg of product.

For product systems where there are several economic products produced or processed, environmental inputs and outputs have to be allocated among these products. In this study, according to the suggestion from the ISO standard, mass-based allocation was chosen.

3.2.4 Data Collection – Inventory Analysis

- Establishment of inventory items: raw materials, energy consumption, air emission (CO_2, NOx, SOx, CO, VOCs, HFCs, heavy metals, etc.), wastewater discharge (BOD, COD, TDS, SS, Total Nitrogen, etc.), solid waste disposal, (transportation type and distance, which were not supplied in time of this study).

- Consult with Japanese experts to develop a common template for LCI data collection (Table D2). Each corresponding industrial association has received a slightly customized template, which was prepared according to their

specific products and processes. The raw material items had been pre-filled, which will facilitate the template completion.

The data that were collected in this investigation consist of:

- Raw materials.

- Utilities: water (pure water for the production process, cooling water, cold water, water for steam production, etc.).

- Products and co-products, by-products, loss.

- Energy consumption (electricity, steam, fuel) for the main process and environmental-control facilities (air, water and solid).

- Environmental loads (air-borne, water-borne emissions), directly from production process as well as from environmental-control facilities. The environmental impacts of solid waste due to the production of petrochemical products are, from our point of view, virtually negligible. In all cases, solid wastes are recycled, regenerated (catalysts, resins, filters) or specially treated and dumped in secure landfills.

➢ With respect to production process level, according to the consensus of the working group, for this preliminary stage, each concerned industrial association would gather input and output data of unit processes into a single subsystem (Figure 3.1), which were provided to the project as inventory data related to one product production. A more detailed look at unit processes, which requires more time and a higher budget, will be subsequently carried out in future studies.

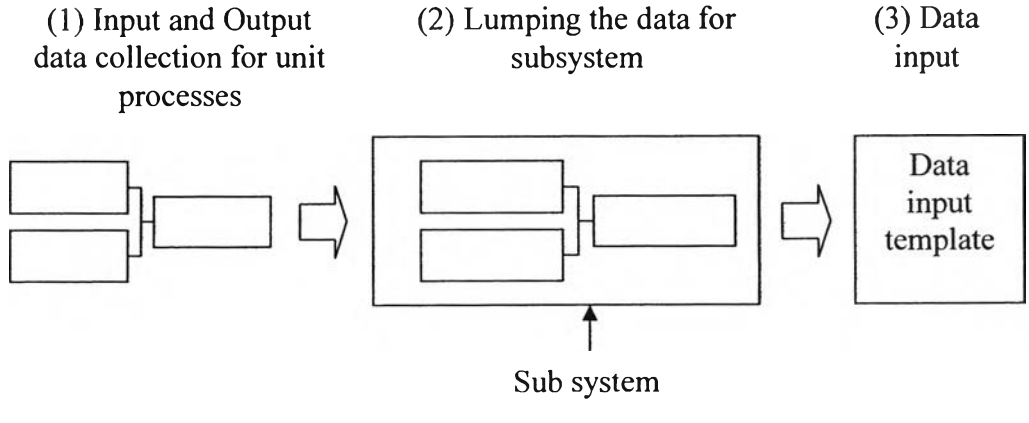

Figure 3.1 Inventory data collection based on the common manual (ignoring the differences in specific technologies being used by different companies).

➢ Distribute the templates to corresponding manufacturer through PTIT, a governmental organization which is responsible for data transfer between the industry and the working group, to ensure the confidentiality of data.

➢ Cross-check the information received from PTIT with other sources like companies' annual environmental reports, electronic databases, etc.

➢ Identify data gaps, fill in secondary data (from Ecoinvent database) or estimated data.

3.2.5 Process Scenarios for Study

In order to analyze the environment performance for average PVC production in Thailand, three scenarios were distinguished in this study:

- Fully integrated process to manufacture PVC domestically;
- Manufacture PVC from imported VCM;
- PVC manufactured in Europe.

LCI data for the last case (PVC manufactured in Europe) were extracted from Ecoinvent database of SimaPro software and used as reference data for comparison. Also the LCI data of EDC and VCM (among other background data) were taken from Ecoinvent database, assumed to be representative data for imported EDC and VCM in Thailand. Data regarding overseas transportation of EDC and VCM were also included by averaging the distance that a freight ship travels from Europe to Thailand is around 9000 miles. System boundaries for collecting LCI data for the first two cases are presented below in Figures 3.2 and 3.3.

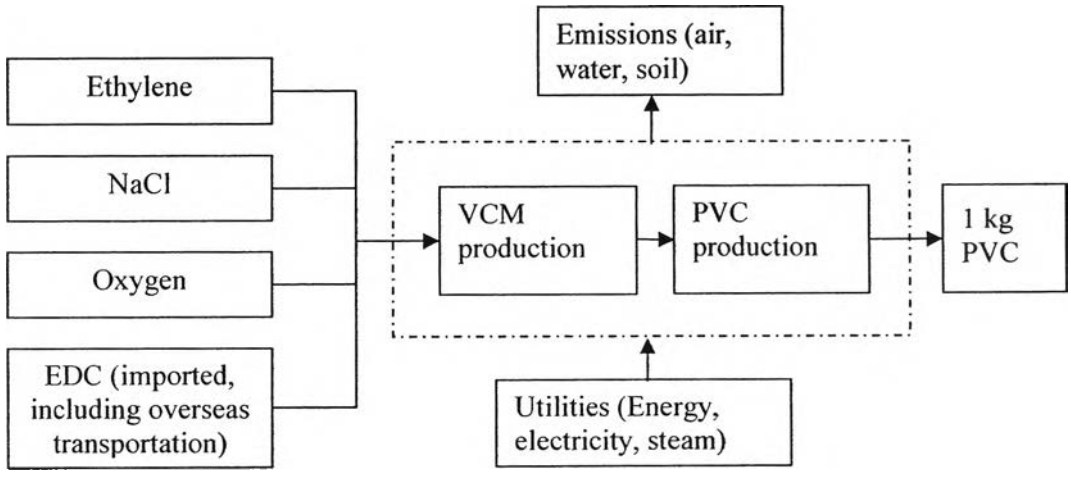

Figure 3.2 System boundary for fully integrated PVC production process.

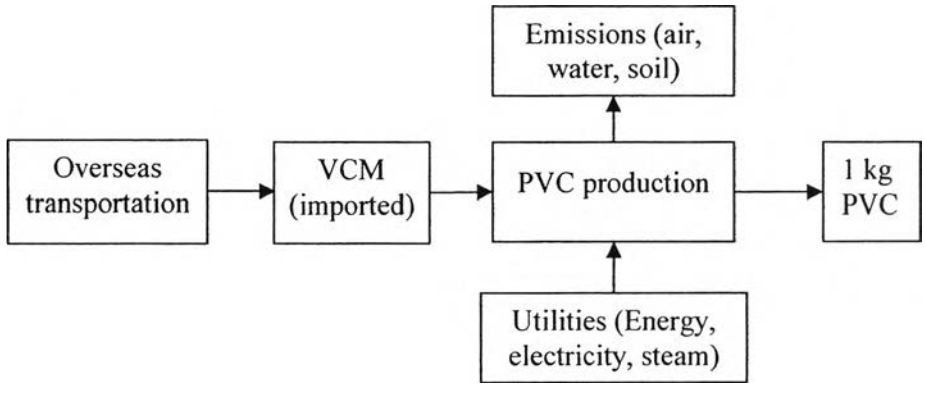

Figure 3.3 System boundary for producing PVC from imported VCM.

3.2.6 Life Cycle Impact Assessment (LCIA)

Carrying out the assessment step comprises the input of LCI data for each scenario into SimaPro project (Figure 3.4), selection of assessment method (Eco-indicator 99, Appendix B) and performance of the calculations to get the potential environmental impacts associated with a particular scenario.

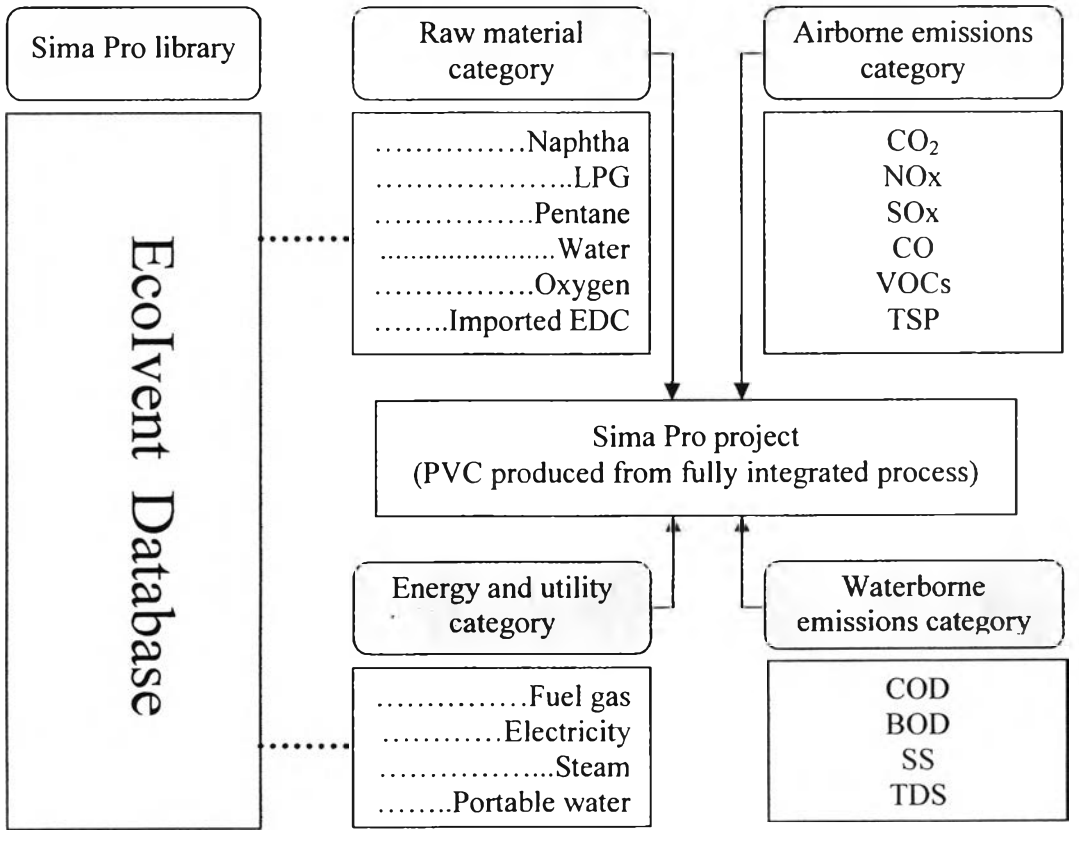

Figure 3.4 Procedure for inputting collected LCI data into Sima Pro project.

For choosing relevant impact categories, according to Global Environmental Outlook for SE Asia (GEO-III) (UNEP, 2002), the following local issues were aimed at due to their present severity on Thailand (or Southeast Asia region in general):

- Ecosystem due to land use;
- Eutrophication (aquatic);
- Particulates (inorganic substances);
- Fresh water (not included in Eco-99 methodology);
- Erosion (no method available for assessment!);

along with critical global issues like climate change, ozone layer depletion, etc. All of these impact categories are linked to three societal concerns (damage categories or end-points in ISO terms): human health, ecotoxicity and resource depletion. Subsequently, based on the calculated results, a simulated scenario representing the current situation of PVC production (the ratio of present domestic and imported VCM, 87.6:12.4, was applied in this case) in Thailand was constructed and used as the basis for improvement recommendations. Finally, the calculated results were verified and their implications communicated.