ENVIRONMENTAL AND ENERGY ASSESSMENT OF PETROCHEMICAL PRODUCTS USING LIFE CYCLE ASSESSMENT (LCA) TECHNIQUE

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ABSTRACT

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Keywords: LCI/ LCA/ VCM/ PVC/ Environmental impacts.

As a part of the Thailand National LCI Database Development project. this research aims to assess the environmental impacts of the petrochemical industry in Thailand covering upstream, middle-stream and downstream industries. Polyvinylchloride (PVC) has been chosen as a model to study the environmental impacts associated with its production using the Life Cycle Assessment (LCA) technique. The scope of the study includes the production of ethylene. vinyl chloride monomer (VCM) and PVC. In addition. three distinguished scenarios are analyzed for PVC production and compared for their environmental performance based on LCI data supplied by industrial associations and electronic databases. They are PVC manufactured from a fully integrated process, from a compounding process using imported VCM, and finally PVC imported from Europe. The results show that the fully integrated process has the poorest environmental performance, whereas the compounding process is better and quite comparable to European technology. The main cause has been shown to be the production of VCM in the fully integrated process, where there is a sizable amount of noxious NOx in air effluent which evidently results in severe respiratory diseases. In addition, the study has found that by increasing the ratio of imported VCM for PVC manufacturing from the present value of 12.4% to 30% or 40%, the overall environmental burdens can be markedly reduced by 20% and 30%, respectively. However. other factors. such as social and economic effects, should be taken into consideration before implementing any change.

บทคัดย่อ

เหงียน เบา เหงียน : การประเมินผลกระทบด้านพลังงานและสิ่งแวดล้อมของผลิตภัณฑ์ปิโตรเคมีโดยใช้เทคนิคการประเมินวัฏจักรชีวิต (Environmental and Energy Assessment of Petrochemical Products using Life Cycle Assessment (LCA) Technique) อ. ที่ปรึกษา : ผศ. ดร. ปมทอง มาลากุล ณ อยุธยา และ ผศ. ดร. มานิตย์ นิธิธนากุล 70 หน้า

งานวิจัยนี้เป็นส่วนหนึ่งของโครงการการพัฒนาฐานข้อมูลวัฏจักรชีวิตของประเทศ โดยมุ่งเน้นที่การประเมินผลกระทบต่อสิ่งแวดล้อมของอุตสาหกรรมปิโตรเคมีในประเทศไทยที่ครอบคลุมทั้งอุตสาหกรรมต้นน้ำ กลางน้ำ และปลายน้ำ โพลีไวนิลคลอไรด์ (พีวีซี) ได้ถูกเลือกเป็นผลิตภัณฑ์ที่ทำการศึกษาผลกระทบต่อสิ่งแวดล้อมที่เกิดจากการผลิตโดยใช้เทคนิคการประเมินวัฏจักรชีวิต ขอบเขตการศึกษารวมถึงการผลิตเอททีลีน ไวนิลคลอไรด์โมโนเมอร์ (วีซีเอ็ม) และพีวีซี นอกจากนี้ยังได้นำ 3 กรณีศึกษา คือ พีวีซีที่ผลิตจากกระบวนการอินทีเกรท จากกระบวนการคอมพาวด์ดิ้งที่ใช้วีซีเอ็มนำเข้า และพีวีซีที่นำเข้าจากยุโรป มาทำการวิเคราะห์เปรียบเทียบประสิทธิภาพด้านสิ่งแวดล้อมจากข้อมูลที่ได้รับจากสมาคมอุตสาหกรรมและจากฐานข้อมูลอิเลคทรอนิกส์ ผลการศึกษาแสดงให้เห็นว่า กระบวนการอินทีเกรทมีประสิทธิภาพด้านสิ่งแวดล้อมที่ต่ำที่สุด ในขณะที่กระบวนการคอมพาวด์ดิ้งมีประสิทธิภาพที่ดีกว่าและใกล้เคียงกับพีวีซีนำเข้าจากยุโรป ซึ่งสาเหตุหลักคือการผลิตวีซีเอ็มในกระบวนการอินทีเกรทที่พบว่ามีการปล่อย NOx สู่อากาศในปริมาณที่มาก อันจะส่งผมถึงโรคระบบทางเดินหายใจที่รุนแรง นอกจากนี้การศึกษายังพบว่า การเพิ่มสัดส่วนวีซีเอ็มนำเข้าต่อวีซีเอ็มที่ผลิตในประเทศจาก 12.4% เป็น 30% และ 40% นั้น สามารถทำให้ภาระต่อสิ่งแวดล้อมโดยรวมลดลงได้ถึง 20% และ 30% ตามลำดับ อย่างไรก็ตาม ตัวแปรอื่นๆ ได้แก่ ผลทางสังคมและเศรษฐศาสตร์ควรจะต้องถูกนำมาพิจารณาด้วยก่อนที่จะมีการปรับเปลี่ยนใดๆ

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GLOSSARY

Allocation	Partitioning the input or output flows of a process or other product system to the product system under study (ISO 14040)
Capital goods	Goods that are one-off investment, like trucks or machines.
Category endpoint	Attribute or aspect of natural environment, human health, or resources, identifying an environmental issue of concern (ISO 14040)
Cut-off criteria	Specification of amount of material or energy flow, or level of environmental significance associated with unit processes or product system to be excluded from a study (ISO 14040)
Damage analysis	To find out the total damage a chemical substance can cause (how many people, the severity of the disease).
Effect analysis	To find out what effect a chemical substance can cause (kind of diseases) with a specific concentration.
Endpoints	Term introduced in (but, unfortunately not defined in) ISO 14042 refers to the final outcome of an environment mechanism. For instance the outcome of climate change can be an increase of seawater level. In older LCA literature this was referred to as the safeguard subject; the issue society wants to protect (see also category endpoint).
Fate analysis	To find out in which environmental compartment (air, water, soil) a chemical substance finally will turn up

Functional unit	Quantified performance of a product system for use as a reference unit (ISO 14040)
Impact category	Class representing environmental issues of concern to which LCI results may be assigned (ISO 14040)
Life cycle	Consecutive and interlinked stages of a products system, from raw material acquisition or generation of natural resources to final disposal (ISO 14040).
Life Cycle Assessment	Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a products system throughout its life cycle (ISO 14040)
Life Cycle Impact Assessment	Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system (ISO 14040)
Life Cycle Inventory Analysis	A phase of life cycle assessment involving the compilation and quantification of inputs and outputs, for a given product system throughout its life cycle (ISO 14040)
Life Cycle Inventory Results	A list of emissions, resource uses, land use, etc. that are collected, before impact assessment is applied.
Midpoints (See also endpoint)	The term midpoint refers to an indicator that is somewhere along the environmental mechanism and the LCI parameter. For instance the CO_2 equivalents that express the radiative forcing are midpoints. If is needed to calculate an endpoint indicator, such as increased seawater level, additional modeling steps are needed.

Normalization	A procedure to show to what extent an impact category contributes to the overall environmental problem.
OECD countries	Those countries (in total 20) who signed the Convention on the Organization for Economic Co-operation and Development.
Product stages	Stages that are used to describe the composition of the product, the use phase and the disposal route of the product.
Product system	Collection of unit processes with elementary and product flows, performing one or more defined functions that models the life cycle of a product (ISO 14040).
Weighting	Is the process in which the various indicators, resulting from an LCA study models the life cycle of a product (ISO 14040), are aggregated in one figure (or a limited number of figures) through the use of subjective weighting factors.
Weighting factor	A factor that is coupled at a certain impact category, which is determined by a panel based on subjective opinions and reflects the importance of the category.