Electricity saving potential and carbon dioxide emission reduction in PVC industry in Thailand

Narisara Wanichwatanyu[1,2,*], Athikom Bangviwat[1,2]

[1]*The Joint Graduate School of Energy and Environment, King Mongkut's University of Technology Thonburi, Bangkok, Thailand*
[2]*Center of Energy Technology and Environment, Ministry of Education, Thailand*

Abstract:
It was reported that petrochemical sector in Thailand consumes 15% to 17% of the total industrial sector's energy consumption. Plastic resin industry in Thailand is one of the downstream sub-sectors of the petrochemical sector, which shares approximately 21% of the energy use of the sector. It is important for the industry to encourage the efficient energy management initiatives in order to minimize the energy cost and to maximize the benefit. In addition to the gain of energy conservation and higher energy efficiency, this will enhance the capability of the industry to compete with the same industry in the global scale. The objective of this research is to analyze the energy efficiency by evaluating the specific energy consumption (SEC) and the energy saving potential of the polyvinyl chloride (PVC) resin industry in Thailand. The analysis consists of four steps. First, the 2013 baseline for energy and material use in PVC resin industry is established. Secondly, the characterization of energy-efficient technologies to improve energy efficiency is discussed, and the potential applications and impacts of these measures are determined. In addition, scaling up the saving energy from each measure and constructing conservation supply curve (CSC) to assess the economic potential for energy efficiency improvement in Thai PVC resin industry are performed. The result shows that the total technical and the cost effective (economic potential) of electricity-efficiency potential for the Thai PVC resin industry in 2013 is estimated to be about 25,355 and 16,625 megawatt-hours (MWh) respectively. Moreover, the economic potential and the total technical of carbon dioxide emission reduction are 10,654 and 6,986 tCO_2, respectively.

Keywords: *-*

**Corresponding author. Tel.: +66-2470-8309*
E-mail address: narisara.wanich@gmail.com

1. Introduction

Petrochemical sector is one of the most energy intensive sectors in Thailand. It consumes energy accounting for 15% to 17% of the total industrial sector's energy consumption (DEDE, 2012). Plastic resin industry in Thailand is one of the downstream sub-sector of the petrochemical sector which shares approximately 21% of the energy use of the sector. Types of plastic resin that are commonly used in the domestic plastic industry are polyethylene (PE), polypropylene (PP), polystyrene (PS), and polyvinyl chloride (PVC). In this research, energy efficiency of Thai polyvinyl chloride (PVC) resin industry is investigated.

Energy efficiency potential of PVC resin industry in Thailand is determined by using information from case study and bottom-up model. In the assessment of energy efficiency, technical potential of a PVC resin factory is firstly estimated by integrating data on efficient measures and scaling up the energy saving into that of the industry. The energy conservation supply curve is then constructed in order to analyze Thai economic potential for the PVC resin industrial sector in base year 2013. Consequently, carbon dioxide emission reduction on this sector is calculated.

2. Methodology

This research, the potential for energy saving in the Polyvinyl Chloride production processes is assessed by collecting data from a factory which is considered as the representative case study for PVC resin industry and using bottom-up approach for the determination of cost of conserved energy. The analysis consists of four steps as follows:

2.1 Establishing a baseline for energy use in the Thai PVC resin industry

Energy use for each of the processes has been subdivided to the major processes and established 2013 as the base year for energy, material use, and production in the PVC resin industry. The base year information is also used to calculate the costs of conserved energy.

2.2 Characterization of energy efficient technologies

To analyze the potential for reducing electricity use and carbon dioxide emissions from PVC production process in the baht, information on electricity savings of a number of technologies and measures commercially available to improve electric efficiency in Thai PVC Resin industry is compiled. For each technology or measure, costs and electricity savings per ton of PVC produced in 2013 are estimated.

2.3 Establishing Conservation supply curves and economic analysis

First, energy saving potential is scaled up by multiplying the potential with the ratio of the total PVC production in Thailand and the production of the representative factory. Then Electricity Conservation Supply Curve (ECSC) is constructed in order to capture the accumulated cost-effectiveness and total technical potential for electricity and fuel efficiency improvements in Thai PVC industry. For this purpose, the Cost of Conserved Electricity (CCE) is calculated for respective technologies, and ranked in ascending order to construct an ECSC.

The Conservation Supply Curve (CSC) used in this study shows the energy conservation potential as function of marginal cost of conserved energy. The CCE can be calculated by

$$CCE = (\text{Annualized capital cost} + \text{Annual change in O\&M costs}) / \text{Annual energy savings} \quad (1)$$

CCE for each measure is plotted against its energy saving potential to establish an ECSC. If a conservation measure is cost-effective, the annual net cost saving is positive, yet for the measures whose CCE is above the electricity cost, the measure is not cost effective. For the analysis, where the electricity price of 4.208 Baht/kWh is used, those measures with their costs of conserved energy below that price is cost-effective. On the other hand, a conservation measure is considered non-cost effective when its CCE is larger than the electricity cost.

2.4 Carbon Dioxide (CO_2) emission analysis

$$CO_2 \text{ emission reduction } (tCO_2) = CO_2 \text{ emission factor} \times \text{total energy saving} \quad (2)$$

By multiplying the amount of saved electricity with the average CO_2 emission factor of 0.4202 tCO_2/MWh, CO_2 emission reduction (tCO_2) can be obtained. The CO_2 emission factor is adopted from IPCC Guidelines for National Greenhouse Gas Inventories 2006 (IPCC, 2007).

3. Results and discussion

Nine (9) major electricity efficiency measures in Thai PVC resin industry are ranked by their cost of conserved electricity (CCE) in Table 1. It is observed that the measure which can save the most energy and reduce the most CO_2 emission is measure 9^{th}, CA (Chlo Alkali) Energy saving by Bi-polar electrolyzer replacement, about 8,730 MWh, and 3,669 tCO_2 respectively, then followed by measure 4^{th}, membrane replacement at CA plant measure, about 5,990 MWh, and 2,517 tCO_2 respectively.

Table1 Electricity efficiency measures in Thai PVC resin industry which are ranked by their cost of conserved electricity (CCE)

No.	Measure/Technologies	Electricity saving (kWh/ measure)	Total cost of Thai PVC production (baht/yr)	Cost of Conserved Electricity (Baht/kWh -saved)	Cost saving (Baht/yr)*	CO_2 emission reduction (tCO_2)
1	Monitoring leakage and improvement in compress air system	1,037,208	1,037	0.001	4,363,533	436
2	Adjust set point pressure for load/unload condition in Air Compressor system	732,147	1,464	0.002	3,079,409	308
3	Membrane washing and Bus bar cleaning at CA plant	2,396,160	599,040	0.250	10,023,137	1,007
4	Membrane replacement at CA plant	5,990,400	2,768,997	0.462	24,930,703	2,517
5	Install VSD at cooling fan B to reduce electricity consumption	3,660,733	1,820,231	0.497	15,222,343	1,538
6	Reduce power consumption by replace new cooling fan blade at VCM production plant	910,457	889,012	0.976	3,212,589	383
7	Replace and improve cooling fan at air compressor system at VCM plant	1,036,339	2,810,666	2.712	3,424,027	435
8	Replace blade of cooling fan with new type at PVC production plant	861,479	3,093,068	3.590	2,736,094	362
9	CA (Chlor-Alkali) Energy saving by Bi-polar electrolyzer replacement	8,730,461	52,731,638	6.040	-15,993,857	3,669

* Electricity price equal to 4.208 Baht/kWh in 2012 (MEA, 2012)

It is envisaged from Fig. 3 and Table 2 that CCEs of eight (8) energy-efficiency measures fall under the electricity price line for Thai PVC resin industry in 2013 (4.208 Baht/kWh) (MEA, 2012). In other words, the cost of investing on these eight (8) energy-efficiency measures to save 1MWh of electricity is less than purchasing 1MWh of electricity with the given price. This is the so-called ‘‘cost effectiveness’’ of an energy-efficiency measure. As a result, the measure 9^{th} is not cost effective.

Table 2 Cost effective and technical potential for electricity saving and CO_2 emission reduction in Thai PVC resin industry for the base year 2013

Base year	Electricity saving potential (MWh/yr)		Carbon dioxide emission reduction (tCO_2/yr)	
	Technical	Cost effective	Technical	Cost effective
2013	25,355	16,625	10,654	6,986

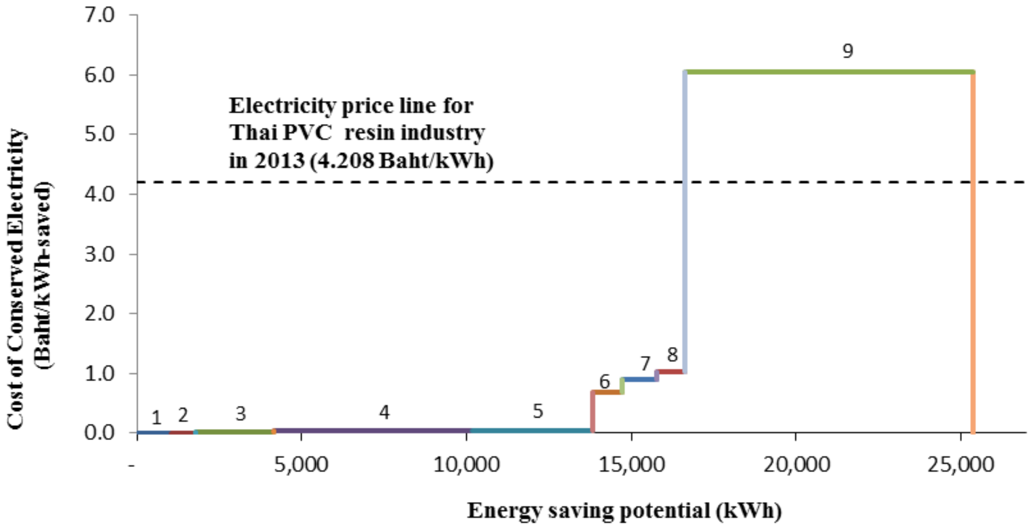

Fig. 3 Electricity conservation supply curve (ECSC) for Thai PVC resin industry.

The total technical electricity saving potential for Thai PVC resin industry in 2013 is equal to 25,355 MWh per year, which corresponds with an amount of CO_2 emission reduction of 10,654 tCO_2. The economic electricity-efficiency improvement potential for Thai PVC resin industry in 2013 was equal to 16,625 MWh per year, corresponding with an amount of CO_2 emission reduction was 6,986 tCO_2. Therefore, if the Thai PVC resins industry implements the recommended energy efficient measures, a large sum of electricity cost can be saved.

4. Conclusions

The energy efficiency improvement potential of PVC resin industry in Thailand is estimated by using bottom-up electricity Conservation Supply Curve (CSC) model. The results demonstrate that the total technical and economic potential electricity-efficiency for the Thai PVC resin industry in 2013 is estimated to be about 25,355 and 16,625 megawatt-hours (MWh), respectively. Moreover, the total technical and the economic potential of carbon dioxide emission reduction are 10,654 and 6,986 tCO_2, respectively.

5. References

Energy, Ministry of Energy, Department of Alternative Energy Developement and Efficiency (DEDE). 2012. Energy end used by economic 2012 [Online]. Available at: http://www.dede.go.th/dede/index.php?option=com_content&view=article&id=1841&Itemid=318&lang=en [Accessed on: Aug 2013].

Intergovernmental Panel on Climate Change (IPCC). 2007. Fourth Assessment Report (AR4): Emission factors for greenhouse gas inventories. 4 April 2014.

Metropolitan electricity Authority, Thailand (MEA). 2012. electricity price [online]. Available at: http://www.mea.or.th/profile/index.php?l=th&tid=3&mid=2986&pid=2985 [Accessed in June 2014].