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Energy Efficiency Potential in Industrial Motor Systems in Thailand

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Abstract: Motor-driven equipment accounts for approximately 60% of manufacturing final electricity use worldwide. A major barrier to effective policymaking, and to more global acceptance of the energy efficiency potential in industrial motor systems, is the lack of a transparent methodology for quantifying the magnitude and cost-effectiveness of these energy savings. This paper presents the results of original analyses conducted for Thailand to begin to address this barrier. Using a combination of expert opinion and available data from Thailand as well as United States and the European Union, bottom-up energy efficiency cost curve models were constructed to estimate the cost-effective electricity efficiency potentials and CO_2 emission reduction for three types of motor systems (compressed air, pumping, and fan) in industry in Thailand. Based on these analyses, the share of cost-effective electricity saving potential of these systems as compared to the total motor system energy use in the Thai industry in base year was 36% for pumping, 47% for compressed air, and 46% for fan systems. The total technical saving potential was 45% for pumping, 55% for compressed air, and 46% for fan systems for industrial motor systems in Thailand.

Keywords: Energy efficiency; Motors systems; Bottom-up model.

1. Introduction

Motor-driven equipment accounts for approximately 60% of manufacturing final electricity use and are ubiquitous in industrial facilities worldwide. A major barrier to effective policymaking, and to more global acceptance of the energy efficiency potential of motor systems, is the lack of a transparent methodology for quantifying this potential based on sufficient data to document the magnitude and cost-effectiveness of these energy savings by country and by region.

This paper and supporting analyses represent an initial effort to address this barrier, thus supporting greater global acceptance of the energy efficiency potential of motor systems, through the construction of a series of motor system efficiency cost curves, by motor system at the country-level. It is important to note, however, the limitations of this initial study based on available data and expert opinion. The purpose of this research is to provide guidance for national policy makers and is not a substitute for a detailed technical assessment of the motor system energy efficiency opportunities of a specific site.

2. Experimental

In the original study, six countries/region were selected that represent varying sizes and levels of industrial development, and for which industrial energy use by sector and some information about motor system efficiency practices were available. These initial six are the United States, Canada, the European Union, Thailand, Vietnam, and Brazil. However, in this paper, only the analysis and results for Thailand is presented.

Thailand's Country-specific data was collected in parallel with the motor system expert consultation. After receiving expert input and completing collection of the country-specific data, the Motor System Energy Efficiency Cost Curves were constructed based on the methodology explained below. For a more detailed explanation of the methodology and data (country-specific and system-specific data) used in the study, refer to McKane and Hasanbeigi (2011) [1].

Following a literature review to develop a base case of information, a data collection framework was developed to obtain expert input to supplement the existing data. Input was received from thirteen motor system experts, including at least four experts for each of the three systems analyzed (compressed air, fans, and pumping). A Delphi-type approach was used in which several iterations of expert opinion were used to refine the final inputs to the analyses.

2.1 Defining Three Base Case System Efficiency Scenarios (LOW-MEDIUM-HIGH)

The approach used was to establish three base case energy efficiency scenarios (LOW-MEDIUM-HIGH) for each of three system types- pumping, compressed air, and fan systems- based on previous research and the experts' opinion. The first step in establishing a base case was to create and test a unique list of system energy efficiency practices representative of each of three efficiency scenarios for each system type. Tables that provide the list of practices defined for each base-case efficiency level for the pumping, compressed air and fan systems can be found in McKane and Hasanbeigi (2011) [1]. The experts were then asked to provide a low to high estimated range of the system energy efficiency (expressed as a %) they would expect to see when assessing a system in an industrial market with the characteristics given for each efficiency scenario. A range of efficiency was requested, rather than a single value, to better align with the variations that are likely to be found in industrial settings.

After defining the base case efficiencies for each motor system, we assigned a "base case" to Thailand for the purpose of providing a reference point for the current (pumping, compressed air, or fan) system performance in Thailand based on the information available. Expert judgment was used for this purpose. The Medium efficiency was assigned to pumping systems, LOW efficiency was assigned to fan systems and LOW efficiency was assigned to compressed air systems for Thai industry.

2.2 Determining the impact of energy efficiency measures

A list of potential measures to improve system energy efficiency was developed for each system type and sent to the experts for review. Ten energy-efficiency technologies and measures for pumping systems, ten measures for the fan systems, and sixteen measures for compressed air systems were analyzed. For each group of measures, we asked experts to provide their opinion on a low to high range of energy savings likely to result from implementation of each measure, taken as an independent action, expressed as a % improvement over each of the LOW-MED-HIGH base cases. The experts were also asked to provide cost information for each measure, disaggregated by motor size range.

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2.3. Construction of Motor System Efficiency Cost Curves

The Efficiency Cost Curve used in this study is an analytical tool that captures both the engineering and the economic perspectives of energy conservation. The curve shows the energy conservation potential as a function of the marginal Cost of Conserved Energy [2]. The Cost of Conserved Energy can be calculated from Eq. (1).

Cost of Conserved Energy
= (Annualized capital cost +Annual change in O&M costs) /Annual energy savings (1)

The annualized capital cost can be calculated from Eq. (2).

Annualized capital cost = Capital Cost*(d/ (1-(1+d)$^{-n}$) (2)

d: discount rate, n: lifetime of the energy efficiency measure.

In this study, a real discount rate of 10% was assumed for the analysis. After calculating the Cost of Conserved Energy for all energy efficiency measures, the measures are ranked in ascending order of Cost of Conserved Energy. In cost curves an energy price line is determined. All measures that fall below the energy price line are identified as "Cost-Effective". That is, saving a unit of energy for the cost-effective measures is cheaper than buying a unit of energy. On the curves, the width of each measure (plotted on the x-axis) represents the annual energy saved by that measure. The height (plotted on the y-axis) shows the measure's cost of conserved energy.

2.4. Calculation of the annual energy savings and the Cost of Conserved Electricity

The calculation and data analysis methodology used was the same for all three motor system types included in these analyses (i.e. pumping, fan, and compressed air systems). The detail of the calculation of energy saving and cost are not presented in this paper because of lack of space and can be found at McKane and Hasanbeigi (2011) [1].

3. Results and Discussion

Figure 1 presents the Pumping System Efficiency Cost Curves for Thailand. Similar figures and tables for the Thai industrial fan and compressed air systems can be found in UNIDO (2010) [3]. The name of the measures related to each number on the cost curve is given in Table 1 along with the cumulative annual electricity saving potential, final CCE of each measure, cumulative annual primary energy saving potential, and cumulative CO_2 emission reduction potential. In Table 1, the energy efficiency measures that are above the bold line are cost-effective (i.e. their CCE is less than the unit price of electricity) and the efficiency measures that are below the bold line in the tables and are shaded in gray are not cost-effective. The results of pumping system efficiency cost curves show that out of 10 energy efficiency measures, 7 measures are cost effective, i.e. their cost of conserved energy is less than the average unit price of electricity in those countries. Table 2 shows the summary of the results for the industrial motors systems in Thailand.

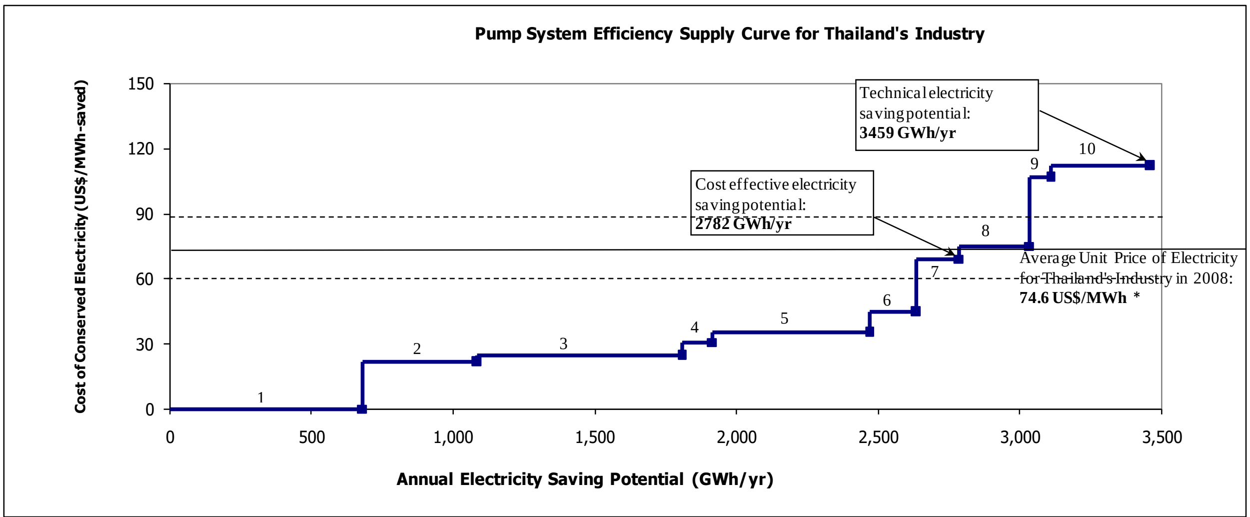

Figure 1. Industrial Pumping System Efficiency Cost Curve for Thailand.

Table 1. Cumulative annual electricity saving and CO_2 emission reduction for Industrial Pumping System efficiency measures in Thailand ranked by their Final CCE.

No.	Energy Efficiency Measure	Cumulative Annual Electricity Saving Potential in Industry (GWh/yr)	Final CCE (US$/MWh -saved)	Cumulative Annual Primary Energy Saving Potential in Industry (TJ/yr)	Cumulative Annual CO_2 emission reduction Potential from Industry (kton CO_2 /yr)
1	Isolate flow paths to non-essential or non-operating equipment	678	0.0	6,823	352
2	Remove sediment/scale buildup from piping	1,084	22.0	10,905	562
3	Install variable speed drive	1,808	24.9	18,194	938
4	Fix Leaks, damaged seals, and packing	1,913	30.6	19,251	993
5	Trim or change impeller to match output to requirements	2,469	35.5	24,849	1,282
6	Use pressure switches to shut down unnecessary pumps	2,631	45.1	26,474	1,365
7	Remove scale from components such as heat exchangers and strainers	2,782	69.1	27,997	1,444
8	Initiate predictive maintenance program	3,032	75.0	30,510	1,574
9	Replace motor with more energy efficient type	3,109	107.3	31,289	1,614
10	Replace pump with more energy efficient type	3,459	112.4	34,809	1,795

*In calculation of energy savings, equipment 1000 hp or greater are excluded

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Table 2 Total annual cost-effective and technical energy saving potential in motors systems studied in Thailand.

	Annual electricity saving potential (100% penetration) (GWh/yr)		**Share of saving from total system energy use in Thai industry in 2008**	
	Cost effective	**Technical**	**Cost effective**	**Technical***
Pumping System	2,782	3,459	36%	45%
Compressed air System	3,741	4,381	47%	55%
Fan System	1,819	1,819	46%	46%

*In calculation of energy savings, equipment 1000 hp or greater are excluded

4. Conclusion

Using the bottom-up energy efficiency cost curve model, the cost-effective and technical electricity efficiency potentials for industrial motor systems were estimated for the Thailand. This study and supporting analyses represent an initial effort to address the lack of a transparent methodology for quantifying the energy efficiency potential of motors systems based on sufficient data to document the magnitude and cost-effectiveness of the resulting energy savings by country and by region. The research framework created to conduct the analyses supporting this study is meant to be a beginning, not an end unto itself.

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