Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Applied Sciences 9 (14): 2630-2634, 2009
ISSN 1812-5654

Market Transformation Due to Implementation of Energy Efficiency Standards and Labels Implementation for Electric Motor

[1,2]P.A.A. Yanti and [2]T.M. Mahlia
[1]Department of Mechanical Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia
[2]Petronas Carigali Sdn. Bhd. Level 18, Tower 1, Petronas Twin Towers, 50088 Kuala Lumpur, Malaysia

Abstract: This study attempts to investigate about the market transformation of electric motor due to implementation of minimum energy efficiency standards and energy labels. The study found that efficiency of electric motor will increase from 90.0 to 92.5% due to implementation of standards and will increase further to 93.5% due to energy labels, this study is only investigate electric motor, however the method is also applicable for predicting market transformation for other product without major modification.

Key words: Energy conservations, energy efficiency, energy utilization, labeling, electric motor

INTRODUCTION

Industrial sectors on average account for more than 40% of the country's electricity consumption share (NEB, 2006). The energy usages are mostly by electric motors, which accounted for more than 45% (Saidur *et al*., 2009). Unfortunately, they are mostly using standard motors instead of high efficiency motors. Therefore, a suitable strategy should be implemented to reduce the energy growth in this sector. One of the most effective way is to adopt energy efficiency standards and labels. Energy efficiency standard has become an important policy in the public agenda nowadays. The theory and methodology on implementation of energy efficiency standards and energy labels is given by Turiel *et al*. (1997), Mahlia *et al*. (2002) and Wiel and McMahon (2001).

In a survey conducted by Energy Commission found that out of annual sales of more than 100,000 units of motors in the country; only about 2% were using the high efficiency motors. When a motor used 4% more efficient, it could save between RM$420,000 to RM$560,000 (US$ 1 = RM$ 3.5) over its lifetime of 15 to 20 years (Fong, 2005). There are currently no minimum efficiency level requirements for electric motors in Malaysia. Currently, there is no authoritative or independent testing facility to test and assess the energy efficiency levels of electric motor in this country. The Standards and Industrial Research Institute of Malaysia (SIRIM) plans to acquire the necessary testing facility to carry out independent testing on the energy efficiency of motors in the future (Energy Commissions, 2005).

Energy efficiency standards and labels usually come together. Standards are more towards technical setting of energy efficiency while labels provided a guideline to the consumers to select more efficient product in the market. According to McMahon and Turiel (1997), energy efficiency standard is the prescribed energy performance of a manufactured product, sometimes prohibiting the manufacturer of products less than the minimum standards. Energy efficiency standards can be either mandatory or voluntary. A mandatory energy efficiency standard is generally the most effective strategy of rapidly improving the energy efficiency of the products. While, voluntary energy efficiency standards is implemented by negotiated between the government and manufacturers, is an alternative option and have merit of being less controversial and hence easier to enact but do not work well in some countries (Egan, 1997). This policy is also aimed to preserve limited nonrenewable energy resources and the environment. Similar study has been conducted on a policy for the introduction of high efficiency electric motors conducted for Brazil (Delgado and Tolmasquim, 2002). Another study on the same topic is deals with energy conservation by installing energy-efficiency motors instead of standard efficiency motors (Akbaba, 1999). Some other studies discuss about implementation of energy standards and label are given by Lin and Rosenquist (2008), Gracia *et al*. (2007), Lu (2007) and Varman *et al*. (2005).

Meanwhile, for energy labels, through educating the consumers will create competition among the manufacturers. The energy labels enable the potential buyer to compare the energy efficiency of products on a

Corresponding Author: P.A.A. Yanti, Department of Mechanical Engineering, University of Malaya, 50603 Kuala Lumpur, Malaysia Tel: +60-3-2331-7136 Fax: +60-3-2331-5172

fair and equitable basis. The energy labels acts as an indicator telling the potential buyer how energy efficient the product. Some other studies discuss about implementation of energy efficiency standards and label are given by Lee and Rajagopalan (2008), Sanchez *et al*. (2008) and Mahlia *et al*. (2005). Despite of causing, the impacts on energy, economical and environmental the program also creating market transformation on the products efficiency. This study attempts to predict potential market transformation by implementing energy efficiency standards for electric motors in Malaysia. The study that related to this subject are presented by Garcia *et al*. (2007), Hurst and Dominguez (2007) and DeAlmeida *et al*. (2008).

MATERIALS AND METHODS

The study was conducted for 3 years started in January 2005 and completed in January 2009. This is included the development of theoretical background and data collections. The methodology has been divided into two sub sections namely; star rating calculations and market transformation.

Star ratings: Energy Commission has proposed a five star rating system for Malaysia's energy labels, which will divide the electric motor efficiency into five classes. The highest efficiency grade receives five stars and the lowest efficiency grade (the minimum energy efficiency standards set for each type of products) will carry one star. The sample of Malaysia's energy labels is presented in Fig. 1 (Energy Commissions, 2009). The calculations is based on the distributions of the products efficiency after the standards enacted. These data are predicted using annual efficiency improvement of electric motor for the year of standards enacted. The methods for star ratings calculation is presented in Table 1.

Market transformation: Two curves described market situation before and after the energy efficiency standards is introduced. The curves are present the unit distribution of electric motors in the market. The market transformation is forcing the average efficiency of the appliances from the first curve (baseline average efficiency) towards the second curve (standards average efficiency) after the standards are implemented. The average efficiency of the appliances distributions is pushed by the standards to be more efficient in the year. The standards are implemented as shown in Fig. 2.

Establishing energy labels encourages the availability of a more efficient product in the market. Manufacturers are willing to produce the most energy efficient product to win the market since it is expected that

Fig. 1: Malaysia's energy label

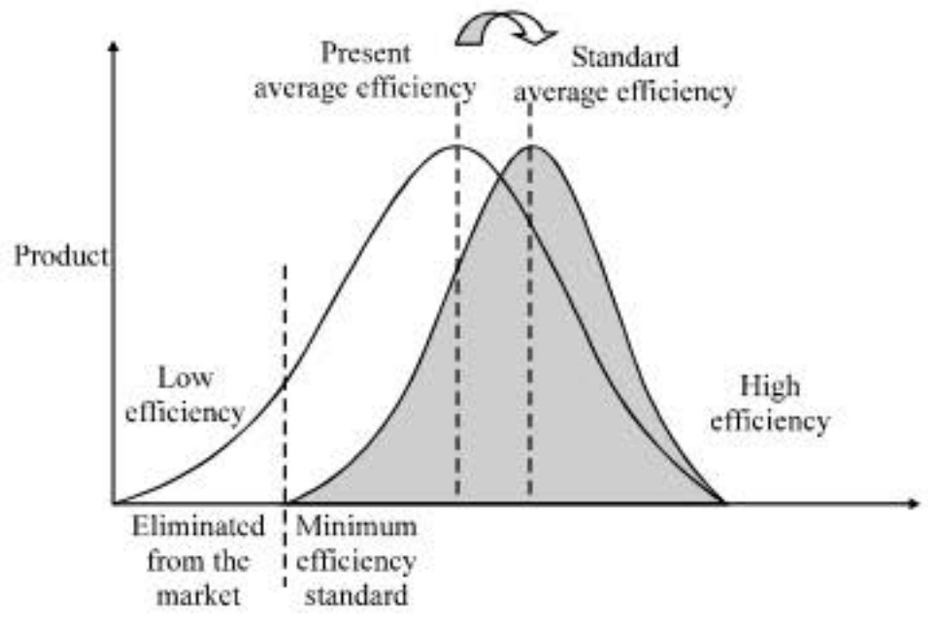

Fig. 2: Market transformation and products distribution due to standards implementation

Table 1: Star rating calculation

Star rating	Minimum values	Maximum values
1	Minimum efficiency	Minimum efficiency + δ
2	Maximum value of 1 star	Minimum value of 2 star + δ
3	Maximum value of 2 star	Minimum value of 3 star + δ
4	Maximum value of 3 star	Minimum value of 4 star + δ
5	Maximum value of 4 star	Unlimited

consumers will purchase more efficient product from the market due to the energy labels. This will encourage the availability of the high efficiency models in the marketplace and increase the average energy efficiency of the electric motors. As a result, the product distribution is represented by three curves, which are the baseline, minimum energy efficiency standards and energy labels. The evolution of market transformation and product distribution due to the energy labels implementation is presented in Fig. 3 (Mahlia, 2004).

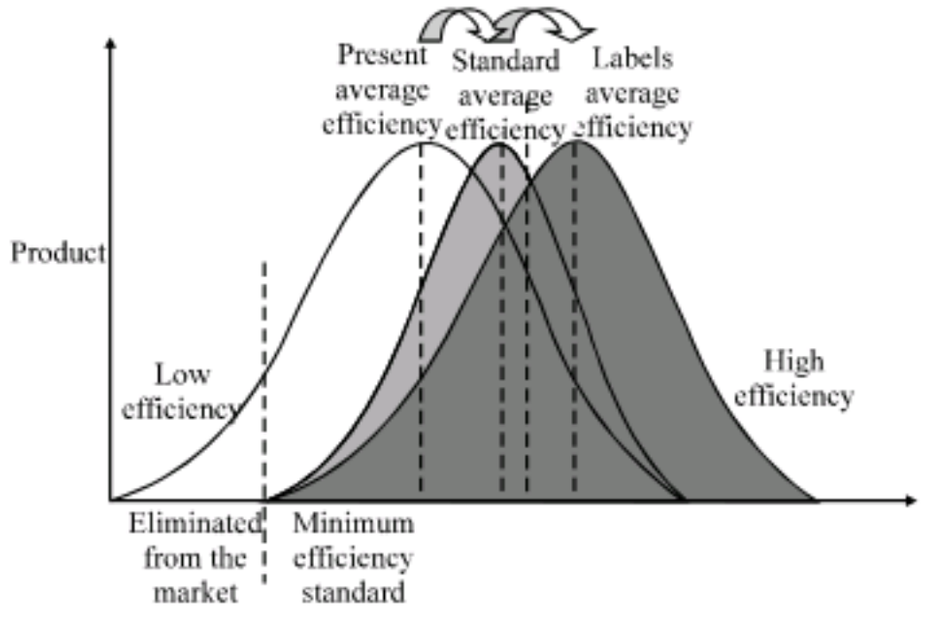

Fig. 3: The evolution of market transformation and products distribution due to standards and label implementation

The three curves represent the unit distributions of the products in accordance with energy efficiency before and after the energy labels is implemented. The average energy efficiency is increased from the first curve without standards, to the second curve with standards and then to the third curve gradually after the labels are implemented (labels average efficiency).

As a result, the market transformation is described based on three steps, which are present average efficiency, standards average efficiency and labels average efficiency. Present average efficiency is the average electric motors efficiency in the market before standards and labels is implemented. This is an average efficiency is determined from market survey data in particular year, which can be predicted for the year of standards enacted by the following equation:

$$\eta_{PAE}^{em} = \frac{1}{n}\sum_{i=1}^{n}\eta_{Ysc}^{em}\times\left(1+AEI_{i}^{em}\right)^{(Ypd-Ysc)} \quad (1)$$

Standards average efficiency can be calculated by the Eq. 2:

$$\eta_{SAE}^{em} = \frac{1}{n}\sum_{i=1}^{n}\eta_{STD}^{em} \quad (2)$$

And labels average efficiency can be calculated by Eq. 3:

$$\eta_{LAE}^{em} = \eta_{LGL}^{em} + 2\delta \quad (3)$$

RESULTS AND DISCUSSION

Star rating calculation: The annual efficiency improvement is defined from the survey that is 0.11%.

Table 2: Star rating values

Star rating	Electric motor efficiency label (%)	Central value (%)
1	91.0≤Eff<92.0	91.5
2	92.0≤Eff<93.0	92.5
3	93.0≤Eff<94.0	93.5
4	94.0≤Eff<95.0	94.5
5	≥ 95	-

Since, the standard is proposed to be enacted in the year 2014, the grade is determined using efficiency distribution data in this particular year. This is based on 1% standards and 0.11% of annual efficiency improvement (Yanti, 2008). From the previous section, the minimum efficiency for electric motor is calculated as 90.0% and average efficiency for electric motor is 92.5%. The average efficiency is set as the baseline efficiency for the label. The star rating calculation and the star rating value is as shown in Table 2.

Expected market transformation due to standards: The efficiency of electric motor will be higher when the energy efficiency standard is introducing. Energy efficiency standards will eliminates inefficient electric motor from the market place. The unit distribution of electric motors in the market represent by two curves that describe market situation before and after the energy efficiency standards implementation that presented in Fig. 2. This study is considering implementing minimum energy efficiency standards for electric motors in the early 2014. Therefore, the efficiency distribution for this year 2007 can be predicted using Eq. 1. The average of electric motors efficiency distributions are from 90.0 % in the year of 2005 to 91.0% in the year of 2014.

The average of electric motor efficiency distributions is increased from 90.0 to 92.5% in the year of standard enacted. This is based on 1% standards and 0.11% of annual efficiency improvement. The market transformation force electric motors efficiency from the first curve (average efficiency 90.0%) towards the second curve (average efficiency 92.5%). The calculations are using Eq. 3, the results are presented in Fig. 4.

Expected market transformation due to energy labels: Introducing energy labels as pair of standards will encourage manufacturers to produce more efficient electric motor, this will create the transformation in the market as presented in Fig. 3. It is expected the consumer will purchase more efficient models from the market due to the labels. This will gradually pull the availability of the high efficient products in the marketplace. The market transformation and the product distribution due to energy labels implementation is calculated using Eq. 2 and 3 is presented in Fig. 5.

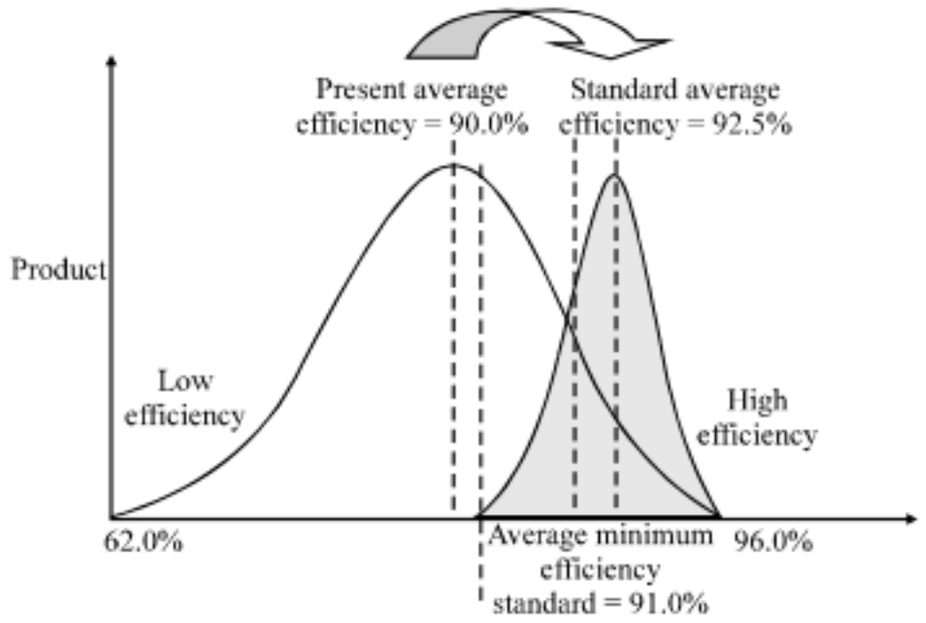

Fig. 4: Market transformations and electric motor distribution due to implementation of standards

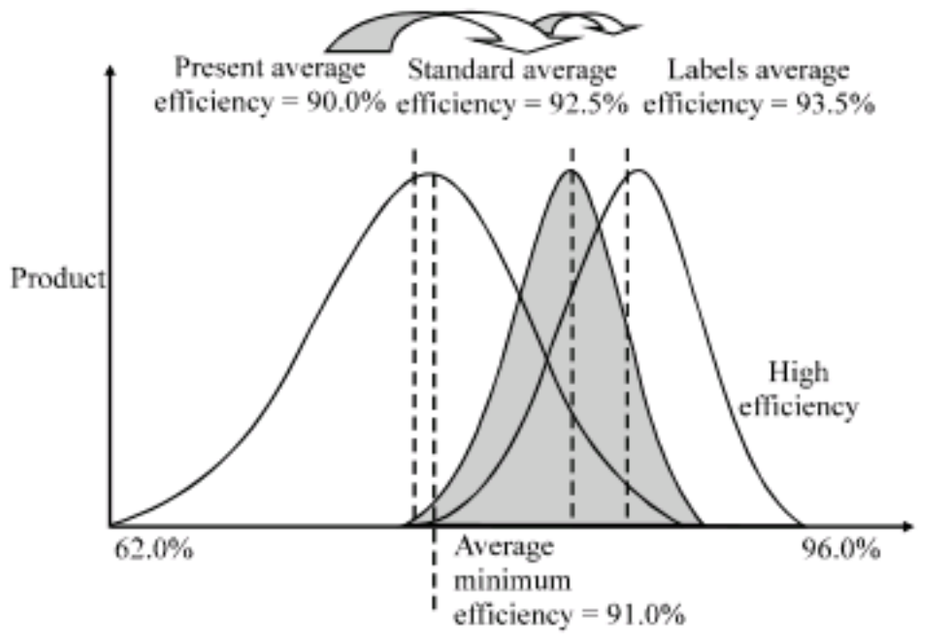

Fig. 5: Market transformations and electric motor distribution due to standards and labels implementation

Energy labels expected will gradually pull the market by improving efficiency of the electric motors to an average 93.5% (grade 3 star) within the period 2014 to 2023. The difference between the standards and labels on the market treatment are, the energy efficiency standards will force the market instantaneously, while the energy labels pull the market gradually.

Another aspect involving motor efficiency is users purchase decisions. Many users are still making their motor purchasing decisions based on initial purchase cost. It is vital to evaluate the differences between motors offered by various manufacturers and only choose those that clearly meet our operating criteria. An investment of 30 to 50% for a high-energy efficient motor, over the cost of a standard motor, can be recovered in a relatively short period of time. Furthermore, with some motors the cost of wasted energy exceeds the original motor price even in the first year of operation. The fact is that on average the initial purchase cost of a motor only makes up 2-16% of the total cost of ownership depending on motor size. Hopefully by educating users through implementing energy efficiency standard and label this problem can be solved and end up with increasing energy efficiency of electric motors in Malaysia industrial sector.

CONCLUSION

The energy efficiency standards provide great benefits to the consumer, national economy, natural environment and local manufacture. The minimum efficiency for electric motor is calculated as 90.0% and average efficiency for electric motor is 92.0%. The average efficiency is set as the baseline efficiency for the label. The average of electric motor efficiency distributions is increased from 90.0 to 92.0% in the year of standard enacted. This is based on 1% standards and 0.11% of annual efficiency improvement. The market transformation force electric motors efficiency from the first curve (average efficiency 90.0%) towards the second curve (average efficiency 92.5%). While, energy labels gradually pull the market by improving efficiency of the electric motors to an average 94% within the period 2014 to 2023. Market transformation can speed up the result of improving energy efficiency of the electric motor and encourage manufacturers improving product design toward more energy efficient to win the market. Finally, it is expected that this studies give an idea of how to calculate market transformation for electric motor. Therefore, the policy makers and energy planner must consider this program as the main concern to gain an optimum energy, economical and environmental impacts.

ACKNOWLEDGMENTS

The authors would like to acknowledge for the Ministry of Higher Education of Malaysia and The University of Malaya, Kuala Lumpur, Malaysia for the financial support under PJP Grant No. FS212-2008A.

NOMENCLATURE

AEI_i^{em}	:	Annual energy efficiency improvement in the year i of electric motor
n	:	No. of year
Ypd	:	Year of predicted
Ysc	:	Year of survey conducted
δ	:	Incremental step size for each grade in the labels
η_{LAE}^{em}	:	Energy labels average efficiency of electric motor
η_{LGL}^{em}	:	Minimum efficiency of electric motor on energy labels (3 star)

η^{em}_{PAE} : Present average efficiency of electric motor
η^{em}_{SAE} : Standards average efficiency of electric motor
η^{em}_{STD} : Efficiency of each electric motor in the year of standards enacted
η^{em}_{Ysc} : Efficiency of electric motor in year of survey conducted

REFERENCES

Akbaba, M., 1999. Energy conservation by using energy efficient electric motors. Applied Energy, 64: 149-158.

DeAlmeida, A.T., F.J.T.E. Ferreira, J.A.C. Fong and C.U. Brunner, 2008. Electric motor standards, ecodesign and global market transformation. Proceedings of the Technical Conference on Industrial and Commercial Power Systems, May 4-8, Clearwater Beach, FL., USA., pp: 1-9.

Delgado, M.A.P. and M.T. Tolmasquim, 2002. Analysis of a feasible tariff policy for the introduction of high efficiency electric motors in Brazil. Energy Conver. Manage., 43: 827-844.

Egan, K., 1997. Stories from Asia: standards and labeling successes, conference on energy efficiency in household appliances. Proceeding of the 1st International Conference on Energy Efficiency in Households Appliances, Nov. 10-12, Springer-Verlag, Florence, Italy Germany, pp: 469-486.

Energy Commissions, 2005. High efficiency motor-your profit drive, homepage of high efficiency motor. Ministry of Energy, Water and Communications. Kuala Lumpur, Malaysia.

Energy Commissions, 2009. Comparative energy label for refrigerator. Ministry of Energy, Water and Communications. Kuala Lumpur, Malaysia.

Fong, L.F., 2005. Efficient Energy Savers, use of Energy-efficient Motors is the Latest Strategy to Save Energy by the Government. The Star, Kuala Lumpur, Malaysia.

Garcia, A.G.P., A.S. Szklo, R. Schaeffer and M.A. McNeil, 2007. Energy-efficiency standards for electric motors in Brazilian industry. Energy Policy, 35: 3424-3439.

Hurst, J. and H. Dominguez, 2007. Raising the standard for electric motor efficiency. InTech, 54: 30-34.

Lee, S.E. and P. Rajagopalan, 2008. Building energy efficiency labeling programme in Singapore. Energy Policy, 36: 3982-3992.

Lin, J. and G. Rosenquist, 2008. Stay cool with less work: China's new energy-efficiency standards for air conditioners. Energy Policy, 36: 1090-1095.

Lu, W., 2007. Potential energy savings and environmental impacts of energy efficiency standards for vapor compression central air conditioning units in China. Energy Policy, 35: 1709-1717.

Mahlia, T.M.I., H.H. Masjuki and I.A. Choudhury, 2002. Theory of energy efficiency standards and labels. Energy Conversion Manage., 43: 743-761.

Mahlia, T.M.I., 2004. Methodology for predicting market transformation due to implementation of energy efficiency standards and labels. Energy Conversion Manage., 45: 1785-1793.

Mahlia, T.M.I., H.H. Masjuki, F.M. Taha, N.A. Rahim and R. Saidur, 2005. Energy labeling for electric fans in Malaysia. Energy Policy, 33: 63-68.

McMahon, J.E. and I. Turiel, 1997. Introduction to special issue devoted to appliance and lighting standards. Energy Build., 26: 1-4.

NEB, 2006. National energy balance. Ministry of Energy Water and Communications Malaysia, Putrajaya, Malaysia.

Saidur, R., N.A. Rahim, H.H. Masjuki, S. Mekhilef, H.W. Ping and M.F. Jamaluddin, 2009. End-use energy analysis in the Malaysian industrial sector. Energy, 34: 153-158.

Sanchez, M.C., R.E. Brown, C. Webber and G.K. Homan, 2008. Savings estimates for the United states environmental protection agency's ENERGY STAR voluntary product labeling program. Energy Policy, 36: 2098-2108.

Turiel, I., T. Chan and J.E. McMahon, 1997. Theory and methodology of appliance standards. Energy Build., 26: 35-44.

Varman, M., H.H. Masjuki and T.M.I. Mahlia, 2005. Electricity savings from implementation of minimum energy efficiency standard for TVs in Malaysia. Energy and Buildings, 37: 685-689.

Wiel, S. and J.E. McMahon, 2001. Energy-Efficiency Labels and Standards: a Guidebook for Appliances, Equipment and Lighting. Collaborative Labeling and Appliance Standards Program (CLASP), Washington DC.

Yanti, P.A.A., 2008. Survey data on electric motor. University of Malaya, Kuala Lumpur, Malaysia.