

CHAPTER 2

LITERATURE REVIEW

2.1 Approaches to Understanding Energy Efficiency Potential by Individual “Widgets” or Detailed Energy-Efficiency Technologies and Measures

The energy end-use approach to estimating potential savings suffers from the limited ability of readers to review critically what assumptions are made and what models are used to derive the costs and savings for specific energy efficiency measures. This is often accompanied by limited guidance to program administrators of how best to achieve the savings i.e., what types of equipment or designs should be promoted (The National Academies, 2009).

In contrast, “widget”-based supply curves look at technologies and measures at a very detailed level. They can involve a multi-hundred or thousand line spreadsheet that tabulates detailed technical measures. They can cover both retrofits and new buildings by establishing separate sets of rows in the spreadsheets for retrofits compared with new buildings. This is the approach that relates most closely to the policies and programs used to obtain energy savings through improved energy efficiency.

Widget-based analyses look at the same types of technologies and measures as whole building or end-use based analyses for residential buildings:

- more efficient appliances by efficiency rating,
- more efficient heating and cooling equipment by efficiency rating,
- additions of insulation to ceilings, walls, and floors,
- substituting CFLs and LEDs for incandescent light bulbs.

For commercial buildings, the more detailed approaches include:

- more efficient lamps, ballasts, and luminaires,
- substitution of more efficient lighting sources for less efficient ones (such as compact fluorescent lamps for general-service incandescents or downlights, or ceramic metal halide lamps for incandescent reflectors, or the use of IR-reflective incandescent reflector lamps instead of conventional ones, or LEDs for colored light sources),
- controls to reset air conditioning system temperatures,
- variable speed fans/drives and pumps,
- lower-pressure fan systems, and,
- occupancy sensors for lighting and air quantities.

While widget-based analyses are easier to review and interpret, they tend to exclude many cost-effective options for systems integration such as:

- using lighting designs that optimize the distribution of light so that it is brightest where the most light is desired and less intense elsewhere,
- using envelope designs that permit daylighting, especially in commercial buildings,
- using envelope measures that are intended to reduce the size or complexity of the HVAC system,
- using separate ventilation systems where the benefits include occupant satisfaction and ability to control the system under non-typical operating conditions, and,

- changing the building's orientation to take advantage of passive heating or cooling.

The amount of efficiency available at any particular cost from a “widget”-based, detailed-end-use-and-technology analysis is generally lower than what would be estimated by a whole building-based analysis. On the other hand, the results are easier to review and validate and may thus be more credible. The discussion of whole building-based analysis noted that a number of commercial buildings achieve 50 percent savings with no increase in first cost. However, such 50-percent-savings buildings are not normally included on supply curves, in part because buildings that achieve this can be seen as unrepresentative of the savings across the sector.

2.2 The Energy Efficiency Measure in Other Countries

The following sections review the energy efficiency measures for New Zealand and the selected countries which have the same climate as Thailand, such as Chinese Taipei, Malaysia, Chile and Vietnam.

New Zealand

The current version of the New Zealand Energy Efficiency and Conservation Strategy (NZECS) is the second to be produced under the Energy Efficiency and Conservation Act 2000. The document is subtitled “Action plan to maximise energy efficiency and renewable energy” and it includes quantitative targets and descriptions of actions.

The review team (PREE, 2009a) found that NZECS is one of the most comprehensive national energy efficiency and conservation strategies. The team was particularly impressed by the legislative requirements that the strategy must be in force at all times and must be regularly reviewed and updated.

New Zealand established standards for energy performance called Mandatory Energy Performance Standards (MEPS) with which the designated products must comply before they can be sold to consumers which were reviewed in consultation with industry to ensure they keep pace with advances in technology. Together with energy labeling, MEPS impel industry to improve the energy efficiency of products. Currently, seven classes of products are covered by MEPS and energy rating labels appear on five standard appliances. The Energy Efficiency and Conservation Authority (EECA) has promoted a voluntary, international endorsement program, Energy Star® which is the global mark of energy efficiency. Energy Star® is awarded to the top 25% of most energy efficient appliances, home electronics and office equipment.

The Equipment Energy Efficiency programme (E3) under an agreed policy framework and funding mechanism aligns its energy-related product standards with Australia, which jointly funds:

- profiling of products and technologies on the market and assessments of their energy efficiency potential,
- cost-benefit analysis of options for intervention,
- consultation documents and regulatory impact statements,
- development and publication of joint Australia/New Zealand Standards,
- compliance (check-testing) of products, and

- a common foundation for regulation.

From those, working with Australia can help New Zealand to follow its obligations under the Australia-New Zealand Closer Economic Relations Treaty Agreement (ANZCERTA) and the Trans-Tasman Mutual Recognition Arrangement (TTRMA). These are open market agreements that trade in goods between the two economies.

The combined programmes target the adoption of ‘best regulatory practice’ among their major trading partners in order to minimize trade problems and ensure alignment with best international practice in standards for energy efficiency testing, performance and labeling.

The majority of houses were not insulated until 1978, when home insulation in New Zealand became mandatory. The number of houses is an estimated at 900,000 or 64% of total housing stock. There are deficient or no insulated houses. Moreover, approximately 300,000 of these are occupied by low-income families.

To solve this problem, lower-income and middle-income families are assisted by EECA to insulate their homes and to install clean efficient heating appliances following the *EnergyWise™ Homes Programme*:

- The EnergyWise™ Home Grants are available for low income households to insulate their houses- including ceiling and under-floor insulation, draught proofing of doors and windows, hot water cylinder wraps and low flow shower heads.
- The EnergyWise™ Interest Subsidy is available for middle-income homeowners for an insulation retrofit and / or a clean heat heating upgrade to their property.

For further improvement in the energy performance of residential buildings, the New Zealand Government revised the Building Code in 2007/08. Therefore new homes require more insulation (in ceilings, walls and floors) and double glazed windows. These new requirements apply to all new houses, and expansion to existing houses, to new multi-unit residential apartments, and to new small buildings (with a floor area up to 300 square metres). The house built to the new Code requirements is expected that to consume about 30% less energy than houses built to the old Code requirements.

The Government has piloted a voluntary Home Energy Rating Scheme (HERS) ongoing on how to progress reducing energy consumption. The modelling tool that supports the HERS (AccuRate) has been aligned with the Building Code so that it can be used as a means of compliance to meet regulatory energy efficiency requirements.

Chinese Taipei

The commercial and residential sectors have strong potential for energy efficiency improvement. The Bureau of Energy (BOE) has recognised this and has determined that restraining the growth of consumption in these two sectors are its second highest priority as stated in the Strategic Promotion of Energy Conservation Policy in the economy. The review team (PREE, 2010a) recommended that a study comparing codes, or at least common sections of codes, to other economies with similar climate and infrastructure conditions should be performed and that a clear and transparent process for improving the codes on a regular basis be developed.

Chinese Taipei's government recognizes that one important aspect of making energy efficiency in the residential sector is to promote changes in consumer behavior. Chinese Taipei has taken an important policy and program to making this sector more energy efficient through a number of efforts:

- Mandatory economy wide building codes for energy saving were enacted in 1997
- Technology R&D Action Plans are being implemented
- BOE Green Building residential building research includes high efficiency demonstrations (e.g. Taipei Zoo House as shown in Figure 2.1)

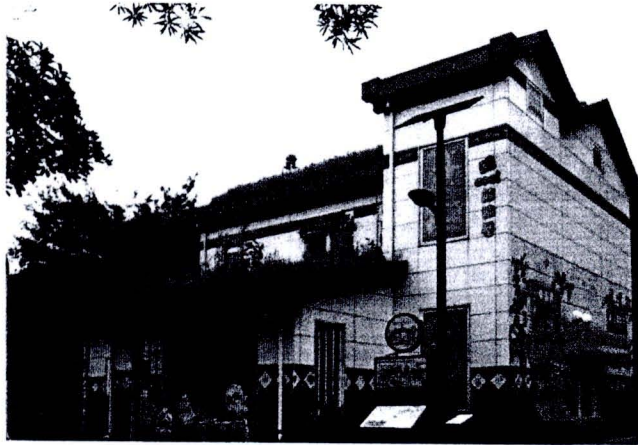


Figure 2.1: Taipei Zoo House

- Mandatory appliance MEPS for some household products have been coupled with voluntary appliance labelling programs.

Therefore, the energy efficiency policy and program measures implemented by Chinese Taipei resulted in savings during 2005 and 2009. Retail chain stores reduced electric use by 12.6 % with an average payback of less than 2.4 years.

To ensure that the energy consumption and the efficiency of specified appliances meet the requirements, Chinese Taipei has enforced post-market surveillance actions.

Air conditioners and refrigerators became part of the mandatory labelling program since 1 July 2010. Currently, 2,354 models of air conditioner and 494 models of refrigerator have completed mandatory energy label applications.

Chinese Taipei implemented the Rebate on High Efficiency Electric Appliances program between 1 October 2008 and 31 March 31 2009. The rebate subsidy was NTD 2,000 per unit for 320,000 units including air conditioners, refrigerators and clothes washers manufactured in Chinese Taipei and marked with an energy saving label which had energy savings of 39.48 GWh and an annual CO₂ reduction of 25,151 tonnes.

The Minimum Energy Performance Standards (MEPS) and Energy Information Labelling (EIL) are two main energy efficiency policies for appliances and equipment. These policies especially Mandatory MEPS and EIL will help the use of high efficiency products. However, some MEPS will be revised to meet minimum energy efficiency specifications according to current available technology and MEPS should be extended to other equipment.

There is a five-level ranking scheme for the energy efficiency labelling program. A ranking of one indicates the most efficient product while a ranking of five indicates that it is least efficient. The label is shown in Figure 2.2. It was found that there are more appliances labeled at level 5 than at 1.

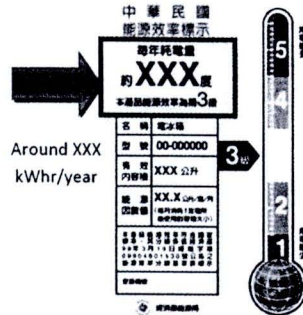


Figure 2.2: Refrigerator Energy efficiency label in Chinese Taipei

The basis for determining the energy efficiency criteria for energy labeled products is to first evaluate the energy performance of products on the market, and then select the middle to top performers on the efficiency distribution curve. The efficiency criteria are then periodically reviewed and revised to reflect market conditions. This measures ensure creditability of the energy label indicated that high energy efficiency products. Chinese Taipei encourages the industry by produce high- efficiency products to promote energy conservation. And BOE also had guidelines for using energy conservation labels to guide consumer preference.

BOE publicized energy efficiency standard draft for incandescent bulbs which estimated that around 22.5 million incandescent bulbs will replaced with LED (light emitting diode) lights. This is a great opportunity for LED technology.

In 1997, Chinese Taipei had economy wide mandatory building energy codes for residential buildings called the Residential Efficiency Standard. It uses a U-factor requirement (for the roof and walls) and a required index level for fenestration. The code is standardized at an economy-wide level but has varied with regional climate. Builders were flexible to meet the code by innovative or combine measures that are not specifically prescribed.

Furthermore, building energy codes, as they currently exist are only for new constructions, which represent only a small percentage (less than 3%) of all buildings. However, if building energy codes are applied to major renovations of existing buildings, there will be a much greater reduction in energy consumption.

Malaysia

In Malaysia, there is no mandatory and voluntary energy code for the energy-use performance of residential buildings. There are a lot of energy users in this sector. Participation of non government in energy efficiency improvement programs is very much needed (PREE, 2011). Currently, some Malaysian non- governmental bodies have been conducting energy efficiency programs to promote residents.

Malaysia already has a strong foundation for developing and implementing both MEPS and Labels. Malaysia has a comparative “five star” label system that is easy to understand and rating (one star worst, 5 stars best) and good information for consumers. In addition, Malaysia has a companion label to the Star Label system and an Endorsement Label from the Energy Commission. Examples of the labels are in Figures 2.3 – 2.4.



Figure 2.3: Comparative Label in Malaysia



Figure 2.4: Endorsement Label in Malaysia

The rating and labelling process is consistent across all products by first, a survey of available products; then, set a three-star product from an average consumption; a reduction range from that average is then set for the four-star, and then, a further reduction range for a five-star product.

Currently, Malaysia has a voluntary rating and label program for 6 domestic products: domestic fans; televisions; air conditioners; ballast, lamp and domestic refrigerators.

The National Energy Efficiency Master Plan correctly notes that “Minimum Energy Performance Standards (MEPS) prescribe the minimum energy efficiency that products shall meet in order to be sold in the market. Similar to standards for product safety, MEPS is a way to protect the consumers from products that has a low energy performance. MEPS can be applied to most technologies; however it should only be applied when there is certainty that alternatives are available and these alternatives are affordable for the consumers.” Malaysia has enacted MEPS for both domestic fans and fluorescent lamp ballasts.



Malaysia also has energy performance testing standards for 8 products and a testing lab (Standards and Industrial Research Institute of Malaysia, SIRIM): Insulation Materials; High Efficiency Motors; Lamps; Ballasts; Domestic A/C; Domestic Refrigerators; Domestic Fans; and Televisions.

Chile

Chile has a range of government institutions working to achieve increased energy efficiency. The body directly responsible for developing and implementing energy efficiency policy and programs is the National Energy Efficiency Program (Programa País de Eficiencia Energética, or PPEE), a program of the National Energy Commission (Comisión Nacional de Energía, or CNE). In addition, significant policy and program development related to energy efficiency takes place within other government agencies responsible for transport, housing, economic development and technology transfer. These institutions, as well as local government and other bodies, need to work cooperatively to achieve a common energy efficiency vision and objectives (PREE, 2009b).

Chile has focused the initial thrust of energy efficiency activities. The results have been achieved in the following areas:

- reduce electricity demand by adoption of compact fluorescent lamps (CFLs) for lighting;
- energy labelling for refrigerators and CFLs;
- since 2007, developed the minimum standards for envelope insulation in homes;
- design tools for energy efficient new buildings, including energy consumption simulation;
- insulation retrofit programs for existing homes;
- energy certification program for residential buildings.

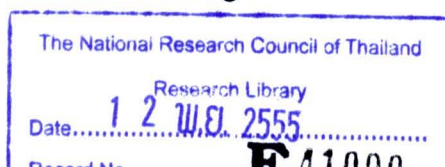
The National Energy Efficiency Program (Programa País de Eficiencia Energética, or PPEE) and the distribution companies have jointly introduced a range of energy efficiency programs directed to their end-use customers by free energy audits, bill-financed sales of efficient appliances (esp. CFLs), etc.

Chile has begun a product labelling program by leveraging the European comparative labelling scheme, which breaks all similar models of a product into one of seven efficiency categories, A (most efficient) through G (least efficient). This has been applied to five product types in Chile, with another five to six planned in 2009-2010. Products covered are for strictly residential applications so far, with future coverage aimed at residential to small commercial applications.

Vietnam

Vietnam's Government has instituted impressive measures to reduce energy consumption and increase energy efficiency in the sector. These measures under the Ministry of Industry and Trade include:

- Publication of standards for minimum energy performance of appliances.
- Adoption of CFL and TFL lighting and hardware in all buildings.



In 2005 the Ministry of Construction has developed a comprehensive building energy code which covered building thermal envelope performance, improved indoor ventilation and lighting conditions and other minimum electrical equipment performance requirements. The code became effective in 2007. However, the Ministry of Construction is also aware of the barriers to implementing the energy efficiency program. The significant barriers include:

- Lack of policies and effective management tools for energy saving and use in building works.
- Low technical capability so that the implementation and enforcement of the building energy code may be hampered.

Although data on energy consumption at the wide sector level can be used to reduce energy consumption, at the sub-sector level, such as end-use data which is relative to electricity consumption by appliance types like refrigerators, rice cookers and air-conditioners, are not available. This may be hard to bring energy efficiency measures to the next implementation level.

For the end-use level, there are two projects of high energy efficiency equipment: Developing standard and providing energy efficiency labels for selected products and technical assistance to domestic producers on energy efficiency compliance. The achievements during 2007-2008 of these two projects are:

- Completed demonstration model for solar water heater;
- Carried out labelling program for three appliances such as 36W of T8 fluorescent lamp, 32W of T5 fluorescent lamp, and electronic ballast;
- Coordinated with Vietnam Standard Centre to develop and issue 3 sets of energy efficiency standards and testing methods for refrigerators, air conditioners and electric fans;
- Conducted pilot Energy Efficiency and Conservation published for households by Vietnam Women's Union in six provinces and cities;
- Support implementation programs in technology transition process from incandescent lamps into compact fluorescent lamps for manufacturers.

The World Bank has supported energy efficiency in Vietnam for DSM planning and pilots with Electricity of Vietnam. The DSM project was implemented from 2000 – 2007 with the objectives are to develop and expand DSM business programs and test new market transformation efforts within the national electric utility. Results of The implementation DSM measures including: the transformation of the CFL market in Viet Nam from less than 1 million lamps a year in 2004 to about 20 million units; Fluorescent tube lamp market transformation; and Supporting programs and technical assistance for DSM efforts; On-going EE awareness campaign through media (reporters), TV and Radio commercial (PREE, 2009c).

The Ministry of Industry and Trade (MOIT) issue a labelling guideline for suppliers to put labels on high-efficiency electric appliances such as electric motors, fans, air conditioners, fluorescent-tube lamps; and ballasts. Technical standards for equipment energy performance will be issued by the Ministry of Science and Technology.

The Electricity Saving Program also calls for MOIT to develop a road map for the replacement of 40 million incandescent lamps with CFLs, FTLs, and T5 lamps. On the

other hand, the national utility, Electricity of Vietnam, has been implementing a national DSM program since 2001, and is currently implementing a national program to distribute compact fluorescent lamps and thin-tube fluorescent lamps.

Mandatory energy standards, such as Minimum Energy Performance Standards (MEPS) will provide efficient and effective solutions in improving energy efficiency of appliances and equipment. At the same time, Mandatory Energy Performance Labeling (MEPL) will enhance the implementation of MEPS. MEPL also could improve the market penetration of energy-efficient products by creating a well-informed society.

Recently, Vietnam has issued MEPS for some products but still has not begun enforcement. Vietnam has also designed both a comparative and endorsement energy label, but they have not developed the implementation and mechanism for applying them (PREE, 2009c).

In conclusion, this research studied the energy consumption in each activity and related factors to understand the energy demands of each important end-use which would cause more energy consumption in the future. Furthermore, estimation of the number of appliances increases because of those activities to plan how to use energy in the most effective and sustainable way possible.