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Application of best practice for setting minimum energy efficiency standards in technically disadvantaged countries: Case study of Air Conditioners in Brunei Darussalam

Xunpeng Shi *

Energy Studies Institute, National University of Singapore, Singapore

HIGHLIGHTS

- Setting MEPS requires significant data, financial resources and technical capacity.
- Application of best practice in technical disadvantaged countries (TDCs) was demonstrated.
- Best practice was successfully applied to Brunei for its AC MEPS.
- For Brunei, COP at 2.9 is recommended and 15% efficiency improvement is achievable.
- The methodology is applicable to other appliances in any TDCs.

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ABSTRACT

Application of the best practice of setting minimum energy performance standards (MEPS) in technically disadvantaged countries (TDCs) faces many barriers. The best practice of determining MEPS has a comprehensive analytical framework including engineering-economic analysis, life-cycle cost-benefit analysis, as well stakeholders' and market impact assessments. However, TDCs usually are lack of reference product classes, market data, and other necessary inputs data. This study demonstrated how to overcome those barriers to apply the best practice to TDCs using the actual experience in setting initial MEPS for Air Conditioners (ACs) in Brunei from scratch with limited secondary data as an example. The series of application works include definition of the product classes and the baseline group; collection of market data; formulation of cost-efficiency relationship from the market data; examination of the economic, environmental, and financial impacts of various MEPS options; revealing of the consumers' willingness to pay; and analysis of the impacts and responses from the industry and consumers. The coordination with the compliance of the Montreal Protocol was also considered. The methodology should also be applicable to setting MEPF for other appliances in any TDCs.

1. Introduction

The improvement of energy efficiency (EE) is a cost-effective policy measure to achieving sustainable energy development but realizing the significant potential efficiency gains often needs strong policy actions [1]. Minimum energy performance (efficiency) standards (MEPS)[1] and energy labeling are two of the most frequently used tools of any energy efficient and conservation program for appliances [2]. MEPS introduces market transformation by eliminating products that fall below the MEPS from the market

Abbreviations: AC, Air Conditioner; BTU, British Thermal Unit; CLASP, Collaborative Labeling and Appliance Standards Program; COP, Coefficient of Performance; DES, Department of Electricity Service, Prime Minister Office, Brunei; EE, energy efficiency; GWP, Global Warming Potential; LCC, the life-cycle cost; MEPS, minimum energy performance standards; NPB, net present benefit; ODP, Ozone Depletion Potential; OEM, Original Equipment Manufacturer; PAMS, Policy Analysis Modeling System; PBP, payback period; S&L, standards and labeling; SCC, Social Cost of Carbon; TDCs, technically disadvantaged countries; UEC, Unit Energy Consumption; WTP, willingness to pay.

* Address: 29 Heng Mui Keng Terrace, Block A #10-01, Singapore 119620, Singapore. Tel.: +65 65165360 (DID); fax: +65 67751831.

E-mail address: xunpeng.shi@gmail.com

[1] MEPS is also frequently referred to as 'minimum energy efficiency standards'. In this paper, both terms are used interchangeably.

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and encouraging suppliers to bring in more energy efficient appliances [3]. Although MEPS is regulatory and compulsive, it may be cost-effective for governments to achieve key environmental, energy security and economic policy objectives [3]. However, the sustainability of the MEPS program depends on how the MEPS level is specified.

From policy makers' perspective, setting MEPS not only need life cycle costs and benefits analysis (LCC analysis) on costs, benefits, and the environment, but also need analysis on other stakeholders, who otherwise might make the policy unworkable or against the government principles, such as protect the disadvantaged groups [4–6]. In those developed counties that has the best practice in MEPS policy making, such as US [6] and Australia [4], justification of MEPS involved detailed evaluation of MEPS's technological feasibility; LCC impact; availability of the higher efficiency appliances in the market; the potential impact on the major stakeholders such as manufactures, households, and the business sectors and issues such as jobs and low income consumers [4–6].

LCC analysis on economic, financial and environmental impact are fundamental part of the best practice. The LCC analysis can ensure that government-mandated programs do not pose a financial burden to consumers and the MEPS has a positive impact on the nation. This LCC analysis has been well accepted in the literature, such as Cardoso et al. [7], Letschert et al. [8], Lu [9], Ni [10], Mahlia et al. [11], Nogueiraa et al. [12], Tao and Yu [13], Vendrusculo et al. [14]. Currently, LCC analysis has been undergone various extension. Bottom up applications of the LCC analysis were also recorded in the recent literature [15].

There are also other recent literature that examines advanced technical details for applying the LCC approach. Siderius [16] introduced the experience curve to modeling the declining trend of product costs, which are currently assumed to be linear. By integrating the experience curve to LCC analysis to appliances in EU, a study [16] found at least twice the energy savings compared to the current approach can be achieved in the case of driers and refrigerator–freezers. This extension of methodology, despite academically sound, however, introduces additional complication to the model and may not be transparent to policy makers. However, in the policy making, the LCC cost-benefit analysis is not the only criterion for deciding a new MEPS because other factors, such as national benefits and environmental protection, must be considered [14].

Another key component of the best practice is to examine the impact on consumers and reveal their responses. The finding of Zeng et al. [17] suggests that MEPS is limited by consumers' willingness to pay (WTP) for efficient products: most consumers in China are only willing to pay less than 10% more for efficient appliances. The WTP of Chinese consumers, however, is noticeably lower than those in European countries, who were found on average to be willing to pay 44% and 50% more for higher efficiency refrigerators and TVs, respectively [17]. Even in oil producing countries, such as Saudi Arabia, the average WTP for energy efficiency products is about 15% [18]. Nevertheless, overtime, the limited WTP may not be a significant barrier for adoption of high efficiency products because as many studies have found, higher efficiency was achieved with declined appliance prices. Meyers et al. [5] found that the purchase cost of fridges would go down after the introduction of MEPS. An IEA report found that in the US, energy consumption of refrigerators and freezers reduced 60% between 1980 and 2001 due primarily to the introduction of MEPS in 1993 [19]. The Chinese case study [17] also shows that an effective incentive set by subsidy may have to be at the size of 20–30% of the retailing prices. As summarized in the literature [4,20], many studies revealed that consumers have extremely high discount rates between 20% and 100%.

This best practice from developed countries, however, are too luxurious to be followed by countries with limited technical resources and data, or TDCs, such as Ghana [21]. Such a TDC often lacks of input data, cannot afford or has no technical capacity to conduct engineering analysis, or has not capacity to provide other systematic support. As shown in the Saudi case [22], the engineering analysis not only needs manufacturing of a prototype product, but also needs technical standards and testing facilities. While a previous study [23] has discussed the initial setting of EE standards in a developing country without sufficient data, other factors that policy makers have to consider were not discussed and thus it offers limited practical guidance. All these academic studies focus on estimation of the economic and environmental impact but have not addressed policy makers' other concerns and thus their findings and experience are not sufficient for policy makers to determine a MEPS level.

This study demonstrates how to apply the best practice for determining MEPS in a TDC using Brunei as an example. It presents a comprehensive assessment of factors such as impact on consumers, vendors and manufacturers that are often the top concerns of policy makers. This study also shows how to collect data that were not available. The paper is motivated by the need of determining an initial MEPS for Brunei, which has no labeling activity, no market data, generally lacks of other support data, and lack of testing equipment and testing capability in its own climate condition.

The paper makes contributions to the literature in a number of ways: first, it demonstrates practical and replicable ways to implement the best practice in a TDC. Second, it proposes some actual ways to collect various localized data, such as energy use pattern, consumers' WTP for high efficiency products and their implied discount rate. Third, this paper demonstrates an econometric method that has not been reported in the literature, to disaggregate actual market data, in which the price-efficiency relationship is often complicated by brands, sizes and other features and thus is not monotonic. Overall, through building the model from scratch, the present analysis uses first hand actual market data that were collected for this study and its methodologies could be replicable in other TDCs that have limited data, resources and capacity and for other appliances. The methodology can also be applied to determining energy efficiency standards other than MEPS.

This paper is organized as follows: after the introduction, the next section provides a background information for the Bruneian case study. Section 3 explains details on the methodology and data to allow the work to be reproduced. This is followed by empirical results from the modeling as well as stakeholders' analyses. Section 5 examines a special issues for ACs, that is, compliance of the Montreal Protocol. The last section concludes the paper with recommendations on MEPS for Brunei's ACs.

2. Energy efficiency initiatives and ACs market in Brunei

Despite the abundance of oil and gas, the high per capita consumption of energy and related CO_2 emissions post significant challenges to the sustainable development of Brunei Darussalam (hereafter Brunei). With a population of just over 400 thousand, Bruneians enjoy a high standard of living. Its per capita GDP at price in 2012 is US$ 41127 (all monetary terms have been converted into US$ unless indicated otherwise), ranked as the 19th highest in the world [24]. The high income, abundance of oil and gas, and cheap energy prices lead to a high consumption of energy and underinvestment in energy efficiency [25]. Per capita primary energy supply was 9.4 tons in 2010 and electricity consumption was around 8507 kW h in 2011, ranked 15th highest in the World [24]. According to one estimation, the average household