



# Sectoral energy efficiency improvements in Taiwan: Evaluations using a hybrid of top-down and bottom-up models

Yi-Hua Wu<sup>a,\*</sup>, Chia-Hao Liu<sup>a</sup>, Ming-Lung Hung<sup>a</sup>, Tzu-Yar Liu<sup>a</sup>, Toshihiko Masui<sup>b</sup>

<sup>a</sup> Industrial Technology Research Institute, 195, Sec. 4, Chung Hsing Rd., Chutung, Hsinchu, 31057, Taiwan, ROC

<sup>b</sup> Center for Social and Environmental Systems Research, National Institute for Environmental Studies (NIES), 16-2 Onogawa, Tsukuba, Ibaraki, 305-8506, Japan

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## ABSTRACT

Improving energy efficiency is an important strategy for reducing energy demand and carbon emissions. Numerous studies reveal that improvements in energy efficiency lead to reductions in the total energy demand and the enhancement of economic growth. However, mainstream papers have adopted top-down or bottom-up approaches to investigate energy efficiency improvements.

In this study, a hybrid of the aforementioned approaches is adopted. A soft-link between the Asia-Pacific Integrated Model/Computable General Equilibrium for Taiwan (top-down) and the Taiwan 2050 Calculator (bottom-up) is employed to evaluate the effects of energy efficiency improvements in Taiwan. We investigate the influence of energy efficiency improvements on the industrial, residential and service, and transport groups, respectively. Energy efficiency improvements decrease energy demand and enhance the growth of gross domestic production (GDP). Moreover, energy efficiency improvements result in a decrease in CO<sub>2</sub> emissions. The industrial group has a comparative advantage over other groups in terms of energy efficiency improvements. However, the subsidies on energy efficiency investments crowd out household consumption. An appropriate fiscal balance scheme could mitigate the crowding-out effects on household consumption, as indicated by our counterfactual analysis. Therefore, energy efficiency improvements are one of the most important strategies for conserving energy and reducing carbon emissions.

## 1. Introduction

Improvements in energy efficiency could reduce energy demands and carbon emissions. In particular, investments in energy efficiency are essential for such improvements. The Taiwanese government subsidized the purchase of high-efficiency electronic devices, such as pumps, motors, and freezers, in 2015, 2016, and 2017.<sup>1</sup> Through investments in energy efficiency, efficient machines, motors, and vehicles have been deployed. The investment in energy efficiency may result in the same level of output with the use of less energy. Moreover, such an investment raises the demand for other commodities and services, such as steel, transport, and wholesale services. Thus, economic growth may be enhanced because of energy efficiency investments. Numerous studies have found that investments in energy efficiency can lead to a reduction in energy demand and the enhancement of economic growth. Ryan and Campbell (2012) propose that energy efficiency

improvements can raise asset price, improve the health quality of employees, boost productivity, and provide a safe working environment. Neves et al. (2008) suggest that energy efficiency improvements can increase social welfare and create employment.

However, most papers in the literature have adopted the top-down or bottom-up approach to investigate energy efficiency improvements. A top-down approach, such as a computable general equilibrium (CGE) model, is used to investigate the impact of energy efficiency improvements on the economy. A bottom-up approach, such as the 2050 Energy Calculator of the Department of Energy and Climate Change (DECC) in the United Kingdom, specifies the technology development, energy production activity, and energy demand.<sup>2</sup> In this study, we use a hybrid of the aforementioned two approaches. A soft-link procedure between the CGE and 2050 Energy Calculator is adopted to study energy efficiency improvements in Taiwan. In the literature, there are numerous research papers proposing the merits of hybrid models. For example,

\* Corresponding author.

E-mail address: [itriA00031@itri.org.tw](mailto:itriA00031@itri.org.tw) (Y.-H. Wu).

<sup>1</sup> See, for instance: <http://www.ecct.org.tw/News/Show?id=5d6d47d177dd4e64be51b02e48890d1b>; <http://news.ltn.com.tw/news/business/breakingnews/1606143> (in Chinese).

<sup>2</sup> Readers can refer to the following link for the display of the 2050 Energy Calculator of the United Kingdom: <http://2050-calculator-tool.decc.gov.uk/#/home>.