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Future energy consumption and emissions in East-, Central- and West-China: Insights from soft-linking two global models

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Abstract

China's role in the global economy and energy markets is expanding, however many uncertainties with regards to the country's future energy consumption and emissions remain. Large regional disparities between China's provinces exist. Scenario analysis for different sub-regions of China will be useful for an improved understanding of China's potential future development and associated global impacts. This study soft-links a global dynamic CGE model and a global technology-rich energy system model. Both models are expanded to include East-, Central-, and West-China. This study shows that soft-linking affects the China-specific reference scenario results in the CGE model considerably. Energy consumption and emissions are decreasing in China until 2050 while regional differences within China remain high.

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Keywords: China; TIMES Integrated Assessment Model; Asian-Pacific Integrated assessment Model; soft-linking; scenario analysis

1. Introduction

China's economy and energy infrastructure progressed rapidly during the past decades, followed by an increase in green-house gas emissions. Analysing pathways for China's future development and potential global impacts relies on global models that incorporate sufficient sub-regional details about China's economy and energy system. Such global tools do however hardly exist [1]. This study therefore links a global economic model - the Asian-Pacific Integrated assessment Model (AIM) - with a global energy system model - the TIMES Integrated Assessment Model (TIAM) – to study future scenarios for East-, Central- and West-China. This paper is structured in four chapters. The methodology of the soft-linking between the models is presented in Chapter 2. Key results are discussed in Chapter 3, highlighting how

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China's future energy demand and emission projections in the AIM model are affected after soft-linking this model with TIAM. Concluding remarks and an outlook for further research is given in Chapter 4.

2. Methodology

2.1. Models, data, and scenario assumptions

The two global optimization models are expanded in order to prepare a linking between the underlying model structures. The global AIM/CGE (hereafter AIM) model used here is expanded from the one-region dynamic country model [2] to a global one that represents 30 provinces of China and several regions of the world with 22 economic sectors and three final demand sectors. The global TIAM model version used here is introducing three sub-regions of China into the ETSAP-TIAM version [3]. TIAM includes highly detailed energy technologies from resource extraction, supply, transformation and final end use in industry, transport, commercial and public services, households and agriculture.

East-, Central- and West-China are defined based on China's Seventh Five-Year Plan, which grouped the different provinces of China into three economic zones to promote economic specialization and division of labour [4]. China-specific base year data are calibrated against official Chinese government statistics, including provincial energy balances and input-output tables. This study assumes that the existing disparities in the economic development of East-, Central- and West-China will be narrowed. Future economic growth projections for China are thus a main driver in both models (Table 1).

Table 1. Future economic growth increase for East-, Central- and West-China, Reference scenario (2005 = 1)

Region	2005	2010	2020	2030	2040	2050
East-China	1.0	1.5	3.5	6.5	9.8	12.3
Central-China	1.0	1.5	3.9	7.5	12.1	15.8
West-China	1.0	1.5	3.7	7.0	11.1	14.4

2.2. Soft-Linking Methodology

The soft-linking of existing large-scale economic and energy system models is commonly used in energy and climate modelling [5]. The soft-linking approach used in this study comprises the following steps:

- Both global models project reference scenarios until 2050.
- The AIM model provides economic projections as feedback for the TIAM model. Combined with population projections, these are translated into future energy service demand drivers in TIAM.
- The TIAM model provides future energy consumption data as feedback to the AIM model. The energy efficiency of economic sectors in the AIM model can thus be improved.
- Iterations are carried out to test convergence between both models. Energy consumption is identified as a key indicator for model convergence.

3. Results

Soft-linking affects China's future energy consumption and CO_2 emissions considerably over the full modelling horizon. Lower scenario results are projected by the AIM Model after linking it with the TIAM model. The existing China-specific disparities between East-, Central-, and West-China remain after soft-linking both models.

The future primary energy consumption in the AIM model is projected to decrease in all sub-regions of China after soft-linking both models (Figure 1). In 2050 the primary energy consumption is reduced by about 28% in both Central- and West-China and by about 13% in East-China. Regional differences in primary energy consumption remain after soft-linking both models, with the highest energy consumption projected in East-China and the lowest in West-China. In absolute terms, the primary energy consumption decreases most in East-China, from about 1529 EJ to about 1136 EJ in 2050 (Figure 1). The three regional results translate into a lower national primary energy projection in 2050. China's primary energy consumption in 2050 is decreasing by about 782 EJ after soft-linking the AIM model with TIAM.

The CO_2 emission projections in the AIM model follow the trend of primary energy consumption (Figure 1). Regional differences between the three sub-regions of China remain, with the highest CO_2 emissions projected in East-China and the lowest in West-China. CO_2 emission projections decrease considerably in all three regions of China after soft-linking, by about 8-9% in East-China and in West-China in 2050. Central-China shows the largest CO_2 emission decrease in 2050 after soft-linking both models, namely from 12.8 Gt to about 9.6 Gt (Figure 1). The three regional results translate into a lower national CO_2 emission projection in 2050. China's CO_2 emission projections in 2050 are decreasing by about 5.4 Gt after soft-linking the AIM model with TIAM.

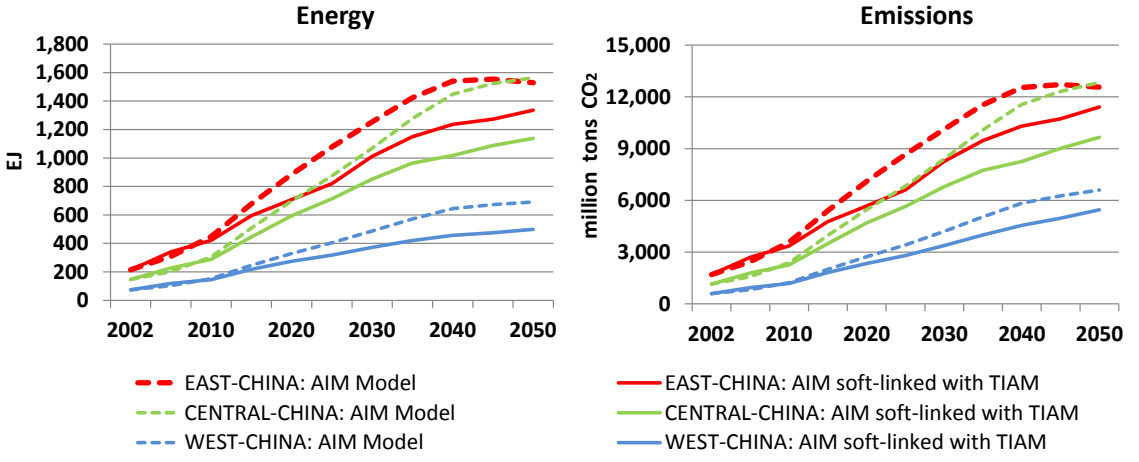

Fig. 1. Future primary energy consumption and emissions for China – AIM model versus AIM soft-linked with TIAM

4. Concluding remarks and outlook

Soft-linking global models with regional China-features allows for interesting, regional insights into China's future economic and energy system development. This study shows that the developed soft-linking methodology can be applied to the AIM model and TIAM model in order to study the impacts of China-specific regional energy and climate policy instruments. Energy consumption is identified as a key indicator for model convergence.

Future research suggests establishing common reference and policy scenarios on a global scale between both models. The results of such a global model-linking exercise with focus on China can feed into an ongoing energy policy debate in China, which is striving to balance international and China-specific regional development and emission reduction targets. In this regard, both models could assess different regional impacts of future energy intensity reduction goals in China and provide more robust future energy and emission projections when soft-linking both models.

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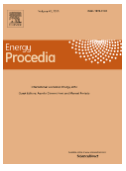

Biography

Dr. Hancheng Dai is a research associate at NIES, Japan. Ms. Peggy Mischke is an international energy specialist, consultant and PhD researcher at DTU, Denmark. Together they are studying pathways for China's low-carbon future in a global perspective, using different economic and energy systemmodelling tools.