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AN EVALUATION OF THE EFFECTS OF TOURISM AND DISTRIBUTED ENERGY ON CO-DEVELOPMENT

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ABSTRACT

Committed to green and low-carbon development, many countries like China is increasing its efforts to promote the development of its service economy such as tourism industries. Considering that tourism is an increasingly important contributor of energy consumption and pollutants emission, its green/low-carbon development will play a significant role for China. Given the characteristics of renewable/green energy resources and tourism, a possible path is promoting the co-development of tourism and distributed energy which can create new economic growth points in addition to reduce the emission of greenhouse gases (GHGs) and critical air pollutants (CAPs) compared to transitional development pattern. This study attempts to develop an evaluation framework to investigate the effects of the co-development of tourism and distributed energy. A typical tourism and distributed energy co-development project in Shenzhen which is a typical low-carbon development city is took as an example to demonstrate the application of the framework and related methods proposed to assess the benefit. The results indicate that the emission reduction effect is 0.5 thousand tonnes (Tt) of CAPs and 7.8 Tt of GHG in 2017. The proposed framework can effectively help China identify the effects of the co-development of tourism and distributed energy, which is helpful to formulate policy and implement actions for next step action aiming at promoting green/low-carbon development and ecological civilization construction.

Keywords: green/low-carbon development, ecological civilization construction, tourism, renewable/green energy resources, co-development, benefits

1. INTRODUCTION

Increasing pressure of environment, climate change and energy issues are forcing many countries like China to deploy green and low-carbon development. Meanwhile, China is putting more efforts on ecological civilization construction[1]. There's growing concern on promoting the development of service economy such as tourism industry which is taken as a new economic growth point[2,3]. For example, the Ministry of Culture and Tourism of China has been established in 2018, aiming at increasing its efforts to promote the development of tourism industries. Tourism is an increasingly important contributor of energy consumption and pollutants emission[4,5]. Promoting its green/low-carbon development is very necessary which will play a significant role in green/low-carbon development and ecological civilization construction of China[5,6]. Given the characteristics of renewable/green energy resources and tourism, a possible path is promoting the co-development of tourism and distributed energy which can create new economic growth points such as energy tourism in addition to reduce the emission of greenhouse gases (GHGs) and critical air pollutants (CAPs) compared to transitional development pattern[7,8].

Numerous studies have been conducted to analysis the energy and/or carbon dioxides emission of tourism industries[9-11]. Tang et al. (2017) proposed a factor decomposition model for analyzing carbon emissions in energy consumption of tourism industries on the basis of a life cycle perspective. Lenzen et al. (2018) conducted a study to quantify tourism-related global

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carbon flows between 160 countries by using carbon footprint and tourism satellite accounts methods. In another study, a 'bottom-up' modeling method was adopted by Tang et al. (2015) to identify the carbon dioxides emission of tourism industries in China. Some studies focus on the development pattern or path of the low-carbon development of tourism industries[12,13]. Wang et al. (2018) and Wang (2017) attempted to explore the development pattern of low-carbon tourism industries through survey research and case analysis. However, few previous studies focusing on exploring the co-development of tourism and energy, especially aiming at establishing an analytical framework and related methods to quantitatively evaluate the effects of the co-development of tourism and renewable/green energy on the basis of a energy structure perspective.

From an international perspective, there is a gap in the knowledge regarding establishing a simply and practicably analytical framework focusing on quantitatively evaluating the effects of the co-development of tourism and renewable/green energy aiming at playing a more important role in green and low-carbon development. It is meaningful to evaluate the effects of specific measures and actions which can help investigate the potential of energy saving and emission reduction of promoting the co-development of tourism and distributed energy to provide an aid in planning related countermeasures for the decision of the government, tourism and energy companies. The current study places emphasis on establishing a multi-dimensional, multi-perspective and achievable framework for the quantitative evaluation of a typical demonstration project that intend to achieve the transition aiming of the co-development of tourism and distributed energy.

2. FRAMEWORK

2.1 Modelling framework for effect evaluation

Given the status of tourism and energy sector, energy transition such as developing renewable/green energy focusing on reducing high-pollution energy consumption and increasing clean and low-carbon energy use to reduce GHG and CAPs emissions is attracting a growing concern. It is not only the government that is interested in developing renewable/green, but also some tourism companies and energy companies that are highly motivated. Especially, the company which focuses on providing traditional high-pollution fossil energy is putting its efforts in providing more clean energy such as by developing distributed energy to face environmental pressure and create new economic growth points..

Based on identifying the characteristics of existing energy consumption of tourism in developing countries and reviewing the experiences of tourism in developed countries in addressing transition challenge, solutions and measures for reduce GHG and CAP emissions from energy use mainly focus on two aspects. First, improving energy efficiency reduces the consumption of energy, especially of high-pollution energy. Second, developing clean and low-carbon energy to replace high-pollution energy optimizes the energy structure. These two types of targets can been achieved with developing tourism and distributed energy. A tourism and distributed energy system integratedly provides heating, cooling, and electricity supply service with clean and low-carbon energy instead of providing by several companies which independently focuses on heating, cooling, and electricity supply service with high-pollution energy. Aim at investigating suitable energy countermeasures to promote the co-development of tourism and distributed energy, a multi-dimensional, multi-perspective and measurable analysis framework is established to identify the effects of developing tourism and distributed energy, as showed in **Fig. 1**.

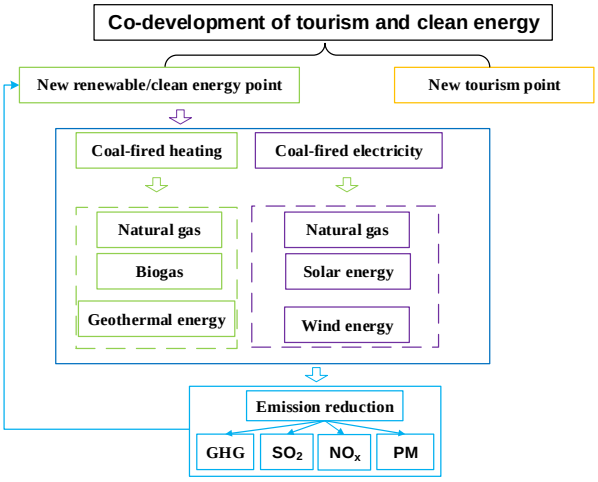

Fig 1 Framework for the modelling of effect evaluation of co-development

2.2 Evaluation methods

Combined with the analysis framework above, based on a bottom-up method, an emission factor method and a with or without comparison method, evaluation methods aiming at quantifying environmental benefits of the co-development of tourism and distributed energy are established. The emission reduction effect on CAPs and GHG can be calculated using Equation (1):

$$\Delta ER_{tn} = \sum_{i=1}^{m}(EC_{itn} \times EF_{it0} - ECR_{itn} \times EF_{itn} + ECEitn \times EFit0) \quad (1)$$

where $\triangle ER_{tn}$ is the amount of emission reduction on GHG and CAPs due to developing tourism and distributed energy in year *tn*; *i* is the type of clean energy which is used to replace coal for use (see **Table 1**); EC_{itn} is coal consumed for providing energy services such as electricity and heating supply without adopting this energy action in year t0; ECR_{itn} is the clean energy use due to the replacement of coal consumption; ECE_{itn} is the reduction of coal consumption due to the improvement of energy efficiency; EF_{it0} is emission factors of different types of energy services provision without adopting this energy action in year *t0*; and EF_{itn} is emission factors of different types of energy services provision with adopting this energy action in year *tn*.

Table 1. Interpretation of i.

No.	Clean energy type
1	Natural gas (NG)
2	Solar energy
3	Wind energy
4	Biogas
5	Geothermal energy

3. EVALUATION OF THE EFFECT OF A TYPICAL PROJECT IN CHINA

3.1 Case background and key data

To explore the environmental benefit for developing tourism and distributed energy in China, a typical tourism and distributed energy demonstration project is chosen as the target for the evaluation. This target is located in the Shenzhen City, Guangdong Province, which is in the eastern region of China. The primary data that are used for the evaluation are obtained from this demonstration project via personal interviews and field investigations, as listed in **Table 2**. Especially, total energy consumption of this project is approximately 6.7 thousand tonnes of standard coal. In addition to, other key data are obtained from literature review, personal interviews and investigations [12,14,15].

Table 2. Energy mix of a typical demonstration project.

Type	Grid electricity	NG	Solar	Wind	Biogas
Electricity supply	76%	0	4%	20%	0
Heating supply	0	96%	0	0	4%

3.2 Results and discussion

Based on the presented framework, methods and key data, the GHG and CAP emission reduction effect created by developing tourism and distributed energy is estimated (illustrated in **Fig. 1**). **Fig. 1** showed that a significant emission reduction effect on CAPs and GHG has been achieved compared to transitional energy supply pattern which provides energy services such as generation and heating (including hot water) independently by several energy companies. An emission reduction of 0.2 thousand tonnes of sulfur dioxide (SO_2), 0.1 thousand tonnes of nitrogen oxides (NO_x), and 0.2 thousand tonnes of particulate matter (PM, $PM_{2.5}$ specifically) has been achieved by this project in 2017. It means that the emissions reduction effect of this project in China is approximately 0.5 thousand tonnes of CAPs. Meanwhile, it generated an emission reduction of 7.8 thousand tonnes of GHG in 2017. In recent ten years, it has produced approximately 5 thousand tonnes (Tt) of CAPs and 78 Tt of GHG. Obviously, given NG and wind energy dominated the energy mix, they produce the greatest contribution to reduce emission, 79% of total GHG emission reduction and 62% of total GHG emission reduction, respectively. It also can be found that the larger the project is, the greater the role of reducing emissions on CAPs and GHG will play.

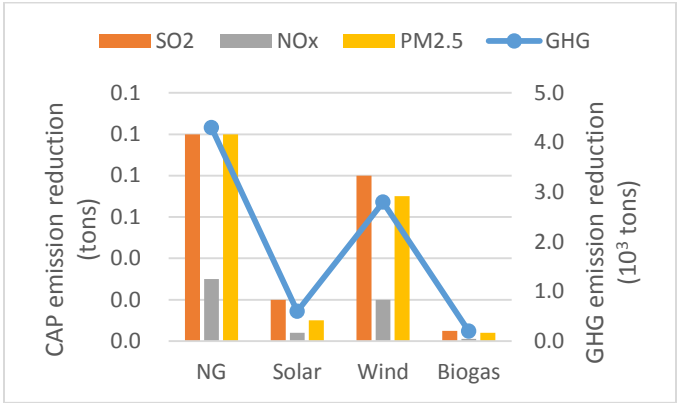

Fig. 1. Emission reduction effect of a tourism and distributed energy demonstration project.

Taking electricity services supply in tourism for example, since renewable electricity such as wind and solar power are intermittent, a constant source such as grid electricity will also be needed to keep the energy supply stable in a long time. Due to the grid electricity dominated by high-pollution and high-carbon energy such as coal, the emission reduction effect generated by the tourism distributed energy system is significant, but the role is limited. As the proportion of cleaner energy such as renewable energy accounted for becomes

higher in the future, the emission reduction effect will be bigger. In the typical case presented in this paper, if the grid electricity dominated by coal is replaced by cleaner energy such as renewable energy, the emission reduction effect of the tourism and distributed energy system will be significantly increase by 0.7 thousand tonnes of CAPs and 10.5 thousand tonnes of GHG in 2017. Therefore, the emission reduction effect generated by the tourism and distributed energy system is significant, but the size of the effect is dependent on the energy mix scenarios and the scale of the use of renewable/green energy. It is also helpful to maximize emissions reductions for different targets. Given that tourism is a very huge industry, with the co-development of tourism and distributed energy, much bigger effects will be produced for green and low-carbon development in China.

4. CONCLUDING REMARKS

This paper highlights on establishing a framework for modelling the quantitative evaluation of the effect of energy solutions aiming at presenting suitable energy countermeasures to achieve the co-development of tourism and distributed energy with the targets of reducing GHG and CAP emissions for sustainable development, especially for developing countries facing these challenges. This analysis framework focuses on implementing “integrated and clean energy services” actions that consisted with tourism and distributed energy systems to achieve transitions based on the characteristics of energy consumption and related GHG and CAP emissions. As a typical developing country pursuing sustainable development, China is took as an example to demonstrate the application of the framework proposed to analysis the effect of developing tourism and distributed energy. Based on the proposed framework, the emission reduction effect of energy countermeasures issued in China to promote the co-development of tourism and distributed energy is estimated.

The results indicate that, due to the implementation of developing tourism and distributed energy, a significant emission reduction effect on CAPs and GHG has been achieved compared to transitional development pattern. There are differences in the emission reduction effects of each energy mix scenario, especially for different targets. This finding means that the proposed framework can not only effectively help China identify the effect of developing tourism and distributed energy on reducing GHG and CAP emissions but can also help China identify key actions and their implementation priority and order to maximize emissions reductions for different targets. This framework can help China generate ideas and develop programs to promote the transition aiming at the co-development of tourism and distributed energy. Moreover, this proposed framework can also help countries similar to China make decisions on suitable energy countermeasures and development pattern to promote the co-development of tourism and distributed energy for green and low-carbon development.

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