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Bridging greenhouse gas emissions and renewable energy deployment target: Comparative assessment of China and India

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HIGHLIGHTS

- India and China's latest renewable energy targets toward 2030 are assessed.
- Carbon emission cap is in line with 2-degree target and governmental commitment.
- The impacts of renewable energy on emissions and mitigation costs are quantified.

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ABSTRACT

Renewable energy has a critical role in limiting the greenhouse gas (GHG) emissions. This paper assesses the implication of aligning renewable energy deployment target with national emission reduction target for mitigation cost. The assessment methodology uses Asia-Pacific Integrated Assessment/computable general equilibrium (AIM/CGE) model to determine the mitigation cost in terms of GDP and welfare loss under alternative renewable targets in different climate-constrained scenarios. A range of country-specific emission constraints is taken to address the uncertainties related to global emission pathway and emission entitlement scheme. Comparative results show that China needs to increase its share of non-fossil fuel significantly in the primary energy mix to achieve the stringent emission reduction target compared to India. The mitigation cost in terms of economic and welfare loss can be reduced by increasing the penetration of the renewable energy to achieve the same emission reduction target. The modeling results show that coordinated national climate and renewable energy policies help to achieve the GHG emission reduction target in an efficient and cost-effective manner.

1. Introduction

India and China's economy will be growing at a rapid pace in the coming decades. To fuel the economic growth, energy demand in both countries is also likely to rise in future. It is expected that both these economies will be among the major emitters of the greenhouse gases in the world under the business-as – usual dynamics. The power sector is the largest source of GHG emissions in both countries. Fossil-fuel dominated power sector is expected to account for more than half of the total GHG emissions by 2050 (Fig. A1). Driven by growing income and improvement in the electrification rate, power demand is expected to rise in future in both countries [1]. As power infrastructures have long lifetime, it would be challenging to decarbonize the power sector while simultaneously meeting the electricity demand without timely climate mitigation actions. Researchers have emphasized the critical role that renewable energy (RE) technologies can play in limiting the GHG emissions to stabilize at 450 ppm CO_2-equiv concentration target by 2100 [2–5] (which is often interpreted as what we call the 2 degree target.)

India and China, both have enormous renewable resource potential that needs to be harnessed to meet their growing electricity demand as well as bringing down the emissions. Both countries have witnessed the tremendous growth in the deployment of renewable energy in the recent years. Energy security concerns, degrading environment and growing political pressure on developing nations to cut down the emissions have compelled the policy-makers to formulate concrete policies and bring supportive measures to foster the renewable energy deployment.

India and China, both contribute significantly to the global economy as well as are also among the major emitters of GHG

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emissions. Their emissions in these countries have grown at much faster rate compared to OCED and other non OCED countries in the last decade. The share of both these country to the global economy was around 42% and contributed around 35% to the global GHG emissions in 2013 [6]. As per the IEA projections, India and China would become the biggest energy consumers by 2030 in absolute terms [1]. Therefore, substantial emission reductions are required by both countries to achieve the 450 ppm CO_2-equiv concentration stabilization target but strong mitigation actions may also have effect the economic growth of these developing countries. Hence, in this study we focus on these two countries to understand the impact of government renewable policies on the energy transitions in next two decades. India may also get advantage from China's renewable policies through technology transfer in the scenario where China is able to implement their pro-renewable policies and develop their grid-connected and off grid-connected market.

In India, the central government promulgated National Action Plan on Climate Change (NAPCC) in 2008 and identified deployment of solar energy technologies as one of the national missions [7]. It envisages the target of producing 15% of the total electricity from renewable energy sources by 2020. Then in 2010, Government of India announced the Jawaharlal Nehru National Solar Mission (JNNSM) with the aim to deploy 20 GW of solar power by 2022 [8]. In addition to that, State Electricity Regulatory Commission (SERC) also released its individual renewable purchase obligation (RPO) targets. In order to achieve this target and attract investment in the renewable energy sector, Government of India has introduced Renewable Energy Certificates (RECs) – a market-based mechanism and also several financial incentives like generation based incentive (GBI), preferential feed-in tariffs, depreciation benefits and tax rebates [9]. As a result of these policies, the grid-connected solar PV capacity has increased 179% in last few years. (from .9 GW in 2011 to 2.63 GW in 2013) Similarly with an increase in the installed wind capacity, India is currently having the fifth position in world wind power market.

The Chinese government also formulated several policies to develop the renewable energy sector. At first, Renewable Energy Law was passed in 2005. Under this law, mid- and long-term development plan for renewable energy were released in 2007 which aims to achieve the target of increasing the share of renewable energy in the China's primary energy consumption. Policies like mandatory connection and purchase policy for renewable generators and renewable power quota were introduced to create a market for the renewable power. Financial incentives like feed-in tariffs and cost sharing mechanism were also given to foster more investment in the renewable energy projects. Then, at 2009 Copenhagen Accord, China had pledged to reduce its emissions by increasing the share of non-fossil fuels in primary energy consumption to around 15% by 2020. Due to the intensive government efforts, China has become the world leader of global wind market in terms of the installed wind power capacity accounting for more than half of the world new capacity installed in 2014.

Before the major UN summit for discussing the global climate change treaty, both India and China have announced ambitious renewable deployment plans. The Indian government announced an ambitious target of increasing the cumulative installed power capacity from renewable sources up to 175 GW by 2022. Out of total 175 GW, Government of India aims to increase the solar power by 100 GW followed by wind 60 GW, and then biomass and small hydro.[2] China has signed a climate deal with the U.S and pledges to reduce the GHG emissions over the next two decades. The Chinese government announced a medium-term target of 20% non-fossil share in the primary energy consumption by 2030 [10].

As the power system is crucial sector for the climate mitigation, several attempts have been made to explore the role of renewable energy in achieving mitigation targets at both global and national scale [4,5,11–16]. At the national scale, Anandarajah and Gambhir [11] analyze the contribution of renewables to achieving the India's 2050 reduction target using bottom-up cost-minimization global model. In their study, the country specific reduction target was estimated based on the single burden scheme for single global emission pathway. Similarly [14] analyzes the extent of subsidy that is required to achieve the certain level of low carbon technologies penetration in electricity sector using the target approach in the BaU and carbon price scenario. Another study conducted by Schmid [17] focuses on the type of policies that can foster the development of renewable energy in India using the econometric analysis. Several studies have assessed the impact of emission reduction target on China's economy in short and long term but have not assessed the role of renewable energy under different emission constraints [12,14,18–22]. Dai et al. [18] assess the contribution of various policies to achieve the 2020 China's Copenhagen commitment using the AIM/CGE (Asia-Pacific Integrated Model/Computable General Equilibrium) model and its impact on the China's economy. Yuan et al. [23] assess the feasibility of the clean energy target till 2020 under different socio-economic scenarios for China and propose the policy roadmap to achieve the emission intensity reduction target. Several researchers also have done comparative analysis between India and China's and focused on the role of renewable in achieving the reduction target as well as air pollution abatement [24–30]. Lucas et al. [27] compare the impact of mitigation action timing on India and China's energy system using the optimization model in the long term. The study considers the same carbon price aligning with the 450 ppm CO_2-equiv concentration stabilization target for India and China [31]. Saveyn et al. [28] compares economic implications of different global GHG mitigation policies for three Asian economies (India, China and Japan) and role the low carbon power technologies and energy efficiency measures can play in achieving the global mitigation target. Dai et al. [32] assess the economic impacts and environmental co-benefits of large-scale development of renewable energy in China toward 2050 and conclude that developing RE not only stimulate output of the upstream industries but also contributes substantially to carbon reduction. Cheng et al. [33] find that coupling the RE development and carbon emission trading scenarios appears to be the most economically efficient scenario to achieve the desired carbon and energy intensity targets at the provincial level of China.

Earlier studies have separately assessed different global mitigation and national renewable policies for India and China. As these policies could strongly affect each other, therefore it is imperative to assess the impact of renewable and climate policies harmonization. This paper aims to address the following three research questions to fill this research gap. First, is it beneficial for the emerging economies like China and India to align their renewable energy target with national climate change policies? Second, how will different renewable energy deployment targets affect the cost of mitigation for two emerging economies, i.e., India and China, under various emission constraints? Third, what changes will occur in the power mix in the alternative renewable energy deployment and national emission reduction target? To address the above mentioned research questions, multiple scenarios are developed taking into consideration different renewable energy deployment targets, and short-term GHG emission constraints aligned with the 450 ppm GHG concentration stabilization target for India and China. Country specific emission constraints are estimated by allocating different global annual emission budget among the nations using two burden-sharing schemes to address the uncertainties. These scenarios are assessed using the AIM/CGE, a top-down

[2] http://pib.nic.in/budget2015/budgetdoc/gbEngRelease.pdf.

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