ORIGINAL ARTICLE

Energy efficiency to mitigate carbon emissions: strategies of China and the USA

Ming Yang[1] · Xin Yu[2]

Abstract In November 2014, the United States of America (USA) and the People's Republic of China (China) governments announced their carbon emission reduction targets by 2030. The objective of this paper is to quantitatively project the two countries' carbon emission reductions that will likely contribute to or facilitate the global climate change mitigation commitment and strategies in Paris in 2015. A top-down approach is used to analyze the relationship between China economic development and energy demand and to identify potentials of energy savings and carbon emission reduction in China. A simple time series approach is used to project carbon emission reduction in the USA. The predictions drawn from the analysis of this paper indicate that both China and the USA should use energy efficiency as first tool to achieve their carbon emission reduction goals.

Keywords Emission peaks in China · Emission declines in the USA · Drivers of carbon emissions

1 Introduction

During the Beijing 2014 Asia-Pacific Economic Cooperation (APEC) meeting on November 13, 2014, the United States of America (USA) and the People's Republic of China (China) jointly announced their targets to mitigate greenhouse gas (GHG) emissions. The president of the USA, Barack Obama, publicized a new target to cut 26–28 % net GHG emissions below 2005 level by 2025. At the same time, Chinese President Xi Jinping broadcasted that China will peak its gross carbon dioxide (CO_2) emissions and to increase non-fossil fuel share of all energy to approximately 20 % by 2030. Being the largest GHG emitting countries, China and the USA account for over 42 % of global GHG emissions (IEA 2013). If any of the two great countries (G2) does not address climate change, global climate change negotiation will not

✉ Ming Yang
    ming.yang7@gmail.com

[1] The Global Environment Facility, World Bank Group, Washington, DC, USA

[2] International Fund for China's Environment, Washington, DC, USA

achieve any substantial commitment for mitigation targets. Now, these G2 have highlighted their critical roles in addressing climate change. The USA submitted its 2025 target to the United Nations Framework Convention on Climate Change as an Intended Nationally Determined Contribution in March 2015. China agreed to peak its CO_2 emissions by means of energy efficiency and renewable energy investments.

President Obama's announcement was supported by the USA energy policy to use energy efficiency as the first tool to achieve its goal in decarbonization in the next 10 years. The new US carbon mitigation goal will double the pace of carbon emission reduction from 1.2 % per year on average during the 2005–2020 period to 2.3–2.8 % per year on average between 2020 and 2025. This ambitious target is grounded in intensive analysis of cost-effective carbon pollution reductions achievable under the existing Clean Air Act of the US Environment Protection Agency (EPA) and will keep the USA on the right trajectory to achieve deep economy-wide reductions of GHG emissions by 80 % below 1990 level by 2050 (US EPA 2014a). In its proposed rule on June 18, 2014, the US EPA considered the following existing policies and programs for its decarbonization target: (1) market-based emission limits; (2) GHG performance standards; (3) utility planning approaches; (4) renewable portfolio standards; (5) demand-side energy efficiency programs; and (6) energy efficiency resource standards. All these six policies and programs except the fourth one are related to energy efficiency.

Similarly, President Xi Jinping's announcement was based on the assumption that energy efficiency will continue serving as the first fuel to power the Chinese economy. From 1980 to 2005, China had remarkably accomplished more than 60 % reduction in energy intensity (energy consumption per unit of gross domestic production (GDP)). Afterwards, the Chinese government pledged to cut China's carbon intensity by 40–45 % at the 2005 level by 2020, and energy efficiency has been used as a tool to achieve this pledged goal. In its 11th Five-Year Plan (2006–2010), the government has set a mandatory target to cut energy intensity by 20 % and actually achieved 19.1 %. During the 12th Five-Year Plan (2011–2015), the government continued setting a target of 16 % reduction by 2015. In the meantime, the government is in the process of developing China's 13th Five-Year Plan (2016–2020). To guide this process, President Xi Jinping called for an energy revolution in the China's energy sector which covers dramatic changes in energy consumption, energy supply, institutional reform, technology innovation, and international cooperation. Following Xi's initiative, the government will likely use multiple measures in reducing carbon emissions in its 13th Five-Year Plan, including new energy intensity reduction target, increased use of market-based mechanisms, and mandatory total energy consumption cap for cities, provinces, and major industrial entities. The following sections present analysis results of the two countries' action plans in climate change mitigation by using the tool of energy efficiency.

2 Methodology used in this study

The methodology used in this study consists of five steps that lead to fulfill the objective of the study. Recall that the objective of this study is to quantitatively project the two countries' carbon emissions and describe energy policies that are related to the emissions, which will likely contribute to or facilitate the global climate change mitigation commitment and strategies in Paris in 2015. The methodology that supports the study to achieve the objective has the following two streams: (1) GHG emission reduction strategies and policies for China, and (2) GHG emission reduction projection for the USA (see Fig. 1).
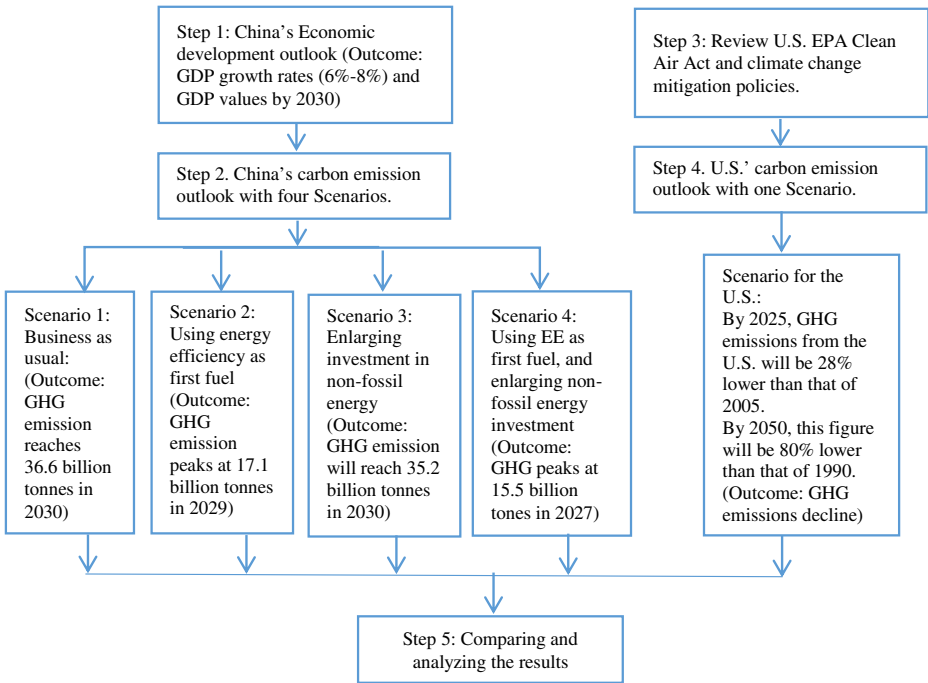
Fig. 1 Methodology framework for this study. Source: (authors' design)

In China, carbon emissions in the next 15 years depend on three government policies: (1) economic development, (2) energy efficiency investment, and (3) non-fossil energy development. A top-down approach with four steps integrating economic development, energy efficiency, and renewable energy investments was designed for China. The first step is, by using historical data, to project China's economic growth rate in the next 15 years. The projected GDP growth rates can be supported by different energy supply scenarios: (1) using coal as major primary energy supply (scenario 1, business as usual); (2) using energy efficiency as the first tool to reduce carbon (scenario 2); (3) enlarging investments in non-fossil energy technologies (scenario 3); and (4) using energy efficiency as the first fuel and enlarging investments in non-fossil energy (scenario 4).

The approach to mapping the road of GHG emission reductions for the USA is much simpler than that for China. The US EPA has developed a number of energy and carbon emission reduction policies for all sectors with a focus on the transport and power sectors. If the US Congress and Supreme Court support the US EPA in mitigate climate change, then carbon emission reduction road in the USA can be easily mapped with a time series model: (1) cutting US GHG emissions by 28 % below 2005 level from 2015 to 2025, and (2) reducing GHG emissions by 80 % of the level in 1990 by the year of 2050.

3 Analysis of GHG reduction target for China

There are two main drivers of China's high growth of GHG emissions: (1) fast and long-lasting economic development, and (2) continued inefficient use of energy. These two drivers are

highly related to the Chinese government economic development and energy policies. There are also two drivers for China's GHG emission reduction: (1) using energy efficiency as the first fuel to power economy; and (2) enlarging investments in non-fossil energy, namely renewable energy and nuclear energy. The analysis of China's GHG emission target is therefore based on the country's economic development, energy efficiency improvement, and non-fossil energy investment.

3.1 China's dream and economic development outlook

The rapid rise of China as a major economic power within three decades is often described as one of the greatest economic success stories in modern times. From 1979 (when economic reforms began) to 2011, China's real GDP grew at an average annual rate of nearly 10 %. In this period, GDP grew 19-fold in real terms, real per capita GDP increased 14-fold, and over 500 million people were raised out of extreme poverty. China is now the world's second largest economy and some analysts predict that it could become the largest within a few years (Fig. 2).

Historical data also show that China's GDP growth rates changed in a cyclical curve with 9–10 years in each period (Fig. 3). The last valley point was in 1998 while the peak point appeared in 2003. Figure 3 also presents a trend curve of the historical GDP growth rates. The following variance of the indicator, namely GDP growth rate, is perceived in the analysis: (1) mean: 9.8 %; (2) range=11.3 %; (3) interquartile range=3.2 %; (4) variance=0.1 %; and (5) standard deviation=2.7 %. It seems that China passed the highest GDP growth rate at the beginning of the twenty-first century. It is unlikely that China's GDP will sustainably grow again at a rate of more than 10 % per annum for a period of 15 years. On the basis of such historical trend, the authors projected that the China's GDP growth rate will continue to decline slightly in the forthcoming 3 years down to approximately 6.5 %, then it will raise again gradually up to 8 % by 2030. To be conservative, this analysis assumes that China's GDP growth rate will be between 6 and 8 % during the next one and a half decades.

The above projection of China's economic development growth rate also complies with the current economic and social development policy of the country. Just after becoming Chinese president in late 2012, Mr. Xi Jinping announced China's dream. He said that the dream is great rejuvenation of the Chinese nation. China's dream is described as achieving the two 100s. The first 100 means that by 2021 which will be the 100th anniversary of the Chinese
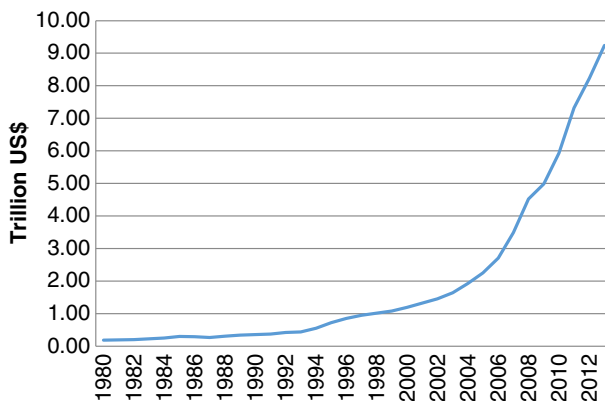
Fig. 2 China's GDP in market price. Source: (World 2014a)
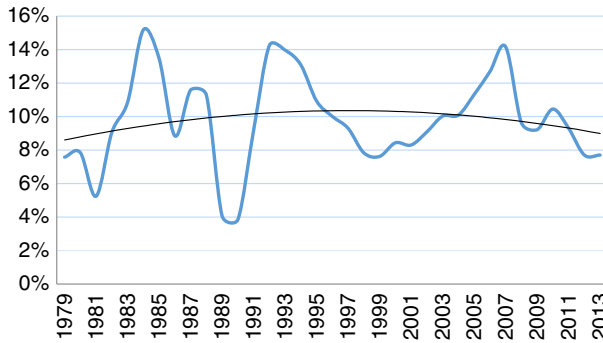
**Fig. 3** China's GDP growth rate. (China Statistic Year Book 2014)

Communist Party, China should become a country with moderately well-off society. The second 100 means that by 2049 which is the 100th anniversary of the founding of the People's Republic China, the country should achieve its goal of modernization, becoming fully developed in the world (Baidu 2014). To achieve these two targets, the national GDP must keep growing at a rate between 6 and 8 % per annum from 2015 to 2030.

China will likely triple its GDP from 2015 to 2030 if its economy is growing at an average rate somewhere between 6 and 8 %. In 2013, China's GDP reached 9.24 trillion United States dollars (US$) at 2010 constant price. By 2030, with an average growth rate of 8 % per annum, China's GDP will reach approximately US$ 35 trillion, which is 3.5-fold as its 2013 level. With an average growth rate of 6 % per annum, China's GDP will be US$ 25 trillion in 2030, which is 2.5-fold as its 2013 level (see Fig. 4).

3.2 China's carbon emissions outlook

3.2.1 China's historical carbon intensity

China has significantly reduced its carbon intensity over the past 30 years. From 1979 to 2012, the country's carbon intensity had been declining from 7.6 kilogram (kg) CO_2/US$ in 1979 to 1.8 kg CO_2/US$ in 2012. The major reduction was achieved during the period of 1979–2002 by means of energy efficiency and renewable energy investments. From 2002 to 2012, this
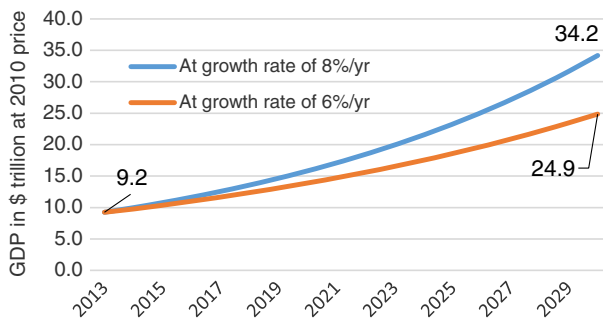
Fig. 4 China's GDP projection

figure did not change very much in the range of 1.8–2.4 kg CO_2/US\$ since China invested significantly in heavy industries and infrastructure (Fig. 5) which were both energy intensive. What will happen to China's energy intensity in the near future?

The section below describes four scenarios about China's energy intensity and carbon emissions during the forthcoming 15 years: (1) business as usual; (2) using energy efficiency as the first tool; (3) enlarging investments in non-fossil fuel technologies; and (4) using energy efficiency as the first fuel and enlarging investments in non-fossil fuel technologies.

### 3.2.2 Business as usual (scenario 1)

In the business as usual scenario, China is assumed to develop its GDP at a rate of between 6 and 8 % per annum, and the country will not use additional policies to promote energy efficiency and non-fossil energy. In other words, China will triple its GDP and keep its carbon intensity unchanged at the level of 2013. As a result, China's total CO_2 emissions will reach 36.6 billion tonnes of carbon dioxide equivalent (CO_2eq) (Fig. 6).

3.2.3 Using energy efficiency as the first tool to reduce carbon (scenario 2)

China's historical energy intensities Similar to carbon intensity reduction trend, China's energy intensity has been declining significantly over the past 35 years. From 1979 to 2012, energy intensity, calculated in tonnes of oil equivalent per \$1000 GDP output in 2011 constant price, was reduced from 0.52 to 0.20 (or by 61.5 %) in China, while this figure was reduced from 0.21 to 0.14 (33 %) in the USA (see Fig. 7). In 2012, energy intensity of China was 42.9 % higher than that of the USA. There is a great potential for China to improve energy efficiency and reduce energy intensity. It seems that the energy intensity figure of 0.2 tonnes of oil equivalent per thousand US dollars (toe/\$1000) was special for both of the two countries. The USA recorded this figure in 1992, 1993, and 1994. After 17 years, China also recorded this figure in 2010 and 2011. In the USA, it took approximately 15 years, from 1996 to 2011, to reduce energy intensity from 0.20 to 0.15 toe/\$1000. By following the USA in implementing more strict energy efficiency policies and standards for buildings, electrical motors, vehicles, and industrial use of energy, China will likely follow the USA in energy intensity reduction and be able to cut its energy intensity from 0.2 in 2015 to 0.15 toe/\$1000 in 2030.
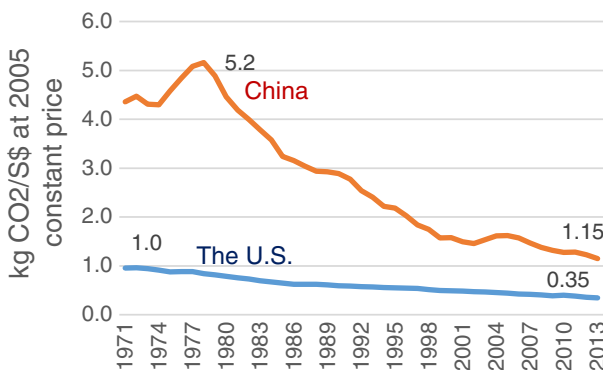
Fig. 5 Carbon intensity in China and the USA

Billion tonnes of CO_2 eq
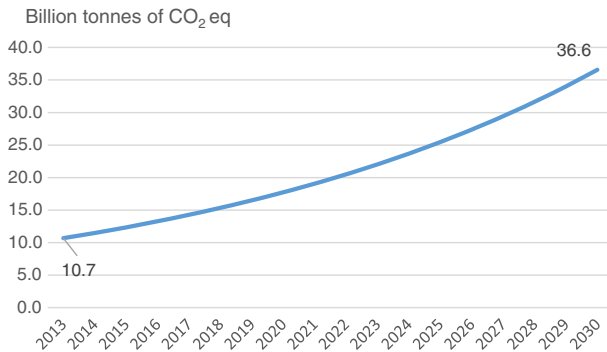
**Fig. 6** China's carbon emissions under scenario 1

Carbon intensity reduction with energy efficiency as the first tool Comparing Figs. 8 and 7, one can see that China's carbon intensity and energy intensity have the same changing pattern in history, implying that they are highly correlated. Reducing energy intensity has direct impact on reducing carbon intensity. Thus, the authors assume that Chinese energy efficiency policies will have direct impact on carbon emission reductions in China and that with appropriate energy efficiency policies, China's carbon intensity reduction path could follow that of the USA.

Carbon intensity in the USA has been constantly decreasing from 1 kg CO_2/US\$ in 1979 to 0.4 kg CO_2/US\$ in 2012. China's carbon intensity from 2014 to 2030 will likely be in a range of 1.2 kg CO_2/US\$ in 2015 to 0.5 kg CO_2/US\$ in 2030. This assumption implies that energy efficiency will be the first tool in China to reduce approximately 47 g (g) CO_2/US\$ of GDP per year! Overall, China's carbon intensity would be reduced from 1.2 kg CO_2/US\$ in 2015 to 0.5 kg CO_2/US\$ in 2030. Multiplying this figure by China's projected GDP gives a picture of China's CO_2 emissions in the next 15 years.

As shown in Fig. 8, China's carbon emission will peak between 2027 and 2029 depending on the implementation of its economic development policy and energy efficiency policy. If the country favors high economic development with an average GDP growth rate of 8 % per annum, carbon emission will peak at 17.1 billion tonnes of CO_2eq in 2029. If the country slows down its economic development with an average GDP growth rate of 6 % per annum, the country's carbon emissions will peak at 12.9 billion tonnes of CO_2eq in 2027. It should be

toe/PPP \$1000 in 2011 constant price
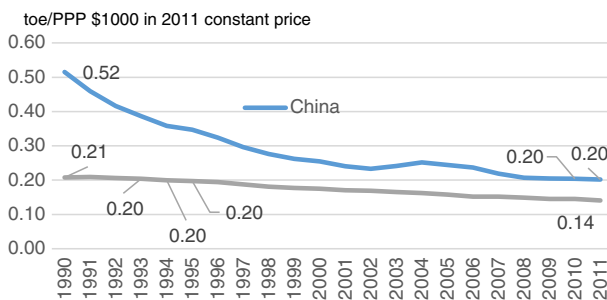
Fig. 7 Energy intensity in the USA and China (World 2014b). Note: toe/PPP means tonnes of oil equivalent/ purchasing power parity
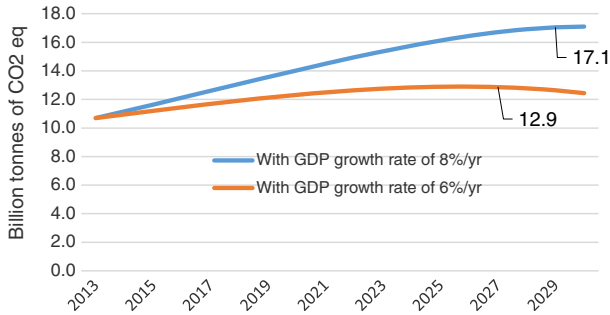
**Fig. 8** China's carbon emission with 0.5 kg CO_2/\$ of EI in 2030

stressed again that energy efficiency must be the first tool to cut the county's energy intensity by 47 g CO_2/US\$ of GDP per year.

3.2.4 Enlarging investments in non-fossil fuel technologies (scenario 3)

Scenario 3 only accounts the impact of non-fossil energy development on carbon emission reductions. In 2013, when China's non-fossil energy production reached 10 % of the country's total energy production, China's carbon intensity was 1.16 kg CO_2/US\$. It means that 90 % of China's fossil energy contributed to 1.16 kg CO_2/US\$. In 2030, if China achieves its target of using 20 % non-fossil fuel in its energy mix, the country's fossil energy will reach 80 %. The contribution of non-fossil energy to carbon intensity reduction will be reduced from 1.16 kg CO_2/US\$ in 2013 to 1.03 kg CO_2/US\$ in 2030 without accounting energy efficiency as the first fuel.

With an assumption that the amount of 0.13 kg CO_2/US\$ (1.16 less 1.03) is reduced linearly from 2013 to 2030, the authors calculated carbon emissions of China under scenario 3 by multiplying the carbon intensities with projected GDP of China from 2013 to 2030. Figure 9 shows the results.

China's carbon emissions would not likely peak if the country enlarges its non-fossil energy share to 20 % by 2030 without using energy efficiency as the first tool. The reason is that
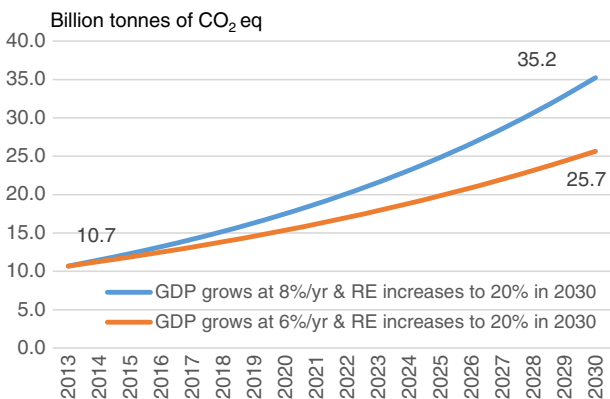
Fig. 9 China's carbon emission with 20 % of non-fossil energy in 2030

China will likely more than double its total energy consumption in the next 15 years; the amount of carbon emissions from additional fossil energy consumption will surpass the amount of carbon mitigation by enlarging non-fossil energy supply from 10 to 20 % of the total energy supply in this period. By 2030, China's total carbon emissions will reach 35.2 and 27.5 billion tonnes of CO_2eq at 8 and 6 % GDP growth rates under scenario 3 (Fig. 9).

3.2.5 Using energy efficiency as the first fuel and enlarging non-fossil fuel to 20 % (scenario 4)

Fortunately, scenario 3 will not likely come true, since China will both use energy efficiency as the first fuel and enlarge non-fossil fuel share at the same time. Scenario 4 integrates these two efforts for carbon emission reduction, and Fig. 10 shows the results.

Under scenario 4, the country's carbon emission will peak between 2024 and 2028 depending on the growth rate of the country's GDP. If the average GDP growth rate is 8 % per annum, carbon emissions will peak at 15.5 billion tonnes of CO_2eq in 2028. If the GDP is growing at 6 % per annum, carbon emissions will peak at 12.2 billion tonnes of CO_2eq in 2024.

4 Analysis of GHG reduction target for the USA

Since 2007, carbon emissions in the USA have been decreasing. Major drivers of GHG emission reductions are related to reduction of air pollutions in the US Analysis on the US Clean Air Act will help understand GHG emission reductions in the past and in the future. The Clean Air Act and its related activities are related to energy efficiency in different sectors, including transport, commerce, households, and agriculture. The last but not least sector for clean air and GHG emission reduction should be the power generation.

4.1 US EPA's Clean Air Act and US climate change mitigation policies

The Clean Air Act is a US federal law designed to control air pollution on a national level. It requires the EPA to develop and enforce regulations to protect the public from airborne
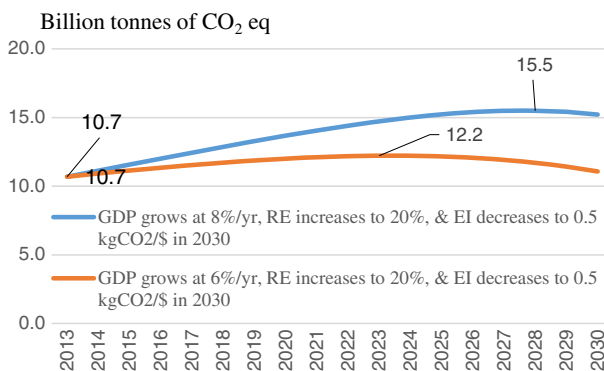
Fig. 10 China's carbon emission with 20 % of non-fossil energy (RE) and 0.5 kg CO_2/$ of energy intensity in 2030

contaminants known to be hazardous to human health. The development of the US Clean Air Act can be traced back from the 1950s. The 1955 Air Pollution Control Act was the first US federal legislation that pertained to air pollution; it also provided funds for federal government research of air pollution. The first federal legislation to actually pertain to controlling air pollution was the Clean Air Act of 1963. The 1963 Act accomplished this by establishing a federal program within the US Public Health Service and authorized research into techniques for monitoring and controlling air pollution. In 1967, the Air Quality Act enabled the federal government to increase its activities to investigate enforcing interstate air pollution transport and, for the first time, to perform far-reaching ambient monitoring studies and stationary source inspections. The 1967 act also authorized expanded studies of air pollutant emission inventories, ambient monitoring techniques, and control techniques (US EPA 2014a).

Major amendments to the law, requiring regulatory controls for air pollution, passed in 1970, 1977, and 1990. The 1970 amendments greatly expanded the federal mandate, requiring comprehensive federal and state regulations for both stationary (industrial) pollution sources and mobile sources. It also significantly expanded federal enforcement. Also, the US EPA was established on December 2, 1970 for the purpose of consolidating pertinent federal research, monitoring, standard-setting, and enforcement activities into one agency that ensures environmental protection (US EPA 2014b).

The 1990 amendments addressed acid rain, ozone depletion, and toxic air pollution, established a national permits program for stationary sources, and increased enforcement authority. The amendments established new auto gasoline reformulation requirements, set Reid vapor pressure (RVP) standards to control evaporative emissions from gasoline, and mandated new gasoline formulations sold from May to September each year in many states. The US Congress authorized the 1990 Acid regulations, and also required for the first time, the addition of continuous carbon monitors including record keeping requirements on regulated electric power generators. The Acid Rain program is a "market-based trading program" and each tonne of carbon emissions is measured with an accuracy greater than 98 %. The accuracy of current emission monitors helps the new regulations which is not "market trading based" but a "performance standard" approach. Without the accuracy of 98 % for monitoring carbon monitors, it is impossible to verify a performance based standard with greater than 98 %.

Since the start of Obama's administration, the US EPA and the US president administration have worked more actively on mitigating GHG emissions. Significant milestones include the following:

- In December 2009, the US EPA found that GHGs are danger to human health and welfare;
- In April 2010, the EPA issued GHG Emissions Performance Standard (EPS) for cars and light trucks for the period of 2012–2016;
- On November 10, 2010, the US EPA made available important resources and guidance to assist state and local permitting authorities as they implement their Clean Air Act permitting programs for GHG emissions.
- In September 2011, the EPA issued GHG EPS for medium and heavy trucks for the period of 2014–2018;
- In August 2012, the US EPA issued GHG EPS for cars and light trucks for the period of 2017–2025;
- In June 2013, President Obama directed the US EPA to reduce carbon pollution from power plants as part of a Climate Action Plan;

- In February 2014, President Obama directed EPA to extend EPS for medium and heavy trucks to post-2018 period (final by March 2015);
- In the first week of June 2014, the US EPA announced a proposal that required reductions in CO_2 emissions from existing fossil-fueled power generation plants. The proposal included emission rate targets for each state, measured as pounds of CO_2 emissions per megawatt-hour of covered generation, as well as guidelines for the development, submission, and implementation of state plans. The emission rate targets vary significantly across individual states, reflecting the application of a series of common building blocks to states with widely different starting points in their respective electricity markets.
- In November 2014, President Barack Obama publicized the target to cut net GHG emissions of the USA by 26–28 % below the level of that in 2005 by the year 2025 with major emission reduction sources from the US power generation and transport sectors.
- On January 20, 2015, US president Obama tackled climate change in the State of the Union address. The president stressed that our climate is changing. He said that the best scientists in the world are all telling us that our activities are changing the climate, and if we do not act forcefully, we will continue to see rising oceans, longer, hotter heat waves, dangerous droughts and floods, and massive disruptions that can trigger greater migration, conflict, and hunger around the globe. He mentioned that climate change poses immediate risks to the US national security according to Pentagon. He also said that the US government has taken actions ranging from the way Americans produce energy to the way Americans use it.

4.2 GHG emission projection in the USA

In 2012, power generation (32 %) and transportation (28 %) were the largest two sectors in GHG reduction in the USA, accounting a total of 60 % GHG emissions in the country (US EPA 2014c). Other GHG emissions in the USA in included industry (20 %), agriculture (10 %), and commerce and household (10 %) (Fig. 11). Since the US EPA has well regulated
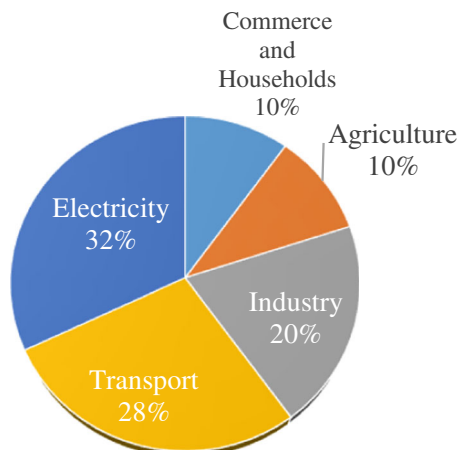
Fig. 11 Total US GHG emissions by economic sector in 2012 (US EPA 2014c)

the transportation sector, GHG emission reduction from the power generation sector will become a key factor in the USA to achieve Obama's 2025 GHG emission reduction target.

In power generation, using coal as primary energy is more carbon intensive than using natural gas or petroleum. In 2012 in the USA, coal accounted for approximately 75 % of carbon emissions from the power sector, but coal-fired power plants only contributed to approximately 39 % of the electricity generation in the country. Other 61 % of power was generated using natural gas (29 %), oil (less than 1 %), nuclear (less than 20 %), and renewable sources (12 %) (US EPA 2014c). If all coal-fired power plants are converted into non-coal-fired plants by 2025 with the same mixed power generation technologies as in 2012, the USA will be able to mitigate 1233 million tonnes of CO_2eq, (61 % of the total target between 2005 and 2025) without taking into account efficiency improvement for the existing power plants. A great potential of carbon emission reduction in the power generation sector is to raise energy efficiency by converting conventional coal power plants (with efficiency of 35 %) into gas-combined cycle power plants (with efficiency of 50 %) or gas-fired co-generation power plants (with efficiency of 95 %). Then, the USA will be able to save 260 million tonnes of CO_2eq by using gas-combined technologies, or 1039 million tonnes of CO_2eq (51 % of the total target between 2005 and 2025) by using gas-fired co-generation technologies. To sum, the USA will be able to achieve its 2025 GHG emission reduction target by technology advancement and energy efficiency improvement in its power sector.[1]

If reducing targeted GHG emissions from power plants fails, the US government still has a number of options. The first is standards for heavy-duty engines and vehicles. In February 2014, President Obama directed EPA and the Department of Transportation to issue the next phase of fuel efficiency and greenhouse gas standards for medium- and heavy-duty vehicles by March 2016. These will build on the first-ever standards for medium- and heavy-duty vehicles (model years 2014 through 2018), proposed and finalized by this administration. The second is energy efficiency standards. The Department of Energy set a goal of reducing carbon pollution by 3 billion tonnes cumulatively by 2030 through energy conservation standards issued during this administration. The Department of Energy has finalized multiple measures addressing building sector emissions including energy conservation standards for 29 categories of appliances and equipment as well as a building code determination for commercial buildings. These measures will also cut consumers' annual electricity bills by billions of dollars. The third is economy-wide measures to reduce other GHGs. The US EPA and other agencies are taking actions to cut methane emissions from landfills, coal mining, agriculture, and oil and gas systems through cost-effective voluntary actions and common sense regulations and standards. At the same time, the State Department is working to slash global emissions of potent industrial GHGs, called hydrofluorocarbons (HFCs), through an amendment to the Montreal Protocol. The US EPA is cutting domestic HFC emissions through its Significant New Alternatives Policy (SNAP) program, and the private sector has stepped up with commitments to cut global HFC emissions equivalent to 700 million tonnes through 2025. These policies and strategies of the US government will ensure the USA to achieve its GHG emission reduction targets.

From 2025 to 2050, the USA needs to continue energy efficiency investments and renewable energy development to achieve its 2050 GHG emission target, namely 80 % lower

---

[1] In China, replacing coal by nature gas in power generation is not priority in the next 20 or 30 years. Natural gas resources in China are not as rich as in the USA. Many Chinese cities are still using coal for heating and cooking. It is priority for city consumers not power plants to replace coal by nature gas in the next two or three decades.
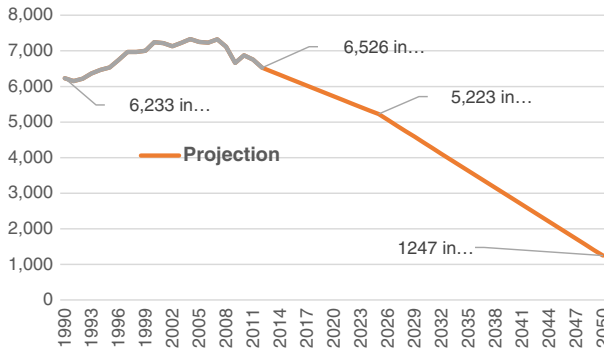
Fig. 12 Carbon emissions in the USA (million tonnes of CO_2eq)

than the level in 1990. Figure 12 shows carbon emission trend in the USA during three time periods, 1990–2012, 2013–2025, and 2025–2050, according to the pledge of the US government.

5 Conclusions

Using historical economic development data, energy data, and empiric analysis methodology, this paper projects GHG emission reduction figures for the USA and China by 2025 and 2030. The analysis shows that China will likely peak its GHG emissions in 2028 at 15.5 billion tonnes of CO_2eq under a high economic development scenario, or peak in 2024 at 12.2 billion tonnes of CO_2eq under a moderate rate of the economic development scenario, if the country uses energy efficiency as the first tool to mitigate climate change and enlarges non-fossil fuel to 20 % of its total energy supply. Without using energy efficiency as the first tool, it would be impossible for China to peak its GHG emissions before 2030.

In the USA, carbon emissions have been decreasing since 2007 and this trend will continue. With the regulation effort of the US EPA on the power sector where energy efficiency acts as the first tool, the USA will reduce its total GHG emissions down to 5.2 billion tonnes of CO_2eq by 2025, or 28 % lower than the level of 2005. This carbon emission reduction will be mainly contributed from power generation sector by replacing coal-fired power plants with high efficient gas-combined cycle technologies and gas co-generation technologies. After 2025, the USA needs to continue making its effort in energy efficiency and renewable energy investments to achieve its pledged target of GHG emission reduction in 2050.

Energy efficiency has become the most important part in the energy policy and strategy for both the USA and China. In these two countries, energy efficiency can greatly reduce carbon emissions with the following ways: (1) dispatching to lower emission units in power generation (natural gas units instead of old coal units); (2) improving the overall efficiency of a coal-fired power plant; (3) providing incentives for electric clients to use more efficient appliances; (4) setting up higher energy efficiency standards and codes for buildings, vehicles, and industrial processes; and (5) developing renewable power to replace old coal-fired power plants, which is more efficient in using natural resources.

Without more strict energy efficiency and non-fossil energy development policies, neither China nor the USA will be able to achieve its carbon emission reduction target by 2030.

Among these energy policies, energy efficiency policy is priority. Energy efficiency has become and will continue to be the first tool to mitigate global GHG emissions and climate change.

Conflict of interest   The authors declare that they have no conflict of interest.

Disclaimer   The views, findings, interpretations, and conclusions expressed in this article are entirely those of the authors and should not be attributed in any manner to the organizations where the authors work.

References

Baidu (2014) Chinese dream: Xi proposed guideline. http://baike.baidu.com/subview/1817221/9342599.htm Cited on November 26, 2014
China Statistic Year Book (2014) National bureau of statistics of China. http://www.stats.gov.cn/tjsj/ndsj/2014/indexeh.htm
U.S. EPA (2014a) History of the clean air act, http://www.epa.gov/air/caa/amendments.html, Cited on December 18, 2014
U.S. EPA (2014b) EPA history, http://www2.epa.gov/aboutepa/epa-history, Cited on December 18, 2014
U.S. EPA (2014c) Sources of greenhouse gas emissions, http://www.epa.gov/climatechange/ghgemissions/sources/electricity.html, Cited on December 18, 2014
IEA – International Energy Agency (2013) CO_2 emissions from fuel combustion highlights 2013, Paris
World Bank (2014a) Catalog sources world development indicators, http://data.worldbank.org/indicator/NY.GDP.MKTP.CD Cited on December 22, 2014
World Bank (2014b) World Development Indicators. http://data.worldbank.org/country/china and http://data.worldbank.org/country/us Cited on December 22, 2014