Chapter 2

Historical and Recent Trends of CO_2 Emissions: Current Status and Ways to Close the Gap towards the 2°C Target

Masahiro Suzuki, Madoka Yoshino,
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Key Messages

- Global energy-related CO_2 emissions stalled while the world GDP grew 3% in 2014, which is an encouraging sign for the start of strongly decoupling emissions growth from economic growth on a global scale. However, it is apparent that much more effort is needed to achieve the 2°C target.
- The degrees of decoupling differ among the three largest emitters. Since 1990, the European Union has shown an evident trend of strong decoupling, achieving economic growth with decreasing CO_2 emissions. During the same period, the United States increased emissions but started to show a decreasing trend in recent years, and China increased emissions whilst also showing a weak decoupling of emissions from economic growth.
- Major driving factors of structural change in emissions differ across countries. However, national climate policies are associated with, and often triggered by, other national priorities such as security, economic growth, domestic and international leadership, and welfare of citizens. Development of an international climate framework for leveraging these national priorities to boost climate actions is essential for bridging the gap towards the 2°C target.
- Mitigation efforts generate long-term benefits while decision-makers tend to worry more about the short-term negative impacts to the economy. Transition to a low-carbon development path essentially requires overcoming this short-term thinking by putting more priority on long-term sustainability. Under the current political reality, however, demonstration of short-term tangible benefits of climate actions could play an important role to encourage more robust climate actions.

1. Introduction

The global distribution of carbon dioxide (CO_2) emissions has changed significantly in recent decades. Many developed nations reached a mature economy in which their economy grew at a relatively small rate or stagnated, and their population stabilised or started to decline. Many developing nations, on the other hand, experienced strong economic and population growth, and increased their share of the world's total emissions – a trend which is likely to continue into the foreseeable future.

Under such circumstances, a number of regulations and other political and economic measures have been put in place worldwide, particularly among developed nations and developing nations with high growth rates, aiming to reduce emissions growth through decarbonising energy systems. Perhaps as a result, according to the International Energy Agency (IEA), world energy-related CO_2 emissions growth stalled while the world gross domestic product (GDP) grew 3% in 2014, which indicates the start of decoupling CO_2 emissions growth from economic growth at the global level (IEA 2015). IEA attributes this trend mainly to the improvement of energy efficiency and the strong investment in low-carbon energies, in particular, renewable energies. However, IEA also warns that neither the current level of effort nor the intended nationally determined contribution (INDC) level will limit the global mean temperature increase to 2°C above pre-industrial levels (IEA 2015), which is required to prevent the most severe consequences of climate change (the 2°C target).

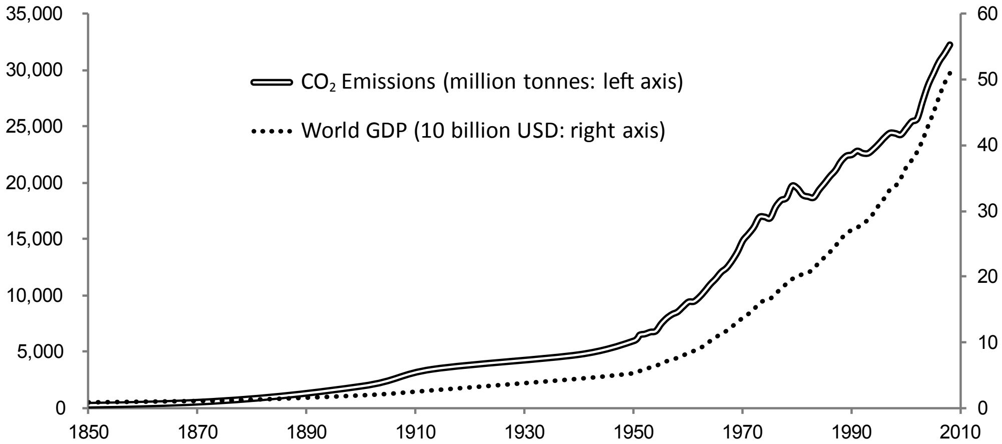
This chapter aims to examine these recent changes in CO_2 emissions, and to identify measures to accelerate this decoupling trend. The rest of this chapter is organised as follows. Section 2 reviews the historical trend in global CO_2 emissions and economic growth both at the global level and by three groups at different development stages: (1) the Organisation for Economic Co-operation and Development (OECD) nations – a group of developed countries; (2) BRIICS (Brazil, Russia, India, Indonesia, China and South Africa) – a group of emerging countries; and (3) rest of the world (ROW) – a group mainly consisting of developing countries. Section 3 then takes a closer look at the world's three biggest emitters: the European Union (EU), the United States (US) and China, with an aim to identify the major drivers of decoupling trends in each country/region.[1] With the identified drivers in mind, Section 4 discusses important elements to further accelerate reducing the emissions to meet the 2°C target with an emphasis on the importance of short-term benefits in the current political reality. Finally, Section 5 presents a summary.

2. The historical CO_2 emissions trend and today's global emissions outlook

This section first analyses the relationship between CO_2 emissions growth and economic growth since the early 19th century with a focus on the changing use of different types of energy resources. It then reviews the global distribution of CO_2 emissions in recent decades and argues the necessity of further emissions reduction to achieve the 2°C target.

2.1 Historical trends of CO_2 emissions and economic growth

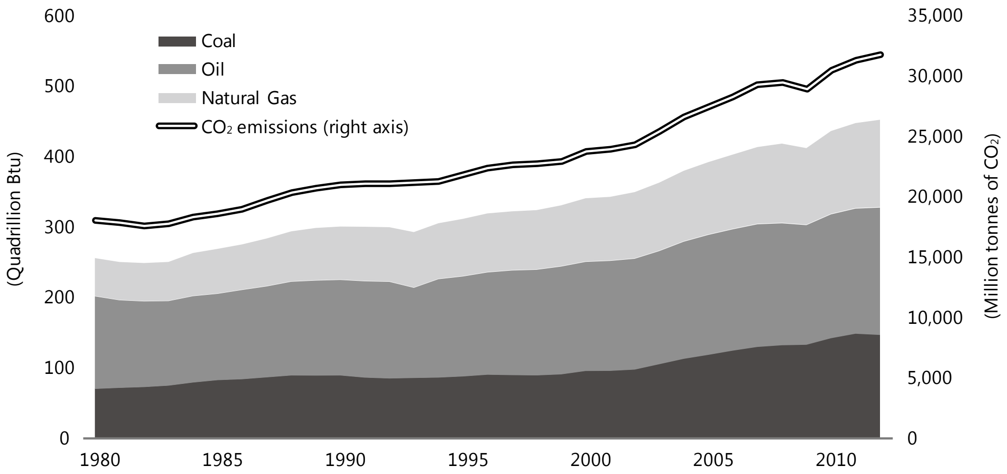
Since the early 19th century when the world started to boost its economy through rapid industrialisation, there has been a strong correlation observed between economic growth and CO_2 emissions growth (See Figure 2.1).



Source: GGDC (2010) for World GDP, Boden et al. (2015) for CO_2 Emissions, re-compiled and calculated by the authors.

Figure 2.1 ***CO_2 emissions and world GDP***

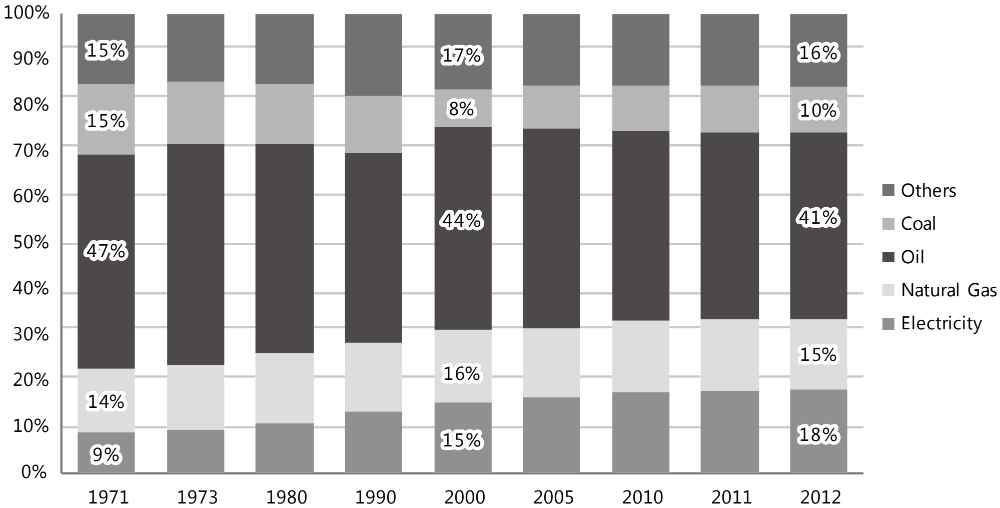
This strong linkage between economic growth and emissions growth has been persistent due to the fact that economic growth has been achieved by consuming an increasing amount of energy, most of which was generated by burning fossil fuels. At first, coal was the dominant resource to empower industrialisation while oil gradually gained greater importance, particularly from the late 19th century when many nations went through militarisation and fuelled their battleships, tanks and aircrafts with oil (Yergin 2011). This shift from coal to oil was further accelerated as a result of the energy consumption revolution in the mid-20th century, and the world energy systems developed into a complex platform that consumes different kinds of fossil fuels including coal, oil and natural gas to meet the continuously rising and diverse demand for energy (Cherp and Jewell 2011). For example, these resources often fulfil a specific demand for energy such as oil for transportation, coal for industrial use as a raw material including for iron and steel production, and natural gas for the demands from industry and households for heating and cooking. Consequently, the demand for all these fossil fuels increased rapidly as the world economy went through continuous growth. As shown in Figure 2.2, CO_2 emissions made a steady increase along with the rising consumption of these fuels.



Source: EIA (2015), re-compiled and calculated by the authors.

***Figure 2.2** Global fossil fuel consumption and CO_2 emissions*

At the same time, the demand for electricity increased significantly and the share in total energy demand grew compared to other forms of energy as illustrated in Figure 2.3.



Source: IEA (2014a), re-compiled and calculated by the authors.

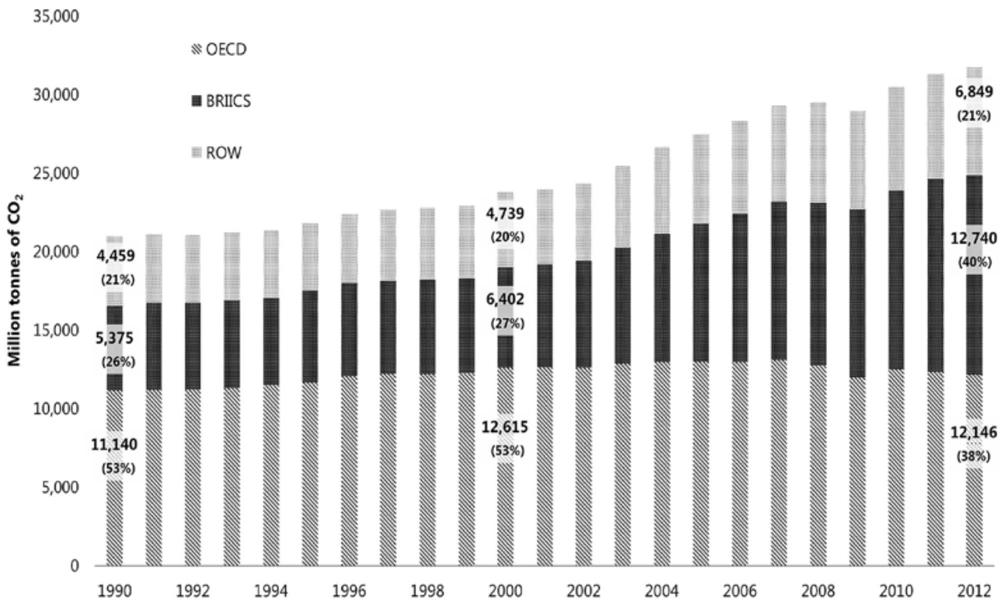
***Figure 2.3** Share of energy sources in the final energy consumption at the global level*

This trend is partly because electricity — which can be produced not only by fossil fuels but also by other types of low-carbon energy sources today such as renewable energies and nuclear fuels — became an important engine to fuel industrial machinery and household appliances.

2.2 Change in global distribution of CO_2 emissions

Each country now fuels its energy systems with different types and amounts of energy resources based on their development level as well as political, economic, social and technological conditions. These differences are reflected in the recent emissions trends, which are clearly observable when comparing OECD, BRIICS and ROW.

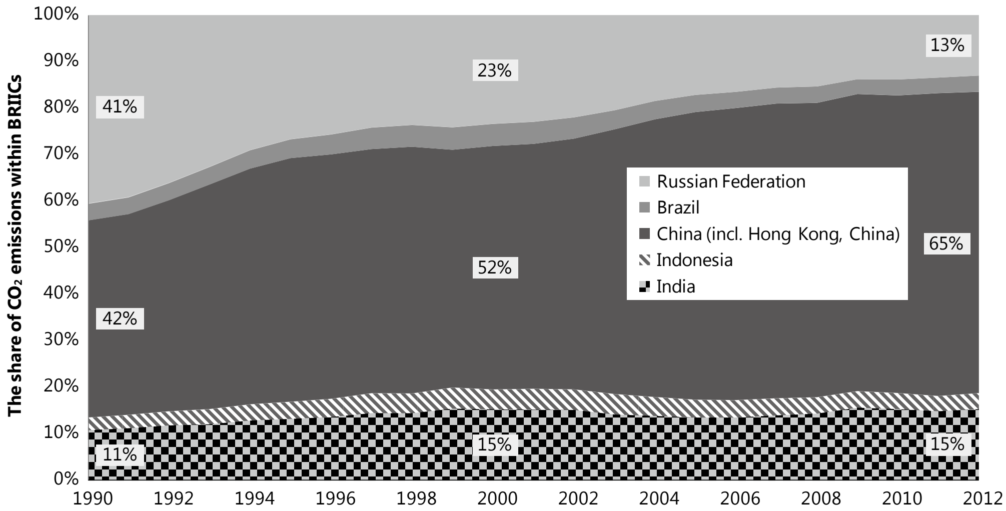
As shown in Figure 2.4, CO_2 emissions from OECD peaked in 2007 at 13,103 million tonnes of CO_2 (Mt CO_2) and saw a slightly declining trend thereafter, resulting in 12,146 Mt CO_2 in 2012. Conversely, CO_2 emissions from BRIICS show a steady and rapid increase compared to the other groups, representing a share of 26 % in 1990 and 40% in 2012. ROW shows an increasing trend from 4,459 Mt CO_2 in 1990 to 6,849 Mt CO_2 in 2012, but the share is maintained at around 20%. Therefore, non-OECD countries increased the share from around 45% in 1990 to around 62% in 2012.



Data source: IEA (2014a), re-compiled and calculated by the authors.

Figure 2.4 ***CO_2 emissions since 1990***

Figure 2.5 presents a closer look at the CO_2 emissions distribution in BRIICS.



Data source: IEA (2014a), re-compiled and calculated by the authors.

***Figure 2.5** Energy based CO_2 emissions of BRIICS between 1990 and 2012*

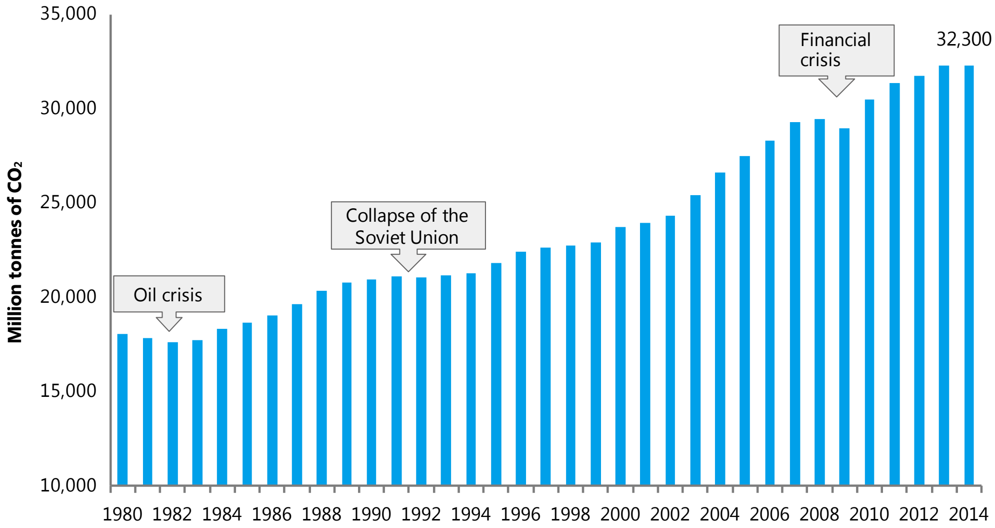
China dominates the share of emissions from BRIICS, with an increase from 42% in 1990 to 63% in 2012, indicating that emissions increased by 3.6 times from 2,277 Mt CO_2 in 1990 to 8,251 Mt CO_2 in 2012, along with the growth of GDP by 7.6 times. The Russian Federation, after the collapse of the Soviet Union, reduced its emissions and its share within BRIICS from 41% in 1990 to 13% in 2012, but maintained approximately 65-80% (1,417 Mt CO_2 in 1997 and 1,660 Mt CO_2 in 2012) of the 1990 leves.

The emission share of India within BRIICS increased by only 4% from 1990 to 2012, although India has significantly increased its emissions from 581 Mt CO_2 in 1990 to 1,954 Mt CO_2 in 2012, which is an increase of 3.4 times. As a whole, energy based CO_2 emissions from BRIICS countries accounted for approximately 25% of the world emissions in 1990 and this share increased to over 40% in 2012, an increase of 2.4 times in 22 years. Therefore, it is critical, considering the share from these countries in the total global emissions, that they peak their emissions as early as possible to achieve the 2°C target.

Although the emissions share of ROW currently remains around 20%, these countries will go through rapid economic growth in the near future and consequently increase their emissions. Therefore, it is important that they leapfrog to the development of a low-carbon society in order to prevent significant amounts of carbon from being locked into the assets of these countries.

2.3 Stalling of CO_2 emissions

These different emissions trends in the developed (OECD), emerging (BRIICS) and developing (ROW) economies resulted in the stalling of CO_2 emissions growth on a global scale in 2014 (IEA 2015). IEA (2015) argues that "(it is) the first time at least in the last 40 years that such an outcome has occurred outside economic crisis" (p.11). According to the IEA, stalling or decreasing emissions has previously been observed several times in correlation with economic stagnation such as during the oil crises in the 1970s and the financial crisis in 2009 (See Figure 2.6).



Data source: IEA (2014a; 2015), re-compiled by the authors.

Figure 2.6 ***Energy-based CO_2 emissions since 1990***

This time, however, the global economy grew by 3%. Based on this fact, the IEA argued that "growth in the global economy and energy-related emissions may be starting to decouple" (IEA 2015; p.11). OECD countries, on average, have demonstrated a continuous trend of strong decoupling in recent years, and now China, the world biggest emitter, is also showing a weakening of the previously persistent link between economy and emissions.

It must be noted that stalling emissions is not enough to achieve the 2°C target and thereby avoid future climate catastrophe. Out of the carbon budget to secure a 50% likelihood of achieving the 2°C target, 3,010 gigatonnes (Gt) of CO_2, almost two-thirds was already consumed by 2014 and the budget will be completely exhausted by 2040 if the current pace of consumption is kept (IPCC 2014; IEA 2015). The level of effort of the submitted INDCs for COP21 or the most likely contents of the expected INDCs from the currently non-submitted nations will only give us another eight months until budget exhaustion, relative to the scenario without INDCs (IEA 2015). This is in line with the analysis from Climate Action Tracker (CAT), an international research consortium, which argues that the current INDC level has "a 92% probability of exceeding 2°C" (CAT 2015).

There already are international discussions taking place on the means to scale up the level of climate efforts to fill this gap towards the 2°C target. The United Nations Environmental Programme (UNEP) Gap Report argues that scaling up and replicating existing climate mitigation actions could reduce 29 Gt CO_2 equivalent (CO_2eq) of GHG emissions in 2030 (UNEP 2014). In order to exploit this mitigation potential, UNEP (2014) calls for creating the right incentives, including carbon pricing, fossil fuel subsidy reform, and the promotion of investment in low-carbon and resource efficient assets. IEA (2015) also suggests the "Bridge Scenario" in which five policy measures are proposed to accelerate the recently observed decoupling trend and to meet the 2°C target. These measures are: (1) improving energy efficiency; (2) reducing the least-efficient coal fired power plants; (3) investing in renewable energies; (4) phasing out of subsidies to fossil fuels; and (5) reducing methane emissions from oil and gas production.

These recommendations are solid and they have been widely accepted as a general policy direction. In order to implement climate actions like these to further reduce emissions, it is critical to demonstrate that additional climate efforts contribute to the benefits of countries in their specific country conditions and needs. In this regard, the next section takes a closer look at the climate/energy policies of three major economies and thus key actors in the international climate negotiation, namely the EU, the US and China, for the purpose of identifying the major driving elements of their decoupling emissions trends.

3. CO_2 emissions trends in the EU, the US and China

This section first reviews the recent emissions trends of the EU, the US and China, and highlights the major driving factors that contribute to their recently observed decoupling trends.[2] While these factors can be diverse, the existing literature (e.g. Amineh and Crijns-Graus 2014; Hayes and Knox-Hayes 2014; and Oberthür and Kelly 2008) often offers arguments based on the following three pillars: (1) energy security; (2) industry and economy; and (3) institutional and social environment. This section applies these pillars to review the three countries/region.

Table 2.1 shows the GDP, CO_2 emissions and CO_2 intensity of the EU, the US and China in 1990 and 2012. The positive growth of GDP is observed in all countries/region, however only the EU records the decrease of CO_2 emissions and shows strong decoupling.[3] On the other hand, CO_2 intensity decreased in the US and China, rather significantly in the latter, which indicates weak decoupling of emissions.

Table 2.1 ***GDP, CO_2 emissions and CO_2 intensity of the EU, the US and China in 1990 and 2012***

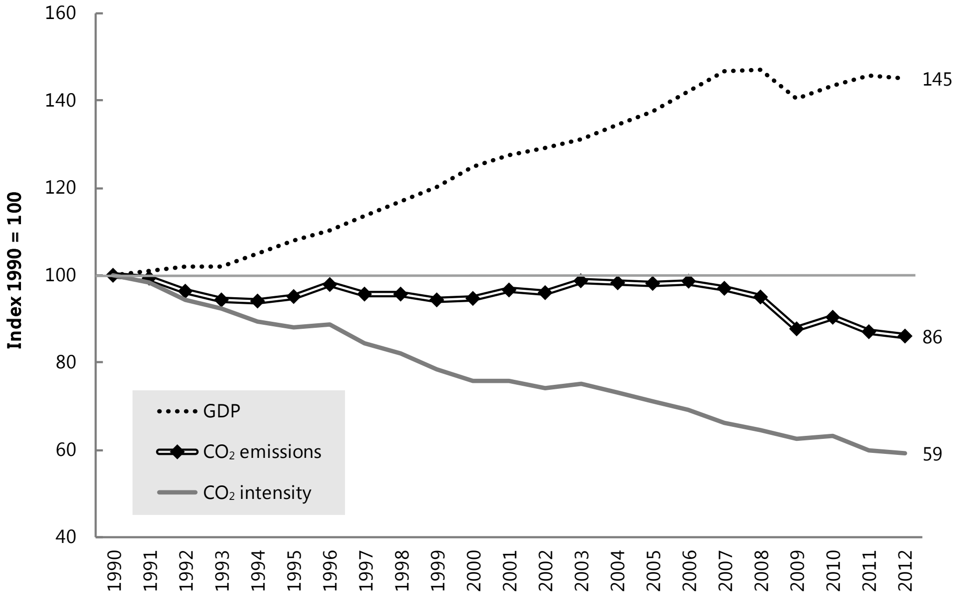
	European Union (EU-28)			United States			China (incl. Hong Kong, China)		
	1990	2012	difference (%)	1990	2012	difference (%)	1990	2012	difference (%)
GDP (billion 2005 US dollars)	10,068	14,614	**45**	8,229	14,232	**73**	626	4,756	**660**
CO_2 Emissions (million tonnes)	4,068	3,505	**-14**	4,869	5,074	**4**	2,278	8,251	**262**
CO_2 Intensity	0.40	0.24	**-41**	0.59	0.36	**-40**	3.64	1.73	**-52**

Data source: IEA (2014a; 2015), re-compiled by the authors.

3.1 EU

3.1.1 Emissions trends and recent climate policy

The EU shows an evident trend of strong decoupling emissions growth from economic growth (see Figure 2.7). In 2012, compared to the 1990 level, the economy in EU member states collectively grew about 45% while CO_2 emissions were reduced by 14% (4,069 Mt CO_2 in 1990 to 3,505 Mt CO_2 in 2012) and emissions intensity was cut by around 40%. The EU explains that this decoupling trend is observed in all the EU member states (EC 2014a).



Source: IEA (2014a), re-compiled and calculated by the authors.

***Figure 2.7* Historical GDP, CO_2 emissions and CO_2 intensity in the EU**

As for the future reduction targets, the EU adopted the Climate and Energy package in 2009, where it set a goal of a 20% emissions reduction by 2020 compared to 1990 levels. The European Commission explains that the EU is currently on track and will exceed this target through reductions of 21% (EC 2014a). Furthermore, in March 2015, the EU submitted its INDC to the UNFCCC, in which the EU aims to achieve at least 40% reduction by 2030 from 1990 levels (Latvian Presidency of the Council of the European Union and the European Commission 2015).

For the purpose of spearheading the transition to a low-carbon economy and achieving these climate targets, the EU has taken various climate measures. Such measures include: (1) introduction and further implementation of the EU Emissions Trading System (EU ETS); (2) establishment of a stringent energy efficiency standard for buildings, equipment and household appliances; (3) setting an energy mix target with increased share of renewable energies; and (4) mandating car manufacturers to improve fuel efficiency. Today, the EU ETS covers approximately 45% of GHGs emissions from the EU member states (EC 2013a). At the same time, the EU is aiming to increase energy efficiency to 20% by 2020 and at least to 27% by 2030, and to expand the share of renewable energies within its energy mix to 20% by 2020 and at least 27% by 2030 (EC 2014b).

3.1.2 Major driving factors behind decoupling trends

Energy Security – *low endowment of fossil fuels drives renewables investment*

The EU is endowed with a limited amount of fossil fuels within its borders, which makes it politically and economically vital to develop renewable energies as a means to enhance energy supply security (IEA 2014b). According to BP, a major oil and gas corporation headquartered in London, the shares of proved coal, oil and natural gas reserves located within EU borders are 0.3%, 0.8%, and 6.3% respectively out of the total reserves (BP

2015). This makes the region heavily dependent on external energy producers. Around 53% of energy consumed in the region in 2013 was procured from foreign sources, and out of this, the external oil dependence exceeded 88% (EC 2014c). Expanding the share of renewable energies will help the EU move towards greater energy self-reliance and security, although the foreign dependence ratio of respective fossil fuels may increase due to the decreasing trend in internal production of those fuels (Amineh and Crijns-Graus 2014). Indeed, renewable energy gets significant policy and financial support in the EU. In 2013, around USD 70 billion or EUR 52 billion of subsidies were provided for renewable energy, which was equivalent to 57% of total global subsidies for renewable energy (IEA 2014a). There needs to be a more holistic and in-depth analysis when assessing the extent of energy security improvement by increasing renewable energies. However, a study conducted by Jewell et al. (2013) which evaluates the future scenarios of long-term energy security in the major econimies under the various ambition levels of climate policies, shows a positive impact for the EU.

Industry and Economy – *low-carbon economy as a core growth plan*

It is at the heart of EU's industrial policy to revitalise its economy, especially after the financial crisis of 2009, by striving to be a global leader in sustainability (EC 2013b; 2014d). In particular, the development of low-carbon technologies is critical to increase energy efficiency, reduce energy demand and thus strengthen EU's industrial competitiveness. This low-carbon policy also aims to create a new market area and job opportunities. A recent communication from the European Commission states that "EU companies cannot compete on low price and low quality products. They must turn to innovation, productivity, resource-efficiency and high value-added to compete in global markets" (EC 2014d; p.8-9). Out of six areas listed in this context as EU's investment priority for innovation, five are directly related to cleaner production and/or green products, and the other is the so-called Key Enabling Technologies (KETs) which "modernise EU industry and make the transition to a knowledge-based and low-carbon resource-efficient economy" (EC 2013b).[4]

Institutional and Social Environment – *climate policy gives legitimacy and authority to EU*

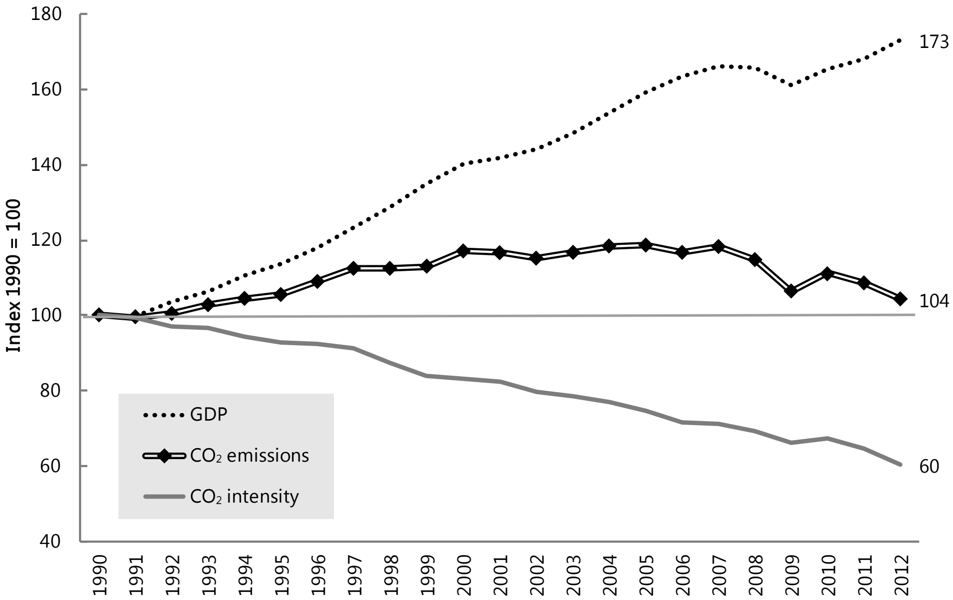
The institutional structure, the role of the public and the societal ideology reinforce each other to push the EU and its member states towards becoming a leader in international climate regime. Climate change is an issue that cannot be solved within national boundaries, but requires collective action among nations. This gives legitimacy to European nations for unification, and to have a centralised authority with an aim to develop coherent policies within the EU member states (Hayes and Knox-Hayes 2014). In addition, Hayes and Knox-Hayes (2014) also argue that there is a political space between EU institutions and EU citizens which enables the EU to develop and exercise ambitious top-down climate policies. Furthermore, there is a shared notion among the member states that the EU should act as a leader of multilateralism (Oberthür and Kelly 2008). In addition, public support on climate policy is fairly strong and stable (See EC 2014e). This social foundation further reinforces the integration of the EU, which contributes to more positive bottom-up movements among the public towards climate goals.

These driving forces are expected to motivate the EU to collectively strive for a further leading role both in internal climate policies and international negotiations. Translating the EU-wide 2020 and 2030 reduction targets into a collection of effective and immediate policy implementations in each member state is significantly challenging, but such a collaborative practice by the EU can provide lessons for the international community to seek even stronger cooperation on a global scale.

3.2 US

3.2.1 Emissions trend and recent climate policy

The US was the largest emitter of CO_2 in the world until 2006 when China took over the position. The US recently started to slow down its growth of CO_2 emissions (see Figure 2.8). In 2012, US CO_2 emissions were 5,074 Mt, which is a reduction of approximately 4% from the previous year and a 12% reduction from 2005.



Source: IEA (2014a), re-compiled and calculated by the authors

***Figure 2.8* Historical GDP, CO_2 emissions and CO_2 intensity in the US**

In 2010, the US submitted its 2020 target of a reduction of about 17% in GHG compared to 2005 levels (US Department of State 2010). The US communicated to the UNFCCC secretariat that its target will conform with the national climate and energy legislation and that the final target will be submitted "in the light of enacted legislation" and under the assumption that other Annex I country parties and more advanced Non-Annex I parties associated with and submit mitigation actions according to the Copenhagen Accord. At the time, the US Congress was considering the Waxman-Markey bill which proposed GHG emissions reduction of 30% by 2025, 42% by 2030, in line with 83% by 2050, compared with 2005 levels. Although it was passed by the House of Representatives, it was never passed in the Senate.

In March 2015, the US submitted its INDC to the UNFCCC Secretariat to reduce GHG emissions by 26% to 28% below the 2005 level (US 2015). Reaching this target will require a significant increase in the speed of GHG emissions reduction to 2.3-2.8% per year, or an approximate doubling compared to the 2020 target (United States of America 2015).

3.1.2 Major driving factors behind decoupling trends

Energy Security – *domestic shale gas increases security and reduces emissions*

Addressing climate change in the US has not been easy work for the federal government or the President but the decoupling trend has occurred anyway, and it has contributed to strengthening energy security. One example is the increased domestic production of shale gas, which has been a major driver to reduce carbon emissions in the US while also significantly increasing energy security. Shale gas production started around the year 2000 and gross shale gas withdrawals increased from 5 billion to 33 billion cubic feet per day in 2013 (US Energy information administration 2014). At the same time, the relative contributions from coal, natural gas without combined cycle have decreased (De Gouw et al. 2014). Natural gas has approximately half the carbon dioxide coefficient compared to coal, meaning that increased production of domestic natural gas has some benefits for energy supply security and CO_2 emissions reduction.[5] The total CO_2 emissions from fossil fuel power plants decreased rapidly between 2008 and 2012 and a significant fraction of this decrease was attributable to the fuel switch from coal to natural gas (De Gouw et al. 2014). According to Wang and Krupnic (2013), increased shale gas production in the US is attributable to various factors including technology innovation, government policy, private entrepreneurship, land and mineral rights ownership, high natural gas prices, market structure, water availability and infrastructure. The R&D policy of the US led to technology innovation and tax credits encouraged private investment for shale gas production (Wang and Krupnic 2013).

Industry and Economy – *green jobs and energy efficiency vitalise the economy*

Since President Barack Obama took office, solar generation has increased by 20 times and wind power by 3 times (White House 2015). Building on this progress, the White House explains that it has secured USD 4 billion commitments from corporations in investment for clean energy. President Obama announced an increase in the share of renewables to 20% by 2030 (White House 2015). Through improving energy efficiency in buildings, utilities, manufacturers, school districts and businesses have saved an average of 2% per year, which is the equivalent of USD 84 million since 2011. Responding to the challenge for "Better Buildings" issued by the President, more than 250 partners have joined this initiative to increase energy efficiency by 20% in 10 years (US DOE 2015). As energy efficiency leads to savings in electricity bills, industry and the public are more willing to be engaged for economic reasons. Domestically, in his 2013 climate action plan, President Obama announced that the carbon pollution from coal-fired power plants will be regulated. Due to the increased stringency of fuel efficiency standards of 54 miles per gallon by 2025, there is a growing market for more efficient passenger vehicles. According to the US Environmental Protection Agency (EPA) administrator Gina McCarthy, US industry sees an opportunity for the shift towards clean energy and is embracing it (EPA 2015a). The year 2014 saw the US as the second largest investor in the world with renewable energy investment at USD 38.3 billion, a 7% increase from the previous year (Frankfurt School- UNEP Collaborating Centre for Climate & Energy Finance 2015).

Institutional and Social Environment – *scepticism, power relations and leadership*

In the US, climate science and research programmes started before 1970s, and the Global Climate Protection Act in 1987 directed the EPA to propose a coordinated national policy and the Secretary of State to coordinate diplomatic efforts to combat climate change (Weber and Stern 2011). However, the uncertainty of climate science and the denial campaign funded by large fossil fuel companies tried to undermine the legitimacy of climate change science and policy. The Union of Concerned Scientists (2015) reports that global warming skeptic organisations have been active in causing doubt about climate change. The report lists organisations which were funded by Exxon Mobil and Koch Foundation, for example. Disinformation has long been the reason for inattentiveness or lower support by the public. Additionally, US stakeholders benefiting from coal and oil production had better access to national policy making, compared to environmentally concerned groups, which was a major reason that the US used to take a more favourable position towards industry (Do and Guay 2006). Due to this situation and the political climate, comprehensive climate bills faced major challenges in passing Congress.

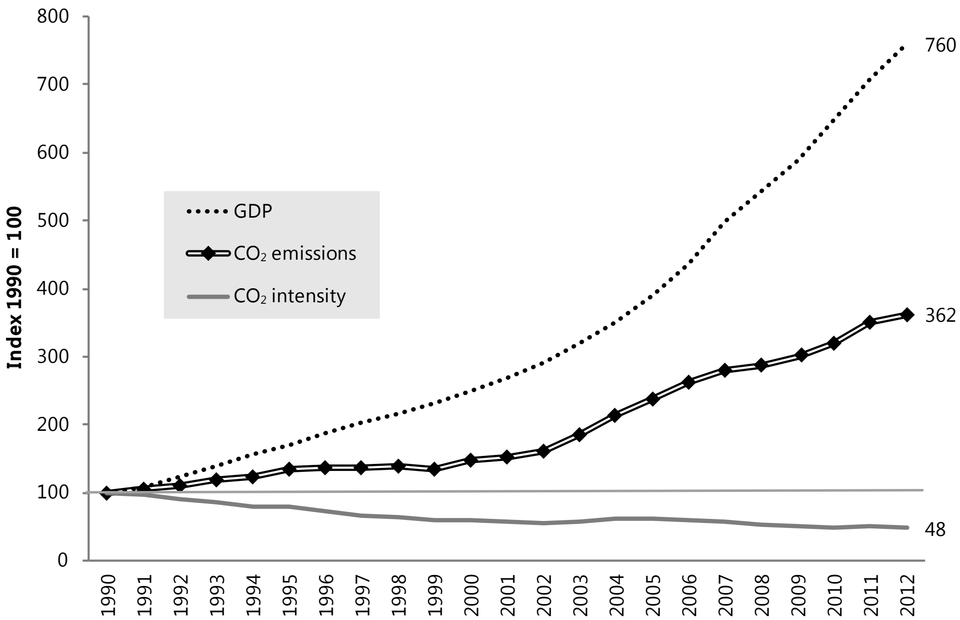
Nevertheless, increasing evidence on climate change was accumulated. For example, the IPCC revealed that anthropogenic GHG emissions are the definite cause of climate change. Climate change impacts, including heat waves, storms and flooding have been widely experienced in the US. In particular, Hurricane Katrina in 2005 and Hurricane Sandy in 2012 were the most damaging on record in the US, costing USD 125 billion and USD 65 billion, respectively (C2ES 2015).[6] From the study conducted by Pew Research Center (2015), the percentage of Americans who consider climate change as a serious problem has increased from 33% in March 2013 to 46% in 2015, showing a growing interest by the US public towards climate change. The industry also seems to be changing its course. In 2015, BP announced that it would cease funding to the American Legislative Exchange Council, a lobbying group misrepresenting climate science to US state legislators (Frumhoff and Oreskes, 2015).

Following the lawsuit of *Massachusetts et al. vs EPA* in 2007, the supreme court ruled that GHGs are air pollutants covered by the Clean Air Act (CAA) and that the EPA must determine whether GHGs endanger public health and welfare. In 2009, EPA announced that the GHGs from new motor vehicles endanger public health and welfare, thus need to be regulated under CAA. In June 2012, the US Court of Appeals D.C. Circuit upheld the EPA's endangerment findings and regulations of GHGs on mobile and stationary sources (e.g. power plants). EPA introduced several measures including emissions standards for passenger vehicles, stationary sources as well as new and existing power plants (EPA 2015b). President Obama often exercises his executive power in dealing with climate change, due to the difficulty in passing a comprehensive climate change bill in Congress. For example, the Obama administration is introducing regulations to cut carbon emissions from existing and new power plants under the Clean Air Act. In August 2015, EPA released the final rules for emissions standards for both new and existing power plants under CAA, namely the Clean Power Plan and Carbon Pollution Standards. States will be submitting their state implementation plans following the rules by September 2016. EPA is also proposing emission standards for heavy vehicles to be finalised by 2016. The US case shows how strong leadership can promote national climate efforts. On the other hand, the Presidential election in 2016 may significantly influence the direction of US climate policies.

3.3 China

3.3.1 Emissions trend and recent climate policy

China's recent emissions show a detaching trend from economic growth. Between 1990 and 2012, CO_2 emissions from China increased around 3.6 times (2,278 Mt CO_2 in 1990 to 8,251 Mt CO_2 in 2012) while the Chinese economy grew more than 6.5 times (IEA 2014a). This contributed to reducing the CO_2 intensity by more than 50% (see Figure 2.9), although it is still 5 and 7 times higher than the US and the EU respectively. Particularly, the rise in CO_2 emissions slowed down after 2005 despite the continued high growth of the economy.



Source: IEA (2014a), re-compiled and calculated by the authors.

Figure 2.9 ***Historical GDP, CO_2 emission, and CO_2 intensity in China***

In 2009 just before COP15, China pledged a carbon-intensity target of 40-45% below 2005 levels by 2020. In March 2011, targets for 16% improvement in energy intensity and for 17% improvement in carbon intensity were included in its 12th Five-Year Plan (2011-2015). Furthermore, in July 2015, China submitted its INDC in which it commits itself to a peak in CO_2 emissions by around 2030, making major efforts to peak early and achieve a reduction in CO_2 emissions per unit of GDP by 60-65% by 2030 from 2005 levels. The country also committed to an increase in the share of non-fossil fuels in primary energy consumption by about 20% by 2030, as well as an increase in the forest stock volume by around 4.5 billion m^3 compared to 2005 levels.

3.3.2 Major driving factors behind decoupling trends

Energy Security - *high growth of economy fuelled by an increase in energy imports*

Energy security is becoming a major concern in China. In the early 2000s, a significant increase in production in energy-intensive industries (e.g. cement and steel) began to erode energy intensity figures that had improved steadily since the early stages of the post-Mao reform era in the late 1970s and 80s. In addition, increasing dependency on foreign energy (coal, oil and natural gas) became a strategic concern among China's leaders (Naughton 2005; Held et al. 2011). While China used to be an exporter of oil and coal, it became a net importer of oil in the early 1990s, mainly from Africa and the Middle East, and a net importer of coal in 2009 mainly from Australia, Indonesia and the US (IEA 2012; Wu et al. 2012).

Industry and Economy - *low-carbon technology entrepreneurs*

China aspires to move from an economy driven by pollution-intensive industries to a nation propelled by clean-technology entrepreneurs; otherwise it would be locked into the most polluting and least profitable segment of the international value chain (Lieberthal and Sandalow 2008).

In addition to exploring a new development approach, the leadership also advocated transforming China into an innovation society and low-carbon development became one of main objectives of the 12th Five-Year Plan (KPMG 2011). The plan identifies seven key new strategic emerging industries, five of which (energy conservation, high-end equipment manufacturing, new energy, new material and advanced automobiles) closely relate to low-carbon development and aim to foster these industries' shares of the economy from 1% at present to 8% by 2015 and 15% by 2020 (Schoen and ChinaFAQs team 2013). The emphasis on technological entrepreneurship meshed well with rising energy security concerns in the early 2000s.

Institutional and Social Environment - *air pollution and political legitimacy*

For China's leadership, the overriding concern is the maintenance of the current political rule. Economic growth, poverty elimination and social stability are all critical to maintaining that rule. After three decades of pro-market reforms, however, income disparities, social tensions and environmental stress have gradually chipped away at the legitimacy of the political leadership's claims. In fact, "the number of environmental protests has increased by an average of 29% every year since 1996, while in 2011 the number of major environmental incidents rose 120" (Liu 2013). The air pollution crisis in Beijing and many other major Chinese cities in 2013 further raised public concern about air quality and emerged as a potent political issue (Wong 2013).

In response to the air pollution crisis, China's State Council released an "Airborne Pollution Prevention and Control Action Plan" in September 2013, which included, for the first time, specific coal consumption targets for provinces (MEP 2013). Furthermore, in November 2014, the State Council released an Energy Development Strategic Action Plan to limit coal consumption to 4.2 billion tonnes of coal by 2020. While these plans have significant impacts on China's CO_2 emissions (Nachmany et al. 2015), they were largely motivated by air pollution concerns. Behind such motivation, there is a concern about the impact of the air pollution crisis on political stability.

Additional factor: Changing Perceptions and Learning Processes

The learning processes through which decision-makers gained knowledge of the costs and benefits of climate policy grew and became more refined in China. While political elites had the perspective and authority to bring energy and politics together, a cadre of experts was well positioned to add scientific basis to those actions. In fact, much of the scientific basis reflected the work of experts who mediated between China's national government and transnational academic networks. Growing information and knowledge about climate change and the exposure of Chinese experts to transnational academic networks, including the IPCC, helped agenda-setting and policy formulation (Stensdal 2012).

With regard to climate change impacts, for instance, several internationally-connected Chinese academics were involved in studies concluding that storms, droughts, flooding, sea level rise and other climate change impacts would have an adverse effect on China's domestic economy, especially when analysed on a regional or sectoral basis (Stern 2006; NDRC 2007; Yin et al. 2012). This conclusion lay in sharp contrast to previous studies that a warmer climate would, on balance, be good for China's economy. More importantly, these scientific data changed the perception of the Chinese leadership on climate change: they became more concerned about the distribution of climate impacts across the country, and, coming back to a familiar theme, about their influence on political stability (Wiener 2008; Lewis 2011).

Over the same period, another group of experts was working on research related to GHG mitigation policy. The most prominent group was using energy models to demonstrate that low-carbon development could be beneficial to China by offering a way to solve resource, energy and environmental challenges at low or even negative costs (Hallding et al. 2009). The idea of low-carbon development therefore matched with the leadership's intention of making China a global player in innovative, clean energy industries (Bradley 2010; Busby 2010).

4. Key elements to strengthen national climate efforts

This section examines the implications of the discussion in Section 3. It further discusses the importance of generating short-term benefits of climate actions as a way to bridge the gap towards the 2°C target.

4.1 Implications from the case studies for further emissions reductions and the importance of bridging national priorities to global objectives

Through examining the EU, the US and China, it has been identified that diverse factors exist for addressing climate change under different political, economic, legal, and social conditions. At the same time, it can be clarified that climate policies are associated with, and often triggered by, other national priorities such as security, economic growth, domestic and international leadership, and welfare of citizens. Some of these priorities are long-term and some are short-term; some are quantifiable and some are not. However, all of these can be categorised as national interests since they are driven mainly by their will to benefit their own countries.

Ostrom (1990) argues that cooperation among diverse actors with varying interests can only be built by ensuring private benefits, in this case national interests, as a primary motivator. Thus the issue is how we can ensure that these individual policies and actions collectively result in solving global issues such as climate change. It is becoming a shared understanding that climate change requires urgent attention and substantive action with strong international cooperation, and that the efforts taken up to now or those currently planned are not enough. Acceleration of efforts is essential even to meet the 2°C target, and some groups of countries argue that this target is insufficient and inadequate to fulfil the ultimate objective of the UNFCCC. More efforts are needed as well as a mechanism to make them happen. In addition, Nives (2001) argues that a national government will not commit to a costly climate policy if it does not have the assurance that global emissions will remain the same or decrease. Even if a country acts and implements an expensive policy measure, if others continue their current behaviour, the country which acted will not benefit. Therefore, it is important to reach an international agreement and re-establish an international climate regime which demonstrates long-term vision, sends clear signals, and incentivise all countries to align their national interests into global climate objectives.

4.2 A way to bridge the gap: short-term tangible benefits of climate actions

National policymakers are concerned about possible economic slowdown and competitiveness loss caused by gearing up climate actions. The core problem is the difference in time scale between climate impacts and economic impacts. A conventional view is that taking strong climate actions will have short-term negative economic impacts, such as slowdown of GDP growth or increased unemployment. These effects may manifest themselves immediately while the benefits from taking such action, namely mitigating climate change, may only become tangible after a relatively long period. This time-scale problem, as well as a high degree of uncertainty about climate risks, makes it challenging to commit and implement stronger climate actions.

The above problem is common to other sustainability issues such as biodiversity loss, land degradation and suspected endocrine-disrupting chemicals. The transition from the current development patterns to sustainable development essentially requires overcoming short-termism and changing policy priority from economy-first to a more holistic and balanced one, by looking wider and further ahead and applying the precautionary principle if necessary (Iverson and Perrings 2012). Still, it is critical to demonstrate the short-term benefits of climate actions to move towards the 2°C target under the current political reality.

The demonstration of short-term tangible benefits of climate actions plays an important role in gearing up climate actions under the current political reality. First of all, it will help provide incentive to policymakers to implement climate actions with such benefits, and secondly it will assist policymakers in convincing various stakeholders including industries to support such actions. There are many climate actions including carbon pricing, reflection of climate risks to investment criteria, and increasing renewable energy share in the electricity grid, that will generate further benefits along with more mitigation effects when these measures become prevalent. Demonstrating the short-term tangible benefits of climate actions will pave the way for this situation.

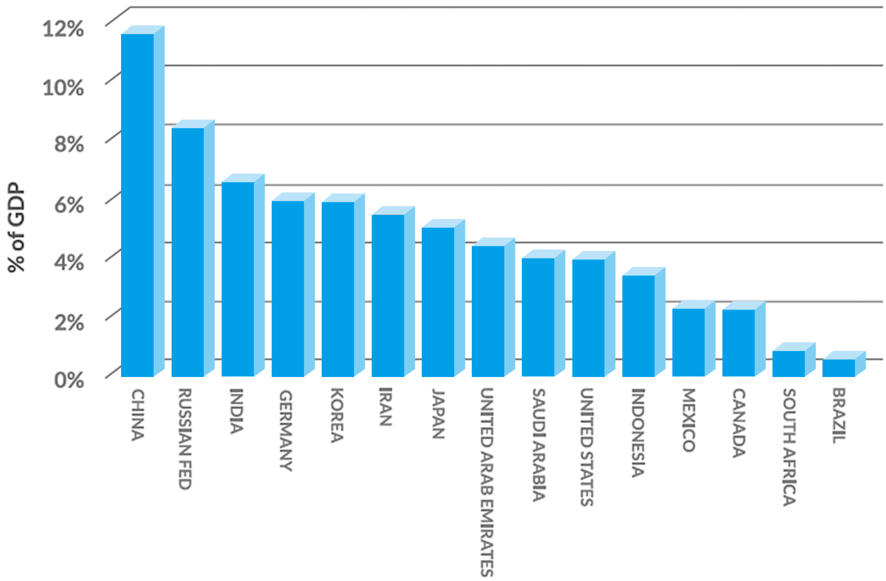
There is an increasing number of studies that reveal such benefits are obtainable. For example, New Climate Economy, an international research initiative to form a clearer understanding on the relationship between climate actions and economic growth, provides several co-benefit examples of climate efforts as outlined below (Global Commission on the Economy and Climate 2014).

1) Job creation effects of climate actions

Promotion of renewable energy contributes to job creation. The International Renewable Energy Agency (IRENA) emphasises that the renewable energy sector generated almost six million jobs in 2012 (Ferroukhi et al. 2013). Considering the vast potential of renewable energy development in the world, an immense number of new jobs can be generated. Moreover, since renewable energy promotes disintegrated power production, it offers additional income opportunity in remote areas.

2) Benefits to public health and crop yield by reducing air pollution

Another example is the improvement in public health and the reduction of crop yield loss by reducing short-lived climate forcers including particulate matters 2.5 micrometers or less in diameter (PM2.5) through measures including regulating vehicle emissions and modernising cooking equipment.[7] According to Hamilton et al. (2014), outdoor PM2.5 exposure caused severe health impacts equivalent to more than 2% of national GDP in many countries, rising to th equivalent of 10% in China in 2010, as shown in Figure 2.10. Although the World Health Organization (WHO) sets an air quality standard of below 10 μg /m[3] of PM2.5, more than 80% of the global population is still exposed to a pollution level exceeding this standard (World Bank 2015). UNEP argues that 2.4 million premature deaths could be avoided by 2030 in addition to the potential saving of the annual loss of 32 million tonnes of crops after 2030 if necessary measures are taken to reduce these emissions (UNEP 2011). Climate efforts are expected to have substantial co-benefits in reducing these emissions. For example, the expected health co-benefits of the Clean Power Plan which has recently been finalised in the US, are estimated to be between USD 12 billion to 28 billion in 2030 (EPA 2015c). The reduction of these impacts would consequently lower health care costs and raise the income of farmers.



Source: Hamilton et al. (2014)

Figure 2.10 ***Cost of mortality from outdoor PM2.5 exposure in 2010***

5. Summary and way forward

The persistent linkage between emissions growth and economic growth is weakening. At a global level, CO_2 emissions growth stalled in 2014 while the economy grew by 3%, although the level of contributions varies among nations. However, this decoupling trend is not strong enough, and the effort level of currently submitted INDCs will not secure the achievement of the 2°C target. To this end, this chapter aimed to identify a means to further accelerate international climate efforts by reviewing the historical relationship between economy, energy systems and CO_2 emissions, and takes a closer look at the recent climate/energy policies and the decoupling trends of the world's three biggest emitters: the EU, the US and China.

A set of general recommendations has already been proposed by several international institutions to fill this gap towards the 2°C target. However, there is ambiguity in translating this internationally-sound objective into national priorities. In this regard, it is important to form a greater understanding on the major driving factors behind the recently observed decoupling trends and other potential short-term benefits of climate efforts in order to promote countries to make more ambitious commitments.

The EU, which shows a strong decoupling trend, leads climate actions to improve energy security, promote economic growth through green investment, and, perhaps most importantly, to secure the legitimacy of unification among European nations while extending the proper level of authority to EU institutions. The US, which began to reduce its emissions over the last decade, is now strengthening its climate actions as a result of strong investment in shale gas development and federal leadership in combating climate change. Such actions have been legitimised and given power by a legal decision to define GHGs as air pollutants. China reduced its CO_2 intensity by more than 50% compared to 1990 levels. Here it was severe air pollution and the consequent rise of a concerned public that gave a push to current political power to act on environmental issues including climate change. The rapid increase in external energy dependence, a political and economic agenda to thrive as a leading nation in low-carbon technologies, and the close engagement of academia in policymaking further promoted China towards strong climate efforts.

It has to be stressed that, at least for now, climate change alone is not considered as a nation's most important political and/or economic agenda in many countries. As seen in the cases of the EU, the US and China, climate actions are associated with, and often triggered by, other national priorities such as security, economic growth, leadership and social welfare. As the findings from New Climate Economy suggest, there are several ways to generate even short-term benefits by decarbonising the economy, such as job creation and human health, and crop yield improvement.

National interests are key to ensuring that countries' climate pledges are ambitious enough to achieve the 2°C target. Another vitally important factor is the establishment of an international climate regime that does not just include all countries, but sufficiently incentivises them to further align their national interests into common climate objectives at a global level. Careful examination should be made of domestic conditions in each country and then relevant experts can inform policymakers of the appropriate way to proceed and strengthen this alignment.

Notes

1. Country/region is in order of the strength in the CO_2 reducing trend thus does not correspond with the amount of CO_2 emitted.
2. The figures of emissions trends do not contain information up to 2014 due to data unavailability from a primary source. This is complemented by referring to secondary sources in texts when available and if appropriate.
3. There is an ongoing discussion on consumption-based emissions, which points out that advanced economies such as the EU have outsourced carbon-intensive production processes outside the territory. For example, the Department for Environment, Food and Rural Affairs of the Government of the United Kingdom (Defra) (2012) reported that territorial emissions of the United Kingdom (UK) reported to UNFCCC have reduced by 27% between 1990 and 2009 while consumption-based GHG emissions of the UK have increased 11% during the same period.
4. Many scholarly articles discuss if a public climate policy can push the innovation of low-carbon technologies (LCTs). Among these, Calel and Dechezleprêtre (2012) found that the EU ETS had only a 1% positive impact on the surge of the new patents related to LCTs since its introduction in 2005. However, they also argue that the policy did encourage firms to install already available LCTs, such as switching to more energy efficient fuels. Thus, one can expect that further reductions could be realized, as long as there are both the economic policies to support the development of LCTs and a climate policy including the aforementioned measures to make them competitive compared to more carbon intensive alternatives.

5. However studies show that due to methane escape during the fracturing and the lifetime of the wells, the footprint from shale gas may be larger over a 20-year timespan and may in fact be comparable to conventional fossil fuels over 100-year timespan (Howarth, et al. 2011). In the long-term, further regulations on GHGs through transition to renewable energies, energy efficient vehicles, as well as banning inefficient power plants will be required to move away from a fossil fuel-based economy.
6. Warmer ocean surface temperature and higher sea levels due to climate change are expected to intensify the impacts of hurricanes. According to the United States Climate Change Action Report, there has been an increase of approximately 0.8°C observed in the average US temperature since 1895, and 2012 was the warmest recorded year in history (US Department of State 2014).
7. In Africa and South Asia, cook stoves are the source of more than 50% of particulate matter.

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