1 Energy and Climate Change

1.1 Introduction

While the world’s climate has always varied naturally, the vast majority of scientists now believe that rising concentrations of “greenhouse gases (GHG)” in the Earth’s atmosphere resulting from economic and demographic growth since the industrial revolution over the last two centuries are overriding this natural variability and leading to potentially irreversible climate change. Scientists warn that the planet is warming faster than previously thought and in order to prevent dangerous climate change we must limit the global mean temperature rise to 2°C from the pre-industrial level. This means that the greenhouse gas concentration in the atmosphere must be stabilized below 450 parts per million (ppm). As the International Energy Agency (IEA, 2014a) noted: “Given the long lifetime of CO₂ in the atmosphere, stabilizing concentrations of greenhouse gases at any level would require a large reduction of global CO₂ emissions from current levels” (p. 7).

According to the Intergovernmental Panel on Climate Change (IPCC, 2013), the global mean temperature rose by 0.85°C during the period from 1880 to 2012. The concentration of carbon dioxide (CO₂)—a major GHG—in the atmosphere has been increasing significantly over the past century compared to the pre-industrial era and it was 40% higher in 2013 than the mid-1800s level. Significant increases have also been observed in the levels of methane (CH₄) and nitrous oxide (N₂O).

Globally, the energy system—supply, transformation, delivery and use—is the dominant contributor to GHG emissions. CO₂ from energy represents almost 70% of global anthropogenic emissions (IEA, 2014a). Policies and actions aimed at significant reductions in GHG emissions by 2020 and beyond would entail drastic changes in the supply and use of energy. The global primary energy demand is expected to grow further by around 20% by 2030 from the 2013 level, whereas about 1.3 billion or 18% of the global population still have no access to electricity (IEA, 2015). Accordingly, the world community faces the dual challenge of the world’s energy needs for development while contributing to GHG emissions reduction. This requires transformation of the energy sector toward cleaner energy sources, as the energy sector accounts for roughly two-thirds of all anthropogenic GHG emissions today.

1.2 A Brief History of the UNFCCC Process

The international political response to climate change began with the adoption of the United Nations Framework Convention on Climate Change (UNFCCC, the Convention) in 1992 and it provides the foundation for intergovernmental efforts to address climate change. The Convention entered into force on 21 March 1994, and now has 196 parties. The countries that have ratified the Convention are called Parties to the Convention. The Convention divides countries into two main groups: those that are listed in its Annex I, known as Annex I Parties or the industrialized countries, currently numbering 43, and those that are not, known as Non-Annex I Parties or the developing countries, currently numbering 153.

As stated in the UNFCCC Article 2, “The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.”

Implementation of the Convention is reviewed at its annual Conference of the Parties (COP) to the UNFCCC, which is the supreme body for making the decisions necessary to promote the effective implementation of the Convention, and its interim sessions. The COP is held together with the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP) and hosted alternately by the regional groups. The permanent Secretariat of the UNFCCC was established in 1996 and located in Bonn, Germany.

The Kyoto Protocol (KP), which was agreed at the third session of the Conference of the Parties (COP3) to the UNFCCC which was held in December 1997 in Kyoto, Japan, supplements and strengthens the Convention. The Kyoto Protocol set legally-binding emissions’ targets for the industrialized countries (Annex I Parties), under which they will reduce their combined GHG emissions by at least 5% from 1990 levels in the KP’s first commitment period from 2008 to 2012. The Kyoto Protocol entered into force on 16 February 2005 and now has 192 parties. The Non-Annex I Parties have no legally-binding emission reduction targets under the KP, but the Protocol set flexible mechanisms, known as the Clean Development Mechanism.

1 The IPCC was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) to assess the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts, and options for adaptation and mitigation.
Energy and Climate: Decarbonizing the Energy Supply in Northeast Asia

The Northeast Asian countries, which represent more than a quarter of the world’s economy and population, are diverse in terms of their socio-economic development and industrial structures. Thus, the region is home to both Annex I (Japan and Russia) and Non-Annex I (the ROK, China, Mongolia, and the DPRK) countries which are Parties to the Convention. According to the current Kyoto Protocol arrangements, two industrialized countries in Northeast Asia, Japan and Russia, had quantified, legally-binding emissions reduction targets for the first commitment period of 2008–2012, and Russia was undergoing the process of transition to a market economy. The other four countries in the region did not have such commitments during the first and second commitment periods of the KP, but as Parties to the UNFCCC, they are required to do so within the framework of the expected new, universal legal instrument to curb GHG emissions. In particular, China, as a fast growing and the top-emitting economy in the world, is drawing international attention in the Post-2020 negotiations. Also, the ROK, as an OECD member, was active in addressing the issues both domestically and internationally. In 2012, these four countries in the Northeast Asian region were among the top-ten emitting countries in the world, while Russia and Mongolia were among the top-ten emission intensive economies globally.

According to the International Energy Agency (IEA) estimates, the global CO2 emissions from fuel combustion amounted to 31.7 billion tonnes in 2012, and the Northeast Asian region was responsible for 37% of the total or 11.8 billion tonnes. As compared to the 1990 level, the global emissions in 2012 were 51.3% higher, while those of the Northeast Asian region doubled. Collectively, the NEA countries were responsible for 60% of the growth in the global emissions level (Table 1.1).

China was responsible for more than two-thirds of total CO2 emissions from fuel combustion in the region in 2012. Russia was the second largest emitter in the region, followed by Japan. But Russia’s CO2 emissions from fuel combustion were 23.9% lower in 2012 than its 1990 level, amounting to 1.7 billion tonnes. Japan’s CO2 emissions from fuel combustion amounted to 1.2 billion tonnes in 2012, 15.8% higher than its 1990 level, whereas Japan had to reduce its economy-wide GHG emissions by 6% during the KP’s first commitment period of 2008–2012. Thus, collectively, the CO2 emissions from fuel combustion of the Annex I Parties in NEA were 10.9% lower in 2012 compared to the 1990 level (Table 1.1, Figure 1.1).

However, the emissions of other Non-Annex I Parties in the region, who are Parties to the Kyoto Protocol but do not have legally-binding targets for their emission reductions, had substantially increased, with the exception of the DPRK. The total amount of the CO2 emissions of these countries amounted to 8.9 billion tonnes in 2012, which was 238.1% higher from the 1990 level. This growth predominantly originated from China.² China’s annual CO2 emissions from fuel combustion had almost quadrupled during the period amounting to 8.3 billion tonnes in 2012, thus emitting an additional 6.0 billion tonnes from the 1990 level. At the same time, the combined emissions of the Northeast Asian countries in 2012 were higher by 5.9
billion tonnes compared to the 1990 level. The ROK had also witnessed a substantial growth of its emissions during the period and the country emitted 2.6 times more CO₂ from fuel combustion in 2012 than in 1990. Mongolia’s CO₂ emissions from fuel combustion also increased and they were 11.8% higher in 2012 from the 1990 level. The DPRK was the only country in the region which witnessed a sharp decrease in its emission level. The DPRK’s CO₂ emissions from fuel combustion amounted to 45.4 million tonnes in 2012, which was 60.2% lower than the 1990 level (Table 1.1, Figure 1.1).

The primary driving forces for CO₂ emissions can be discussed using the Kaya identity. The Kaya identity states that the total level of emissions can be expressed as a product of four indicators: carbon intensity of energy supply; energy intensity of gross domestic product (GDP); per capita GDP; and population. The average annual changes in these indicators during the period from 1990 to 2012 are illustrated in Table 1.2.

Collectively, the level of CO₂ emissions from fuel combustion in the NEA region saw a 2.1% year-on-year increase during the period from 1990 to 2012, although the annual growth rates varied by country. China had the highest annual growth in its level of CO₂ emissions followed by the ROK. The average annual percentage changes in the emissions of China and the ROK were 6.1% and 4.4%, respectively, over the period, while those of Japan and Mongolia were 0.7% and 0.4%, respectively. At

<table>
<thead>
<tr>
<th>Country/Region</th>
<th>Amount, Million tonnes of CO₂</th>
<th>Change from 1990 level</th>
<th>Percentage change, %</th>
<th>Volume change, Million tonnes of CO₂</th>
<th>Share of volume change, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>1,223.3</td>
<td>15.8</td>
<td>166.6</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>1,658.9</td>
<td>−23.9</td>
<td>−519.9</td>
<td>−8.8</td>
<td></td>
</tr>
<tr>
<td>NEA Annex I Parties</td>
<td>2,882.2</td>
<td>−10.9</td>
<td>−353.3</td>
<td>−6.0</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>8,250.8</td>
<td>262.2</td>
<td>5,973.1</td>
<td>101.0</td>
<td></td>
</tr>
<tr>
<td>ROK</td>
<td>592.9</td>
<td>158.6</td>
<td>363.7</td>
<td>6.1</td>
<td></td>
</tr>
<tr>
<td>Mongolia</td>
<td>14.2</td>
<td>11.8</td>
<td>1.5</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>DPRK</td>
<td>45.4</td>
<td>−60.2</td>
<td>−68.6</td>
<td>−1.2</td>
<td></td>
</tr>
<tr>
<td>NEA Non-Annex I Parties</td>
<td>8,903.4</td>
<td>238.1</td>
<td>6,269.7</td>
<td>106.0</td>
<td></td>
</tr>
<tr>
<td>NEA Total</td>
<td>11,785.6</td>
<td>100.8</td>
<td>5,916.4</td>
<td>100.0</td>
<td></td>
</tr>
<tr>
<td>World Total</td>
<td>31,734.3</td>
<td>51.3</td>
<td>10,760.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source data: IEA, 2014a.

Figure 1.1: CO₂ Emissions from Fuel Combustion by NEA Countries, 2012

Source data: IEA, 2014a.

\[ C = \frac{P(G/P)(E/G)}{C/E}, \] where: C = CO₂ emissions; P = population, G = GDP, and E = primary energy consumption.
the same time, Russia and the DPRK witnessed 1.2% and 4.1% annual declines in their emissions levels (Table 1.2).

According to the Kaya decomposition, the CO2 emission increases were mainly driven by population and per capita GDP growth in the region, despite the fact that the energy intensities of GDP and carbon intensities of energy supply had been declining. During the period 1990–2012, the population in all of the NEA countries had been growing, except for Russia, although their living standards have been improving, but for the DPRK. At the same time, the energy intensity of GDP was declining in all the countries, although its extent varied by country. China was the top runner in reducing the energy intensity of its GDP. However, the carbon intensity of energy supply in China and Japan had increased by 0.4% and 0.5% per year, respectively, while in other countries it decreased (Table 1.2).

1.4 The Energy Mix in Northeast Asia

The TPES of the countries in Northeast Asia collectively amounted to 4.4 billion tonnes of oil equivalent in 2012, with China’s TPES accounting for two-thirds of the regional total. China’s TPES had more than tripled during the period 1990–2012 and equaled 2.9 billion tonnes of oil equivalent in 2012. Therefore, reducing the carbon intensity of energy supply in China is a significant factor for mitigating GHG emissions in the region. Among other things, energy efficiency improvements, massive deployment of renewable and clean energy sources, as well as shifting from coal to other cleaner energy sources, such as natural gas, are essential (Table 1.3).

The energy sector was responsible for more than half of the region’s total CO2 emissions from fuel combustion in 2012, followed by manufacturing and construction, accounting for 54% and 27% of the total. Therefore, in addition to energy industries, the manufacturing and construction sectors could be other potential target sectors for GHG emission reduction actions in the region (Figure 1.2).

The fact that non-renewables still dominate the energy mix, makes the energy system the largest contributor to GHG emissions. In 2012, non-renewables (coal, oil, natural gas and nuclear) supplied 91.6% of the TPES in the Northeast Asian countries collectively. The shares of non-renewables in the energy systems of the industrialised
economies (Japan, Russia and the ROK) in the region were higher than the regional level, with the highest level, for the ROK, standing at 98.2%. China, which accounts for two-thirds of the regional TPES, generated 89% of its energy from non-renewables. The DPRK, the poorest economy in the region, was the regional leader in terms of decarbonising its energy supply, producing 15.8% of its TPES from renewables (Figure 1.3).

Coal, the most polluting among the fossil fuels, was still the dominant fuel for energy generation in the developing NEA countries, China, Mongolia and the DPRK, accounting for more than two-thirds of their TPES. However, in the industrialized countries, oil was the largest source of energy in Japan and the ROK, while natural gas...
supplied more than half of Russia’s TPES. Therefore, a shift from coal to natural gas is desirable in the region as a bridging action toward renewables and other clean and sustainable energy sources. More detailed discussion on this matter will be made in the latter sections (Table 1.4).

### 2. Decarbonizing the Energy Supply in Northeast Asia

#### 2.1 The Intended Nationally Determined Contributions (INDC)

The countries in NEA have been making certain efforts toward reducing their GHG emissions since the inception of the UNFCCC and the Kyoto Protocol. As described earlier, the energy intensities of the economies in the region have been declining by 2% per annum since 1990, while the global rate was 1.4% (Table 1.2). Given that energy is responsible for most of the GHG emissions, this trend is an encouraging one. However, these efforts are as yet insufficient to curb the emissions and enable the shift to a zero-carbon world within this century. Therefore, it became of utmost importance to upscale emission reduction actions to a new level globally, where the Northeast Asian region would play a key role.

In advance of the new global climate deal to be negotiated at the upcoming UNFCCC COP21 in Paris, the major economies in the region, namely, Japan, Russia, China and the ROK, have submitted their Intended Nationally Determined Contributions (INDC) to the UNFCCC Secretariat. A summary of the key targets stated in these INDCs is given in Table 2.1. For comparison, the INDCs of the United States and European Union are also provided.

The INDC emission reduction targets are as follows:

- Russia plans to reduce its GHG emissions within a range of 25%–30% by 2030 compared to the 1990 level;
- China plans to lower its emission intensity of GDP by 60%–65% by 2030, compared to the 2005 level;
- Japan aims to reduce its GHG emissions by 26% by FY2030 compared to the FY2013 level, which is equal to a 25.4% reduction in 2030 from the FY2005 level.

At the same time, the member states of the European Union (EU) are ready to commit to a binding target of a 40% reduction in GHG emissions by 2030 compared to the 1990 level, while the United States intends to achieve an economy-wide reduction of its GHG emissions of 26–28% below its 2005 level and to make its best efforts to attain the higher level of a 28% reduction.

The above stated targets on GHG emission reductions will be implemented domestically in all the countries, with the exception of Japan. Japan is not participating in the implementation of the second commitment period (i.e. 2013–2020) of the Kyoto Protocol as Japan and Russia left the Kyoto Protocol, rejecting the new Kyoto targets. However, Japan is implementing a bilateral mechanism called the Joint Crediting Mechanism (JCM) to facilitate GHG emission reduction projects in developing countries. The first JCM document was signed with Mongolia in January 2013.

#### 2.2 The Carbon “Budget” for the Two-Degree Target

The Intergovernmental Panel on Climate Change (IPCC, 2013) stated that: “Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions” (p. 19). Scientists warn that in order to prevent dangerous climate change the global mean temperature rise from the pre-industrial level should be limited to 2°C, and at COP16 of the UNFCCC held in 2010 in Cancun, Mexico, global leaders agreed to ensure this limit. Then negotiations on a new legal, global agreement for the post-2020 climate regime began at COP17 held in Durban, South Africa, in 2011 and set the deadline for adopting this deal at COP21 to be held 30 November–11 December 2015 in Paris, France.

"Even by staying within our carbon budget and keeping the global temperature rise to 2°C above pre-industrial levels. The international scientific community estimates this budget to be 1 trillion tonnes of carbon (WRI, 2015)."

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1 Million tonnes of carbon dioxide equivalent.

2 The carbon budget is the estimated amount of carbon dioxide the world can emit while still having a likely chance of limiting the global temperature rise to 2°C above pre-industrial levels. The international scientific community estimates this budget to be 1 trillion tonnes of carbon (WRI, 2015).
levels, some regions will still experience an increased risk of sea level rise, forest fires, water shortages and other devastating impacts" (WRI, 2015, p. 1).

Hence, a key question is: What level of greenhouse gas emissions is consistent with the two-degree path? There are several answers to this question.

The World Resources Institute (WRI, 2015) stated that while the world is not on the 2°C path, the right amount of ambition for mitigating GHG emissions can still put into the 2°C path. One of the ambitions is that roughly three-quarters of the world’s fossil fuel reserves must remain unburned.

Also, the United Nations Environment Programme (UNEP, 2014) noted that “…there is a medium likelihood to stay within the two degree limit if the following conditions are met:

• Global emissions peak sometime between 2015 and 2021;

### Table 2.1: Intended Nationally Determined Contributions (INDC) of Selected Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Date Submitted</th>
<th>Key Points</th>
</tr>
</thead>
</table>
| Russia | 1 April 2015 | • Limit anthropogenic greenhouse gas emissions in the country to 70–75% of 1990 levels by 2030 (i.e. a 25%–30% reduction by 2030 compared to 1990 levels), subject to the maximum amount for the absorption capacity of forests (Russia’s forests account for 25% of the world forest resources, whereas the share for boreal forests accounts for 70% of the global total);  
• The INDC indicator is to be achieved without use of international market mechanisms (Russia, 2015). |
| China | 30 June 2015 | • Achieve peak CO₂ emissions around 2030, while making its best efforts for earlier achievement;  
• Lower CO₂ emissions per unit of GDP by 60% to 65% from the 2005 level by 2030;  
• Increase the share of non-fossil fuels in primary energy consumption to around 20%;  
• Increase the forest stock volume by around 4.5 billion cubic meters from the 2005 level (China, 2015). |
| ROK | 30 June 2015 | • A 37% reduction of its “business as usual (BAU)” emissions by 2030, with the BAU in 2020, 2025 and 2030 amounting to 782.5 MtCO₂eq, 809.7 MtCO₂eq and 850.6 MtCO₂eq, respectively;  
• Launched the GHG and Energy Target Management System (TMS) for the industrial sector;  
• Launched a nation-wide Emission Trading Scheme (ETS) in 2015 that covers 525 entities accounting for 67.7% of national GHG emissions;  
• Will strengthen the average emission standard for automobiles to 97 g/km in 2020 from 140 g/km in 2015 (ROK, 2015). |
| Japan | 17 July 2015 | • A 26% GHG emission reduction by FY2030 (i.e. by 31 March 2031) compared to the FY2013 level (i.e. a 25.4% reduction compared to the FY2005 level);  
• As the energy-originated CO₂ emissions in Japan account for 90% of the country’s total GHG emissions, the above target implies that the energy-originated CO₂ will be reduced by 25% in FY2030 compared to FY2013 or a 24% reduction compared to the FY2005 level;  
• About 22–24% of total power generation in 2030 will come from renewables, with hydro and solar power accounting for 8.8–9.2% and 7%, respectively;  
• The Joint Crediting Mechanism (JCM) is not included as a basis for the emission reduction target, but the amount of emission reductions and removals acquired under the JCM will be counted as Japan’s reduction (Japan, 2015). |
| EU | 6 March 2015 | • Commit to a binding target of an at least 40% domestic reduction in GHG emissions by 2030 compared to 1990 (EU, 2015). |
| US | 31 March 2015 | • Achieve an economy-wide reduction of its GHG emissions by 26–28% below the 2005 level in 2025 and to make its best efforts to attain a 28% reduction;  
• Does not intend to utilize international market mechanisms to implement its 2025 target (US, 2015). |

Source: Compiled from the respective countries’ INDCs (2015) submitted to the UNFCCC Secretariat.
Global emissions in 2020 are approximately 40.0 to 48.3 Gt CO₂ eq/yr; By 2050 global emissions decrease by 48 to 72% relative to 2000” (p. 3).

However, global CO₂ emissions have been on an increasing trend since 1971, when global CO₂ emissions data became available, and there has been no indication of them levelling off soon. Similarly, the total emissions for the Northeast Asian countries are also increasing, although at a slightly slower pace than the global trend. This is due to the fact that although the NEA region is home to economies with high emissions growth, such as China and the ROK, it is also home to economies who witnessed substantial reductions in their GHG emissions levels due to their economic setbacks over the period, such as Russia and the DPRK (Figure 2.1).

As the greenhouse gases have a long lifetime, remaining in the air for several centuries, the cumulative build-up of these gases in the atmosphere matters most. According to the IPCC estimates, the world can support a maximum carbon dioxide (CO₂) emissions “budget” of 3,000 gigatonnes (Gt) in order to preserve a 50% chance for staying below the 2°C limit, with 1,970 Gt having already been emitted before 2014. “Accounting for CO₂ emissions from industrial processes and land use, land-use change and forestry (LULUCF) over the rest of the twenty-first century leaves the energy sector” with a carbon budget of 982 Gt” (IEA, 2015, p.18). With the current level of more than 30 Gt of global CO₂ emissions the world would run out of the “budget” in just three decades. This means that after 2050 the world has no choice but zero emissions.

Furthermore, as mentioned earlier, limiting the global mean temperature to below a 2°C rise means that the greenhouse gas concentration in the atmosphere must be stabilized below 450 parts per million (ppm). According to the Climate Scoreboard (2013), only the low-emissions path of 450 ppm will be consistent with the 2°C limit, while the Business As Usual (BAU) path would lead to a global atmospheric CO₂ concentration of 980 ppm and a global mean temperature rise of 4.9°C over the pre-industrial level. The low emissions path requires levelling-off the global CO₂ emissions before 2025 and reducing the emissions by more than two-thirds of the current level (Figure 2.2).

In fact, this level of 450 ppm will not reverse the changing climate we are facing now. As pointed out by

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1 Energy sector refers to energy supply, energy transformation, including power generation, and energy consuming sectors (including buildings, industry, transport and agriculture).
James Hansen et al. (2015), if humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, the annual mean CO₂ concentration in the atmosphere needs to be stabilized below 350 ppm. But, we had already crossed over this threshold in 1987 and are witnessing various adverse effects of the changing climate worldwide. According to the Mauna Loa Observatory, the level of atmospheric...
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Greenhouse gas concentration has been growing at an accelerating rate from decade to decade and it equaled 397.16 ppm in 2014 (NOAA-ESRL, 2015a). Thus, the remaining room for not crossing the next threshold is getting smaller (Figure 2.3).

According to the “Low Emissions Path” of Climate Interactive, illustrated in Figure 2.2, the global CO₂ emissions per year will peak at 41.26 gigatonnes (Gt) in 2020 and then decline to 12.46 Gt by 2050. This means that the world has an annual “extra” carbon budget of less than 3,000 tonnes a year until 2020 and then will have to reduce it to a level less than half of the emissions in 1990 (Table 2.2).

### Table 2.2: Carbon Budget of Northeast Asia Consistent with the Low Emissions Path

<table>
<thead>
<tr>
<th>Year</th>
<th>Global CO₂ Emissions Gt/year</th>
<th>CO₂ Emissions from Fuel Combustion</th>
<th>Annual Carbon “Budget” (MtCO₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>World total Gt/year</td>
<td>Share of global total %</td>
<td>World, total MtCO₂</td>
</tr>
<tr>
<td>1990</td>
<td>27.64</td>
<td>20.97</td>
<td>20,974</td>
</tr>
<tr>
<td>2000</td>
<td>29.36</td>
<td>23.76</td>
<td>3,756</td>
</tr>
<tr>
<td>2005</td>
<td>33.72</td>
<td>27.49</td>
<td>27,494</td>
</tr>
<tr>
<td>2010</td>
<td>36.7</td>
<td>30.48</td>
<td>30,482</td>
</tr>
<tr>
<td>2011</td>
<td>37.7</td>
<td>31.35</td>
<td>31,345</td>
</tr>
<tr>
<td>2012</td>
<td>38.6</td>
<td>31.73</td>
<td>31,734</td>
</tr>
<tr>
<td></td>
<td>Average 2010-2012.</td>
<td>37.7</td>
<td>31.2</td>
</tr>
<tr>
<td>2020</td>
<td>41.26</td>
<td>34.17</td>
<td>34,174</td>
</tr>
<tr>
<td>2030</td>
<td>27.37</td>
<td>22.67</td>
<td>22,669</td>
</tr>
<tr>
<td>2040</td>
<td>18.29</td>
<td>15.15</td>
<td>15,149</td>
</tr>
<tr>
<td>2050</td>
<td>12.46</td>
<td>10.32</td>
<td>10,320</td>
</tr>
</tbody>
</table>

Notes: 1. The annual carbon budget is estimated as the difference between the estimated and current levels of CO₂ emissions, and the current level is the average value of 2010–2012;
2. The share of CO₂ emissions from fuel combustion for 2020 and beyond is estimated to be equal to the current level of its share of global CO₂ emissions, i.e. 83%.
3. The NEA share of total CO₂ emissions from fuel combustion for 2020 and beyond is estimated to be equal to the current level of its share of world CO₂ emissions from fuel combustion, i.e. 36%.


2.3 Substituting Coal with Natural Gas as a Bridge for Phasing Out Fossil Fuels

Energy efficiency improvements have great potential for GHG emissions reduction, especially in the manufacturing and construction sectors. Studies suggest that many efficiency improvements are priced at 1–3 cents per kWh—about one-fifth the cost of electricity generated from new coal- and natural gas-fired plants. Efficiency is not only cheaper than all other options, it also increases personal income by reducing energy bills and frees money that can be spent elsewhere to encourage employment.

According to the “Low Emissions Path” of Climate Interactive, illustrated in Figure 2.2, the global CO₂ emissions per year will peak at 41.26 gigatonnes (Gt) in 2020 and then decline to 12.46 Gt by 2050. This means that the world has an annual “extra” carbon budget of less than 3,000 tonnes a year until 2020 and then will have to reduce it to a level less than half of the emissions in 1990 (Table 2.2).

Similarly, the remaining “extra” carbon budget from fuel combustion in Northeast Asia is estimated to be 1,077 million tonnes of CO₂ a year until 2020 and then will have to accelerate annual reductions to 7,567 million tonnes of CO₂ by 2050, that is, by 67% or two-thirds from the current level of 11,307 million tonnes of CO₂ (Table 2.2).

The Mauna Loa Observatory, located in Hawaii, is part of the National Oceanic and Atmospheric Administration (NOAA), Earth System Research Laboratory (ESRL), Global Monitoring Division (GMD) in the United States. The continuous, high-precision measurement of changes in atmospheric CO₂ concentrations started at the observatory in March 1958.
energy generation is indispensable. The countries in the region are making efforts to this end. The share of clean energy in China’s energy mix keeps progressing and China is leading the global development of wind energy with 20 million kW of installed capacity annually. Moreover, China is among the global leaders for development and utilization of solar and renewable energy. Still, however, “China confronts the problem of optimizing its energy use structure, and in particular managing its shift away from low-efficiency, highly polluting sources” (Zhou, 2010, p. 31). Mongolia aims to increase the share of renewable energy in its energy generation to 20–25% by 2020 from the current 4% (MNETM, 2010). However, the results of these actions are still far from putting them on the global 2°C target path. Therefore all the countries in Northeast Asia need to take more robust action if they are to realize the global mission of arresting and eventually reducing the concentration of anthropogenic GHGs in the Earth’s atmosphere.

An experts meeting held in Bonn on 3 June 2015 during

Figure 2.4: World CO₂ Emissions Composition by Fuel Type

![Graph showing CO₂ emissions by fuel type, 2012 total: 31,734.4 MtCO₂. Natural gas, 6,439.8 (20%), Coal, 13,923.8 (44%), Oil, 1,205.4 (36%). Source: IEA, 2014a.]

Table 2.3: NEA CO₂ Emissions from Fuel Combustion by Fuel type, 2012 (MtCO₂)

<table>
<thead>
<tr>
<th>Country</th>
<th>Coal</th>
<th>Oil</th>
<th>Natural Gas</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>419.7</td>
<td>535.8</td>
<td>259.8</td>
<td>1,215.3</td>
</tr>
<tr>
<td>ROK</td>
<td>291.2</td>
<td>183.6</td>
<td>106.0</td>
<td>580.8</td>
</tr>
<tr>
<td>Russia</td>
<td>425.2</td>
<td>350.0</td>
<td>864.9</td>
<td>1,640.1</td>
</tr>
<tr>
<td>DPRK</td>
<td>42.9</td>
<td>2.5</td>
<td>-</td>
<td>45.4</td>
</tr>
<tr>
<td>Mongolia</td>
<td>10.7</td>
<td>3.5</td>
<td>-</td>
<td>14.2</td>
</tr>
<tr>
<td>China, incl. Hong Kong</td>
<td>6,794.0</td>
<td>1,163.1</td>
<td>272.2</td>
<td>8,229.3</td>
</tr>
<tr>
<td>NEA Total</td>
<td>7,983.7</td>
<td>2,238.5</td>
<td>1,502.9</td>
<td>11,725.1</td>
</tr>
<tr>
<td>Share by fuel type, %</td>
<td>68%</td>
<td>19%</td>
<td>13%</td>
<td>100%</td>
</tr>
</tbody>
</table>


Table 2.4: Selected Indicators of Fossil Fuels

<table>
<thead>
<tr>
<th>Factors</th>
<th>Coal (Lignite)</th>
<th>Oil</th>
<th>Natural Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default net calorific value (NCV), (TJ/Gg)</td>
<td>11.9</td>
<td>42.3</td>
<td>48.0</td>
</tr>
<tr>
<td>Default carbon content (kg/GJ)</td>
<td>27.6</td>
<td>20.0</td>
<td>15.3</td>
</tr>
<tr>
<td>Default CO₂ emission factor for combustion (kg/TJ)</td>
<td>101,000</td>
<td>73,300</td>
<td>56,100</td>
</tr>
</tbody>
</table>

the UN Climate Change Conference underlined that the “deep decarburization of global energy systems is technologically and economically feasible, but requires immediate and strong action” (UNFCCC, 2015). As indicated in the World Energy Outlook 2014 Factsheet, the share of renewables in total power generation rises to 33% in 2040, whereas energy demand grows by 37% and fossil fuels continue to dominate the power sector with a share of 55% of the total. “China sees the largest increase in electricity generation from renewables, more than the gains in the EU, US and Japan combined” (IEA, 2014b, p. 3).

But, as discussed in the previous section, the global carbon budget in 2050 will be 20,867 million tonnes of CO₂ (MtCO₂) less than its level in 2012, with coal accounting for 13,934 MtCO₂ or 44% of global CO₂ emissions from fuel combustion (Figure 2.4).

In Northeast Asia, coal accounted for 7,983.7 MtCO₂ or 68% of total CO₂ emissions from fossil fuel combustion in 2012, and the region’s total carbon budget in 2050 will be 7,567 MtCO₂, less than this level. Therefore, if coal were completely phased out by 2050, there would be a chance for the region to stay on the low-emissions path (Tables 2.2, 2.3).

Due to cost and budget constraints, complete and immediate replacement of the current and expected coal-fired power plants with renewable energy sources will be a huge challenge for any country. Thus, as a transitional step, coal could be completely replaced by natural gas. Natural gas is the cleanest fuel among the fossil fuels and it has high calorific value and contains much less carbon than coal. Per unit of energy generated, natural gas emits half as much CO₂ than coal emits (Table 2.4).

In the NEA region, where potential gas resources, such as those in Russia, are located, this option could be a major transitional step in levelling off its GHG emissions earlier than expected, especially in China. Coal accounted for 83% of China’s total CO₂ emissions from fossil fuel combustion in 2012 (Table 2.3).

A recent move to build a major pipeline to transport gas from Russia, which has the world’s second largest proven reserves of natural gas, to China, the largest energy consumer in the region, will be a substantial boost for replacing coal by natural gas. The planned pipeline would carry approximately 39 billion cubic meters of natural gas from Russia to China (Hanner, 2014).

3. Conclusions

Energy and climate change need to be addressed simultaneously within long-term energy security issues, and shifting energy generation from greenhouse gas intensive resources to lower or zero-emission alternatives should be considered. Scientists warn that the planet is warming faster than previously thought and we must limit the global mean temperature rise to 2°C from the pre-industrial level in order to prevent dangerous climate change. Aimed at achieving this climate goal, a universal, legally-binding climate deal is scheduled to be agreed at the upcoming 21st session of the United Nations Framework Convention on Climate Change (UNFCCC)-COP21 to be held later this year in Paris.

It is a fact that the aggregate GHG emissions in Northeast Asian countries have grown at a pace two-times faster than the world average over the period 1990–2012. This situation necessitates the countries in the region taking more robust action toward reducing their greenhouse gas emissions. During the period from 1990 to 2012, GHG emissions have been increasing in all Northeast Asian countries, except in Russia and the DPRK. These increases were mainly associated with population and per capita GDP growth, although energy and carbon intensities were on declining trends in all countries of the region, except in China and Japan.

The energy sector is responsible for more than half of total greenhouse emissions in NEA, with coal being the largest contributor to the region’s CO₂ emissions from fossil fuel combustion. If the region is to stay within the boundaries of its carbon budget in compliance with the global 2°C target, coal needs to be completely phased out by 2050. Despite the fact that renewables are becoming technologically and economically more viable for energy generation, immediate implementation will be a huge challenge for the Northeast Asian countries. Therefore, as a transitional step, owing to potential resources of natural gas in the region, coal could be replaced by natural gas before 2050. Subsequently, all fossil fuels need to be replaced with renewable energy or other zero-emission alternatives.

References


