Coal Pollution in China

Term Paper – BUEC 663

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Executive Summary

China is one of the world’s largest coal producers and consumers. Not surprisingly pollution associated with coal-burning is always an issue for China. Among the various emissions from coal-burning sulfur dioxide and carbon dioxide are the two biggest trouble makers with the former answering for acid rain and the latter global warming. This paper is to provide a through review on China’s current coal production and consumption situation; how the emissions of coal-combustion are involved with acid rain and global warming; and what measures China has taken to date to address those issues.

http://cn.tech.yahoo.com/061117/555/2offk_pic2.html

Introduction

1. The Current State of China’s Coal production and consumption

Coal is the most important energy source in China. The US, Russia, and China are the top three coal-richest countries. The US has the world’s largest coal reserve of 246.6 billion metric tons, according to BP’s Statistical Review of World Energy. Russia ranks the second with a reserve of 157 billion tons, followed by China with that of 114.5 billion
While oil remains the largest single source of energy in most parts of the world, coal is the dominant source of fuel in China. Both its coal production and consumption are the No.1 in the world. Industry is the major energy consumer. Coal accounts for 70% of China’s total energy consumption. 80% of the power industry is fueled by coal. China’s double-digit economy, from this point of view, can be called a coal-fueled economy. The graph and pie chart below show the energy production and consumption in 2004.

**Production – 1.846 btce**
- Coal: 1.956 Billion tons
- Oil: 175 Million tons
- Power: 2187 Billion kWh

**Consumption – 1.97 btce**
- Coal: 69%
- Oil: 22.3%
- Natural Gas: 2.5%
- Hydro: 5.35%
- Nuclear: 1%

It can be seen that China’s economy is heavily dependent on the coal industry. The following graph gives a better view of how China’s GDP is correlated with its energy industry (where coal has the lion’s share of 70% of annual coal consumption). The curves

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below imply the close correlation between the China’s GDP growth and its Energy Industry.

![China’s Energy Consumption and GDP, Annual Growth](chart.png)

During the period from 1980 to 2000, the growth rate of energy consumption is roughly half the growth rate of GDP, saving China a huge amount of coal burning. But the early of the new millennium saw a faster increase of the energy usage than that of GDP. In response to the surge in energy growth, China has set an ambitious target of reducing energy intensity (energy use per unit of GDP) by 20 percent over the next 5 years³.

2. Emissions of Coal Burning

Coal has been notorious for being the ‘dirtiest’ source of energy. Emissions of coal combustion include carbon dioxide, carbon monoxide, nitrogen oxides, sulfur, particulates, and mercury. The table below shows the pollutants emitted from the combustion of natural gas (methane), oil, and coal. Clearly coal is the ‘dirtiest’ one generating the highest amount of pollutant of each type.

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### Pollutants and Hazards to Health

#### 3.1 Acid Rain

Acid rain is formed when SO2 and NOx emitted from coal burning combine with water vapor. Sulfuric acid (H2SO4) and Nitric Acid (HNO3) are the major products in the chemical process. These acids at the extreme end of the acid pH scale travel hundreds and thousands of miles and come down to the surface in the form of acid rain\(^4\). It is harmful to the plant and vegetation on the surface, marine life in the water, all kinds of birds and animals, and biodiversity of the environment as a whole.

Coal combustion is to blame for the formation of acid rain. China produces and consumes about 2 billion tons of coals on a yearly basis. To make it even worse is that the sulfur content of the coal mines located in China is unusually higher (1.1%) than that of most other countries and places in the world. This translates into 25.5 million tons or more of sulfur dioxide gases into the air every year\(^5\).

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<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Natural Gas/Methane</th>
<th>Oil</th>
<th>Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>117,000</td>
<td>164,000</td>
<td>208,000</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>40</td>
<td>33</td>
<td>208</td>
</tr>
<tr>
<td>Nitrogen Oxide</td>
<td>92</td>
<td>448</td>
<td>457</td>
</tr>
<tr>
<td>Sulfur Dioxide</td>
<td>1</td>
<td>1,122</td>
<td>2,591</td>
</tr>
<tr>
<td>Particulates</td>
<td>7</td>
<td>84</td>
<td>2,744</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.000</td>
<td>0.007</td>
<td>0.016</td>
</tr>
</tbody>
</table>

\(^4\) [http://www.saag.org/%5Cpapers20%5Cpaper1944.html](http://www.saag.org/%5Cpapers20%5Cpaper1944.html), Hari Sud, China: Industrialization Pollutes Its Countryside With Acid Rain

\(^5\) Ibid.
The situation of acid rain had become very serious in 1996 affecting 30% of China’s total territory. But it got even worse with the affected areas expanding quickly\(^6\) over the years following. According to the annual ‘Statement on the Environment’ issued by the State Environmental Protection Administration (SEPA), in 2002, acid rain covered 54.4 percent of the total 487 monitored cities, a 7.2% growth compared to what it was in 2001\(^7\). Today it has covered the areas from the south Yangtze River to the east of the Qinghai-Tibet Plateau, half of China’s total territory.

Acid rain causes great damage to the quality of the soil. It disturbs the original neutral pH value of the soil and makes it harder for crops’ root to absorb water. It has become a common practice for some parts of China that farmers actually have to use a large amount of lime to neutralize the soil acidity before they plant seeds into it. And they have to use more and more lime each year because the frequency of the acid rain is making the soil more and more acid. Acid rain also deteriorates the water body. It brings down harmful metals (e.g. mercury) into lakes and rivers, which is capable of changing the genes of many water species and has even pushed some of them to the verge of extinction.

### 3.1.1 International Influence

But the story does not end up within the boundary of China at all. Sulfur dioxide goes up into the air body, which is by all means unsplittable for the whole globe as a whole, then brings down harmful particles into the water body, which is equally inseparable as the air body. In recent years quite a few China’s neighboring countries have raised complaints

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\(^6\) [http://us.tom.com/english/1902.htm](http://us.tom.com/english/1902.htm), *Industrial Pollution, Acid Rain in China*  
that they are affected by the acid rains which can be traced back to China’s coal burning. Among those neighbors there are Japan, South Korea and India (who is also notorious for being a big polluter in fact). The US has joined the disgruntled group as well by complaining that one third of its lakes and rivers are so contaminated by mercury that children and pregnant women are advised to avoid or limit eating fish caught there. And US scientists say 30% or more of the mercury residing into US ground or waterways comes form other countries, in particular, China\(^8\). Acid rain has had such a negative impact both domestically and internationally and China has to look into the issue and explore methods to battle against it.

### 3.2 Global Warming

Carbon dioxide, the culprit of global warming, accounts for 97% of the total emissions of coal combustion. According to the US Energy Information Administration (EIA)’s old report (2002), China won’t be able to overtake the US’s dominant position of carbon dioxide emission for at least one decade. But its 2006 report made adjustments to its forecast based on China’s robust two-digit GDP growth. The red line of the graph below depicts the pattern of China’s CO2 emission for the period from 1980 to 2020. Coal consumption grows much faster starting from around 2002 compared to the old forecast, and is about to overpass that of the US in 2013. This is largely due to the fact that Chinese government has to maintain the economic growth to keep the country with a 1.3 billion population stable both politically and economically. With no immediate access to

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\(^8\) [http://yaleglobal.yale.edu/display.article?id=5058](http://yaleglobal.yale.edu/display.article?id=5058), Matt Pottinger, Invisible Export-A Hidden Cost of China’s Growth: Mercury Migration, Dec. 20, 2004
cleaner energy sources like oil/natural gas, more amount of coal has to be put in use.

One thing special with carbon dioxide is that it stays in the air body for over one hundred years. So the carbon dioxide emitted several decades ago matters the same with that being newly emitted today. Taking this cumulative effect into account, it will take many decades for China to overrun the US on the total amount of CO2 emission. The EIA report says that US historical and projected CO2 emission for the period of 1920 to 2025 is still more than doubling that of China.

After letting out into the air from coal combustion, carbon dioxide stays in the air body and absorbs the heat energy from the earth while letting in the light energy from the sun. The molecule of carbon dioxide becomes unstable after siphoning the heat energy and will only be able to restore to its original stable state by releasing the energy absorbed. The heat is sent out partially to the space and partially back to the earth. Consequently carbon dioxide acts like a greenhouse by letting in the sun’s light energy and bouncing back the earth’s heat energy.
Currently the amount of carbon dioxide in the atmosphere is increasing at the rate of one part per million per year. If this continues, some meteorologists expect that the average temperature of the earth will increase by about 2.5 degrees Celsius. This doesn’t sound like much, but it could be enough to cause glaciers to melt, which would cause coastal flooding\(^9\). The chart below shows the causal relationship between carbon dioxide and the global warming.

\[ http://www.worldviewofglobalwarming.org/: \text{ Global warming at the extremes of the earth.} \]

China is the second largest country for carbon dioxide emission (US being the No.1). It let out 2.7 billion tons of CO2 in 1994. In 2002 the cumulative effect has reached to a level of 4.1 billion tons, 1.53 times that of ten years ago\(^10\). It is China’s responsibility to cut down on its CO2 and take actions against the global warming.

4. Measures China has taken to address Sulfur Dioxide Emissions


4.1 Command-and-Control Approaches

China has long been using command-and-control measures to limit the SO2 emission before starting the pilot projects of market-based instruments in late 1990s. The following discussion takes the city of Taiyuan for example. With a population of 2.7 million, Taiyuan is a heavily polluted industrial city in the coal belt of northern China. It is a landlocked city with mountains on three sides, a natural ‘trap’ for the emissions and pollutants from coal burning. The SO2 concentration is 200ug/m3 in 2000 while the average national level is 60ug/m3, and the average annual SO2 emission is 258,000 tons in the same year\(^{11}\). Particulate matter (PM) and sulfur dioxide represent a serious threat to the environment and public health in Taiyuan. The sky is tinted with a brownish color most of the time, and the air breathed in has a coalish smell. How to improve the situation remains a pressing concern for the local government.

Beginning from the early 1980s, the local government of Taiyuan has taken a series of steps to address the pollution problem: setting standards for stack gas concentration of SO2, closing small boilers, wet-method, using lower sulfur coal (-1.3%), adding limestone to fuel, and coal washing, etc\(^{12}\). With the first two more of a command type, all the others are technology-oriented approaches.

Admittedly, those methods have made great contributions toward alleviating Taiyuan’s SO2 problem so far. But without taking much of the market-side elements into consideration, those command-and-control methods under the background of China’s the-

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\(^{11}\) http://www.irr-neram.ca/Mexico/Presentations/Actual\%!20Presentation/Krupnick.ppt#259,5,Background (Continued), Alan Krupnick, Building Capacity for Environmental Management and Emissions Trading in Taiyuan, China, Jan.2005

\(^{12}\) Ibid
then planned-economy could not go as far as the local government expected. This was the case particularly for the late 1990s, when the planned-economy was ailing with lacking in economic incentives, suboptimum allocation of resources, bureaucratic red-tapes, unsound legal environment, etc.

Take setting the stack gas SO2 standards for example. The data collection for setting up pollution concentrations largely depend on self-reports from the individual enterprises because there is currently no reliable monitoring system. The self-reported data is complemented by periodic stack testing from the local EPB (Environmental Protection Bureau). These estimated concentrations are combined with limited data on pollutant flows to calculate mass emissions from the enterprises, which form the basis of a small emissions levy fee of $25 per ton. Those proceeds are used to support the operations of local EPBs, with the balance returned to the enterprises to improve their emission control system\textsuperscript{13}. Lack of monitoring and the weak penalty of only $25 per ton are two major limits and not surprisingly the emission-standard-setting has not done a satisfactory job so far.

4.2 Market-Based Instruments – Total Emission Control and Emissions Trading

Chinese government embarked on transforming from the planned-economy to a market-based economy in 1992. A good many of market-based economic reforms were introduced into various fields. In energy sector, e.g. Total Emission Control and Emissions Trading were borrowed from the US’s \textit{Cap and Trade} to reduce the level of

\textsuperscript{13} Ruth Greenspan Bell, Choosing Environmental Policy Instruments in the Real World, March 2003, OECD Global Forum on Sustainable Development: Emissions Trading
SO2 emissions; and Taiyuan was chosen to be one of the places to host the pilot projects. The local authorities of the City of Taiyuan set out an extremely ambitious environmental protection target for its Tenth Five-Year Plan, where it demands the city’s SO2 emission in 2005 to be cut down by 50% of the 2000 level. Success or not, the pilot project were going to put the target-setting on test and provide experience and lessons for future decision-making.

*Total Emission Control (TEC)* policies focus on local air quality, are designed to address issues of acid rain and transboundary emissions across wider regions. Emission trading uses market-based mechanisms to encourage emission reductions at the lowest possible economic cost14.

Basically two steps are involved. First, local environmental authorities set the caps on sulfur dioxide emitted by factories and power plants and the latter should try not to go over the pollution limits. Second, if a factory/power plant’s sulfur dioxide is less than the level of the limit, then it may accumulate credits (the difference between its actual emission level and the limit) for its future operation or trade the credits with the factory/power plant whose sulfur dioxide emission exceeds the limit and therefore need more ‘quota’ for the extra part. It can be seen that the system is an ‘organic’ combination of commands from the authorities (for the part of caps-setting) and the automatic flowing of resources (emission permit) following the rules of supply and demand.

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The central government plans to promote Taiyuan’s TEC and ET experience to other parts of China who are suffering from SO2 as well. The following is the implementation phases proposed by experts\(^{15}\):

*Phase 1: a pilot phase with trading limited to large power plants (i.e. annual SO2 emission greater than 5,000 tonnes) in the TCZs (Total Control Zones);*

*Phase 2: an expanded pilot with trading between all power plants in the TCZs on the basis of phase 1;*

*Phase 3: a nationwide program including all power plants in China; and*

*Phase 4: an expanded nationwide program including other types of high stack sources.*

4.3 What is accomplished through the pilot projects in Taiyuan

TEC and ET were very new to China at that point of time. Understandably a large part of the effort and time were spent on developing the understanding of how the whole system work; what infrastructure (including legal mechanism) should be in place to ensure its implementation, and the details involved in various aspects of the program. Discussions and talks were held at every level of the local and provincial governments to reach consensus of how to make the pilot project go forward.

Some accomplishments were made apart from the broad understanding and analyzing\(^{16}\). The Taiyuan EPB enacted a regulation that provides the legal basis for emission trading; an allowance tracking system (ATS) and an emission tracking system (ETS) were


developed; and the Taiyuan EPB issued allocations through 2005 of the goals that had been established through the 10th (1000-1005) 5-year plan.

4.4 Comments/Critiques on the Market-Based Instruments

1. TEC and Emission trading have the potential to reduce environmental control cost

The table below\(^17\) is the marginal cost analysis of the technology-oriented command-and-control approaches. Estimates of those costs have a wide range from $60 to $1,160 per ton. It is a common thing that the local authorities (EPB, short of Environmental Protection Bureau in this case) do not have a full access to the historical data (e.g. the coal production/consumption/emissions data of an enterprise) and field experience based on which the right decision could be made. Therefore it might run a risk of mandating a power plant to take the high cost measure while in fact the lower ones can do the job. This wide spectrum of abatement cost and the possibility of power maluse by the authorities speak for the option of market-based instruments, where the cost and benefit are allocated automatically (and perhaps optimally) by the market demand and supply.

<table>
<thead>
<tr>
<th>Control Measure</th>
<th>Where Applied</th>
<th>$/Ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treat post-combustion gas</td>
<td>Taiyuan District Heating</td>
<td>($60)</td>
</tr>
<tr>
<td>Flue Gas Desulfurization (FGD)</td>
<td>Eastern Mountain Plant</td>
<td>($80)</td>
</tr>
<tr>
<td>Lower sulfur coal (-1.3%)</td>
<td>Taiyuan #1&amp;#2, Taiyuan Iron&amp;Steel</td>
<td>($100)</td>
</tr>
<tr>
<td>FGD (simplified)</td>
<td>Taiyuan #1</td>
<td>($240)</td>
</tr>
<tr>
<td>FGD</td>
<td>Taiyuan #1 (Planned)</td>
<td>($180)</td>
</tr>
<tr>
<td>Add limestone to fuel</td>
<td>Coal Gasification Plant (Planned)</td>
<td>($130)</td>
</tr>
<tr>
<td>Coal washing</td>
<td>Future Sites (Possible)</td>
<td>($1,160)</td>
</tr>
</tbody>
</table>

2. A way out of the dilemma of inadequate levy penalty

The low-level levy fee has long been criticized for insufficient incentive to curb emissions. The levy fee is increased accordingly for a couple of cities including Beijing. But Taiyuan might not be ready for issuing a higher ticket because of some complex political and institutional issues. Besides, the unsound economic situations of many industrial enterprises in Taiyuan also make the idea of a higher levy fee unviable. Levy fee is perceived by many as a special tax, which can drag down a firm’s cash position and make the financials appear unfavorable to investors. An introduction of the emission trading empowers the firms with the options to choose low-cost pollution technologies or to pay extra money for more emission permits. It is more viable than simply increasing the levy fee in that polluters can make their own decisions based on the firms’ economic positions.

3. Better infrastructures/groundwork need to be put in place.

The market-based instruments like TEC and emission trading are fairly new to China. As a matter of fact, the groundwork for the system is still far from getting ready. No consistent monitoring, oversimplified tracking and record-keeping system, and weak data processing capacity, etc, all these bottlenecks can put a limit on the successful application of the MBI (Market-based Instrument). CEMs (Continuous Emission Monitors), the monitoring system that is widely used in the US, has been installed to a couple of polluting units in Taiyuan. But the number is still far below the ideal level where a TEC and ET can be put into full play. There have been plans and talks ongoing about installing more CEMs, but the tardiness and inefficiency are a source of concern.
4. Unsound and weak legal environment

The legal system in China is not independent of the interference/control from the government. Therefore it is not capable of rendering timely support to the real world issues. As a western scholar once commented\(^\text{18}\), ‘the mere writing of laws says little about the force and effort of those laws on actions’. Therefore, the writing of the law is one thing, while the enforcement in the real world might be another thing. Because the position of the government is superior to the legislation in China, there is no efficient remedy in the case that government fails to implement or enforce laws.

Besides, lacking of stringent penalties is another downside for environment-related laws and regulations. In some cases the polluters even figured out that it is cheaper to breach the law than to abide by it. Based on the international experience, legal penalties should be high enough that the polluters have the incentive to either keep the emission within the quota or to purchase extra permit should it go beyond it. But currently the penalty imposed on a per violation basis is less than $4000, which is significantly lower than the international practice and fails to deter the wrongdoers.

In short, China’s current legal framework is still not ready for the successful implementation of TEC and ET. More work needs to be done to get a transparent, healthy and efficient legal framework in place before the TEC and EC can be brought into full play.

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5. Measures China has taken to address Carbon Dioxide Emissions

Just like the case of dealing with SO2 emissions, Command-and-Control approaches also played a very important role in cutting down the CO2 emissions before the Market-based Instrument which is currently widely in use in China---CDM, was introduced into China in the late 1990s. Basically all the Common-and-Control approaches are quite similar in terms of the mechanisms and outcomes, be it for SO2 or for CO2. Therefore the following discussion will focus on how the CDM works in China.

5.1 Background knowledge of CDM

The Clean Development Mechanism (CDM) is an arrangement under the Kyoto Protocol allowing industrialized countries with a greenhouse gas reduction commitment (so-called Annex 1 countries) to invest in emission reducing projects in developing countries as an alternative to what is generally considered more costly emission reductions in their own countries.

Essentially CDM works in a way that industrial-country polluters can offset their emissions of carbon dioxide by financing the emission-abatement projects in the developing countries.

As of 21 February 2007, 513 projects had been registered by the CDM Executive Board as CDM projects. These projects reduce greenhouse gas emissions by an estimated 114 million ton CO2 equivalent per year. The following is an illustration that how the CDM emission reduction is distributed country wise.

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20 Ibid.
Distribution of CDM emission reductions, by country.


5.2 How the project Approval Procedure works in China
China has been actively involved in the world’s CDM market as the second largest CO2 producer (the US being the first) and the country with the largest potential for future emissions (please refer to part 2 for details). The central government of China passed the Interim Regulations for CDM in June 2004. And the CDM Approval Procedure is set up based on the Regulations. The following chart provides an idea of how the proposed project flows in the framework.


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21 Ibid.
First the CDM project application is submitted to NDRC (National Development and Reform Commission) for review. After preliminary analysis NDRC will then forward the application to National CDM Board Meeting for a thorough evaluation. A Letter of Approval is going to be issued by NDRC contingent upon the fact where all the criteria are met by the project. Otherwise a Letter of Rejection will be issued. But occasionally NDRC sends the application package back to the applicant if it thinks the application is not complete or there is still room for improvement. In this case clear indications shall be given to the applicant.

5.3 China’s accomplishments with CDM

Statistics show that China is among the top players in CDM market, overtaking India and Brazil as the largest supplier of Certified Emission Reductions (CERs) to the market. As of May 12, as many as 46 Chinese projects had received CDM approval. So far only 7 of these have been registered with the CDM Executive Board, out of a total of 150 registered projects worldwide; however, they represent more than 30 percent of the expected Certified Emission Reductions (CERs) from CDM initiative this year.

The State Council of China released a guideline memo in 2005 to simplify the CDM project approval procedures, which was complex to many. China’s current portfolio of projects has a wide span of areas including but not limited to, renewable energy, energy

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23 Ibid.
efficiency, waste handling and disposal, methane recovery and utilization, and reduction of trifluoromethane (HFC-23) emissions\textsuperscript{24}.

Most of China’s CDM projects are conducted bilaterally with an industrialized partner through the broker market. Currently three major international entities are responsible for evaluating CDM in China, namely, Norway’s Det Norske Veritas Certification Ltd., SGS United Kingdom Ltd., and TUV Suddeutschland\textsuperscript{25}.

China is attracting more and more eyeballs as it is getting more and more active in the world’s CDM market. CDM works well for the benefit of both industrialized group and the developing group. On one hand developing countries who are not obligated with the emission-cutting can sell the fictive emissions saved by their emission-reducing projects. On the other hand, by buying extra emissions the developed countries can lower the cost to meet their emission obligations compared to taking other actions (technical upgrade or legal penalties). And having had many pollution-cutting projects financed by the emissions buyer from the industrialized world, China has been a beneficiary for sure.

5.4 Challenges

But some challenges and unpredictables are looming ahead. China is not obligated to reduce the GHGs emissions before 2012. But what will happen after 2012 is still a question mark. In the case that China will be assigned the reduction obligation, the excessive cost associated with the emission-cutting (technical upgrading, issuing new

\textsuperscript{24} Ibid.
\textsuperscript{25} Ibid.
laws and regulations, putting infrastructure in place, etc) could be a huge burden to the big emitters. Whether they can survive the test is unknown.

Another challenge is that establishing a CDM project is a multi-stage process—from identification and formulation of the activity to obtaining certification—and has proved taxing for project developers. Unfortunately China is focusing too much on selling CDM and getting the financial support right away at this stage, while nonchalant to cultivating local experts who can help to design and develop the project in a systematical manner. This is obviously a barrier to the sustainable development of CDM in China because local expects have an advantage over the foreign consulting firms due to the complexity of China’s energy sector and the lack of availability of key data.

Overall CDM is a very promising market-based instrument to help China get financial support and invest in emission-abatement projects given China’s huge emission potentials. But in the meantime it also needs to work out solutions to and get prepared for the unpredictables and challenges looming ahead.