Challenge in Regulating the Coal Industry - Experience in China

Senlin LIU
China Institute of Atomic Energy, Beijing 102413, CHINA

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By the end of 2015, there are about 6850 Coal Enterprises above Designated Size in China, and there are about 10.8 thousand coalmines, in which there are more than 7 thousand small-size coalmines, and the average single well production capacity is less than 350 thousand tons per year.

There are more than 5.4 thousand coalmines with production capacity of less 90 thousand tones per year and their annual production output of less 20%.

The new data in 2015 show that the number of coalminers is about 5,100 thousands which is decreased by 15% from that of about 6,000 thousands in 2010.

Since 2013, for China Coal Industry (CCI) it has become the most difficult task to inhibit the rapid expansion of coal production capacity and resolve excess capacity.
1. Introduction

Before 2013, any of the coal-mining had not been regulated by radiation protection regulations in China.

In some local governments in China, some specific standards were issued for the exploitation of coal, for example, DB65/T 3471-2013: *Limit of natural radionuclides in the exploitation of coal resources*, it is issued by the Xinjiang Uygur Autonomous Region in 2013. See in table 1.
Table 1 Limit of natural radionuclides in the exploitation of coal resources in Xinjiang Uygur Autonomous Region in China

<table>
<thead>
<tr>
<th>Classification</th>
<th>Radionuclides</th>
<th>Limits of activity concentration, Bq g⁻¹</th>
<th>Screening Level of Gamma radiation dose rates, nGy h⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exemption of regulation</td>
<td>$^{238}\text{U}$, $^{226}\text{Ra}$, $^{232}\text{Th}$</td>
<td>&lt;0.1</td>
<td>&lt;50</td>
</tr>
<tr>
<td>Restriction of utilization</td>
<td></td>
<td>0.1-3.7</td>
<td>50-1,700</td>
</tr>
<tr>
<td>Prohibition of exploitation</td>
<td></td>
<td>&gt;3.7</td>
<td>&gt;1,700</td>
</tr>
</tbody>
</table>

It is a graded approach.

In Xinjiang Uygur Autonomous Region, there are some coals in which the activity concentration of natural radionuclides is very high. So that the local government has established the local standard to control their exploitations.
In February 2013, the Ministry of Environmental Protection (National Nuclear Safety Administration-NNSA) issued a Policy Statement: the requirement of radiation protection on activities of Mineral Resources Development and Utilization, in which the mining and utilization of some stone coalmines shall comply with Chinese BSS. See in Table 2.

- It is included a list of mineral resources in which the activities of mining and utilization of these mineral resources shall comply with the requirements of radiation protection.
- There are two criteria to judge whether or not to comply with the requirements.
- The first criteria is that the minerals should be within the list, and
- The second criteria is that the activity concentration of any radionuclides in the Uranium or Thorium decay chains in raw material, intermediates, tailings, or other residues in the listed minerals should be more than 1Bq g⁻¹, then
- This activity of mining and utilization shall be regulated by the CBSS.
Table 2  Lists of the mineral resource in which the development and utilization being regulated by environmental radiation regulations in China

<table>
<thead>
<tr>
<th>No.</th>
<th>Industries</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Rare earth</td>
<td>Mining, beneficiation and smelting of each classes of Rare-earth ores, including Monazite, Bastnasite, Xenotime and Ion-absorbed rare earth ore</td>
</tr>
<tr>
<td>II</td>
<td>Niobium, Tantalum</td>
<td>Mining, beneficiation and smelting of ores including Niobium and Tantalum</td>
</tr>
<tr>
<td>III</td>
<td>Zirconium, Zirconia</td>
<td>Mining, beneficiation and smelting of zirconite (or zircon sand) and baddeleyite</td>
</tr>
<tr>
<td>IV</td>
<td>Vanadium</td>
<td>Mining and smelting of Vanadium</td>
</tr>
<tr>
<td>V</td>
<td>Stone coal</td>
<td>Mining and utilization of stone coal</td>
</tr>
</tbody>
</table>

Now in China just only the mentioned five types of minerals, when the activity concentration of natural radionuclides in them is more than 1Bq g⁻¹, is managed by radiation protection regulations. But for some minerals there is a high exposure to workers with low activity concentration of natural radionuclides, they are not regulated.
From the present situation of coal management in China, the major issues are as follows,

- A big population of underground coal miners, about 6 millions. All of them is not managed as radiation workers, maybe the exposures to some of them will be regulated as occupational exposure.
- A big amount of residues from the production of coal may be managed by radiation protection regulations as very low level radioactive wastes with long life of radionuclides from natural origin.
- As the exploitation and utilization of coal resources, due to the bad management and control of its use, a new radiation legacy occurs in a city.
- For small-sized coal, particularly in stone coal, there is a relatively high radon concentration.
- For the transportation of raw coals and its products and residues, there is no regulation on radiation safety.
2. Radioactivity in Chinese Coal

Figure 1 The distribution of the nature occurred radionuclides of coal in China coal mine
In China, the national output-weighted values of activity concentration of natural radionuclides in Chinese coal are follows:

- $^{238}\text{U}$, 28.2 (2.1-525.8) Bq kg$^{-1}$
- $^{226}\text{Ra}$, 24.5 (1.4-699.0) Bq kg$^{-1}$
- $^{232}\text{Th}$, 26.4 (2.2-102.0) Bq kg$^{-1}$
- $^{40}\text{K}$, 61.8 (0.9-817.4) Bq kg$^{-1}$
- $^{210}\text{Po}$, 16.2 (2.5-86.4) Bq kg$^{-1}$
- $^{210}\text{Pb}$, 23.3 (1.7-248.0) Bq kg$^{-1}$

In general, the activity concentration of the radionuclides from natural origin of coal in China is the same level with that of worldwide average value. But some special cases existed in China.
2. Radioactivity in Chinese Coal

There are several situations as follows:

- Some coal mines in Xinjiang Uygur Autonomous Region, the activity concentration of natural radionuclides is more than 10 Bq g⁻¹. For mining and use of this coal, the issues on radiation protection is severe, so that in 2013 a local government standard was established in the Region for the control of exploitation and utilization of coal.

- The activity concentration of natural radionuclides in coal mine is less than 1 Bq g⁻¹, but the underground radon concentration is more than 10 thousands Bq m⁻³. So the exposure to coal miners is more than 10mSv per year. For example the small-sized coal mines in China.

- The activity concentration of natural radionuclides in stone coal is usually more than 1 Bq g⁻¹, so that in China the mining and use of stone coal should comply with CBSS since 2013.
3. Challenge in RP of Coal Industry

The first challenge is the management of NORM residues in Coal Industry in China.

Table 3 The output of solid wastes from the production of Coal in China, tones

<table>
<thead>
<tr>
<th>Radionuclides</th>
<th>Distribution of activity concentration(C), Bq/g</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.1&lt;C&lt;0.5</td>
</tr>
<tr>
<td>Uranium</td>
<td>3.54×10⁷</td>
</tr>
<tr>
<td>²³²Th</td>
<td>2.75×10⁷</td>
</tr>
<tr>
<td>²²⁶Ra</td>
<td>2.90×10⁷</td>
</tr>
</tbody>
</table>

The table is shown the output of solid wastes with different activity concentration of Uranium, ²³²Th and ²²⁶Ra generated in the production of coal. There are 7.96×10⁵ tones of solid radioactive wastes in which the activity concentration of Uranium is more than 1Bq/g, and there are 2.08×10⁵ tones of solid radioactive wastes in which the activity concentration of ²²⁶Ra is more than 1Bq/g, and there is no solid wastes in which the activity concentration of ²³²Th is more than 1Bq/g.
The first challenge is concerned with issues of the long-term safety of NORM residues in coal industry.

- A big amount of NORM residues with very low level is.
- A great long-life of radionuclides from natural origin is.
- 1Bq g⁻¹, what is it? It is just only a line mark to distinguish the type of Exposure Situations for NORM exposures. So for NORM residues in coal industry, what is the criteria for judgement of NORM residue being radawaste or not? (in general, the criteria is clearance level)
- What is the design criteria for final disposal repository used to disposal of NORM residues or wastes?
The second challenge is the management of coalminer’s exposures in Coal Industry in China.

Table 4  The arithmetic mean value of Radon concentration in the underground coalmines in China, Bq m⁻³

<table>
<thead>
<tr>
<th>Types</th>
<th>Measured Value</th>
<th>Estimated Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ranges</td>
<td>Mean values</td>
</tr>
<tr>
<td>Large-size coalmines</td>
<td>18-65</td>
<td>49.0</td>
</tr>
<tr>
<td>Middle-size coalmines</td>
<td>22-1,963</td>
<td>173</td>
</tr>
<tr>
<td>Small-size coalmines</td>
<td>14-3,115</td>
<td>631</td>
</tr>
<tr>
<td>Stone coalmines</td>
<td>136-4,183</td>
<td>1,244</td>
</tr>
</tbody>
</table>

The arithmetic mean radon concentrations in underground coalmines of three types were estimated based on the recent monitoring results and publications.

Except the large-size coalmines, there exist some coalmines in which the underground radon concentrations are more than 1,000 Bq m⁻³ in China, in particularly, for the stone coalmines, the mean value is nearly 6,000 Bq m⁻³.
3. Challenge in RP of Coal Industry

The second challenge is the management of coalminer's exposures in Coal Industry in China.

Table 5  The effective dose to underground coal miners in China

<table>
<thead>
<tr>
<th>types</th>
<th>Number of coal miners, 10³</th>
<th>Annually individual effective dose, mSv y⁻¹</th>
<th>Annually collective dose, man Sv</th>
<th>Normalized collective dose, man Sv per 10⁴t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large-size coalmines</td>
<td>1,000</td>
<td>0.28</td>
<td>280</td>
<td>3.2×10⁻³</td>
</tr>
<tr>
<td>Middle-size coalmines</td>
<td>1,000</td>
<td>0.55</td>
<td>550</td>
<td>1.9×10⁻²</td>
</tr>
<tr>
<td>Small-size coalmines</td>
<td>4,000</td>
<td>3.3</td>
<td>1.32×10⁴</td>
<td>2.1×10⁻¹</td>
</tr>
<tr>
<td>Stone coalmines</td>
<td>50</td>
<td>10.9</td>
<td>545</td>
<td>8.4×10⁻¹</td>
</tr>
<tr>
<td>TOTAL</td>
<td>6,000¹)</td>
<td>2.4²)</td>
<td>1.46×10⁴</td>
<td>8.1×10⁻²³ ³)</td>
</tr>
</tbody>
</table>

Notes: 1) The number of coalminers involved in stone coalminers are not included in the total for underground miners, because they have been included in those for small-sized coalminers.
2) Derived by total collective dose being divided by the number of underground coalminers.
3) Derived by total collective dose being divided by the total output of coal.
The second challenge is the management of coalminer’s exposures in Coal Industry in China.

For large-sized and middle-sized coalmines, there are relatively good management of work, good mining tools, and good ventilation system, but for small-sized coalmines, including stone coalmines, the poor ventilation system is major reason of the relatively high radon concentration on site.

From table 5, it is shown that the annual average effective dose to underground coalminers in small-sized coalmines is 3.3 mSv per year, and that of stone coalmines is 10.9 mSv per year.

The number of coalminers for small-sized coalmines (including stone coalmines) in China is about 4 millions, it is a very big group in the world.

To improve the mining tools and underground ventilation system for small-sized coalmines is a great task of China Coal Industry and National Regulatory Body of radiation protection.
### Table 6  Additional annual average effective dose to the population in houses built with carbonized brick in typical provinces in China, mSv y⁻¹

<table>
<thead>
<tr>
<th>Province</th>
<th>Effective dose within mine zone</th>
<th>Effective dose within non-mine zone</th>
<th>Additional dose</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>External</td>
<td>Radon</td>
<td>External</td>
</tr>
<tr>
<td>Hubei</td>
<td>1.4</td>
<td>3.4</td>
<td>0.57</td>
</tr>
<tr>
<td>Zhejiang</td>
<td>2.3</td>
<td>8.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Jiangxi</td>
<td>1.6</td>
<td>2.4</td>
<td>0.73</td>
</tr>
<tr>
<td>Anhui</td>
<td>1.2</td>
<td>4.7</td>
<td>0.54</td>
</tr>
<tr>
<td>Hunan</td>
<td>1.9</td>
<td>2.7</td>
<td>0.56</td>
</tr>
</tbody>
</table>

The third challenge is the management of public exposures enhanced by the exploitation and utilization in China.
The third challenge is the management of public exposures enhanced by the exploitation and utilization in China.

In Chinese history, the coal was always used to be made of bricks (called carbonized bricks), and then to build house. It is popular in Zhejiang, Jiangxi, Anhui, Hubei and Hunan provinces in northern China.

From the table 6, it was shown that all the additional dose to the general public living the houses in the 5 provinces is more than from 3.1mSv to 6.8mSv per year.

For this case, it is a new radiation legacy concerning the NORM exposures enhanced by human activities. It is a typical case that the NORM exposure (from the building of house with carbonized bricks, which is called practice in 1996 version of IAEA BSS) is managed as Planning Exposure Situation but the resultants have to be managed as Existing Exposure Situation (the exposure to the general public living in the houses built with carbonized bricks).

To decease the exposures to the general public living in the above mentioned house is needed to establish a national action plan.
Some minerals exploitation and utilization have been regulated since 2013 by NNSA.

MORM residues with activity concentration of radionuclides from natural origin being more than 1 Bq g\(^{-1}\) should be managed as radwaste.

The annually averaged individual effective dose to the underground coalminers in small-sized coalmines is more than 3 mSv per year, and that of stone mines is 10.9 mSv per year in China.

The annual additional individual effective dose to the general public living house built with carbonized bricks is at least more than 3 mSv per year.

A systematic approach is used to make a decision on the regulation actions in China national regulation.
4. Remarks

Determination of activity concentration and Screening approach

- NORM Activity Concentration
  - <1Bq/g(U/Th) or 10Bq/g(40K)
    - Effective Dose
      - <1mSv/a
        - No regulation
        - Existing Exposure Situation
        - Exemption
          - >1mSv/a
  - >1Bq/g(U/Th) or 10Bq/g(40K)
    - Effective Dose
      - <1mSv/a
        - Working place monitoring
      - >1mSv/a
        - Individual dose monitoring
        - Authorization
          - registrament
          - License
          - Planning Exposure Situation
3. Challenge in RP of Coal Industry

Table 9  Annual collective effective dose within a radius of 80km from stone coal plants

<table>
<thead>
<tr>
<th>province</th>
<th>Coal-fired plant</th>
<th>Installed capacity(kW)</th>
<th>Population (10^4)</th>
<th>Annual collective dose (man Sv)</th>
<th>Normalized collective dose[man Sv(GW a)^{-1}]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunan</td>
<td>Yiyang</td>
<td>5,600</td>
<td>904</td>
<td>1.7</td>
<td>3.0 × 10^2</td>
</tr>
<tr>
<td>Zhejiang</td>
<td>Anren</td>
<td>750</td>
<td>762</td>
<td>1.9</td>
<td>6.7 × 10^2</td>
</tr>
</tbody>
</table>

Table 10  Weighted average of normalized collective effective dose to the public from the airborne effluents within a radius of 80km of coal-fired power plants, man Sv(GW a)^{-1}

<table>
<thead>
<tr>
<th>Luohe plant(300)MW</th>
<th>Qinhe plant(100MW)</th>
<th>Small-sized Coal-fired plant(9MW)</th>
<th>Countrywide-weighted collective dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.24</td>
<td>10.4</td>
<td>48.2</td>
<td>16.5</td>
</tr>
</tbody>
</table>
我国煤炭产能家底

新建改扩建煤矿14.96亿吨，其中约8亿吨属于未经核准的违规项目。

截至2015年底，全国煤矿总规模为57亿吨，正常生产及改、扩建煤矿39亿吨，停产煤矿3.08亿吨。

2014年全国煤炭消费同比下降2.9%，2015年预计下降4%左右。

三年暂停审批新建项目、调整制度工作日，关闭退出煤矿4900处，全国煤矿数量控制在5000处左右。