The coal industry in Europe and coal combustion products in construction industry

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Joint RASSC/WASSC Topical session: Challenges in Regulating NORM Industries
Coal in Europe 2013
lignite production, hard coal production & imports

EU-28 million tonnes

- lignite 407
- hard coal 114
- imports 216

Source: EURACOAL members – * 2012 data
Note: bars show million tonnes of coal equivalent (Mtce) while figures at top of bars show millions of physical tonnes (Mt)
## EUROPEAN COAL MARKET

<table>
<thead>
<tr>
<th></th>
<th>2015</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mt</td>
<td>Mt</td>
</tr>
<tr>
<td>Domestic hard coal production</td>
<td>100.3</td>
<td>105.7</td>
</tr>
<tr>
<td>Hard coal imports</td>
<td>191.6</td>
<td>204.9</td>
</tr>
<tr>
<td>Lignite production</td>
<td>398.1</td>
<td>400.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>690.0 (-3%)</strong></td>
<td><strong>711.3</strong></td>
</tr>
</tbody>
</table>

The European coal market has continued to decline since 2012 because of low wholesale electricity prices, loss of market share to subsidised renewables and pressure from environmental regulation as well as the limited availability of public and private finances for new projects.

*From: EURACOAL*
European Association for Coal and Lignite aisbl
## EUROPEAN COAL MARKET

### HARD COAL

<table>
<thead>
<tr>
<th>Producing country</th>
<th>2015 Mt</th>
<th>2014 Mt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Czech Republic</td>
<td>8.2</td>
<td>8.7</td>
</tr>
<tr>
<td>Germany</td>
<td>6.7</td>
<td>7.6</td>
</tr>
<tr>
<td>Poland</td>
<td>72.2</td>
<td>72.5</td>
</tr>
<tr>
<td>Romania</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Spain</td>
<td>3.0</td>
<td>3.9</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>8.7</td>
<td>11.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100.3 (-5%)</td>
<td>105.7</td>
</tr>
</tbody>
</table>

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From: EURACOAL
European Association for Coal and Lignite aisbl
# EUROPEAN COAL MARKET

## LIGNITE

<table>
<thead>
<tr>
<th>Producing country</th>
<th>2015</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mt</td>
<td>Mt</td>
</tr>
<tr>
<td>Bulgaria</td>
<td>36.8</td>
<td>32.6</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>38.1</td>
<td>38.2</td>
</tr>
<tr>
<td>Germany</td>
<td>178.1</td>
<td>178.2</td>
</tr>
<tr>
<td>Greece</td>
<td>45.4</td>
<td>50.6</td>
</tr>
<tr>
<td>Hungary</td>
<td>9.2</td>
<td>9.5</td>
</tr>
<tr>
<td>Poland</td>
<td>63.1</td>
<td>63.7</td>
</tr>
<tr>
<td>Romania</td>
<td>22.4</td>
<td>22.0</td>
</tr>
<tr>
<td>Slovak Republic</td>
<td>1.8</td>
<td>2.2</td>
</tr>
<tr>
<td>Slovenia</td>
<td>3.2</td>
<td>3.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>398.1 (-1%)</strong></td>
<td><strong>400.7</strong></td>
</tr>
</tbody>
</table>

*From: EURACOAL*

European Association for Coal and Lignite aisbl
EUROPEAN COAL MARKET

**Last news:**

- coal prices continued their decline to a low of 45 $/tonne, low freight rates and exchange rate movements (Russia, Colombia) additionally affected coal prices,

- **OKD**, the only producer of hard coal in the **Czech Republic** announced its filling for insolvency in May, 2016,

- **Germany**, in 2016, only two mines remain in operation in line with the plan to close all hard coal mining by 2018,

- in **Spain** the mining sector is confronted with difficulties, finally decision is taken to close 26 mines out of 27 by 2018. EC support this decision… More than 3000 jobs are in danger…,

- **UK**, after last coal mines were closed in 2015 the secretary of state for Energy and climate change proposed a consultation on the closure of all coal-fired PP without CCS by 2025….,

- **Poland**, due to serious economic troubles Kompania Węglowa will be re-organised as the Polska Grupa Górnica (PGG – Polish Mining Group) starting 1 May 2016, with include 11 mines (only)…
IAEA Safety Reports Series:

NORM in coal industry

- Lignite excavation
- **Hard coal mining (underground)**
- **Coal combustion**
- Coke production and use
- Unconventional coal use
- **Coal Combustion Products (CCP)**
- Transport in coal industry
Sources and pathways of radiation risk in coal industry

Electricity generation from coal

MINE
Hard coal exploitation

- Gangue
- Radium-bearing formation water
- Radioactive sediments
- Occupational hazard caused by radon and radon progeny

POWER PLANT

- Combustion – efficient mass reduction process
- Coal combustion products
- Surface dump
- Building materials and construction works

volatile pollutants

coal
Discharge of radium-bearing waters into surface

- All coal mines have to pump water out of the underground galleries.
- In 25 out of about 30 coal mines in Upper Silesia brines occur with high concentration of radium (also reported in Germany and Czech Republic).
- Some proportion of radium remains in underground galleries due to spontaneous precipitation or technical measures (up to few thousands of m$^3$) but about 40% of the total inflow is pumped onto surface causing serious contamination.
Coal mining area, Upper Silesia POLAND

The Vistula river catchment area affected by radium rich brines discharge
# Radium in The Vistula River basin

<table>
<thead>
<tr>
<th>River</th>
<th>discharging mines</th>
<th>Discharged Activity</th>
<th>Activity concentration in sediments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ra-226</td>
<td>Ra-228</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MBq/day</td>
<td></td>
</tr>
<tr>
<td>Gostynia</td>
<td>Bolesław Śmiały</td>
<td>141,2</td>
<td>275,5</td>
</tr>
<tr>
<td></td>
<td>Wesoła</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Piast</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ziemowit (partly)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potok Goławiecki</td>
<td>Ziemowit (most of the water)</td>
<td>36,9</td>
<td>65,3</td>
</tr>
<tr>
<td>Vistula</td>
<td>Silesia</td>
<td>23,4</td>
<td>24,9</td>
</tr>
<tr>
<td></td>
<td>Brzeszcze</td>
<td>1,3</td>
<td>1,3</td>
</tr>
</tbody>
</table>

* after the Gostynia River mouth  
** after the Goławiecki stream mouth
Radium in mine waters

[kBq/m$^3$]

Maximum activity concentration noticed in a year
Radium in sediments
[Bq/kg]
Current legislation

- **Since 1989:** Geological and Mining law identified NORM as a natural hazard existing in underground mines. Monitoring and control system defined in subsequent OH&S regulation,

- **Since 2004:** COUNCIL DIRECTIVE 96/29/EURATOM of 13 May 1996 – translated into Atomic Law - no subsequent regulation dealing with NORM

Only underground mining and other workplaces underground are subject to regulation
Current legislation
Monitoring of radiation exposure in underground mines

- Exposure to radon: direct measurement of radon progeny
- Exposure to external gamma radiation caused by presence of water and sediments containing high amount of radium isotopes
- Effective committed dose caused by accidental intake of water and sediments

\[ E = E_\alpha + E_\gamma + E_{Ra} \]

- Environmental aspects: 0.7 kBq/m³ – limits of activity concentration of \(^{226}\text{Ra} + ^{228}\text{Ra}\) in mine water discharged into inland water
COUNCIL DIRECTIVE 2013/59/EURATOM

of 5 December 2013
laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation

- Notification for NORM industry
- Exemption criteria and clearance levels (only for solids)
- Licence in case of discharge of liquids
- NORM mixing/dilution option
- Limits for construction materials lower than clearance levels
New directive implementation

- Graded approach – three levels authorisation system
- Notification for NORM industry
- Broadened list of NORM industry defined (21 cases)
- Diversification of responsibility:
  - WUG (Mining Authority) for mining NORMs
  - GIS (Main Sanitary Inspectorate) for other NORMS
Identified NORM industry

- Oil and gas
- Other underground mining (copper, zinc lead, salt – uranium excluded due to art. 30.3)
- Primary iron and steel production
- Non ferrous metal smelting – scrap/residues recycling
- Coal combustion and coal combustion products use
- ....

Coal mining ?
Problems encountered

- Criteria for exemption
- NORM residues above clearance level
- NORM residues above limit for radioactive waste (> 10 kBq/kg)
- NORM in liquid phase
Criteria for exemption

• Clearance limits (1 kBq/kg)
• Effective dose ➔ competence and responsibility for assessment
• Liquid effluents ➔ no limits expressed as activity concentration..
3. Notwithstanding the exemption criteria laid down in Article 26, in situations identified by Member States where there is concern that a practice identified in accordance with Article 23 may lead to the presence of naturally-occurring radionuclides in water liable to affect the quality of drinking water supplies or affect any other exposure pathways, so as to be of concern from a radiation protection point of view, the competent authority may require that the practice be subject to notification.
EU BSS Article 65
Operational protection of members of the public

In addition, these discharge authorizations shall take into account, where appropriate, the results of a **generic screening assessment** based on internationally recognised scientific guidance, where such an assessment has been required by the Member State, to demonstrate that environmental criteria for long-term human health protection are met.

*Who knows how?*
Coal mining area, Upper Silesia POLAND

The Vistula river catchment area affected by radium rich brines discharge
EU BSS  Article 30
Release from regulatory control

3. Member States shall ensure that for the clearance of materials containing naturally-occurring radionuclides, where these result from authorized practices in which natural radionuclides are processed for their radioactive, fissile or fertile properties, the clearance levels comply with the dose criteria for clearance of materials containing artificial radionuclides.

(10 μSv instead of 1 mSv for „normal” NORM !)

Clearance levels set as 1kB/kg are not valid?
Radium rich water from uranium mine is different from this one released from oil and gas rigs?
Proposed solution

Clearance limits for liquids as for solid residues.

- limits for drinking water?
- natural background?
- possible accumulation on sediments?
- risk to overestimate the problem with severe consequences for coal mines.

The most reliable quantity:

1 kBq/m$^3$ for sum of $^{226}$Ra and $^{228}$Ra

...in Czech republic 0.5 kBq/m$^3$ for total alpha activity, in Germany no limits....
NORM residues above clearance level

• Classification in case of lack of secular equilibrium: *which criteria should be applied - either as for whole decay series or set for individual radionuclides?*

• No suggestion concerning final treatment for residues in the range:

  \[ 1 \text{ kBq/kg} < \text{NORM} < 10 \text{ kBq/kg}. \]

• *NORM waste > 10 kBq/kg* are radioactive waste?
To be or not to be radioactive waste?

EU BSS definition:

"radioactive waste" means radioactive material in gaseous, liquid or solid form for which no further use is foreseen or considered by the Member State or by a legal or natural person whose decision is accepted by the Member State, and which is regulated as radioactive waste by a competent regulatory authority under the legislative and regulatory framework of the Member State;
Existing approach based on exclusion

Regulation of the Council of Ministers

from 14 December 2015

regarding radioactive waste and spent nuclear fuel

Exclusion for:

• Soil and rocks moved due to mining activity
• Extractive waste
• Soil and ground moved due to construction works,

If maximal activity concentration of a radionuclide (or sum, relevantly) is lower than:

10 x limits for radioactive waste

• No remarks about other possible NORMs
Article 2

Scope

1. This Directive shall apply to all stages of:
   (a) spent fuel management when the spent fuel results from civilian activities;
   (b) radioactive waste management, from generation to disposal, when the radioactive waste results from civilian activities.

2. This Directive shall not apply to:
   (a) waste from extractive industries which may be radioactive and which falls within the scope of Directive 2006/21/EC;
   (b) authorised releases
(assumption 10) Moreover, while covering the management of waste from the extractive industries which may be radioactive, this Directive should not cover such aspects as are specific to radioactivity, which are a matter dealt with under the Treaty establishing the European Atomic Energy Community (Euratom).
DIRECTIVE 2006/21/EC

NORM

DIRECTIVE 2011/70/EURATOM
Proposed solution

a special category of radioactive waste or extra category „NORM” apart form radioactive waste at all …

but …. 

• no justification in the directive (definitions needed)

• subsequent regulation needed and only one premise in the directive exists…….
Article 30
Release from regulatory control

1. Member States shall ensure that the disposal, recycling or reuse of radioactive materials arising from any authorised practice is subject to authorisation.

... ...

4. Member States shall not permit the deliberate dilution of radioactive materials for the purpose of them being released from regulatory control. The mixing of materials that takes place in normal operations where radioactivity is not a consideration is not subject to this prohibition. The Competent Authority may authorise, in specific circumstances, the mixing of radioactive and non-radioactive materials for the purposes of re-use or recycling.
COUNCIL DIRECTIVE 2013/59/EURATOM of 5 December 2013
laying down basic safety standards for protection against the dangers
arising from exposure to ionising radiation

\[ I = \frac{C_{Ra-226}}{200} + \frac{C_{Th-232}}{300} + \frac{C_{K-40}}{3000} \]
Existing approaches ..........

\[ I = \frac{C_{Ra-226}}{A_1} (1 - \varepsilon) + \frac{C_{Ra-226}}{A_2} \varepsilon + \frac{C_{Th-232}}{A_3} + \frac{C_{K-40}}{A_4} \]

[Standards Institution of Israel, 2009].

\[ I = \frac{\rho d}{250} \left[ \frac{C_{Ra-226}}{880} (1 + 18\varepsilon) + \frac{C_{Th-232}}{530} + \frac{C_{K-40}}{8800} \right] \]

[Nuccetelli et al., 2015]

\[ I = \frac{C_{Ra-226}}{880} (1 + 0.07\varepsilon\rho d) + \frac{C_{Th-232}}{530} + \frac{C_{K-40}}{8800} \]

\[ C_{Th-232} = 0.5(C_{Ra-228} + C_{Th-228}) \]

[Austrian Standard Institute, 2009].
Building materials in Poland

- Regulated at the level of Atomic Law
- Existing subsequent regulation
- Guideline for laboratories issued by ITB
- About 20 laboratories involved
- ITC/PT organised
- Rules based on RP 112, but two indexes are used
  - **Th-228** instead of **Th-232**
  - Applied also for use of NORM in civil engineering
Activity concentration indexes

\[ f_1 = \frac{C_{Ra-226}}{300} + \frac{C_{Th-228}}{200} + \frac{C_{K-40}}{3000} \]

\[ f_2 = C_{Ra-226} \]

Where \( C \) is activity concentration of relevant radionuclide in Bq/kg

\[ f_1 < 1 \quad \text{and} \quad f_2 < 200 \]
Radionuclides of concern

uranium decay chain

238U
4.47x10^9 y

234Th
24.1 d

234Pa
6.7 h

230Th
8x10^4 y

230Pa
1.17 min

226Ra
1600 y

222Rn
3.823 d

218Po
3.05 min

214Bi
19.7 min

214Pb
26.8 min

218At
1.75 sec

218Rn
0.019 sec

210Bi
5.01 d

210Pb
stable

210Po
138.4 d

99.97%

99.37%

0.63%

0.03%

0.04%

0.1%

99.97%

99.96%

99.96%

99.99995%
Radionuclides of concern

thorium decay chain

- $^{232}$Th
  - $^{228}$Ra $1.4 \times 10^{10}$ y
  - $^{228}$Ac $6.13$ h
  - $^{228}$Th $1.91$ y
- $^{224}$Ra $3.84$ d
- $^{224}$Rn $55$ sec.
- $^{220}$Rn $55$ sec.
- $^{216}$Po $0.15$ sec
- $^{212}$Po $0.304$ μsec
- $^{212}$Bi $60.6$ min
- $^{212}$Pb $10.64$ h
- $^{208}$Pb stable
- $^{208}$Tl $3.1$ min
- $^{226}$Ra $1600$ y
- $^{222}$Rn $3.823$ d
- $^{210}$Pb $22.3$ y
- $^{210}$Po $138.4$ d
### Radionuclides contributing to external exposure

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>$T_{1/2}$</th>
<th>by progeny</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{238}U$</td>
<td>$4.5 \times 10^9$ a</td>
<td>-</td>
</tr>
<tr>
<td>$^{234}U$</td>
<td>$2.5 \times 10^5$ a</td>
<td>-</td>
</tr>
<tr>
<td>$^{226}Ra$</td>
<td>1600 a</td>
<td>directly</td>
</tr>
<tr>
<td>$^{222}Rn$</td>
<td>3.8 d</td>
<td>-</td>
</tr>
<tr>
<td>$^{210}Pb$</td>
<td>22 a</td>
<td>directly</td>
</tr>
<tr>
<td>$^{228}Ra$</td>
<td>5.7 a</td>
<td>-</td>
</tr>
<tr>
<td>$^{228}Th$</td>
<td>1.9 a</td>
<td>-</td>
</tr>
</tbody>
</table>

- $^{234}Th$
- $^{214}Bi, ^{214}Pb$
- $^{214}Bi, ^{214}Pb$
- $^{228}Ac$
- $^{212}Pb, ^{212}Pb, ^{208}Tl$
Rationale for $^{228}$Th
Coal Combustion Product

- **Fly Ash (FA)** is obtained by electrostatic or mechanical precipitation of dust-like particles from the flue gases.
- **(Furnace) Bottom Ash (BA)** is a granular material removed from the bottom of dry boilers, which is much coarser than FA though also formed during the combustion of coal.
- **Boiler Slag (BS)** is a vitreous grained material deriving from coal combustion in boilers at temperatures of 1500 to 1700°C, followed by wet ash removal of wet bottom furnaces.
- **Fluidized Bed Combustion (FBC) Ash** is produced in fluidized bed combustion boilers.
- **Semi Dry Absorption (SDA) Product** is a fine grained material resulting from dry flue gas desulphurization with lime acting as the sorbent.
- **Flue Gas Desulphurization (FGD) Gypsum** is a natural gypsum like product which is obtained by wet desulphurization of flue gas and special treatment of the adsorbed products.

- More than 140 Mt are created yearly
CCP for building materials

- No real problem, more than 70% of several hundreds CCP samples tested in GIG passed the criteria set in directive,
- Mixing during building materials production assure appropriate dilution level,
- No CCP with high content of natural radionuclides reported besides only few cases (Serbia, Croatia, Hungary, Bosna & Herzegovina)

but ...

Strong fears exist in construction industry in countries where this problem have not been regulated in term of radiation safety up till now
• COST is an intergovernmental framework for European Cooperation in Science and Technology, allowing the coordination of nationally-funded research on a European level.

• COST has a very specific mission and goal. It contributes to reducing the fragmentation in European research investments and opening the European Research Area to cooperation worldwide.
NORM - summary

- No solution for NORM above clearance level ⇒ real risk to overestimate problem enclosing NORM in a category of radioactive waste
- No requirements defined for radiation protection experts involved in NORM
- Difficulties in regulating liquid NORM
- No recommendation (criteria) concerning environmental impact caused by NORM discharge

Direct contact with environment, long enough interaction makes NORM waste being an significant factor influencing ecosystem with high probability.
NORM – Building materials

CCP – no rationally justified fears about using them as amendment to building materials!

Balanced approach to $^{232}\text{Th}$ measurement is expected:

- Actually, $^{228}\text{Ra}$ or /and $^{228}\text{Th}$ are measured
- In majority of cases, secular equilibrium in thorium decay series exists and assumption $^{232}\text{Th}=^{228}\text{Ra}=^{228}\text{Th}$ is justified
- For NORM often such assumption is not valid $\Rightarrow$ do not demand direct measurement of $^{232}\text{Th}$
Conclusion

The strong need exists to solve noticed problems at the pan-European level in order to avoid further discrepant and inconsistent implementation of the new directive requirements into Members States regulation system.

*What we need is:*

- **Scientific justification for treatment NORM above clearance level**
- **Training and knowledge exchange platform**
European activities

- **Transposition EU Basic Safety Standards Directive** - a project on the EU Member States’ strategies to transpose Directive 2013/59/EURATOM modernising European radiation protection legislation carried out by **RISKAUDIT IRSN/GRS International** is a non-profit European Economic Interest Grouping (EEIG) established in 1992,

- **HERCA** - voluntary association of the Radiation Safety Authorities in Europe where they work together in order to identify common significant radiation protection issues and propose harmonization and/or practical solutions towards a common approach for these issues,

- **Research Fund for Coal and Steel (RFCS)**

- **European Coal Combustion Products Association e.V. (ECOBA)**
Thank you for the attention ......