Part 3

# ASH AND SLAG HANDLING

## 3.7. Analytics

### 3.7.34. On the experience of resolving the coal ash handling problem in different countries world-wide (as of 2014)

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## ABSTRACT

A review paper contains the data on volumes of coal ash production and utilization in different countries, including the data on ash storage at TPP landfills and their beneficial use.

Main applications and volumes of coal ash beneficial use in various industries are given.

Information about the best available technologies relating to coal ash handling in different countries of the world is presented.

The issues concerning legislation, adopted in different countries of the international community with regard to coal ash handling, are highlightened. By that, the following is considered: the trends of power generation sector development in the countries, the plans of different states with regard to the accident at the Fukushima nuclear power plant, renewable energy, clean coal technologies plans, etc.

The paper includes information on international cooperation in the field of coal ash handling.

It also covers the issue relating to training of personnel in the field of coal ash handling.


## 1. VOLUMES OF COAL ASH PRODUCTION AND UTILIZATION. COAL ASH APPLICATIONS

One of the main fuel in the energy sector of the majority of countries is coal. Its combustion results in production of solid coal combustion by-products (CCPs), main part of which is represented by ash and slag. Recently the share of coal in the fuel mix tends to grow. In this regard, the coal ash handling problem becomes more and more actual, requiring effective solutions and technologies. The situation in Russia is exacerbated by the fact that ash ponds of the vast majority of coal-fired power plants and other solid-fuel power stations (hereinafter - coal-fired power plants) are close to their design filling. This puts the Russian power engineers before the urgent need to take effective measures to address the coal ash handling problem, despite the fact that they are by-products of TPPs [1].

According to [2] and [3] in 2010 total production of CCPs of the energy sector of the countries world–wide made about 780 million tons; about 53% of CCPs of that amount were utilized. In many developed and developing countries of the world a level of CCPs utilization, the main of which is coal ash, ranges from 40 to 100% of their annual output [1]. Fig. 1 and 2 shows the level of production and utilization of CCPs in various countries in 2010, according to [2] and [3].

***European Community (EU).*** Statistics of the European Coal Combustion Products Association (ECOBA) relating to production and utilization of CCPs [4] reflects the data on such typical coal combustion production as fly ash, bottom ash, boiler slag, ash from FBC-boilers, as well as desulphurization products like spray dry absorption product and FGD gypsum.

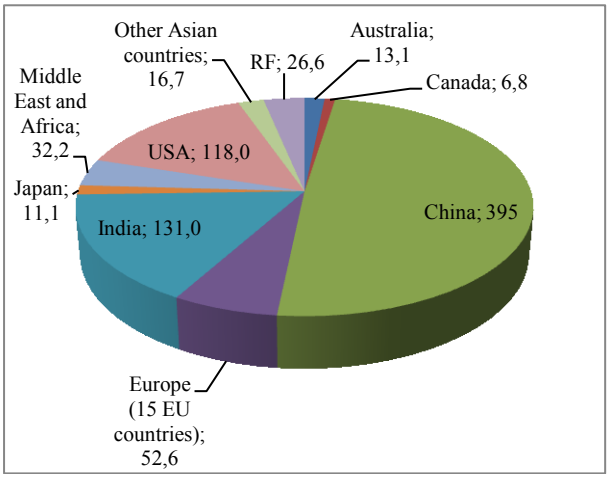


**Fig.1. Production of CCPs in different countries in 2010, mln t.**

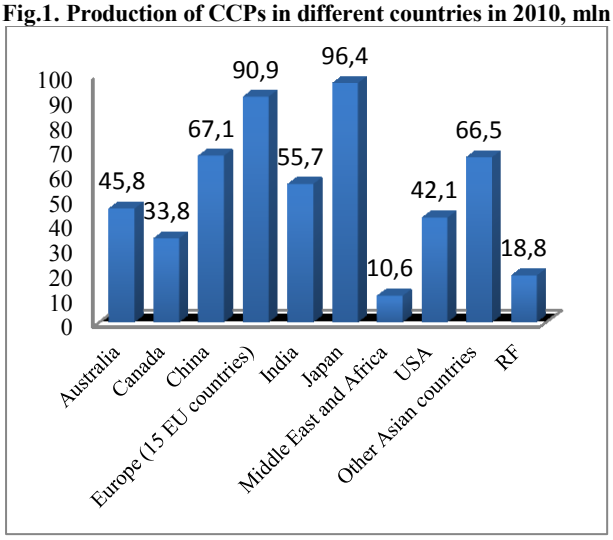


**Fig.2. Utilization of CCPs in different countries in 2010, %.**

ECOBA statistics reflect the situation in EU15 countries only, since there is not data from 13 new member-states. This statistics is prepared annually by the members of ECOBA starting in 1993. So, in EU15 the beneficial use of CCPs made 52%; considering mine filling it constituted about 90% [4]. By that, in EU countries new coal-fired power units are under introduction. Recently in EU28 above 145 million t of CCPs were produced [4]. The development of CCP production in the EU15 from 1993 to 2010 is shown in Fig. 3. Total amount of CCP production decreased from 57 million t in 1993 to 55 million t in 1999 and then it increased to 64 million t in 2005 due to higher electric and thermal energy generation at coal-fired power plants. Since 2006 the permanent increase in CCP production can be seen. In 2010 the total amount of CCPs, produced at TPPS of EU15, made 48 million t.

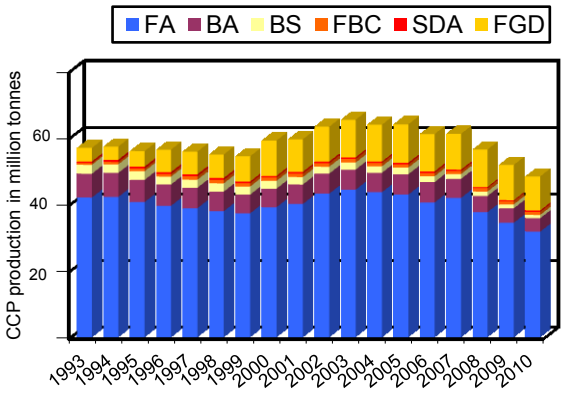


**Fig.3. Development of the CCP production in Europe (EU 15) from 1993 to 2010 (FA – fly ash; BA – bottom ash; BS – boiler slag; FBC – fluidized bed combustion; SDA – spray dry absorption; FGD – flue gas desulphurisation) [5]**

The CCPs are mainly utilized in the building material industry, civil engineering, road construction, for construction work in underground coal mining as well as for recultivation and restoration purposes in open cast mines [4]. In 2010, about 52 % of the total CCPs are used in the construction industry, civil engineering and as construction materials in underground mining and about 40 % for the restoration of open cast mines, quarries, and pits. About 2 % were temporarily stockpiled for future utilization and about 6 % were disposed of (Fig. 4).

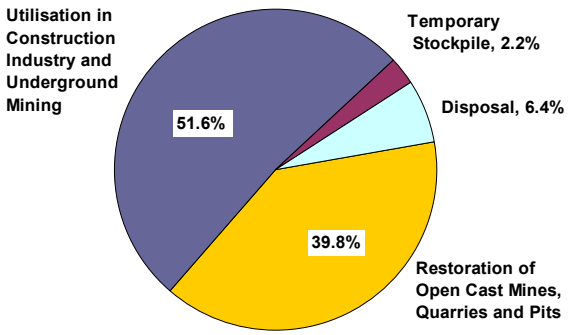


**Fig.3. Utilisation and disposal for CCPs in Europe (EU 15) [5]**

***USA.*** According to [6] in the U.S. in 2012, the level of utilization of CCPs increased by 5% compared to 2010. Total production of CCPs was 110 million t, 78 million t from that amount made coal ash. Moreover, most of the by-products were used in the construction industry; more than 20% are used for mine filling [6].

Fly ash production and utilization statistics from 1966 to 2012 according to [6] is represented in Fig.5.

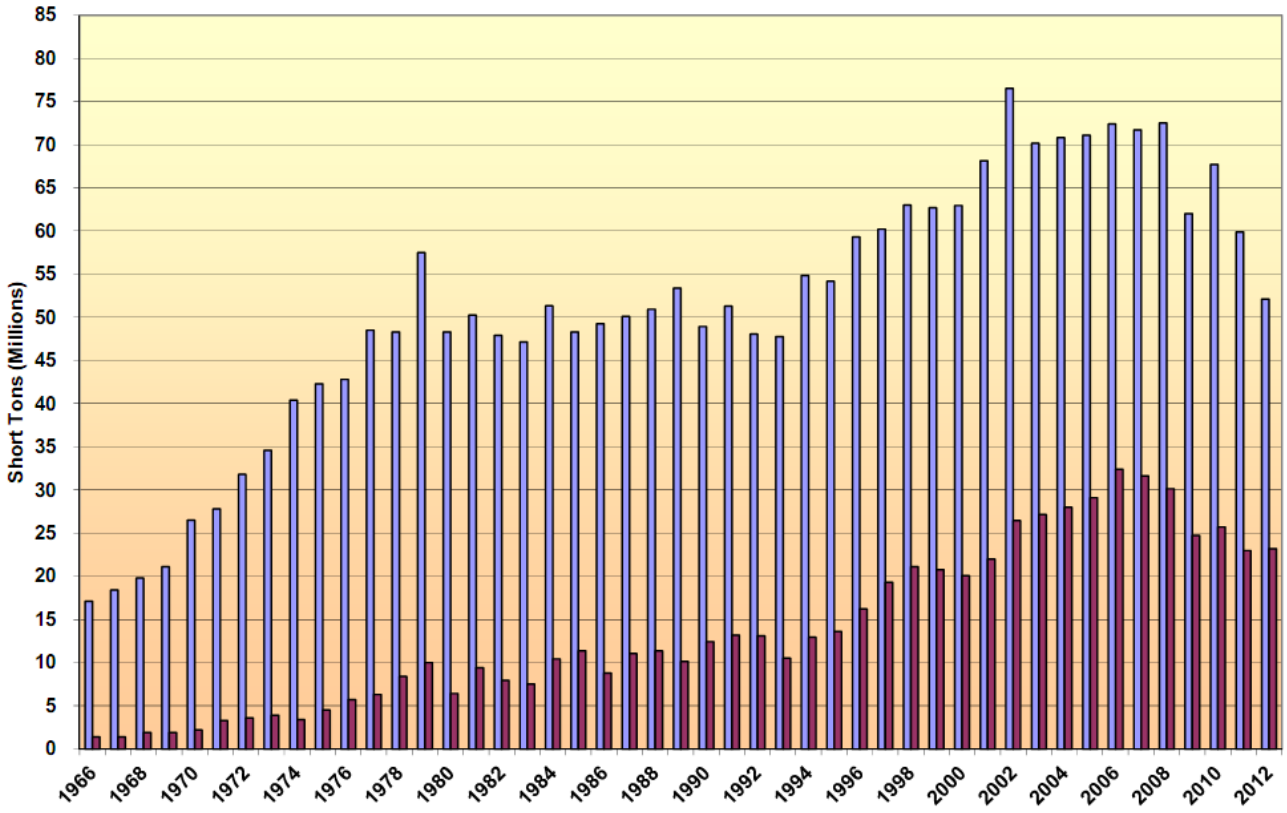


**Fig. 5. Fly ash production and utilization statistics from 1966 to 2012**

***Australia***. In Australia in 2012 production of CCPs was 12.8 million t that is about 1 million t less, than in the previous year. In 2008 the level of beneficial use of CCPs made 31%, in 2009 – 34%, in 2010 – 41%, in 2011 - 48% and in 2012 – 42%, 79% of which was used in high-tech applications, for example, in production of cement binders, concrete and mineral fillers [7].

***India***. In India in 2012, the level of utilization of fly ash from TPPs was about 50% at the level of its production of 200 million tonnes, that is by 70 million tonnes more than in 2010 [8].

In Russia, according to the expert estimation, the level of coal ash utilization is less than 20% out of 27 million tons produced.

***India***. In India in 2012 the level of TPP fly ash utilization made about 50 % at its production of 200 million t, that is by 70 million t more than in 2010 [8]. In 2013 the level of fly ash utilization was 130 million t at its production of 235 million t. Fly ash is mainly utilized in the following applications: manufacture of building materials (bricks, blocks, tiles, light weight aggregates, concretes, cements, light weight blocks, wood substitute for panels, composites, coatings, catalysts); production of bio fertilizers, bio pesticides, etc. and for use in agriculture; waste land development, mine fills; construction of roads, embankments, dams and infrastructure projects etc.[8].

***China.*** Government statistics on fly ash output and utilization is given in table 1 [9].

Table 1. **Statistics on fly ash output and utilisation**

| Year | Fly ash output (million tons) | Fly ash utilisation (million tons) | Utilisation ratio |
|---|---|---|---|
| 2005 | 302 | 199 | 66 |
| 2006 | 352 | 232 | 66 |
| 2007 | 388 | 260 | 67 |
| 2008 | 395 | 265 | 67 |
| 2009 | 405 | 271 | 67 |
| 2010 | 417 | 280 | 67 |
| 2011 | 428 | 287 | 67 |
| 2012 | 440 | 294 | 67 |

In Fig.6 dynamics of fly ash production and utilisation since 2005 to 2012 can be found.

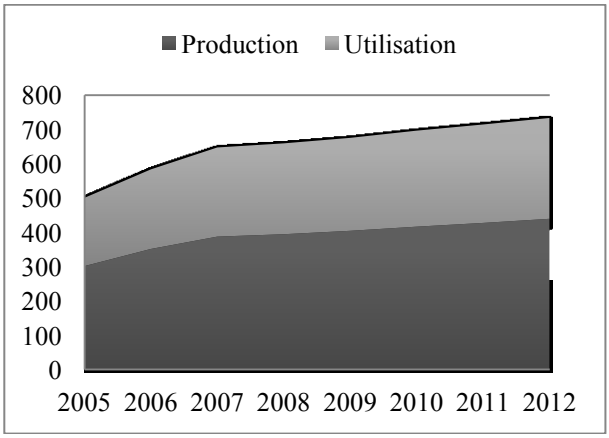


Fig.6. **Fly ash production and utilisation in China**

According to [9] fly ash is currently used in China for:

- building materials: such as baked brick and ceramsite, gas ash concrete and cement admixture (or blended material), etc.
- road engineering: such as roadbed layer materials, side slope and bituminous concrete admixture.
- construction projects: concrete and mortar admixture.
- agribusiness: used as fertilizer or used to improve soil quality
- backfill: engineering or mine backfill.
- others: such as extraction of Aluminum, etc.

Fig. 7 contains information relating to beneficial applications of fly ash in China.

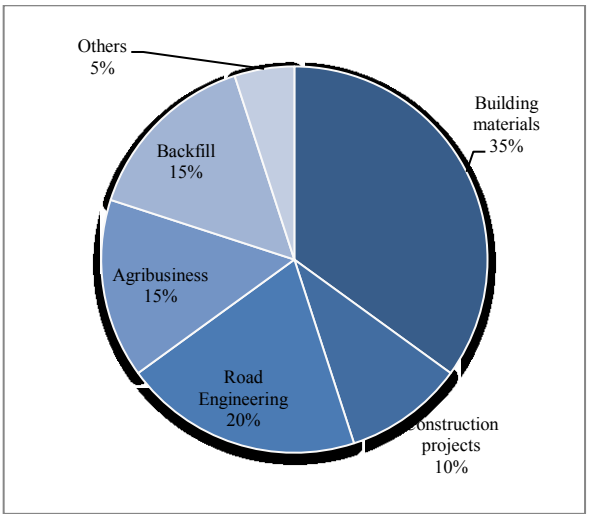


Fig.7. **Fly ash applications in China**

***Russia.*** In Russia according to the expert estimation, the level of beneficial use of coal ash is less 20 % at the level of its production of 27 million t [1]. Since the beginning of 2007, in the open sources of information there is no statistics available relating to the coal-fired TPPs in Russia as a whole, as well as data reported from the largest energy generation companies, having coal-fired power units, on the volumes of coal ash production and use. In addition, there's no information concerning applications and volumes of coal ash use in different industries.

## 2. BEST AVAILABLE COAL ASH HANDLING TECHNOLOGIES IN THE COUNTRIES OF THE WORLD

A large enough range of technologies of beneficial use of coal ash in different countries of the world community has been developed.

The most extensive scope of coal ash is the construction industry, where it is used for the production of building materials and products, as well as in the projects of industrial, civil and infrastructure construction.

**Enterprises, producing construction materials and products**: cement, aerated concrete, foam concrete, ash bricks, tiles, light fillers, ash blocks, dry mortars, porous synthetic wood, etc.

For example, one of the efficient key coal ash applications is manufacture of walls from cellular autoclaved concrete. These wall panels can be used for the construction of residential buildings; in their composition up to 90% ash is included [10].

**Projects of industrial, civil and infrastructure construction**: construction of residential and industrial buildings, levelling the sites for industrial and civil construction; construction of roads, bridges, embankments, dams, airfields and other various infrastructure facilities, etc.

By that high-tech application of ash can be found: for example, production of high-quality cement and concrete. There may be low-tech applications - for example, the use of ash in infrastructure purposes.

**Agriculture and landscape construction**. Ashes are effectively used for agricultural purposes in order to improve the structure and composition of the soil, for the production of fertilizers. Effective use of ash for reclamation of disturbed and inarable lands, as well as levelling the areas for agricultural production and landscape con-

struction.

**Small-tonnage high-tech applications.** It is also possible to use such low-capacity technologies such as extraction of aluminosilicate cenospheres and rare earth metals to produce various kinds of high-tech products, etc.

**Increasing the explosion and fire safety of mining enterprises**. Unclaimed part of coal ash can be used for filling the worked-out mine tunnels to avoid methane explosion and increase in the fire and technological safety of mining enterprises.

**On the possibility and use of co-processing of coal ash together with wastes from other industries**. For example, while manufacturing the artificial porous wood (APW), coal ash is used together with plastic industry wastes. As a result, APW is formed having better technical and economic performance than other types of commercial artificial and natural wood, available in the world market [11].

*For outdoors application*s: sidings of houses, decking, docking, beams, garden furniture and sidewalks, patios, exterior window and door frames, fences, roof slate, railway sleepers, marine piers, etc.

*For indoors application*s: floors, ceilings, doors, interior windows and door frames, interior padding the walls, shelves, cabinets, furniture, veneer, etc.

It's also possible to apply coal ash together with residues of municipal sewage runoffs, allowing to resolve the problem of utilization of the sewages and CCPs.

Detailed enough information on different technologies of coal ash application is presented in the section "Ash handling" of the Information Electronic Constantly Updated Open System "The Best Available and Perspective Nature Protection Technologies in the Russian Power Industry" (OIS BAT) - http://osi.ecopower.ru.

## 3. LEGISLATION OF THE COUNTRIES OF THE WORLD RELATING TO THE COAL ASH HANDLING PROBLEM

At the moment, in fact, the only international instrument concerning the coal ash handling issues is the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. There are no other international documents, regulating the activity in the field of coal ash handling available today. Each country has its own national legislation relating to coal ash handling, according to which they are assigned the status of "wastes" or "non-wastes".

As noted in [1], there is no common legal definition of ash in different countries. In this regard, it is not clear: if ash is waste, product or recycled materials? In addition, the experts dealing with coal ash don't also operate with the generally accepted terminology. Currently, attempts are being made by the members of the World Wide Coal Combustion Products Network - www.wwccpn.org (IACEE MPEI is a part of the Network) to develop a common terminology for ash, generated from combustion of coal and other solid fuel (peat, pet coke, garden and wood industry wastes, as well as other solid residues of organic origin). The legal definition of ash in different countries is mainly based on national legislation.

For example, in EU coal ash is considered to be a product after successful completion of REACH regulation, which entered into force on 1 June 2007. In the UK ashes received the "end-of-waste" status according to EU Directive 2008/98/EC dated November 19, 2008. In U.S. ashes are currently identified as products or wastes, depending on the legislation of the relevant state. In accordance with the legislation of South Africa ash and slag are wastes, although in practice they are products. Changing the environmental legislation in Australia resulted in receiving by CCPs the status of products, and no wastes, although until recently they were officially wastes, as it is now accepted in Russia.

***EU***. On June 1, 2007, in EU REACH regulation entered into force. It is the system to regulate the production, placing on the market and use of chemicals on their own, and in mixtures and products [12]. The basis of this system, called REACH (Registration, Evaluation, Authorisation and restriction of Chemicals) is based on the following elements:

- registration of chemical compounds;
- assessment of the technical dossier and / or substances;
- issuance of permits for marketing and use;
- restrictions on the manufacture, placing on the market and use;
- harmonized classification and labeling;
- access to information.

In addition, each manufacturer or importer must register marketed or imported substances in the European Chemicals Agency (ECHA), located in Helsinki [13]. Since June 1, 2008 CCPs, not registered according to REACH, can't be produced or marketed.

According to [4] in EU emissions from industrial installations have therefore been subject to a EU-wide legislation. Individual member states may set their own national legislation but all member states must comply with EC Directives, although derogations may be permitted. The most important Directives are:

- IPPC – Integrated Pollution Prevention and Control
- LCPD – Large Combustion Plant Directive
- IED – Industrial Emissions Directive

As a result of these regulations the emissions from power plants are reported in the European Pollutant Release and Transfer Register (E-PRTR [14]), which replaces and improves the previous European Pollutant Emission Register (EPER).

In accordance with [12] EU political decisions regarding clean coal technology led to modifications in power plant technology and installations of de-NOx and de-SOx system, those regarding subsidization of national coal mining to increased use of imported coal, those to reduce $CO_2$ emissions to increased use of biomass and production by renewable systems (wind-, solar-, hydropower). The later one does not only effects power producers but also producers of energy intensive production processes, e.g. cement industry, glass industry.

After the nuclear accident in Fukushima in April 2011 the future of nuclear power in national energy plans was again discussed and led to different political decisions in the member states, e.g. the stop of nuclear power in Germany. For example, in Germany, politicians decided to close nuclear energy sector, although a few months before they decided to extend the life of nuclear power plants. In other EU countries the plans to build new nuclear power plants are either frozen or remain in force.

With regard to renewable energy, the world needs more than doubled share of renewables in energy generation by 2030 - from the current 13 to 30% to reduce the human impact on climate, considers a head of the UN Industrial Development Organization (UNIDO) Kandeh Yumkella.

"Our new goal is to receive 30% of the energy from renewables by 2030" - said the UN official in the Reuters interview.

***India.*** It was during early 1991 that fly ash caught the attention of Department of Science & Technology, Government of India. Appreciating the overall concern for environment and the need for safe disposal and gainful utilization of fly ash, the Government of India commissioned Fly Ash Mission during 1994 as a joint activity of Ministry of Environment and Forests, Ministry of Power and Department of Science & Technology with Department of Science & Technology (DST) as the Nodal Agency. The focus was on Technology Demonstration Projects for developing confidence in fly ash technologies towards large scale adaptation [8].

Fly Ash Mission was operative from August 1994 to 31st March 2002 with its original mandate, though with requisite navigation and moderations based on learning values and market conditions. Thereafter it is continuing with same broad objectives and new thrust under the names Fly Ash Utilization Programme (up to 2007) and then as Fly Ash Unit (FAU), Department of Science and Technology (DST), Govt. of India, New Delhi.

In addition, in parallel with the increasing public confidence in the economic efficiency and environmental safety of fly ash and ash products based on the principle of sustainability, a set of national standards, rules and regulations, guidelines, and relevant legal documents has been developed. Exercise to update the existing standards and make new standards is in full swing. More than 50 standards are updated and prepared. Commercialization and large scale utilization have started. Hundreds of multiplier effects have come up, generating economic wealth more than US$ 3 billion, employing more than 1 million people and saving more than 75 MnT CO2 per annum [8].

***China***. China's regulatory framework creates numerous laws and regulations to restrict solid waste discharge and promote a "circular economy" [10].

There are three main laws in China related to fly ash utilization:

- Law on Promotion of Clean Production (2002);
- Law of Prevention and Control of Environmental Pollution by Solid Waste (2004);
- Circular Economy Promotion Law (2008).

Law on Promotion of Clean Production (2002) defines means of clean production and sets forth incentives for clean production in the forms of tax cuts and subsidies.

Law of Prevention and Control of Environmental Pollution by Solid Waste (2004) comprehensively revises the original version (1996) by introducing the "Producer Responsibility System"; expands producer responsibility, and calls for the establishment of a mandatory recycling system.

Circular Economy Promotion Law (2008) provides a legal framework for developing the economy, raising energy efficiency, protecting the environment and realizing sustainable development based on the 3R (reduction, reuse and recycle) principles.

Administrative Measures of Fly Ash Utilization are released in 1994, and currently under revision by NDRC and MIIT. After the central government released the administrative measures of fly ash utilization, the surrogates at the provincial and municipal level started to release their local regulations.

For example in Shanghai, the municipal government decided to levy a special R&D fee (0.4 RMB per ton of fly ash output) on power stations in order to support the research of fly ash utilization in Shanghai.

***Russia***. Most legal documents that are still in use have been developed during the Soviet era. The main legal act of the federal level to regulate economic activity in the field of waste management is now a Federal Law №89-FZ of 24.06.1998 (as amended from 25.11.2013) "On Production and Consumption Wastes", which is periodically in accordance with the legislative procedures amended and completed. On July 21, 2014, the Federal Law №223-FZ was adopted. It provides adoption of drastic measures to reduce industrial impact of enterprises on the environment. The main lever is economic incentives for implementation of the best available technologies through the establishment of tangible environmental charges.

With regard to regulatory and technical documents for the power industry, IACEE MPEI together with the leading industry experts has developed some basic guidelines (RD), which act to date [15]:

- RD 34.27.109-96. Guidelines for designing pneumatic ash disposal systems from boilers, plants of dry ash delivery to customers and its discharge to ash dumps / Vishnya B.L., Putilov V.Y. JSC "Uraltechenergo", Yekaterinburg, 1997, 170 p.
- RD 34.02.103-98. Estimation procedure of technical and economic indices of ash and slag removal systems of TPPs in view of ecological requirements / Putilov V.Y., Avtonomov A.B., Borichev K.P., Orlov A.V., Malikova E.A., etc. NTF "Energoprogress", Moscow, 1998, 79 p.
- RD 153-34.1.-27.512-2001. Guidelines for calculating erosion in pipelines of pneumatic transportation plants of fuel-pulverizing and ash and slag disposal systems of TPPs / Putilov V.Y., Putilova I.V., Vishnya B.L., Borichev K.P., Malikova E.A. MPEI, M., 2001, 20 p.

However, it should be noted that the RD are unclaimed for various reasons.

As noted in [1], the current situation relating to effective solution of the coal ash handling problem in Russia is as follows:

- no single state responsibility center for addressing the coal ash handling problem;
- no holistic set of legal and regulatory documents, encouraging maximum beneficial coal ash use for replacement of the natural resources;
- no target state funding of researches in the field of coal ash handling;
- actual disinterest in deed and not in word of top managers of the vast number of energy companies in effectively addressing the coal ash handling problem, that is proved by the extremely low rates of beneficial use of ash in various sectors of the economy;

- lack of information about activity of energy companies and specialized organizations at their websites and other electronic media in the field of coal ash;
- lack of qualified experts in coal ash handling in the majority of energy companies and specialized organizations.

Harmonization of legislation on coal ash handling is one of the essential conditions for increase in the beneficial use of coal ash, especially it refers to countries being the trade partners, for example Russia and EU.

Without solving this problem, effective spreading the world's best technologies in the field of coal ash handling is unlikely possible.

## 3. INTERNATIONAL COOPERATION IN THE FIELD OF COAL ASH HANDLING

***World–wide Coal Combustion Products Network (www.wwccpn.org)*** was established under the initiative of the American Coal Ash Association (ACAA) in 1999 and is a result of effective non-state cooperation of internationally-recognized experts in handling CCPs, from which coal ash from power plants and boiler-houses is the most large-capacity by-products. IACEE MPEI represents Russia in WWCCPN. WCCPN members are constantly interacting with each other and other leading experts in CCP handling to discuss solutions of common problems, achievement of the best results in research and development and implementation of the new technologies for CCP use [15].

***European Coal Combustion Products Association (ECOBA)*** was founded in 1990 by European energy producers to ensure the effective and high quality use of CCPs. IACEE MPEI actively cooperates with ECOBA and is its affiliated member since 2006. One of the main objectives of ECOBA is to promote exchange of information and documents on ash handling issues between the national and international organizations, including through participation in international scientific conferences and workshops presenting analytical reports on the EU state as a whole or its individual members [15].

***International conferences and workshops***. Organization and participation in international scientific conferences and workshops on coal ash is another way of international cooperation of all the interested persons, involved in the coal ash handling activity.

***Creation of information systems of the open access***. Another form of international cooperation in the field of coal ash handling is placing of relevant scientific, technical and analytic materials in the information systems of the open access. For this purpose in 2010 - 2011 in frames of MPEI Development Program the constantly updated electronic information system of the open access "Best Available and Perspective Nature Protection Technologies in the Russian Power Industry" was created in Russian and English (OIS BAT) - http://osi.ecopower.ru. The System is registered in the Rospatent of the RF as a data base.

OIS BAT contains the results of system researches on different aspects of ecological problems in power engineering, submitted by the authors to the Editorial Board of the System; proceedings of international and Russian workshops and conferences on ecology in power engineering; expert analytic materials on different directions of nature protection activity. Great attention while developing and updating the System is focused on issues related to CCPs handling. In addition to that, a section "Ash handling" is a part of the World Wide Coal Combustion Products Network (www.wwccpn.org).

## 4. PREPARATION OF EXPERTS IN THE FIELD OF COAL ASH HANDLING

***Russia.*** Till now there are no high schools in Russia, teaching the students on ash handling problem. Due to reforming of the Russian educational system after 2015 Bachelor's and Master's qualifications will be the main for graduates of Russian technical high schools, and the Engineers will not be prepared.

In addition to the target training of dedicated experts within the base education, a system of training and retraining of experts can and should be arranged. It's for the personnel, due to some reasons responsible for the coal ash handling problem in power companies.

For practical solution of a problem on target preparation of graduates it is necessary to complete the following primary tasks:

- define a need of various economy branches of the state in such experts;
- develop the Curricula of bachelors' and masters' training;
- select the interested basic educational institutions having training facilities and methodological framework, being to the maximum extent ready and meeting the above-stated Curricula, where it is possible to arrange such a preparation of experts with minimum expenses;
- make the required changes in educational standards;
- create education facilities for preparation of experts in the basic educational institutions selected in a corresponding order;
- start preparation of experts.

If to estimate a real time for becoming the first experts, it is possible to assume that it will occur in 8-10 years or even more after they start to make practical solutions on all the complex of problems. But time presses, though target preparation needs to be arranged all the same.

Creation of systems on professional skill improvement and professional retraining of experts does not require so much time. There are two possible alternatives here: improvement of professional skill and professional retraining [15].

For example, in the Center of training and retraining of experts named "Ecology in Power Engineering" of the Moscow Power Engineering Institute (CPPEE MPEI, Moscow, Russia), listeners of the courses receive up to date information on the best solutions, technologies and approaches in the field of coal ash handling, as well as prepare their diplomas relating to reconstruction of ash removal systems at coal-fired power plants with regard to the best world practices in this field [1].

In Novocherkassk Institute of Reclamation Engineering of Donskoi State Agrarian University (Novocherkassk, Russia) students receive knowledge about the technologies of TPP ash disposal sites reclamation and use of coal ash to improve inarable and disturbed lands.

**EU.**

***Greece.*** In Aristotle University of Thessaloniki, stu-

dents of the Civil Engineering Faculty, being prepared under the base education, gain knowledge on the use of coal ash in various construction techniques.

***Poland***. In Warsaw Polytechnic University a program of professional development relating to effective use of coal ash in the construction sector of Poland is realized.

At the Agronomy Department of the West Pomeranian University of Technology in Szczecin students gain knowledge on technologies of ash disposal reclamation; the use of coal ash for levelling the sites, designated for residential or industrial construction; on technologies to improve the quality of poor and disturbed land to be used for agricultural purposes and formation of artificial landscapes. At the Faculty of Civil Engineering and Architecture students receive information about the use of coal ash in various construction techniques.

Perhaps, in other institutes or universities of the world students and listeners are trained on specific aspects of the coal ash handling problem, but more complete information about that was not found.

## 5. CONCLUSION

The article presents the available statistics on the coal ash production and utilization in EU, USA, Australia, China, India and Russia, including data on the beneficial use of ash.

The main directions and volumes of beneficial use of ash in various industries are also described.

The paper provides information about the best available coal ash handling technologies in the countries of the world, including new developments and technologies of combined utilization of coal ash together with wastes from other industries.

It describes the aspects of legislation, adopted in different countries of the world in terms of coal ash handling: basic rules, regulations, standards, etc., considering the trends of energy development world-wide, the plans of different states with the accident at the Fukushima nuclear power plant, the plans of renewable energy and clean coal technologies development, etc.

The paper includes information on international cooperation in the field of coal ash, including informing the public through ash conferences and workshops, placing scientific, technical and analytical materials in the information system of open access.

It covers the issue of personnel training in the field of coal ash, including training and retraining of staff working in power companies.

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