Coal Ash- Understanding a Valuable Commodity

NCC Annual Fall Meeting
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Milwaukee, WI

RCRA 1976 – Energy Goal & Objective

- **RCRA -42 U.S. Code § 6902 - Objectives and national policy**
- **Objective "**The objectives of this chapter are to promote the **protection of health and the environment** and to **conserve valuable material and energy resources by"… "providing technical and financial assistance to State and local governments and interstate agencies** for the development of solid waste management plans (including resource recovery and resource conservation systems) which will promote improved solid waste management techniques (including more effective organizational arrangements), new and improved methods of collection, separation, and recovery of solid waste, and the environmentally safe disposal of non-recoverable residues;"
- **"**The Congress finds **with respect to materials**, that ...**millions of tons of recoverable material which could be used are needlessly buried each year**" and that "the **recovery and conservation of such materials can reduce the dependence of the United States on foreign resources and reduce the deficit in its balance of payments."**

CCP Resource Recovery

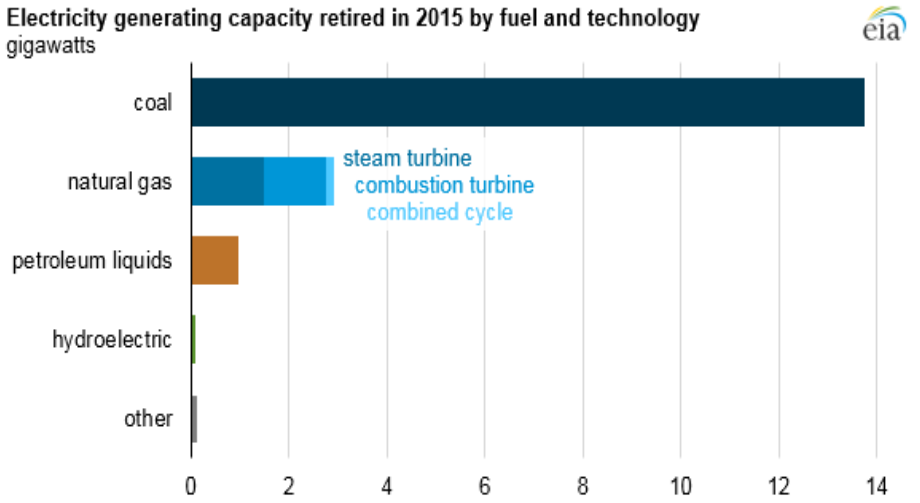
- Coal Ash History Meets The Goal of RCRA- Best Resource Recovery Story - “Untold”
- 2014 Data - 129.7M Ton Produced; 62.4M Ton Utilized – 48%
- Resource Produced For Construction
  - Sand & Gravel - 914 Million Ton (up 7.5%%)
  - Cement - 89.1 Million Ton (up 9.1%)
  - Gypsum - 33.7 Million Ton (up 4.7%)
  - CCPs - 129.7 Million Ton (up 13% due to Scrubbers)
- Strategic Material Resource Value- REE

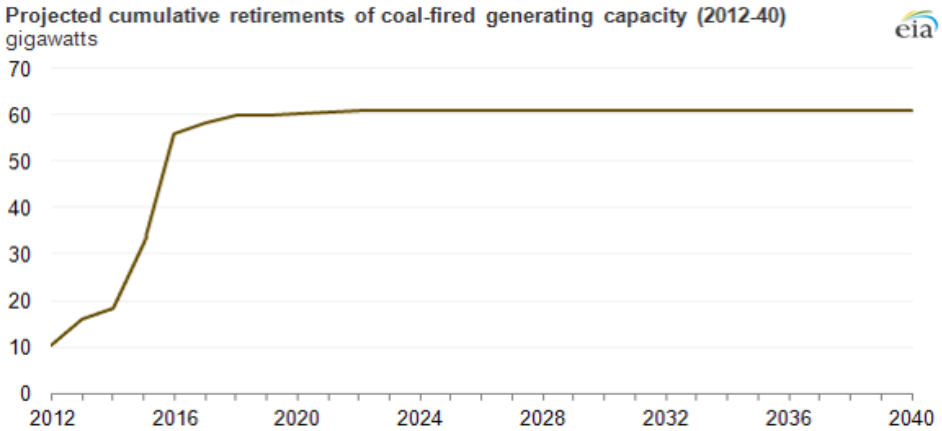
CCR Resource Impacts

- Regulatory Climate & E&P Tech Have Rapidly Changed The CCR Resource Markets
- Focus Today Is On Regulatory Impacts
  - MATS, MACT, CCR, ELG, CPP Etc.
  - 2015 & 2016 Hard Hit Years On Plant Closings
  - 60 GW Reduction By EOY 2016
  - 19.6 GW Announced For Shutdown by 2025
  - Compliance Costs & Methods Indirectly Reduce Ash Quality & Resource Recovery

Capacity Reductions Impact CCRs

- Total 310 GW Current Capacity
- 48-60 GW Closing- Primary MATS & MACT
  - ➢ Capacity Factor <45%
  - ➢ Units < 200MW
  - ➢ Av Age 54 Yr
  - ➢ Most w/o SO2 Controls
- Announced Unit Closing- 19.6 GW - CCR & ELG Regulation – Ash Volume 8M TPY Reduction

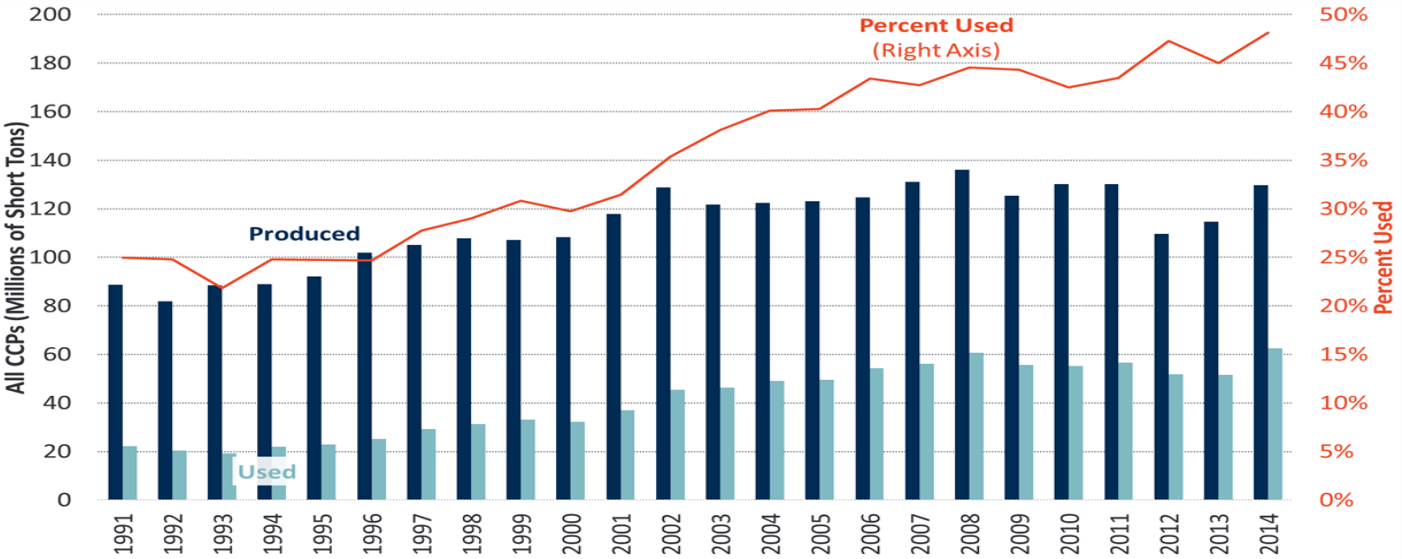




Source: EIA Annual Energy Outlook 2014 Reference Case and Annual Electric Generator Report

CCP Production & Use History

- CCP Production 129.6 MM Ton- Fly Ash, Bottom Ash & FGD
- Fly Ash & Bottom Ash Production Down- FGD Production Up
- Utilization Rebounding After Regulatory Clarity- Subtitle D
- EPA Support For Fly Ash In Concrete & Gypsum In Wallboard



SOURCE: American Coal Ash Association Production and Use Survey

CCP - Cost Control Value

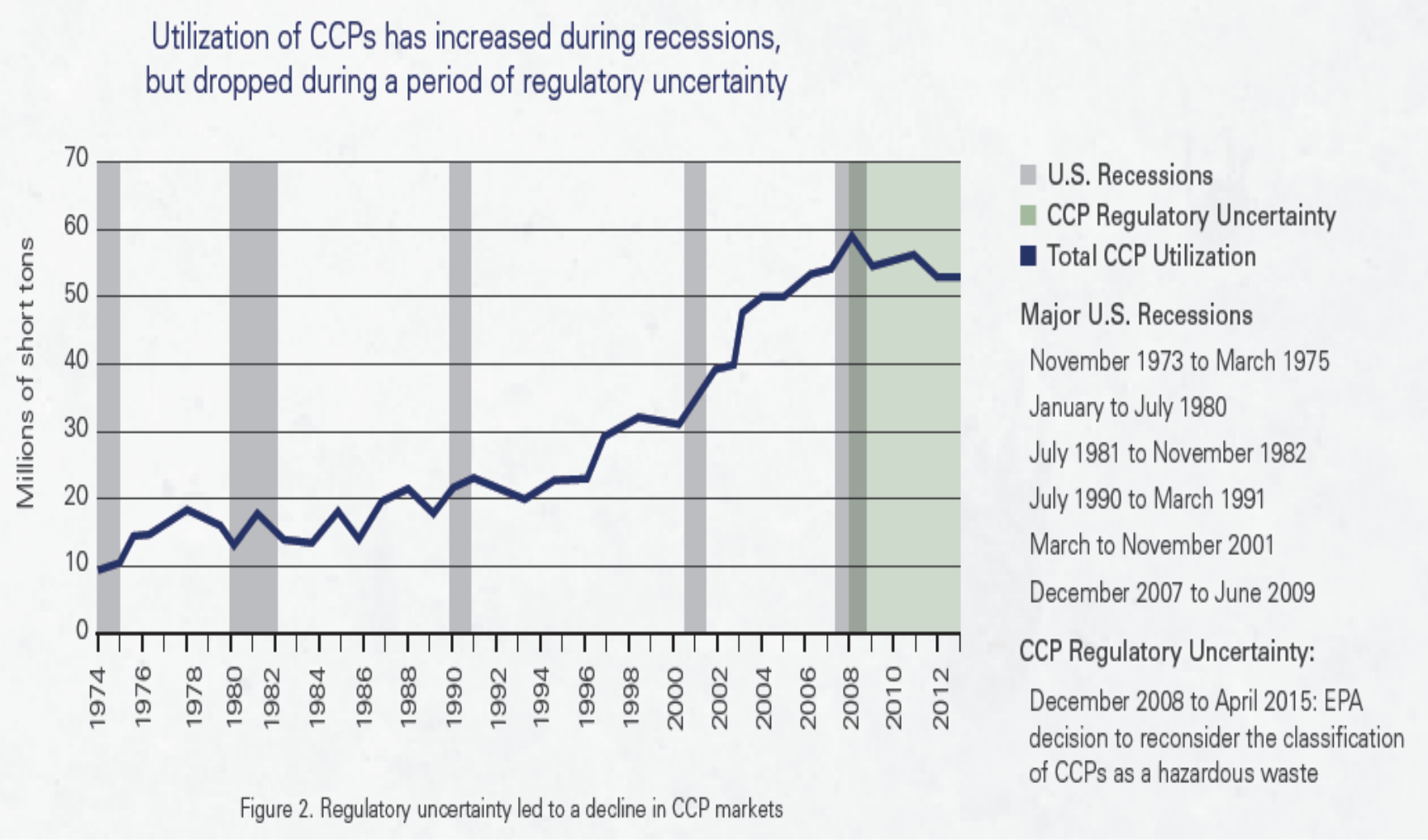
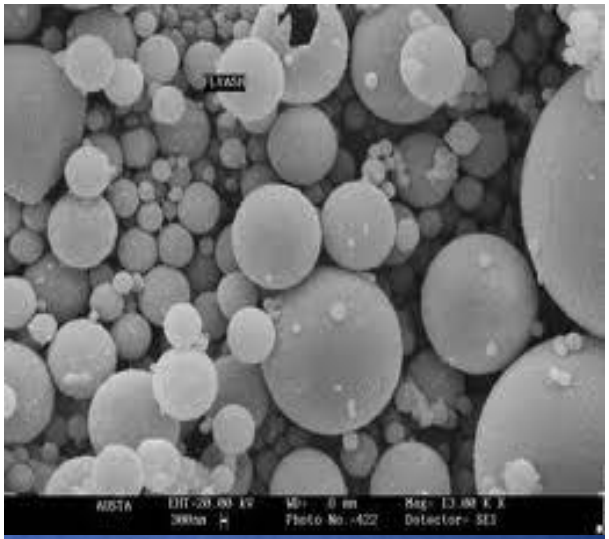


Figure 2. Regulatory uncertainty led to a decline in CCP markets

SOURCE: ARTBA CCP Production and Use Historical Analysis, 2015

Traditional Value Impacts & Uses

- CCP Value - $6-$14B/Year
- CCPs – 3%-New Home Costs- <½ $$ Of Replaced
- Cement-$80-$110
- Fly Ash- $20-$90
- Gypsum - $5-$35
- Life-cycle Costs Decrease w/ CCPs
- Highway Concrete Lifespan Extension



- Ready Mixed Concrete
- Wallboard
- Roofing Shingles
- Carpet Backing
- Lightweight Plastics
- Lightweight Aggregates
- Agriculture Sulfur Source
- Oil & Gas Drilling

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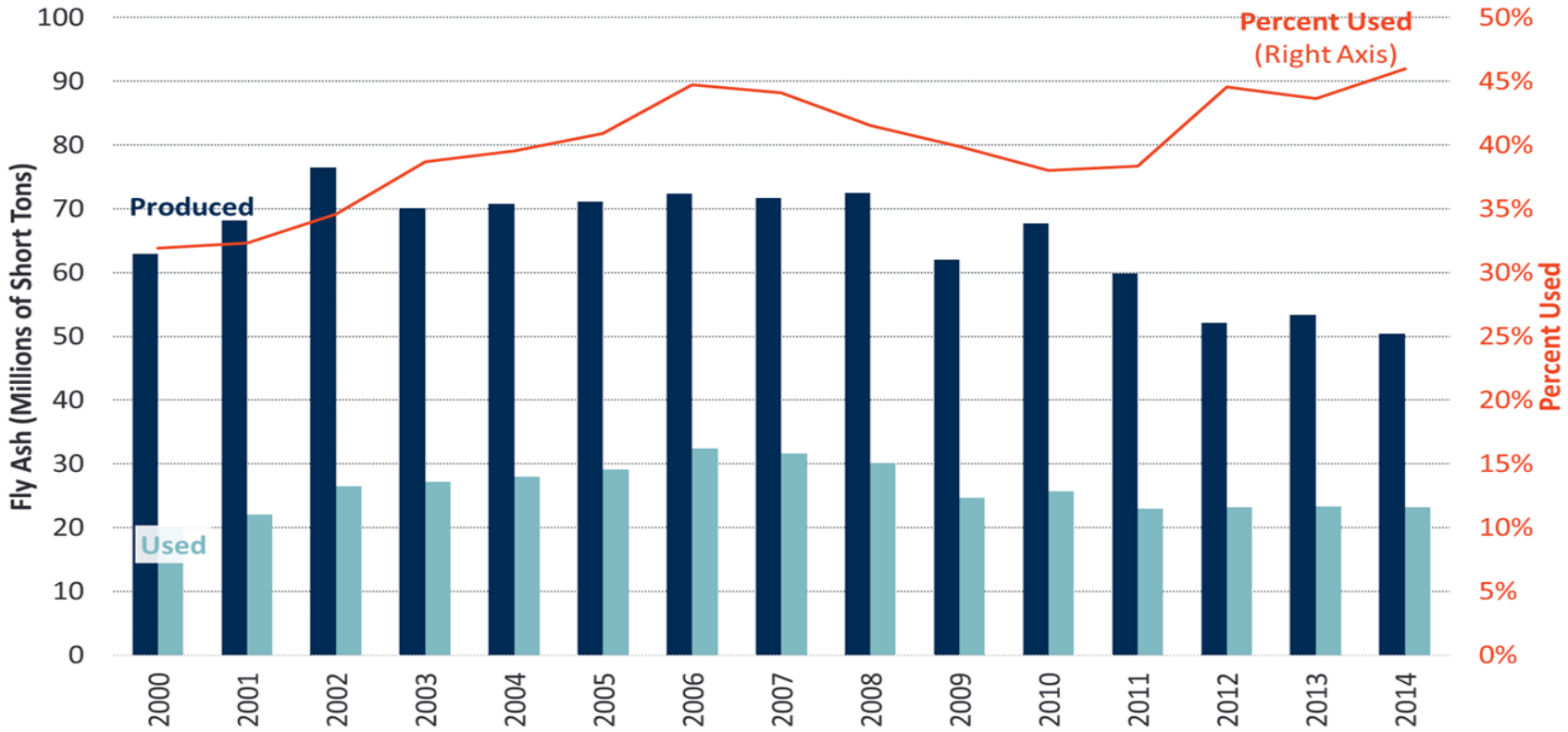
Fly Ash Production & Use

- 2014 Fly Ash Use In Concrete – 13.1 M Ton vs. 12.3M Ton (6.5% Inc)



Bottom Ash Resource Use

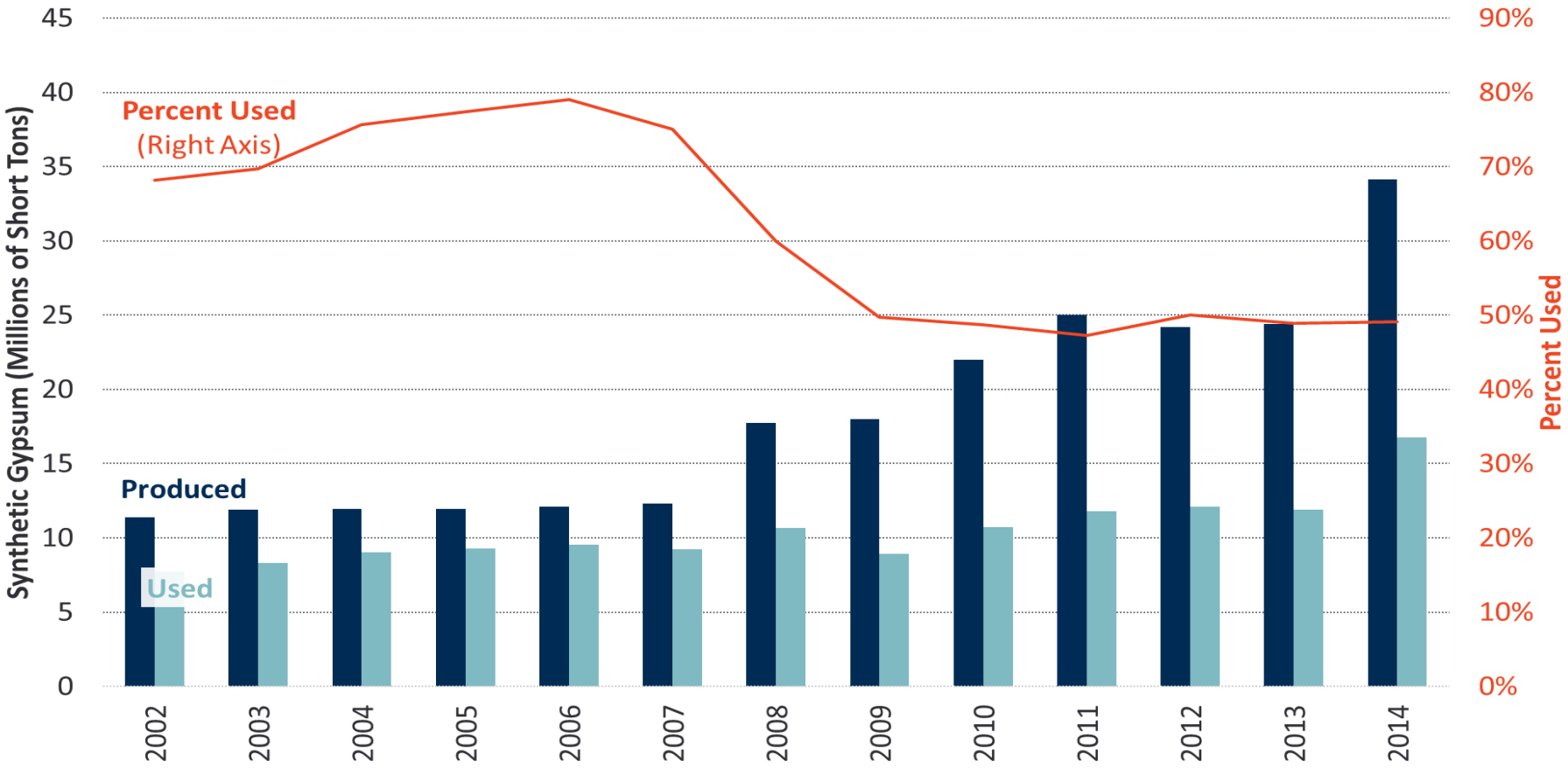
- De-icing Skid Control
  - Salt Replacement
  - $5-$15 vs $50-$70
- Bottom Ash LWA
  - Processed to replace LWA
  - Typical Block -35 – 38 lb
  - Bottom Ash LWA Block – 28-32 lb
  - Product priced in $15-$30/t
  - Replaced product - $30-$50/t
  - Avoids Mine Operation
  - Avoids Kiln Operation
  - Avoids Disposal

Gypsum Utilization

- Wallboard Manufacture
  - 50% Of Production
  - $1-$10/Ton
- Cement Manufacture
  - 5% Added to All Cement
  - Set Control
  - $1-$10/Ton
- Agriculture Application
  - Sulfur Nutrient Defficiency
  - Crops Consume 16-18 lb/ac
  - 90% Purity vs Mined @ 70-80%
  - $15-$35/Ton

FGD Gypsum Production & Use

- Half Of Wallboard Manufactured In US Utilized Recovered CCP Gypsum



2015 Projected CCP Production

- Coal Remains ~30% Fuel Mix – Announced Closings Equate To 5M TPY
- Production Volume & Reclaimed CCPs Offer Resources For Needs
- Certain Markets Impacted By Loss Of Plants Or CCP Quality

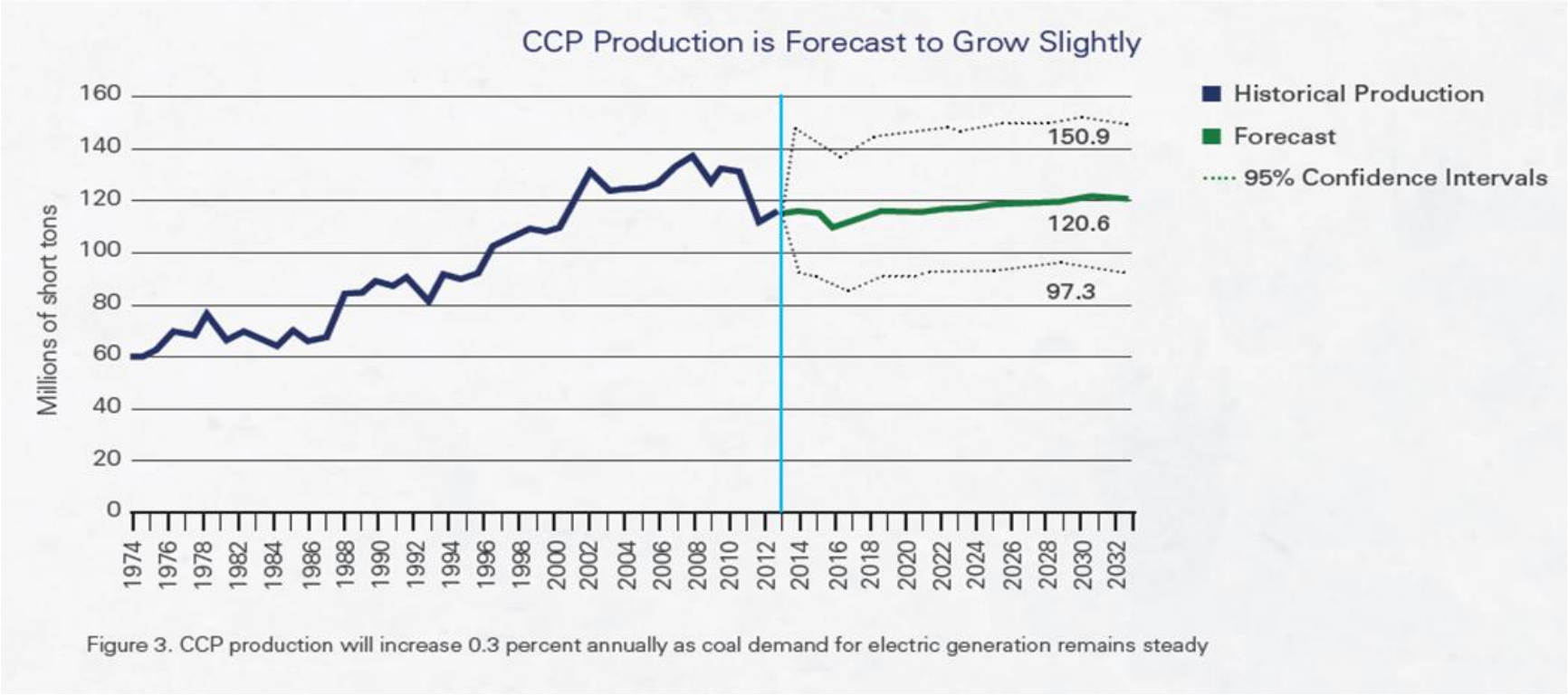


Figure 3. CCP production will increase 0.3 percent annually as coal demand for electric generation remains steady

SOURCE: ARTBA CCP Production and Use Historical Analysis, 2015

Future Resource Applications

- Beneficiated Ash – Traditional Construction Markets
- Strategic Resource Applications-REE
  - REE Demand Within Green Energy & Technology Applications Continues
  - China Supplies 80%+ Of World Supply
  - Supply Concentration Has Caused Political Related Price Volatility- China 2010 Restrictions On Exports Caused Wild Increases Followed By Innovation And Price Collapse By 2012 – Honda 2016 – Magnets w/o REE @ 10% Cheaper & 8% Lighter
  - Long Term-Higher Demand – Supply Concentration Needs Solution- CCRs May Be One Option

Rare Earth Elements

17 REE-15 Lanthanides – 2 Types

Rare Earth Elements (Lanthanides Group) Selected End Uses			
Light REE (more Abundant)	Major End Use	Heavy REE (Less Abundant)	Major End Use
Lanthanum	Hybrid Eng, Metal Alloys	Terbium	Phosphos, Perm Magnets,
Cerium	Auto Catalyst, Petro Refining, Metal Alloys	Dysprosium	Perm Magnets, Hybrid Eng
Praseodymium	Magnets	Erbium	Phosphors
Noedymium	Catalyst, Petro Refining, Hard Drives, Hybrid Eng	Yttrium	Red Color, Fluorescent lamps, ceramics, metal alloy agent
Samarium	Magnets	Holmium	Glass coloring, lasers
Europium	TV & Computer Screens	Thulium	Medical X-Ray Units
		Lutetium	Catalyst in Petro Refining
		Ytterbium	Lasers, steel alloys
		Gladolinium	Magnets
**Use 500kg/kw capacity			
Source: DOI, USGS Circular 930-N			

REE – Strategic-Political & Regulatory Risk

- DOE Research - Currently 10 Phase I Projects – 6 Bench Scale & 4 Pilot; Goal 4 Projects Advance
- Enriched REE Concentrations In Ash & Coals- 2X To 4X Crustal; Approach 60% Of Commercial Deposits (1,000 mg/kg)
- Access To Reserves Required For Both Traditional & Future Uses
- Policies & Regulations Must Provide Pathway To Access
- Regulatory Constraints On Access Need Alignment

US DOE R&D Projects – December 2015

Type of Project	Research Host	Location	Materials	Process	DOE ($000s)	Private ($000s)	Total ($000s)
Bench Scale	University of Wyoming	Larimie, WY	PRB Coal Ash	CO2, FeChloride under Supercritical Conditions	660	221	881
Bench Scale	Duke Unviversity	Durham NC	Various CCB	Solvent Extract & Membrane Filtration	720	183	903
Bench Scale	West VA University	Morgantown WV	NApp Coal Mine Drainage	Extraction from AMD & AMD Sludges	750	201	951
Bench Scale	Neumann Systems Group	Colorado Sp, CO	PRB/E Bit & Anthr Coal & Ash	Supercritical CO2/Solvent & Acid-Base Extr	750	237	987
Bench Scale	Batelle	Columbus OH	OH Coal & Ash	Closed Loop Digestion	710	190	900
Bench Scale	University of North Dakota	Grand Forks, ND	ND Lignites & Refuse	Separate, Extr & Concentrate	749	188	937
Pilot Scale	University of KY	Lexington KY	Central App Prep Refuse	Qtr TPY Physical & Chemical Seaparation	1,000	320	1320
Pilot Scale	Physical Sciences, Inc	Andover MA	Ash E KY Fire Clay & Antracite Refuse	1-5 TPD Physical-Chemical Separation	999	251	1250
Pilot Scale	Southern Res Institute	Birmingham AL	Cent App & E Bitum Coal	Plasma Based Testing on Ash	1,000	290	1290
Pilot Scale	Tusaar Inc	Lafayette, CO	KY & OH Coal Ash	Extraction & Metal Sorption	984	246	1230

Summary Impacts On CCP

- Coal Use Will Be Impacted By Cheap Natural Gas (Capacity Factor) & Regulatory Impacts (Closures)
- CCP Use As A Valued Resource Continues
  - Volumes Impacted In Certain Markets
  - Quality Impacted By Regulation
  - Beneficiation Technologies Applied To Reclaim
  - Reclaim Of Impoundment & Landfill Ash Ensures Long Term Availability With Beneficiation
  - Transportation Longer Distances Required
  - At 30% Of Fuel Mix – Volumes Meet Demands
- Future Uses Include REE Options

QUESTIONS

2014 ACAA CCP Survey Data

American Coal Ash Association
38800 Country Club Drive
Farmington Hills, MI 48331
Email: info@acaa-usa.org
Phone: 720-870-7897
Fax: 720-870-7889
Internet: www.ACAA-USA.org

2014 Coal Combustion Product (CCP) Production & Use Survey Report

Beneficial Utilization versus Production Totals (Short Tons)

2014 CCP Categories	Fly Ash	Bottom Ash	Boiler Slag	FGD Gypsum	FGD Material Wet Scrubbers	FGD Material Dry Scrubbers	FGD Other	FBC Ash	CCP Production / Utilization Totals
Total CCPs Produced by Category	50,422,238	12,478,705	2,694,056	34,123,820	12,596,231	1,255,775	344,551	15,768,766	129,684,142
Total CCPs Used by Category	23,181,723	6,063,028	1,706,621	16,750,990	1,163,434	275,999	0	13,285,766	62,427,561
1. Concrete/Concrete Products /Grout	13,126,930	609,558	0	423,613	0	0	0	0	14,160,100
2. Blended Cement/ Feed for Clinker	3,391,272	1,197,398	0	1,308,208	120,509	0	0	0	6,017,388
3. Flowable Fill	84,734	2,672	0	0	0	0	0	0	87,406
4. Structural Fills/Embankments	2,805,515	1,928,492	51,659	1,586,234	311,183	0	0	0	6,683,084
5. Road Base/Sub-base	365,868	306,936	12,992	0	0	0	0	0	685,796
6. Soil Modification/Stabilization	176,112	720,791	0	0	0	0	0	0	896,903
7. Mineral Filler in Asphalt	68,707	0	9,758	5,197	0	0	0	0	83,662
8. Snow and Ice Control	0	736,397	101,359	0	0	0	0	0	837,756
9. Blasting Grit/Roofing Granules	0	127,114	1,530,853	0	0	0	0	0	1,657,968
10. Mining Applications	1,392,935	41,330	0	813,419	578,244	229,766	0	13,151,161	16,206,855
11. Gypsum Panel Products	0	0	0	11,221,836	0	0	0	0	11,221,836
12. Waste Stabilization/Solidification	279,323	475	0	16,390	0	0	0	134,605	430,794
13. Agriculture	62	10	0	1,332,708	0	0	0	0	1,332,781
14. Aggregate	0	181,107	0	0	0	0	0	0	181,107
15. Oil/Gas Field Services	512,100	4,708	0	0	0	46,233	0	0	563,041
16. Miscellaneous/Other	978,165	206,039	0	43,384	153,498	0	0	0	1,381,086

Summary Utilization to Production Rate

CCP Categories	Fly Ash	Bottom Ash	Boiler Slag	FGD Gypsum	FGD Material Wet Scrubbers	FGD Material Dry Scrubbers	FGD Other	FBC Ash	CCP Utilization Total
Totals by CCP Type/Application	23,181,723	6,063,028	1,706,621	16,750,990	1,163,434	275,999	0	13,285,766	62,427,561
Category Use to Production Rate (%)	46%	49%	63%	49%	9%	22%	0%	84%	48%
2014 Cenospheres Sold (Pounds)	4,862,361	Data in this survey represents 180 GWs of Name Plate rating of the total industry wide approximate 302 GW capacity based on EIA's July 2015 Electric Power Monthly.							

Notes:

These are estimates for entire U.S. utility and IPP sectors calculated by dividing the survey respondents data by the portion of the overall industries coal burn they represent, as reported in the July 2015 EIA Electric Power Monthly (58%).