CENTER FOR ADVANCED SEPARATION TECHNOLOGIES

Update on the Latest Development from CAST

U.S.A.-India Coal Working Group, Washington, DC
November 18, 2005

by

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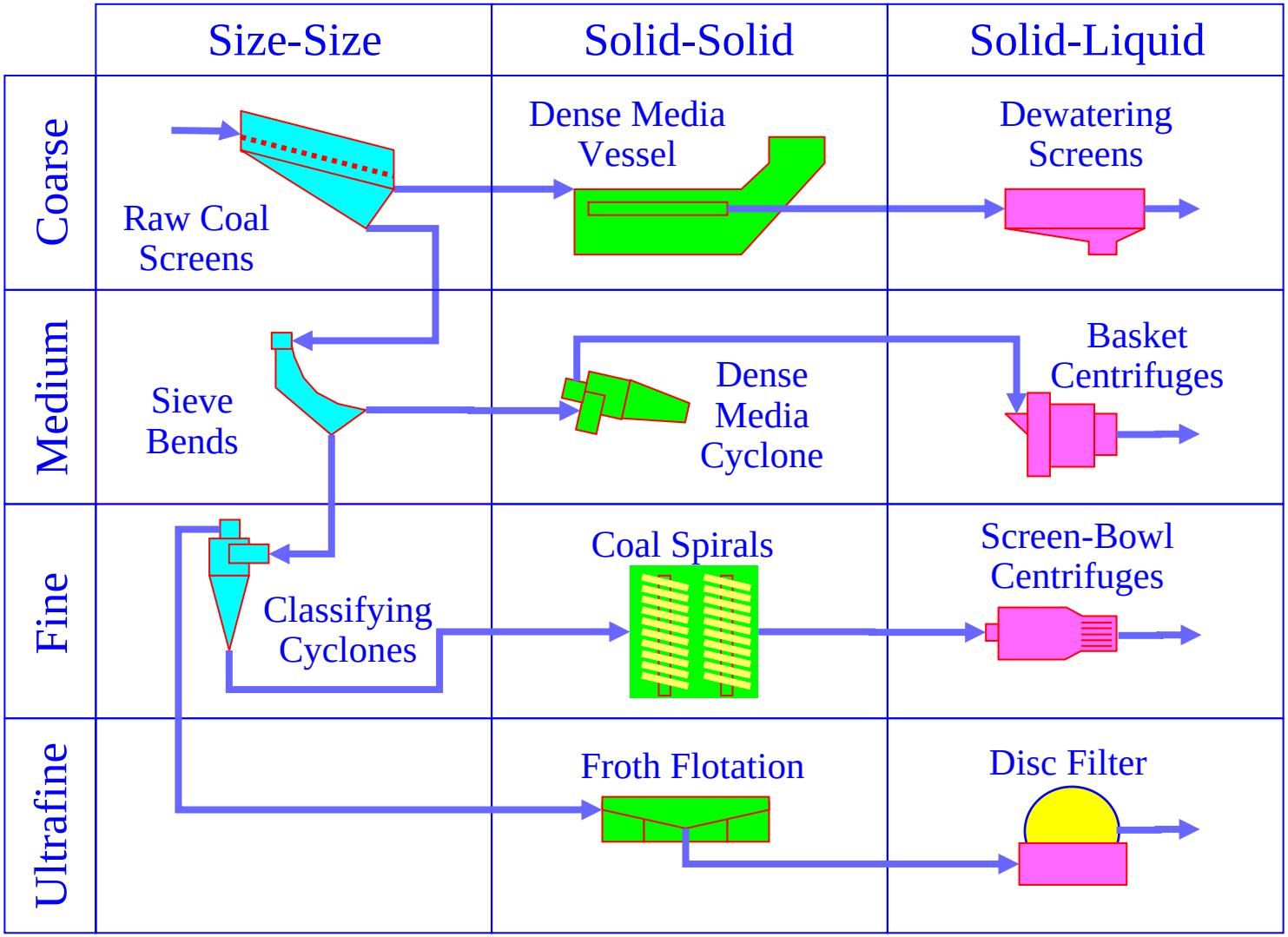
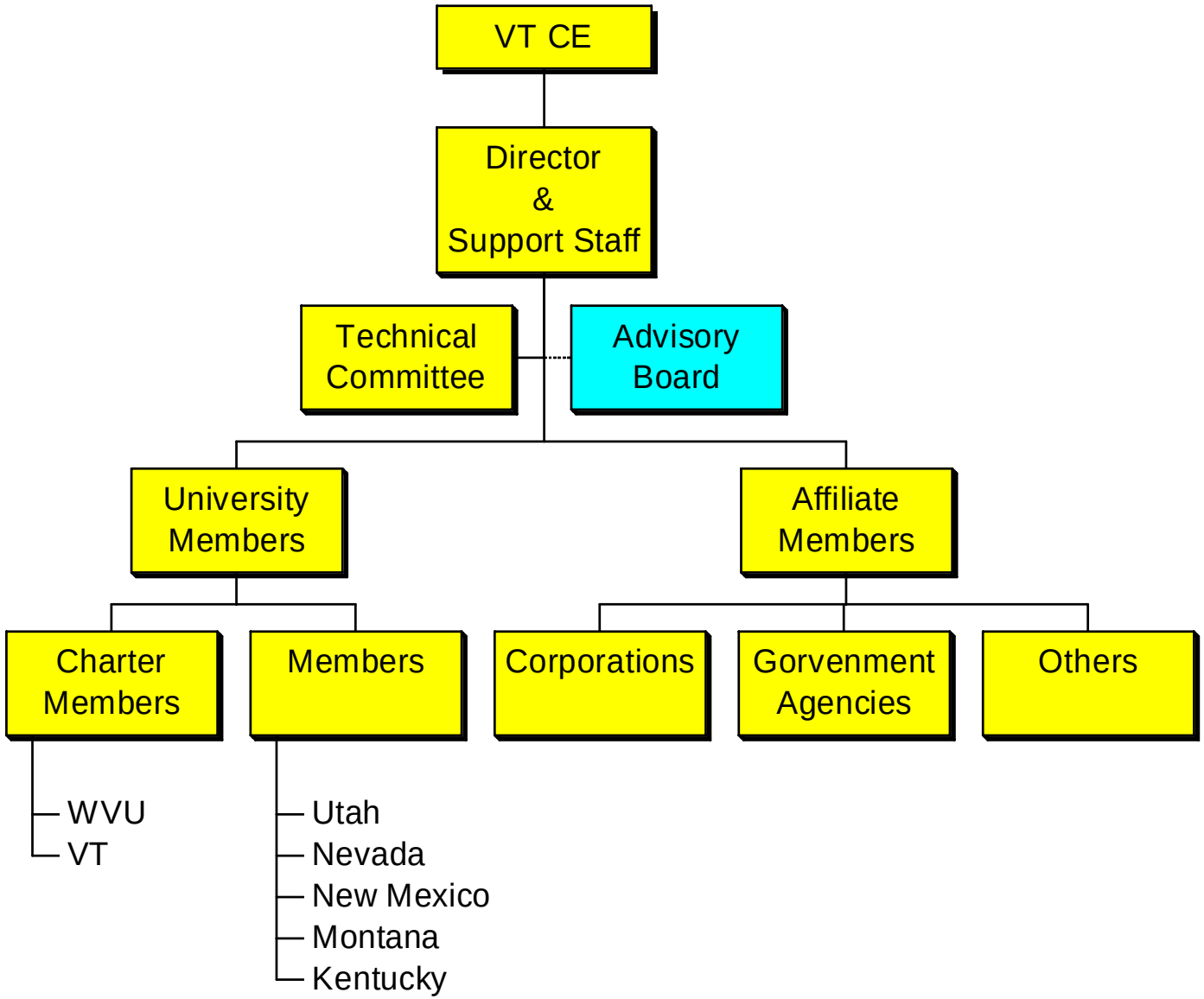
http://www.castconsort.org

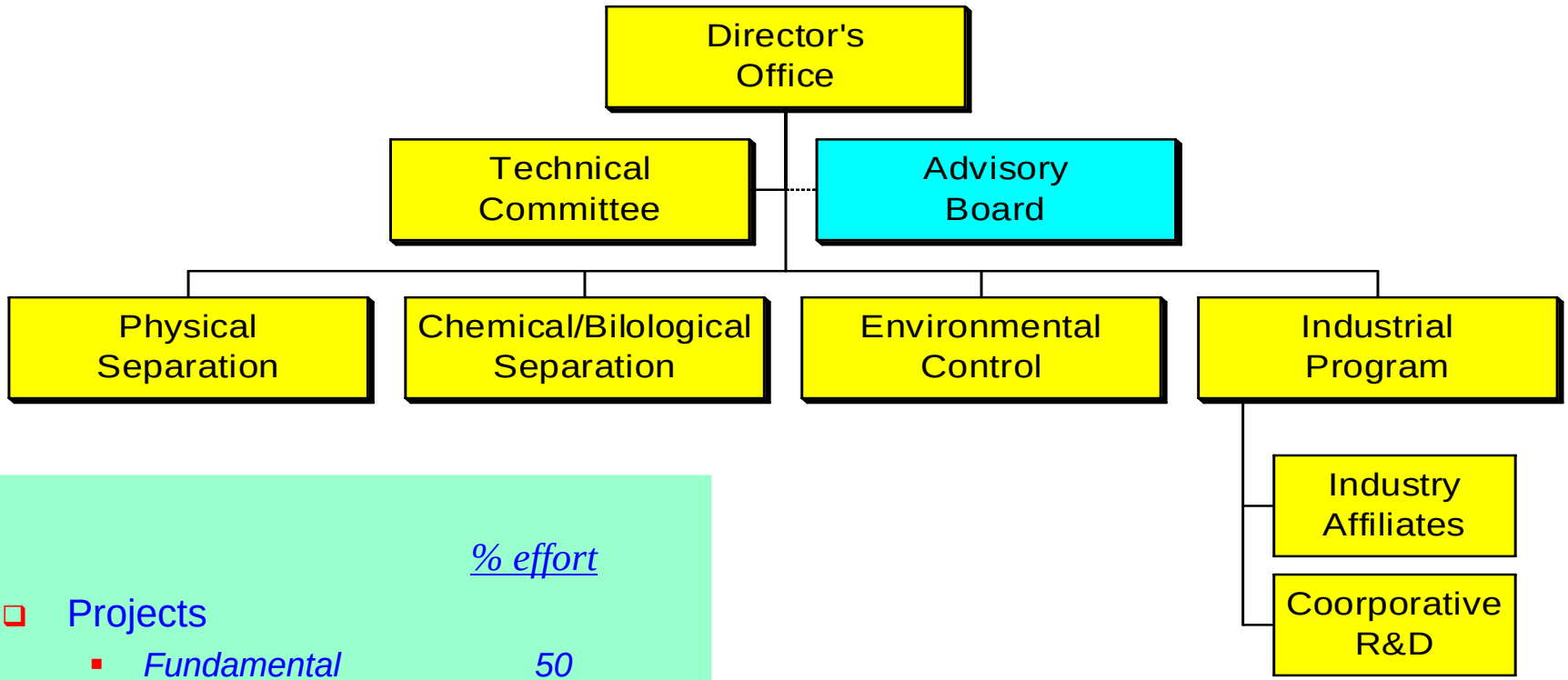
Separation Processes Used for Coal



Organization



CAST Program



	% effort
❑ Projects	
▪ *Fundamental*	*50*
▪ *Applied*	*50*
❑ R&D Areas	
▪ *Coal*	*50*
▪ *Minerals*	*50*

Roadmaping workshop:

Charleston, WV,
August 14-15, 2002
67-page roadmap

Industry Advisory Board

- Richard Lawson,
  - *Chairman, Energy, Environment and Security Group, Ltd.*
- Bart Hyita,
  - *Vice President, Operation, CONSOL Energy*
- David Peugh,
  - *Vice President, Arch Minerals*
- John Marsden,
  - *Vice President, Phelps Dodge Mining Company*
- Edward Dowling,
  - *Vice President, Cleveland Cliffs*

Energy Policy Act 2005

(1) innovations for existing plants (including mercury removal);

(2) gasification systems;

(3) advanced combustion systems;

(4) turbines for synthesis gas derived from coal;

(5) carbon capture and sequestration research and development;

(6) coal-derived chemicals and transportation fuels;

(7) liquid fuels derived from low rank coal water slurry;

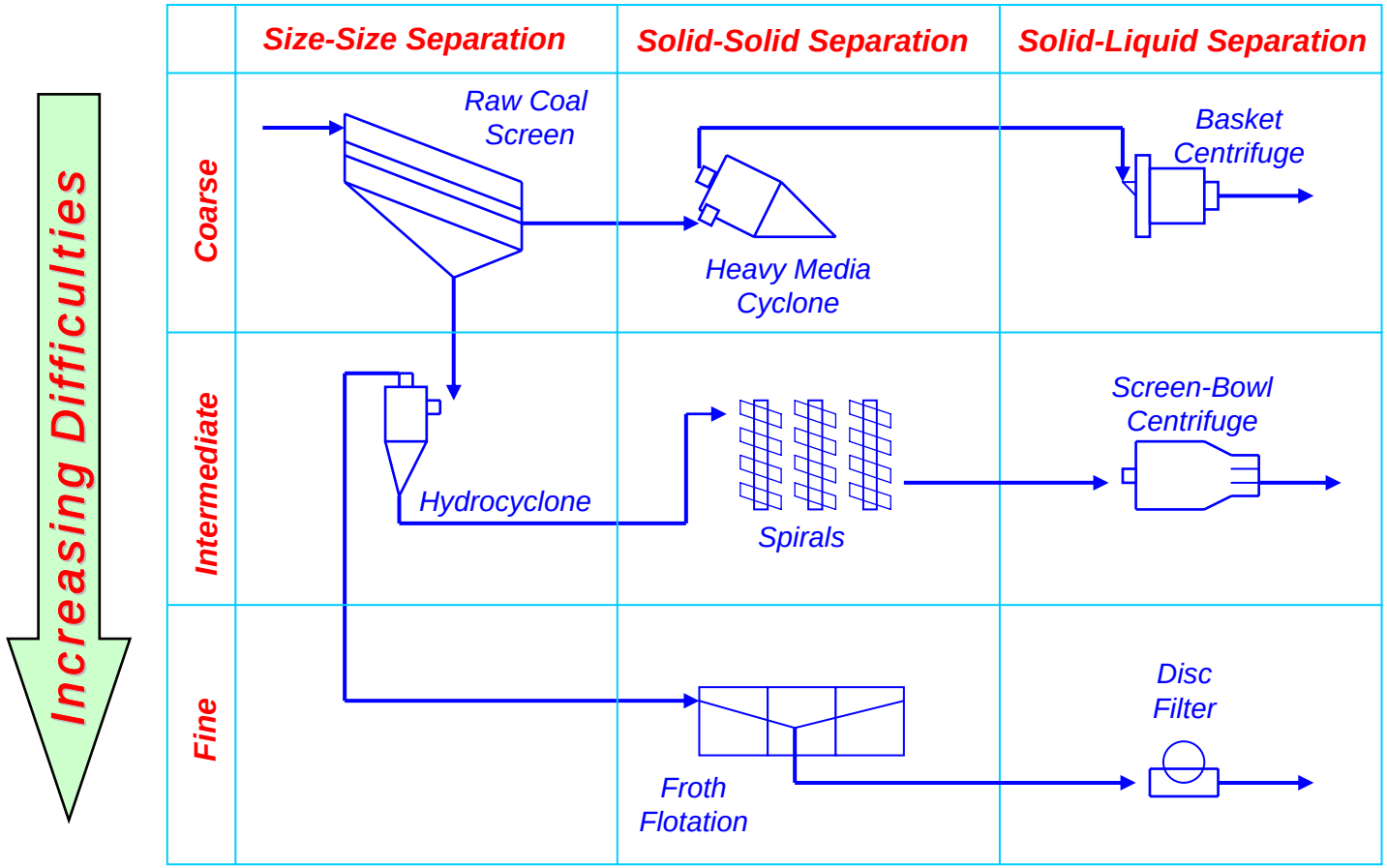
(8) solid fuels and feedstocks;

(9) advanced coal-related research;

(10) advanced separation technologies; and

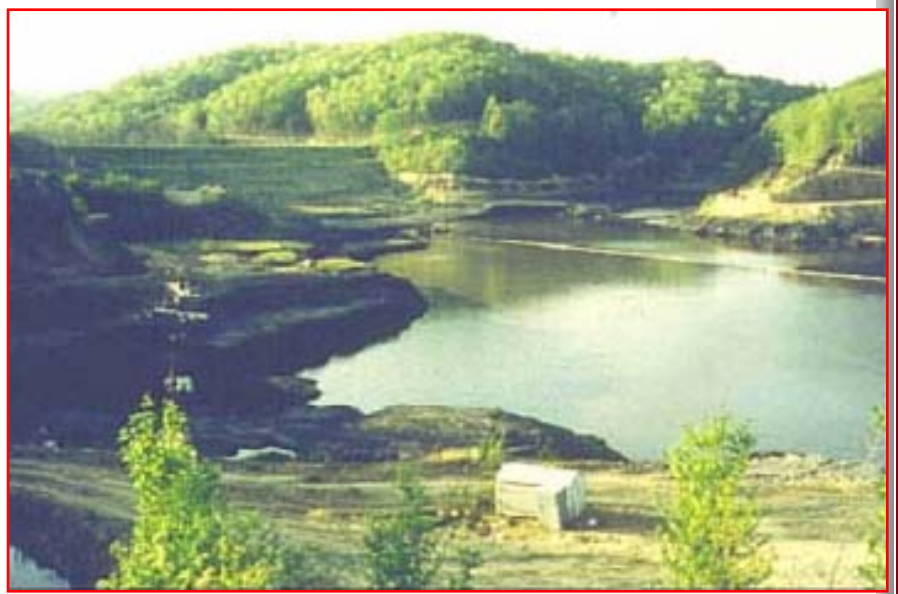
(11) fuel cells for the operation of synthesis gas derived from coal.

Simplified Flowsheet



Impoundments

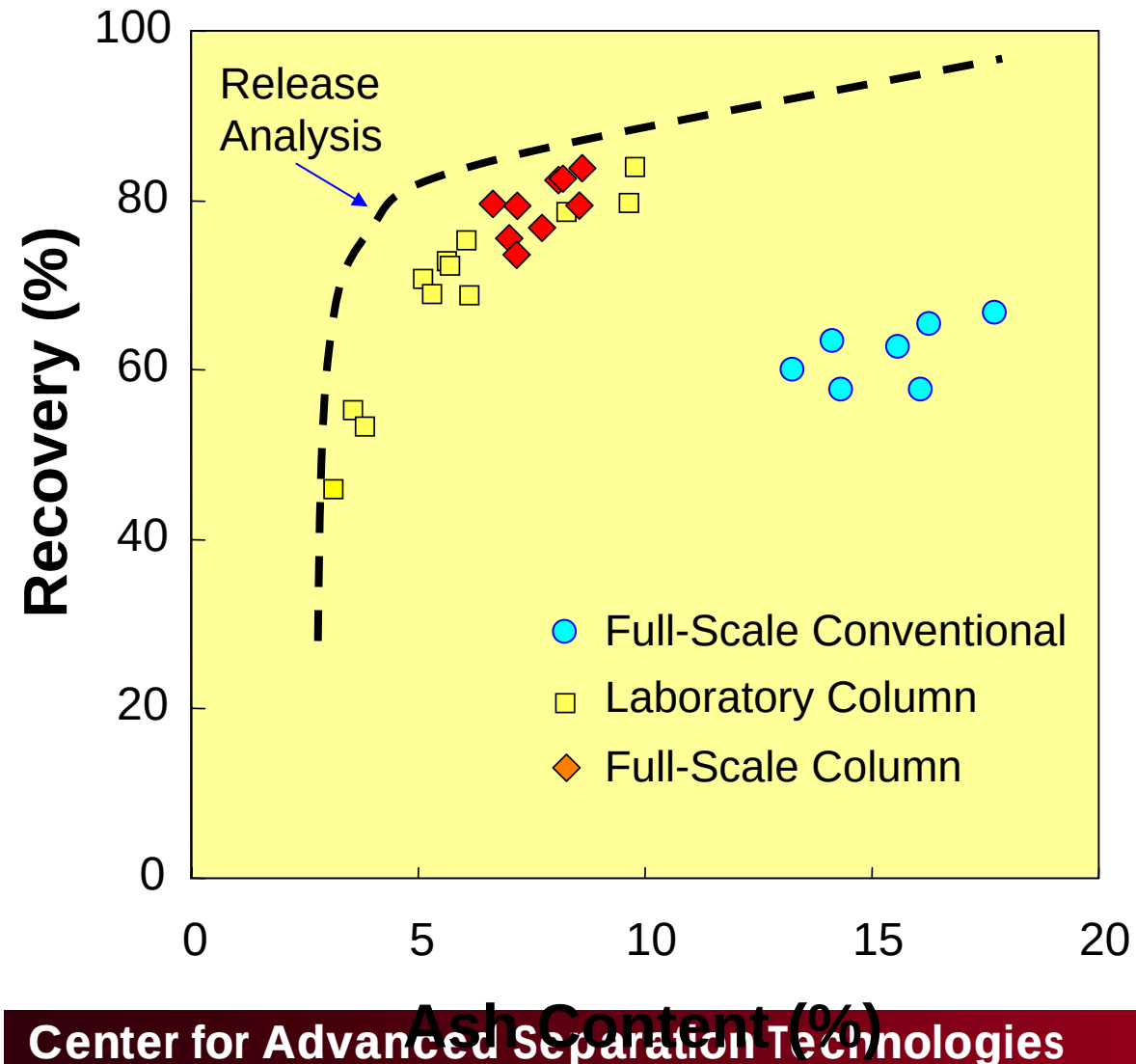
- 3 billion tons of fine coal
  - *In 713 impoundments*
  - *Mostly in Central Appalachia.*
- Main cause
  - *Lack of appropriate Separation Technologies*
    - *Solid-Solid (Fine particles)*
    - *Solid-Liquid (Dewatering)*



Application of Advanced Separation Technologies

- **Use of advanced separation technologies at Middle Fork**
  - ***Recovered coal***
  - ***Reuse of impoundment***
    - ***No new impoundment***
    - ***No new permits***

Microcel Flotation



Recovery:
60.1% vs. 79.9%

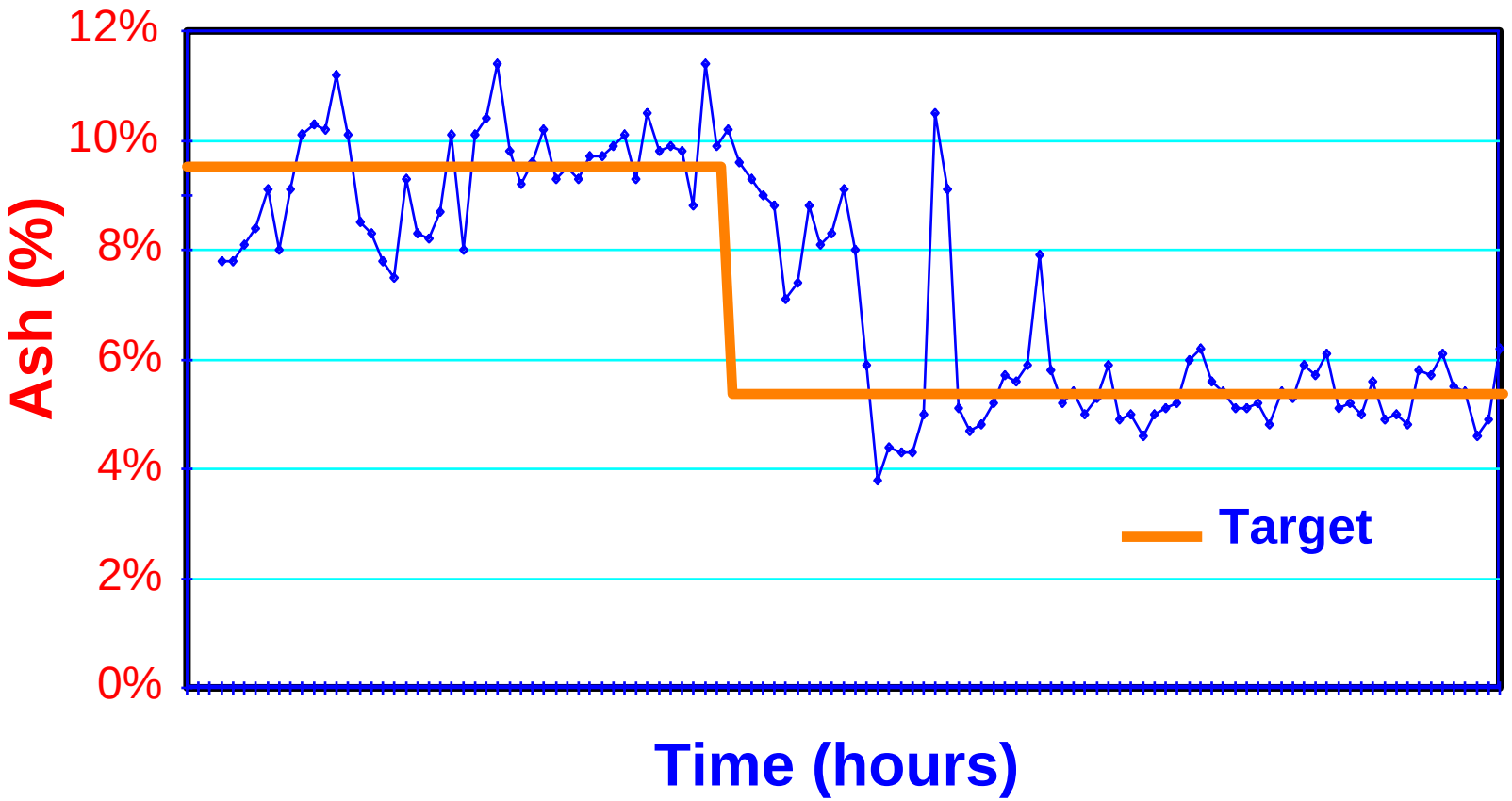
Yield:
38.9% vs. 47.8%

Tonnage:
38.9 vs. 47.7 tph
(8.9 tph gain)

Value:
$1.86 MM/yr

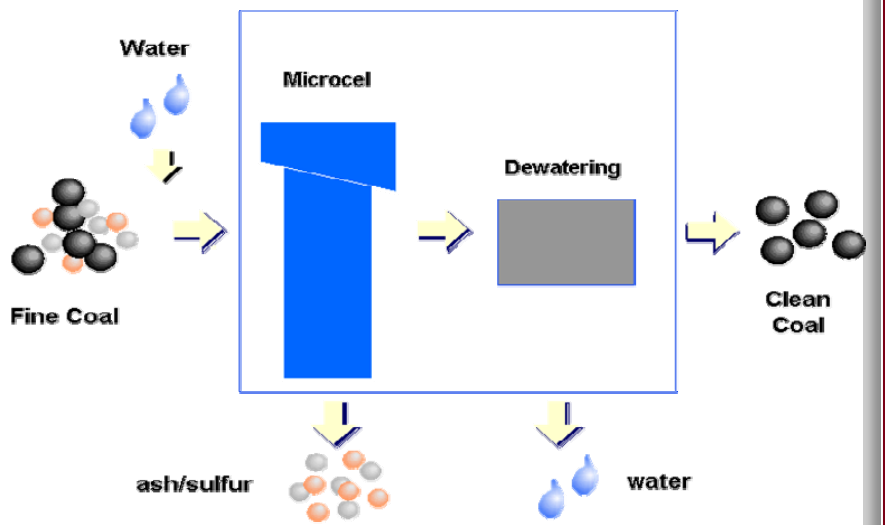
Microcel Flotation

Cleaner Coal at BHP Billiton



Advanced Coal Cleaning Technologies

- Microcel flotation
- Dewatering
  1. *Dewatering aids*
     - *Licensed to Nalco*
     - *Pinnacle pond recovery plant*
       - *Due to completion in January 2006*
  2. *Hyperbaric centrifuge*
     - *Licensed to Decantor*
     - *Pilot-scale tests is being carried out*
  3. *Hyperbaric horizontal belt filter*
     - *Pilot-scale tests planned in 2005*
  4. *Dewatering by displacement*
     - *An engineering company is exploring commercialization potential*
  5. *Polymer injection system for Screen-bowl centrifuges*
     - *18 installations*



Pond recovery at Pinnacle Mine

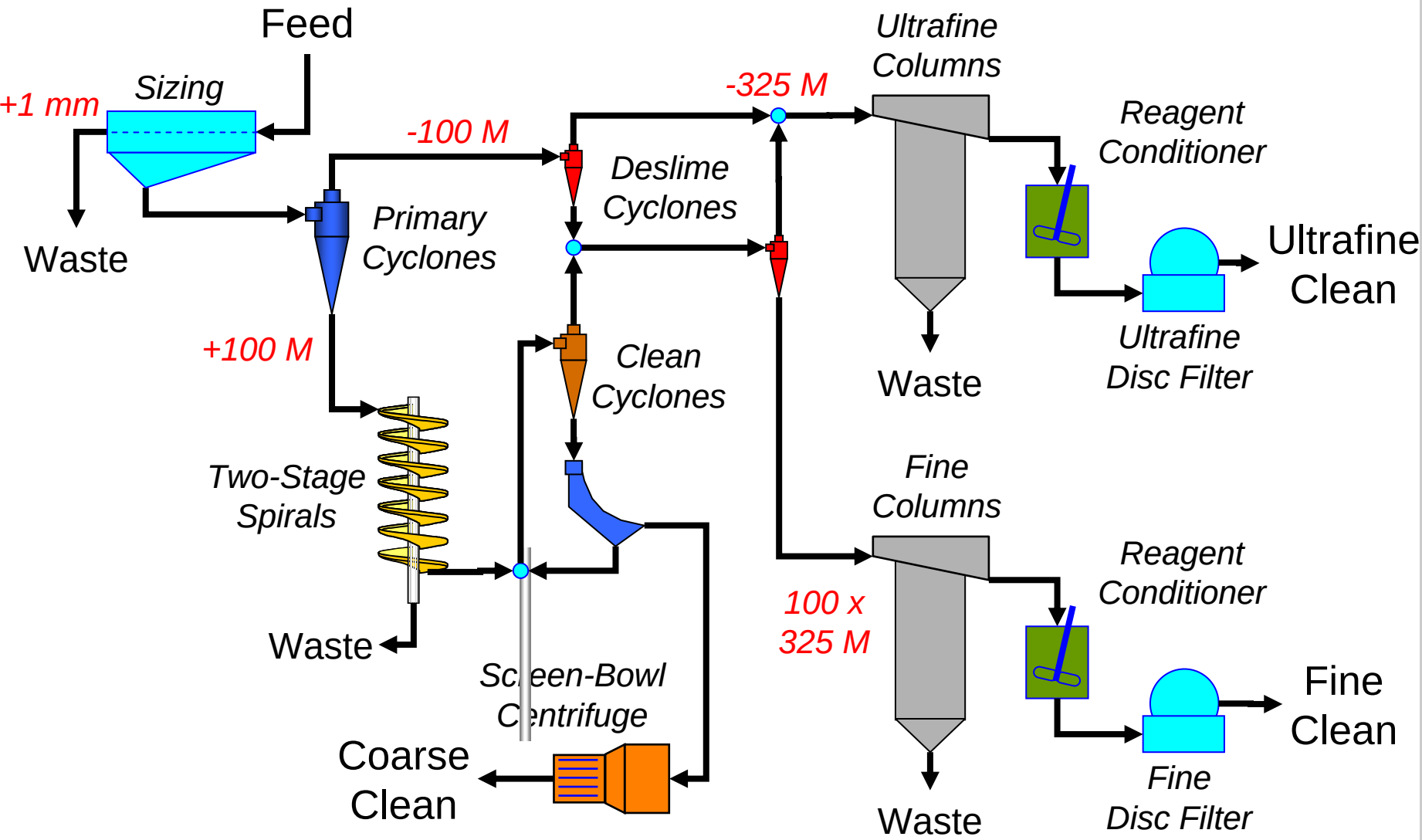
Wyoming County, WV

- Pilot-scale tests
  - *Moisture reduction*
    - *From 29% to 16%*
  - *Throughput*
    - *2-3 times higher*
  - *200 tons/hr plant is being built by Bea Technologies*

Dewatering Aids (2)

Pinnacle plant flowsheet

(due to completion in January 2006)

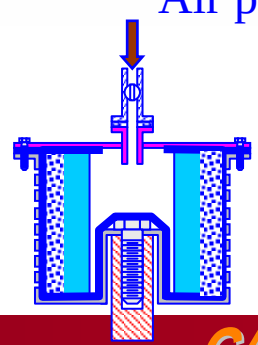


Hyperbaric Centrifuge

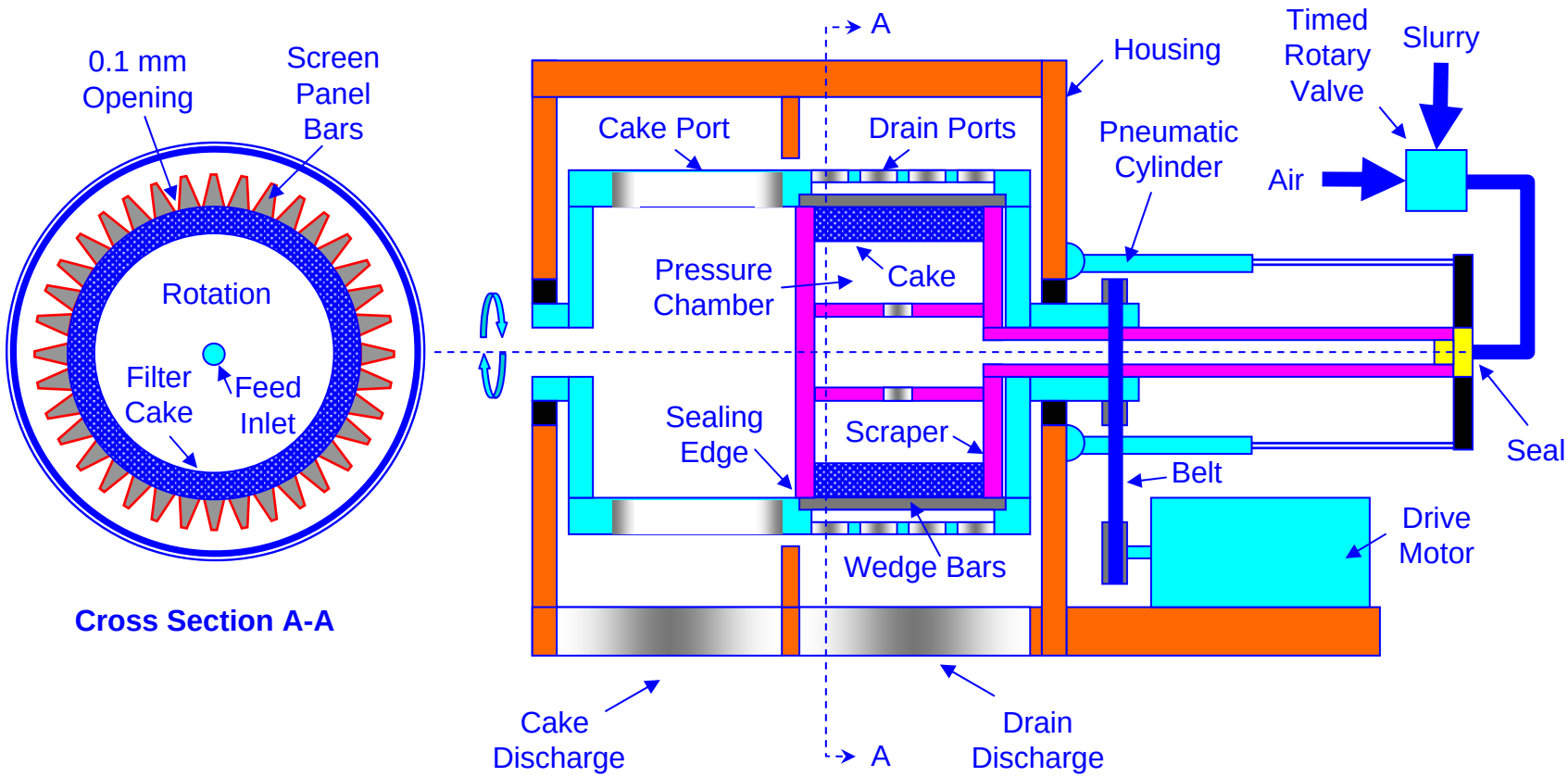
Table 60 Effect of Using Compressed Air for the Centrifugal Filtration of a Pittsburgh Coal[3]

Drying Cycle or Centrifugation Time (sec)	Cake Moisture (wt %)		
	Air Pressure[1] Alone	Centrifugal Force[2] Alone	Centrifugal Force[2] & Air Pressur[1]
30	27.5	24.4	14.2
60	25.8	22.6	12.9
120	23.8	21.0	10.6

[1] 100 kPa of air pressure; [2] 2000 G; [3] 0.45 inch cake thickness.

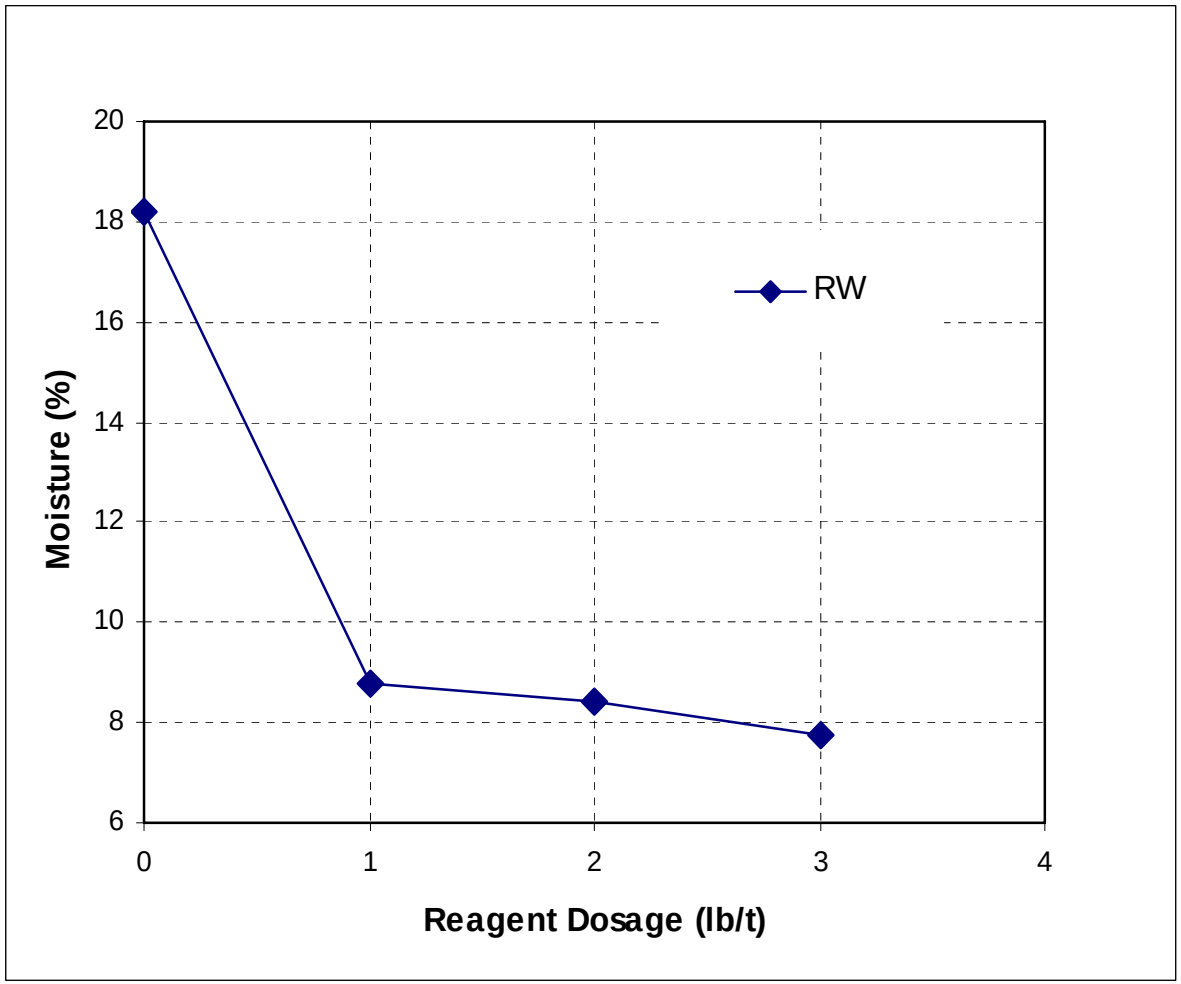


Semi-continuous unit



Hyperbaric Belt Filter (1)

Filtration at 30 psi (2 bar) gives <10% moisture.

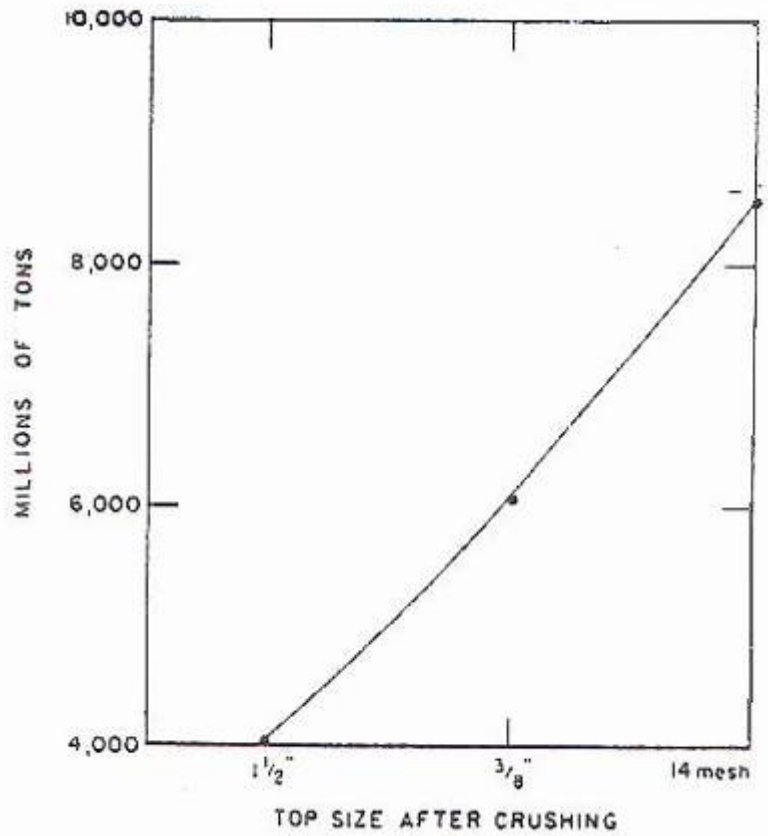


Dewatering by Displacement (2)

Butane Dewatering Test Results and Potential Impact on U. S. Coal Reserve

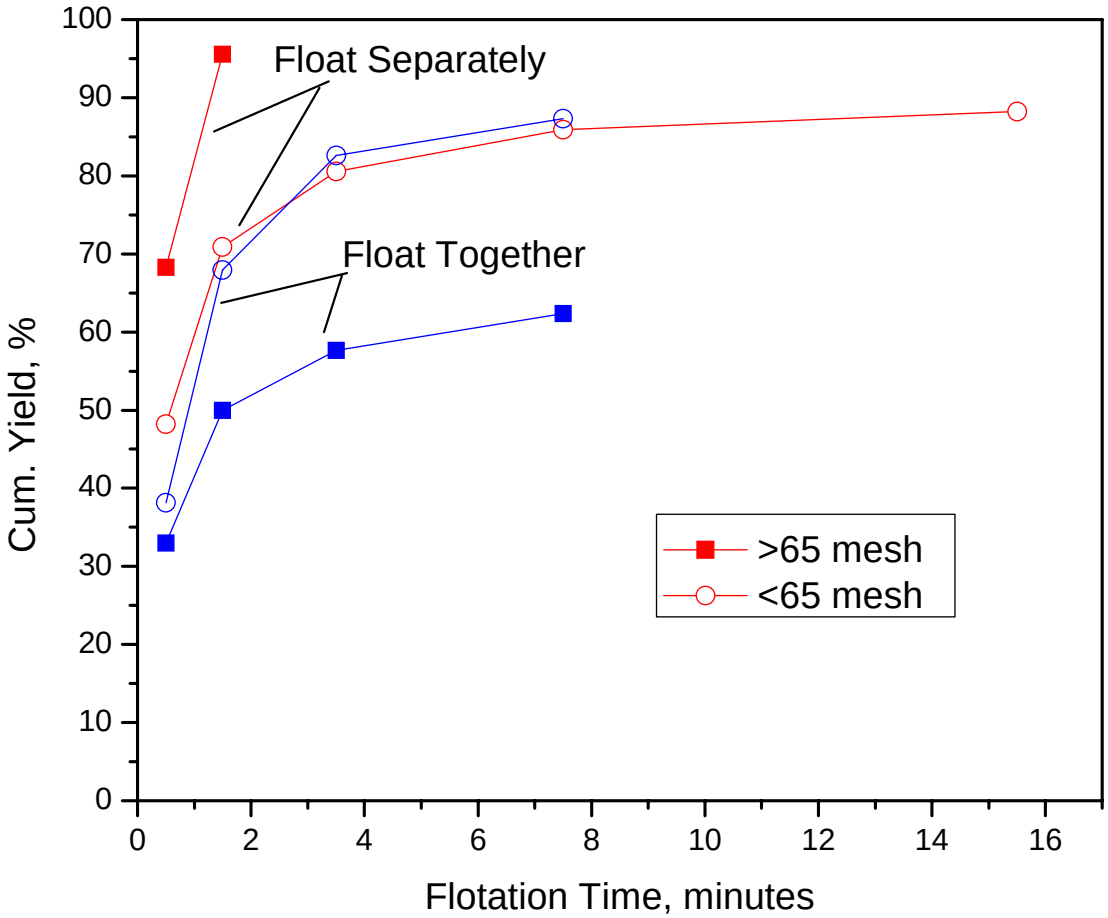
Results show that dry coal can be obtained without thermal drying.

M_b/M_c Ratio	Percent Moisture at Specified Feed Solids Content		
	5% Solids	15% Solids	30% Solids
0.5	---	15.1	9.6
0.75	---	10.7	6.5
1.0	12.5	8.8	>1.0
1.5	5.5	3.5	---
2.0	1.4	1.1	---



By decreasing the top size of the coals cleaned from 1.5 inches to 14 mesh, US can double its reserve for compliance coal (DOE report by Cavallero, et al. 1991)

Indian Coal


Float Separately
Float Together
>65 mesh
<65 mesh
Cum. Yield, %
Flotation Time, minutes
0
10
20
30
40
50
60
70
80
90
100
0
2
4
6
8
10
12
14
16

A Solution for Indian Coal