Hot Gas Filtration GdPS

A route map and summary of options available and merits of each based on purchasers unique circumstances

Modified for AFS April 29 Discussion

Table of Contents

Program Overview

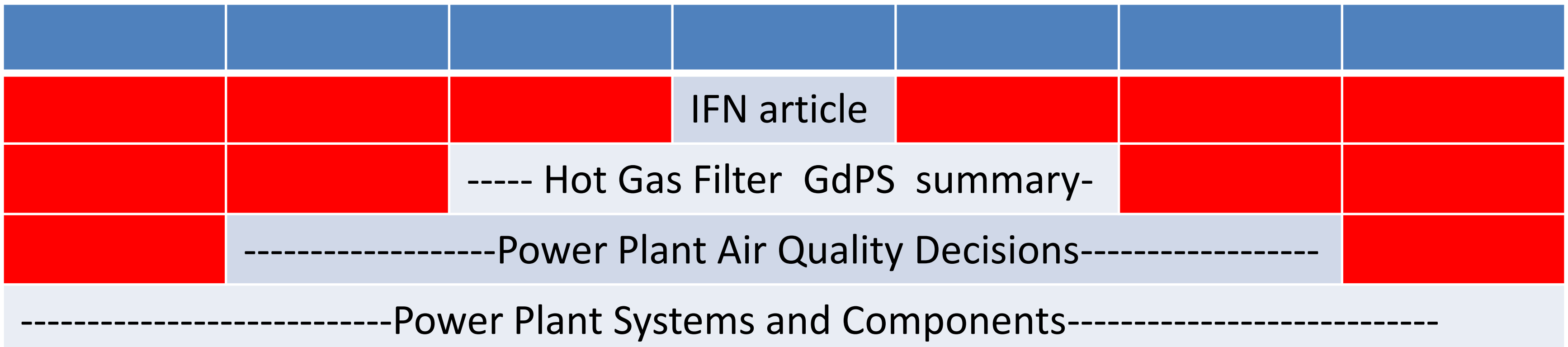
General

- The 90 minute session will be focused on a slide by slide display of the summary power points.
- As each slide is displayed there is the opportunity for discussion. It would start with the slide author if he so wishes
- Designated panelists as well as the entire group will be encouraged to ask questions and make observations
- Panelists and participants are encouraged to submit power points to be included in the summary
- Anyone is encouraged to submit articles and presentations for inclusion in the Intelligence System
- The Filtration News article in June will be based on the conclusions reached in the session
- The summary and the intelligence system will be continually updated

“Specific

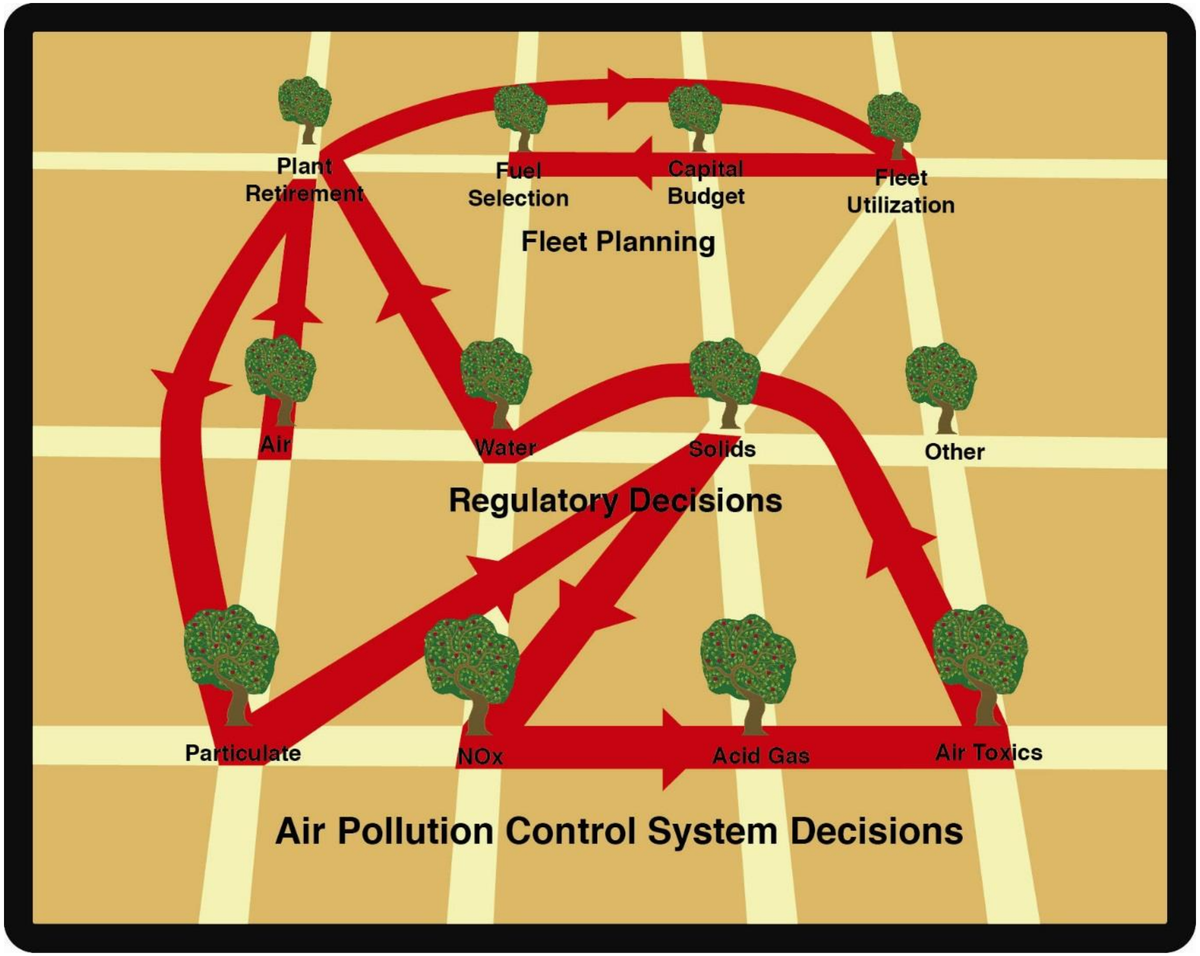
- Provide access to hot gas filter GdPS upon registration
- Provide updated version of HGF GdPS prior to the event
- Provide contact among presenters and attendees before , during and after the event.
- Conduct the program as a series of panels
- Presenters sit at designated tables during lunch and continue discussions
- Continuing upgrading of Hot Gas Filter GdPS and articles in IFN

Hot Gas Filter Summary is part of a whole system



The summary is part of a whole system. It is route map to the larger database display (Power Plant Air Quality Decisions) This in turn is part of a complete service for coal fired power plant operators- *Power Plant Systems and Components.* The June Filtration news article will be a compressed version of the revised summary as shaped by the AFS session.

Global Decision Positioning System (GDPS) to select hot gas media



Panelists

Company	Name
AEP	Tom Hart
Consultant	Rich Miller
Donaldson	Eddie Ricketts
ETS	John McKenna
Haldor Topsoe	Nate White
Purolator	Pavlos Papadopoulos
Testori	Clint Scoble

Regulatory, Economic and plant specific impacts on filter choice.

Power Points and Authors 1

Subject	Author
Regulations and Technology	Mcilvaine
Emission limits-World	Mcilvaine
China limits	Mcilvaine
U.S. regulations	Hot topic
Cement and other	Mcilvaine
PM 2.5 ambient	Troutman - Sanders
Condensibles	Siemens
Method 5 catch	Siemens

Power Points and Authors 2

Subject	author
TBD	
TBD	
TBD	
TBD	
TBD	
TBD	
TBD	
TBD	
TBD	

Regulations and technology are changing the hot gas filter choices

- China and the U.S. are leading the way with tough particulate emission requirements for power plants.
- Ambient regulations in U.S. states and counties as well as stack regulations for certain cities and provinces in China are much tougher than the national requirements
- The definition of particulate involves size fractions e.g 2.5 microns and physical state (discrete or condensable)
- Requirements involve new and existing installations each with a different set of site specific conditions
- The need to reduce mercury, other toxic metals, HCl, and SO2 changes the particulate reduction decisions.
- Upgrading dry precipitators with new electricals is one option
- One very active retrofit option is replacing the internals of precipitators with fabric bags.
- Wet precipitators are being used in some of the newer U.S. and Chinese installations
- Various dry scrubber/ fabric filter combinations are popular
- The ceramic catalytic filter offers potential of small foot print and with DSI can also capture acid gases.
- Metal filters offer an alternative separation at temperatures of 850F and extraction of heat from the clean gas.

Emission limits for coal plants around the world in mg/Nm3

pollutant	China Guangzhou, Shanxi	Sinopec Guangzhou	Zhejiang with SCR and WESP	China national regional l	U.S Existing/new	EU Existing/new
NOx	50	1.4 to 28.5	23,7	200/100	1060-640/117	200/200
SO2	35	2.85 to 7.6	15	200-400/100	350/65	400/200
PM	5	3.4 to 4.6	3.08	30	45/8	50
SO3	5	0.08				
Hg	0.003	0.0004 ug		.03	0.002/0.001	

China now has the most stringent particulate limits

- Due to pressure from citizens due to smog, the Chinese government is initiating the toughest air regulations of any country
- Tough national standards have now been followed by even more stringent standards in a number of cities and even provinces
- the new national standard of 30 mg/Nm3 for particulate was already tougher than the regulation for existing U.S. coal plants or for plants in the EU.
- The new regulation in Guangzhou and Shanxi limits dust to only 5 mg.
- Existing precipitators will not be able to meet these limits. Zhejiang is meeting the new requirements with a wet precipitator.
- Sinpoec Guangzhou is meeting the standards with a dry scrubber fabric filter system complete with activated carbon injection installed by Longking

U.S regulations will dictate new hot gas filter approaches

McILVAINE

MATS and CSAPR

Mercury and Air Toxics Standards (MATS)

- Limits emissions of toxic air pollutants from coal and oil fired power plants
- Primary pollutants of concern are mercury, hydrogen chloride (HCl) and fine particulates ($PM_{2.5}$)
- FINAL RULE: Compliance by April 2015 with possible extensions of up to 2 years

Cross State Air Pollution Rule (CSAPR)

- Referred to as the "Good Neighbor" rule
- Regulates emissions from one state that may have a negative impact on air quality in a downwind state
- 28 states in the eastern half of the U.S. must limit state-wide emissions of precursors to ozone formation (NOx, SO_2 and $PM_{2.5}$)
- FINAL RULE issued August 2011 with first phase to begin in 2012
  - But, the rule did not take effect as scheduled due to litigation
  - August 2012: US Court of Appeals vacated the rule and remanded it to EPA
  - April 2014: US Supreme Court reversed Court of Appeals and reinstated CSAPR
  - November 2014: EPA issued new compliance dates of 2015 to 2017

Together, MATS and CSAPR will require coal plants to install:

- FGD or Dry Sorbent Injection (DSI) to control SO_2 and acid gases (HCl)
- SCR or SNCR to control NOx
- Fabric filters or electrostatic precipitators to control particulate matter
- Activated carbon injection units to reduce mercury

Cement, power and other industries have tight emission standards

- Waste to energy plants have been subjected to tight particulate limits for some time
- Cement plants are finding that precipitators are inadequate to meet regulations in most countries
- The new MACT regulations in the U.S. provide tough requirements for industrial boilers and cement plants
- The MATS regulations in the U.S. provide particulate challenges related to using particulate as a surrogate for toxic metals
- Mining operations, pulp mills and other industries are also facing the necessity of improving particulate capture
- Particulate removal GDPS™ has to take into account the requirements for reduction of other pollutants

PM 2.5 ambient standards will require reduction

TROUTMAN SANDERS
ATTORNEYS AT LAW

Fine Particulate Matter ($PM_{2.5}$)

- Lowered annual standard to 12 ug/m^3 in December 2012
- EPA expects all areas to attain without new control requirements (except CA)
- Vacatur of de minimis levels (SILs and SMCs) could make permitting difficult
  - w/o SMCs, could require onsite monitoring
  - w/o SILs, could make modeling more difficult
- EPA's implementation rule also vacated
- EPA resets the baseline date; NC objects

PM 2.5 includes fiterables and condensibles

SIEMENS

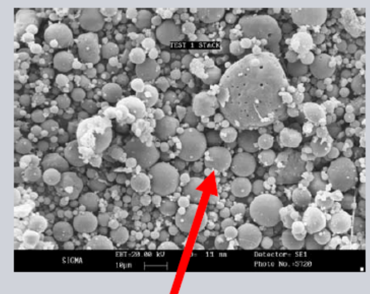
What is $PM_{2.5}$?

Filterable Particulate

- <2.5 microns in size
- Exists as solid particulate at temperatures of 250°F or higher
- Collected in “front-half” filter of PM test apparatus
- Represents @ 25% of $PM_{2.5}$ emitted by sources

Condensable Particulate

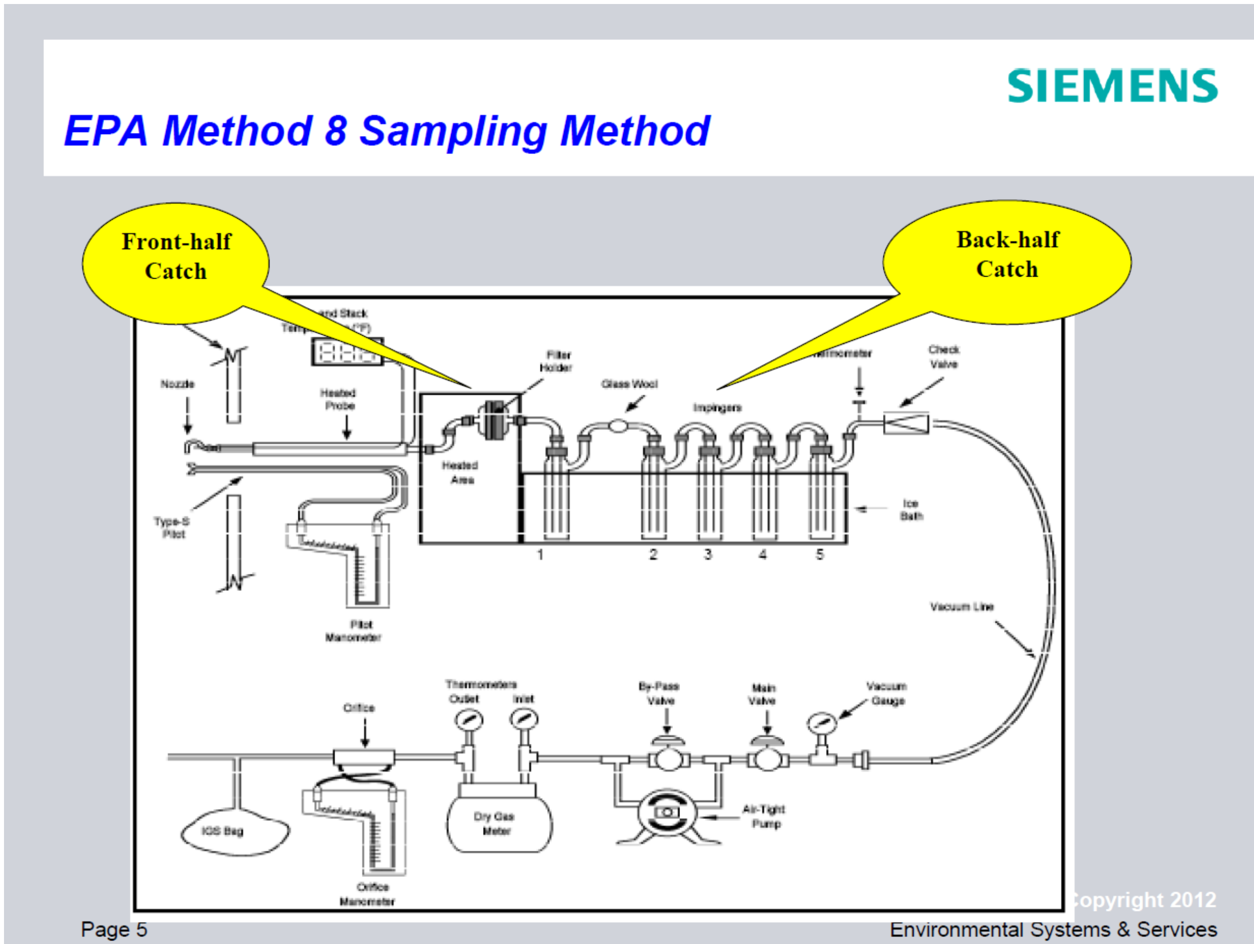
- <2.5 microns in size
- Vapors that condense at ambient temperatures
  - SO_3 – H_2SO_4 sulfuric acid mist (@ 0.5 micron)
  - Toxic metals – cadmium, chromium, lead, magnesium
- Collected in “back-half” impingers in PM test apparatus
- Represents @ 75% of $PM_{2.5}$ emitted by sources
- Has not been required to date to meet PM_{10} standards



10 µ particle

Environmental Systems & Services

Condensibles captured in back half of sampling train



Decision Route – Reasons to address hot gas alternatives

Webinars

March 5, 2015	**Mercury Measurement and Capture (Session 2)** 105 minutes MORE
February 26, 2015	**Mercury Measurement and Capture** 106 minutes MORE
January 29, 2015	**MATS Compliance Choices** 91 minutes MORE
January 8, 2015	**Fabric Selection for Hot Gas Applications** 120 minutes MORE
October 23, 2014	**Dry Scrubbing** 104 minutes MORE
October 2, 2014	**Precipitator Improvements** 84 minutes MORE

Intelligence system key words

categorys	keywords
regulatory	CSAPR. Industrial Boiler MACT Legislation MATS NAAQS
Analysis by consul-ants	AECOM, Burns & McDonnell, Farber Golder, Kiewit, Sargent & Lundy
Other organiz-ations	EPRI, EERC, Reaction Engineering, Troutman-Sanders

Existing APC and Process Impact

Power Points and Authors 1

Subject	Author
System Impacts	Mcilvaine
Boiler efficiency-APH	Paragon

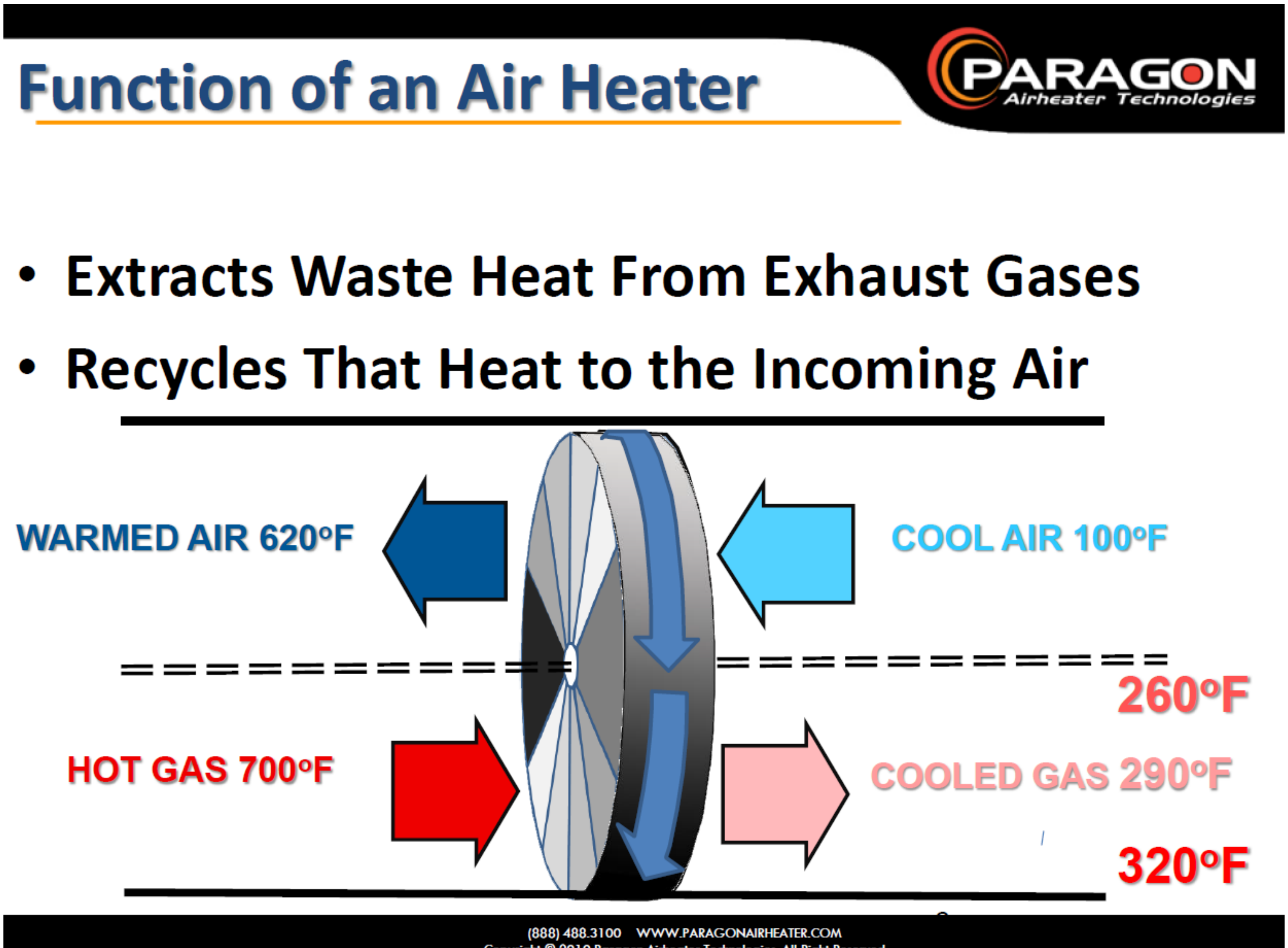
Power Points and Authors 2

Subject	author
TBD	
TBD	
TBD	
TBD	
TBD	
TBD	
TBD	
TBD	
TBD	

System impacts

- Heat extraction decisions must be made simultaneously with particulate control because of the inter-relationships
- The precipitator efficiency increases as the inlet temperature is reduced.
- The ability to use lower cost bags is enhanced by reducing both the gas temperature and the acid dew point
- Reduction of precipitator or baghouse inlet temperature to the acid dew point will cause corrosion and plugging problems
- Clean hot gas offers a big potential for energy recovery
- Existing rotary air heaters have inlet air leakage of 10% making the dust collectors larger than need be
- The SCR increases SO_3 which will lead to more condensable particulate
- Activated carbon for mercury control increases particulate emissions
- Dry scrubbers increase the particulate load and potential emissions and wear on bags
- Wet scrubbers downstream of a precipitator can improve total particulate capture

Boiler efficiency is a function of heat transfer in the air heater but limited by the acid dew point



Decision Route – System impacts

Webinars

March 5, 2015	**Mercury Measurement and Capture (Session 2)** 105 minutes MORE
February 26, 2015	**Mercury Measurement and Capture** 106 minutes MORE
January 29, 2015	**MATS Compliance Choices** 91 minutes MORE
January 8, 2015	**Fabric Selection for Hot Gas Applications** 120 minutes MORE
October 23, 2014	**Dry Scrubbing** 104 minutes MORE
October 2, 2014	**Precipitator Improvements** 84 minutes MORE

Intelligence system key words

category	keywords
products	Air heater, SCR, SO3, PM 2.5
Analysis by consul-ants	AECOM, Burns & McDonnell, Farber Golder, Kiewi, MHPS, Paragon, Sargent & Lundy
Other organiz-ations	EPRI, EERC, Siemens

Precipitator/Scrubber Options

Power Points and Authors 1

Subject	Author
All options	Mcilvaine
Upgrade precipitator	KC Cottrell
Component upgrade	KC Cottrell
Recent SEI designs	SEI
Wet precipitators	Mcilvaine
Wet ESPs	Siemens
WESP and SO3	Mcilvaine
Siemens recent installations	Siemens (now Foster Wheeler)

Power Points and Authors 2

Subject	author
Scrubber PM capture	Mcilvaine
Dry scrubber, baghouse	longking
Dry sorbent injection	Lhoist
Reagents create PM 2.5	
TBD	
TBD	
TBD	
TBD	
TBD	

Options to meet tough particulate emission limits

- Upgrade existing precipitator with new more efficient electricals
- Buy a larger precipitator- may have to double size
- Use sorbent injection prior to the air heater to reduce the acid dew point and then make the air heater bigger to reduce the precipitator inlet temperature and improve efficiency
- Install a wet precipitator after the existing precipitator and scrubber
- Replace the precipitator with a fabric filter
- Add precipitator after the fabric filter
- Replace the precipitator with a hybrid fabric filter/ESP
- Combine particulate and scrubbing in one system with a dry scrubber and fabric filter
- Install a catalytic filter or hot gas filter to meet 850 F.

Upgrade ESP to meet MATS

ESPs for MATS Compliance

KC Cottrell Inc.

- Many existing power stations use ESPs for particulate collection.
- A properly designed ESP can achieve the required MATS limit for PM.
- Existing ESPs designed for previous limits may not need to be replaced.
- A variety of upgrade options can be employed, many in parallel, to improve performance.
- There is no single solution.

Specific upgrade options-KC Cottrell

ESP Upgrade Options

KC Cottrell Inc.

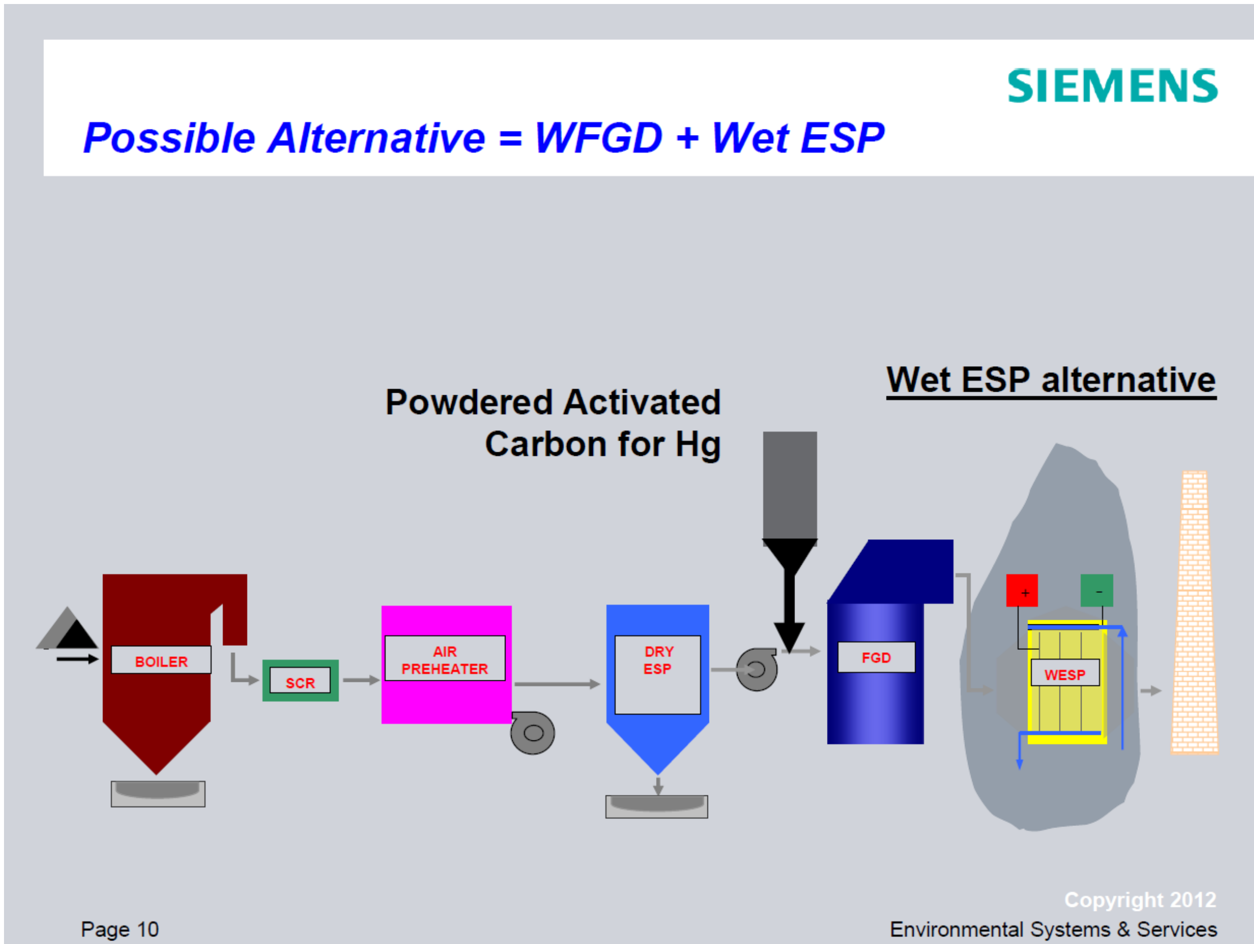
- Improve gas distribution
- Change Internals – collectors, electrodes
- Improve Rapping
- Modern control systems
- Increased power: more T/R sets
- High Frequency T/R sets
- Raise the roof
- Additional inlet/outlet fields
- New parallel ESPs
- Conversion to baghouse

Recent SEI Designs

Wet precipitators can be part of the most elaborate or simple system

- The ultimate system has an SCR, fabric filter, wet scrubber, and then a final wet electrostatic precipitator
- Often overlooked is the simple option as follows
  - A lime wet scrubber captures particulate and SO2
  - A downstream Wet Esp removes the remaining particulate
  - The two can be combined in one tower
- Advantages
  - Low cost and easy retrofit
  - Flyash/lime/gypsum encapsulates the mercury and toxic metals
  - Good landfill material
  - High efficiency

Wet ESP is very efficient device for SO3 and total particulate capture



Wet ESPS for SO_3 and fine particulate

- Several WESPS were installed in U.S. to reduce the SO_3 plume in the period around 2000
- Subsequently the solution to SO_3 was determined to be dry injection
- However, WESPS have been installed on new plants to capture both the SO_3 and fine particulate
- Siemens was the major supplier (now Foster Wheeler)

Wet precips used for PM 2.5 and H2SO4 at some new U.S. plants

SIEMENS

New Coal Plant WESPs not in ICR Data

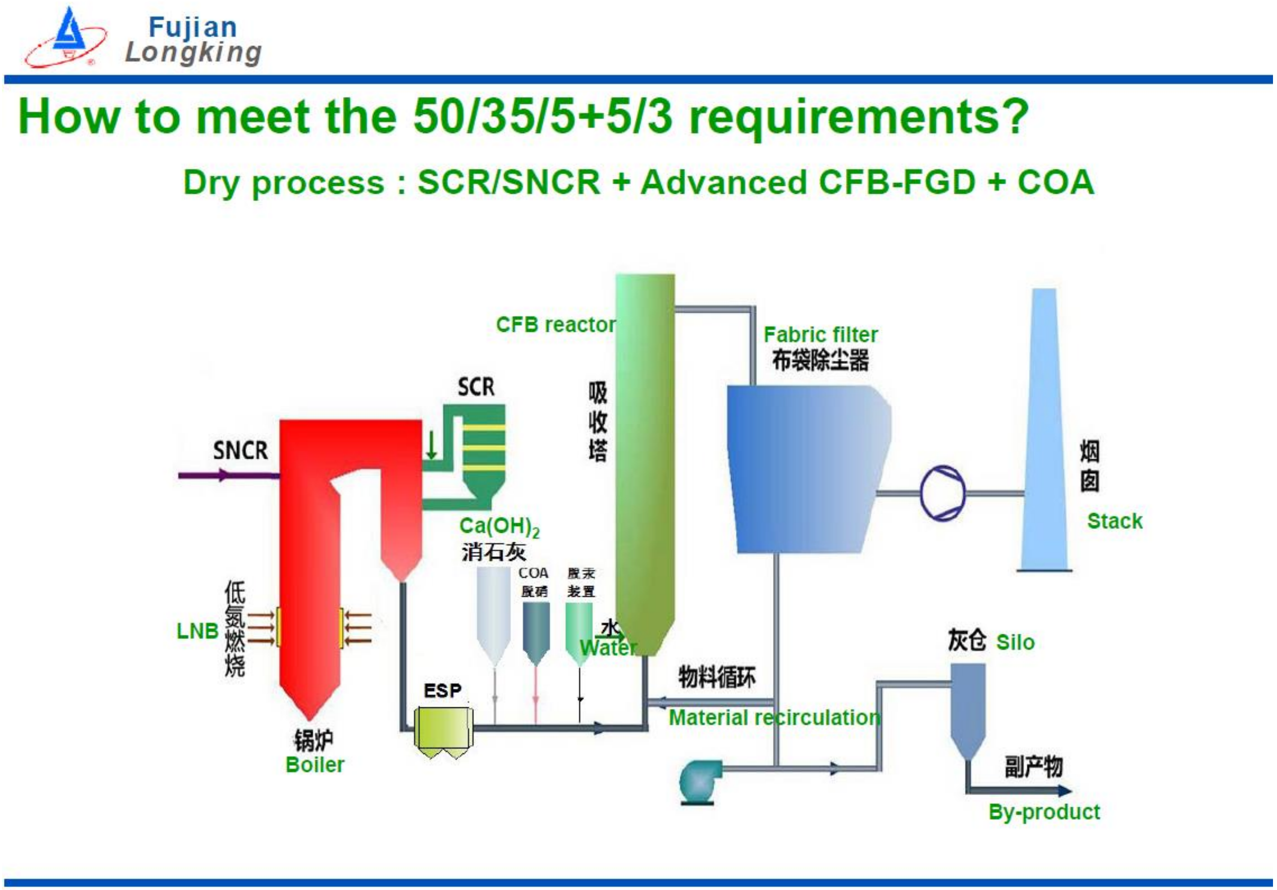
Facility	Unit Size (MW)	Fuel	APC Control Technology	Status
Elm Road	2 x 615	Pittsburgh #8	FF / WFGD / WESP	Online
Trimble County	750	Blend of Bituminous & Sub-bituminous	ESP / FF / WFGD / WESP	Online 2011
Prairie States	2 x 750	Southern IL Bituminous	ESP / WFGD / WESP	Summer 2012 & Fall 2012

Environmental Systems & Services

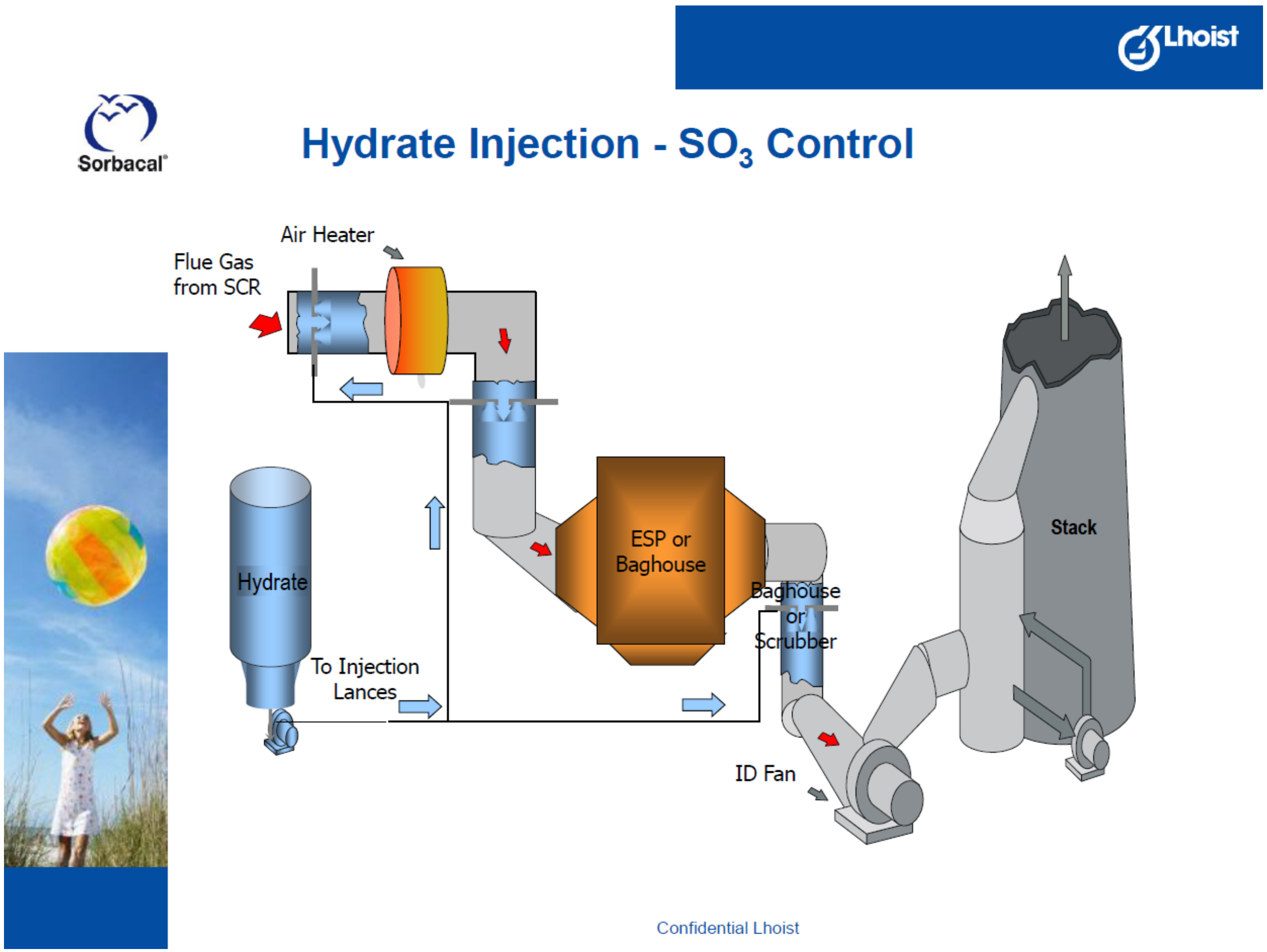
Scrubber capture of fine particulate

- Typical spray tower wet scrubbers do not remove much particulate if there is an efficient precipitator ahead of it
- A tray tower scrubber is slightly more efficient
- During an exceedance the scrubber can remove most of the particles
- At an emission of 0.2 lbs /mm btu from the precipitator, the scrubber will capture more than 0.l lbs/mm btu
- Wet scrubbers do not remove much SO3 when it is converted to sub micron hydrochloric acid aersosols
- With the new mass monitoring requirements particulate must be measured in the wet stack following the scrubber
- If the scrubber adds to or reduces the particulate it will now be recorded. Previously opacity monitors prior to the scrubber were the basis of determining excedances

Dry scrubber , fabric filter to meet the low emission rates.



Hydrated lime injection at 3 points



Reagents generate particles smaller than 2.5 microns

Membrane: Improves Filtration Efficiency

- Many utilities will be forced to add and/or increase their sorbent injection levels to comply with lower HG/HCL/acid gas emission limits.
- Several of these sorbents including Powder Activated Carbon (PAC), Trona, and lime products can have portions of their particle size distributions less than 2.5 microns.
- A higher efficiency membrane filter will allow these very fine/ submicron sorbent fractions to be filtered more reliably and efficiently.

Decision Route – Precipitator, scrubber

Webinars

October 23, 2014	**Dry Scrubbing** 104 minutes **MORE**
October 2, 2014	**Precipitator Improvements** 84 minutes **MORE**

Intelligence system key words

category	keywords

Fabric filter Synthetic media

Power Points and Authors 1

Subject	Author
Depends on locatiion	Mcilvaine
Influence of conditions	KC Cottrell
Media selection parameters	Mcilvaine
Fiber shape	Testori
Media characteristics	
Fiber blends	Testori
Finishing /treatment	Testori
Membrane comparison	Donaldson

Power Points and Authors 2

Subject	author
Surface vs Depth	Donaldson
Clean filter efficiency	Donaldson
High temperature media options	IEA
Relative bag costs	ETS
Media selection	Testori

Fabric Filters for hot gas filtration

- Fabric filters can be prior to or after the SO2 scrubbing device
- Various cleaning mechanisms impact bag and media selection
- A range of fibers and media is available depending on widely varying site specific condtions

Bag material considerations-KC Cottrell

Bag Material Considerations

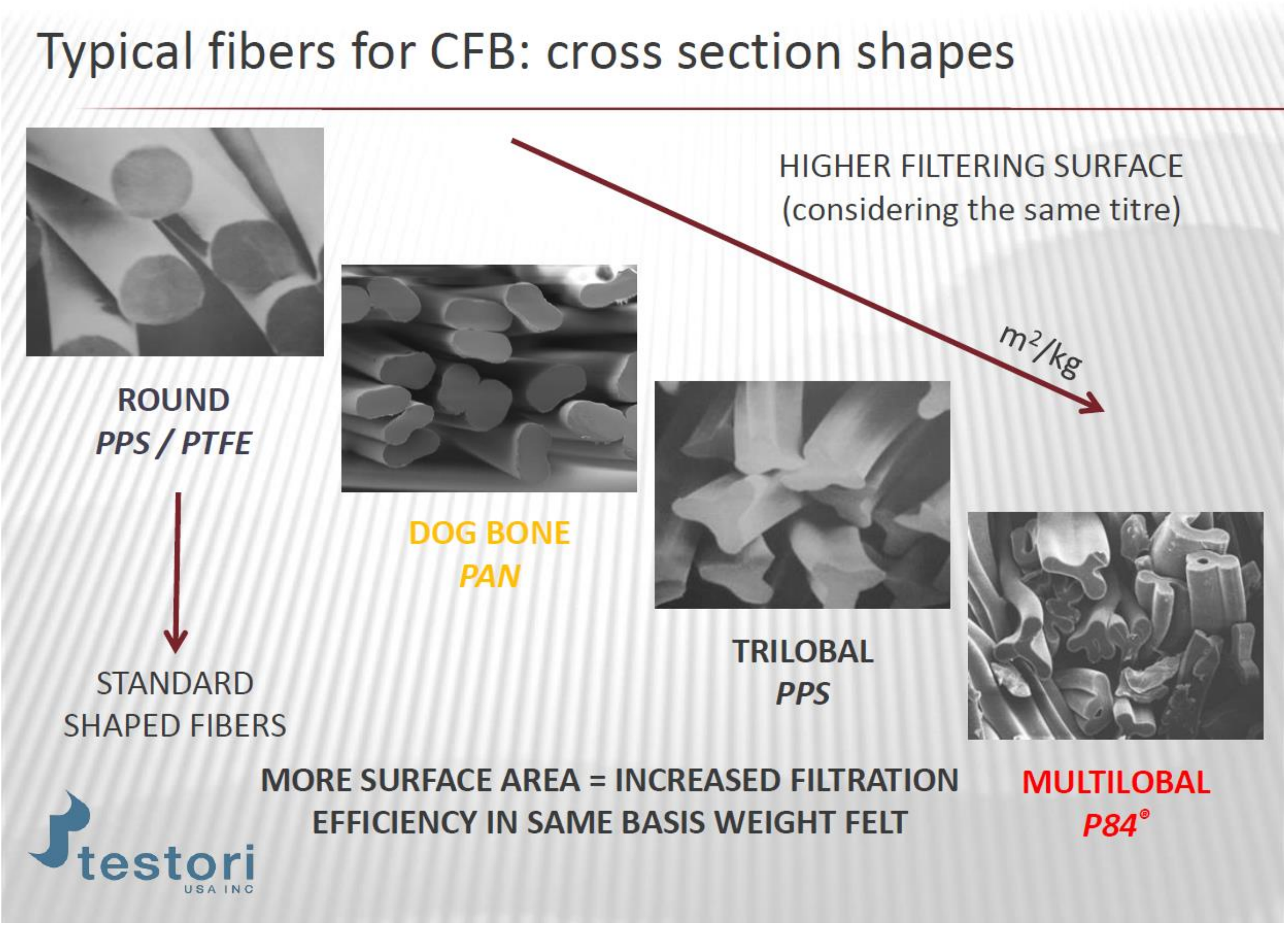
KC Cottrell Inc.

- Operating temperature
- Moisture
- Chemistry
- Abrasion resistance
- Filtering Mechanism
  - Depth vs. Surface Filtration

Parameters affecting media selection

Subject	options					
fiber	pps	P84	ptfe	glass	ceramic	acrylic
media	Non woven	Membrane laminate	woven	sintered		
Plant conditions	Emission limit	Area available	Fan lmits	Mercury removal	SCR	FGD
gas	Flyash load	Sulfuric acid	Sulfates/	Activated carbon	temperatu re	Other acid gases
Bag shape	Tubular	Pleated	cartridge			
cleaning	Hi vol med Pressure air	High pressure air	Reverse air	shaker		

Fiber shape-Testori



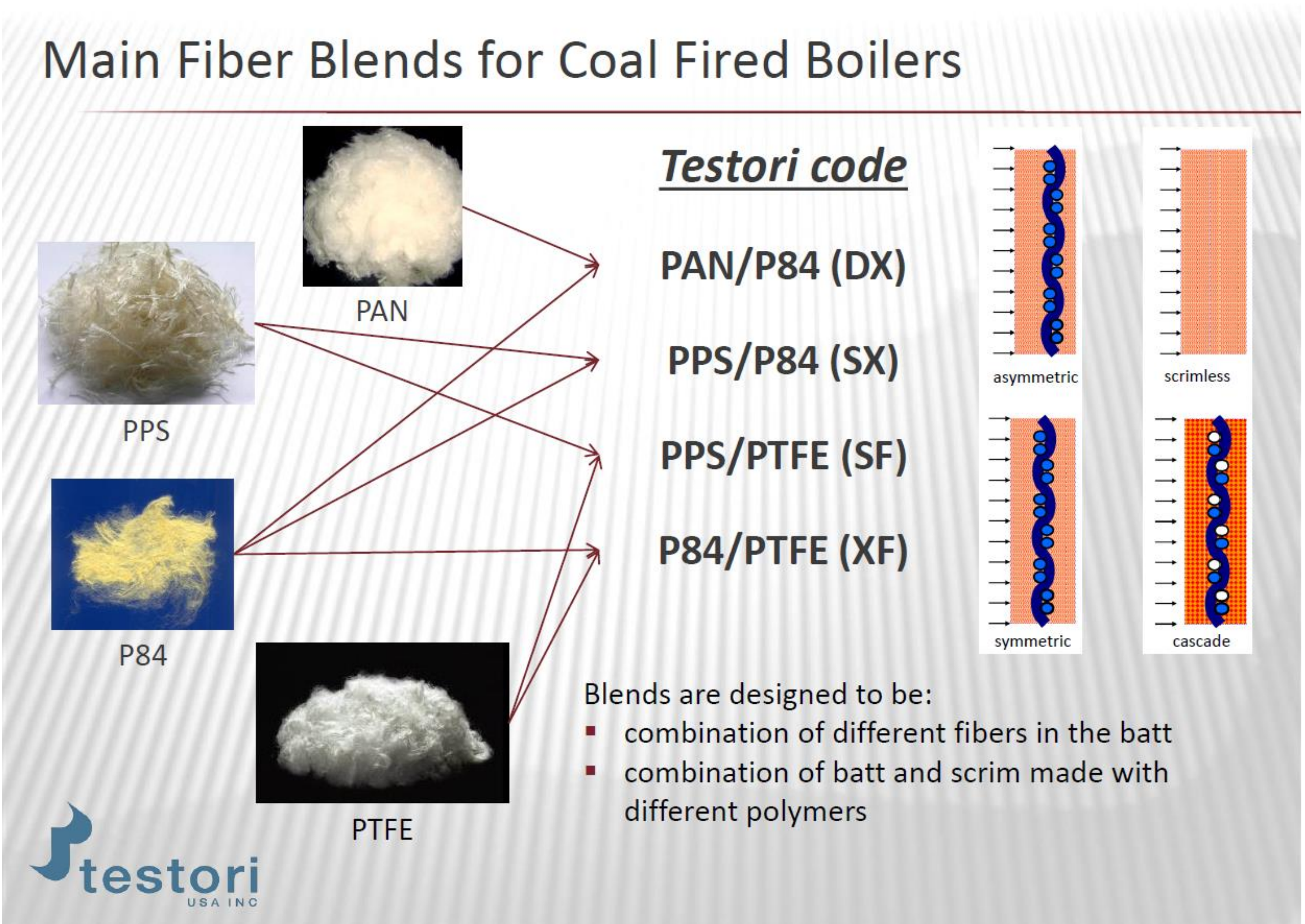
Dust Collector Fiber Options

Material Characteristics

Fiber Type	Maximum Operating Temperatures Degrees F (C) Dry Heat	Moist Heat	Chemical Resistance Strong Acids	Weak Acids	Strong Alkalis	Weak Alkalis	Solvents	Oxidizing Agents	Hydro-lysis
UHMWPE	176 (80)		****	****	****	****	****	****	****
Polypropylene	200 (93)	200 (93)	****	****	****	****	****	***	****
Polyester	275 (135)	200 (93)	***	***	*	**	***	****	*
Nylon (Polyamide)	250 (121)	225 (107)	*	***	***	***	***	***	**
PTFE	500 (260)	500 (260)	****	****	****	****	****	****	****
Glass	500 (260)	500 (260)							

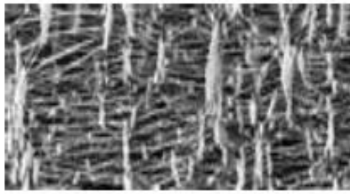
Hydrophobic versus Hydrophilic
Oleophobic versus Oleophilic

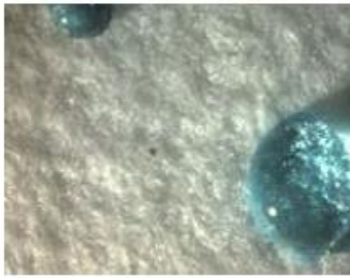
Fiber Blends for coal fired boilers

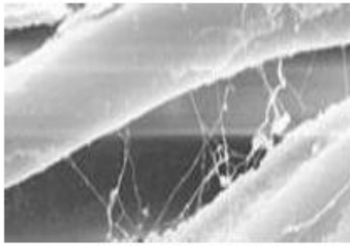


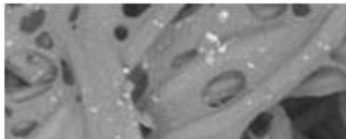
Needlefelts: Finishing and Treatments for CFB

	Description	*Fibers*	*Benefit*
ePTFE MEMBRANE	Expanded PTFE membrane laminate on the dust side	PAN, PPS, P84, GLASS, PTFE	- Controlled low emissions - Better efficiency - Cleanability - **Disadvantage**: abrasion, oils, special install, tight fit
KLEENTES	- Fluorinated resins for bath impregnation of the felt	PAN	- Water repellency - Better cake release - Suitable for sticky dust
MANTES	-PTFE resins for bath impregnation of the felt	PAN, PPS, P84, PTFE	-Water and oil repellency - Very good cake release - Increased bag lifetime - Adds surface area
RHYTES	-Fluorinated and PTFE resins (high concentration) for bath impregnation of the felt	PAN, PPS, P84	- Water and oil repellency - Better cake release - Suitable for sticky dust
SUPERNOVATES	- Copolymer foam deep coating suitable for temperature up to 200°C	PPS	- Better filtration efficiency - Very low emissions below $5 mg/Nm^3$



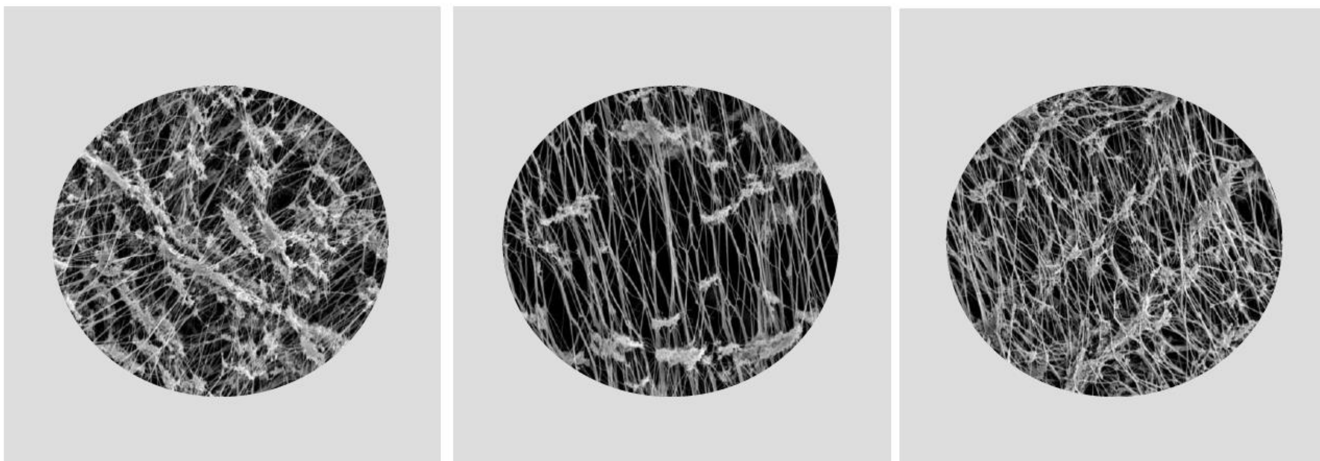






Range of membrane efficiencies

Tetratex® Membrane Products
Particular to the Challenge



Tetratex	Tetratex *EXTREME®*	Tetratex High Efficiency

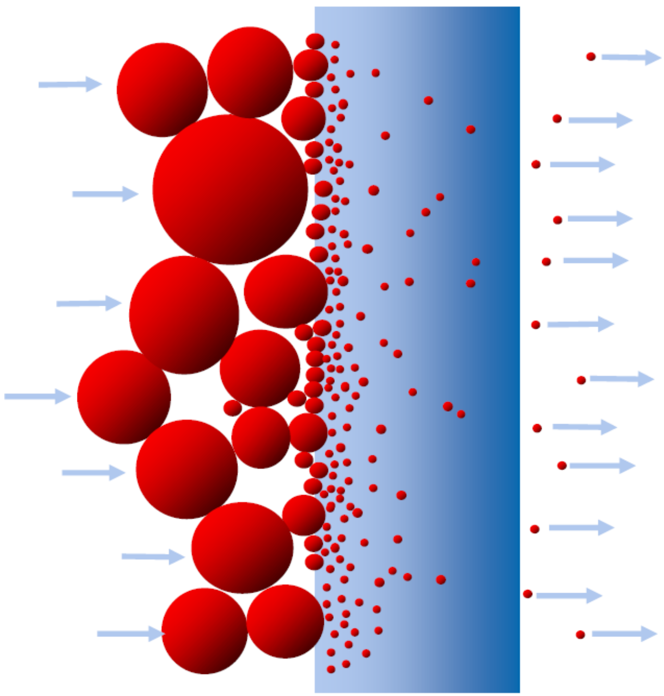
Donaldson. FILTRATION SOLUTIONS

Committed To Solving Your Filtration Challenges

Tetratex

Donaldson cites depth filtration disadvantages

Conventional Filter Media: Depth Filtration



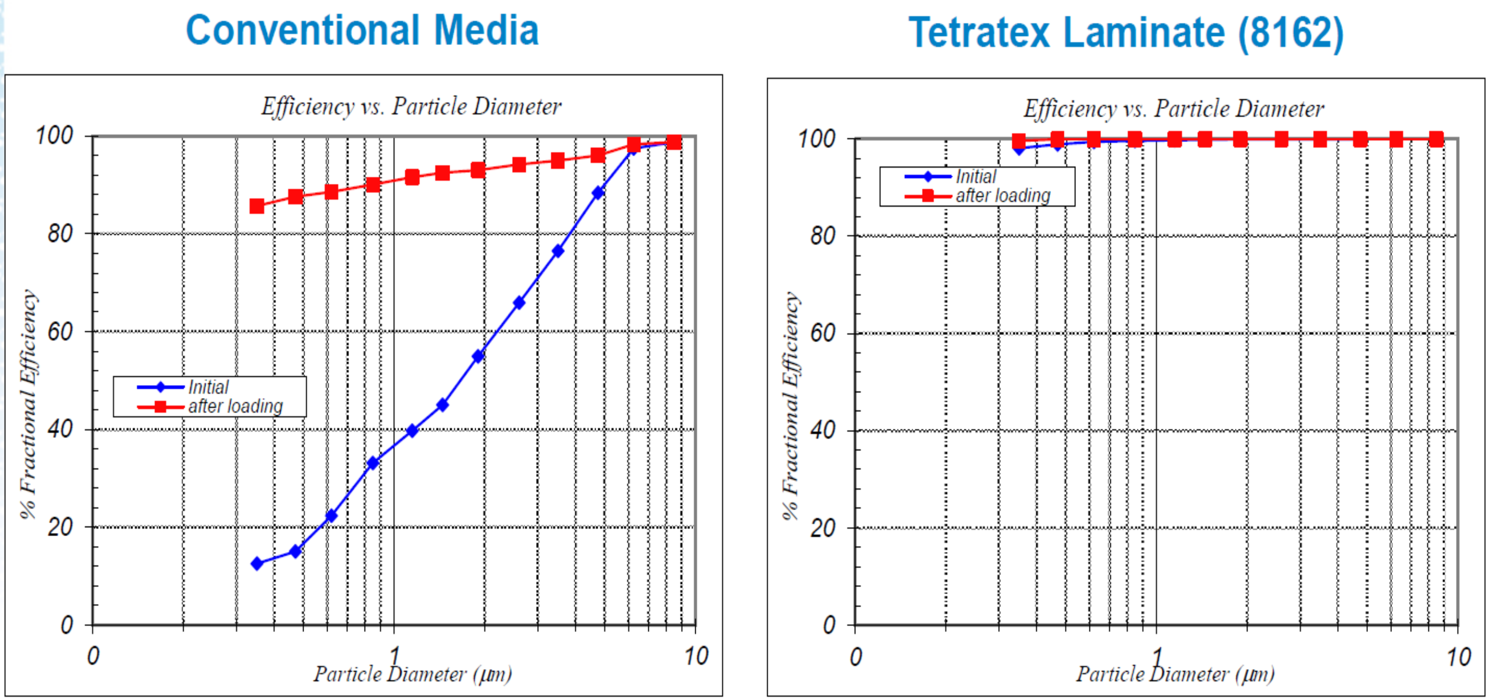
- Efficiency relies on primary cake formation
- Dust cake restricts airflow
- Requires high cleaning energy, which impacts mechanical stresses
- Fine particles migrate into media causing abrasion damage
- Leads to blinding - High pressure drop

Donaldson. FILTRATION SOLUTIONS

Tetratex

Membrane laminate has higher efficiency on smaller particles particularly prior to loading

Efficiency Comparison: 16oz PPS



*** Independent test results conducted by LMS Technologies Inc. May 2012**

Committed To Solving Your Filtration Challenges

Donaldson. FILTRATION SOLUTIONS

Tetratex

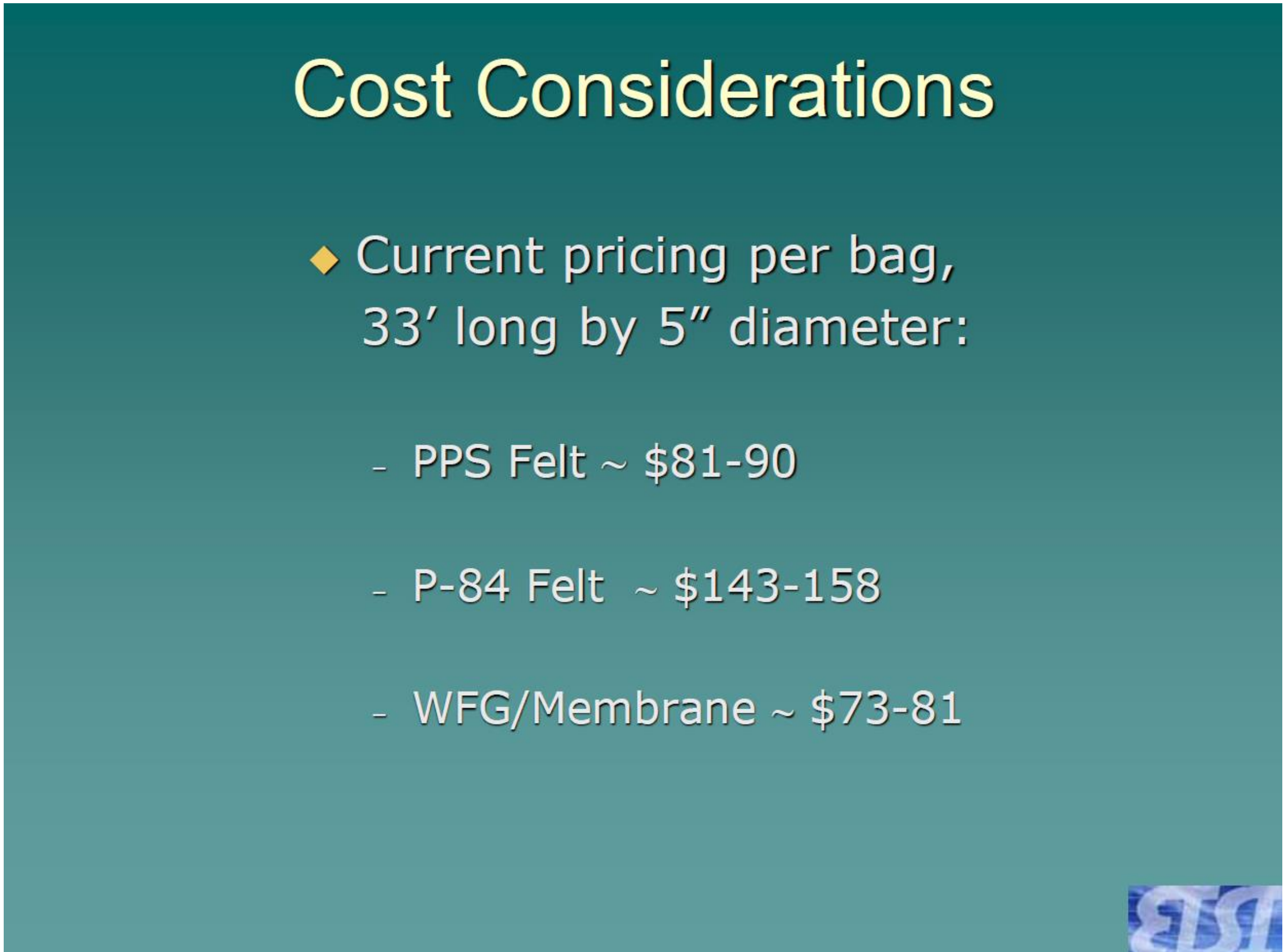
High temperature fiber options

FF: Fabric types

Table 3 **Fabric types** (Stark, 2012; Popovici, 2011; Johnson and McMenus, 2011)

Name	Maximum operating temperature	Remarks	Relative cost
Acrylic felt (PAN or polyacrylnitrile)	130°C	Lowest maximum operating temperature.	£
PPS felt (Polyphenylenesulphide)	190°C	Degrades at higher temperatures with >12% oxygen. Resist chemical and thermal attack. Effective when laminated with ePTFE.	££
Aramid felt	204°C	Not as capable as PPS in chemically active flue gas	£££
Woven fibreglass	260°C	Fragile, require tight tolerances. Suitable with reverse-air cleaning systems.	£
P84 felt by Evonik Fibres (polyimide, PI, multi-lobal, tri-lobal)	260°C	Dimensional stability over 204°C but requires oversizing of filter to maintain proper bag to cage fit. Small pore size of 0.5-1 μm (traditional needle felt scim have a pore size of 15-20 μm).	£££
Pleated elements	Dependant on scim fabric	A/C <3.5:1. Applicable only when additional cloth area is needed to lower A/C ratio and eliminate inlet abrasion.	£££££

Relative bag costs



Media selection-Testori

Selecting Media

FILTER MEDIA SELECTION CHART FOR POWER						
FIBER TYPE	COMMON BRAND NAMES	TEMP LIMITS* F/C	RESISTANCE TO ACIDS	RESISTANCE TO ALKALIS	RESISTANCE TO HYDROLYSIS	RESISTANCE TO OXIDATION
COTTON	NA	180°/85°	Poor	Good	Good	Good
PVC	Rhovyl, Clevyl	150°/65°	Excellent	Excellent	Excellent	Excellent
POLYPROPYLENE	Herculon	190°/90°	Excellent	Excellent	Excellent	Poor
NYLON	Enka, Antron	230°/110°	Poor	Excellent	Poor	Good
HOMOPOLYMER ACRYLIC	Dolanit, Aksa	257°/125°	Good	Fair	Good	Good
POLYESTER	Fortrel, Dacron, et al.	300°/150°	Good	Poor	Poor	Good
PPS	Torcon, Procon, et al.	375°/190°	Excellent	Excellent	Excellent	Fair
ARAMID	Nomex, Conex, et al.	400°/205°	Poor	Excellent	Poor	Fair
POLYIMIDE	P84	450°/235°	Fair	Poor	Good	Good
PTFE	Profilen, Toyoflon, et al.	500°/260°	Excellent	Excellent	Excellent	Excellent
FIBERGLASS	NA	550°/285°	Good	Fair	Excellent	Excellent

*Dry heat only

Testori USA, Inc.
www.testori-usa.com

testori USA INC

Decision Route – fabric filter media

Webinars

January 8, 2015	**Fabric Selection for Hot Gas Applications** 120 minutes **MORE**
INTERWEB VIEWS	CHINESE
INTERWEB VIEWS	English
October 23, 2014	**Dry Scrubbing** 104 minutes **MORE**

Intelligence system key words

category	keywords

Fabric filter bags and filters

Power Points and Authors 1

Subject	Author
Tubular bags	Mcilvaine
Pleated and other	TBD
Leakage at seams	Mcilvaine
P-84 for ESP retrofit	Mcilvaine
Enel has converted ESPs	*ENEL
Russia , Chile	*ENEL
Eskom	* Eskom
* At Evonik conference	

Power Points and Authors 2

Subject	author
Money point Dry FGD	N.A
Low pressure , long bag	KC Cottrell

Tubular bags

Tubular bags remain the major choice for higher temperature conditions and heavy dust loadings.

Pleated bags are more expensive and are generally used where space is tight

The main use of wovens is in glass bags with reverse air cleaning.

Most tubular bags are non-woven felts.

Pleated and other bag designs

- TBD

Leakage at bag seams

- Power plants are reporting activated carbon on the clean side of bags. It is an emission problem and causes bag wear
- W.L Gore says that their new taped seam prevents this problem
- Suppliers of synthetic laminates say this only applies to glass bas with membranes and not synthetic bags where seams can be fused
- W.L. Gore cites specific comparisons in the cement industry where the new seam has measurably different outlet emissions.
- NFM has a taped bag which they apply in some but not all situations
- The longer a bag is pulsed the more the sewing holes can expand
- With the new requirements which are as low as 5 mg/Nm3 or even lower, this is a problem which needs to be addressed
- The general attachment of the bag and potential leaks at interfaces is also a matter to be considered

P 84 and high performance fibers for ESP retrofits

- A huge market is developing for substituting filter bags for ESP internals
- The low installation cost vs. a new stand alone baghouse justifies higher bag costs
- Existing precipitators are subject to greater temperature variations and other conditions which can be controlled in a new installation
- P84 and other high performance fibers are being embraced for this retrofit application
- Enel and Eskom are two examples

ENEL has converted ESPs

Fabric Filters running in Enel's national fleet

Enel
ENERGY TO LIFE

Plant	Capacity (MWe)	FF type	Installation	Supplier	Year	Bag Lenght [m]	Comp.	Emissions guarantees [mg/Nm3] (°)	Expected FF Emiss. in Operation [mg/Nm3]
Fusina 1&2	2 x 160	PJ, HP/LV	Conversion	TMK	1999	8,5	2	<30	<15
Genova 6	160	PJ, HP/LV	Conversion	TMK	2003	9	4	<30	<15
Sulcis 2 (*)	340	PJ, HP/LV	New (**)	Aster	2005	8,5	16	<25	<15
Torrevald. 1÷3	3 x 660	PJ, HP/LV	New (**)	TMK	2005	8	16	<10	<9
Brindisi S.# 3&4	2 x 660	PJ, HP/LV	Conversion	TMK	2010-12	8	4	<20	<10

(*) Circ.Fluid.Bed Boiler (CFB) (**) Over the existing Electr. Precip. ESP foundations (°) hourly basis

- Italian references regarding conversions from electrostatic precipitators (ESPs) to fabric filter (FFs) are all "brown field" installations.
- "Conversion" means "transformation" from an electrostatic precipitator to a fabric filter using the previous casing.
- "New" fabric filters → to use only the existing foundation of the old previous electrostatic precipitator and to design new filter steel structure and casing.
- There is in addition a small fabric filter installed in a ~ 30 MWe Biomass PP in Calabria (South of Italy)

Acronym: PJ pulse jet; HP/LV high pressure low volume type; ESP Electrostatic Precipitator; TMK Termokimik spa ; Torrevald.: Torrevaldaliga North power plant.

Enel has FF on boilers in Russia, Chile, Spain (Evonik presentation)

Fabric Filters in Enel's abroad fleet and programs

Enel
ENERGY TO LIFE

Plant	Country	Capacity (MWe)	FF type	Installation	Supplier	Year	Bag Lenght [m]	Comp.	Emissions guarantees [mg/Nm3]	Expected FF Emiss. in Operation [mg/Nm3]
Alcudia	Spain	2 x 125	PJ, HP/LV	New	Fisia Babcock	n.a.	8	6	<20	<15
Alcudia	Spain	2 x 130	PJ, IP/IV	New	ABB/BWE	n.a.	7	6	<20	<15
Tarapacà	Chile	158	PJ, IP/IV	New	ALSTOM	2013	10	8	<10	<10
Bocamina I	Chile	128	PJ, IP/IV	New	ALSTOM	2007	8	6	n.a.	20
Bocamina II	Chile	350	PJ, HP/LV	New	Slavex	2012	6,5	20	<30	<15
Reftinskaya 5	Russia	300	PJ, IP/IV	Conversion	ALSTOM	2013	8	4	<50	<20
Reftinskaya 7	Russia	500	PJ, HP/LV	Conversion	Clyde Bergmann	2014 (°)	8,5	16	<50	<20
Reftinskaya 4	Russia	300	PJ, IP/IV	Conversion	ALSTOM	2015 (°)	8	4	<50	<20

(°) Note: expected date / schedule to be confirmed.

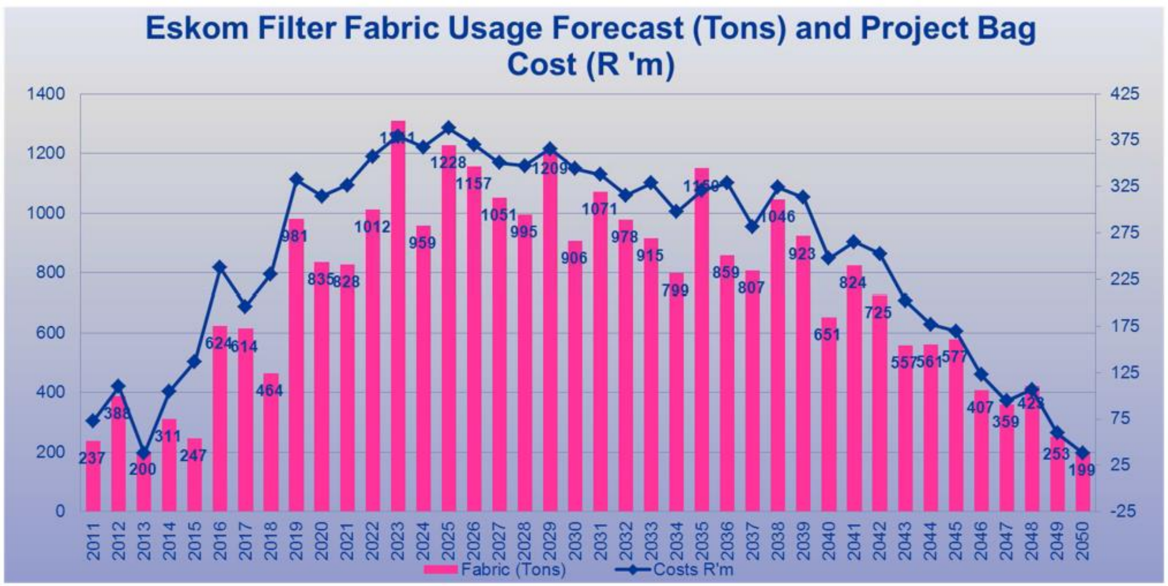
- The filters in Russia could be taken as the more challenging in terms of operation and maintenance considering the very high dust content of the coals (up to 40%) and the high NOx inside the flue gas.
- About the remaining units in Russia: #1÷ 4 and #8 ÷ 10 the conversion of the existing electrostatic precipitators ESP to fabric filters FF are today foreseen before the end of this decade.

Other Acronym: HP/LV High Pressure Low Volume type, IP/IV intermediate Pressure - Intermediate Volume, n.a. not available

Eskom will be spending $ 100 million/yr for bags (Evonik Presentation)

Fabric Usage Forecast following FFP Retrofit

Eskom



This equates to an average consumption of approx. 350 000 bags per year.
Currently all bags are disposed of in a Class H:H Hazordous Waste Dump at Holfontein (350 000 bags = +1 000 000 m^2 of fabric)

1923–2013

Money point Dry FGD P84/PPS

- N.A.

One option is a low pressure long bag design

Recent Trends in Fabric Filters

KC Cottrell Inc.

- Low pressure pulse, long bag design
- Online cleaning
- No bypass on start-up
- Filter as reactor (primary or secondary)
- Increasingly lower emission rates
- Use of PTFE membranes

Decision Route – bags and filters

Webinars

January 8, 2015	**Fabric Selection for Hot Gas Applications** 120 minutes **MORE**
INTERWEB VIEWS	CHINESE
INTERWEB VIEWS	English
October 23, 2014	**Dry Scrubbing** 104 minutes **MORE**

Intelligence system key words

category	keywords

Ceramic and metal filters

Power Points and Authors 1

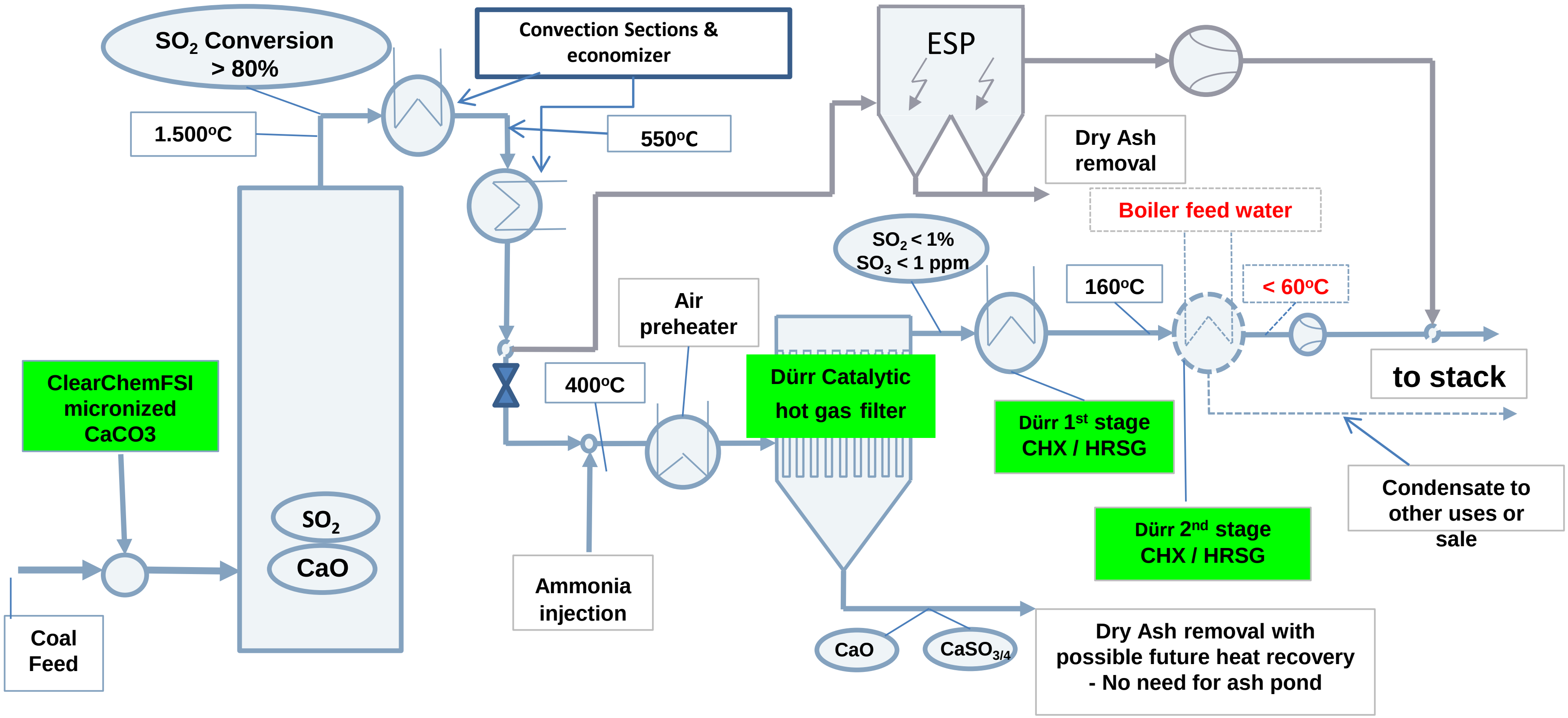
Subject	Author
Catalytic filter with powdered limestone	Durr
Catalytic filter- ceramic and 3 layer	Haldor Topsoe
Catalytic filter	Tri-mer
Metal filters	Purolator

Power Points and Authors 2

Subject	author

ClearChemFSI™ Existing U.S. Coal-Fired Boilers

Side Stream Application – Example existing ESP



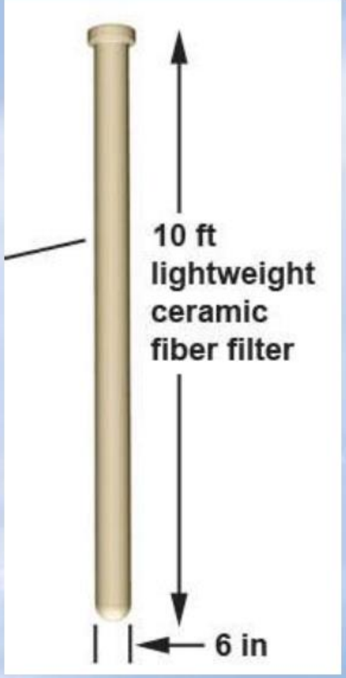
Input from Haldor Topsoe

TBDF

Catalytic filter with embedded catalyst

Filter Element

UltraCat Catalyst Filter: Structure and Size



Nano-bits of NOx, CO, VOC catalyst are embedded into the walls and adhere to the fibers.

Tri-Mer® CORPORATION

50 YEARS 2010

Input from Purolator

- TBD

Decision Route – Metal and Ceramic Filters

Webinars

January 8, 2015	**Fabric Selection for Hot Gas Applications** 120 minutes **MORE**
October 23, 2014	**Dry Scrubbing** 104 minutes **MORE**
INTER WEBVIEWS	TO BE INCLUDED
INTER WEBVIEWS	TO BE INCLUDED

Intelligence system key words

category	keywords
Product	Catalytic filter, metal, ceramic
companies	Durr, Filtration Group, Haldor Topsoe, Purolaor