Recent developments in particulate control

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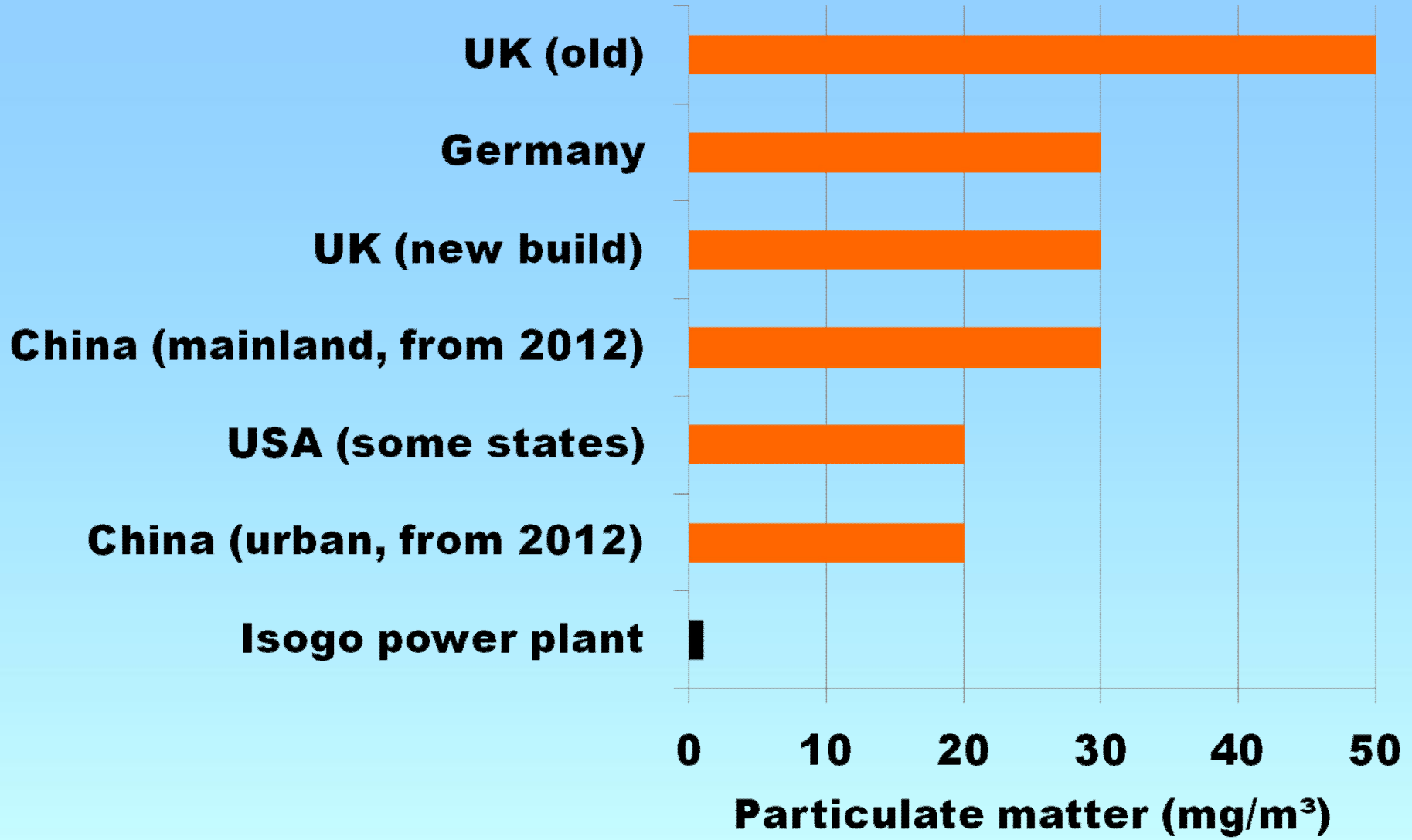
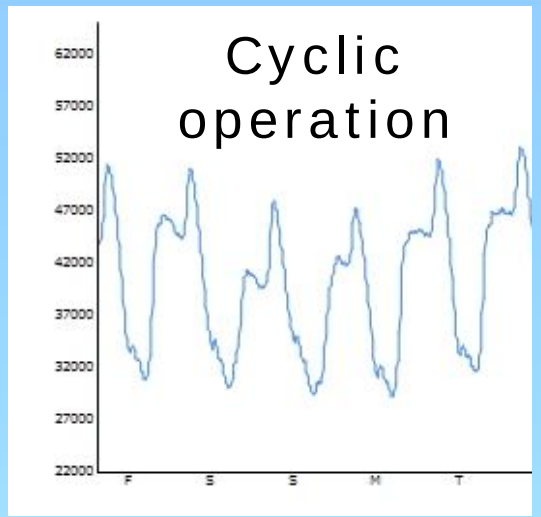
Contents

Introduction: Emission Limit Values (ELV) in 2012

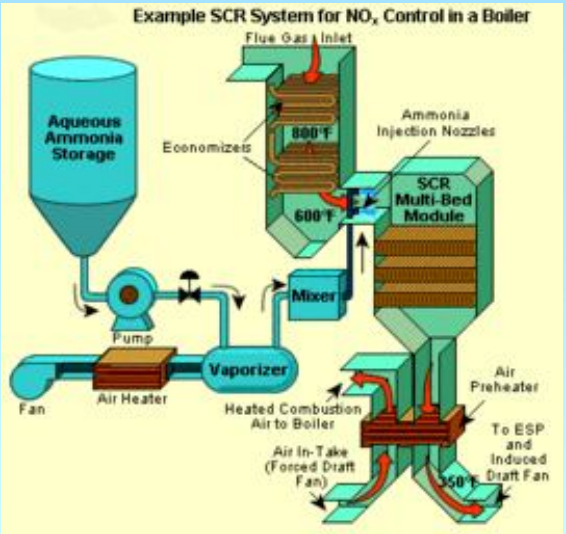


Introduction: Times are changing...

Different coals

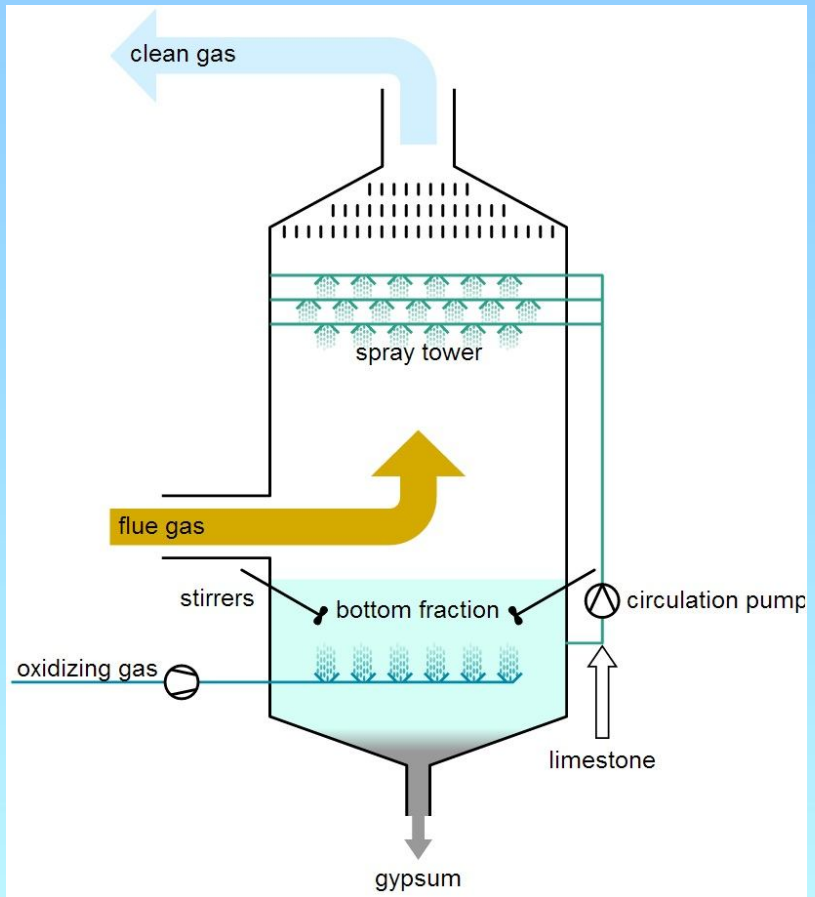


Emission reduction technologies

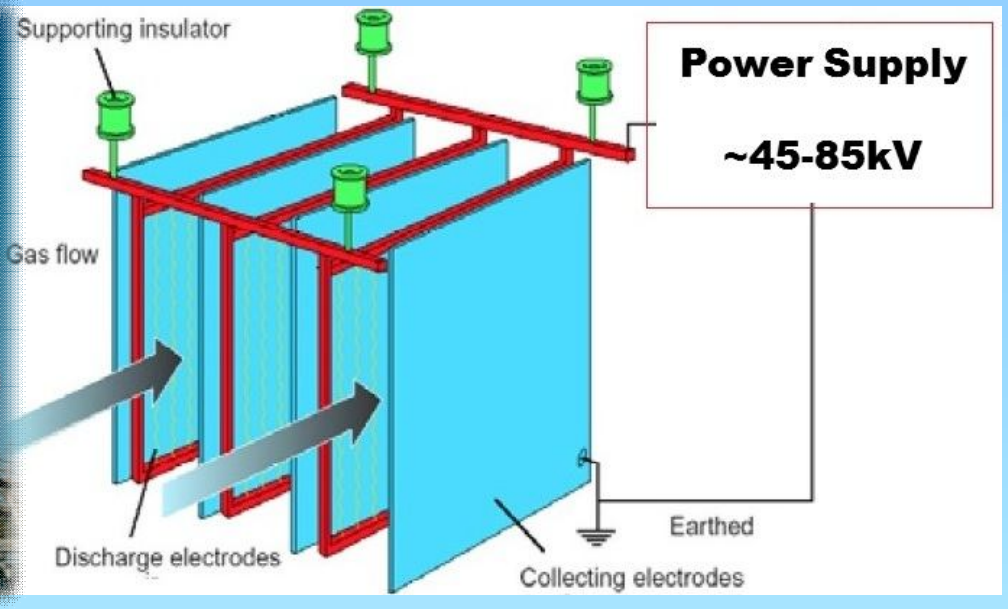


Introduction: Times are changing...

- Wet flue gas desulphurisation (wet FGD)
- Further reduce fly ash from particulate control by ~60%
- Power plant in China
  - Dry ESP outlet 23.4 mg/m³
  - Wet FGD outlet: 6.2 mg/m³



Electrostatic precipitator (ESP)



- ~80-90% of fleet
- 130-180ºC (cold side)
- Operation:
  - Charging
  - Migrating
  - Accumulating
  - Rapping

Low resistivity particulates:

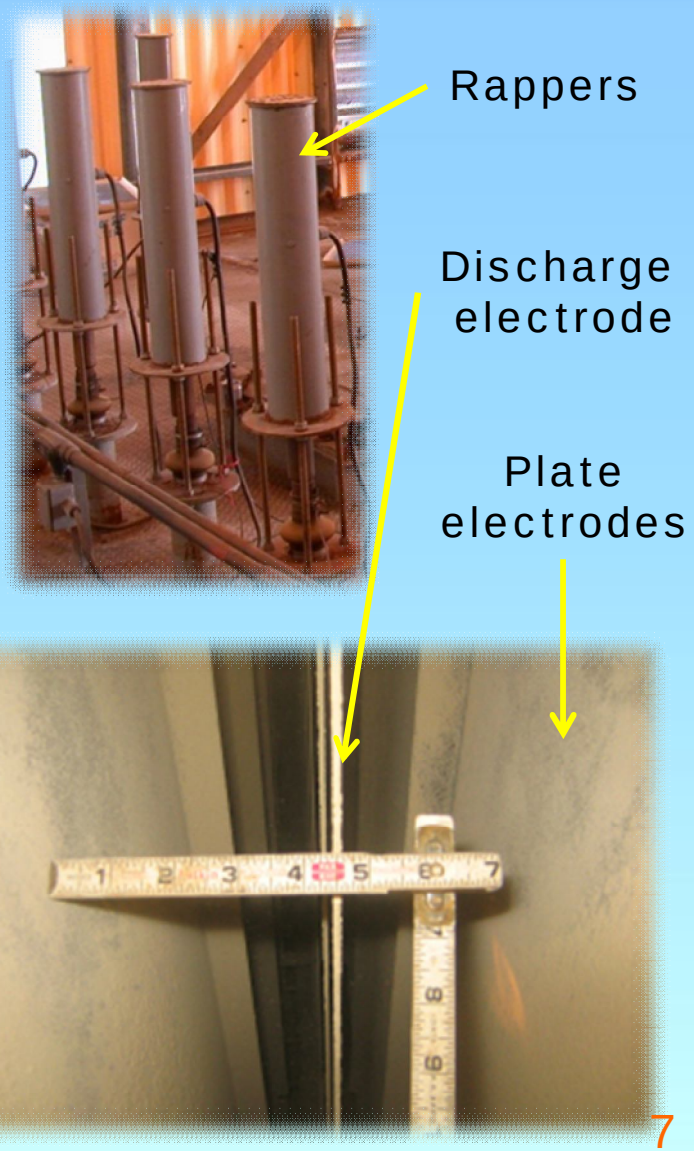
- Does not migrate/accumulate

High resistivity particulates:

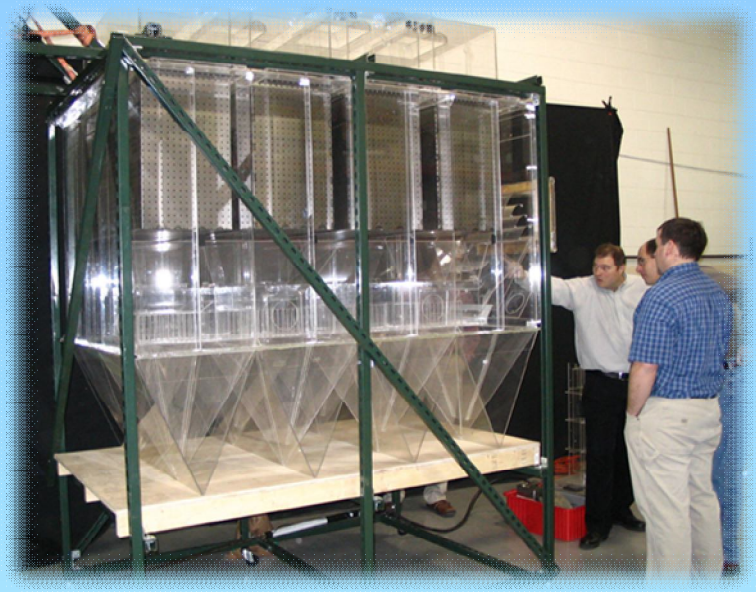
- Results in sparking

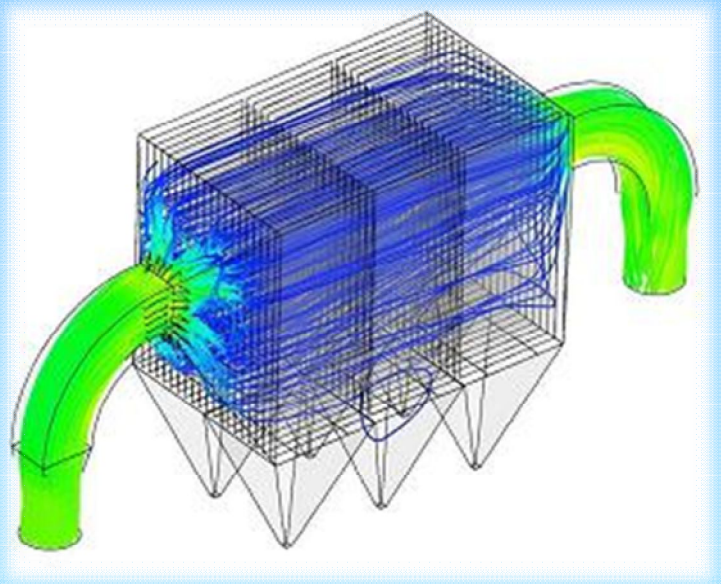
ESP: Maintenance & Upgrade

- Discharge electrodes
  - Upgrade to rigid pipe design
- Plate electrodes:
  - Wider plate spacing (23-30 cm to 41-46 cm)
  - Increase plate width and height (aspect ratio of 0.8)
- Rappers:
  - Upgrade and add more
  - Minimise air leakage



ESP: Flow distribution





Traditional methods (physical models, tests)

- Time consuming
- Expensive

Computational fluid dynamics (CFD)

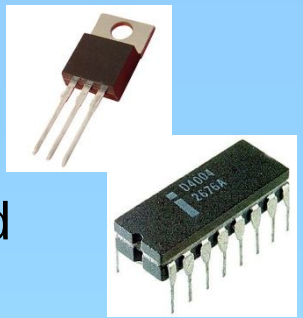
- Quick
- Lower cost

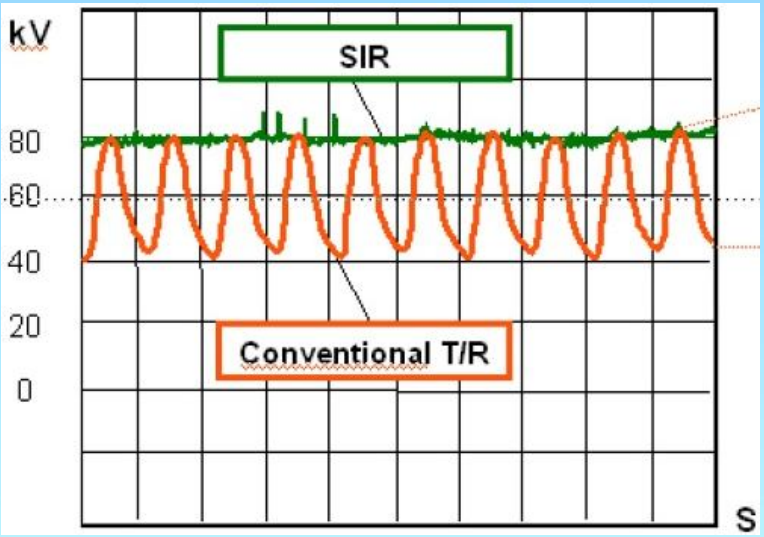
SteagEnergy Services, Iskenderun power plant, 2012

- ESP outlet emissions from 65 mg/m^3 to 55 mg/m^3

ESP: Power supply and control

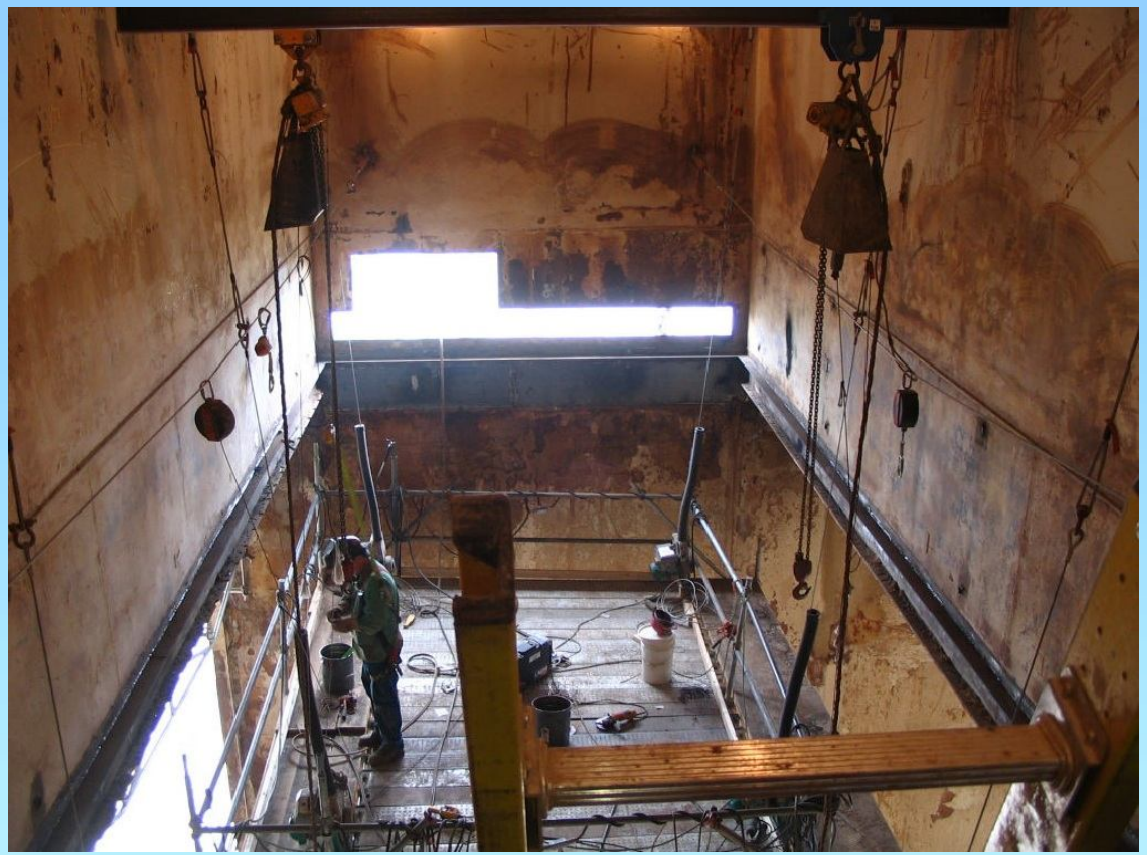
- Conventional T-R sets superseded by modern switched mode power supplies (SMPS)
- Basic on/off control superseded by sophisticated microprocessor based controls (MBC)





- Waigaoqiao power station: Outlet emissions from 25 to 12 mg/m^3 and auxiliary load from 871 to 266 kW

ESP: Rebuilding & adding fields



Rebuild of Aiysis coal fired power plant (China):

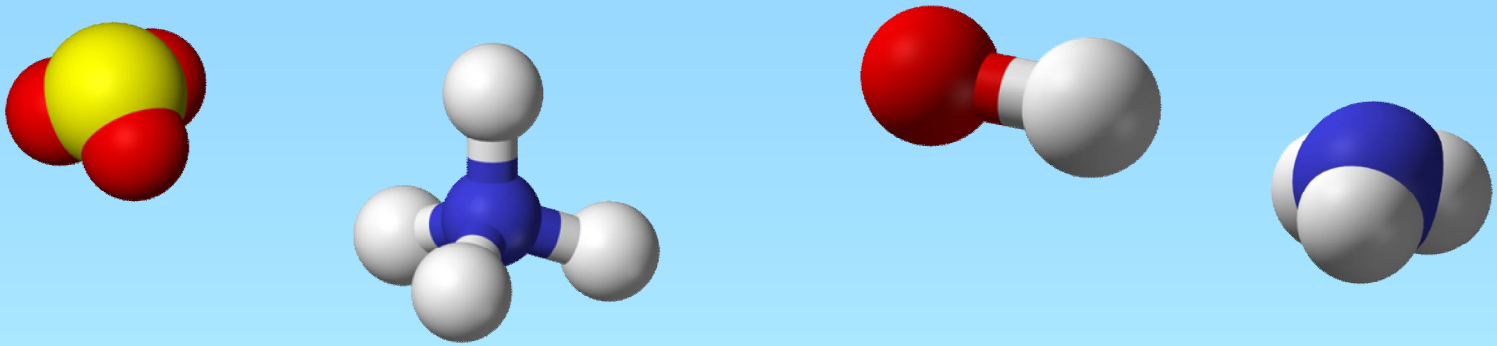
- 265 mg/m³ reduced to 31.5 mg/m³

Statistical analysis:

- 86% of existing ESP upgraded to meet 30 mg/m³ ELV

ESP: Flue gas conditioning (FGC)

- Low sulphur coal = high fly ash resistivity
- FGC chemicals: Sulphur trioxide and ammonia



- 2012: Guangdong Pinghai power station, SO_3 FGC system:
  - Moderate capital cost & short outage period
  - ELV of 45 mg/m^3 met
  - 99.65% collection efficiency

Retrofit and new build ESP

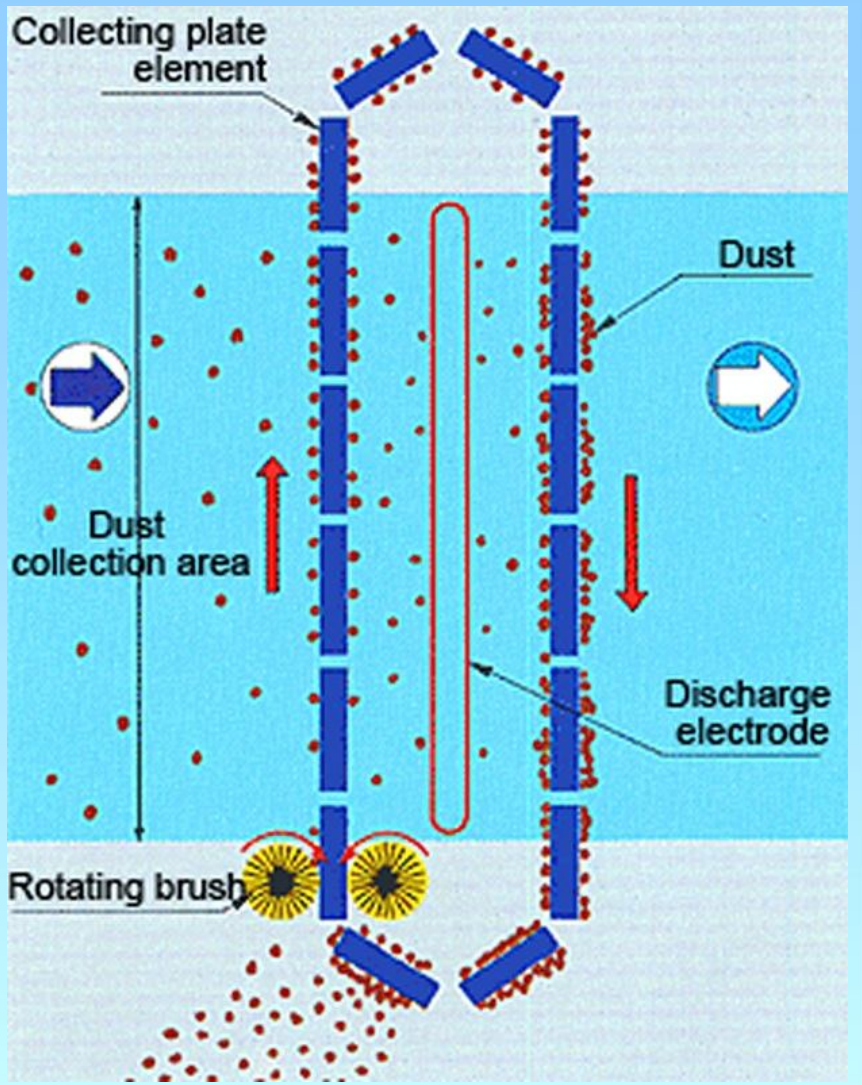
ESP variation	Main advantages
Colder side ESP	➢ Lower parasitic load ➢ Smaller site footprint
Moving electrode ESP	➢ Effective 'rapping' for highly resistive ash ➢ Smaller site footprint
Wet ESP	➢ Aerosol capture ➢ Plume free stack ➢ Smaller site footprint
Electromechanical double-zone ESP	➢ High collection efficiencies with high and low resistivity fly ash

Colder side ESP

- Operates at 90-100ºC
- Increases specific collecting area, decreases resistivity and parasitic load
- Increases fouling and corrosion
- Tosho Nanyo (Japan): Colder side ESP by Alstom:
  - 6.7 mg/m³ emission
  - 50% power reduction
- Mitsubishi Heavy Industries installed on >10 GW of Japanese coal plant

Moving electrode ESP (MEEP) Hitachi

- Rapping causing excessive re-entrainment
- Rapping replaced with brushing in last fields
- Reduces re-entrainment
- Smaller site footprint
- 99.4% with highly resistive fly ash
- 30 Installation in Japan

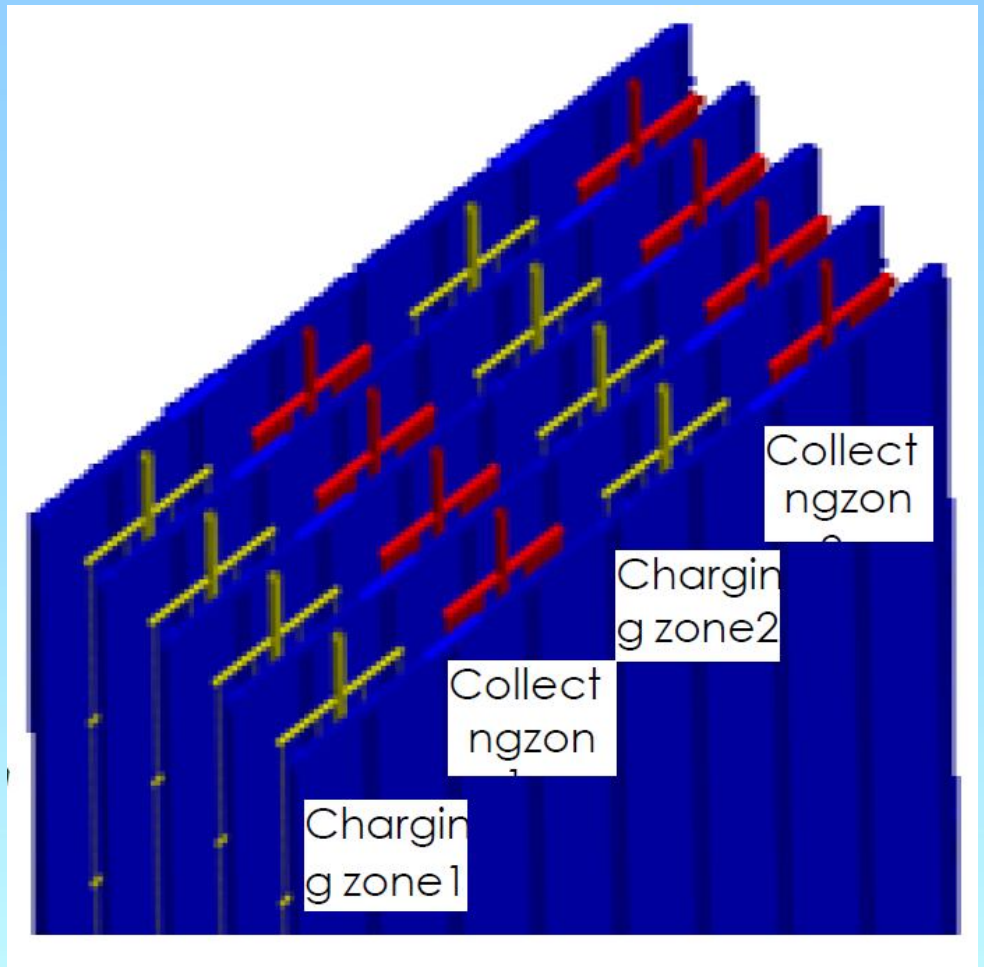


Wet ESP

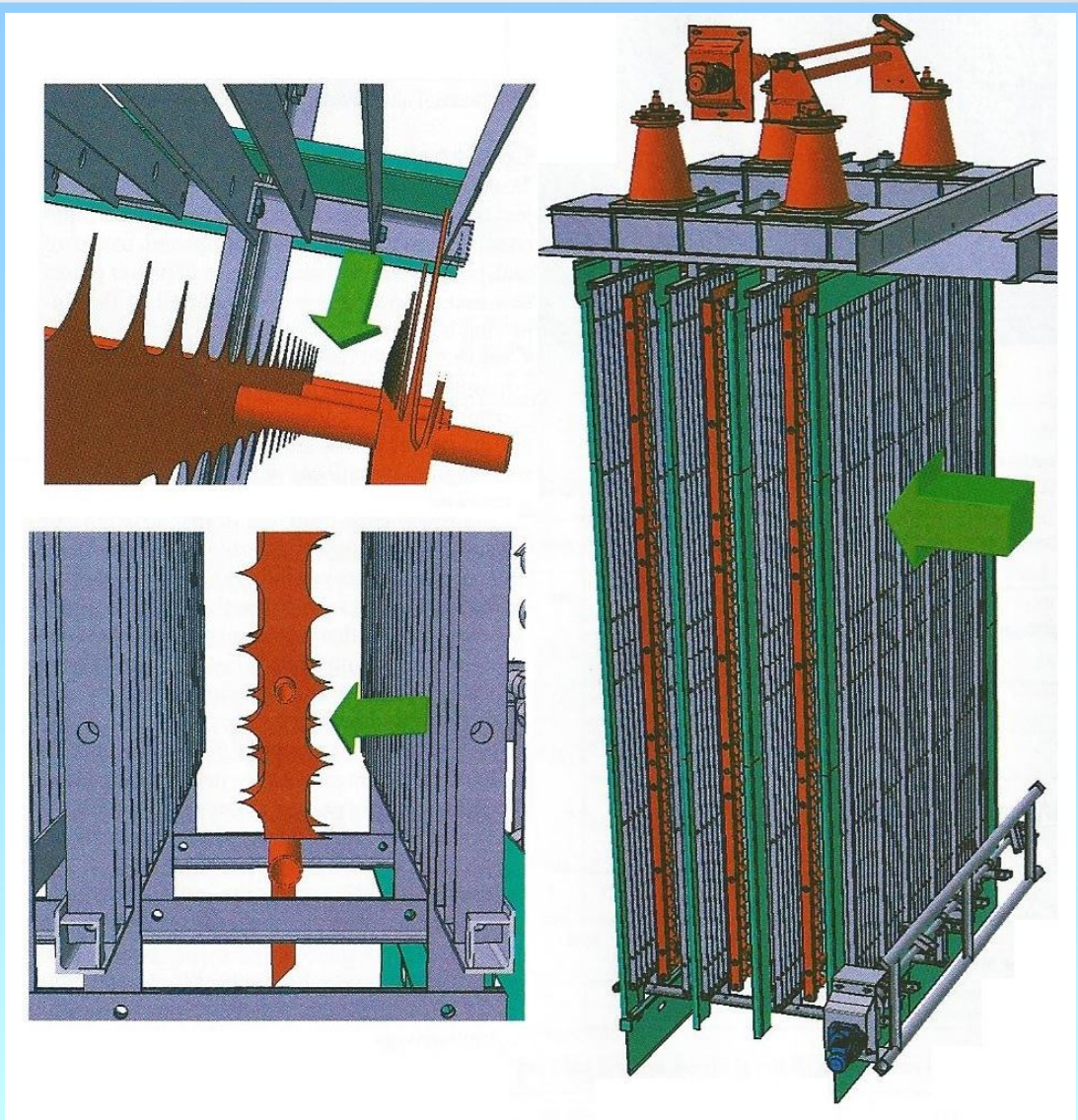
- Water washes off fly ash from plate electrodes
- High collection of all resistivity fly ash
- Can condense out water for a plume-free stack
- Incorporated into wet scrubbers = multi-pollutant control

Electromechanical double-zone ESP

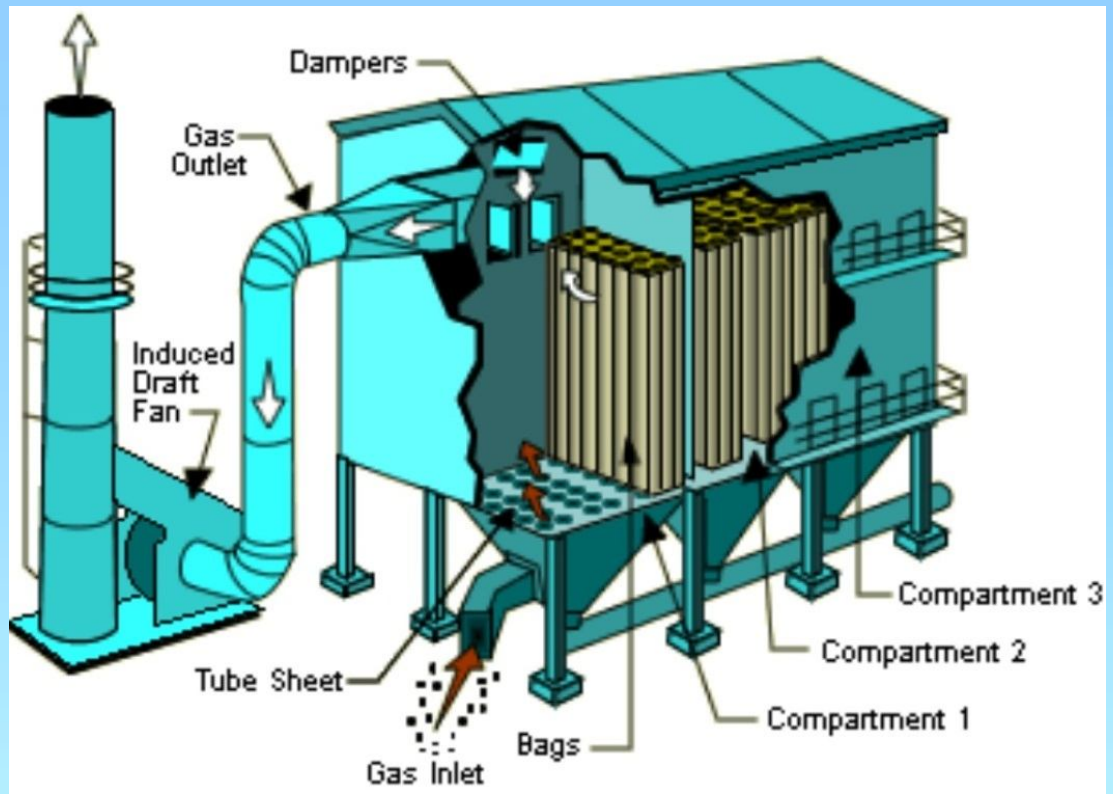
- Fujian LongKing
- Separate zones and power supply
- ~80 kV DC
- 99.96% collection efficiency
- 74 Installations in China in 2011



Cross Flow ESP (Alstom)



Fabric Filters (FF)



- 120 to 180ºC
- Essentially a vacuum cleaner
- 'High O&M costs
- Pulse jet' cleaning

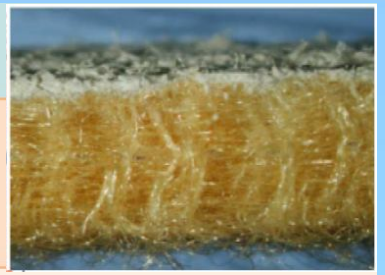
FF: Fabric types

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.	£££££

FF: Treatments and coatings

Table 4 Fabric treatments and coatings (Stark, 2012)



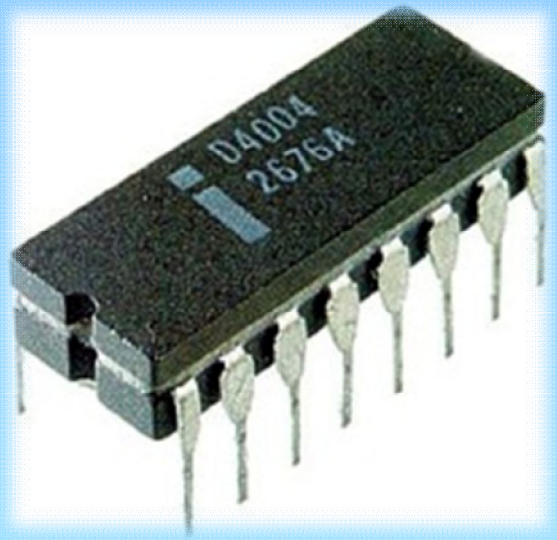
Treatment name	Maximum operating temperature	Remarks
PTFE coating (not membrane)	260°C	Improve filter cake release, sacrifices ability to maintain consistent airflow leading to increased cleaning frequency or high pressure loss.
Expanded PTFE (ePTFE) membrane	260°C	Laminated to collection surface, average pore size of this scim is 0.5 to 1 µm, low pressure drop with long filter bag lifetime.
Singeing	–	Removes some fabric surface area, improves filter cake release
Teflon	–	Resistance against acid attack. High pressure drop and potential blinding with cohesive particulate.
Glazing and silicone	–	Improve cake release
Calcium hydroxide	–	Most common
Calcium carbonate	–	Most common

- PPS felt (fabric) laminated with ePTFE (coating) is effective

FF: Microprocessor control

- Cleaning schedule

- Only clean bags when necessary
  - Prolong lifetime (minimum abrasion)
  - Maximum particulate capture from filter cake



- Random cleaning order minimizes re-entrainment

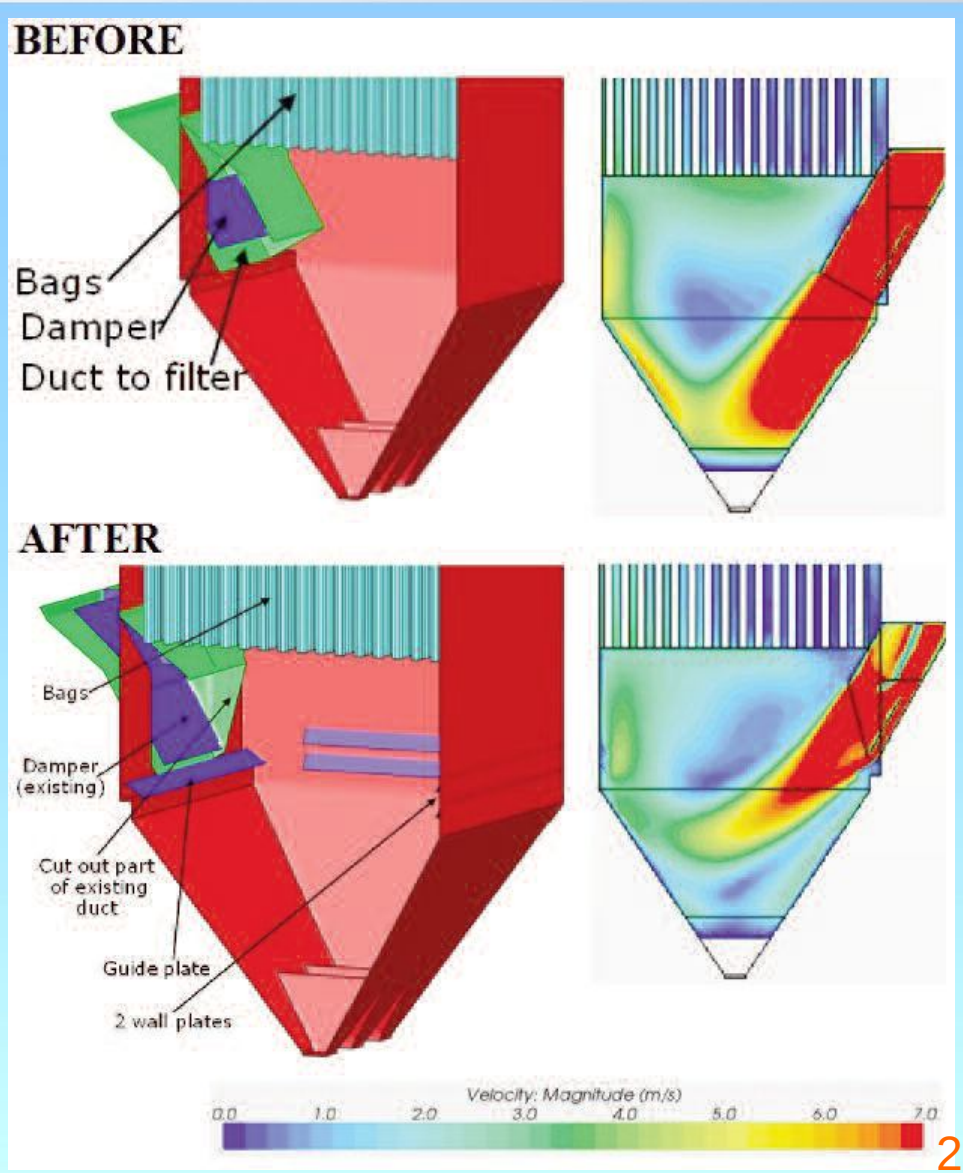
FF: Flow distribution

Traditional methods (physical models and in situ trial and improvement tests)

- Time consuming
- Expensive

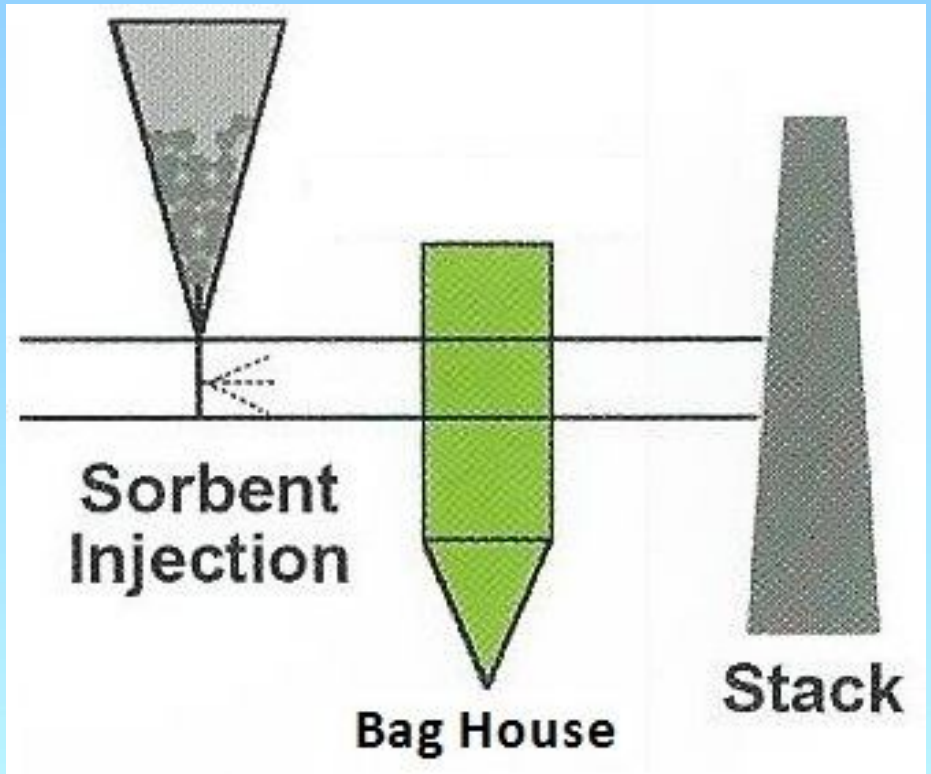
Computational fluid dynamics (CFD)

- Quick
- Lower cost

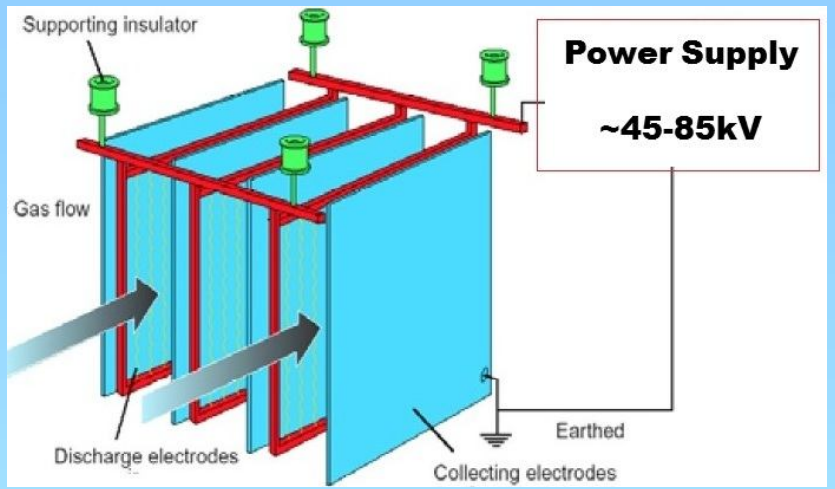


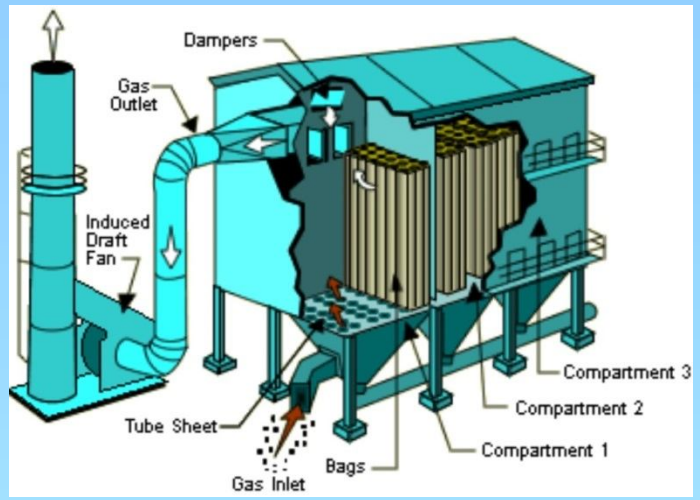
Sorbent injection: Multi-pollutant control

- Sorbent injection upstream of the FF
- Reaction in filter cake
- Activated carbon for mercury / ammonia for NOx / sodium based sorbent or lime for sulphur dioxide
- Contaminated fly ash not sold, treated or landfilled



Hybrid ESP/FF Systems





ESP

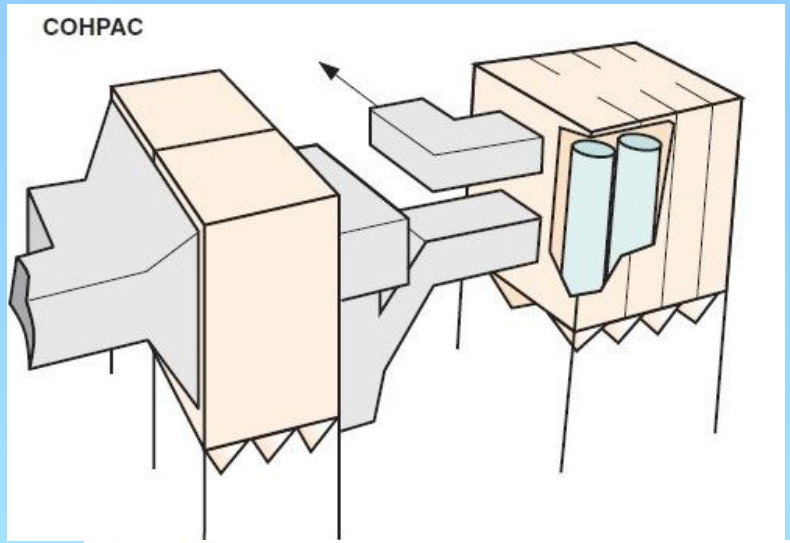
- Low pressure drops
- Low costs all round

FF

- High collection efficiency (will capture rapping peaks)
- Multi-pollutant capture

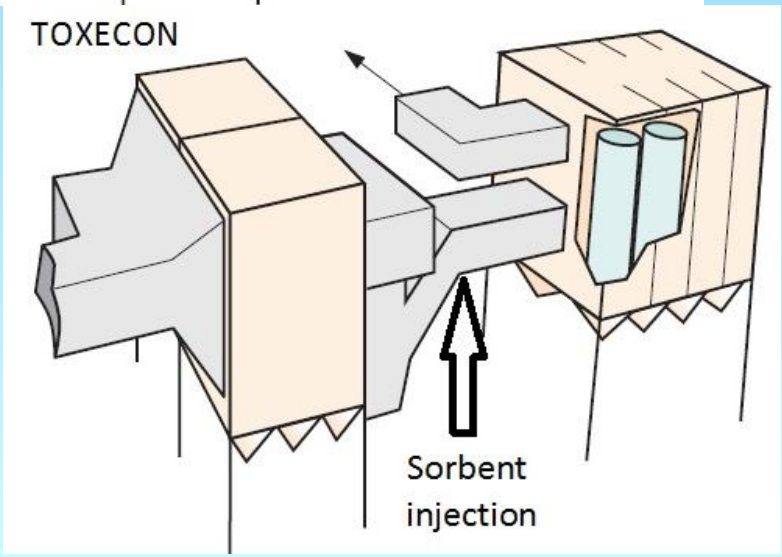
Hybrid ESP/FF Systems

Electric Power Research Institute (USA)



COHPAC

- Compact hybrid particulate collector
- Small FF downstream of ESP
- Proven technology

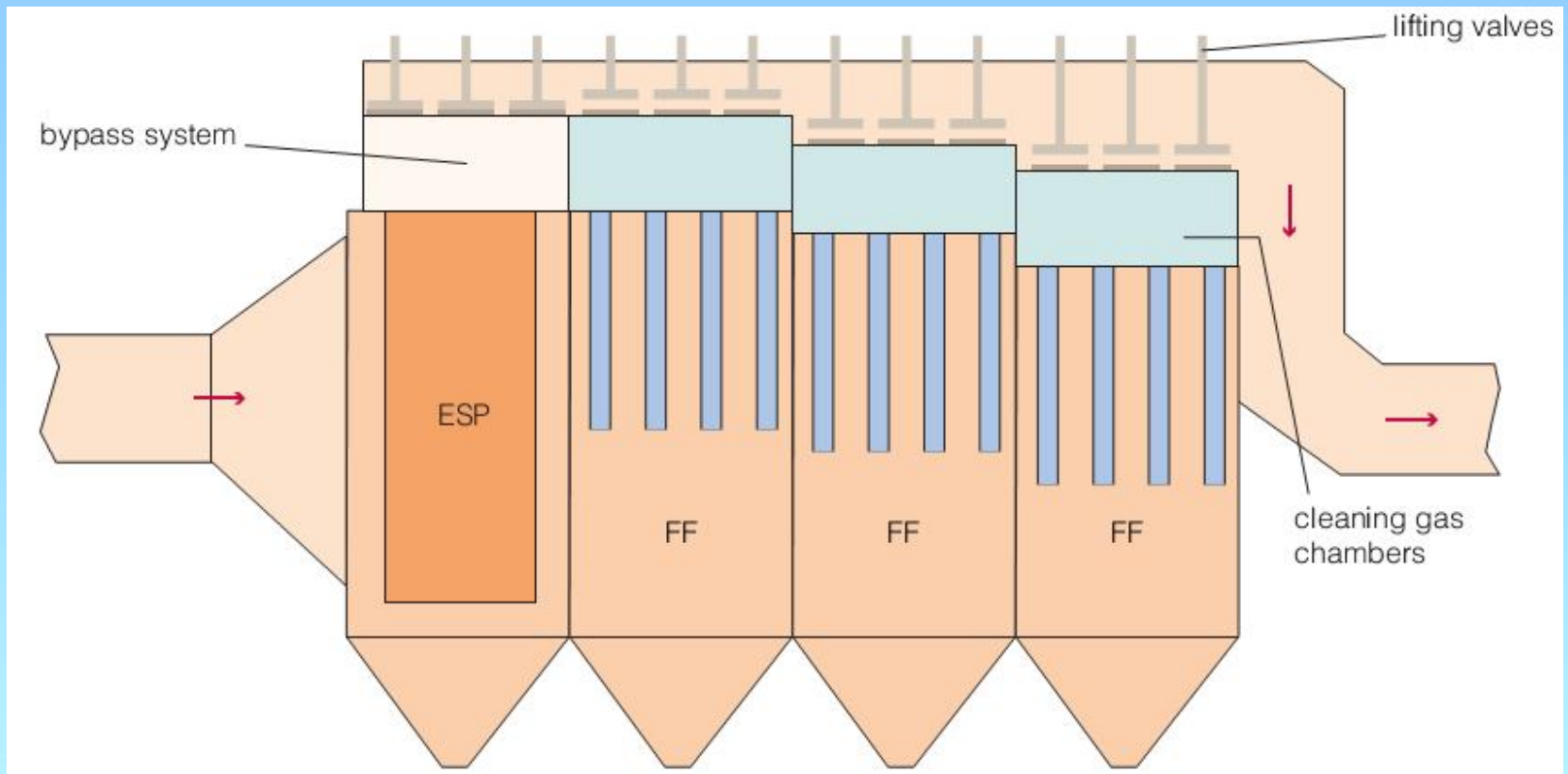


TOXECON

- COHPAC coupled with sorbent injection
- Successful small scale demonstration

Fujian LongKing (China)

- Electrostatic-fabric integrated collector (EFIC)



660 MWe unit at Boasham power plant (China):

- 99.8% collection efficiency
- 30 mg/m^3 outlet emission

Summary

	Cold side dry ESP	FF (pulse jet)	Hybrid ESP/FF
Collection efficiency (%)	99.81	>99.95	99.80
Pressure drops	Low	High	Medium
Parasitic load	Low	High	Medium
Reliability	High	Low	Medium
Other pollutants *could contaminate fly ash	No	Yes*	Yes*
Capital cost of new build	££	££££	£££
Capital cost of retrofit, given old ESP installed	£ (upgrade)	££ (install in ESP case)	£ (last field) ££ (polishing)
Operating and maintenance cost	££	££££	£££

Thank you for listening

Questions?

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