Elgin System India Private Limited.

Coroboth®

Pulse Power System For ESP

Launched by

ELGIN SYSTEM INC., CANADA

For a Clearer Sky

Elgin System India Private Limited

Corporates Brief—Who we are?

Elgin System Inc., a Canada based technology R & D corporation in the field of betterment of the pollution control, provides the tailored technical solutions. The sectors for the R & D cover thermal power plants emission control, water treatment, soil reactivation.

Elgin System Inc. has its subsidiary registered at Raipur of Chhattisgarh state of India to implement the projects and carry out the services after sales.

Our Activities in Thermal Power Sector—What We Do?

Globally more and more concerns have been expressed by the general public towards the control of the emission from the thermal power plants, that drives the need for the thermal power plants to restrain the emission as low as possible.

The governments gradually and steadily revise the emission policies to cater to the demands of the general public.

The thermal power plants, in deference to the call from the updated government rules/notifications as well as functioning its role with CSR, have to respond to the need.

We devote ourselves into the betterment of the performance of the ESP , a critical emission control equipment installed in the thermal power plant.

What we do is to utilize the advanced & matured technology developed by us to retrofit the installed ESP to improve its performance to satisfy the emission requirements.

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ESP Retrofit

Options & Comparison

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ESP performance improvement—Options

Conventional options:

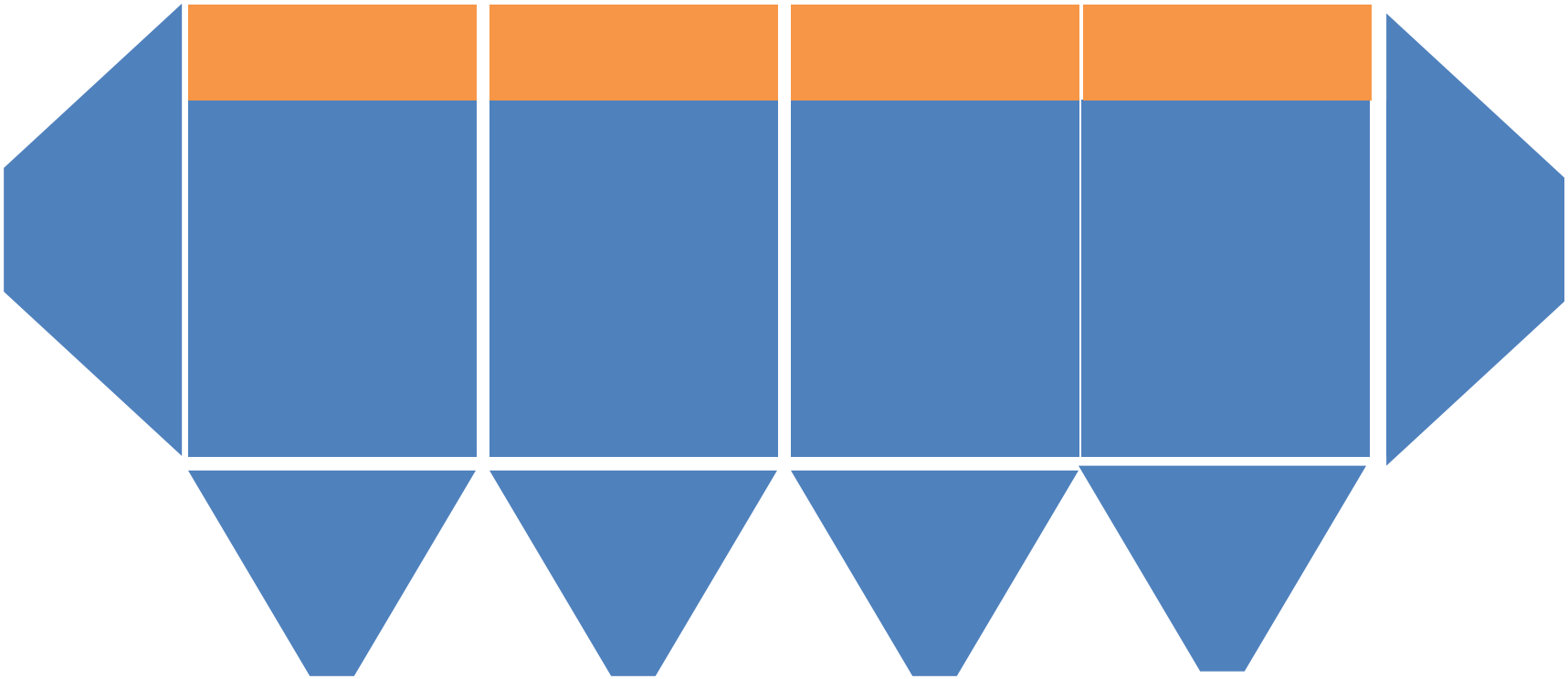
1. Size augment
2. Flue Gas conditioning
3. Bag filter
4. Rotating collecting plates

Latest options basically involve the replacement of the electric system, i.e.:

1. Adopting HF transformer
2. Adopting COROBOTH® pulse power system

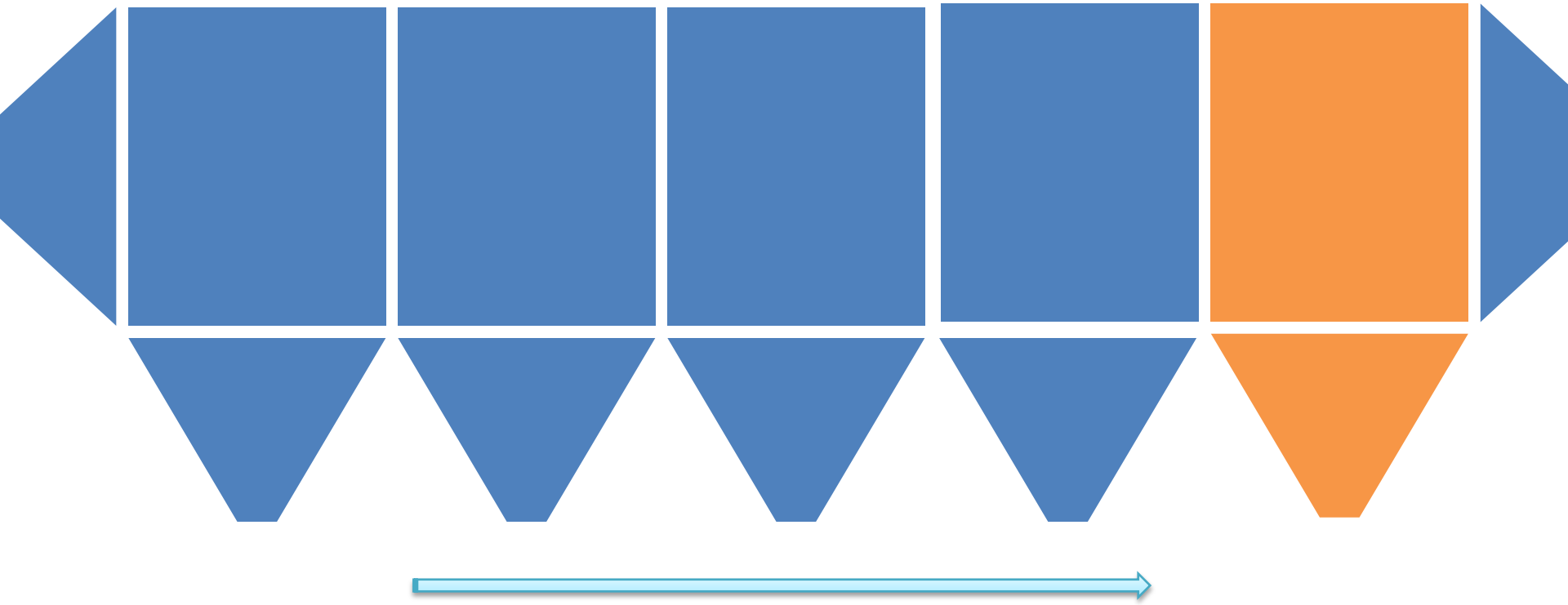
CONVENTIONAL OPTIONS

1. Size Augment – Height Increase of ESP



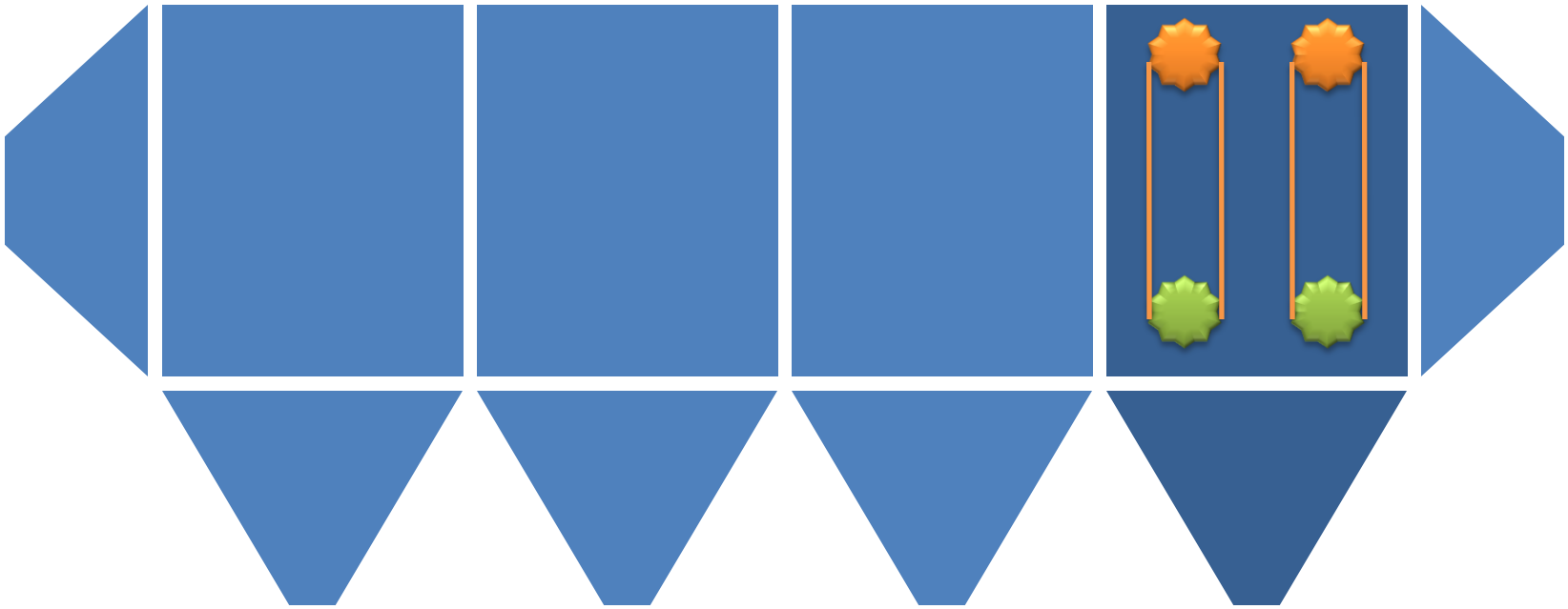
CONVENTIONAL OPTIONS

2. Size Augment – Addition of field(s) of ESP



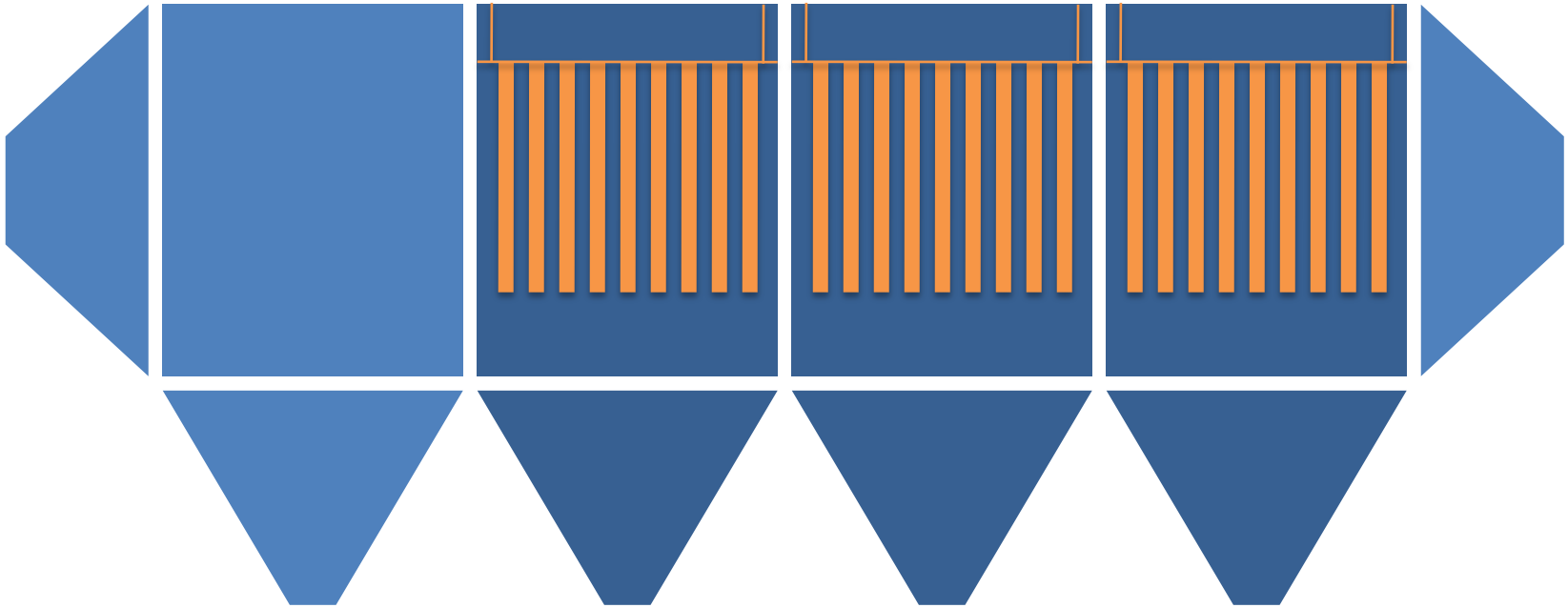
CONVENTIONAL OPTIONS

3. Rotating collecting plates



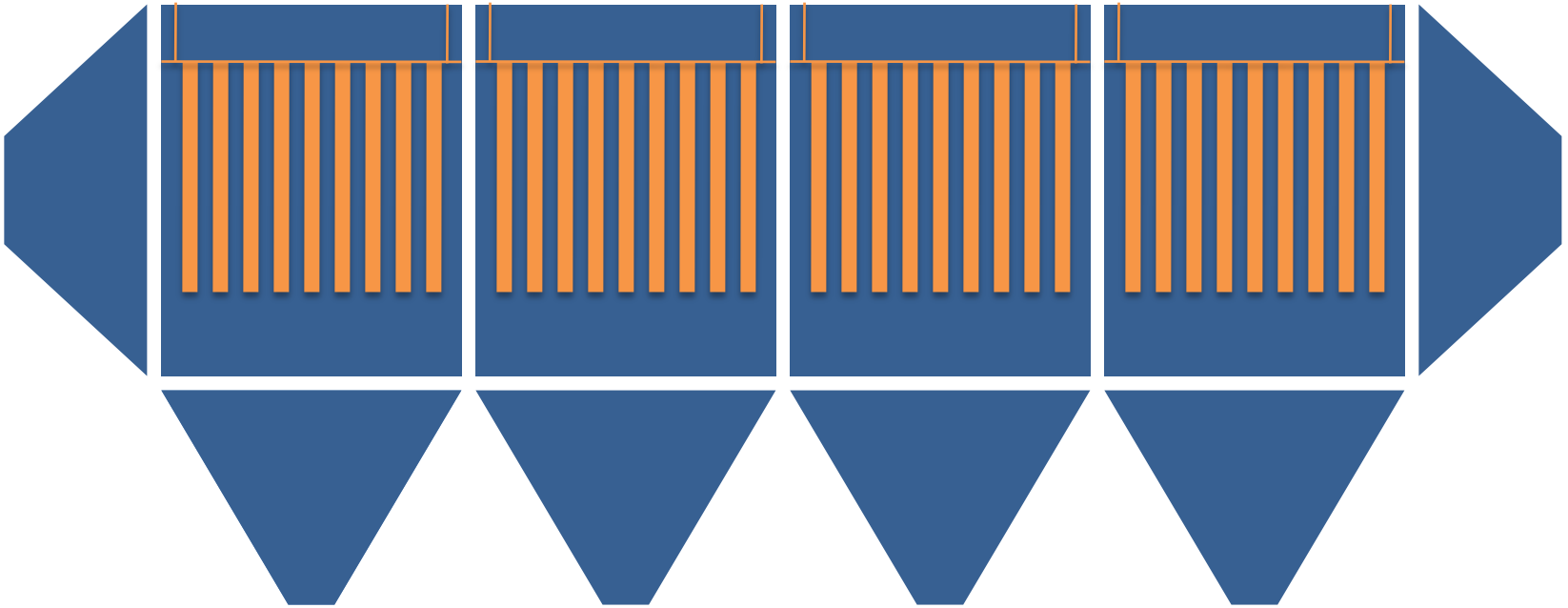
CONVENTIONAL OPTIONS

4. Hybrid option (ESP + Bag filter)



CONVENTIONAL OPTIONS

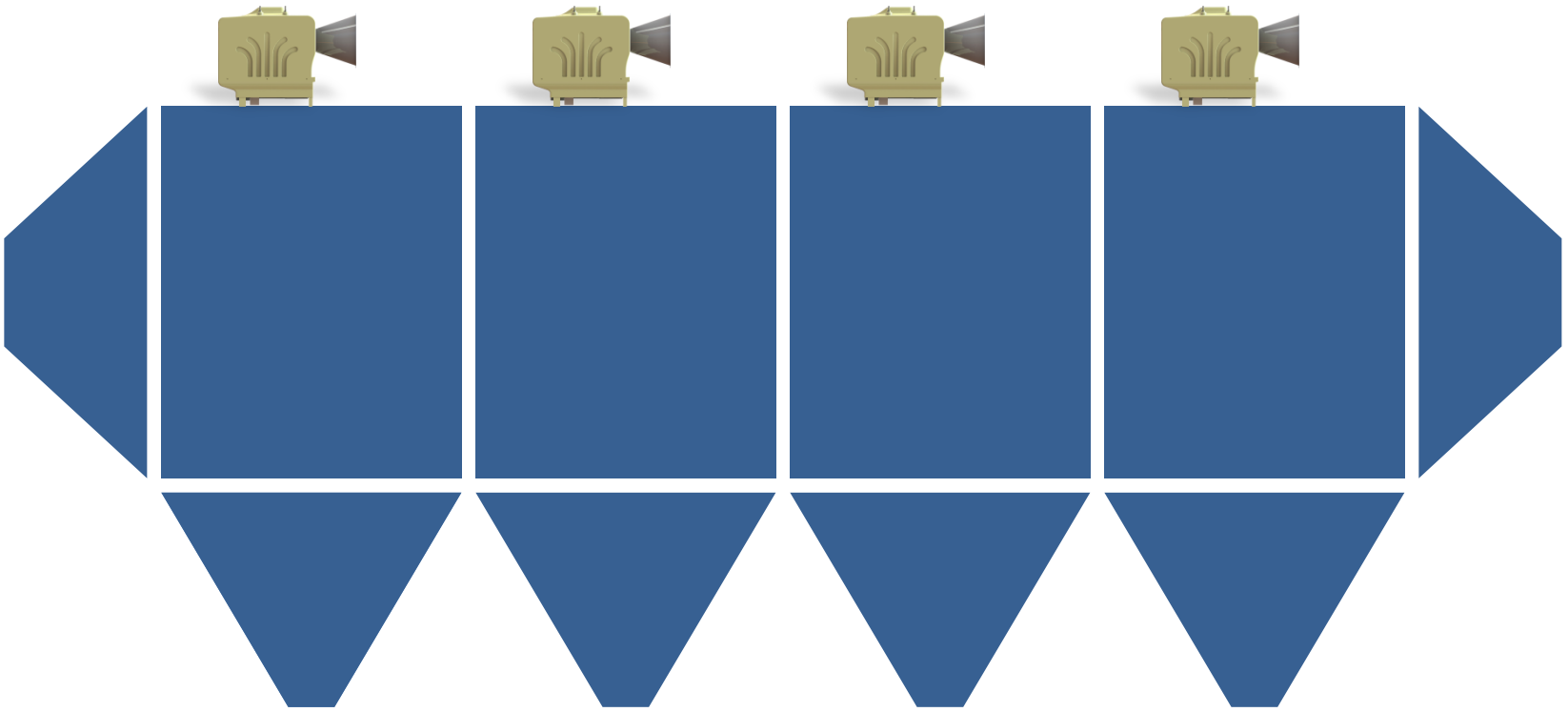
5. Bag filter option



All fields of ESP to be changed to Bag filters

LATEST OPTIONS

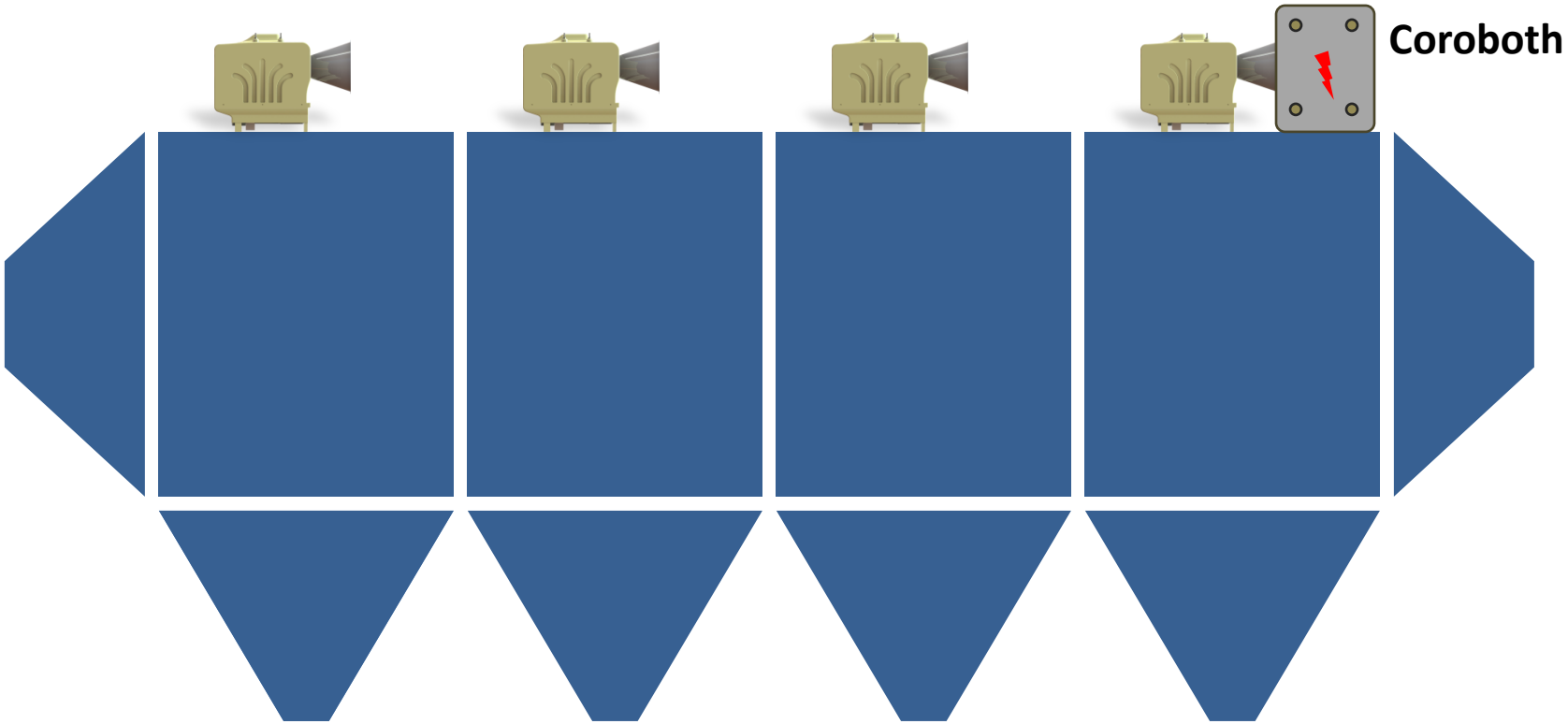
1. Adopting HFTR



All fields or certain filed(s) to be replaced by HFTR

LATEST OPTIONS

2. Integrated **Coroboth®** pulse power system

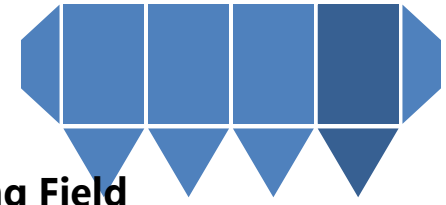


Certain field(s) to be equipped with Coroboth®

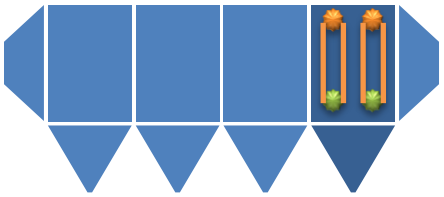
Options Summery

Height Increase

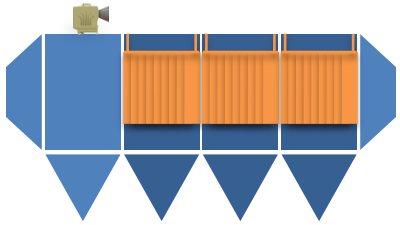
Rotating Field



Field(s) Addition



Rotating Plates

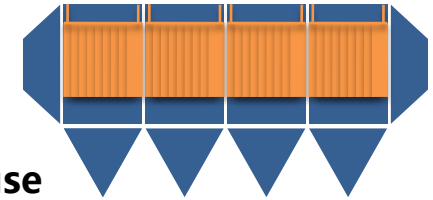


Hybrid

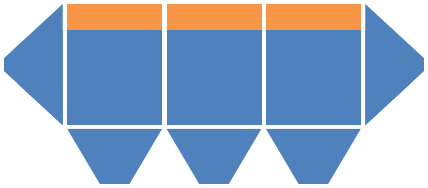
Field(s) Addition

Hybrid

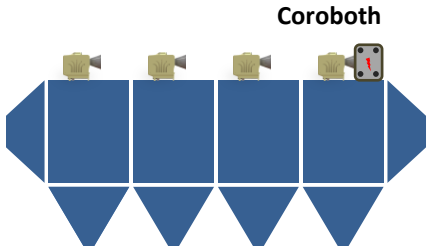
Bag house



Bag house



Height Addition



HF+ coroboth

HF+ Coroboth

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Retrofit Options	Time required	Estimated Cost
Height Increase	1 month	Min. USD 1.8 million
Rotating Plates	2 months	Min. USD 2.5 million
Field(s) Addition	2 months	Min. USD 1.8 million
Hybrid	2 months	Min. USD 2 million
Bag House	2 months	Min. USD 2.5 million
HFTR+Coroboth	2-3 weeks (On-line retrofit)	Only USD 1 million

For a Clearer Sky

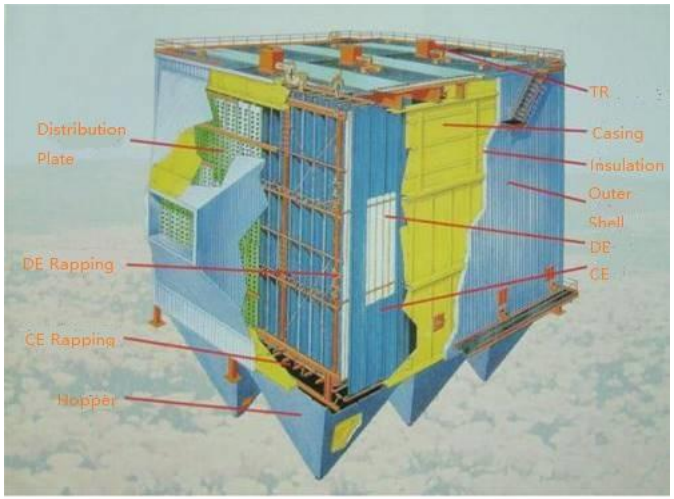
ESP performance improvement—How We Do?

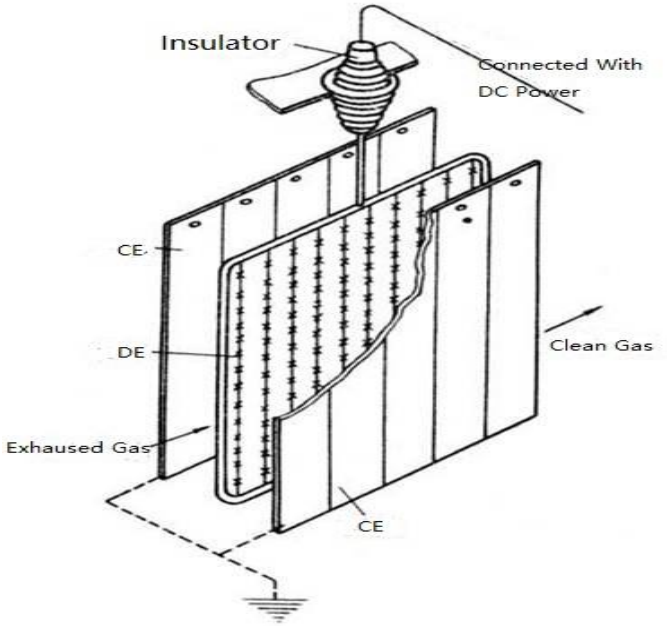
How we do to improve the performance of the installed ESP is totally different from the conventional methods as adopted by others.

We adopt our patented Pulse Power(**Coroboth®**), a proven, matured and advanced system to replace the existing power system of the installed ESP to improve the efficiency of the ESP and finally achieve the targeted emission level as desired.

The entire retrofit process does not require to alter/modify the mechanical portion of the installed ESP whereas only the overhauling procedures as instructed by the original ESP supplier are to be followed.

ESP PERFORMANCE PRINCIPLE





In ESP the flue gas stream is passed between two electrodes, across which a high potential difference is maintained. Out of the two electrodes, one is the discharging electrode and the other a collecting electrode. Because of high potential difference and the discharge system, a powerful ionizing system is formed. Gas ionization is the dissociation of gas molecules into free ions and potentials as high as 40-60kV are used. Consequently, ionization creates an active glow zone (blue electric discharge) called the corona or corona glow.

As the particulates in the carrier gas pass through this field, they get charged and migrate to the oppositely charged collecting electrode. The particles, once deposited on the collecting electrode, lose their charge and are removed mechanically by rapping or vibration to a hopper placed below.

MOST PROBABLE REASONS STATED FOR UNDER PERFORMANCE OF ESP

Dr. B. Sengupta, Member Secretary, Central Pollution Board, New Delhi precisely pointed out the reasons for the under performance of ESP in the Paper published in 2007 << Assessment of Requirement of Bag Filter vis a vis ESP in thermal Power plants>> as follows:

Fundamental Problems	Mechanical Problems	Operational problems
➢ High Resistivity particles ➢ Re-entrainment of collected particles ➢ Poor gas flow ➢ Gas velocity too high	➢ Poor electrode alignment ➢ Vibrating or swinging corona wires ➢ Distorted collecting plates ➢ Excessive dust deposits on collecting electrodes and corona electrodes ➢ Air leakage into hopper, shells or gas ducts ➢ Formation of dust mountain in ESP inlet and outlet ducts	➢ Full or overflow hoppers ➢ Shorted corona sections ➢ ESP overloaded by excessive gas flow ➢ Process upsets (poor combustion, steam leaks, etc.) ➢ Rectifier sets or controls poorly adjusted ➢ Poor adjustment of rapper intensity/frequency

THE ROOT FACTOR FOR ESP PERFORMANCE

IS THE PROBLEM OF HIGH ASH RESISTIVITY?

OSTENSIBLY YES, BUT MATERIALLY NO.

It is a known that all the mechanical and operation problems can be rectified/improved through the overhauling of the ESP and better operation practices.

It is also a known fact that even if after the correct overhauling of the ESP or betterment of the operation practices the performance of ESP could not be desired. The reason is the high specific resistivity of the flying ash.

"Due to presence of low sulphur and alkalis and consequently having very high ash resistivity ($10^{12}\Omega\cdot cm$—$10^{14}\,\Omega\cdot cm$) it is difficult to achieve good ESP performance."

THE ROOT FACTOR FOR ESP PERFORMANCE

IS THE PROBLEM OF HIGH ASH RESISTIVITY?

OSTENSIBLY YES, BUT MATERIALLY NO.

The existing R & D also shows that :

1. It is easy for ESP to collect the flying ash with the specific resistivity between $10^4\Omega\cdot cm$--$10^{10}\Omega\cdot cm$.

1. It is not easy for ESP to collect the flying ash with the specific resistivity between $10^{10}\Omega\cdot cm$--$10^{11}\Omega\cdot cm$ because the spark rate will increase whereas the voltage will decrease to affect the efficiency of the ESP.

1. It is hard or impossible for the ESP, under the conventional electric power supply system equipped, to collect the flying ash with the specific resistivity higher than $10^{11}\Omega\cdot cm$ because there is the incurrence of the back corona and dramatically reduce the efficiency of the ESP.

THE ROOT FACTOR FOR ESP PERFORMANCE

IS THE PROBLEM OF HIGH ASH RESISTIVITY?

OSTENSIBLY YES, BUT MATERIALLY NO.

Our R & D shows:

1. For the flying ash with specific resistivity between $10^4\Omega\cdot cm$--$10^{10}\Omega\cdot cm$, the collecting efficiency can be improved by increasing the density of the secondary current BUT the power consumption has to be increased. This is due to that large portion of the current is wasted in the fields.

1. For the flying ash with specific resistivity above $10^{11}\Omega\cdot cm$, the more particulates can be charged by increasing the secondary output BUT this results in the incurrence of the back corona which decreases the collecting efficiency.

1. For DC power supply to ESP the back corona could be avoided through the intermittent power supply or Charge Ratio power supply, BUT the average voltage dramatically reduces whereas the peak voltage has no improvement. This can not substantially increase the collecting efficiency of ESP.

THE ROOT FACTOR FOR ESP PERFORMANCE

IS THE PROBLEM OF HIGH ASH RESISTIVITY?

OSTENSIBLY YES, BUT MATERIALLY NO.

Hence the dilemma:

Once there is the severe incurrence of back corona, for the SCR power system, the only way to increase the collecting efficiency is to increase the field voltage of the ESP. BUT once the field voltage is increased the back corona will occur which again decrease the collecting efficiency.

Hence for SCR power system for ESP there has to be a compromise, i.e. to select a relatively low average working voltage to restrain the back corona and then achieve the ideal collecting efficiency.

SO THE REAL PROBLEM IS THE POWER SUPPLY SYSTEM EQUIPPED WITH THE ESP.

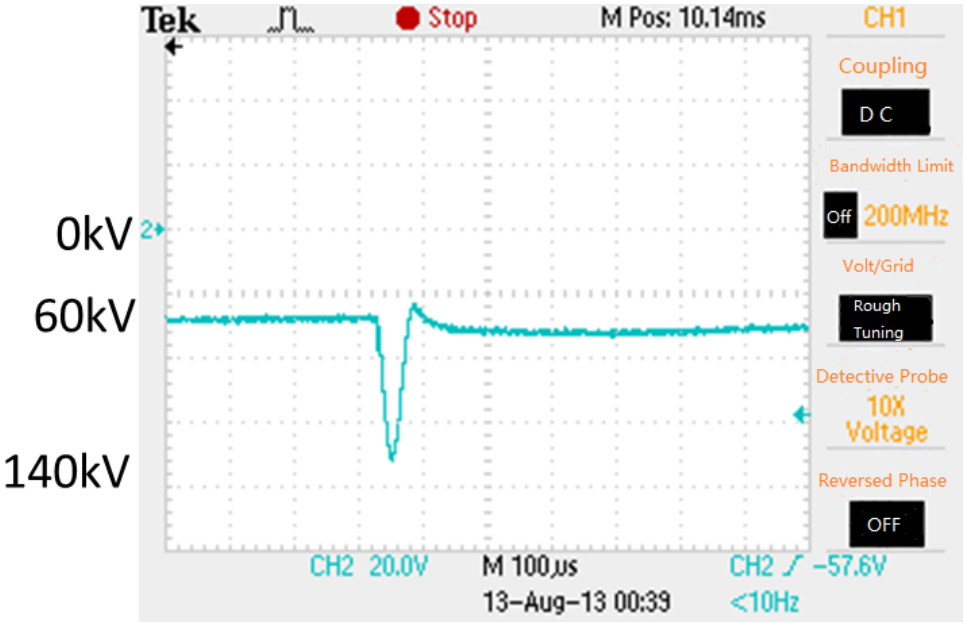
WE HAVE THE SOLUTION --- COROBOTH® SYSTEM

Elgin System India Private Limited.

WHAT IS COROBOTH®?

Since 2008 we initiated the R & D for the power supply for the ESP to tackle the problem of poor performance and the dilemma as mentioned before. We officially launched the COROBOTH® system in the year of 2013.

COROBOTH® is High Frequency Fundamental Wave Superimposed DC power Supply. It outputs MW level energy periodically.



Equivalent Output Energy --- 16 MW

Pulse width --- < 50 us

Working Frequency --- 100 PPS

The field voltage can be increased to 90 kV to 140kV in transient time

For a Clearer Sky

WHAT IS COROBOTH®?

Patent Information:

Coroboth® fundamental wave superimposed pulse power is the trademark jointly owned by M/s: Elgin System Inc. and M/s: Doway.

Coroboth® fundamental wave superimposed pulse power has been respectively patented as invention in China with the patent number of 201310331171.8, 201310340613.5.

Coroboth® fundamental wave superimposes pulse power has been patented as Utility Model in China with the patent number of 201320478930.9, 201320466732.0.

What are the salient features of COROBOTH®?

1. Capturing capacity & capability on the different particle size

Relationship between the particle size and particulate charge		Relationship of carrying capacities among different particulate sizes under different power supplies(times)	
size (μm)	Carrying principle	Conventional DC Power	**Coroboth®**
0.5-1.5	Diffusion Charge	1	**26 times**
10	Diffusion Charge	1	**20 times**
10-20	Both diffusion charge and electrical field charge	1	**17 times**
> 20	Electrical field charge	1	**0.95 times**

What are the salient features of COROBOTH®?

2. Comparison of Vai and Vp among different Power supply systems for ESP

Vai & Vp values comparison			
	SCR	HF	**Coroboth**
Vai	45kV	60kV	**60kV**
Vp	63kV	62kV	**140kV**
Vai × Vp	2835kV^2	3720kV^2	**8400kV^2**
Increased times of ω	1	1.3	**3**

Coroboth ® the effect on particle is 3 times of SCR type power supply and 2.3 times of HF power supply.

ω is the migration velocity. Vai is the average voltage. Vp is the peak voltage.

What are the salient features of COROBOTH®?

3. Comparison on other aspects for ESP efficiency

Description	Properties & Response	Collecting Efficiency under DC Power Supply	Collecting Efficiency under COROBOTH
SiO2	Occupies majority portion of the flying ash with high specific resistivity above $10^{11}\Omega\cdot cm$	Low	High
Al2O3			
Alkali (Cao, K2O)	Neutralization with SO3, Surface conduction reduces and resistance increases	High	High
Na2O	The more ratio and less resistance	High	Normal
SO3	The more ratio, surface conduction increases and resistance reduces	High	Normal
Un-burnt carbon	Specific resistivity of $10^{2}\Omega\cdot cm$ to $10^{3}\Omega\cdot cm$	High	Normal
Temperature	At 150 degree Celsius the resistance reaches peak point, lower than this resistance reduces	At low temp.--- High	Normal

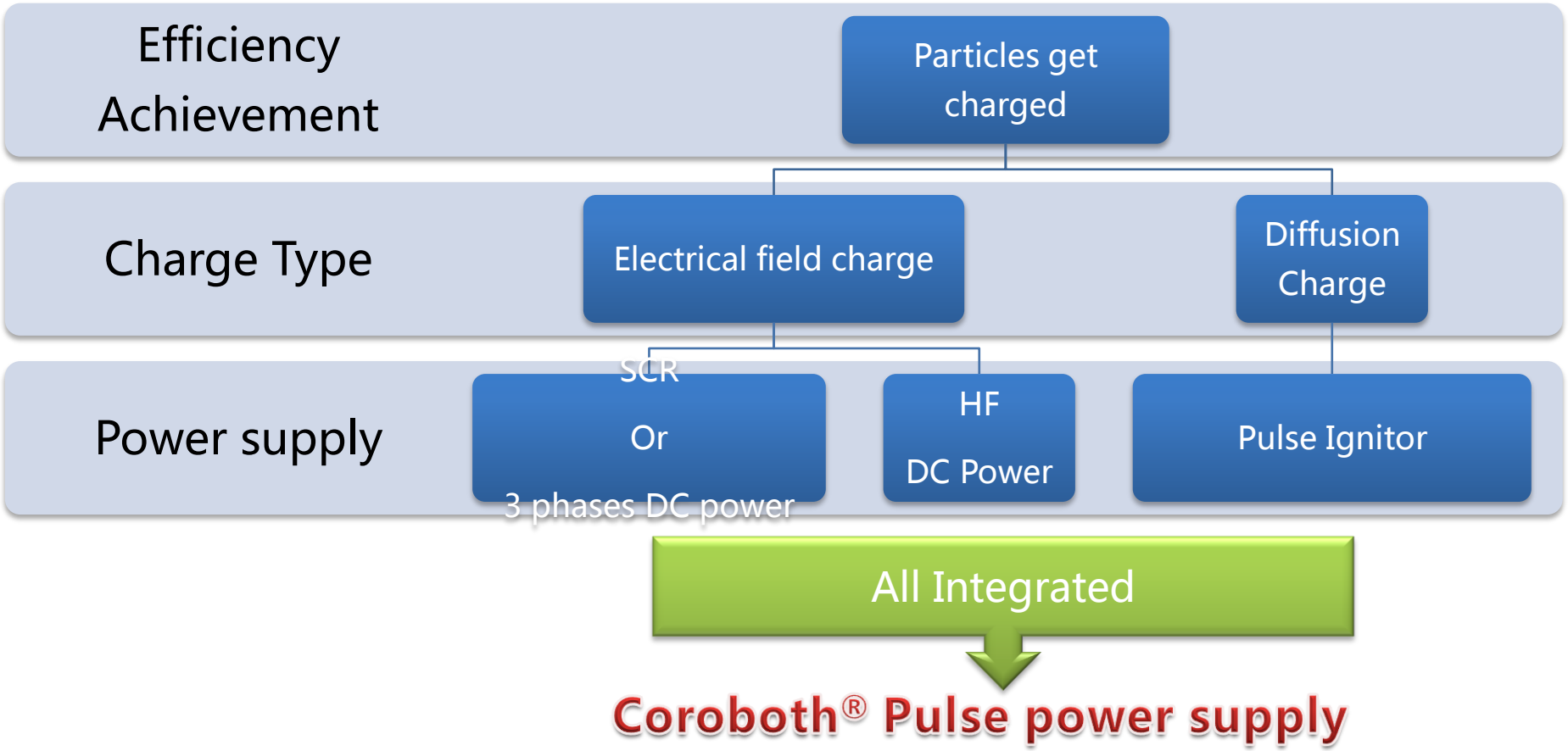
What are the salient features of COROBOTH®?

4. Comparison on other aspects for ESP efficiency

Description	Properties & Response	Collecting Efficiency under DC Power Supply	Collecting Efficiency under COROBOTH
NH3	➢ Small portion reacts with Sox to form sticky and soft subjects which reduces the specific resistivity a little bit ➢ When larger portion of NH3 counters the high resistivity ash to form more sticky subjects and difficulty to fall down which increases the resistance and incurs the back corona	Small portion --- High Large portion --- Chock Large portion --- Corrosion	Normal
Moisture	Moisture in the flue gas and the SO3 can together affect the surface conduction of the ash, the more moisture the less resistance	High	Normal

What are the Salient features of COROBOTH®?

5. Electrical Field Charge & Diffusion charge



What are the salient features of COROBOTH®?

6. Power Consumption reduces --- Comparison

Comparison of Input power of different power system under same collecting efficiency					
Description	Unit	SCR	HF	Coroboth	Remark
DC Base voltage	kV	50	58	39	DC voltage Max. 60kV
Pulse voltage	kV			50	CE spacing of 400mm
PRF	Hz			100	
I Corona	mA	700	810	350	DC current Max. 1200mA
P Field consumption	kW	35	47	15	
P input	kW	55	52	18	

Coroboth® input power calculation formula:

Pout=DC Base × I Corona + Vps × Ips × 50 × PRF × 10^{-6}

At the same emission level, Coroboth® Power consumption is over 67% less than SCR power.

What are the salient features of COROBOTH®?

7. Capacity & Capability to Capture High Specific Resistivity Ash

COROBOTH® Pulse Power System has the capacity and capability to capture tiny and high specific resistivity ash.

Coroboth® Pulse Power System

Capacity & Capability ---- Several times or more than ten times

How does COROBOTH® work --- The technical background

1. Coroboth® invention theoretical background --- Deutsch formula and its correction formula

① $\eta = 1 - e^{-f\omega}$: f ——A / Q, the SCA(m^2 / m^3/S)
A——TCA (m^2)
Q——GAS FLOW VOLUME (m^3/S)
ω——MIGRATION VELOCITY (m/S)

② $\omega = \frac{PV_pV_{ai}a^2}{6\pi u}$

$\omega \approx \beta$ VpVai

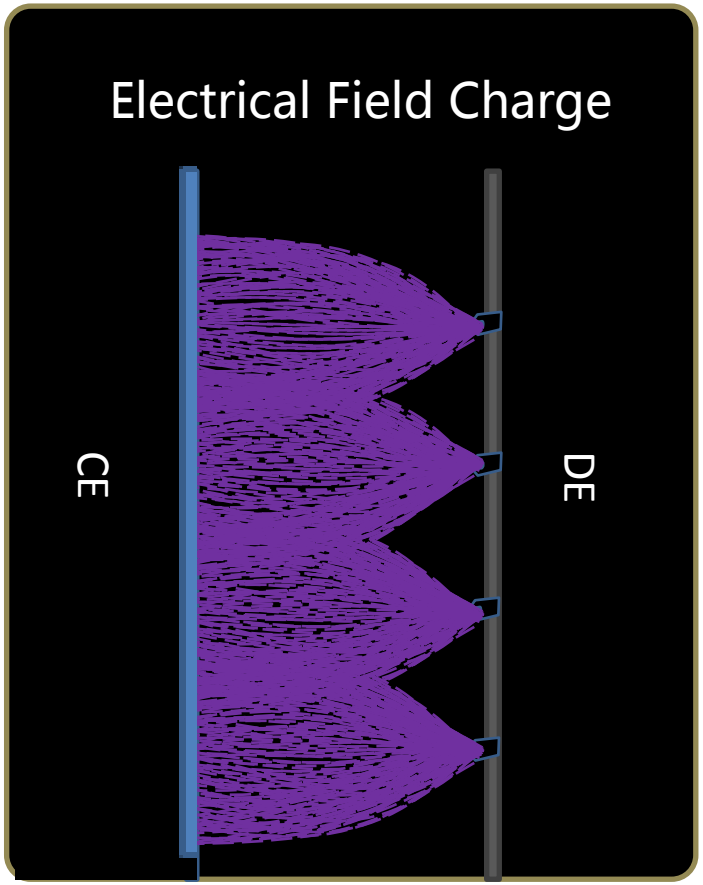
β—constant ; V_p—Peak voltage ; V_{ai}—average voltage ; Note: $\omega \propto V_p \times V_{ai}$

a) According to formula ①, when the SCA and gas flow volume are fixed, the only option to increase the collecting efficiency is to increase the migration velocity ω.

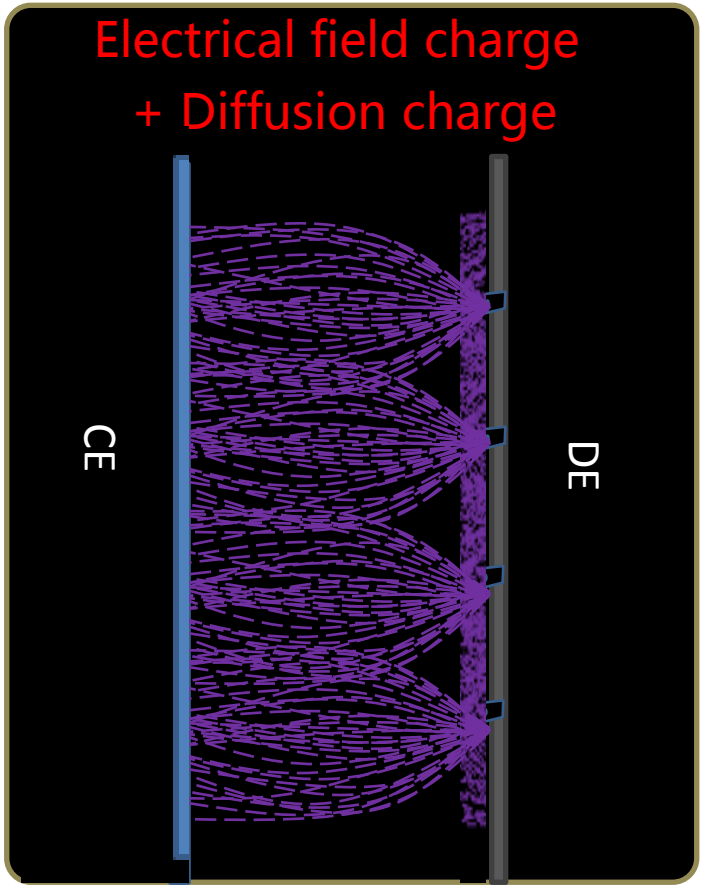
b) In order to increase the migration velocity ω, according to formula ② , the V_p and V_{ai} have to be increased. In the DC power supply system and to avoid the electrical field flash over, it is hard to increase the Vp value whereas COROBOTH pulse power system is able to increase the Vp substantially without causing electrical the field flash over in microsecond, this happens in less than 75μs,the output single pulse wave is equivalent to MW level energy.

How does COROBOTH® work?

1. Coroboth® --The corona form



DC power working



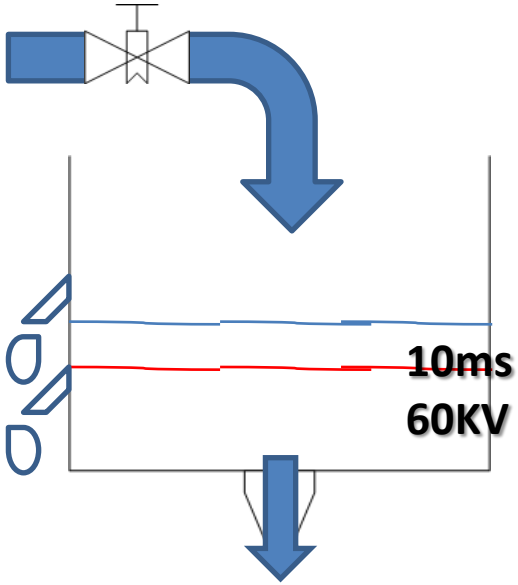
COROBOTH® Pulse power working

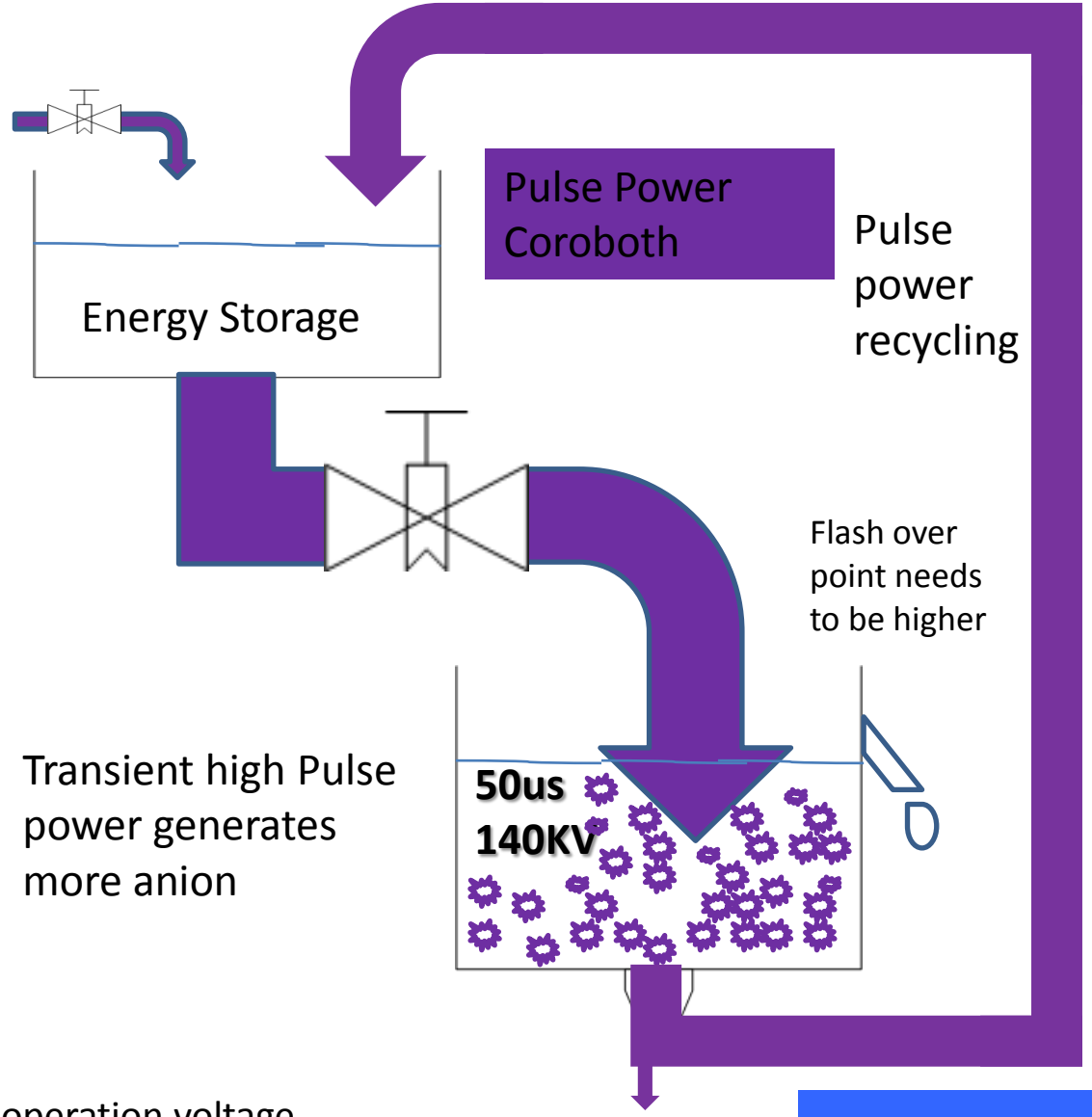
How does COROBOTH® work?

2. Coroboth®-- Function

The mechanical of ESP is like a water tank which leaks water continuously. The voltage like the level, the higher the better.

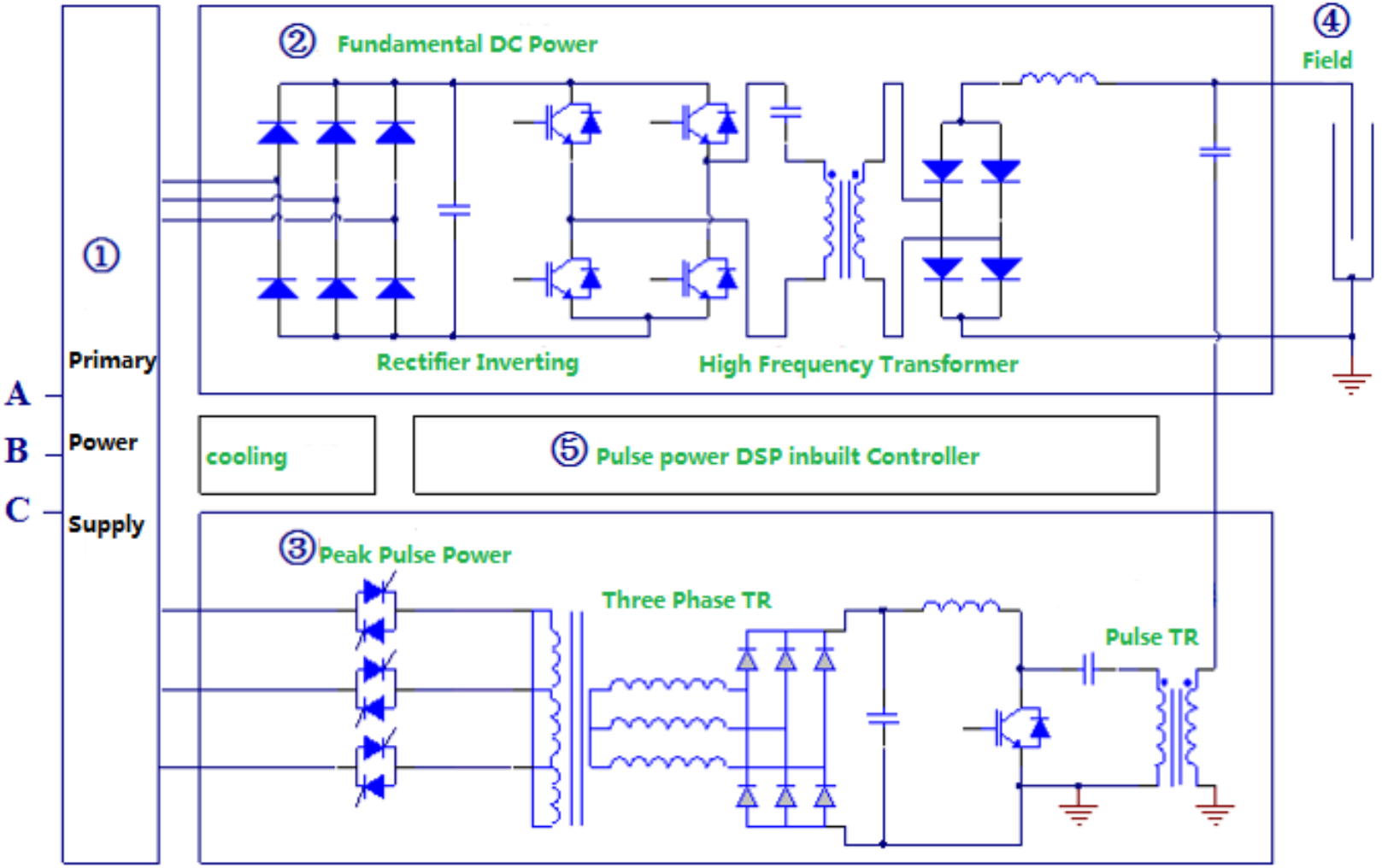
DC power (SCR, 3 PHASE, HF)



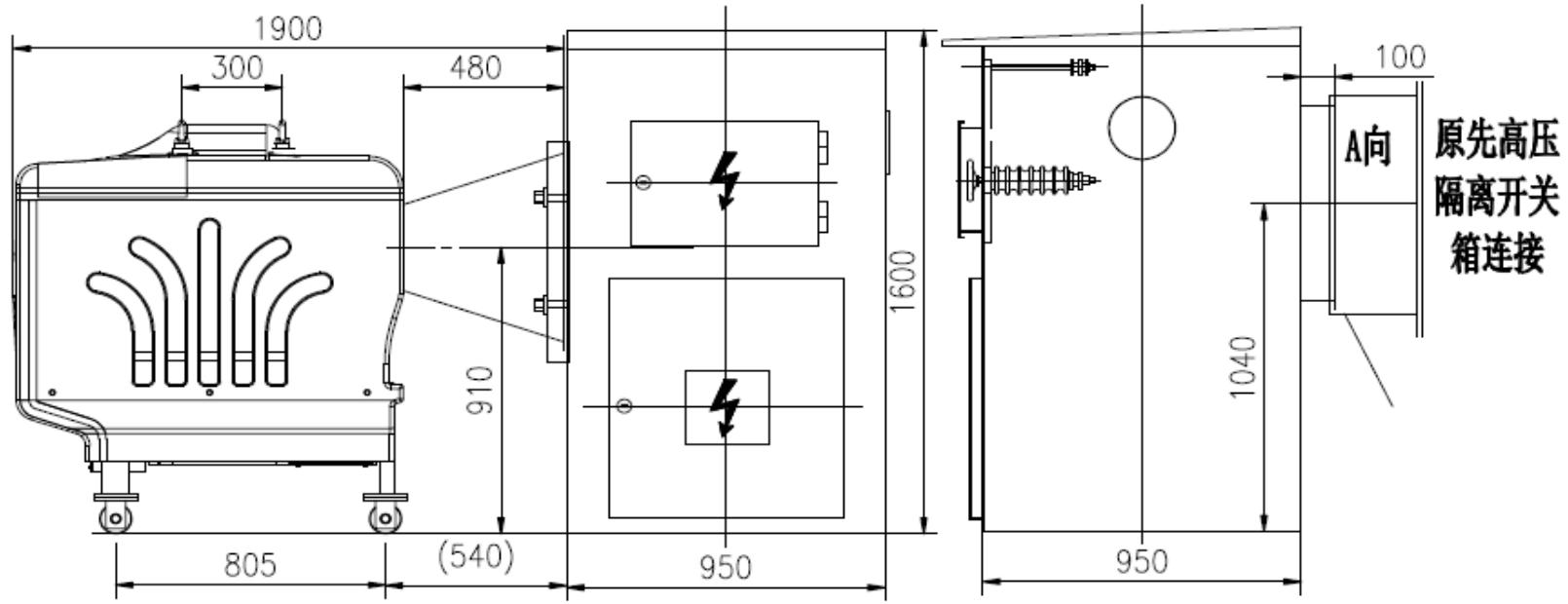


Flash point needs to be higher than the operation voltage

COROBOTH® Functioning Electric Diagram



COROBOTH® Construction



Fundamental wave output voltage： 60kV

Fundamental wave output current： 1.2A

Pulse output voltage： 80kV with the adjustable range between 0~100%

Pulse output frequency： 0~100Hz

Power： 16MW

Maximum current： 200A

COROBOTH® Construction

Stable & Reliable

Pulse power TR temp. rising less than 10 ℃

Adopting special magnetic material and special architect design to ensure the temp. rising less than 10 ℃.

Isolation protection technology

- All the DI, DO signals are isolated through optoelectronic system
- IGBT is driven by fiber.
- The driven power is dually isolated by isolated TR and switch power.

Fault Protection technology

- Dual watch dog (hardware & software)
- IGBT drive board has double over-current protection, both open circuit and short circuit protected.

COROBOTH® Construction

Stable & Reliable

Advance insulation material and processing

- The most international advanced insulation material and the insulation design are adopted.
- The acetylene emission is zero.

Outdoor protection class and complete fault protection

- The case adopts the industrial ABS with rigid construction.
- The protection class is IP55.
- Complete Fault protections are available.

Upto 60℃ working environmental temp.

- The recycling air cooling technology adopted can blow away the heat generated by the equipment.
- Tested that it works when the enviornmental temp. reaches 60 ℃

COROBOTH® Construction

Stable & Reliable

SS and Anti-corrosion design

- The control box, HV outlet flange, even small fixing bolts and nuts are of SS material.
- The base is Salt spray treated which ensures the reliable operation in the plant located at sea shore or in tropic area.

Highest level of screening of components

Coroboth adopts the makes of the components of:
ABB, SCHNEIDER, MIT LV electric components, INFINEON IGBT, TI chip, PHOENIX terminal, APPLE IPAD RTU, complex busbar, aviation sealing fitting, MOXA communication unit, IFIX configuration software

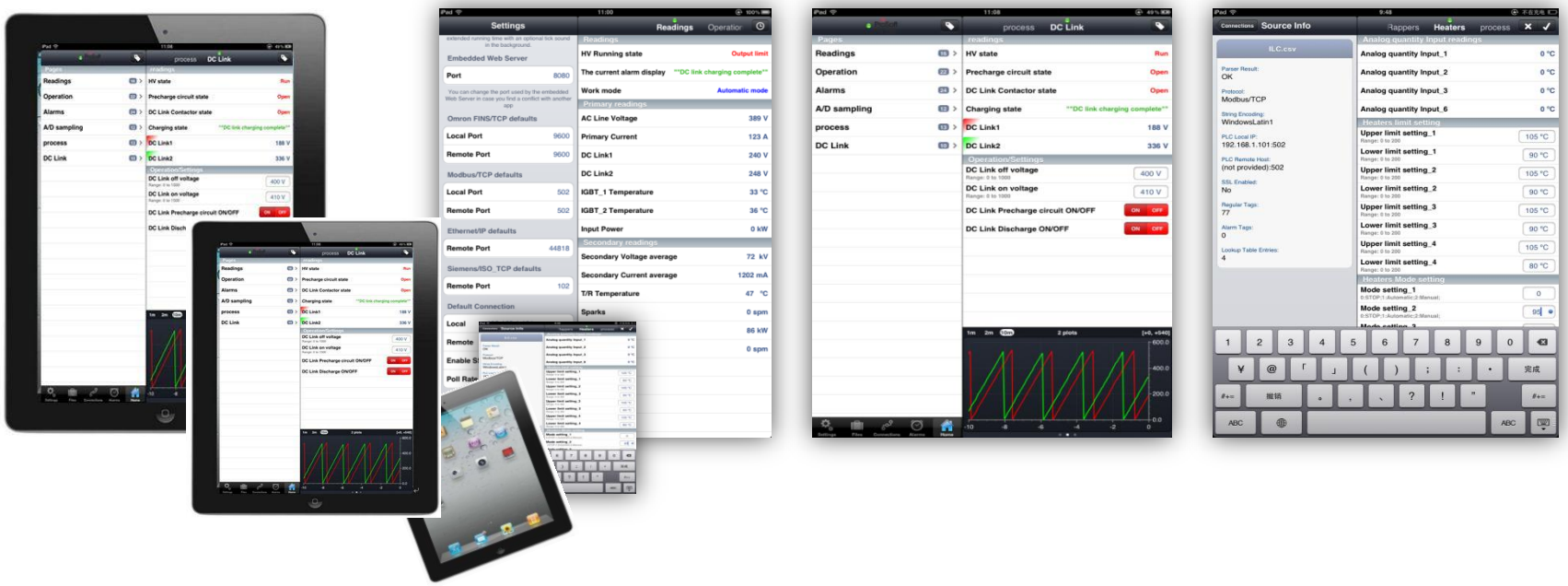
Severe thunderstorm stable operation

The linear isolation and fiber transmission are adopted for the signals. All passed the thunderstorm test. COROBOTH can safely be in operation under the thunderstorm weather condition.

COROBOTH® Construction

Wireless operation system

- To achieve the all weather on- site operation, the IPAD wireless RTU is developed to facilitate the operation.



Elgin System India Private Limited.

COROBOTH® --- Service After Sales

- The project office at **Raipur, Chhattisgarh** ready for 24 X 7 quick response to the services as requested by the client.
- Sustainable optimization services to help the client to obtain:
  - Particles size distribution data
  - Particle specific resistivity data among 20-800℃
  - Report of ESP power supply system influence on the grid and improvement suggestion
  - The optimized power supply mode, rapping mode and actual emission.(In general it is divided into 3 groups, i.e. A: minimum emission priority, B: minimum power consumption priority and C: both considering mode.
  - ESP E&IC deficiency analysis and improvement suggestion
  - ESP mechanical deficiency analysis and improvement suggestion

Testing facilities available： MS2000 Malvern laser particle analyzer ； 20-800℃ particle specific resistivity analyzer； FLUKE electric energy analyzer and data collecting system； MATSUSHIMA PFM Portable emission analyzer and GPS data transfer system； DC/AV150KV HV METERS； D030-IIB Multi function calibration instrument； FLUKE 100MHZ Dual channel oscilloscope； DEOD DATA BASE MODULE

Summary of Coroboth® Pulse Power System

> High efficiency for capturing particle < PM10

> High efficiency for capturing high specific ash resistivity particle

> Improve ESP efficiency and substantially reduce emission

> Reduce power consumption

Once Again

The perfect solution for ESP efficiency improvement

Coroboth®