

BUILDING A WORLD OF DIFFERENCE

AIR QUALITY CONTROL TECHNOLOGIES TO COMPLY WITH REVISED ENVIRONMENTAL NORMS

PRATIK MEHTA – AIR QUALITY CONTROL SPECIALIST

27 April 2016



BLACK & VEATCH
Building a world of difference.®

AGENDA

About Black & Veatch

AQC Technologies And Black & Veatch Experience

Client's Testimonials



ABOUT BLACK & VEATCH



BLACK & VEATCH BY THE NUMBERS

2014
revenue
\$3.0B

founded
1915

7,000
Active projects
at any given
time

0.38
recordable
incident
rate

Projects
in **100**
countries

0.07
lost time
incident
rate

110+
offices
worldwide

10,000
global
workforce

projects
on **6**
continents

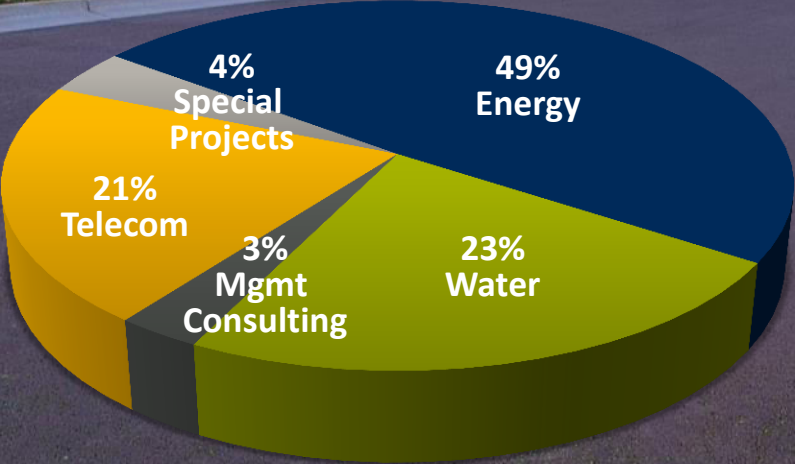
FINANCIAL STRENGTH

\$425M
Equity

\$500M+
Bonding Capacity

\$500M+
Invested Balances

\$3.0B
2014 Revenues



AIR QUALITY CONTROL

COUNTERING UNCERTAINTY WITH CUSTOMIZED
PLANNING & TECHNICAL SOLUTIONS



BLACK & VEATCH CAPABILITIES

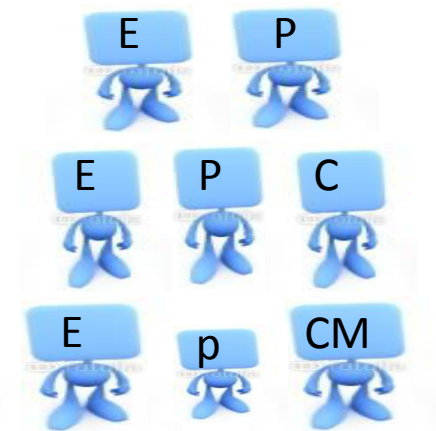
ENGINEERING SERVICES

- Feasibility Reports
- Detail Project Reports
- Owner's Engineering Services
- Lender's Engineering Services
- Detail Engineering Services

PROJECT SERVICES

- Project Management
- Construction Management
- Startup Services
- Operator Training
- Outage Management

EXPANDED SCOPE



AQC TECHNOLOGIES AND BLACK & VEATCH EXPERIENCE

PARTICULATE CONTROL
TECHNOLOGIES



LIMITS FOR PARTICULATE MATTER

For the Units installed before December 31, 2003

Now the **TARGET** is :

100 mg/Nm³

Units installed between January 1, 2004 and December 31, 2016

Now the **TARGET** is :

50 mg/Nm³

Units to be installed from January 1, 2017

Now the **TARGET** is :

30 mg/Nm³

SOLUTIONS TO MEET THE TARGET PARTICULATE MATTER LIMIT:

- Dual flue gas conditioning
- Upgrading the existing ESP
 - Mechanical Upgrade
 - Electrical Upgrade
- Conversion of existing ESP into baghouse
- New baghouse (Pulse Jet Fabric Filter)



COMPARISON OF PARTICULATE CONTROL TECHNOLOGIES

PM Control Technologies	DESP	FF
Controlled particulate emissions, mg/Nm ³	30 - 50	15 - 20
Capital Cost	High	Medium
Operations and Maintenance (O&M) Cost	Low	High
Auxiliary Power	Medium	Medium (higher induced draft [ID] fan energy consumption)
Pressure Drop	Low	Medium
SO ₃ Removal	Low	Low
Fine Particulate Removal	Low	Medium
Mercury Removal	Low	Medium
Fuel and Operating Flexibility	Low	High
Maximum Temperature Limitations	None	Yes
Minimum Temperature Limitations	Yes	Yes
Reagent Injection for Multipollutant Capabilities	Limited	Good

QUALIFICATION AND EXPERIENCE LIST OF PARTICULATE CONTROL TECHNOLOGIES

Client	Plant / Location	Capacity (Net MW)	COD	Contract Structure
Kansas City Power & Light Co.	La Cygne Unit 1; Kansas	800	2015	OE
Empire District Electric Co.	Asbury Unit 1; Missouri	213	2015	OE
City Water, Light & Power, Springfield, IL	Dallman Unit 4, Illinois	200	2012	EPC
Westar Energy	Lawrence Energy Center Units 4-5; Kansas	530	2012	EpCM
Louisville Gas & Electric Company - Kentucky Utilities	Ghent Generating Station; Kentucky	2100	2011	OE
Sandy Creek Energy Associates, L.P. and Brazos Sandy Creek Electric Cooperative	Sandy Creek Energy Station, Unit 1; Texas	898	2011	EPC

Flexible Contracting Structure – Suits to Client Needs



QUALIFICATION AND EXPERIENCE LIST OF PARTICULATE CONTROL TECHNOLOGIES (EPC BASIS)

Client	Plant / Location	Capacity (Net MW)	COD	Contract Structure
Oklahoma Gas and Electric Company	Sooner Generating Station Units 1 and 2, Red Rock, Oklahoma	2 x 570	2019	EPC
City Water, Light & Power, Springfield, IL	Dallman Unit 4, Illinois	200	2012	EPC
Sandy Creek Energy Associates, L.P. and Brazos Sandy Creek Electric Cooperative	Sandy Creek Energy Station, Unit 1; Texas	898	2011	EPC
Plum Point Energy Associates, LLC	Plum Point Energy Station; Arkansas	660	2010	EPC
Omaha Public Power District	Nebraska City Unit 2, Nebraska	663	2010	EPC
City Public Service of San Antonio	J.K. Spruce Unit 2; Texas	750	2010	EPC

Black & Veatch has extensive experience and knowledge to help you achieve the new emission particulate target limit.



AQC TECHNOLOGIES AND BLACK & VEATCH EXPERIENCE

NO_x CONTROL TECHNOLOGIES



LIMITS FOR NO_x

For the Units installed before December 31, 2003

Now the TARGET is :

600 mg/Nm³

Units installed between January 1, 2004 and December 31, 2016

Now the TARGET is :

300 mg/Nm³

Units to be installed from January 1, 2017

Now the TARGET is :

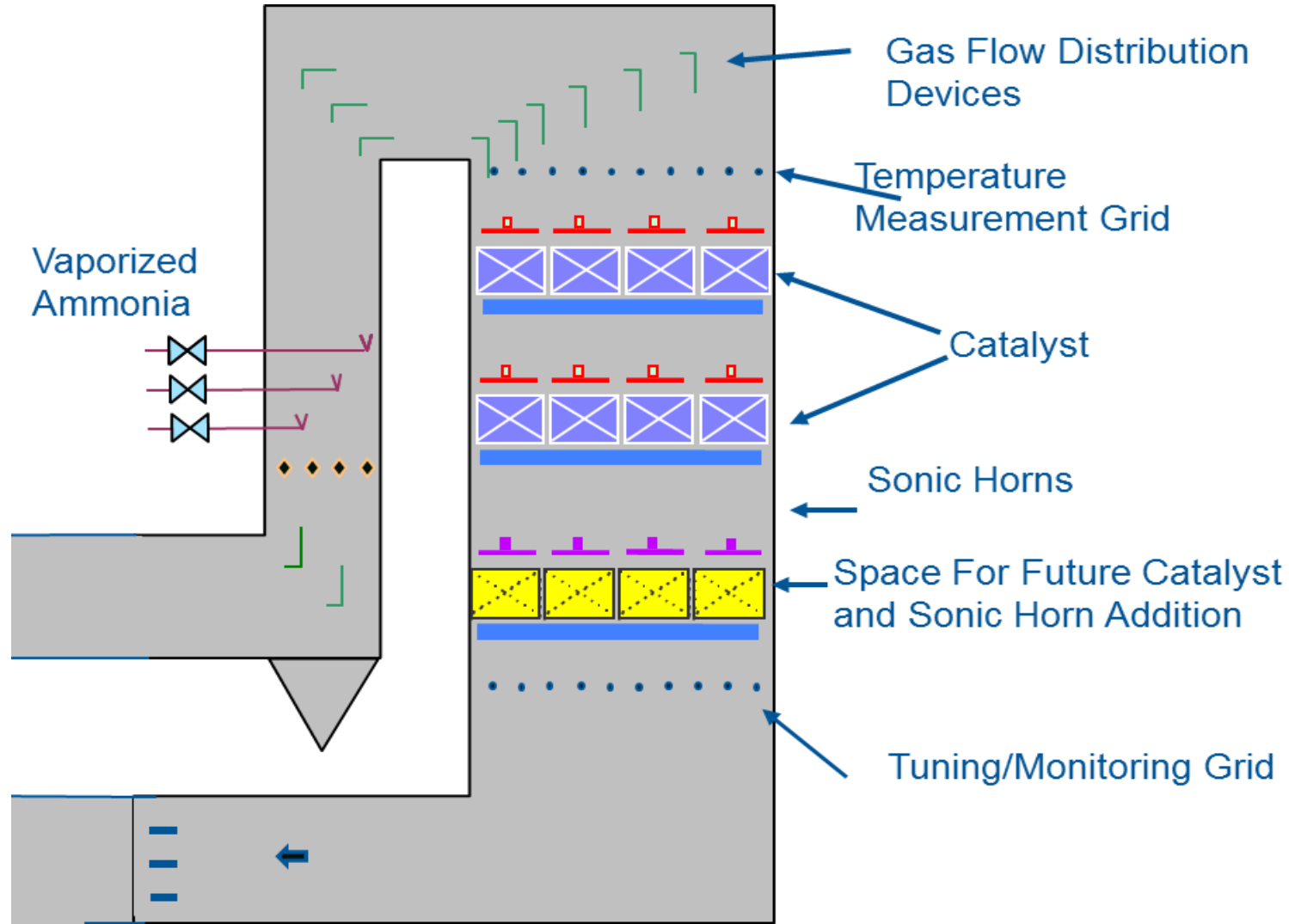
100 mg/Nm³

SOLUTIONS FOR EXISTING PLANTS TO MEET THE TARGET NO_x LIMIT

- Upgrading Low NO_x Burners
- Over Fire Air in conjunction with upgraded LNB
- Boiler tuning and Combustion optimization
- Selective Non Catalytic Reduction
- Hybrid SCR

SOLUTIONS FOR NEW PLANTS TO MEET THE TARGET NOX LIMIT

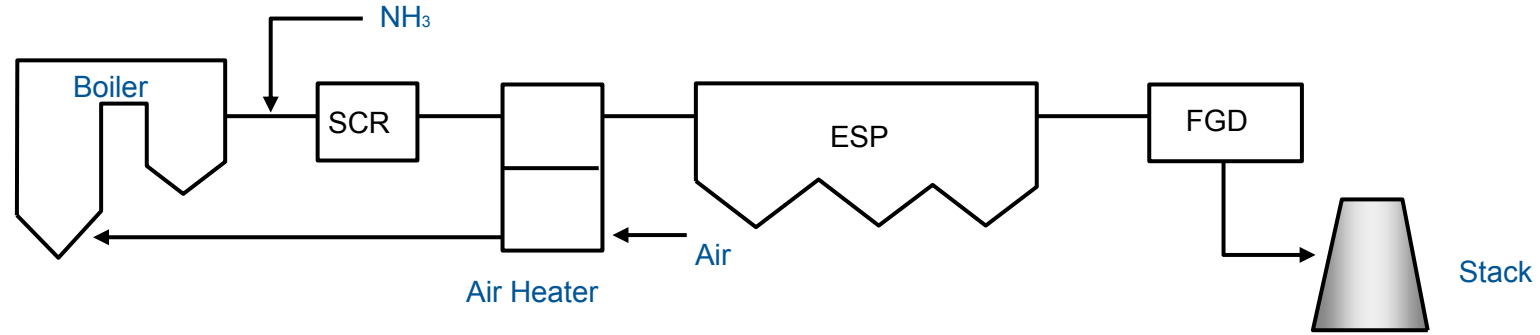
- Selective Catalytic Reduction



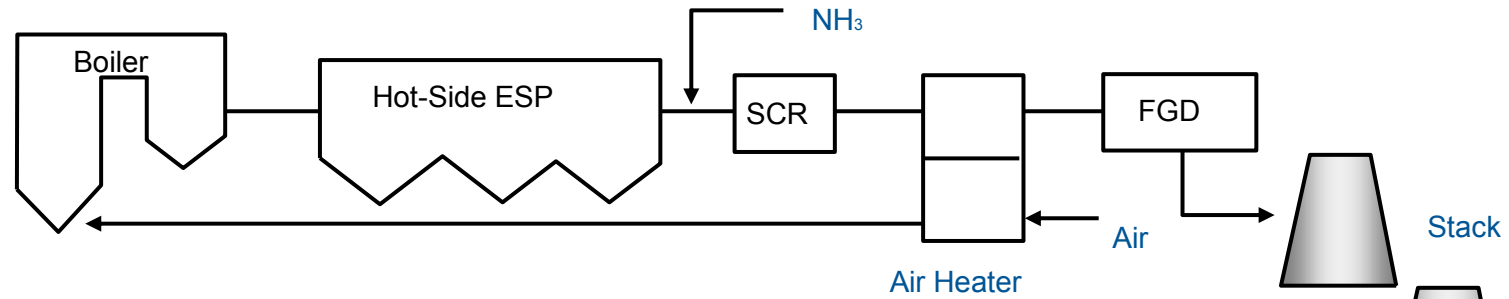
SCR reactor and ducting

ALTERNATE SCR ARRANGEMENTS

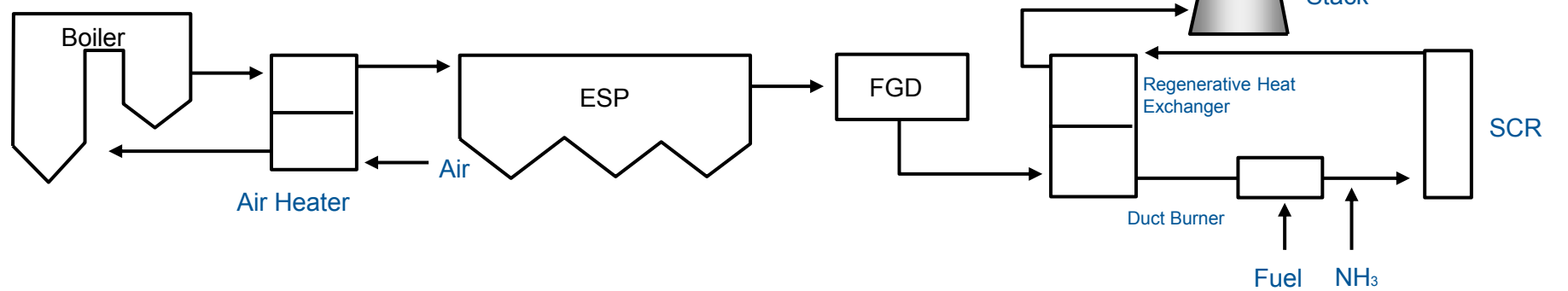
High Dust



Low Dust



Tail End



COMPARISON OF NO_x CONTROL TECHNOLOGIES

NO _x Control Technologies	SCR	SNCR	In-Duct Hybrid SCR
Controlled NO _x emissions, mg/Nm ³	60 – 75 ¹	210 – 250 ¹	135 - 160 ¹
Capital Cost	Highest	Medium	High
O&M Cost	Highest	Medium	High
Control Efficiency	High	Medium	Medium/High
Auxiliary Power	Highest	Medium	High
Pressure Drop	Highest	Medium	High
Balance-of-Plant (BOP) Impacts	Air heater fouling	Air heater fouling	Air heater fouling
Fly Ash Sales Impact	Possibly	Possibly, increased potential over the SCR	Possibly
Safety and Hazard Risks	Yes	Yes	Yes
Additional Pollutant or Byproduct Formation	Ammonium bisulfate	Ammonium bisulfate	Ammonium bisulfate
Additional AQC Equipment Required	Hot-side DESP may be required for high dust application	None	Hot-side DESP may be required for high dust application

Notes:

1. When used in conjunction with LNB and OFA.

QUALIFICATION AND EXPERIENCE LIST OF NO_x CONTROL TECHNOLOGIES

Capacity (Net MW)	Plant / Location	Capacity (Net MW)	COD	Contract Structure
Golden Valley Electric Association (GVEA)	Healy Power Plant, Unit 1 and Unit 2; Healy, Alaska	76	2017	EPC
Kansas City Power & Light Co.	La Cygne Unit 2; Kansas	715	2014	OE
Kansas City Board of Public Utility	Quindaro Unit 2; Kansas	102	2011	OE
Sandy Creek Energy Associates, L.P. and Brazos Sandy Creek Electric Cooperative	Sandy Creek Energy Station, Unit 1; Texas	898	2011	EPC
Plum Point Energy Associates, LLC	Plum Point Energy Station; Arkansas	660	2010	EPC

Black & Veatch has extensive experience regarding the evaluation, design and application of all types of NO_x emissions reduction technologies for projects using coal, oil and natural gas as fuels.

QUALIFICATION AND EXPERIENCE LIST OF NO_x CONTROL TECHNOLOGIES (EPC BASIS)

Capacity (Net MW)	Plant / Location	Capacity (Net MW)	COD	Contract Structure
Golden Valley Electric Association (GVEA)	Healy Power Plant, Unit 1 and Unit 2; Healy, Alaska	76	2017	EPC
City Water, Light & Power, Springfield, IL	Dallman Unit 4, Illinois	200	2012	EPC
Sandy Creek Energy Associates, L.P. and Brazos Sandy Creek Electric Cooperative	Sandy Creek Energy Station, Unit 1; Texas	898	2011	EPC
Plum Point Energy Associates, LLC	Plum Point Energy Station; Arkansas	660	2010	EPC
Omaha Public Power District	Nebraska City Unit 2, Nebraska	663	2010	EPC
City Public Service of San Antonio	J.K. Spruce Unit 2; Texas	750	2010	EPC
Indianapolis Power and Light Company	Harding Street Station Unit 7; Indiana	460	2005	EPC
Associated Electric Cooperative, Inc.	New Madrid Station Units 1-2; Missouri	2 x 638	2001	EPC

QUALIFICATION AND EXPERIENCE LIST OF NO_x CONTROL TECHNOLOGIES (SCR – B&V DESIGN)

Capacity (Net MW)	Plant / Location	Capacity (Net MW)	COD	Contract Structure
Golden Valley Electric Association (GVEA)	Healy Power Plant, Unit 1 and Unit 2; Healy, Alaska	76	2017	EPC
Alabama Electric Cooperative, Inc.	Lowman Power Station Units 1, 2 and 3; Alabama	90, 250, 250	2009	EPCM
Northern Indiana Public Service Company	Bailly Unit 7 and 8, Schahfer 14, Michigan City 12; Indiana	175, 420, 560, 520	2003- 08	EPCM
Jacksonville Electric Authority	St. John's River Power Park; Florida	2 x 670	2008	EPCM
Vectren/Alcoa	Culley Unit 3, Warrick Unit 4, A.B. Brown Unit 1 and 2	287, 320, 265, 265	2003- 05	EPCM
Indianapolis Power and Light Company	Harding Street Station Unit 7; Indiana	460	2005	EPC
Dayton Power and Light Company	Stuart Units 1, 2, 3, 4 and Killen Unit 2, Ohio	585 (each) and 600	2003- 04	EPCM
City Water, Light & Power, Springfield, IL	Dallman Unit 31, 32, 33; Illinois	80, 80, 190	2003	EPCM
Associated Electric Cooperative, Inc.	New Madrid Station Units 1-2; Missouri	2 x 638	2001	EPC

AQC TECHNOLOGIES AND BLACK & VEATCH EXPERIENCE

SO₂ CONTROL
TECHNOLOGIES



LIMITS FOR SO₂

For the Units installed before December 31, 2003

Now the Target is :

600 mg/Nm³ (<500MW)

200 mg/Nm³ (>500MW)

Units installed between January 1, 2004 and December 31, 2016

Now the Target is :

600 mg/Nm³ (<500MW)

200 mg/Nm³ (>500MW)

Units to be installed from January 1, 2017

Now the Target is :

100 mg/Nm³

SOLUTIONS TO MEET THE TARGET SO₂ LIMIT

- Wet flue gas desulphurization (FGD) systems
 - Limestone based FGD
 - Ammonia based FGD
- Sea water FGD
- Spray dryer absorbers (SDA)
- Circulating dry scrubbers (CDS)
- Duct sorbent injection



Cardinal FGD retrofit

COMPARISON OF SO₂ CONTROL TECHNOLOGIES

SO ₂ Control Technologies	WFGD	SDFGD	SWFGD
Controlled SO ₂ emissions, mg/Nm ³	50 - 75	80 - 100	100 - 120
Capital Cost	High	Low	Medium
Reagent Cost	Low	High	None
O&M Cost	High	Medium	Low
Auxiliary Power	High	Medium	Medium
Pressure Drop	High	Medium	Medium
SO ₃ Removal	Medium	High	Medium
Hydrogen Chloride Removal	High	High	High
Hydrogen Fluoride Removal	High	High	High
Particulate Removal	PM device upstream with some removal in FGD	PM device downstream with FGD providing no PM control	PM device upstream with some removal in FGD
Oxidized Mercury Removal	High	Negligible	High
Stack	Corrosion-resistant lining required	Carbon steel stack allowed	Corrosion-resistant lining required
Material of Construction	High corrosion-resistant alloy or nonmetallic liner or fiberglass reinforced plastic (FRP)	Carbon steel	High corrosion-resistant alloy or nonmetallic liner or FRP
Liquid Waste	Yes - may require wastewater treatment plant	None	Yes - discharge to sea
Byproduct Sales Impact	Saleable	Not saleable	None
Additional AQC Equipment Required	Gas-to-gas reheater	None	Gas-to-gas reheater

QUALIFICATION AND EXPERIENCE LIST OF SO₂ CONTROL TECHNOLOGIES

Client	Plant / Location	Capacity (Net MW)	Commercial Operation Date	Contract Structure
Oklahoma Gas & Electric Company (OG&E)	Sooner Generating Station, Units 1 & 2; Red Rock, Oklahoma	2 x 570	2019	EPC
Eskom	Kusile Units; Witbank, South Africa	6 x 800	2018	EpCM
Louisville Gas & Electric Company	Mill Creek Units 1-4; Kentucky	1200	2015	OE
Kansas City Power & Light Co.	La Cygne Unit 1; Kansas	800	2015	OE
Orlando Utilities Commission	Stanton Energy Center Unit 1; Florida	460	2013	Ep
City Water, Light & Power, Springfield, IL	Dallman Unit 4, Illinois	200	2012	EPC

Black & Veatch has extensive experience with the all predominant SO₂ reduction processes. In total, Black & Veatch has experience with FGD systems installed on more than 42,600 MW of generating capacity.

QUALIFICATION AND EXPERIENCE LIST OF SO₂ CONTROL TECHNOLOGIES (EPC BASIS)

Client	Plant / Location	Capacity (Net MW)	Commercial Operation Date	Contract Structure
Oklahoma Gas & Electric Company (OG&E)	Sooner Generating Station, Units 1 & 2; Red Rock, Oklahoma	2 x 570	2019	EPC
Indianapolis Power and Light Company	Petersberg Unit 4; Indiana	550	2012	EPC
City Water, Light & Power, Springfield, IL	Dallman Unit 4, Illinois	200	2012	EPC
Sandy Creek Energy Associates, L.P. and Brazos Sandy Creek Electric Cooperative	Sandy Creek Energy Station, Unit 1; Texas	898	2011	EPC
Plum Point Energy Associates, LLC	Plum Point Energy Station; Arkansas	660	2010	EPC
Omaha Public Power District	Nebraska City Unit 2, Nebraska	663	2010	EPC
City Public Service of San Antonio	J.K. Spruce Unit 2; Texas	750	2010	EPC



QUALIFICATION AND EXPERIENCE LIST OF SO₂ CONTROL TECHNOLOGIES (WET FGD – B&V/CHIYODA DESIGN – EPC BASIS)

Client	Plant / Location	Capacity (Net MW)	Commercial Operation Date	Contract Structure
Alabama Electric Cooperative, Inc.	Lowman Power Station Units 1, 2 and 3; Alabama	90, 250, 250	2009	EPC
American Electric Power	Cardinal Units 1, 2 and 3; Ohio	620 (each)	2008-09	EPC
American Electric Power	Clifty Creek Units 1-6; Indiana	220 (each)	2009	EPC
American Electric Power	Conesville Unit 4; Ohio	840	2009	EPC
American Electric Power	Kyger Creek Units 1-5; Ohio	220 (each)	2008	EPC
Dayton Power and Light Company	Stuart Units 1, 2, 3 and 4; Ohio	585 (each)	2008	EPC
Dayton Power and Light Company	Killen Unit 2; Ohio	600	2008	EPC
Southern Company	Crist Station Unit 6 and 7; Florida	740	2007	EPC

CLIENT'S TESTIMONIALS



We had a very strong partner in having Black & Veatch, a company that really worked with us to make sure that what we needed out of this project was delivered.

– Wisconsin Power & Light
Columbia Energy Center Air Quality Control
Retrofit



We've been coming back to Black & Veatch for 60 years.

– Senior Vice President, Strategy
Westar Energy





Black & Veatch has been a true partner with our air quality projects. The innovative design and construction of this project enabled us to meet and surpass our objectives.

– Director of Construction
Vectren SCR Retrofit Projects

Innovative air quality control retrofit design provides cleaner air to more than 5 million Florida residents.

– St. Johns River Power Park
St. Johns River Power Park NO_x Reduction Project



Building a **world** of difference.®

Together



BLACK & VEATCH

www.bv.com