



# WSA & SNOX™ technology for the production of sulfuric acid in power plants

RESEARCH | TECHNOLOGY | CATALYSTS

Presented by Patrick Polk

January 17, 2013

# Agenda

---

- WSA process
- SNOX<sup>TM</sup> process
- Economics compared with limestone scrubbing

# Wet gas Sulfuric Acid (WSA)

---

- 95-99.97% of the sulfur content is recovered
- Sulfur is recovered as concentrated sulfuric acid of commercial grade
- No waste products
- Exothermic process
- Simple lay-out
- First reference in 1980
- Over 115 references



# WSA applications

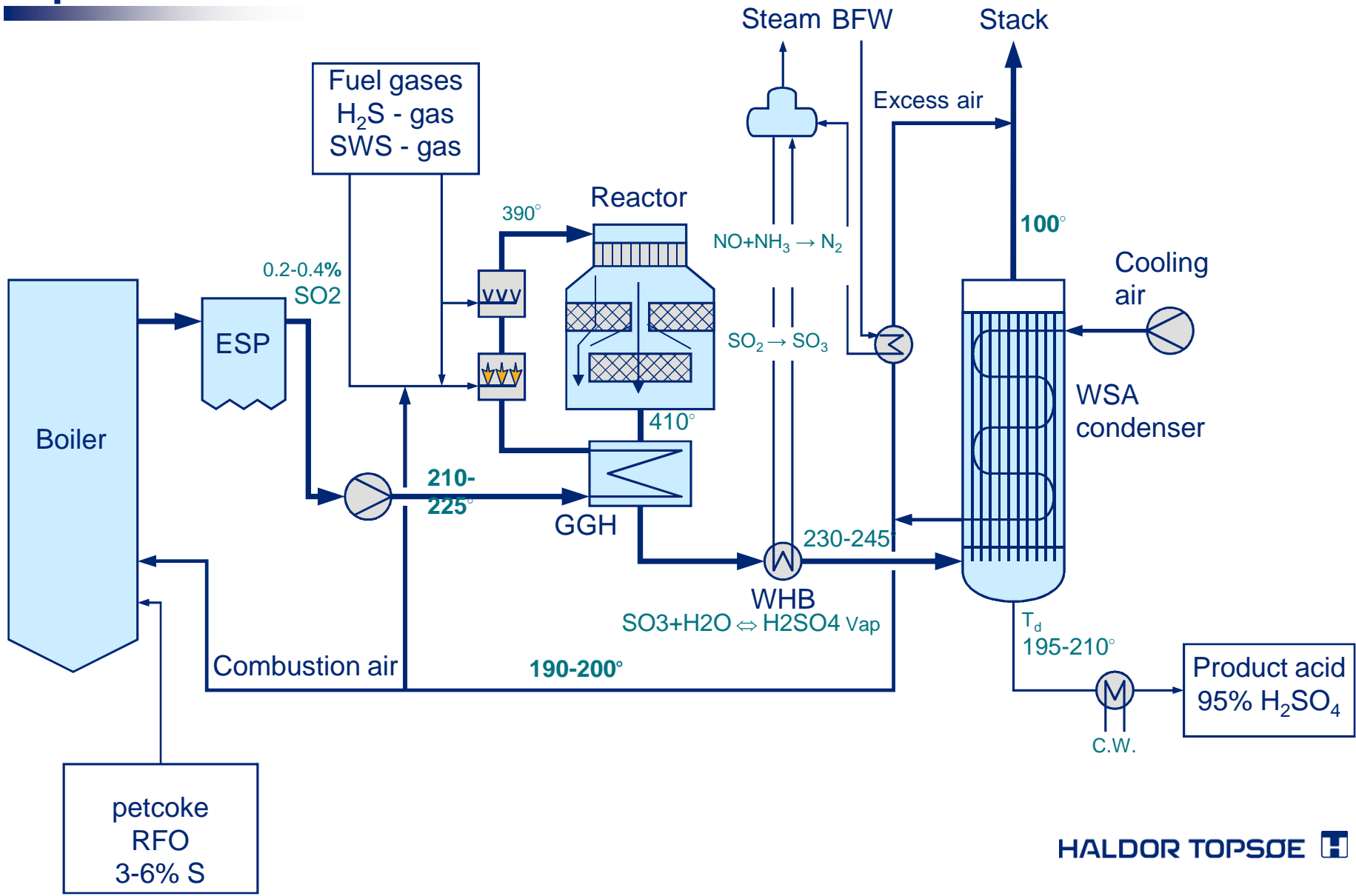
---

- Refineries
  - SAR, Amine off-gas, SWS off-gas, Claus tail gas
- Coal Gasification
  - Rectisol, Selexsol acid gas treatment
- Metallurgical and mineral industry
  - Smelter off-gas
- Power Plant
  - Boiler flue gas
- Coking, Viscose, Petrochemical, etc.

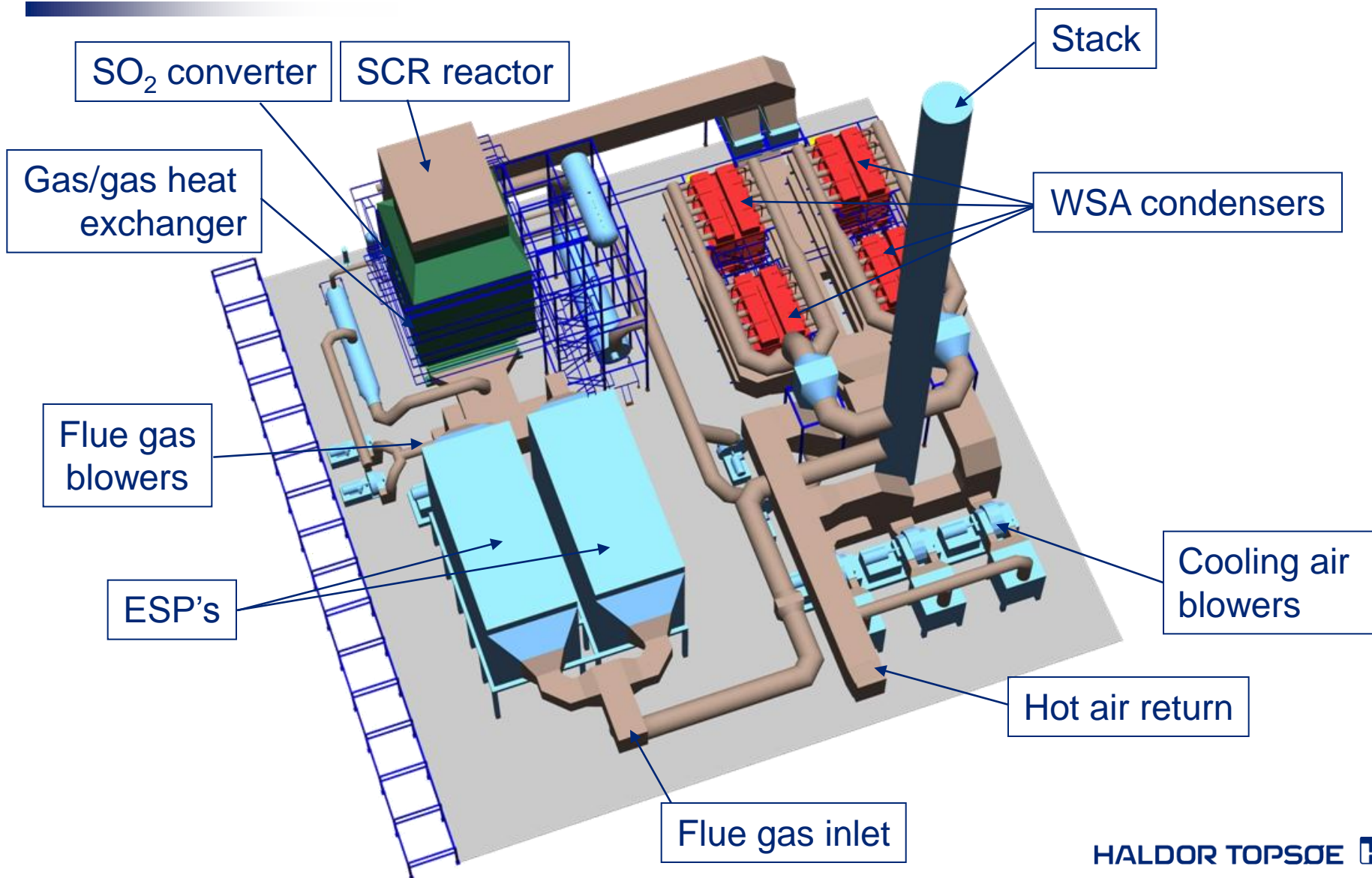
**SNOX = WSA + NOx removal**

**SNOX™ flue gas treatment  
increases thermal efficiency  
and reduces CO<sub>2</sub> emission  
when using high sulfur coal  
or petcoke for power generation**

# Boiler with SNOX™ for high sulfur coal or petcoke



# SNOX™ – bird's eye view





# Additional heat recovered in SNOX™ plant

Catalytic SO<sub>2</sub> oxidation:



Gas phase SO<sub>3</sub> hydration:



Acid condensation:



Total reaction heat recovered by converting the SO<sub>2</sub> in the flue gas to 95% H<sub>2</sub>SO<sub>4</sub> at 200°C is 3.45 BTU per lb sulfur in the fuel or 0.17 BTU per lb fuel with 5% S.

Additional heat recovered by cooling the flue gas from typically 185°C (365°F) with WFGD to 100°C (212°F) with SNOX™ is 0.57 – 0.70 BTU per lb fuel.

# With SNOX dirtier is greener

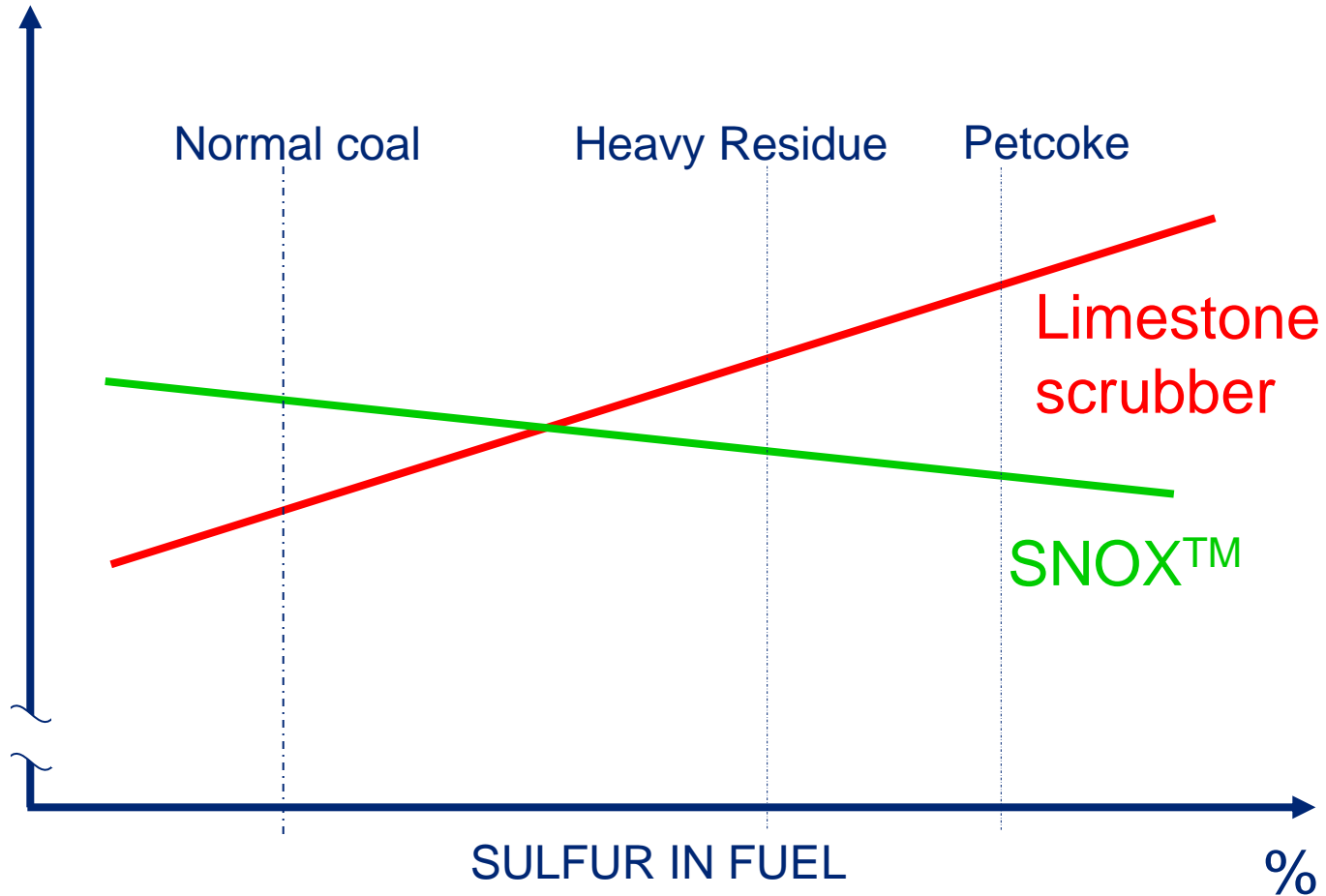
With 5 % sulfur in coal or petcoke and SNOX™ as FGD:

- Steam production is 5% higher compared to current alternatives. This corresponds to a 5% reduction of CO<sub>2</sub> emission at the same steam production.
- Replacing limestone FGD ( $\text{CaCO}_3 + \text{SO}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{CaSO}_4 + \text{CO}_2$ ) reduces CO<sub>2</sub> emission by 2% compared to wet limestone FGD and by 4 - 5% compared to burning the fuel in a CFB boiler ( $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$ ).

# Cost of flue gas desulfurization

\$/kWh

TOTAL COST (CAPEX + OPEX) OF  
FLUE GAS DESULFURIZATION



# Comparison of operating costs

**Basis: Petcoke**  
**300 MW electric power**  
**Unit: USD per year**

**Downshot  
PC boiler  
with SNOX™**

**CFB boiler  
with SCR DeNOx  
and limestone FGD**

## **Income:**

Sales of sulfuric acid at \$30/t	3,600,000	0
----------------------------------	-----------	---

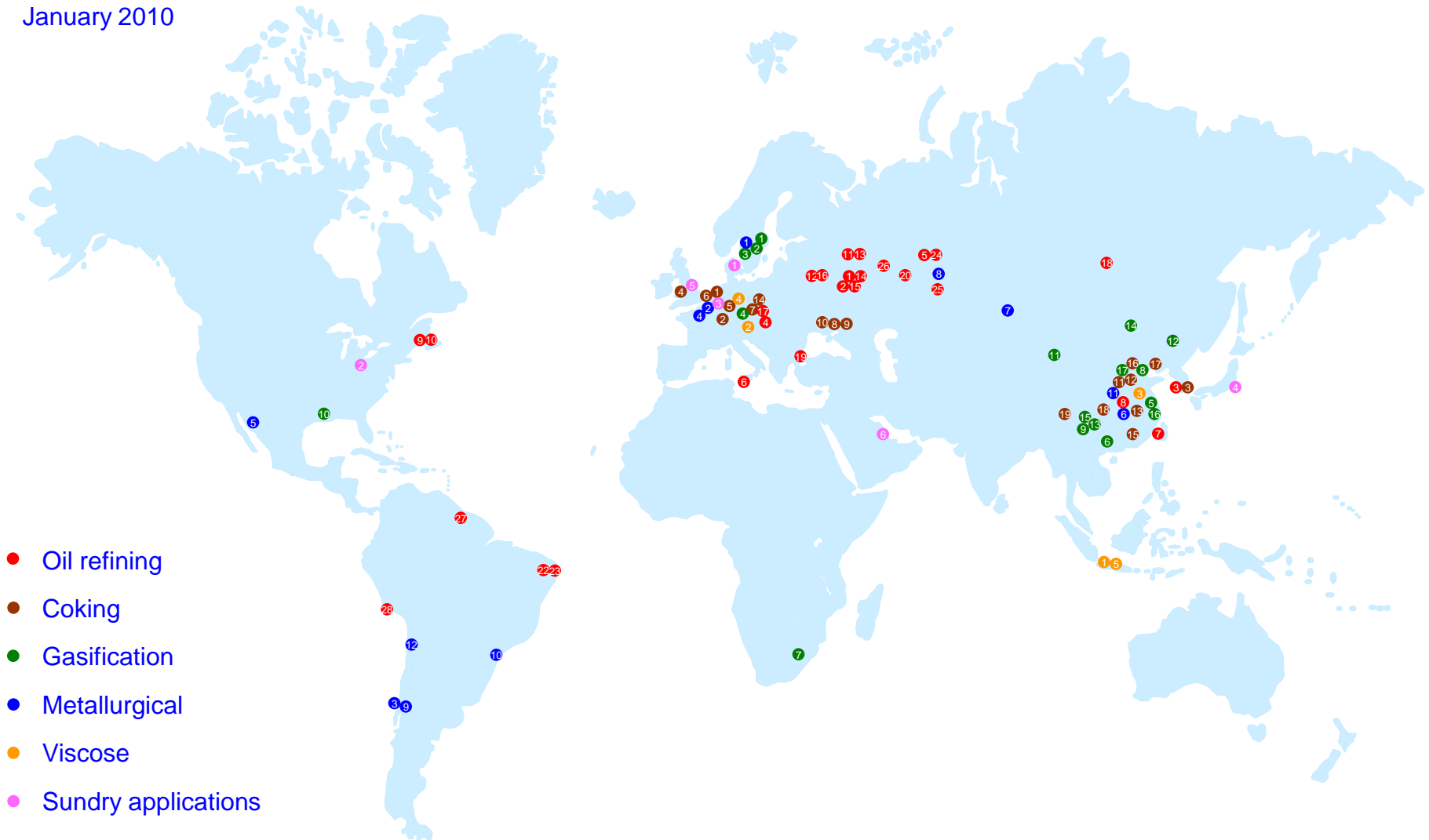
## **Costs:**

Limestone at \$20/t	0	7,500,000
Ammonia at \$300/t	600,000	240,000
Waste disposal at \$20/t	0	12,000,000
Additional petcoke consumption at \$40/t	0	400,000
Total costs	<u>600,000</u>	<u>20,000,000</u>

<b>Net operating income</b>	<b>+ 3,000,000</b>	<b>– 20,000,000</b>
-----------------------------	--------------------	---------------------

# WSA/SNOX™ – references (location)

January 2010



# WSA/SNOX™ plants – references

---

## Contracted plants:

- 35 in oil refining (including 4 SNOX™)
- 30 in coking industry
- 24 in gasification
- 13 in metallurgical industry
- 7 in viscose industry
- 8 in other industries (including 2 SNOX™)

# SNOX™ references

Plant	Capacity (flue gas)	Start-up	Fuel
Nordjyllandsværket, Denmark	1,000,000 Nm <sup>3</sup> /h 900 MM SCFD	1991	Coal
Raffineria di Gela, Italy	1,200,000 Nm <sup>3</sup> /h 1,075 MM SCFD	1999	Petcoke + RFO
OMV Refinery, Austria	820,000 Nm <sup>3</sup> /h 735 MM SCFD	2007	RFO + sour gas
Petrobras RNEST, Brazil	2 x 650,000 Nm <sup>3</sup> /h 2 x 582 MM SCFD	Expected 2014	Petcoke + sour gas
Ohio Edison, USA (demonstration plant)	135,000 Nm <sup>3</sup> /h 121 MM SCFD	1991-96	Coal

# SNOX™ – Raffineria di Gela, Italy

## Raffineria di Gela, Sicily, Italy

Boilers: approx. 250 MW<sub>e</sub>  
+ steam and heat

Fuel: **90% Petroleum coke**

Additional fuel: Oil and gas

Total flue gas flow: 1,200,000 Nm<sup>3</sup>/hr  
**1,075 MM SCFD**

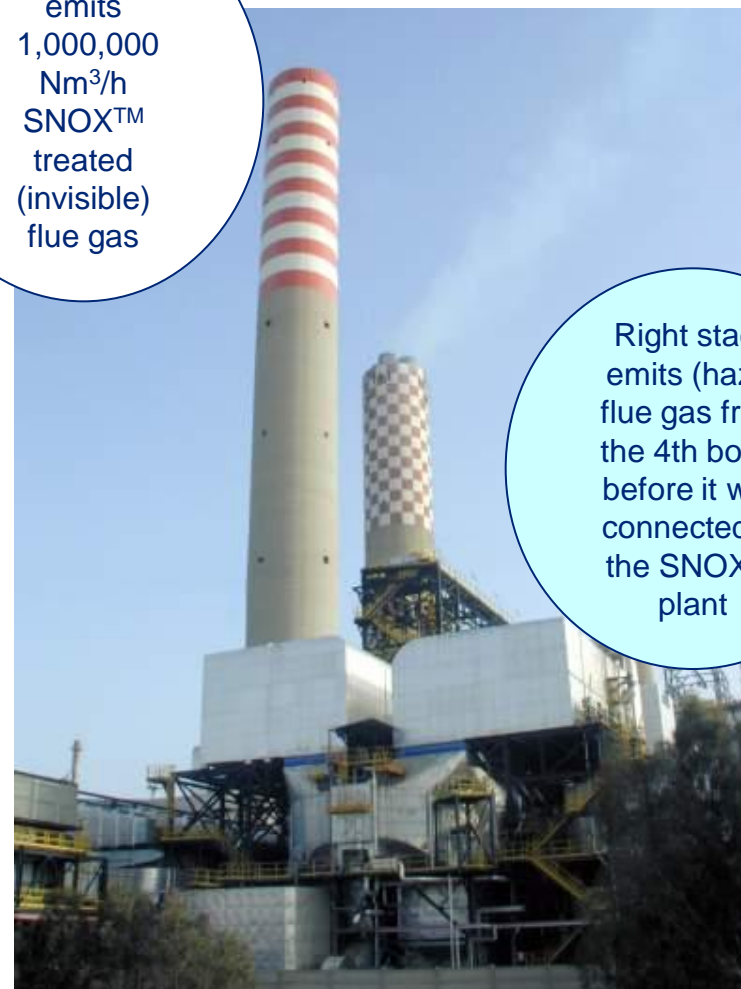
H<sub>2</sub>SO<sub>4</sub> (95%): 225 t/d

SO<sub>2</sub> removal: 96.5%

Commissioned: 1999

Left stack  
emits  
1,000,000  
Nm<sup>3</sup>/h  
SNOX™  
treated  
(invisible)  
flue gas

Right stack  
emits (hazy)  
flue gas from  
the 4th boiler  
before it was  
connected to  
the SNOX™  
plant





# SNOX™ – OMV, Austria

## OMV Refinery, Schwechat, Austria

Boilers: 180 MW<sub>e</sub>  
+ 1,000 t/h steam

Fuel: **Visbreaker residue**

Additional feed: Claus tail gas

Total flue gas flow: 820,000 Nm<sup>3</sup>/hr  
**735 MM SCFD**

H<sub>2</sub>SO<sub>4</sub> (94%): 225 t/d

SO<sub>2</sub> removal: 98%

Commissioned: 2007



# Eight good reasons for SNOX™

---

- Excellent heat recovery
- Reduced CO<sub>2</sub> emissions
- No process chemicals except NH<sub>3</sub> for SCR
- No process water consumption
- No production of waste solids and liquids
- Valuable sulfuric acid product
- Clean, proven and reliable technology
- Low operating & maintenance costs.

# Thank you for your attention!

