

REINHOLD ENVIRONMENTAL Ltd.



**2019 REINHOLD Round Table  
Presentation**

June 24 & 25, 2019, in Birmingham, Alabama / Hosted by Southern Company

All presentations posted on this website are copyrighted by Reinhold Environmental, Ltd (RE). Any unauthorized downloading, attempts to modify or to incorporate into other presentations, link to other websites, or obtain copies for any other uses than the training of attendees to RE's Conferences is expressly prohibited, unless approved in writing by RE or the original presenter. RE does not assume any liability for the accuracy or contents of any materials contained in this library which were presented and/or created by persons who were not employees of RE.

---

# The importance of SCR O&M performance to minimize the total cost of ownership of your SCR

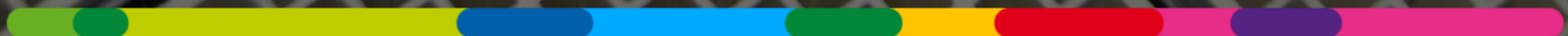
*Xavier Henry, Director, Chemistry Department*

*Reinhold Round Table, 25<sup>th</sup> June 2019, Alabama*

---



Catalyst  
Management  
Solutions



---

# ENGIE Laborelec: leading independent SCR solution provider

## *SCR solutions by operators for operators*

---

- **ENGIE is the world's largest IPP**, having introduced SCR technology in its fleet more than 20 years ago, with Engie Laborelec being its expertise center for the power value chain
- **20+ years experience with independent SCR asset management**, including turnkey delivery of tailor-made catalyst and O&M solutions, **for more than 100 SCR's worldwide** in Europe, America, Africa and Asia
- Experience with **all types of catalyst and fuels** (coal, gas, fuel oil, biomass/biofuel, waste)
- **Independent laboratory** for SCR catalyst testing, reference for VGB round-robin testing
- **Unlike OEM's**, Laborelec is **part of a utility group**, being directly involved in **O&M return of experience**, as well as **SCR design and commissioning experience**

Why is SCR O&M performance as important as catalyst performance for SCR design and operation ?

---

# 01

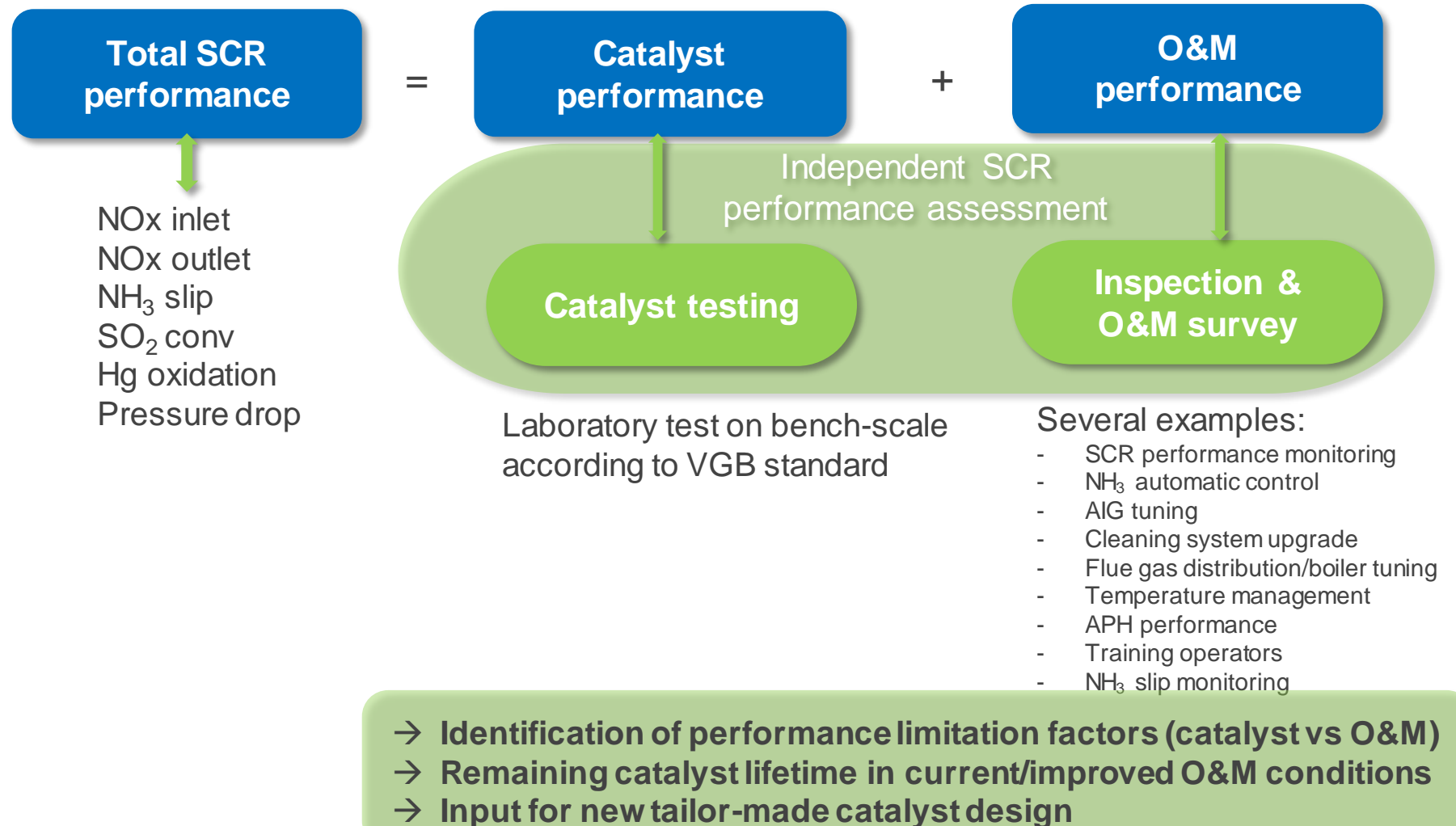
Improving the total SCR deNO<sub>x</sub> system performance

---



# SCR performance assessment as operator best practice

*Focus on lowest Total Cost of Ownership*

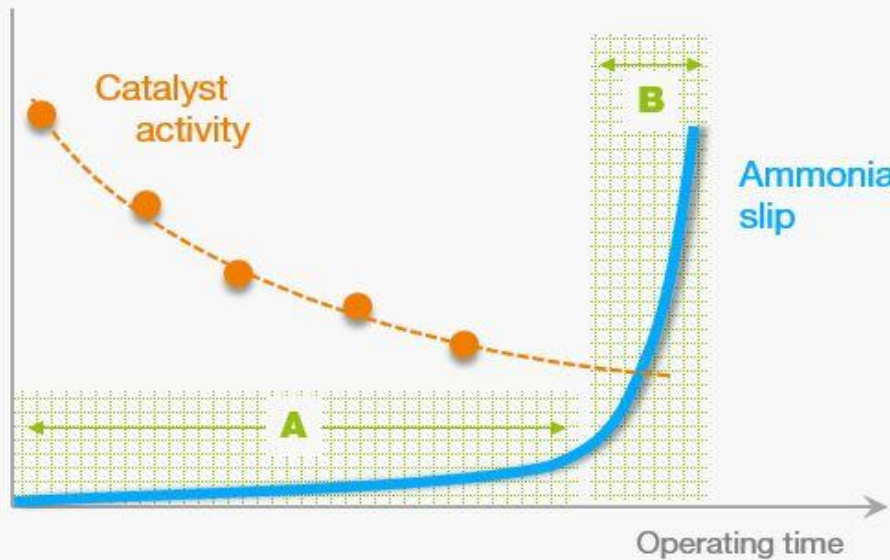


# Why is catalyst testing important?

Catalyst performance decreases with time → need for ageing assessment

## The importance of regular catalyst testing

Lagging indicator (ammonia slip) versus leading indicator (catalyst activity)



→ Reflects both catalyst and O&M performances

Ageing of the catalyst → decrease of DeNO<sub>x</sub> efficiency

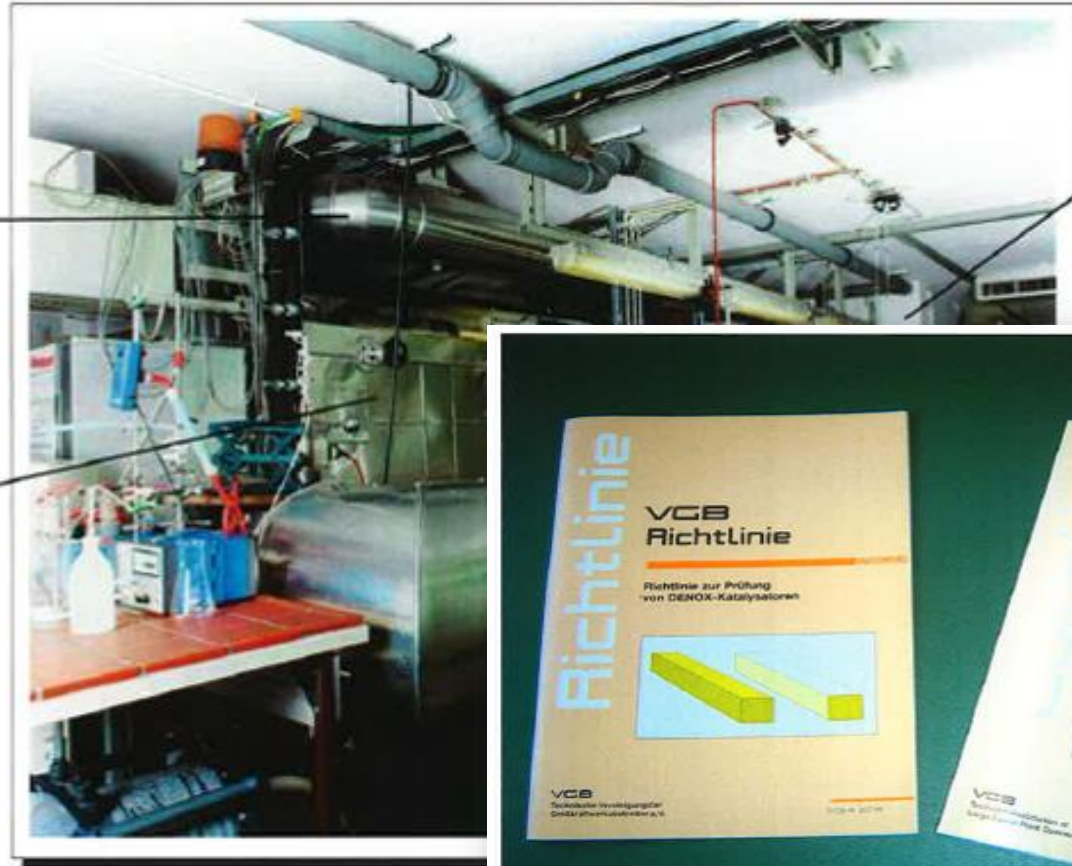
Need to regularly test the catalyst in laboratory (leading key indicator of ageing)

# Catalyst must be tested in bench-scale, actual plant conditions

*Follow VGB/EPRI standard and be independent from OEM*

exhaust duct

2 measuring chambers

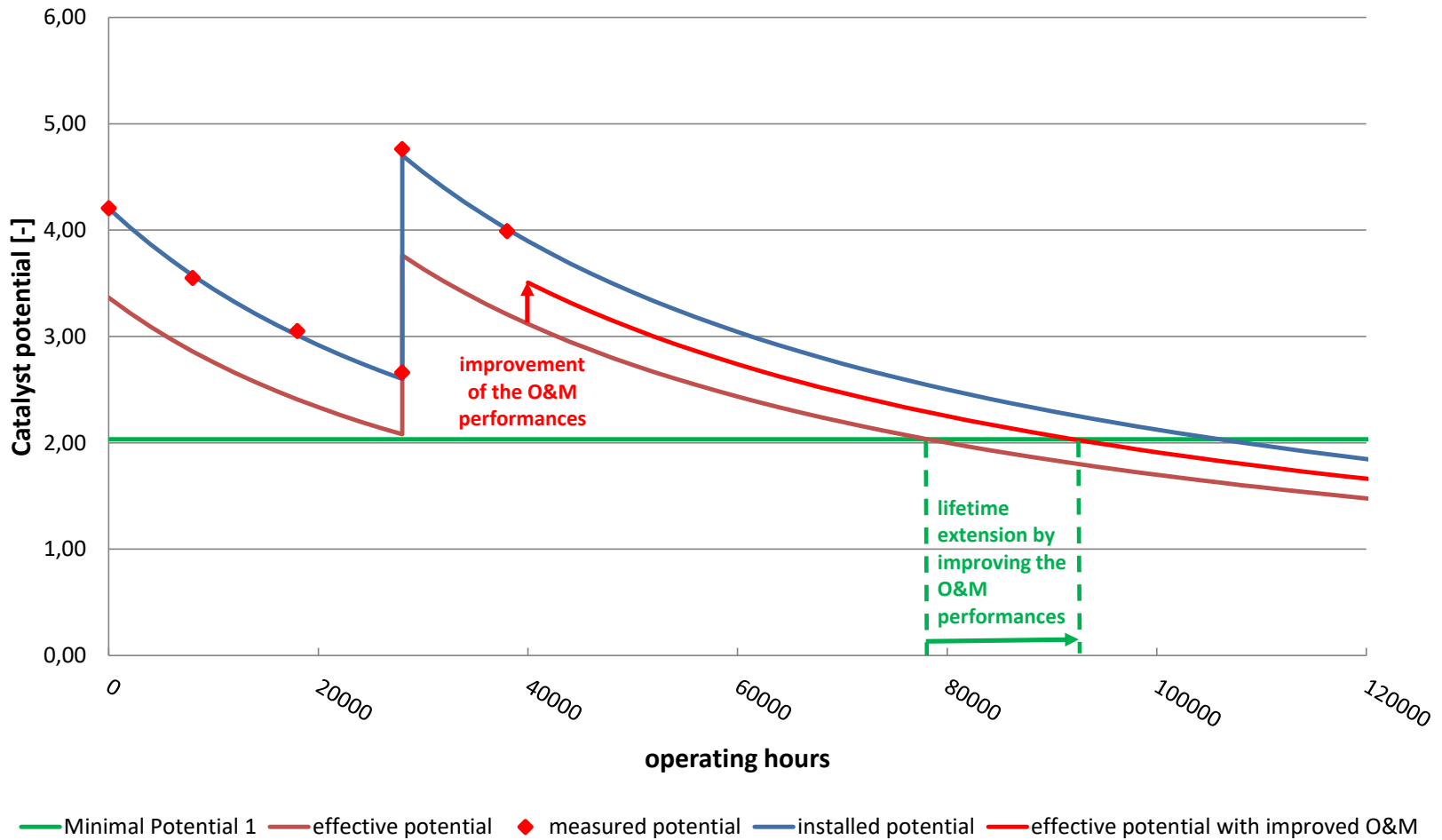


separate boiler room



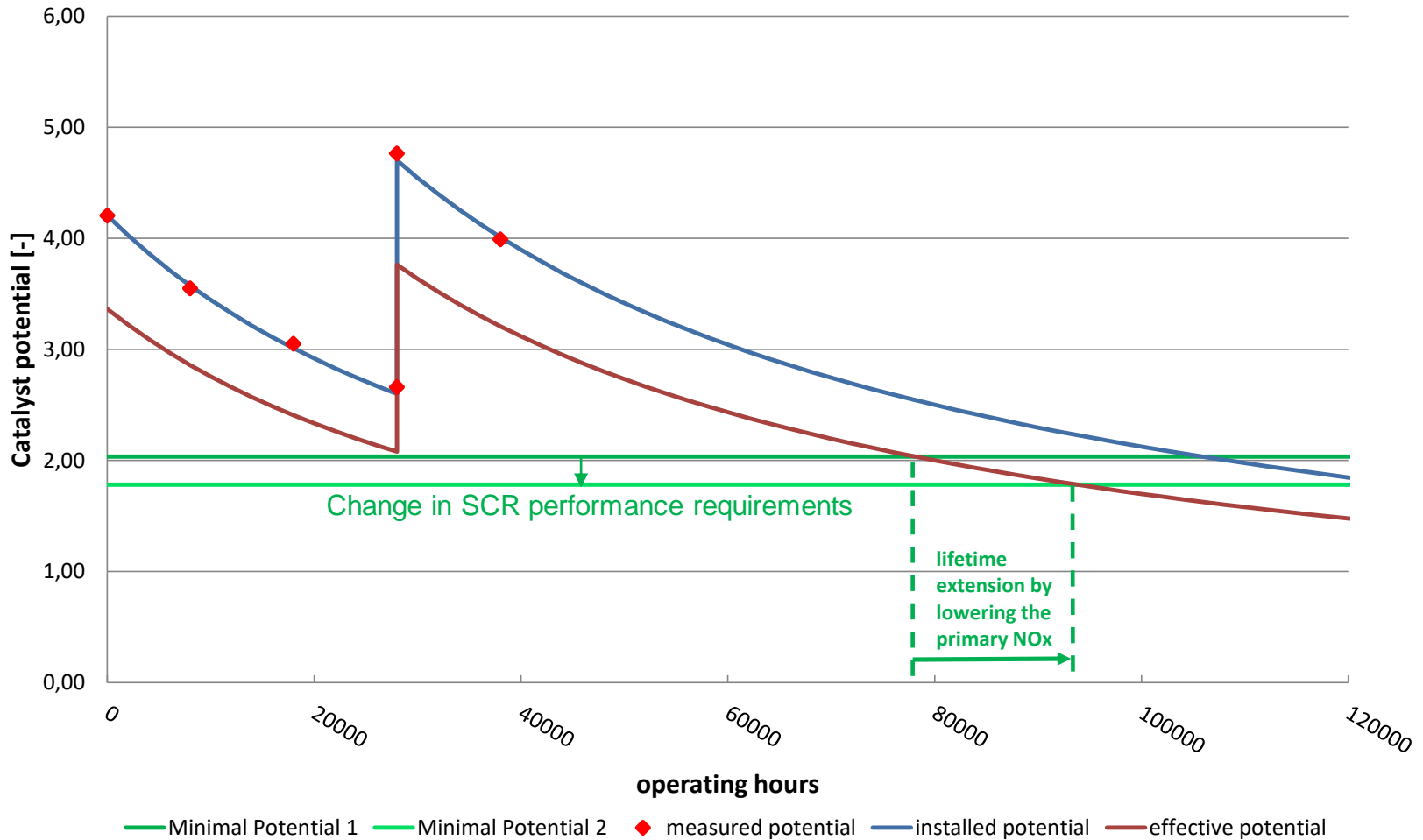
# Why is the SCR O&M performance important ?

## Potential for SCR deNOx catalyst lifetime extension



# Why is the SCR O&M performance important ?

## Potential for SCR deNOx catalyst lifetime extension





**Total SCR performance  
improvement: Case studies**



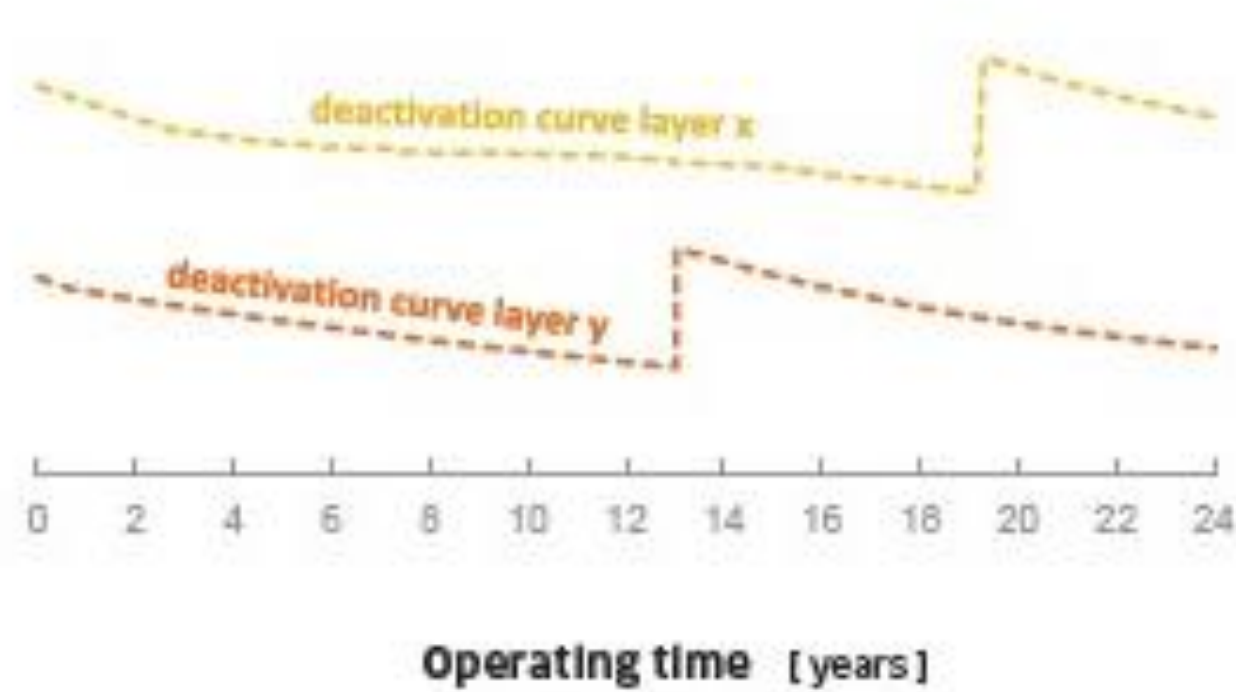
---

# Case #1: independent SCR catalyst testing saves money

*Extension of catalyst lifetime beyond OEM guarantee*

---

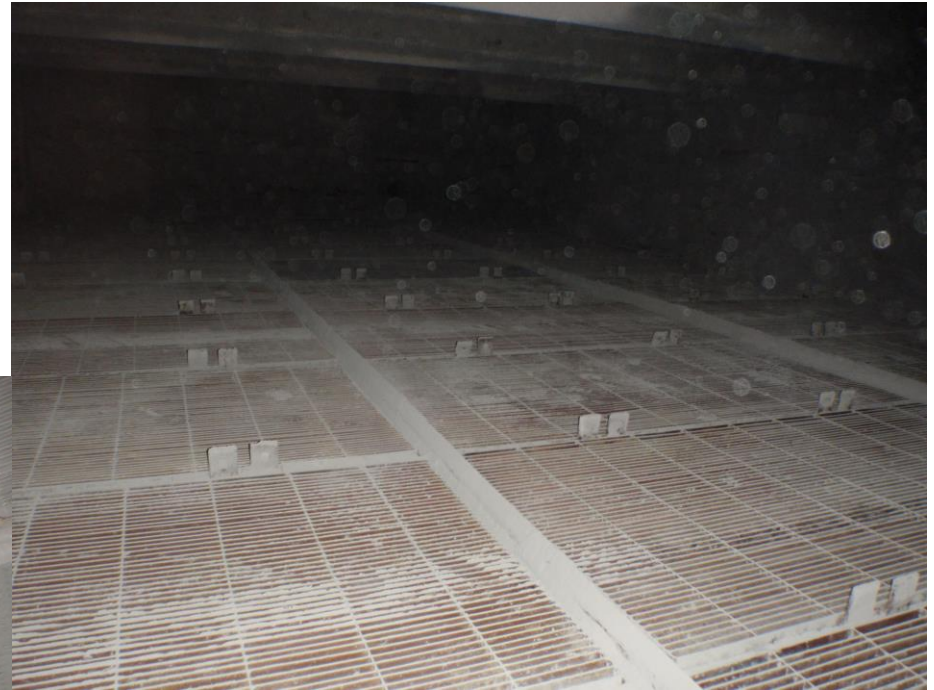
- Real example of a German coal plant (460MWe) performing independent SCR performance assessment every year, with **catalyst layers reaching >> 10 years lifetime**



# Case #1: independent SCR catalyst testing saves money

*Extension of catalyst lifetime beyond OEM guarantee*

- High-dust SCR
- 2+1 design, parallel reactors
- 82% NO<sub>x</sub> reduction rate
- Mix of South African and Polish coals



- State-of-the-art O&M performance
  - No plugging, nor erosion
  - Good NH<sub>3</sub>/NO<sub>x</sub> distribution
  - Balanced and stable combustion

# Case #1: independent SCR catalyst testing saves money

## *Extension of catalyst lifetime beyond OEM guarantee*

- Compare real case to plant with strategy to replace/regen each 3 years.
- Key assumptions: 1x500MWe, 160 catalyst modules per layer, 2+1 layers configuration

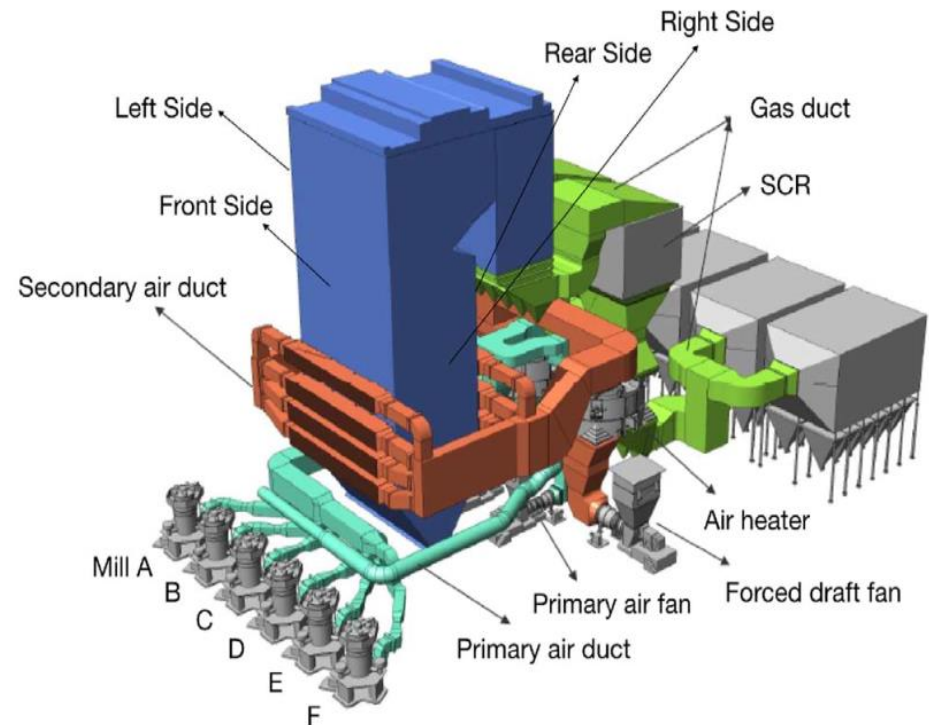
	OEM case 3 years replacement	Real case Independent condition-based asset management
Cat supply costs	\$540-800k each 3 years	\$540-800k each 6 years
Cat installation costs	\$120k each 3 years	\$120k each 6 years
Average total costs	\$217-307k per year	\$110-153k per year
<b>Minimum net savings</b>	/	<ul style="list-style-type: none"> <li>➤ \$107-154k per year</li> <li>➤ Or \$642-924k on 6 years</li> </ul>

Additional savings: reduced catalyst disposal costs, reduced purchasing overhead, etc.

## Case #2: catalyst and O&M performances must be combined

*Greenfield project, 660MW, SCR included*

- **660 MW coal-fired boiler.** The boiler is a supercritical opposed-fired, pulverised-fuel boiler producing steam at 259 bar and 569 °C
- The boiler is equipped with **2 parallel high-dust SCR deNO<sub>x</sub> reactors with a 2+1 layers configuration**
- At the **start of operation of the boiler in 2012**, 2 honeycomb (HC) catalyst layers were installed by EPC, justified by low coal ash content
- **Acoustic sonic horns**, as per EPC design
- **Sub-bituminous** coal blend



## Case #2: catalyst and O&M performances must be combined

*Basis for real lifetime extension potential and decision making (cat vs O&M)*

- O&M team planned SCR budget based on OEM/EPC guarantee: new catalyst each 3 years
- Engie Laborelec tested independently the used catalyst in our laboratories in Belgium & Germany:
  - Yearly testing, based on international standards such as VGB guideline S302 (2013)
  - Identification of catalyst lifetime extension potential: minimum 5 years >> OEM/EPC recommendation
  - But assumption of good O&M performance...



## Case #2: catalyst and O&M performances must be combined

*Basis for real lifetime extension potential and decision making (cat vs O&M)*

- Detailed SCR inspection and O&M data was performed to identify catalyst lifetime bottlenecks



- Our analysis shown that the catalyst plugging issue was due to a combination of:

- Wrong catalyst design
- Wrong sonic horns design
- Wrong sonic horns O&M

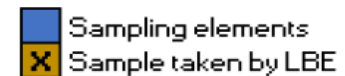
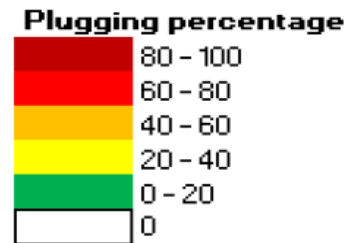
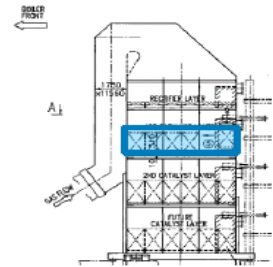
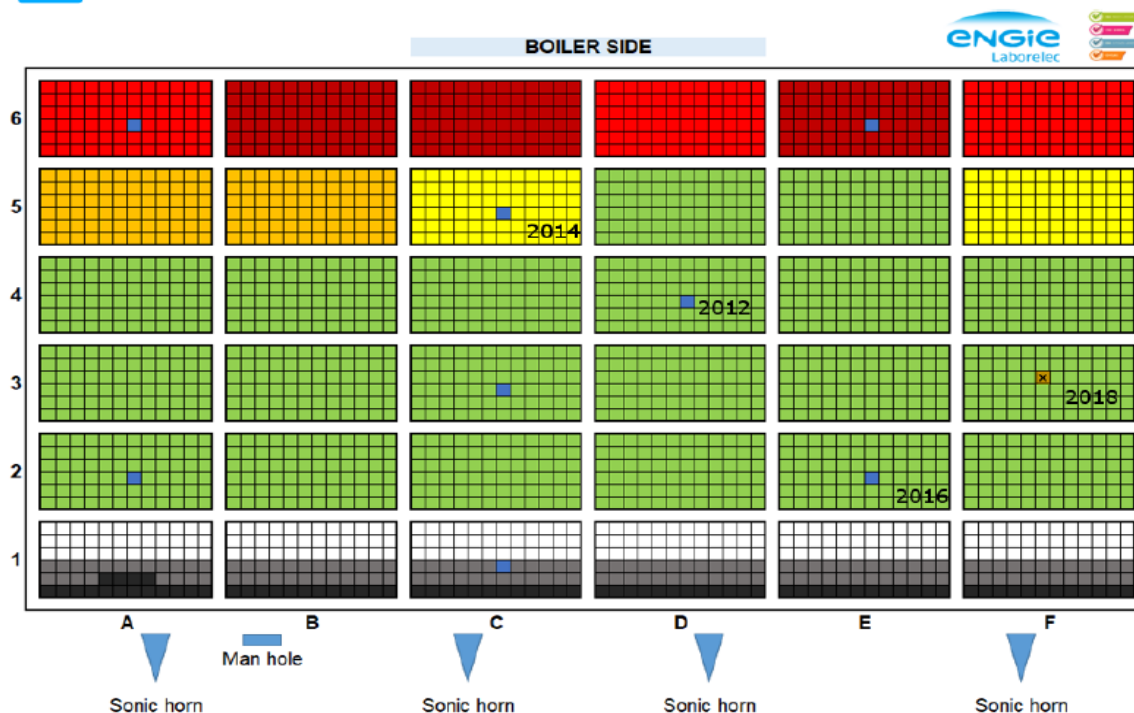


**O&M performance prevents to reach 5 years catalyst lifetime, despite high catalyst activity**

# Case #2: catalyst and O&M performances must be combined

*Basis for real lifetime extension potential and decision making (cat vs O&M)*

## Top Layer: Map Severe plugging



- Quantification of plugging issue allows to derive actual remaining catalyst lifetime in existing O&M conditions → Next step is to improve O&M conditions to extend catalyst lifetime

# Case #2: catalyst and O&M performances must be combined

## Combination of cleaning system upgrade and tailor-made catalyst design

First inspection by Laborelec

O&M improvement of sonic horns

pressure drop in mbar							
	2012	01/2015	10/2015	02/2016	11/2016	04/2017	04/2018
<b>Key event</b>	Start operation			Right after replacement of the top layer with mixed spare/new HC catalyst		3 months after replacement of the bottom layer with plate catalyst	New coal with >75% more ash
<b>Top Layer</b>							
Reactor A	2,0	2,9	4,0	1,8	2,5	2,8	10,5
Reactor B	2,0	4,0	4,0	1,8	2,4	2,6	10,0
<b>Bottom layer</b>							
Reactor A	2,0	2,5	3,0	4,5	8,3	1,5	1,6
Reactor B	2,0	2,5	3,0	4,0	6,1	2,0	2,1

End of previous coal contract, test of several new coal blends

Implementation of final coal blend

## Case #2: catalyst and O&M performances must be combined

*Impact of new coal blend: very high plugging rate of 50-75% on top layer*



View from bottom layer



Significant impact on the flow distribution due to HC plugging, but the bottom plate layer with improved O&M of sonic horns resisted well with a pressure drop of 1-1,2 dP

## Case #2: catalyst and O&M performances must be combined

*Significant impact of new coal properties on both catalyst and O&M*

	Previous	New
Ash content (coal)	2.9%	5.5% <i>189%</i>
Na <sub>2</sub> O+K <sub>2</sub> O (coal fly ash)	0.8%	3.0% <i>370%</i>
Na <sub>2</sub> O+K <sub>2</sub> O (catalyst surface build-up in 2 years)	1.6%	3.4% <i>208%</i>
SO <sub>3</sub> (coal fly ash)	0.33%	5.5% <i>1667%</i>
SO <sub>3</sub> (catalyst surface build-up in 2 years)	7.6%	20.1% <i>265%</i>

→ The parallel huge relative increase of ash content, alkali's and sulphur in the coal has led to a significant higher catalyst deactivation rate, itself further accelerated by deteriorated O&M conditions

## Case #2: catalyst and O&M performances must be combined

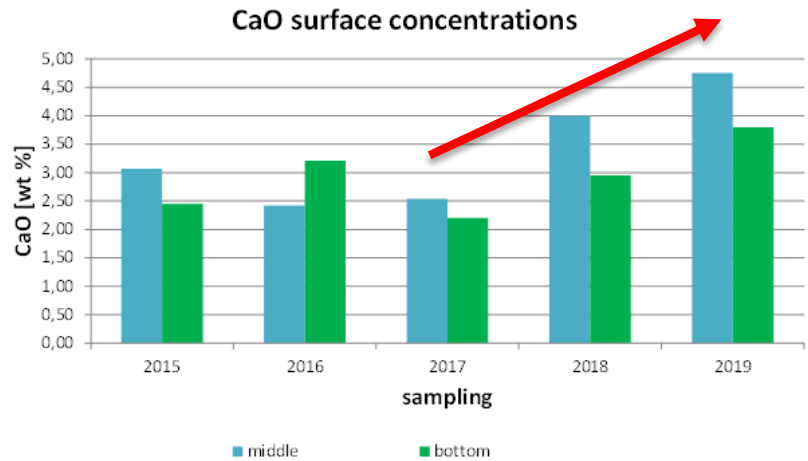
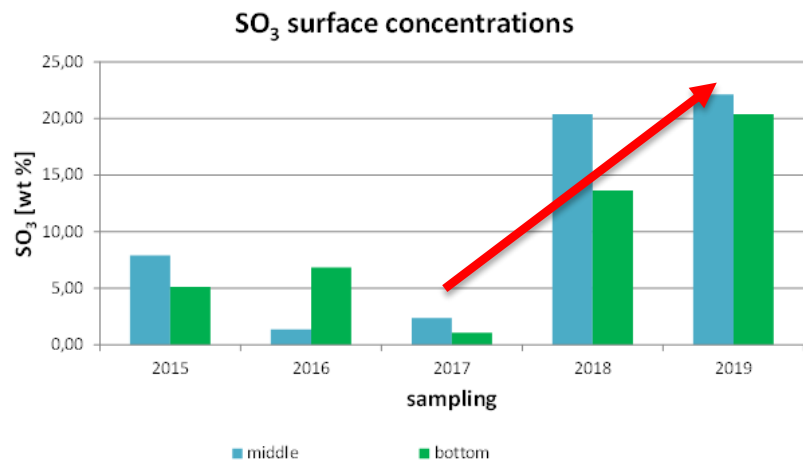
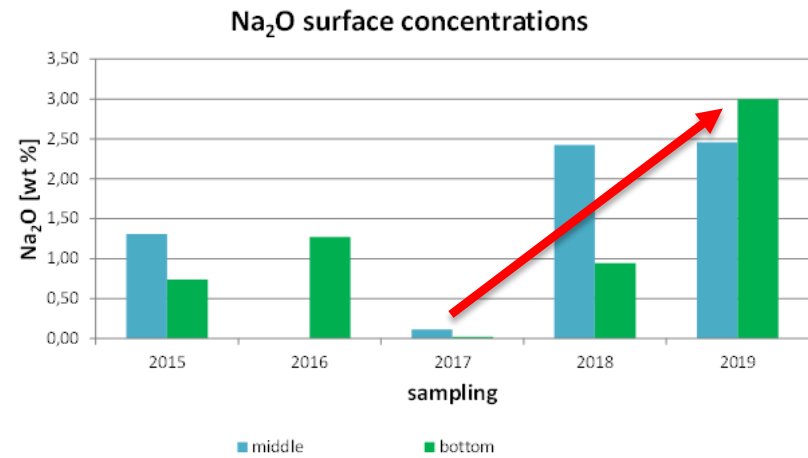
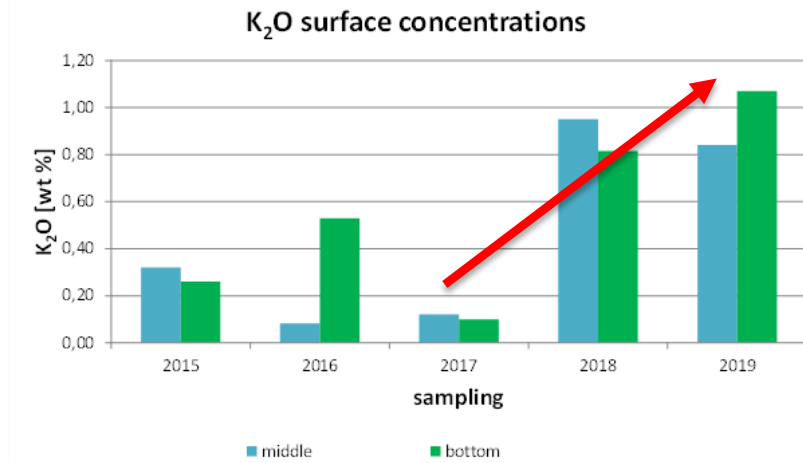
*Significant impact of boiler instability on SCR O&M performance*

		Oct 2017		Feb 2018		April 2018		Aug 2018		Dec 2018 (lower load)	
		A	B	A	B	A	B	A	B	A	B
Average SCR outlet T	°C	401	410	420	420	392	402	396	405	383	389
Max SCR outlet T	°C	419	430	432	443	414	427	423	432	407	416
Max inlet NOx	ppm	271	260	264	228	235	220	254	211	231	205
Average inlet NOx	ppm	211	183	239	202	199	177	222	178	186	157
Average outlet NOx	ppm	26	30	27	29	24	33	27	31	Out	Out
Average inlet O <sub>2</sub>	%vol	n.a	n.a	4,4	3,6	4,8	3,6	4,9	3,6	4,3	3,2

- Design temperature is 400°C (752°F)
- Design NOx inlet is 200 ppm
- Strong imbalance of primary NOx A and B side, about 30ppm more NOx in A side, as well as O<sub>2</sub> imbalance, with higher O<sub>2</sub> content on A side
- Higher temperatures in B side

# Case #2: catalyst and O&M performances must be combined

*Huge increase of surface layers due to coal chemistry and temperature*



## Case #2: catalyst and O&M performances must be combined

*Impact of both coal chemistry and SCR O&M on catalyst performance*

Catalyst	Pore Volume [cm <sup>3</sup> /g]	BET Surface area [m <sup>2</sup> /g]
Top layer (A)	0,067	32,4
Top layer (B)	0,066	34,6
Bottom layer (A)	0,112	45,8
Bottom layer (B)	0,082	40,5

Significant decrease of both average pore volume and BET

## Case #2: catalyst and O&M performances must be combined

*Impact of both coal chemistry and SCR O&M on catalyst performance*

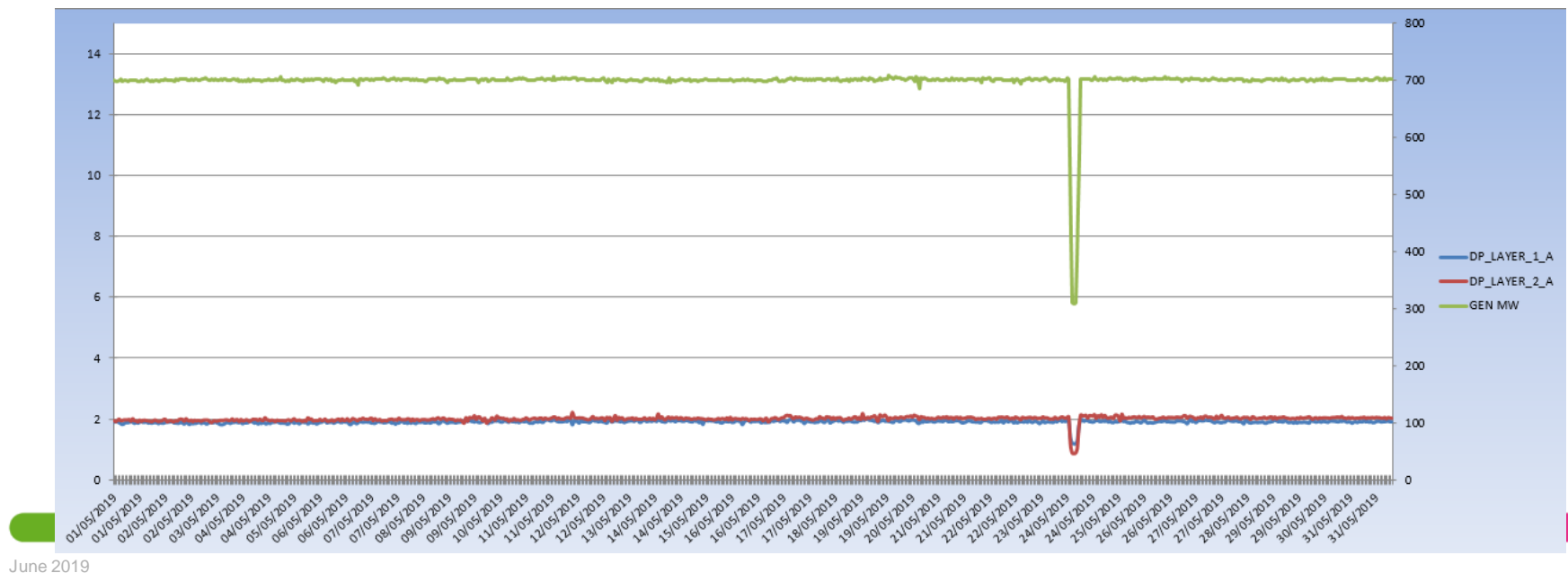
Catalyst	Activity K/K <sub>0</sub> 01/2016 [Nm/h]	Activity K/K <sub>0</sub> 01/2017 [Nm/h]	Activity K/K <sub>0</sub> 12/2017 [Nm/h]
Top layer (HC)	100%	89,8%	52,1%
Bottom layer (plate)	-	100%	48,9%

- Historical deactivation rate of 10-14%/8000 operating hours (OH)
- Increase of deactivation rate due to new coal operation, reaching about 50%/8000 OH
- Combined effect of higher flue gas temperature and coal chemistry

## Case #2: catalyst and O&M performances must be combined

*Combination of cleaning system upgrade and tailor-made catalyst design*

- In order to solve the issue of the new coal blend operation, the following was implemented during outage Jan'19:
  - Replacement of the last honeycomb layer by a Laborelec plate design against plugging
  - Upgrade of the complete sonic horns system towards a stronger design, with additional on-site training of power plant staff regarding sonic horns O&M best practices
- **Successful project achievement, with ~0,8 dP per layer, fully stable since the last 6 months**



---

## Case #3: No one-size-fits-all solution

*Each power plant requires a tailor-made approach*

---

- 730MW USC, bit coal fired, from 2013
- Mix of Columbian, Russian and Illinois-basin coals, blended to 1,5% sulphur
- EPC installed plate catalyst, combined with steam sootblowers
- SCR in 4+1 configuration was delivered without sootblowers on spare level



---

## Case #3: No one-size-fits-all solution

*Challenge the status-quo based on catalyst+O&M assessment*

---

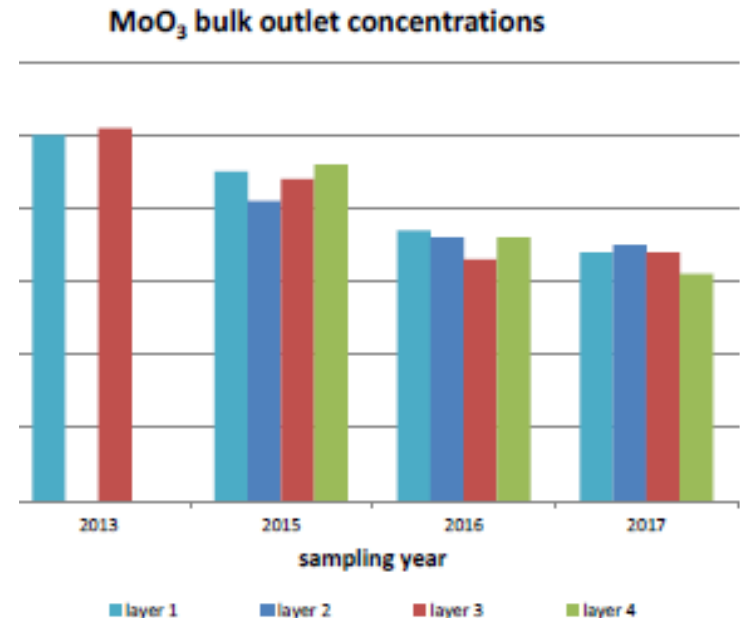
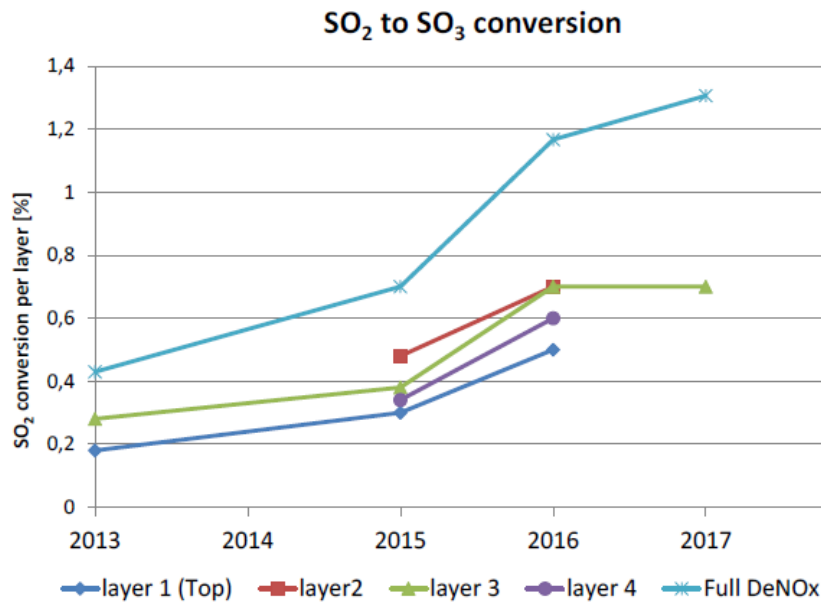
- Several SCR inspections demonstrated the very low plugging rate of plates with steam sootblowers, with even a limited erosion of the plates



## Case #3: No one-size-fits-all solution

### *Challenge the status-quo based on catalyst+O&M assessment*

- Issue of Mo evaporation and increase of SO<sub>2</sub> conversion rate with time, leading to blue plume issues, even with wet FGD

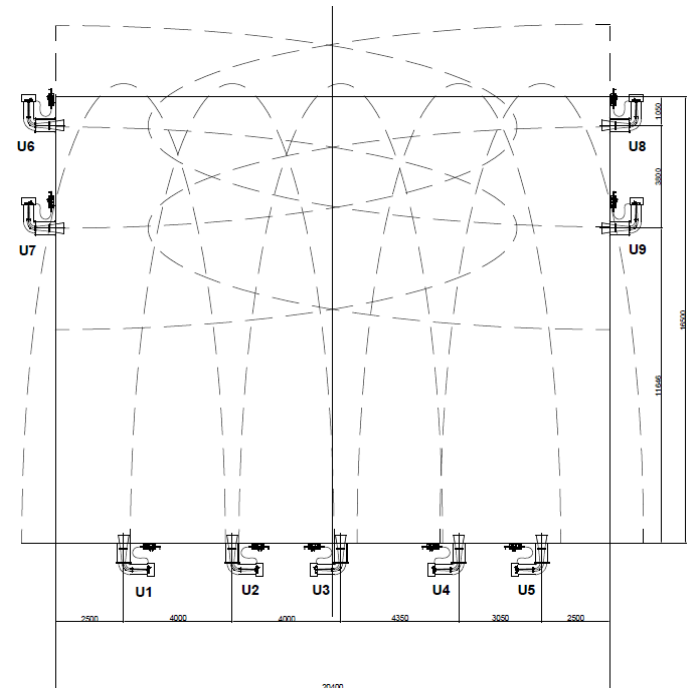


→ Decision to upgrade with low SO<sub>2</sub> conversion honeycomb and sonic horns

## Case #3: No one-size-fits-all solution

### *Switch from sootblowers to sonic horns*

- Applicability of sonic horns was confirmed by turning off sootblowing on layer 4
  - Visual inspection after several months: limited ash accumulation
  - Access on 3 sides of SCR, so entire catalyst surface could be covered easily, even though access doors and structural steel limited choice of position in side walls



---

## Case #3: No one-size-fits-all solution

### *Switch from plates to honeycomb*

---

- Design of honeycomb optimized for lifetime management strategy (match with fixed outage schedule), SO<sub>2</sub> conversion and pressure drop
- Visual inspection results after 1 year (June 2019):
  - Honeycomb catalyst layer with sonic horns is as clean as layers with plate catalyst and sootblowers
  - Both CAPEX and Total Cost of Ownership (TCO) reduction could be achieved



---

## Case #4: SCR O&M improvement to extend catalyst lifetime

*Replace/regen catalyst is not cost effective to solve O&M issues*

---

- 4x600MW coal-fired plant with significant plugging issue, limiting the actual catalyst lifetime despite relatively high remaining catalyst activity
- Blend of international bituminous coals, 2+1 layers design, honeycomb catalysts



---

## Case #4: SCR O&M improvement to extend catalyst lifetime

*Replace/regen catalyst is not cost effective to solve O&M issues*

---

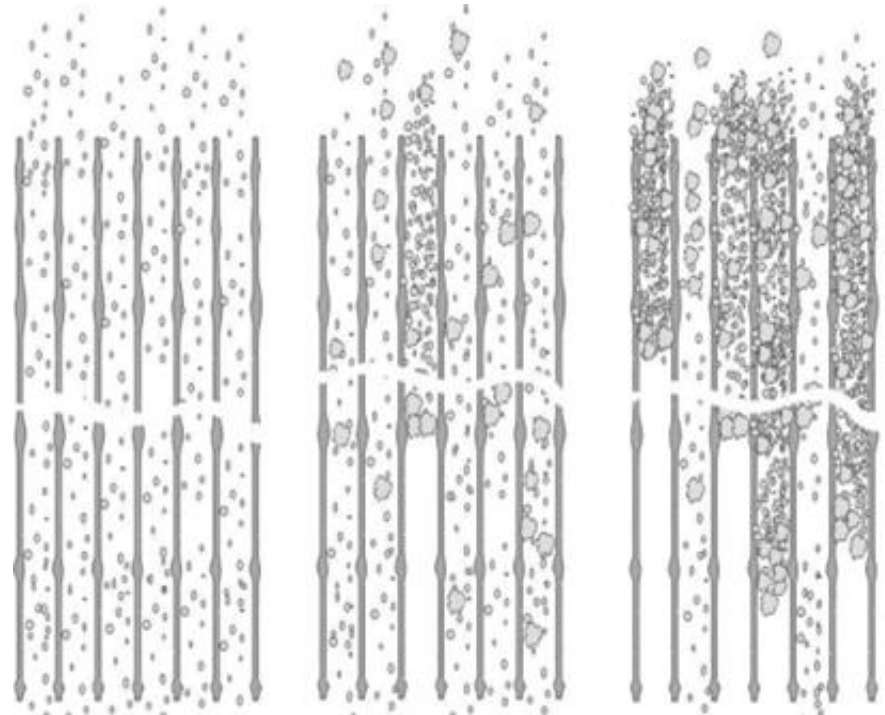
- Plugging of >50% in several areas of the catalyst layer



## Case #4: SCR O&M improvement to extend catalyst lifetime

*Replace/regen catalyst is not cost effective to solve O&M issues*

- Vacuum cleaning is not strong enough to remove the plugging within the catalyst, while air lancing will lead to catalyst damage
- Plant operators often decide to replace or regen the layer, which is very costly, especially taking into account that the catalyst activity is still high enough to reduce NOx emissions
- **Laborelec uses a specific cleaning technique combining specialized vibration and sponge blasting technologies to fully remove catalyst plugging in-situ, without catalyst damage**



---

## Case #4: SCR O&M improvement to extend catalyst lifetime

*Replace/regen catalyst is not cost effective to solve O&M issues*

---



---

## Case #4: SCR O&M improvement to extend catalyst lifetime

*Replace/regen catalyst is not cost effective to solve O&M issues*

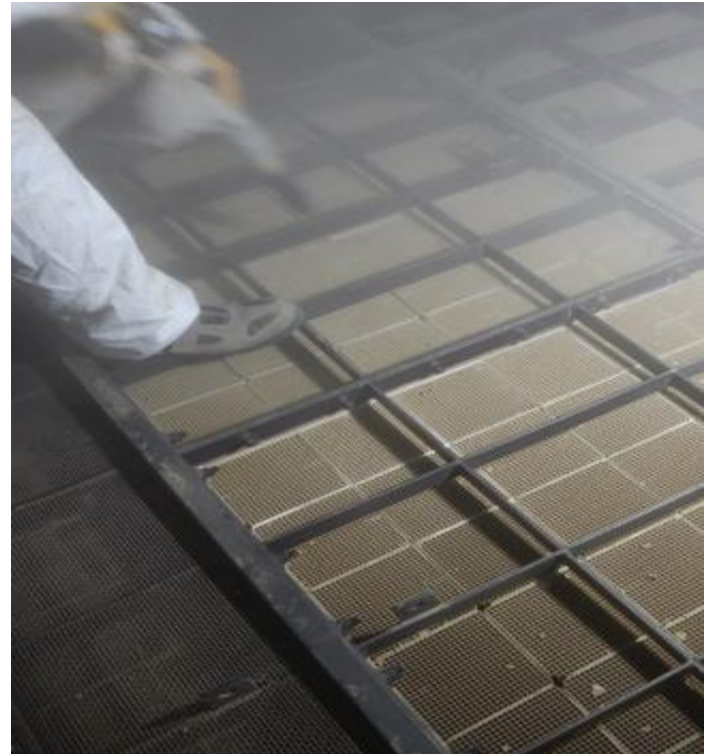
---

BEFORE



AFTER

(>90% plugging removal)



# Case #4: SCR O&M improvement to extend catalyst lifetime

## Optimized NH<sub>3</sub> injection leads to extended catalyst lifetime

- Example:

- The outlet NO<sub>x</sub> measurement shows more homogenous NO<sub>x</sub>: 23 → 12,5% RMS

- Reduction of the NH<sub>3</sub> slip → catalyst lifetime extension of ~ 2 years

- Especially important with lower and lower NO<sub>x</sub> emissions limit targets

- **AIG tuning must be condition-based** (basis = independent cat+O&M SCR performance assessment)

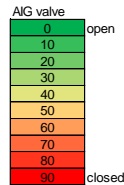
Situation before tuning Reactor A

Grid Valve setting projected on measuring grid

SA1	SA3	SA5	SA7	SA9	SA11
50	40	20	30	30	10
40	40	20	30	30	10
40	40	30	30	30	10
40	40	30	30	30	10

Reactor B

SB1	SB3	SB5	SB7	SB9	SB11
30	30	40	30	30	40
20	20	30	30	30	30
0	10	10	10	10	20
0	0	0	0	10	20



SA1	SA3	SA5	SA7	SA9	SA11
39	30	26	42	21	35
32	27	35	37	44	43
36	31	27	34	59	42
43	33	27	33	43	31

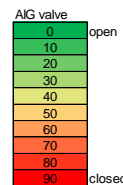
SB1	SB3	SB5	SB7	SB9	SB11
42	25	26	38	45	35
40	22	24	39	35	37
41	28	31	54	43	41
50	29	28	39	40	29

average NO<sub>x</sub> = 35ppmvd  
RMS = 23%

average NO<sub>x</sub> = 36ppmvd  
RMS = 23%

SA1	SA3	SA5	SA7	SA9	SA11
50	60	50	50	30	50
50	50	40	40	50	40
40	50	50	40	60	30
50	20	30	30	50	20

SB1	SB3	SB5	SB7	SB9	SB11
50	50	50	50	30	50
50	50	40	50	50	60
10	10	20	40	30	40
0	10	40	30	50	20



SA1	SA3	SA5	SA7	SA9	SA11
42	52	40	46	35	48
32	41	47	41	38	33
44	44	42	42	43	44
37	38	38	42	36	31

SB1	SB3	SB5	SB7	SB9	SB11
59	44	43	51	38	39
44	50	48	45	37	36
42	44	45	44	53	45
40	49	39	50	45	42

average NO<sub>x</sub> = 41ppmvd  
RMS = 13%

average NO<sub>x</sub> = 45ppmvd  
RMS = 12%

# Case #4: SCR O&M improvement to extend catalyst lifetime

*Reducing combustion unbalance increases catalyst lifetime*

Example of flue gas distribution	A side	B side	Comment
NO <sub>x</sub> [vpm]	212	187	Combustion effect
O <sub>2</sub> [%]	3,2	3,7	Combustion effect
Temperature [°C]	386	394	Combustion effect
NH <sub>3</sub> flow [l/s]	68	77	Despite lower <u>DeNO<sub>x</sub></u> on B
Flue gas flow	Lower	5-15% higher	Distribution, O <sub>2</sub> and T impact A side (more plugged) due to lower velocities

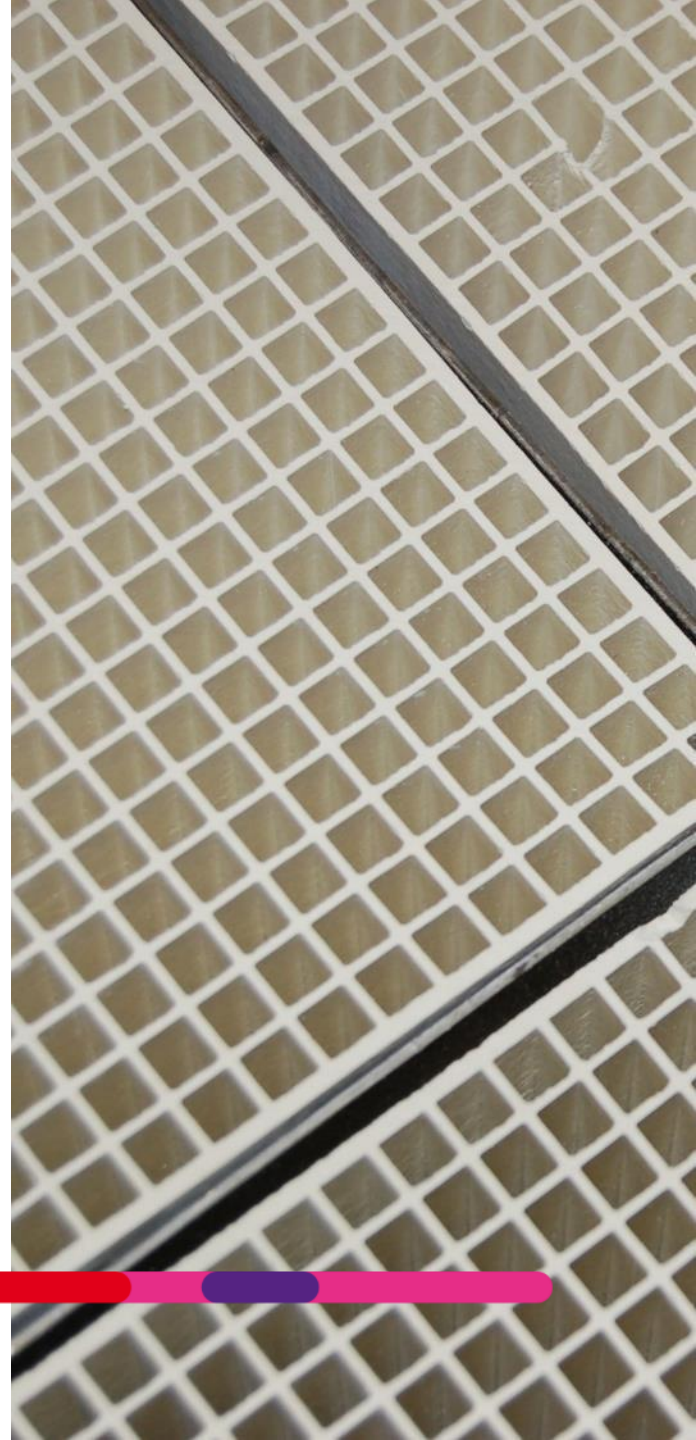
Unbalance (left-right)	Good practice	Before optimisation	After optimisation
Δ Total secondary air [kg/s]	<10	~ 20	3-7
Δ FEGT [°C]	<10	~ 10	2-7
Δ O <sub>2</sub> [%w]	<0.5	~ 1	0.3-0.7
Δ primary NO <sub>x</sub> [ppm]	<10	~ 20	<5

---

# 03

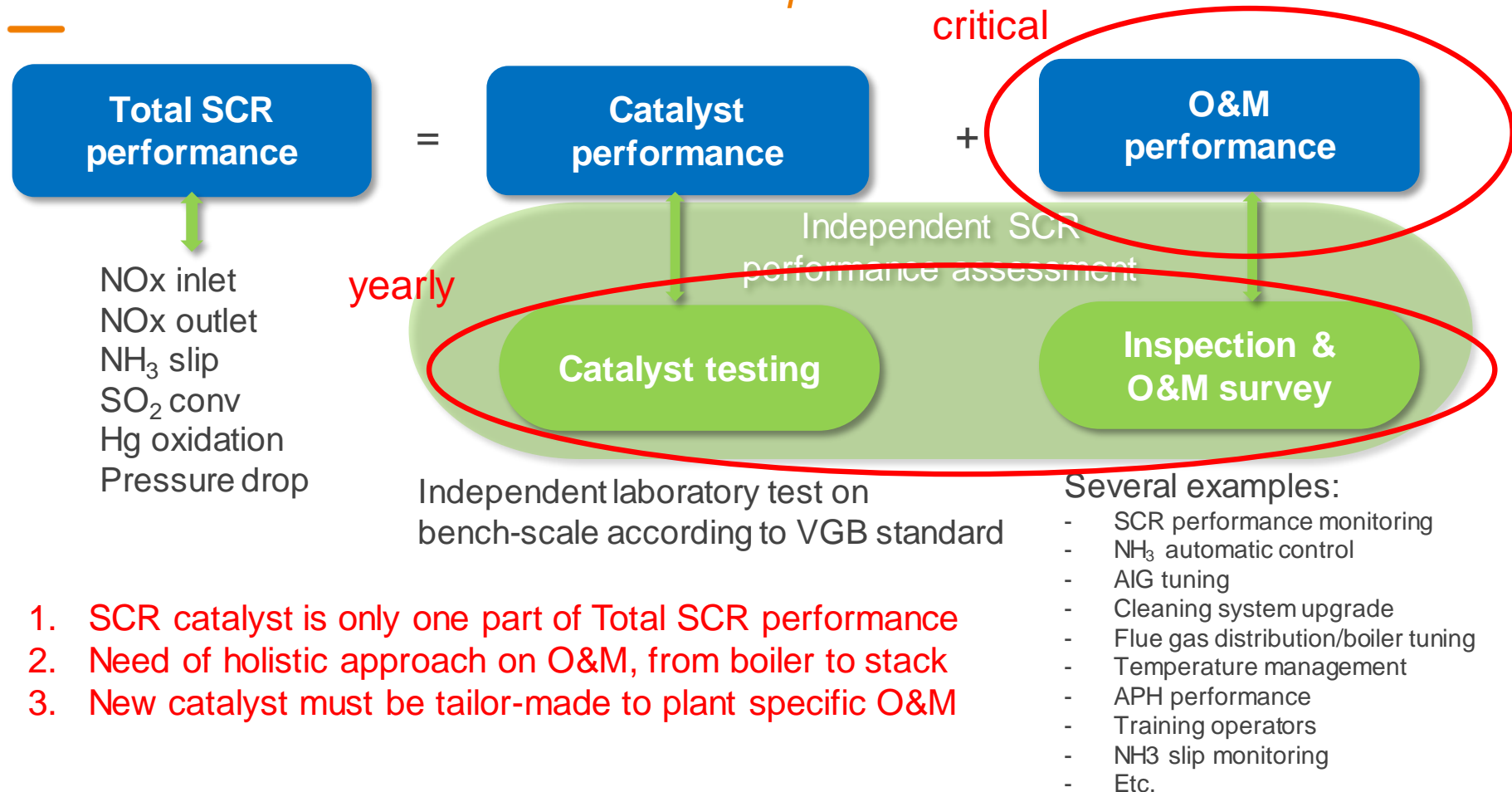
## Conclusions

---



# SCR performance assessment as operator best practice

Focus on lowest Total Cost of Ownership



1. SCR catalyst is only one part of Total SCR performance
2. Need of holistic approach on O&M, from boiler to stack
3. New catalyst must be tailor-made to plant specific O&M

---

## Conclusions

*Catalyst+O&M performances = key for lowest SCR Total Cost of Ownership*

---

- The total SCR performance management approach presented in the different cases shows the **strong influence of O&M performance** (combustion, AIG tuning, plugging issue, new coal composition, flow maldistribution, etc.) **on the SCR total performance**, on top of catalyst performance itself
- Industry best practices show the need to **perform yearly SCR catalyst testing & on-site SCR system detailed inspection and O&M performance survey**
- **The independence towards catalyst manufacturers is key to avoid the risk of bias in the recommendations but also because of lack of O&M experience.** Need for independent support focusing on the sole interest of the power plant operators, and bringing the necessary multidisciplinary to handle the SCR from a comprehensive point of view
- **The proper combination of catalyst improvement** (new tailor-made catalyst design) **and SCR O&M improvement** (e.g. advanced catalyst cleaning technology, combustion and AIG tuning) **is key** to maximize catalyst lifetime and reduce its SCR total cost of ownership
- **Catalyst and O&M performances should never be looked at independently from each other**
- **Any potential O&M improvement need should be condition-based and plant specific**, and can be assessed through yearly independent total SCR performance assessment

---

# Do not hesitate to contact us!

*Richard Sample - ReNOx – r.sample@renox-us.com*

*Michael Ware – ReNOx – m.ware@renox-us.com*

*Peter Harrison – ReNOx – p.harrison@renox-us.com*

Visit our website: [www.renox-us.com](http://www.renox-us.com)

---

