



Improving techno-economic assessments of Carbon Capture and Storage (CCS) routes: inclusion of flue gas pre-treatment steps

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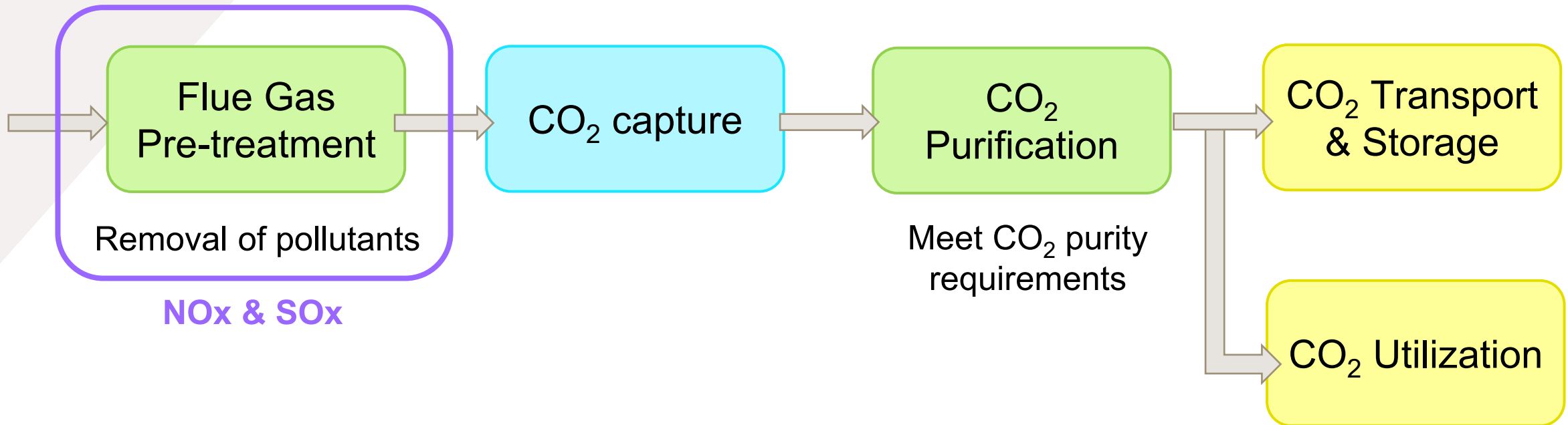
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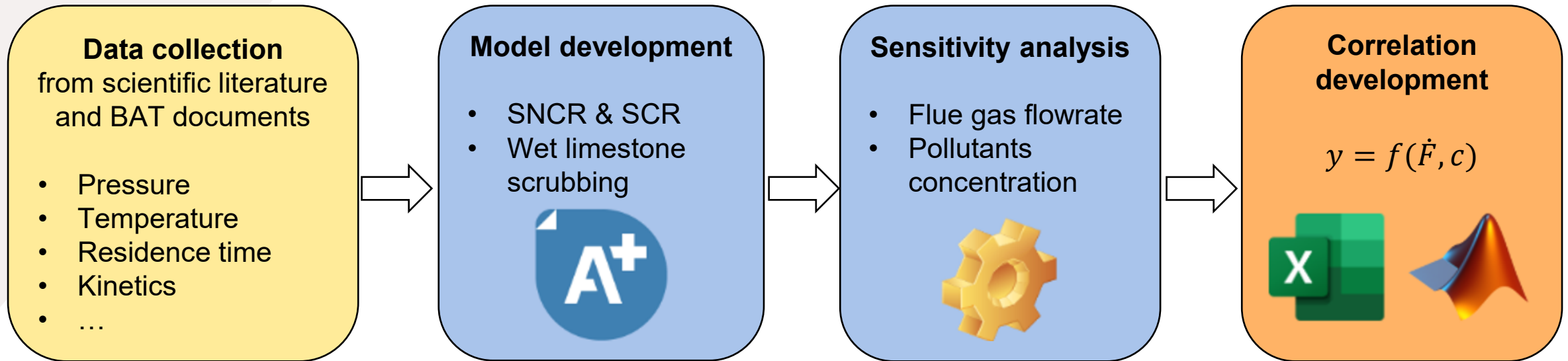
CCUS: Some steps are often excluded



Typically excluded in TEAs



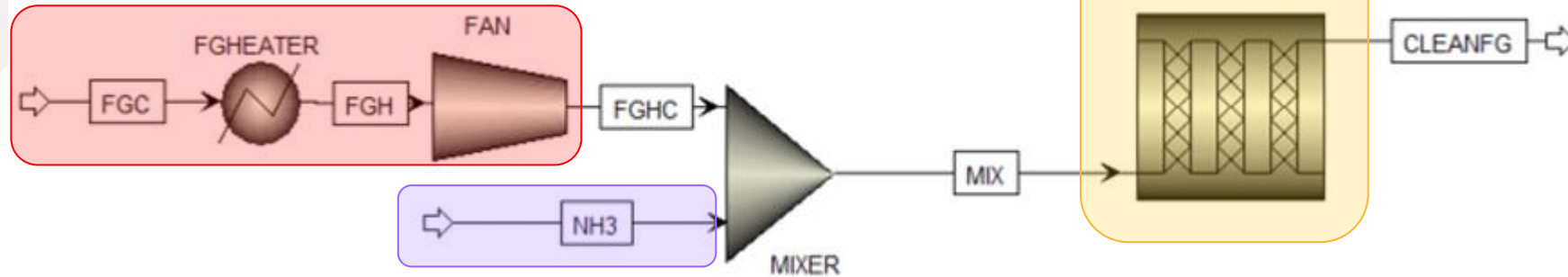
Methodology



DeNOx: SCR



Flue gas conditioning:



→ 90% NO_x reduction

Aqueous ammonia:
24.5 wt% NH₃

NO reduced over vanadium oxide catalyst



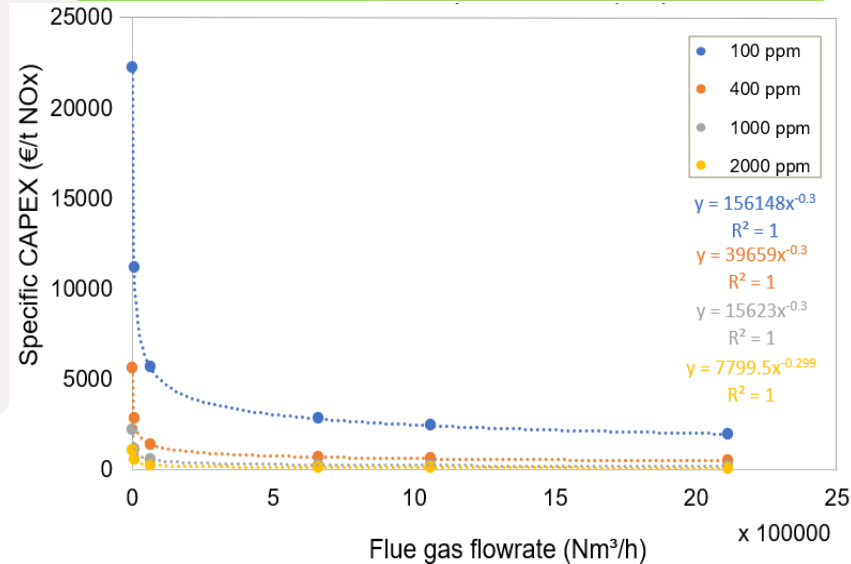
DeNOx: SCR



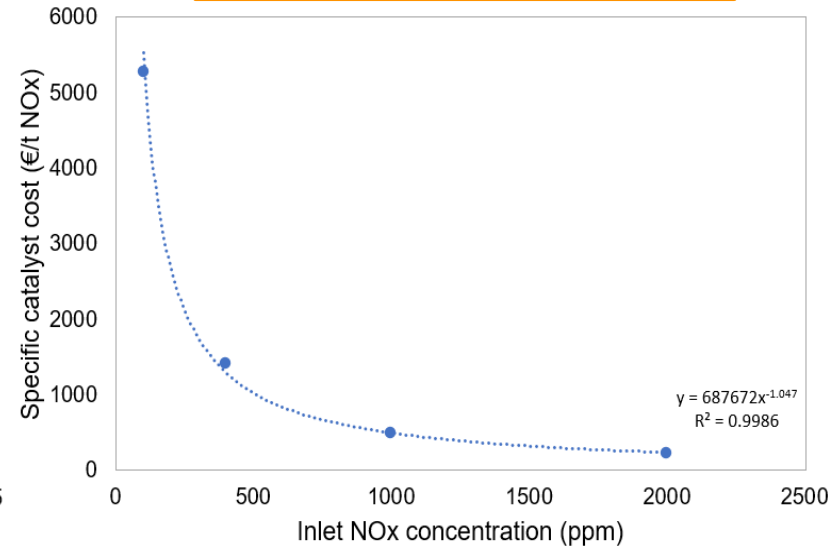
$$\text{Spec. NAC} = \text{Spec. CAPEX} + \text{Spec. CaC} + 0.57 \cdot p_{NH_3} + \text{SED} \cdot p_E$$

200 – 2.10⁶ Nm³/h
100 – 1000 ppm NOx

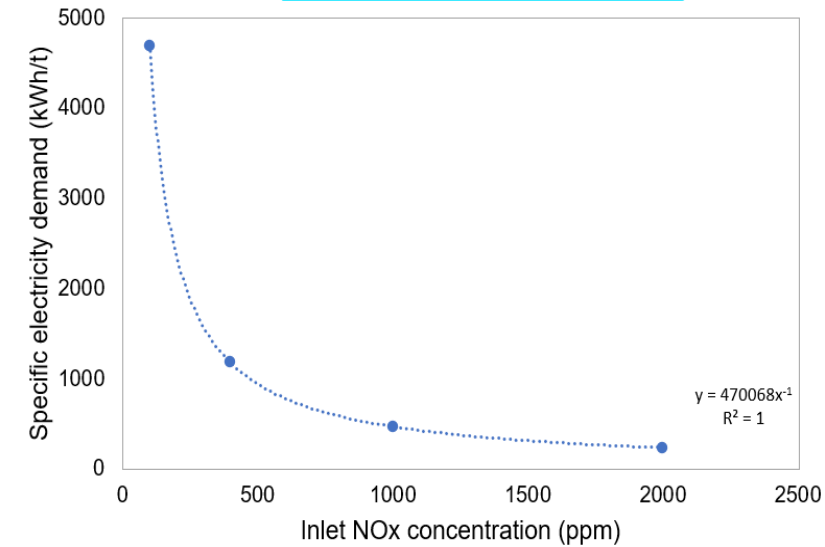
$$\text{Spec. CAPEX} = 1.5783 \cdot 10^7 \cdot C_{NO_x}^{-1.001} \cdot \dot{F}^{-0.3}$$



$$\text{Spec. CaC} = 687672 \cdot C_{NO_x}^{-1.047}$$



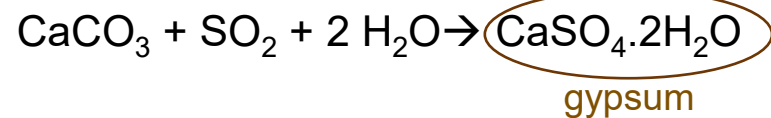
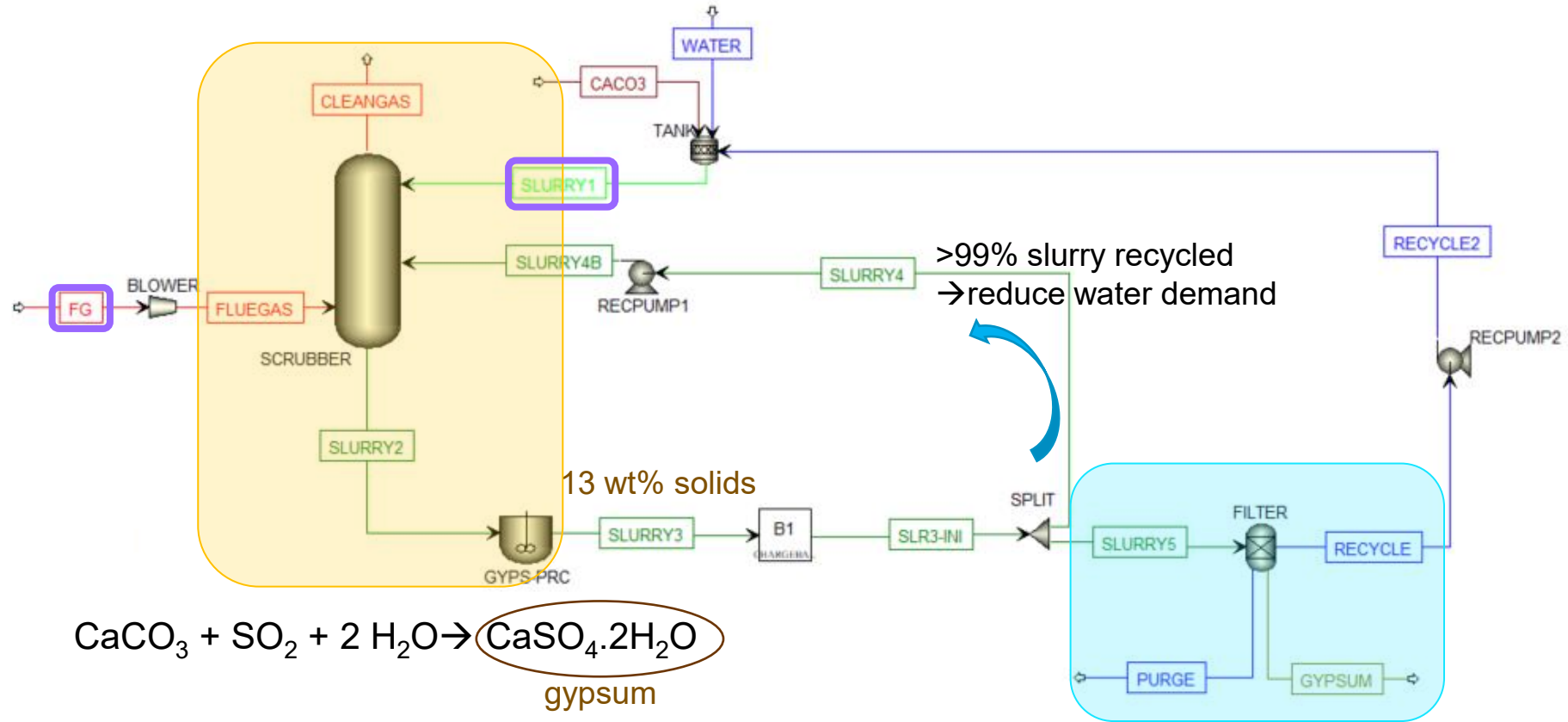
$$\text{SED} = 470068 \cdot C_{NO_x}^{-1}$$



For 300–800 ppm & 10,000–1,000,000 Nm³/h:

Spec. NAC = €2039–7134/t NOx > < €2480–4000/t (literature)

DeSOx: wet limestone scrubbing



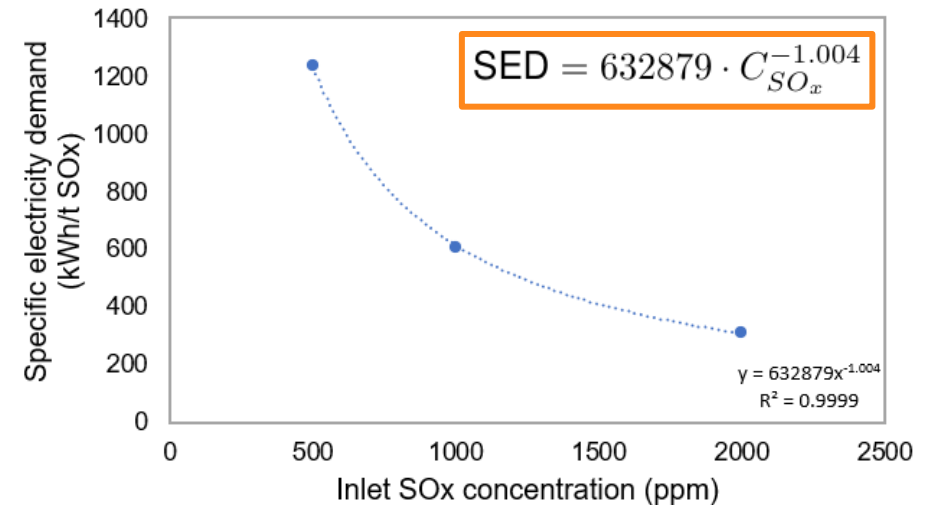
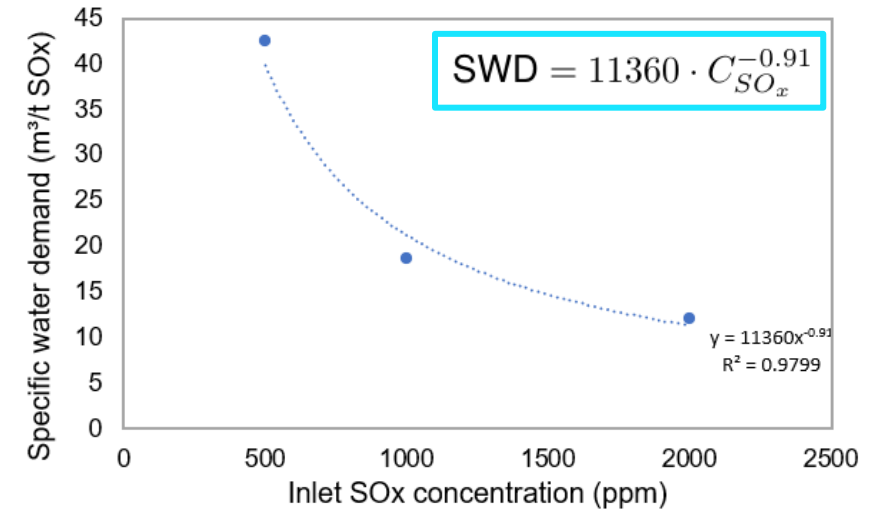
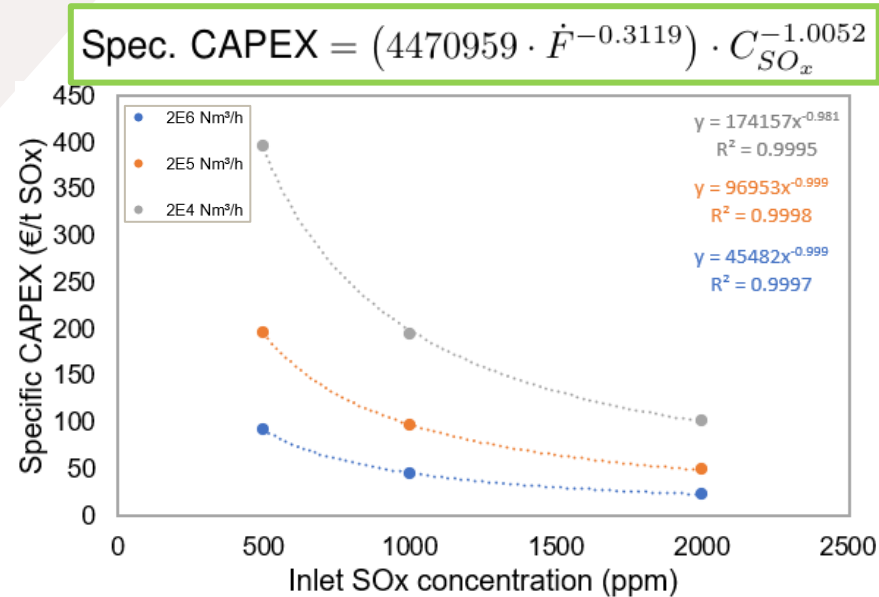
→ 98-100% SO₂ reduction

DeSOx: wet limestone scrubbing



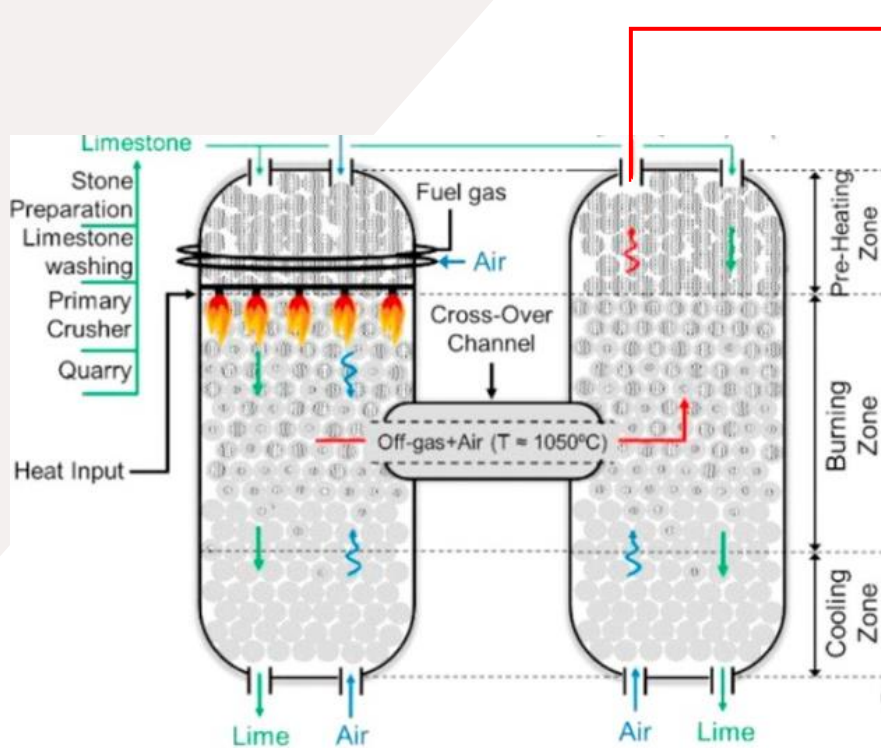
$$\text{Spec. SAC} = \text{Spec. CAPEX} + 1.56 \cdot p_{CaCO_3} + \text{SWD} \cdot p_W + \text{SED} \cdot p_E$$

$2.10^4 - 2.10^6 \text{ Nm}^3/\text{h}$
 $500 - 2000 \text{ ppm SOx}$



For 500–1000 ppm: Spec. SAC = €167–600/t SOx
> < €400–700/t (literature)

Application to the case of the lime sector



- Flue gas**
- Flowrate: 68,000 Nm³/h
 - 21 mol% CO₂
 - 784 ppm NO_x
 - 80 ppm SO_x

SCR: → €1788/t NO_x

Wet scrubbing: → €3773/t SO_x

TOTAL: €7.38/t CO₂ captured

Simoni *et al.* <https://doi.org/10.1016/j.rser.2022.112765>

Next steps



- Consider **other** DeSOx (or combined DeNOx/DeSOx) **technologies**
→ most suitable options for specific case studies
- Include **polishing steps**
 - Conventional treatments are insufficient
 - Compliance with CO₂ transport/utilization quality standards
- Account for **variability** in permitted pollutants **limits** across different CO₂ capture technologies
 - Absorption
 - Adsorption
 - Membrane-based separation
 - ...

Acknowledgements



Thank you for your attention!

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