

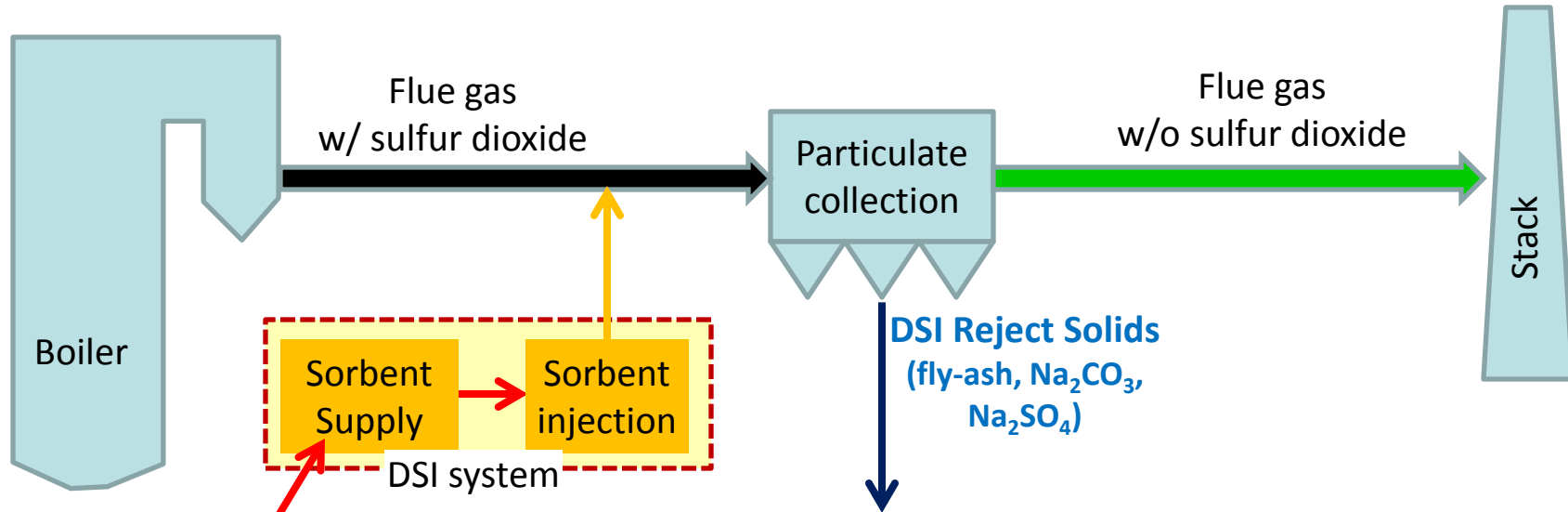


NeuStream[®]-DR: Improving the effectiveness of DSI while substantially reducing the chemical cost

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Current DSI Systems



Truck or railcar fill

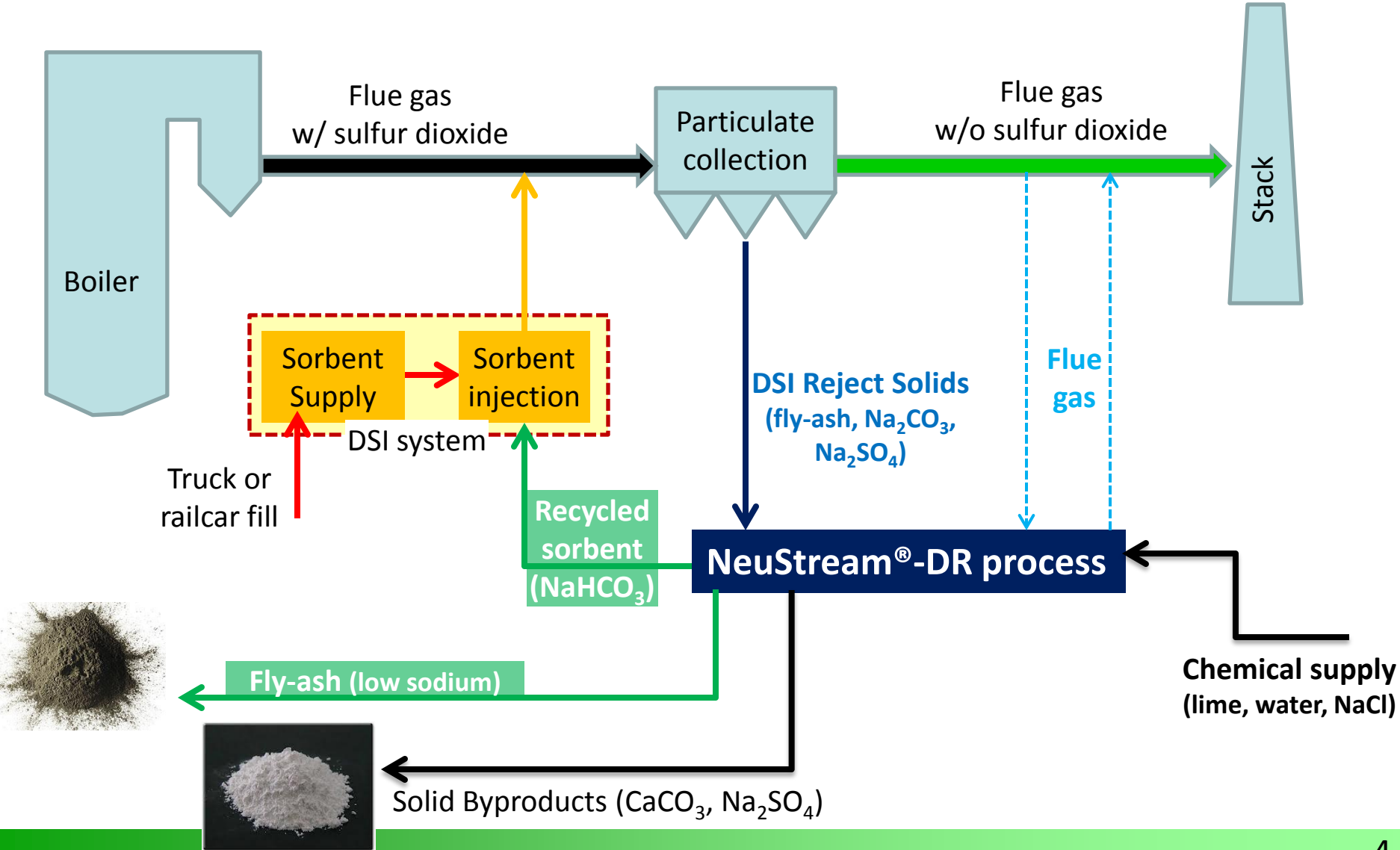
- Dry sorbent injection (DSI) is a low CapEx (< 20% compared to wet scrubber), high OpEx, alternative desulfurization/acid gas system
- Most current DSI installed for MATS compliance:
 - Target high acid gas removal, but low (~<50%) SO₂ removal
 - Sorbent injection: Lime, Trona, SBC (in furnace or upstream of air pre-heater)
- Mostly installed on units burning low-sulfur coal

Challenges With Current DSI Systems



- High operating cost (up to 2/3's of injected sorbent is un-reacted)
- SO₂ removal too low for higher-sulfur coal. Achieving >90% removal no feasible with calcium and too costly with sodium
- Calcium sorbent decreases performance of ESP (resistivity)
- Impact of large flows of sorbent on ESP and baghouse when used for higher sulfur removal
- Leachability of heavy metals (As, Se) in post-DSI fly ash with sodium sorbent

NeuStream[®]-DR Process



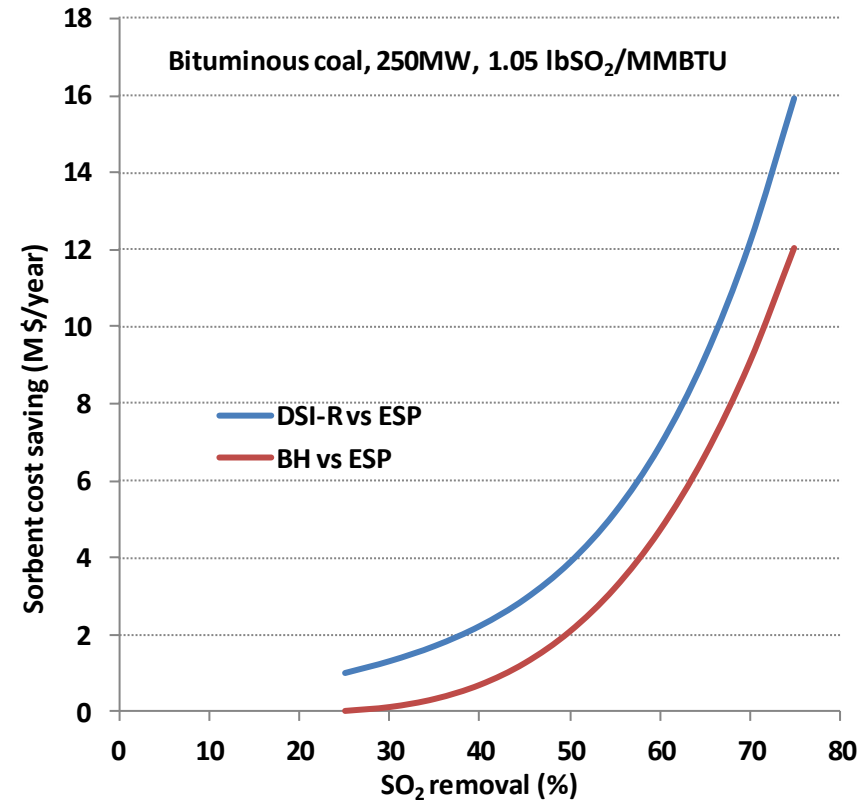
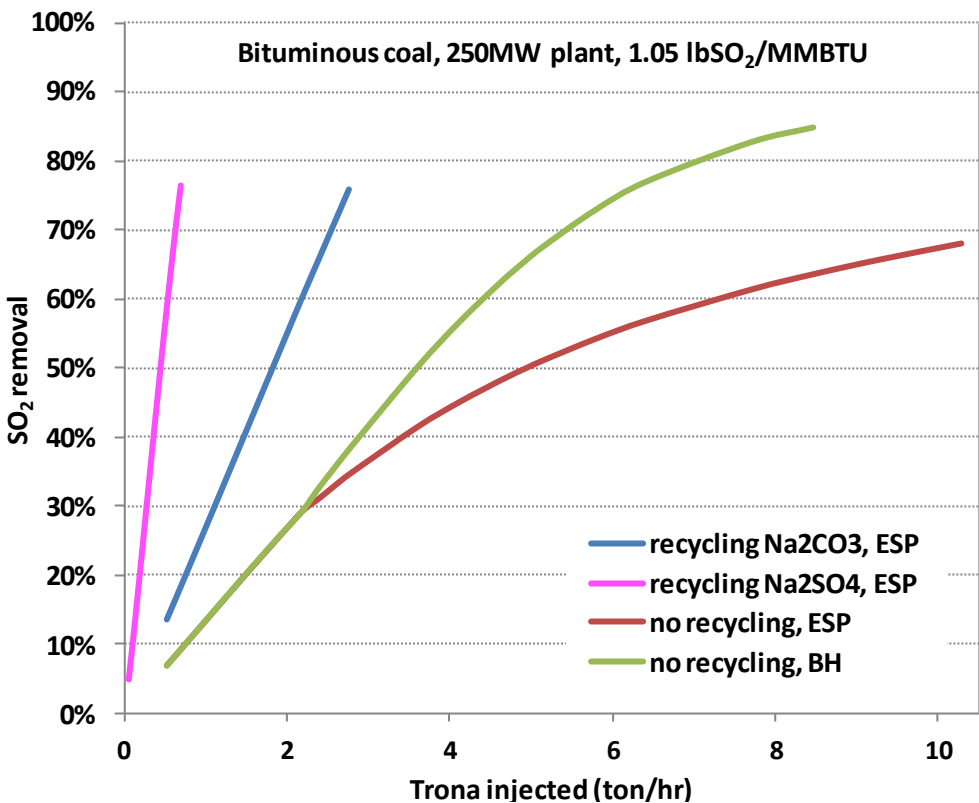
NeuStream[®]-DR:



Post DSI Fly Ash Recycling for Sorbent Recovery

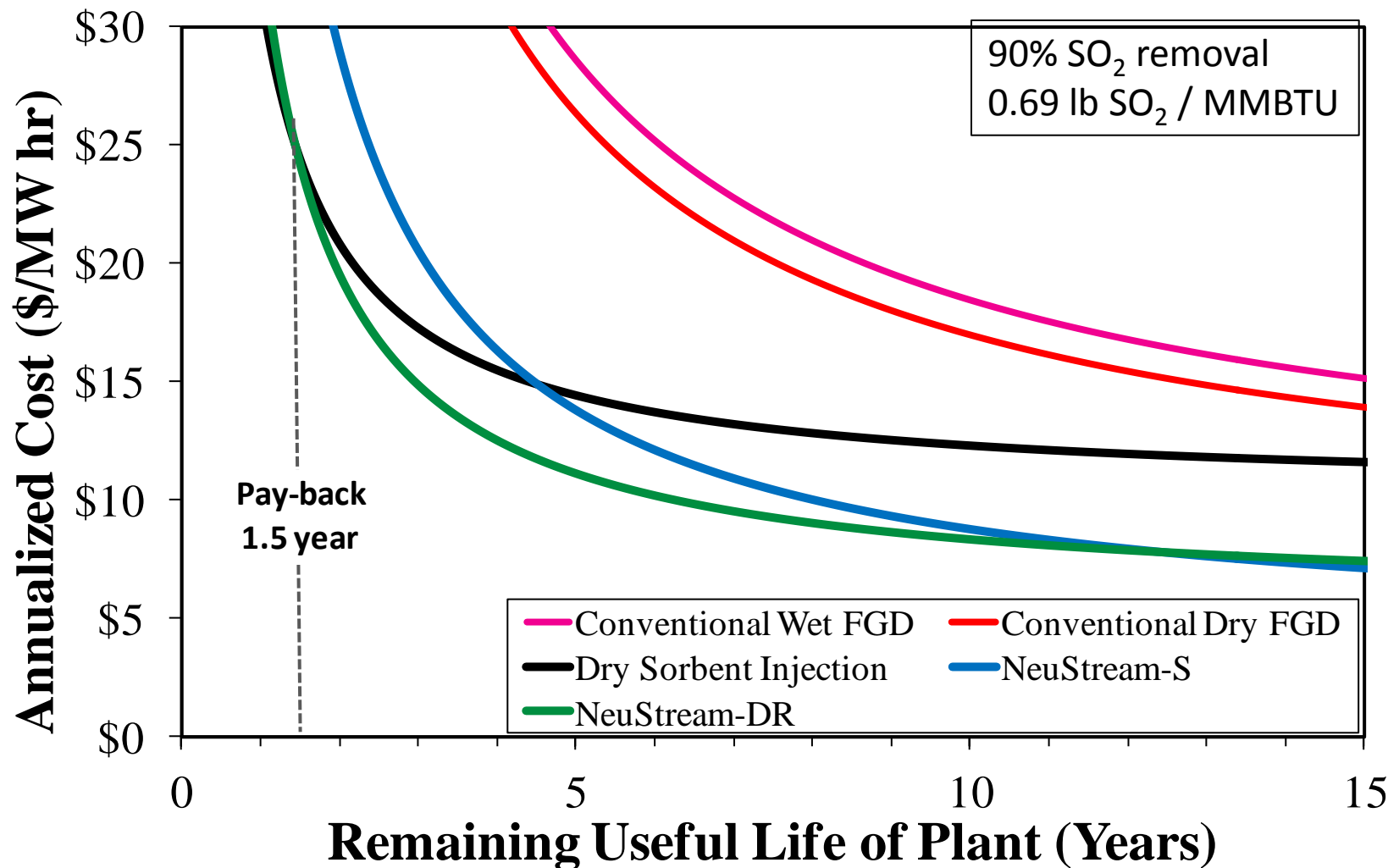
- *NeuStream[®]-DR* enables an equivalent performance and much lower system cost alternative to wet/dry FGDs (low to moderate sulfur coals)
- *NeuStream[®]-DR* enables economical use of trona as a higher performance, more reliable alternative to limestone/lime DSI
- *NeuStream[®]-DR* recovers and recycles **wasted** sorbent and decreases DSI sorbent cost by 60%-80%
 - Recover over 90% of un-reacted trona and convert to 100% sodium bicarbonate
 - Secondary (optional) process recovers reacted trona (sodium sulfate)
- *NeuStream[®]-DR* provides greater design flexibility for DSI systems:
 - Higher SO₂ removal (or ability to burn higher sulfur coal) by injecting more trona at lower cost
 - Injection on cold side of pre-heater to increase reliability without sacrificing removal efficiency

NeuStream[®]-DR Cost Comparison: 250MW Coal Plant, Bituminous Coal



- Lower NSR required for BH vs ESP: significant savings on sorbent costs at high removal
- NeuStream[®]-DR has 2 advantages: recycles unused sorbent and generates SBC (lower NSR to achieve same removal) → maximum savings, at lower CapEx, shorter construction time, and lower parasitic power

NeuStream[®]-DR Cost Comparison: 250MW Coal Plant, PRB Coal



Source: 2010 IPM cost models, Sargent and Lundy for EPA

NeuStream[®]-DR: Potential OpEx Savings



- Typical NSR for 90% SO₂ removal with baghouse:

3.3 (unmilled Trona) - 2.6 (milled Trona)

- For 90% SO₂ removal, 1.6 – 2.3 Na₂:SO₂ unreacted

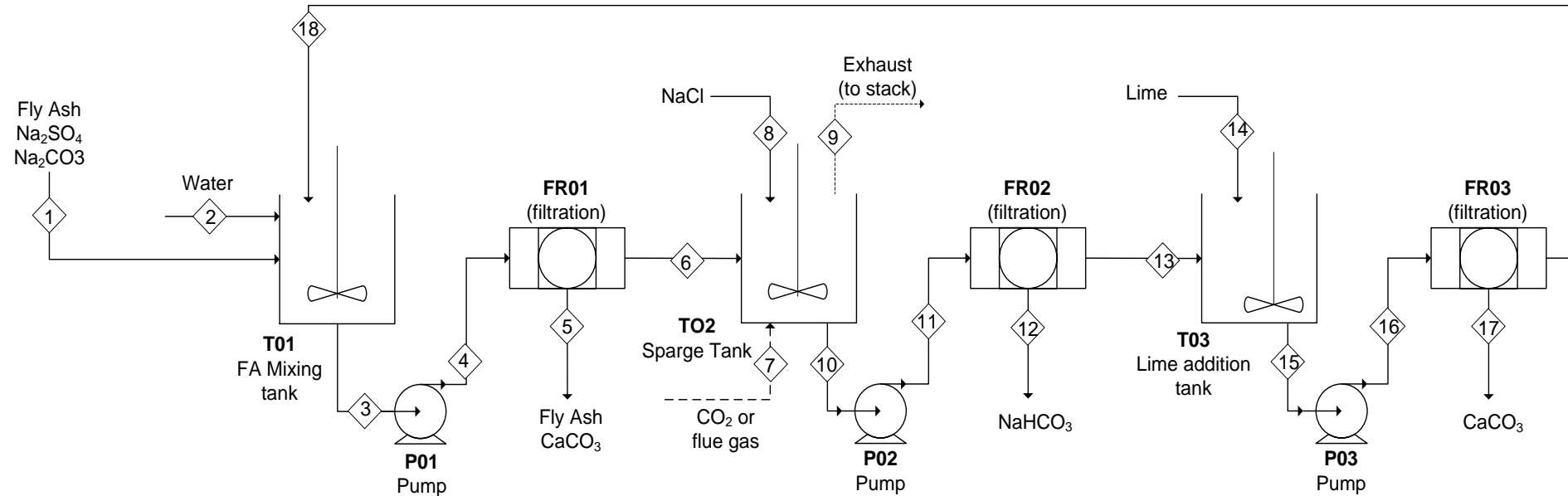
Reference: IPM Model – Revisions to Cost and Performance for APC Technologies: Dry Sorbent Injection Cost Development Methodology, Sargent and Lundy, 2010.

- Typical 250MW plant: 10,000 BTU/kw-hr, 0.69 lb SO₂ / MMBTU, NSR = 3.26

	ton trona /hr	\$/hr	\$/yr*	\$ / ton SO ₂
Total Trona Injection	6.6	\$1,191	\$8,349,885	\$1,535
Unreacted Trona	4.8	\$862	\$6,044,702	\$1,112
*80% capacity factor				

	Potential Savings (\$/yr) @ 95% Recovery of Unreacted Trona
Trona Savings	\$6,045,000
Lime Costs	\$805,000
Total Savings	\$5,240,000 (63%)

NeuStream[®]-DR Process Flow



NeuStream[®]-DR system:

- Reduces sodium concentration, and hence leachability, of post-DSI fly ash → similar to pre-DSI fly ash
- Process independent of DSI injection and power generation process
- Simple, reliable design, no exotic chemicals

NeuStream[®]-DR Pilot Results



Property	Lab Results		Batch Process Pilot Results	
	3 step	3 step w/ wash	3 step	3 step w/ wash
Purity	88%	90%	79% ± 1.4%	On-going
Yield	82%	98%	76% ± 3.7%	On-going

Powder low properties of recycled solids are very close to post-DSI fly ash mix (easy flow, slightly better than trona)

Toxicity characteristic leaching procedure per SW846 6010C

mg/L	Raw fly ash	Post DSI solids, unprocessed	Post NeuStream [®] -DR
Chromium	0.066	0.18	0.25
Selenium	0.084	0.48	0.071
Arsenic	ND	0.21	0.033

- *NeuStream*[®]-DR process offers major advantages:
 - Up to 80% decrease in DSI OpEx with optional NaSO₄ converter
 - Removes most of the soluble sodium from fly ash
 - Low power usage and water consumption
 - Small footprint, simple operation
- Gives utilities added flexibility:
 - Install DSI now due to MATS Regulations
 - Add *NeuStream*[®]-DR later for cost control, greater SO_x control, cleaner fly ash

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