

Predicting Non-Process Element Behavior in Modern Pulp Mills

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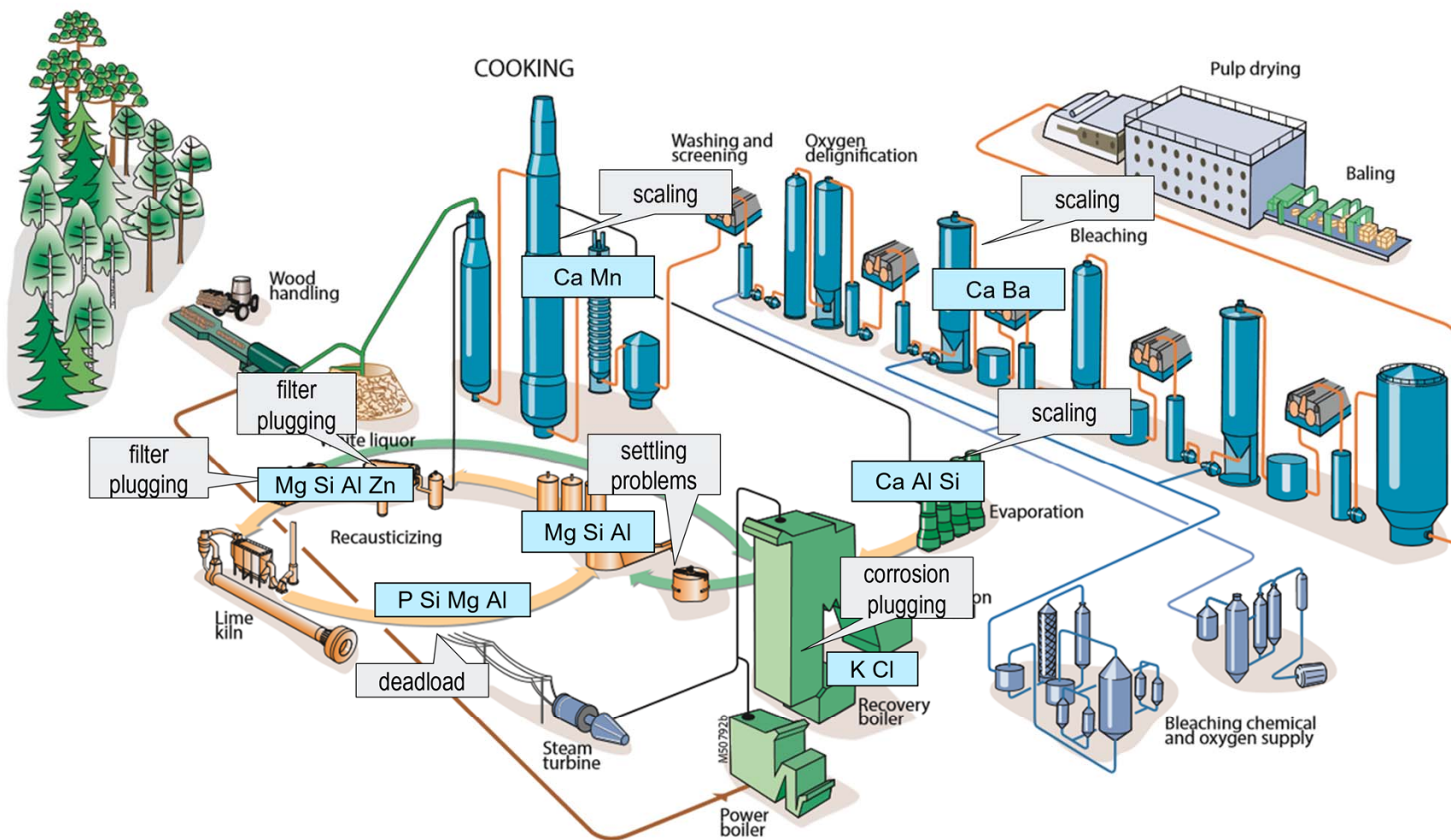
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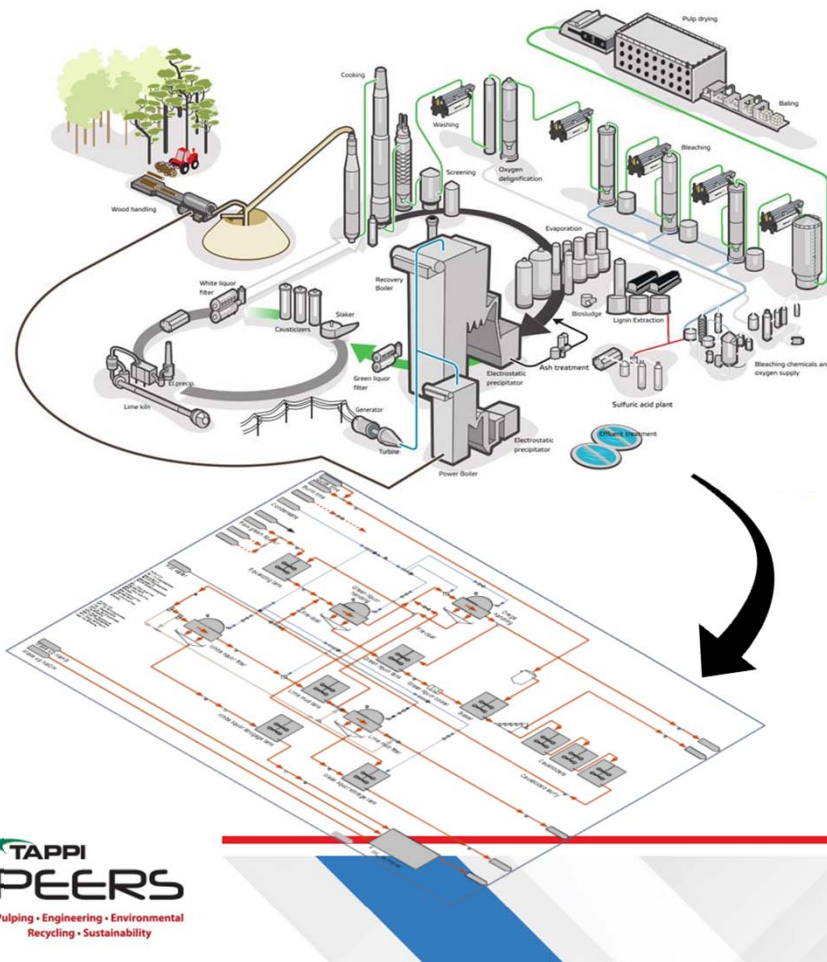
Contents

- Problems caused by NPEs (Non-Process Elements)
- Introduction to NPE model
- Model validation by sampling and analysis
- Case example 1: Changing the lime kiln fuel
- Case example 2: Reusing bleaching filtrate
- Model validation and limitations
- Future use of NPE model





NPEs and modeling objectives

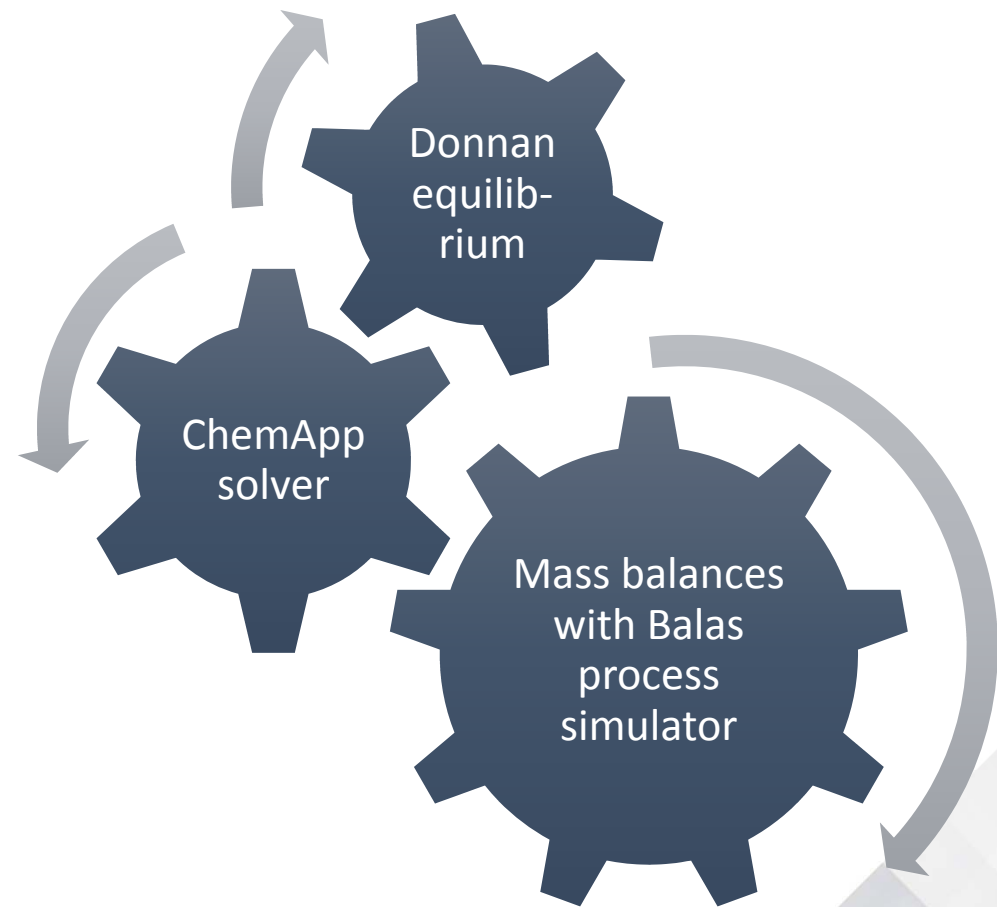


- NPEs do not actively participate in the pulping process
 - In our model: Ba, Sr, Zn, Cu, Fe, Mn, K, Cl, P, Si, Al, Mg (Na, S, Ca)
- Objectives with NPE model
 - Minimize dead load in the mills
 - Enhance resource utilization (e.g., less make-up chemicals)
 - Improve operational efficiency and sustainability

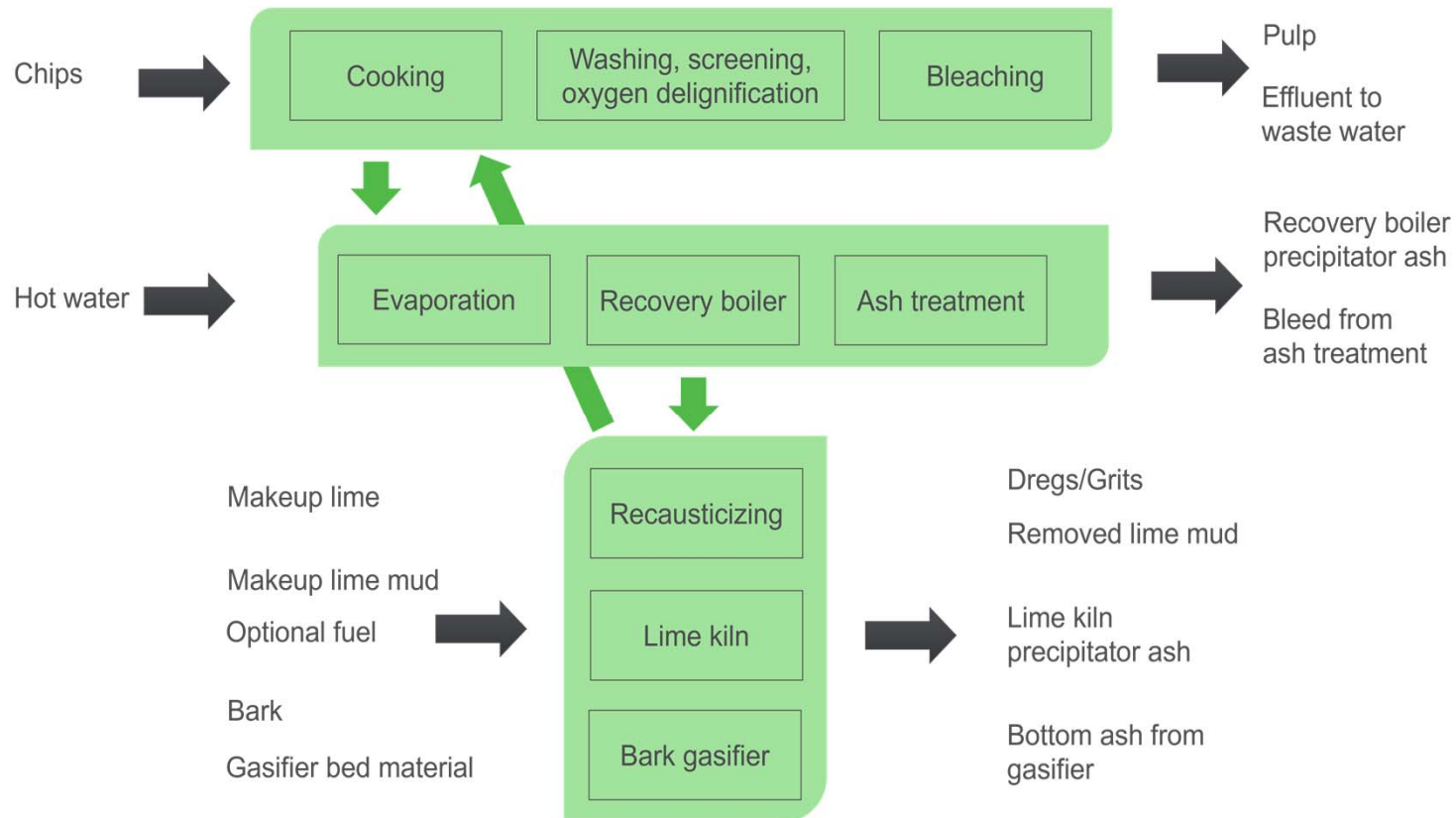


Modeling NPE behavior

- Model development in co-operation with VTT Technical Research Centre
- Mass balances combined with thermodynamic equilibrium calculations of multi-phase systems
- Water inside the pulp fibers is modeled as a second aqueous phase



Model scope and process streams



Main samples for model validation

Evaporation and recovery boiler

- Weak black liquor
- Strong black liquor
- As-fired black liquor
- ESP ash from recovery boiler
- Treated ash

Recausticizing

- Raw GL
- Clear GL
- GL dregs
- Make-up lime
- Lime mud
- Burnt lime
- ESP ash from lime kiln
- White liquor

Gasification

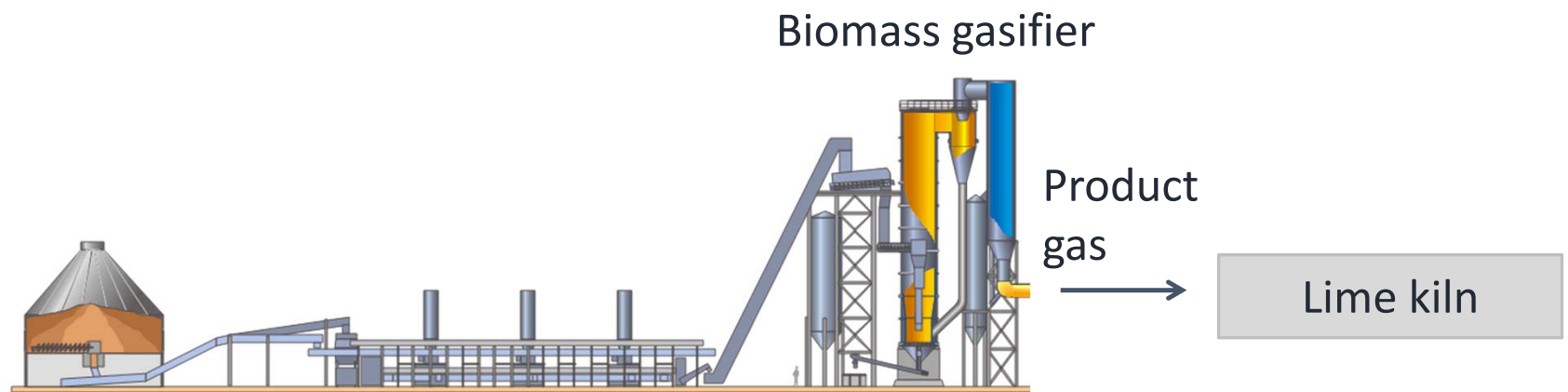
- Bark
- Gasifier bed material
- Bottom ash from gasifier

Fiber line

- Wood chips
- Pulp after different washers
- Filtrates after different washers



Case example 1: Changing the lime kiln fuel



- Biomass gasification = biomass dryer, a gasifier (often a CFB), and a lime kiln optimized for burning the product gas
- For decarbonizing pulp mills



NPE enrichment in burned lime

Product gas content	mg/Nm3
K	700
Al	200
Mg	700
Si	1 100
P	200
Mn	100
Fe	100

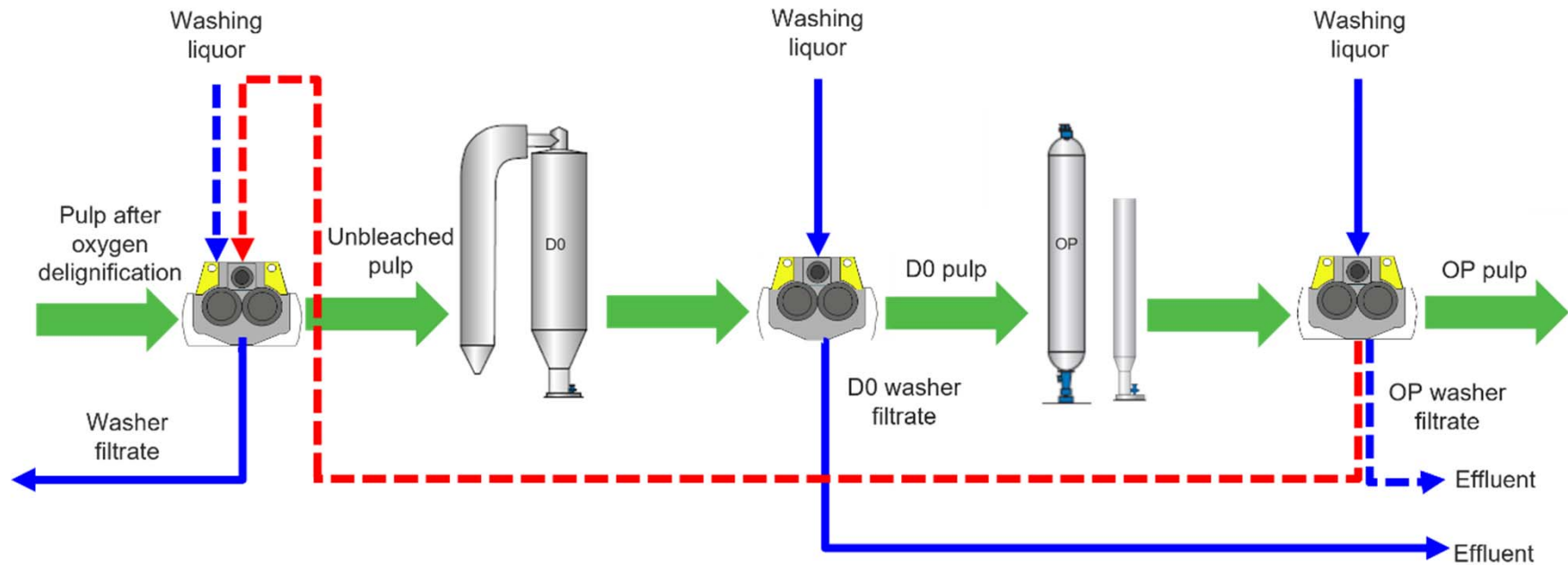
- NPEs originate from bark and bed material
 - Some remain in the bottom ash
 - The rest enter the product gas

NPE content in burned lime	Increase (%)
K	900
Mg	300
Si	80
P	20
Mn	300
Fe	300

- Some NPEs enrich in burned lime (compared to natural gas)
 - If P level maintained constant:
7 kg_{dry}/Adt more make-up lime



Case example 2: Reusing bleaching filtrate



- Objective: recycle the OP/alkaline filtrate back into the process
- Reduce fresh water usage
- Decrease the environmental load (lower effluent amount and COD)



Effects of bleaching filtrate recycling

Increase (%)	Oxygen-delignified pulp after wash press (30% ds)	Wash filtrate from unbleached pulp	D0 filtrate	Weak black liquor	Bleached pulp
Na	68	100	29	1	1
K	-5	13	-6	0	0
S	86	66	9	0	1
Cl	2 500	2 200	11	33	0
Ca	13	21	5	-1	69
Mg	37	25	14	5	25

- Significant increase only in Cl in weak BL (removed by ash treatment)
- Effluent approximated to decrease by 4 m³/Adt; COD by at least 20%

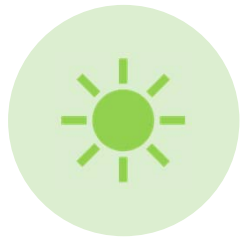


Model validation and limitations

- Process streams sampled and analyzed for NPEs
 - Model validated partly, some more data needed to reduce uncertainties
- Thermodynamic equilibrium approach does not work with all elements
 - Some reactions must be constrained based on empirical data
- Model cannot predict whether the solids that form contribute to scaling
 - Nor how the organics in the process streams affect the solubility of metals
- Model is steady-state



Future use of NPE model



Renewable fuels in
lime kiln



New raw materials
for pulp



Reduced freshwater
usage



Land-filled waste
minimization



Thank you!

