Harnessing the Power of Dried Biosolids – More than a Decade of Experience

2023 North East Residuals and Biosolids Conference

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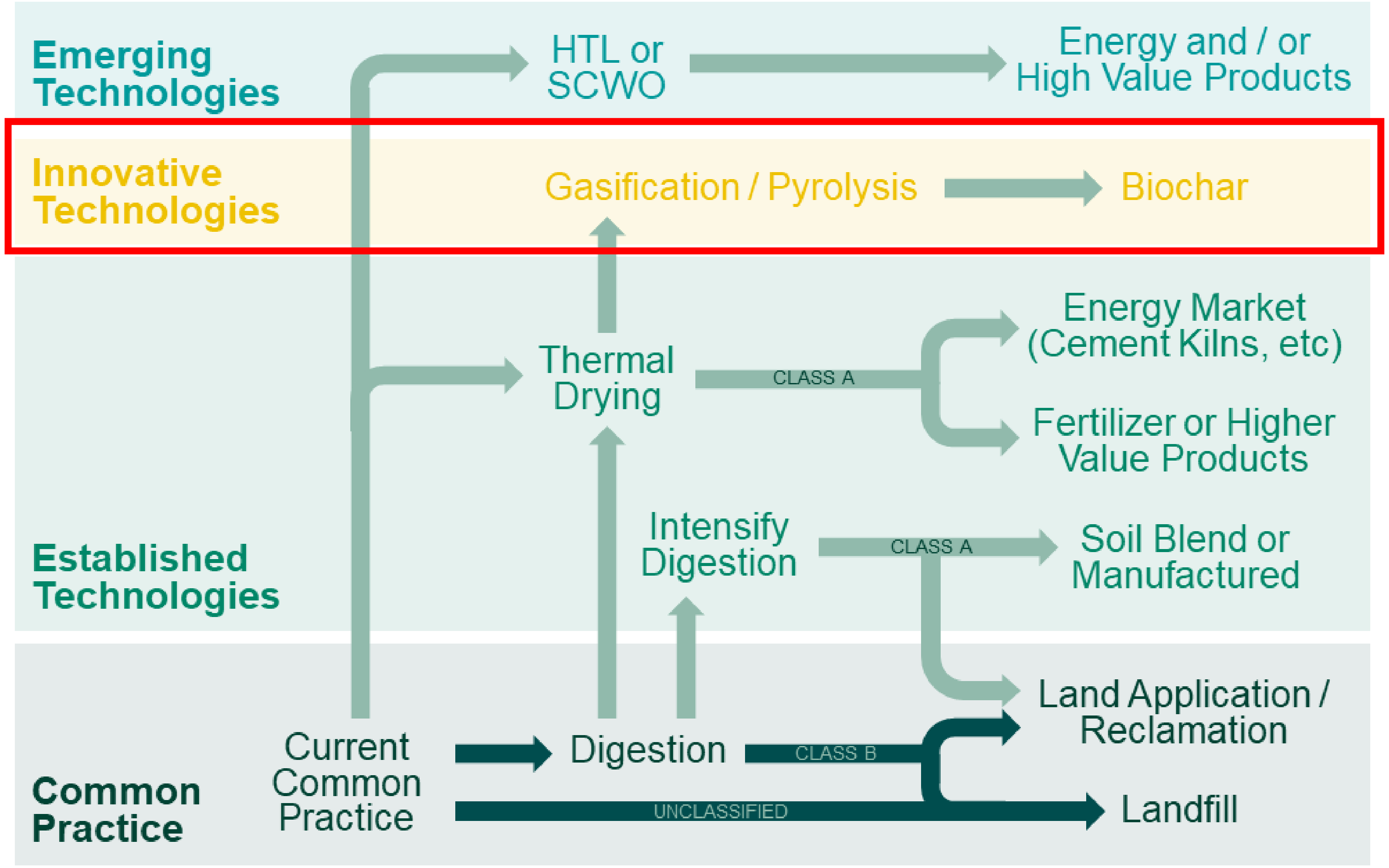
Outline

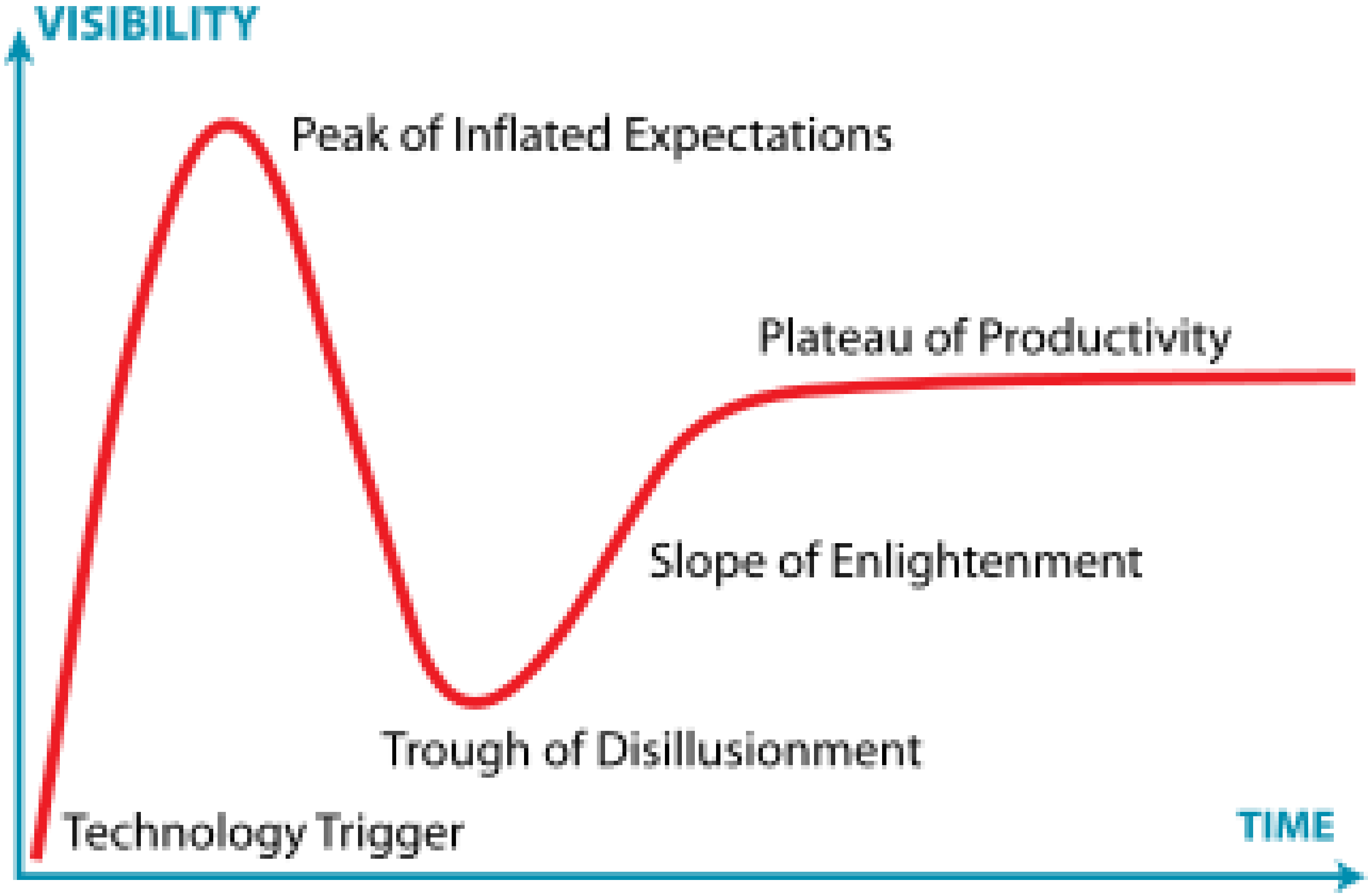
- Introduction and Plant Background
- Technology Selection / Overview
- Installation and Performance Testing
- Lessons learned and Process Improvements
- PFAS Impacts
- Summary / Final Thoughts

Biosolids Innovation Roadmap

- How to deal with rising cost for beneficial use or disposal?
- How to deal with restrictions to landfilling or land application?
- How to deal with changing regulations and/or end market changes?
- What about emerging contaminants?
- What if options to landfill or land apply go away in the future?



Technology Development – Hype Curve



Background & Plant Design Data

- Plant Located about 30 miles west of Minneapolis
- City population of approximately 15,000 during initial planning in 2006
- Population was projected increase to 30,000 by 2025 but growth slowed in 2008 recession
- 2021 Estimates now around 16,400
- Design flow of 4.3 MGD
- Extended Air Activated Sludge
- Design biosolids loading of 7,000 dry lbs/day
- Previously used Reed Beds and had desire to move away from Class B Land Application
- In operation for > 14 years

Biosolids Processing Goals and Options

Goals

- Provide treatment to achieve exceptional quality (E.Q.) biosolids
- Provide best available treatment for biosolids – "set the benchmark"
- Positive public perception
- Low operating cost (ie. minimize energy consumption)
- Beneficial use
- Reliable and proven treatment technology
- Minimize carbon footprint

Evaluated Multiple Options (Digestion, Alkaline Stabilization and Drying)

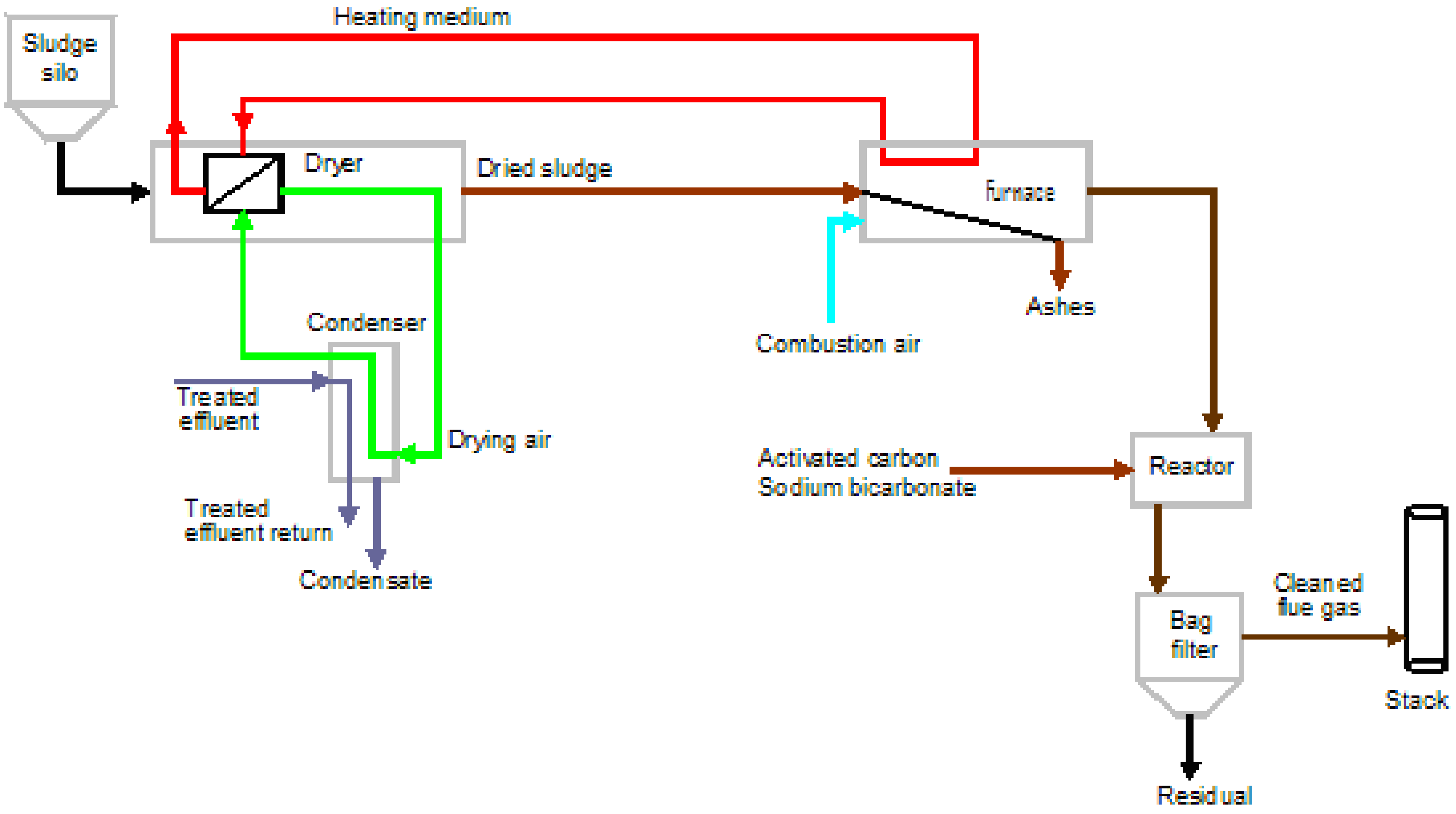
Drying met all goals, except 1 – Energy Intensive!

Selected Kruger BioCon and Energy Recovery System

- ~$5 million in savings over 20-year lifecycle

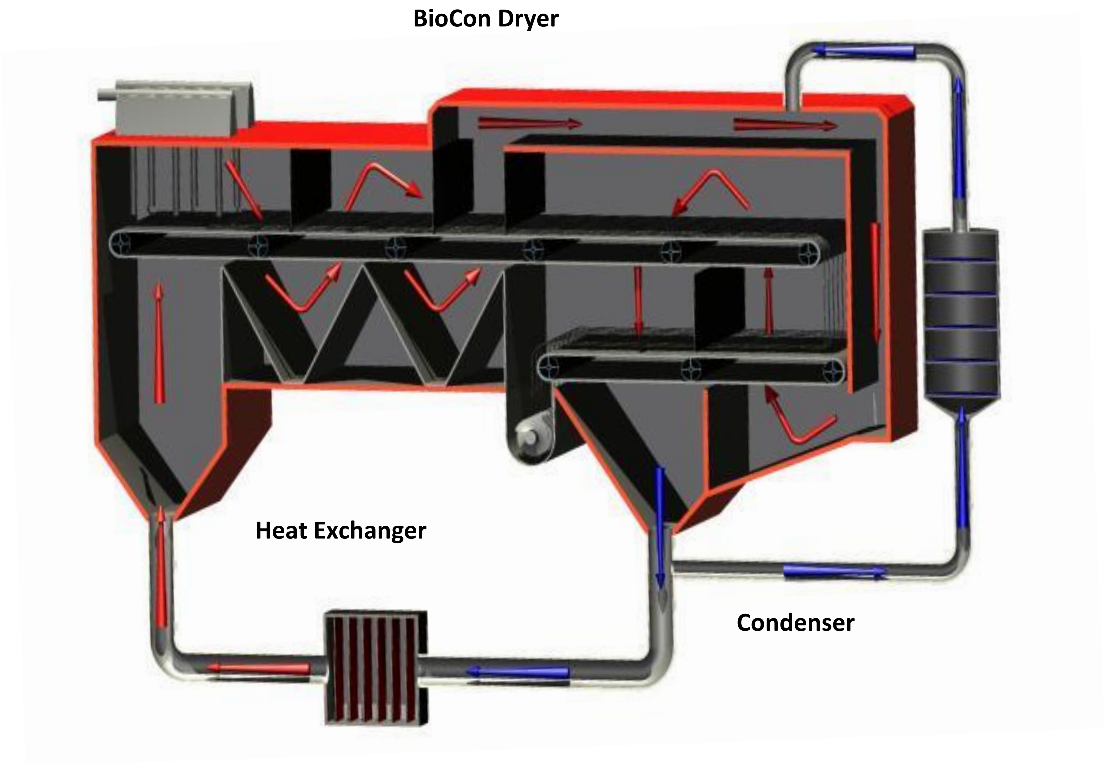
Technology Selection / Overview

Kruger BioCon ERS System - Overview

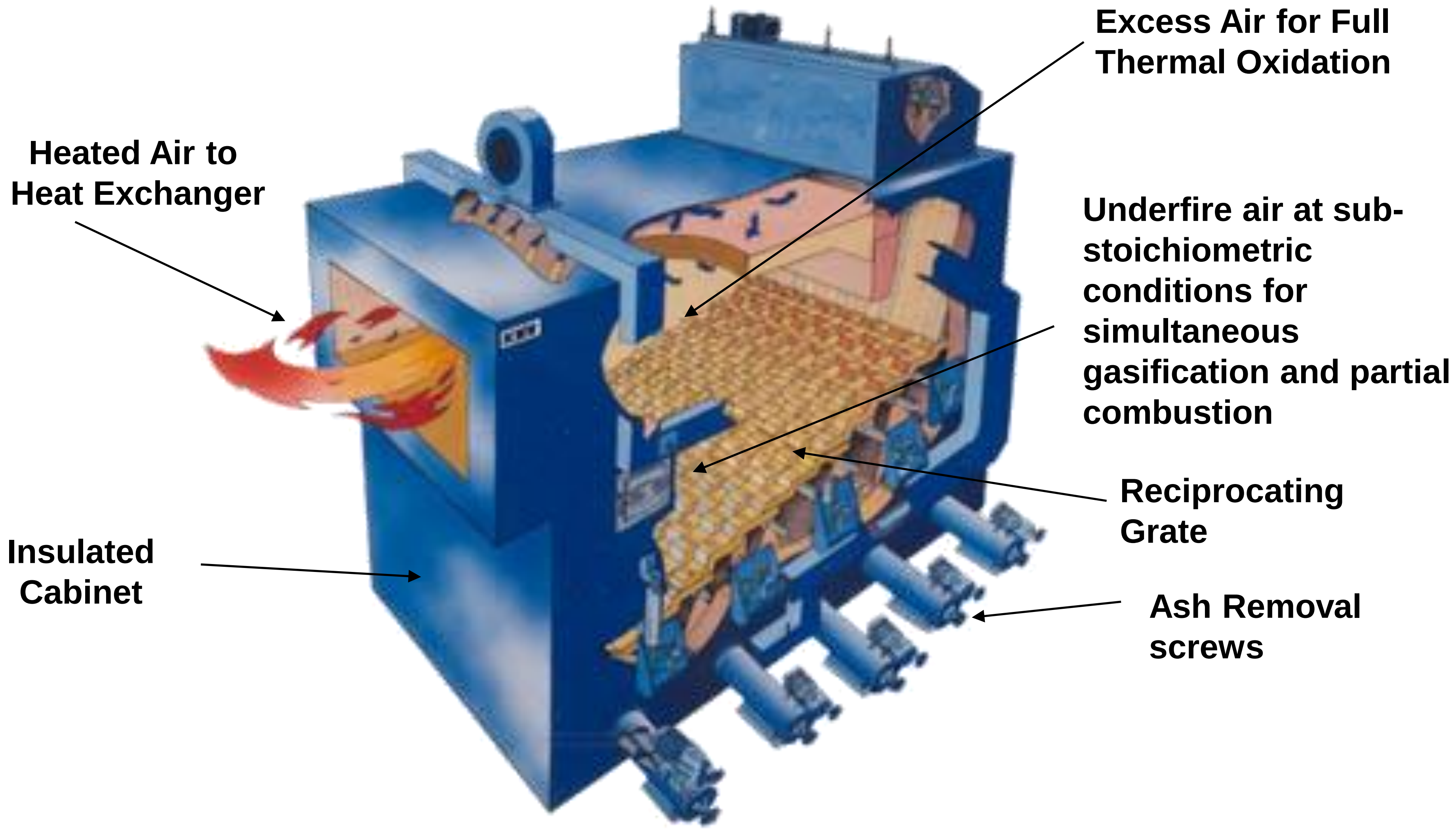


BioCon Belt Dryer

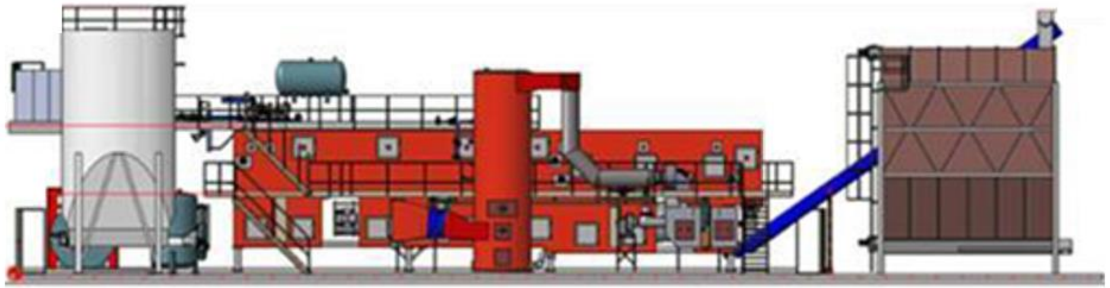
- Indirectly Fired Convection Dryer w/ 304 SS Mesh Belt
- Flexible Heating Source – Air to Air chosen here
- Large biosolids drying surface area (thin strings)
- Two Zones (typical)
  - First Zone: 15 minutes at < 180 C (356 F)
  - Second Zone: 45 minutes at < 120 C (248 F)
- Closed Loop with water removed via condenser

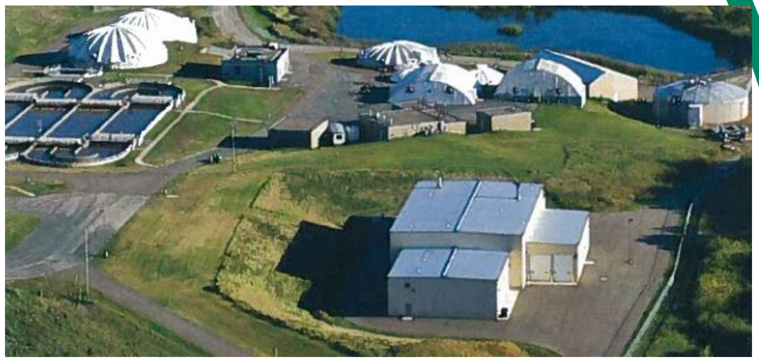


Biosolids Furnace

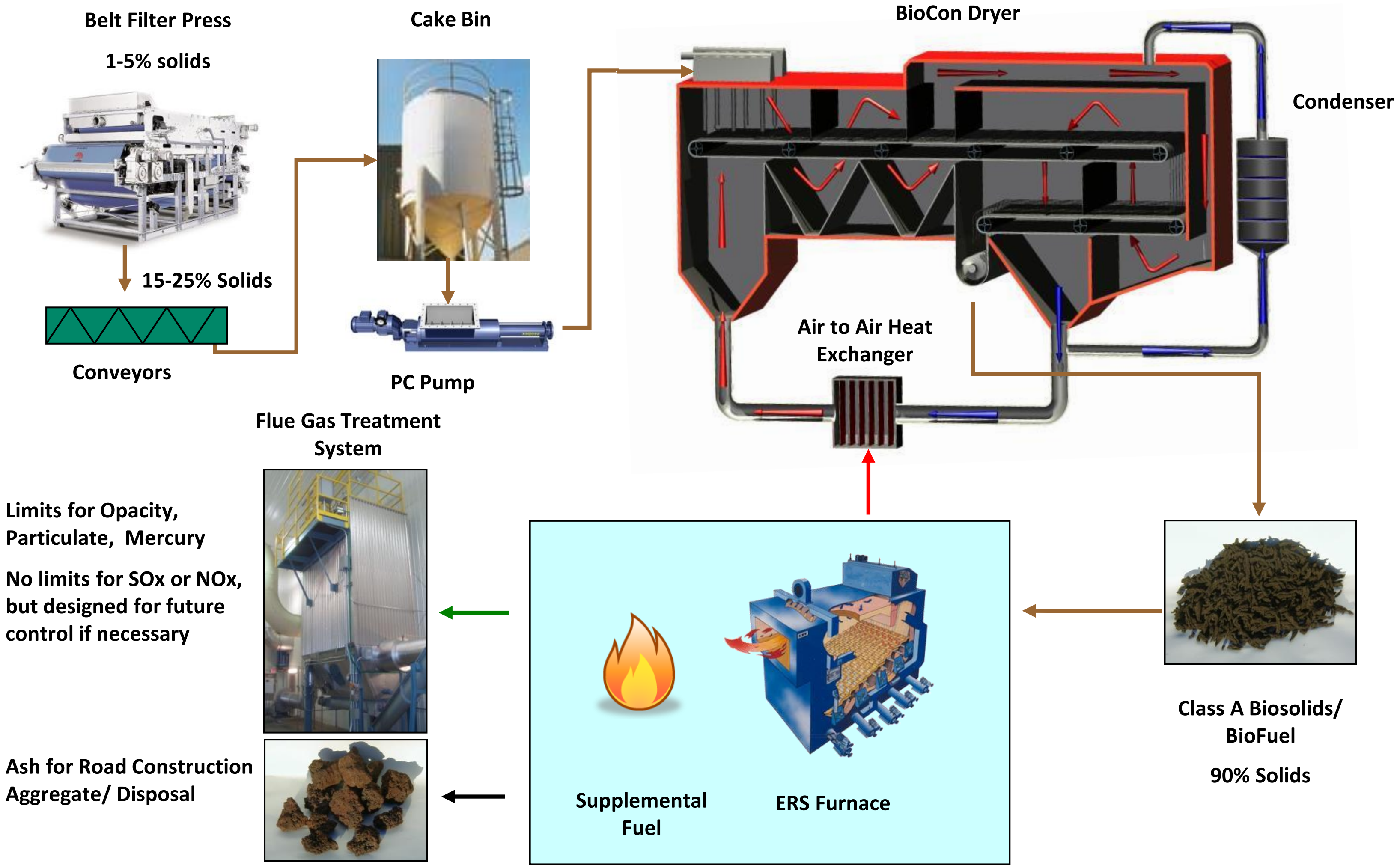


Installation / Start-up / Performance Testing

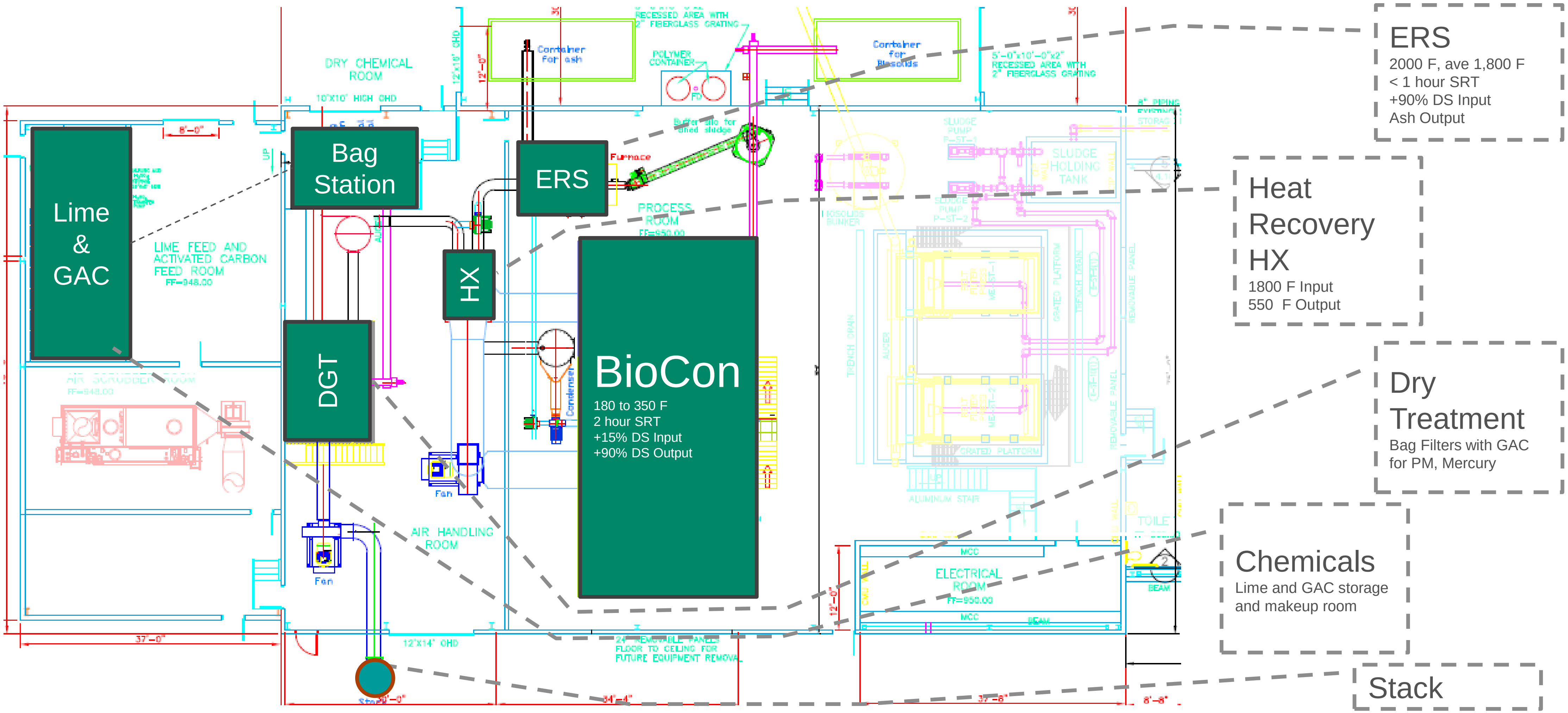




Process Overview



Buffalo, MN – Full-scale Implementation



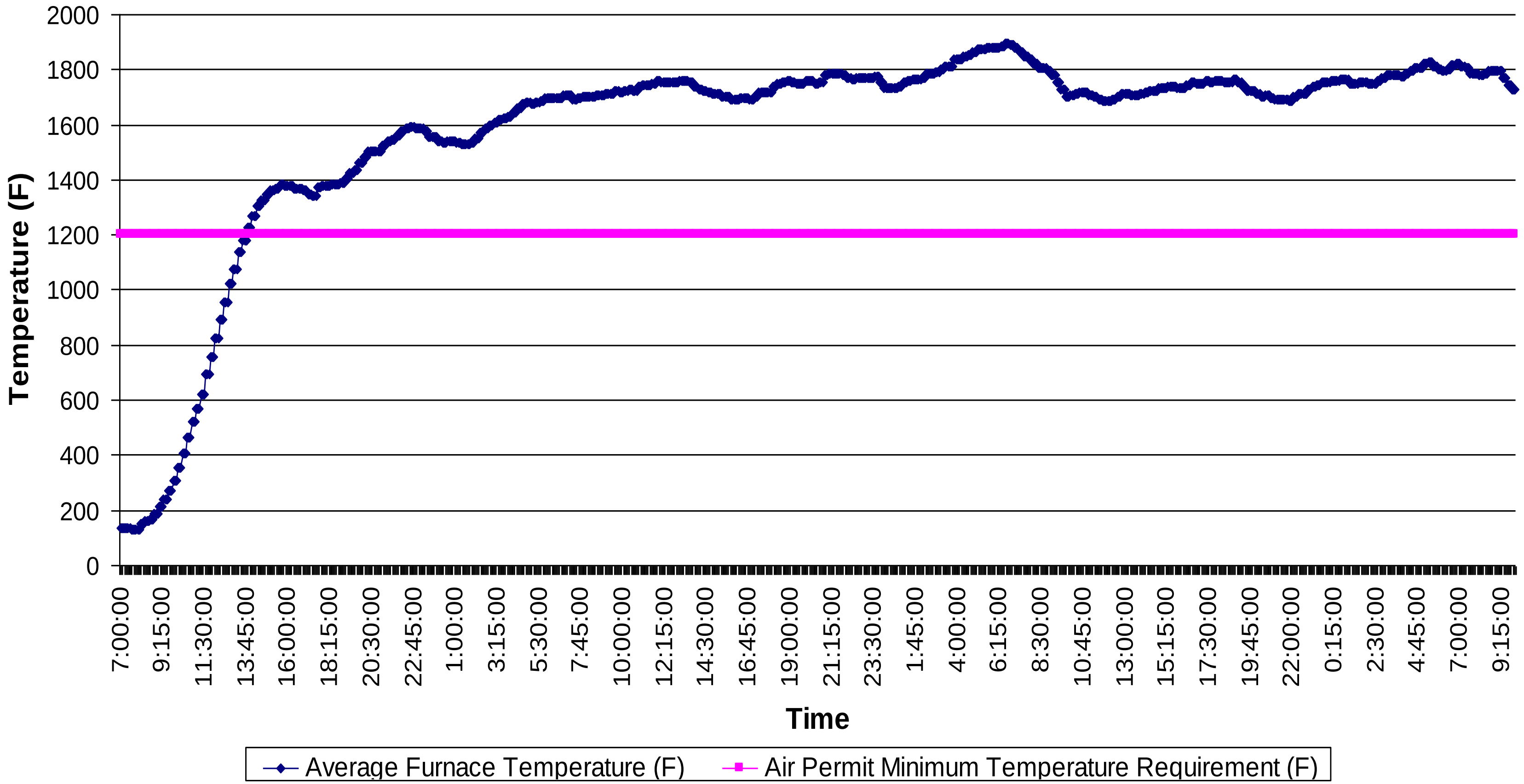
Air to Air Heat Exchanger

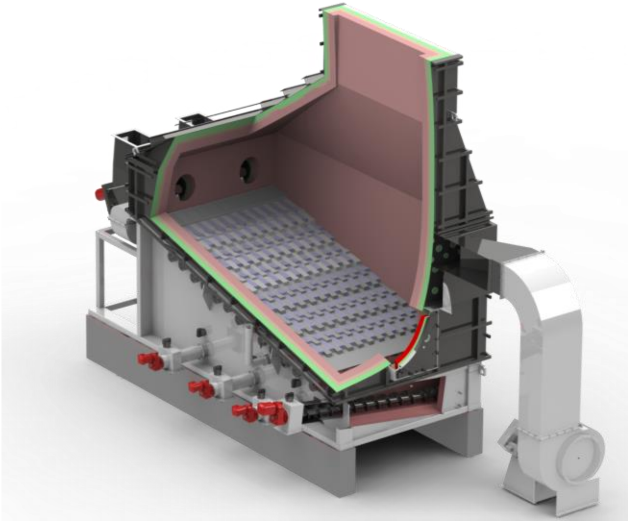
- Heat From Furnace recovered indirectly by air to air heat exchanger
- No steam boiler
- Tubular Heat Exchanger
- Flue Gas Recirculation to reduce temperature and increase efficiency
- Contains Stand-by burner for dryer only operation
- Includes fire-tube soot blowers for online cleaning (original sonic horns didn't work!)

Permit Limits and Requirements

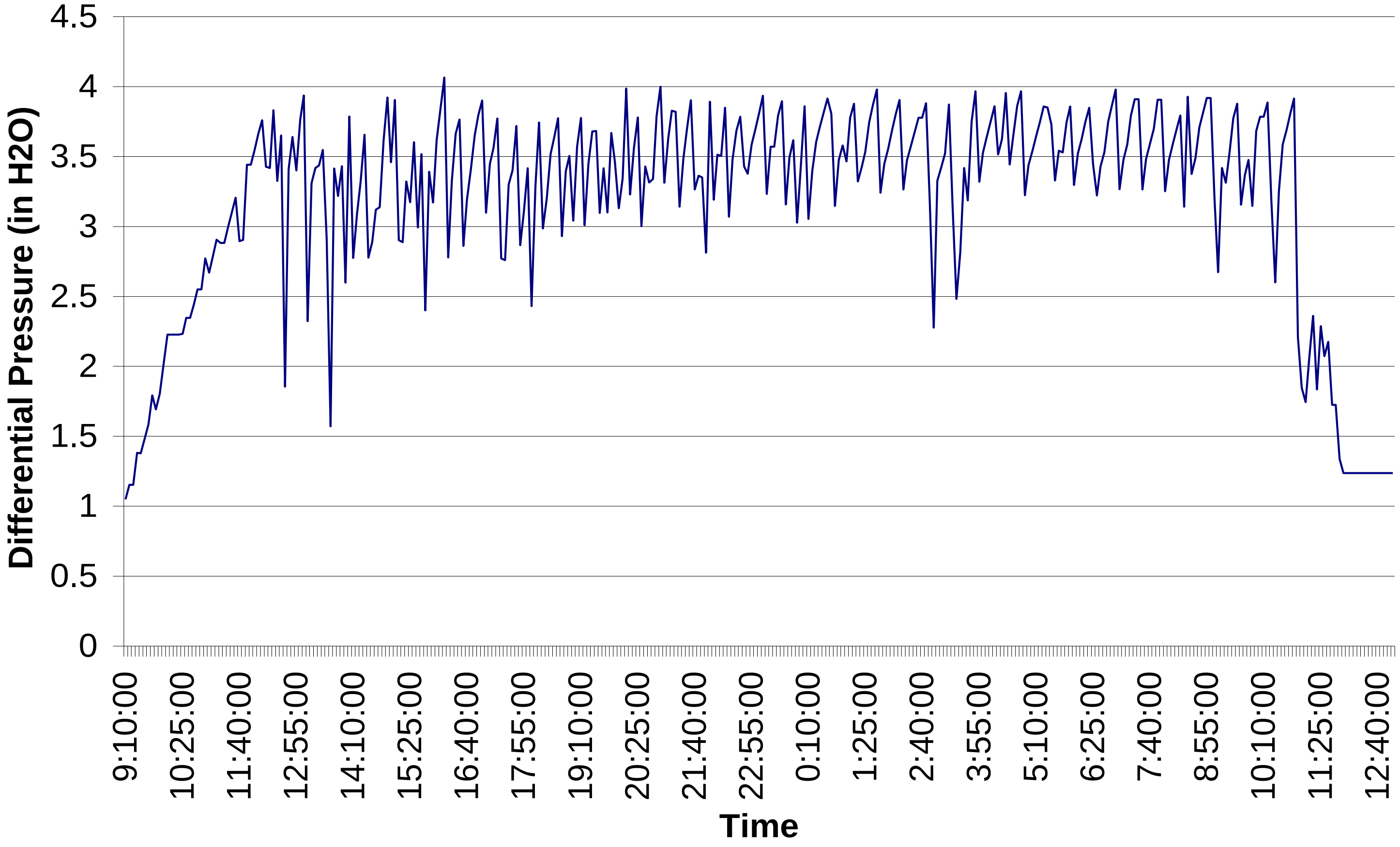
Pollutant	Limit	Required Treatment	Treatment Method	Treatment Monitoring
VOC's	--	Complete destruction	After combustion chamber, 1200F for 0.3 seconds	Thermocouple
Particulate Matter	1.30 lbs/ton dry biosolids combusted, ≤ 20% opacity	≥ 99% removal PM_{10}	Baghouse Filtration System	Furnace feed rate, pressure drop over baghouse, visual inspection of emission
Mercury	≤ 4 lbs/12 months	≥ 80% removal efficiency	Activated carbon injection upstream of baghouse filter	AC feedrate and operation verification
SO_x*	None	None	Hydrated lime injection upstream of baghouse filter	Lime feedrate and operation verification
*Not required by current air emissions permit				

Minimum Furnace Temperature





Bag Filter Differential Pressure



Performance Test - Emission Control Results

Parameter	Run 1	Run 2	Run 3	Average
Plant Operations (Hg Run Times)				
FurnaceTemperature, °F	1876	1896	1866	1879
Furnace Feed Rate, LB/HR	414	435	432	427
Sludge Solids as Fed, % w/w	89%	89%	89%	89%
Sludge Mercury Content, mg/kg, dry	0.74	0.85	0.63	0.74
Mercury Input Rate, LB/HR	0.000273	0.000329	0.000242	0.000281
Activated Carbon Feed, LB/HR	1.04	1.04	1.05	1.04
Particulate Test Results				
GR/DSCF (Dry+WC_{org})	0.0032	0.0030	0.0029	0.0030
LB/HR (Dry+WC_{org})	0.060	0.056	0.055	0.057
LB/Ton Dry Sludge (Dry+WC_{org})	0.33	0.30	0.28	0.30
Mercury Test Results				
µg/dscm	<0.11	0.20	0.17	0.16
LB/HR	<0.0000009	0.0000016	0.0000012	0.0000013
LB/YR (24/365)	<0.008	0.014	0.012	0.011
Control Efficiency	>99.7%	99.5%	99.5%	99.6%

Exceeds SSI Limits = 0.004 gr/dscf (9.6 mg/dscm)

Exceeds SSI Limits = 1 µg/dscm (0.0010 mg/dscm)

Biosolids Heat Value Data

Dry Biosolids HHV

– 6,700 Btu/lb (design)

– 7,031 Btu/lb (measured)

Volatile Content

– 60% (design)

– 66% (measured)

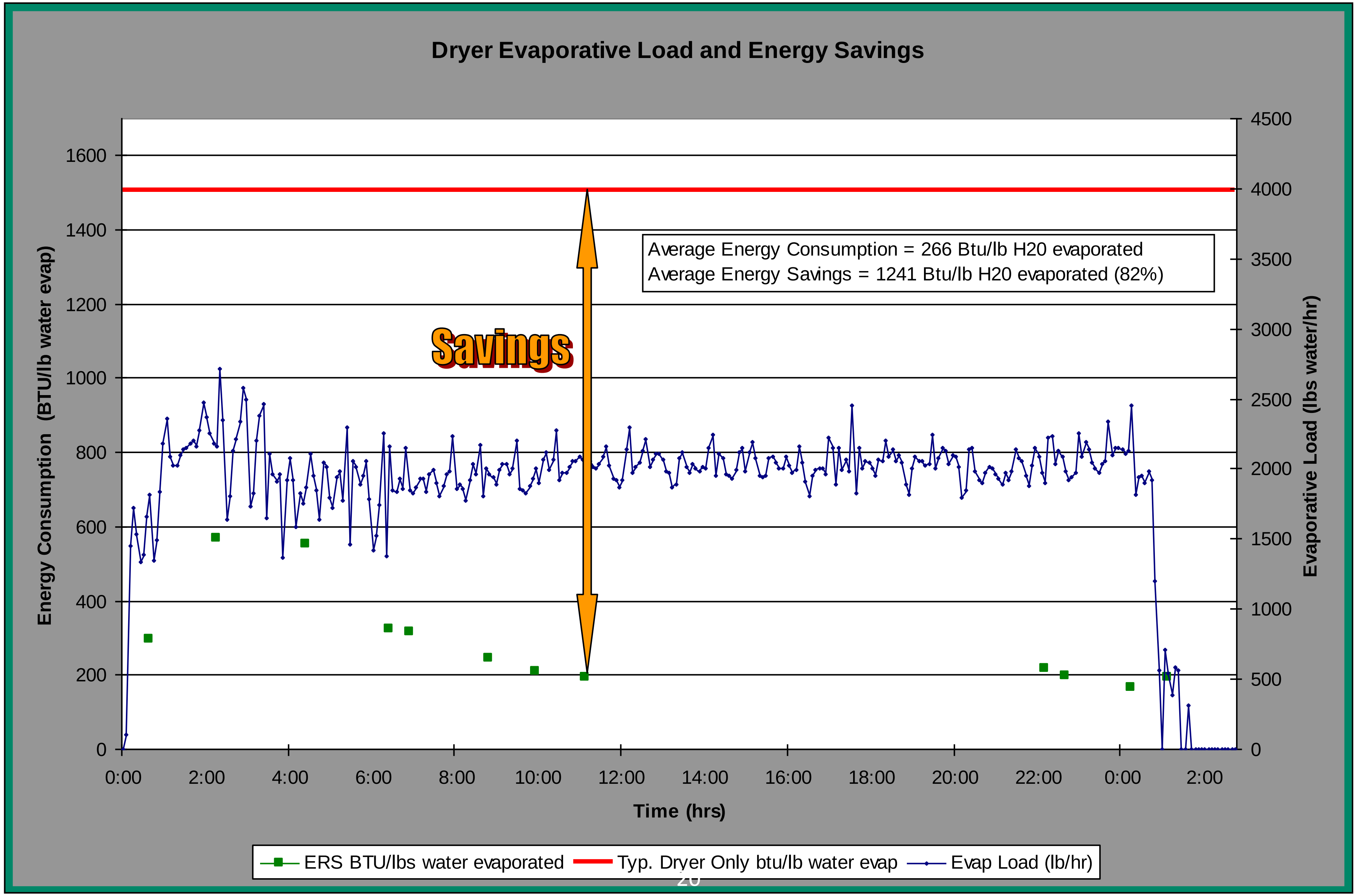
Fixed Carbons = 3.19%

Ultimate Analysis		
Carbon	39.46	%
Hydrogen	4.58	%
Nitrogen	6.35	%
Sulfur	1.29	%
Ash	30.39	%
Oxygen	17.93	%

Solid Content	Energy Requirement (BTU/lb H_2O evap.)
18%	574
21%	343
22%	164

Dryer systems without energy recovery typically require 1,400 – 1,600 Btu/lb H_2O evap.

Performance Test - Energy Efficiency



Lessons Learned and Process Improvement

Reduced Ferric for Phosphorus Removal

- Rely more on Biological Phosphorus Removal
  - Use ferric only for polishing
  - ~95% reduction in ferric use
- Change improved burn and reduced clinkering
- Also reduced sludge volume
- Lowered ash content
- Cleaner flue gas lines
- Required dewatering polymer change

Other improvements and observations

- Polymer modifications which change also helped to improve dewatering performance
- Reduced natural gas use from about 400 therms down to 80 – 100 therms
- Most stable with small amount of natural gas and nice and slow
- Replaced grates with worn air holes – new grates all moving in synchronization for better agitation (2019)
- Replaced refractory (2020)
- Air heat plug fan belts
- Added shredder after rotary valve

Some other improvements

- Improved dust collection in ash area (only one drop point for ash so roll off bin is moved periodically for even fill)
- Changed level indicators on liquid sludge, cake and dried biosolids bins
- Added catwalk to top of cake bin
- Addition of water softening system to condenser
- More recently some bleach to condenser water as well
- Changing conveyors to stainless steel

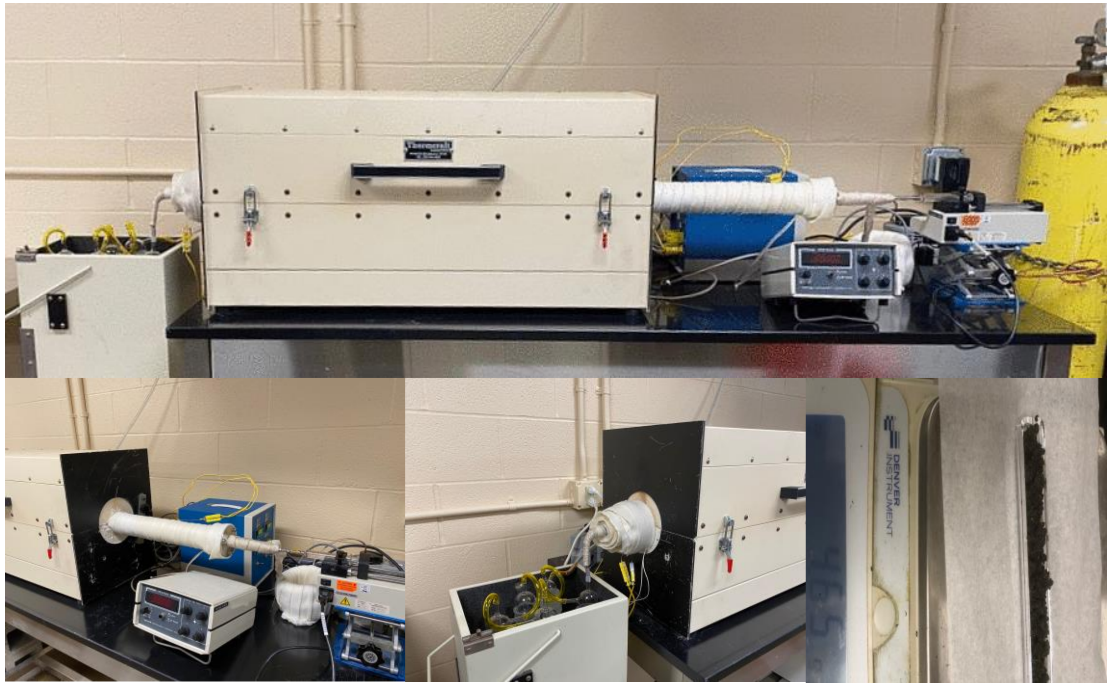
Thermal Oxidation of Emerging Contaminants

Fate of PFAS in Sludge & Emission

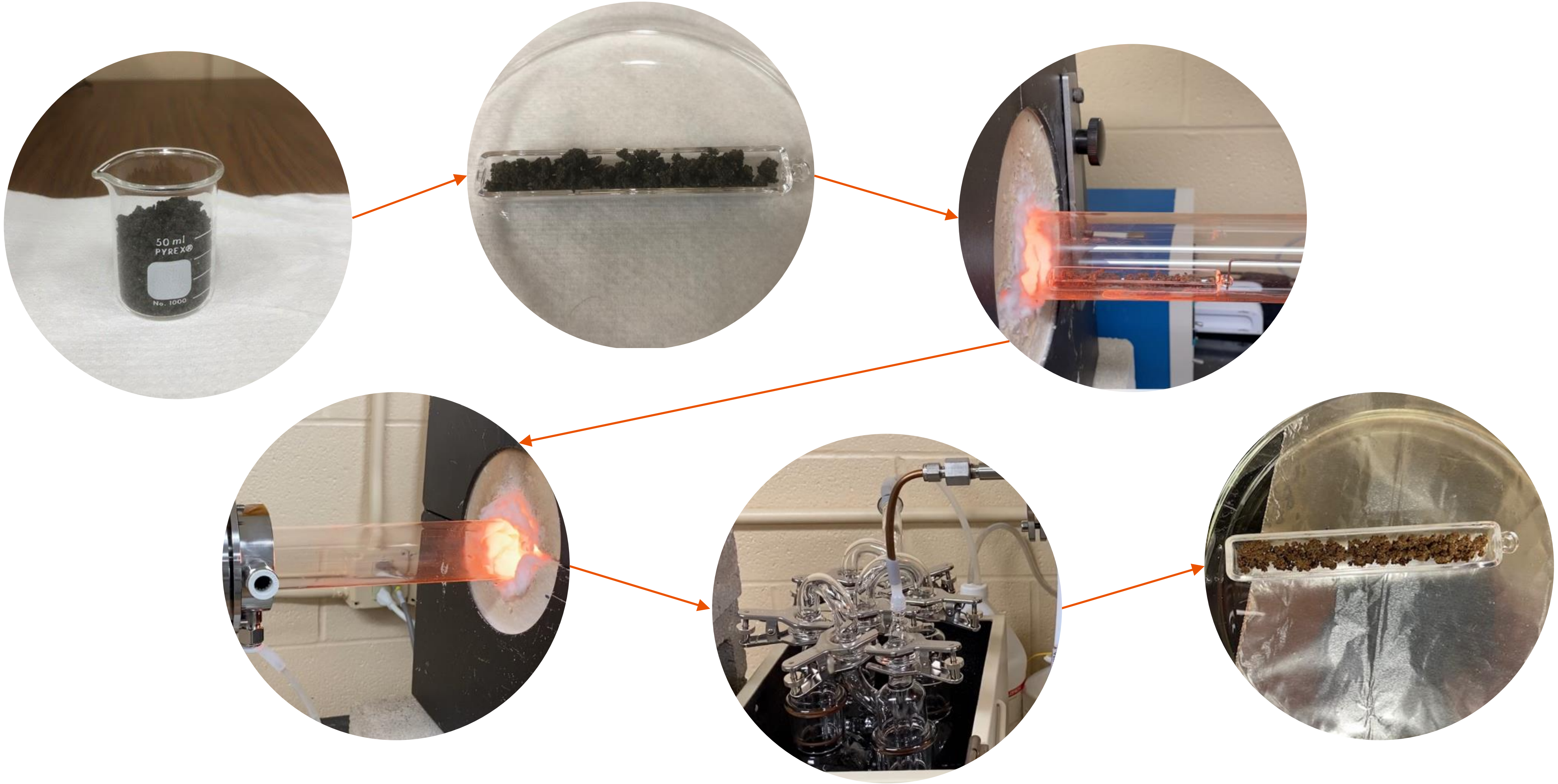
- Laboratory scale test
- Self-funded study
- Phase I: PFAS transport test
- Phase II: Thermal decomposition test
- Phase III: Site specific testing

Study Deliverables & Real World Test

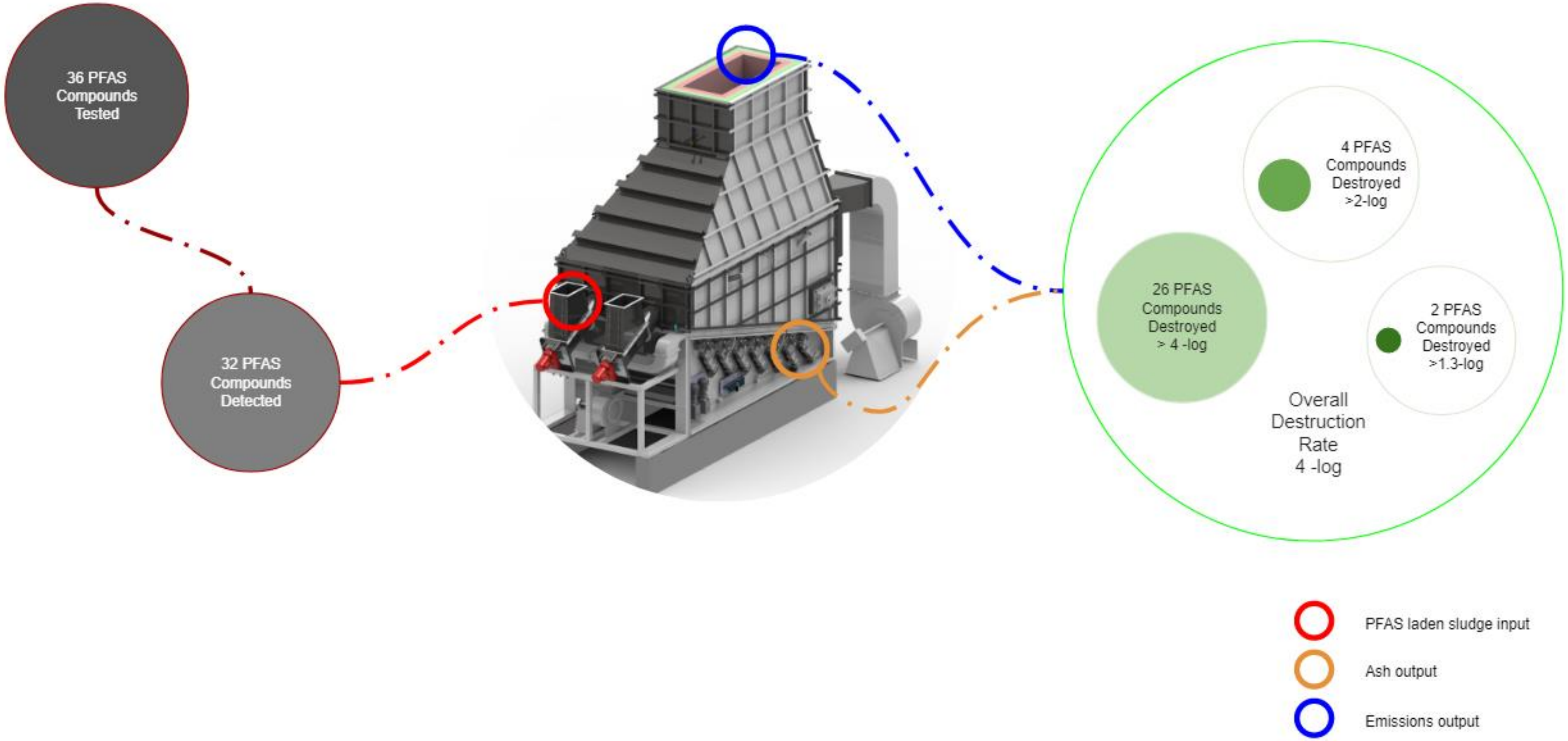
- Verify thermal conditions for destruction of PFAS
  - Develop a Fluoride mass balance
- Identify chemical pre-treatment to reduce regulated emission
  - Acquire knowledge to address this emerging market with data driven design/solutions
- Determine design criteria to fine tune
  - ERS for PFAS destruction
  - APC for emission



Testing solids, liquids and gases



Oxidation of PFAS Laden Sludge



Summary / Final Thoughts

Final Thoughts – Application for Today

- Increasing challenges for traditional beneficial use and disposal
- Emerging contaminant impacts are “unknown” driver
- Increasing interest in thermal conversion technologies for mass minimization and energy recovery
- Innovations in the industry can be slow – some notable failures
- *But* lots of current development!
- **Buffalo, MN is one example with a long operational track record!**

Awards

American Council of Engineering Companies 2009 Engineering Excellence – Grand Award

- 1 of 2 Wastewater Projects Selected
- 1 of 24 Global Projects Selected
- Over 240 Finalists

Minnesota American Council of Engineering Companies – Grand Award

Minnesota Society of Professional Engineers (MSPE) 2009 Seven Wonders of Engineering Award

AECOM Delivering a better world

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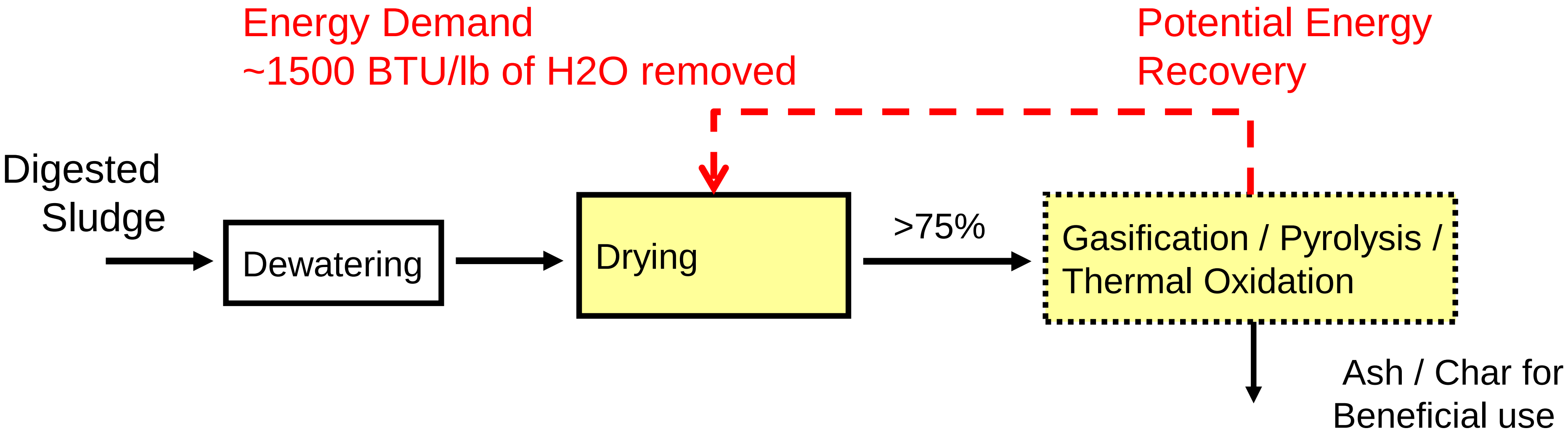
Recovering Energy After Digestion: Dewatering + Drying prior to Thermal Oxidation



- Dewatering performance is important: Reduce energy for drying
- No need for pelletization, however dried material needs to be not dusty
- In case of gasification, syngas is thermally oxidized to generate heat for drying