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Evaluating Thermal Drying
Energy and Economics

NEWEA
WORKING FOR WATER QUALITY

Session 13: Energy/Residuals

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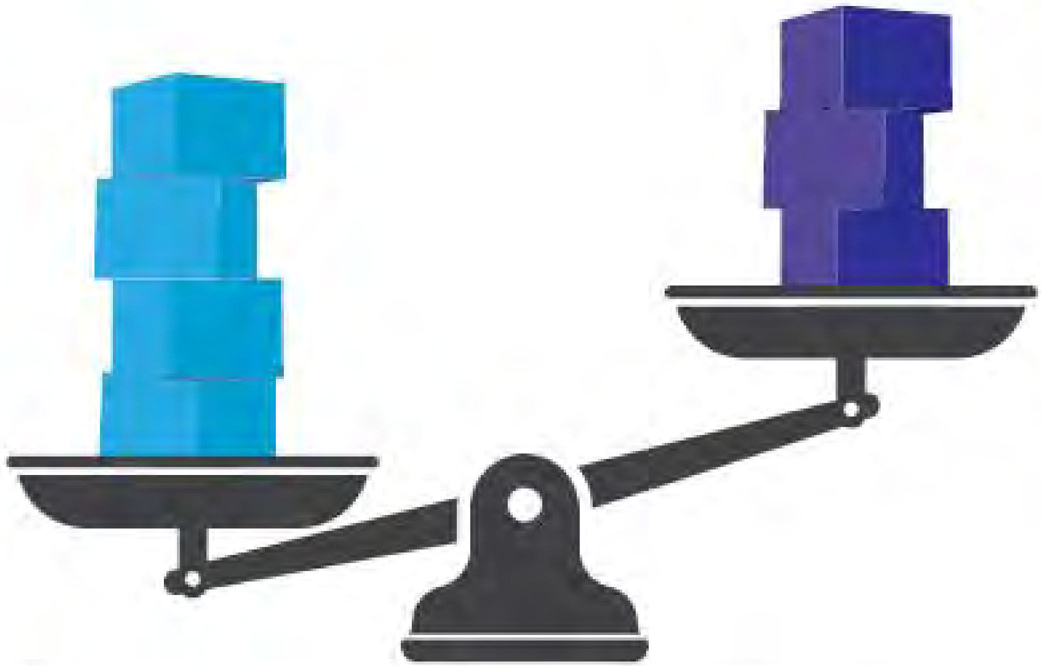
Why Evaluate Thermal Drying



Pros

Volume Reduction (70%-85%)
Class A Beneficial Reuse
Less Odorous Product
Reduces Truck Traffic

Cons

Energy Consumption
Safety Concerns
Capital Investment

Agenda

Drying and Energy Use

Planning Considerations

Case Studies

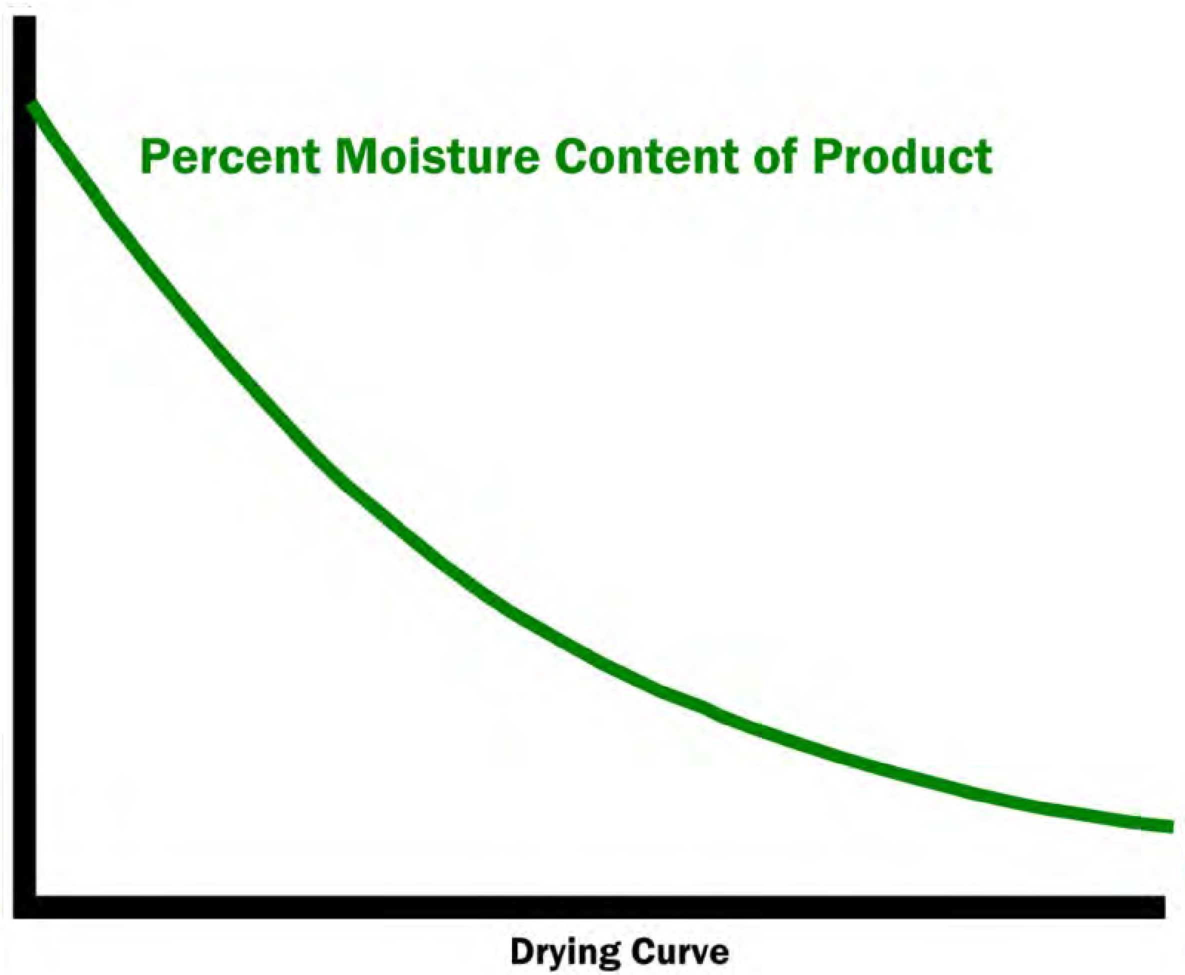
Gas/Energy Consumption

Water Evaporation

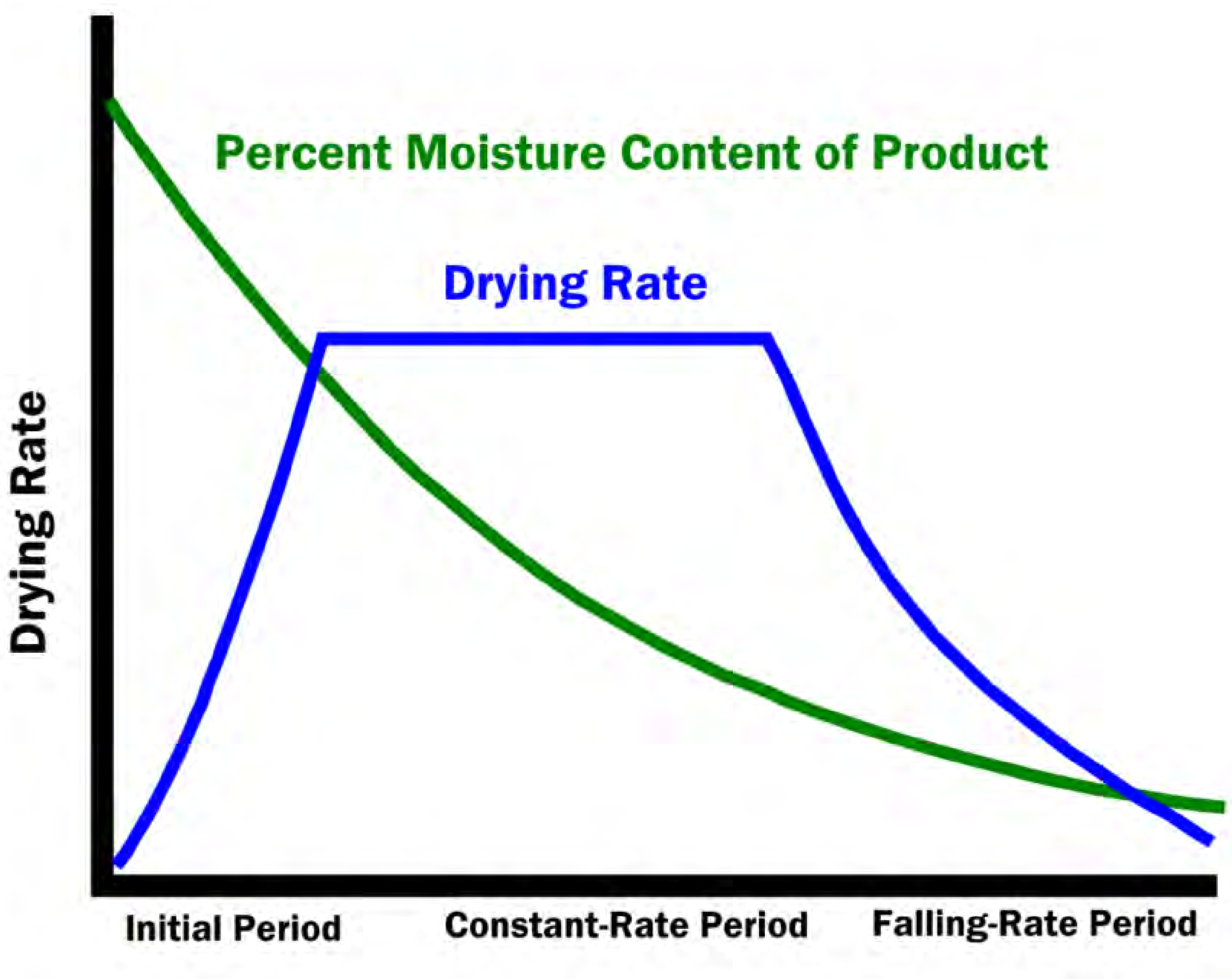
Theoretical: 960 Btu/lb of water

Actual: 1,300-1,600 Btu/lb of water

Dryer Curve

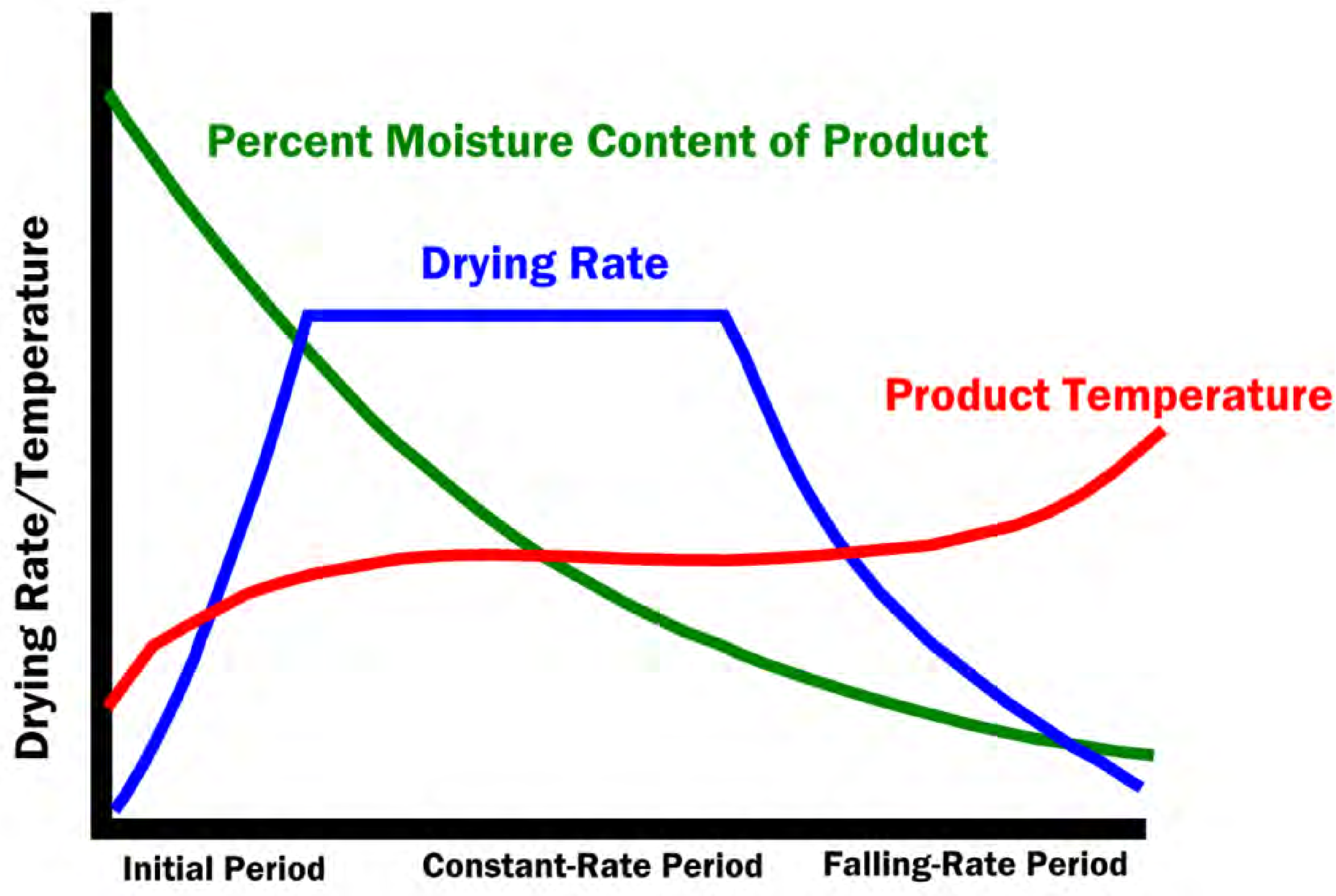


Dryer Curve



Percent Moisture Content of Product
Drying Rate
Drying Rate
Initial Period
Constant-Rate Period
Falling-Rate Period

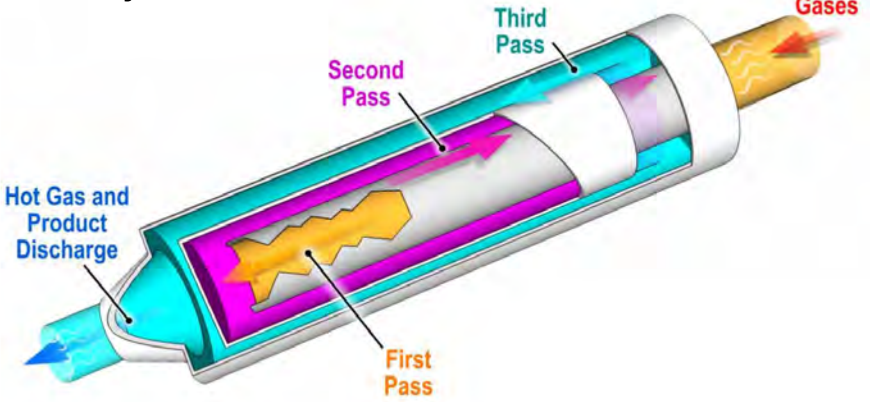
Dryer Curve


Percent Moisture Content of Product
Drying Rate
Product Temperature
Drying Rate/Temperature
Initial Period
Constant-Rate Period
Falling-Rate Period

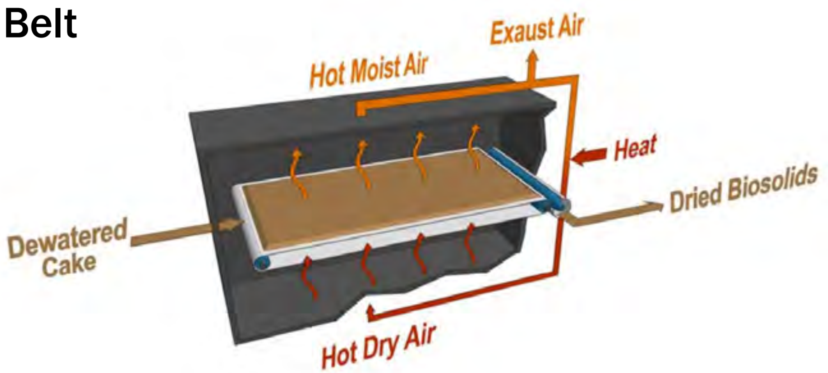
Heat Transfer Mechanisms (to Product)

Convection

Rotary Drum



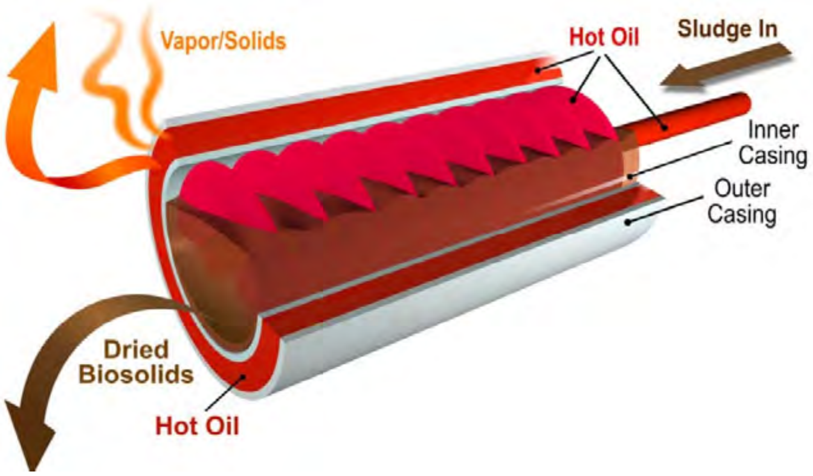
Belt



Heat Transfer Mechanisms (to Product)

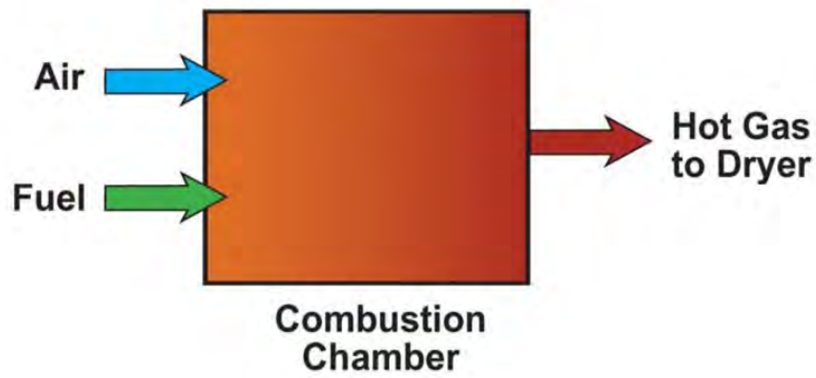
Conduction

Contact (Paddle)

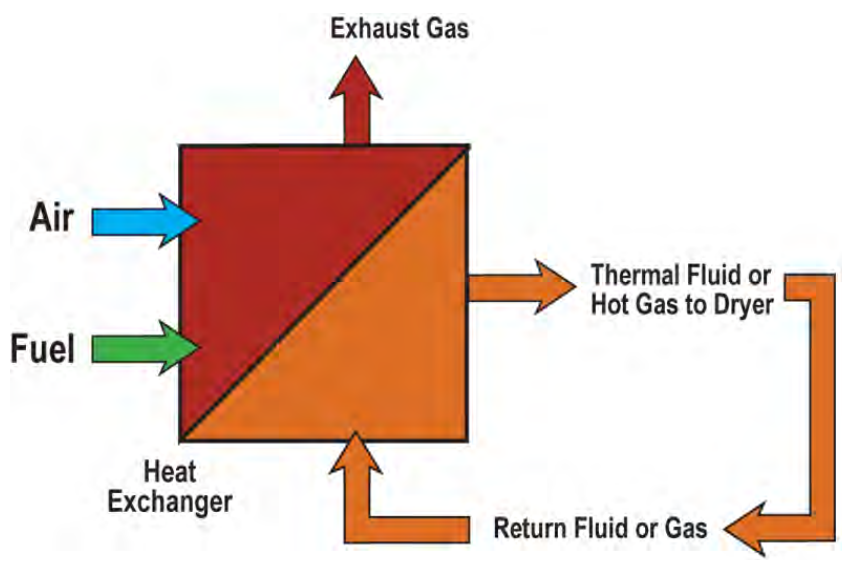


Heat Transfer Mechanisms (to Medium)

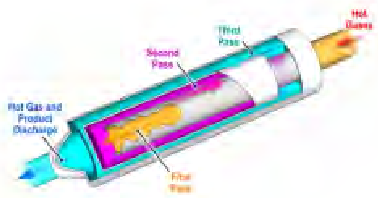
Direct

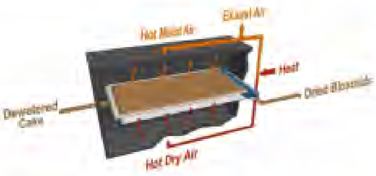


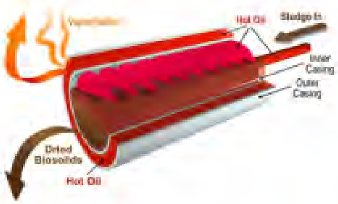
Indirect



Dryer Technology Comparison







	Rotary Drum	Belt	Contact (Paddle)
Heating Medium	Flue Gas: 650 - 1,100°F	Hot Water or Air: 190 - 300 °F	Thermal Oil: 430 °F Steam: <290 psi
Typ. Thermal Efficiency	1,200 - 1,600 BTU per lb H2O evap. per hour	1,300 - 1,700 BTU per lb H2O evap. per hour*	1,400 - 1,600 BTU per lb H2O evap. per hour
Typ. Min. Throughput	4,000 lb H2O evap. per hour (15 dtpd @ 24/7 w 24%TS Feed)	1,000 lb H2O evap. per hour (4 dtpd @ 24/7 w 24%TS Feed)	70 lb H2O evap. per hour (3 dtpd @ 24/7 w 24%TS Feed)
Product Diameter	Pellet: 2 - 4 mm	Granule: 1 - 8 mm	Granule: 0 - 15 mm

Upstream and Downstream Process Impacts

Theoretical Energy Balance – 10 DTPD, 1.5k Btu/lb, 25%TS

	Energy Demand	Useful Recovered Energy		Net Energy Balance	
Dryer (Standalone)	- 3.6	-	=	- 3.6	MMBtu/hr
Anaerobic Digestion + Dryer	- 2.7 (- 0.8 - 1.9)	+ 3.5	=	+ 0.8	MMBtu/hr
Dryer + High-Temp Ther. Proc.	- 3.6	+ 1.6*	=	- 2.0	MMBtu/hr

** Based on lab-scale and initial demonstration scale results from biosolids pyrolysis*

Energy Content of Solids

~8,000 Btu/lb

Combustion Risk

- Oxygen
- Ignition Source
- Combustible Dust

O_2

Critical Temperatures	Degrees F
Temperature at which self heating can occur	±122
Dust layer ignition temperature	320-700
Dust cloud ignition temperature	680-1,020

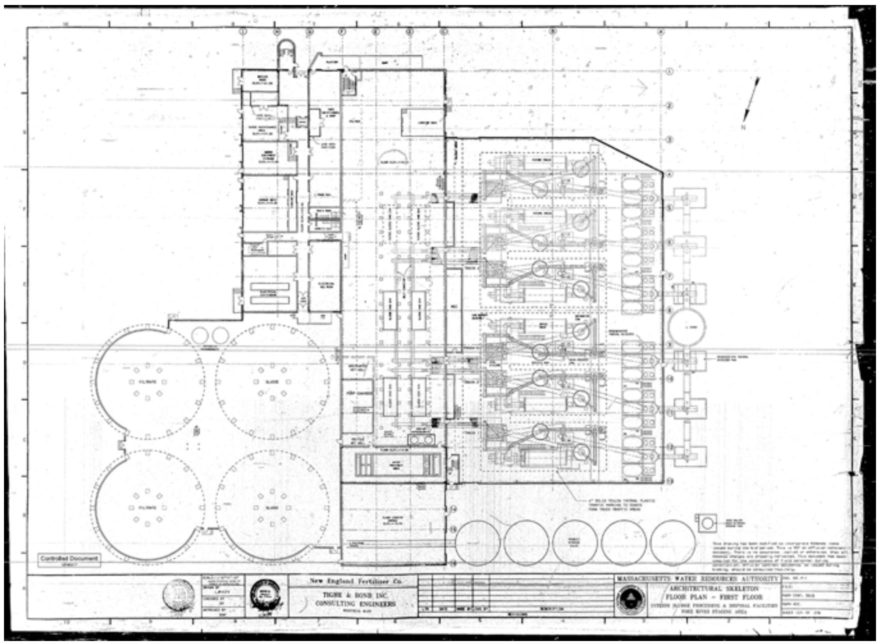
Source: UK HSE

Combustion and Explosion Mitigation Measures

- Temperature monitoring
- CO monitoring
- Nitrogen blanket
- Sprinklers
- Explosion panels

Dust Hazard Analysis is now an OSHA enforceable requirement!

Case Study: MWRA Fore River Plant

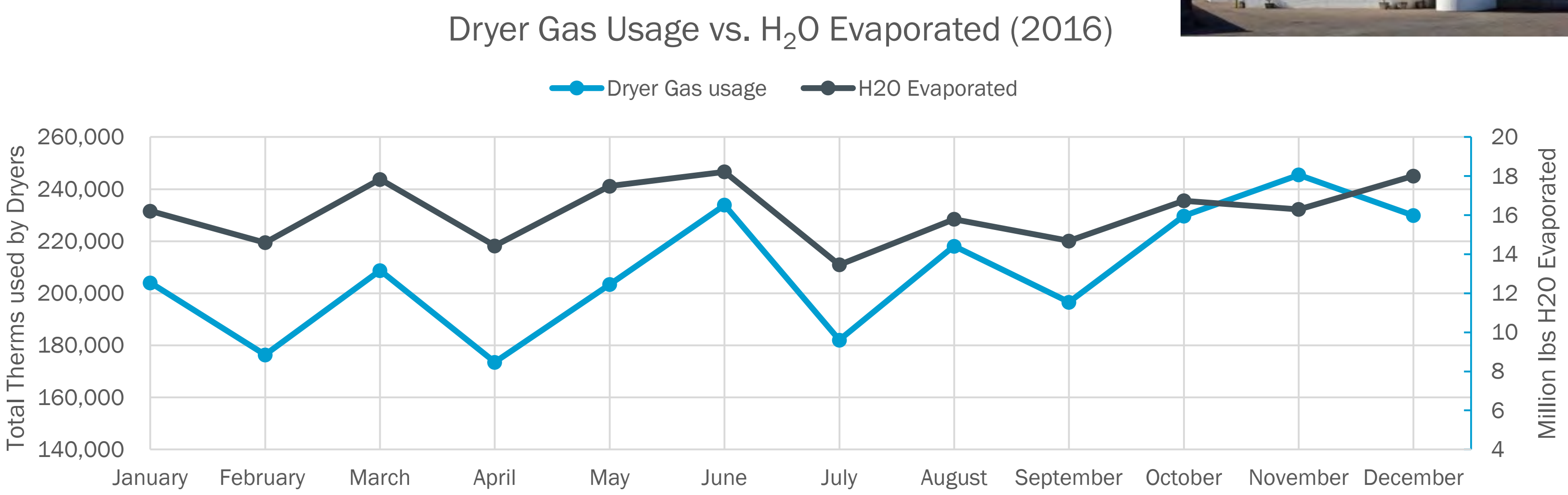


(6) 30 DTPD Drum Dryers

- (4) Installed in 1991, (2) in 2001
- AA = 100 to 110 DTPD

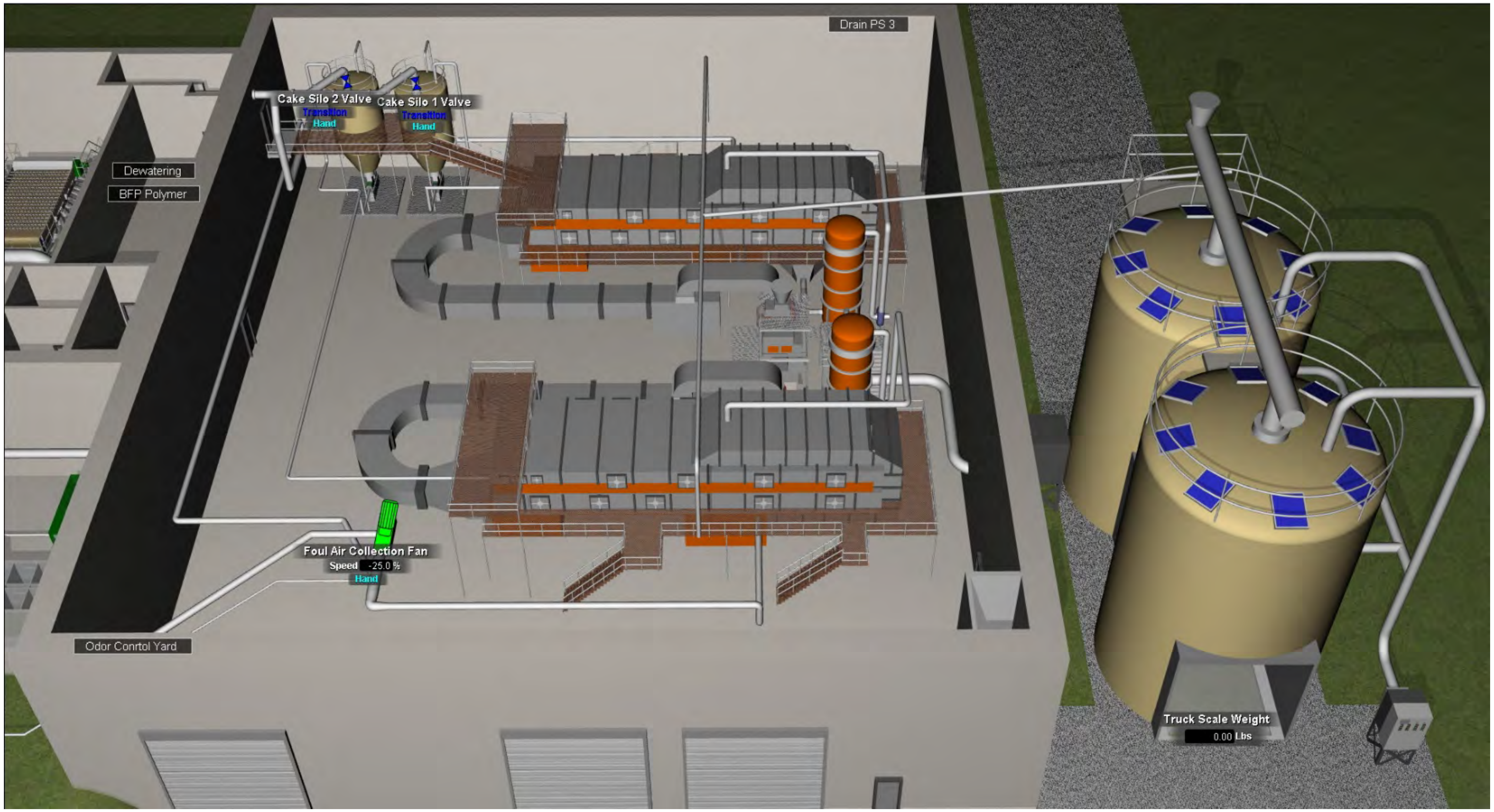
Case Study: MWRA Fore River Plant

- Evaluated thermal efficiency as part of a long-term planning exercise



- AA (2016) = 1,293 Btu/lb H_2O evaporated vs Design Rating = 1,302 Btu/lb H_2O evaporated
- 10% more efficient than similar US facility

Case Study: Town of Cary, NC



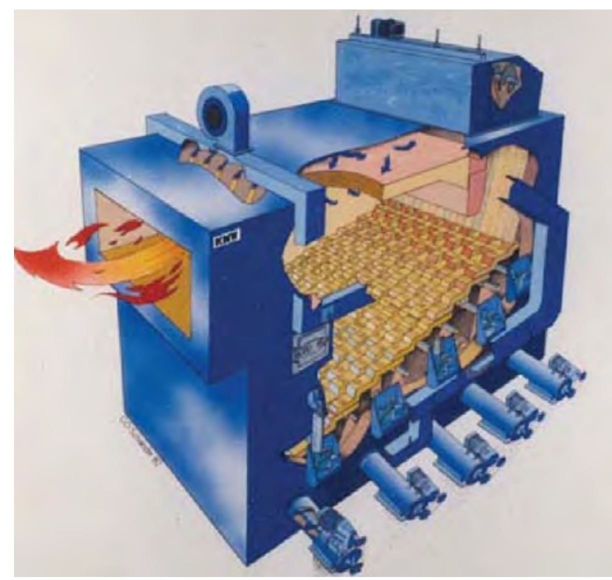
(2) 10 DTPD Belt Dryers

- (2) 65 CY Cake Silos (2d)
- (2) 300 CY Product Silos (21d)

Case Study: Town of Cary, NC

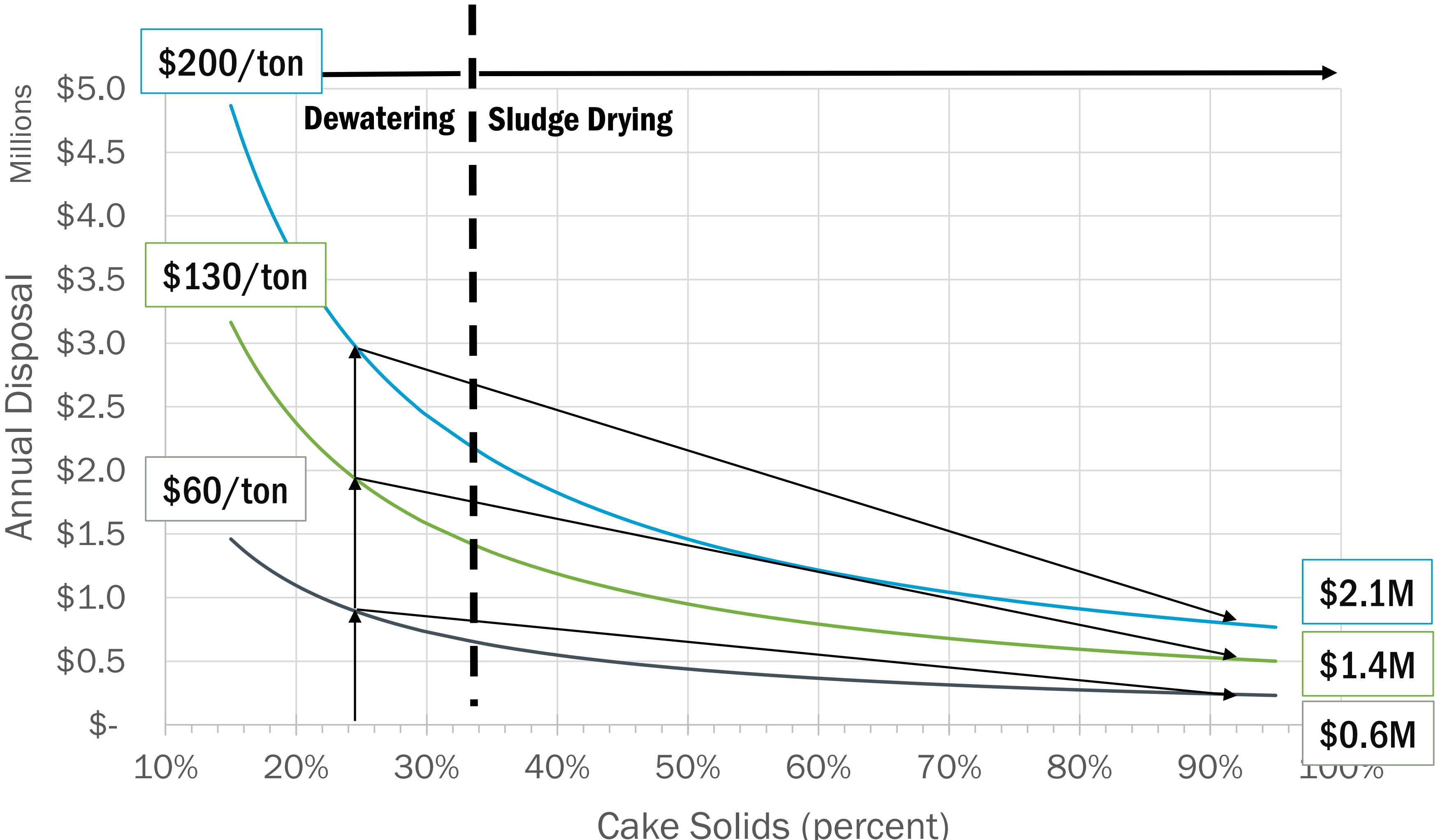
- Later work successfully permitted Class A product as a non-waste fuel under USEPA (40 CFR)
- Provides future flexibility to retrofit with product furnace to fuel dryer

- First energy recovery furnace deployed in Buffalo, MN
  - Operational hours: 4,160 hrs per year (~50% uptime)



Dryer Economics – Gross Savings

10 Dry Tons Sludge per Day



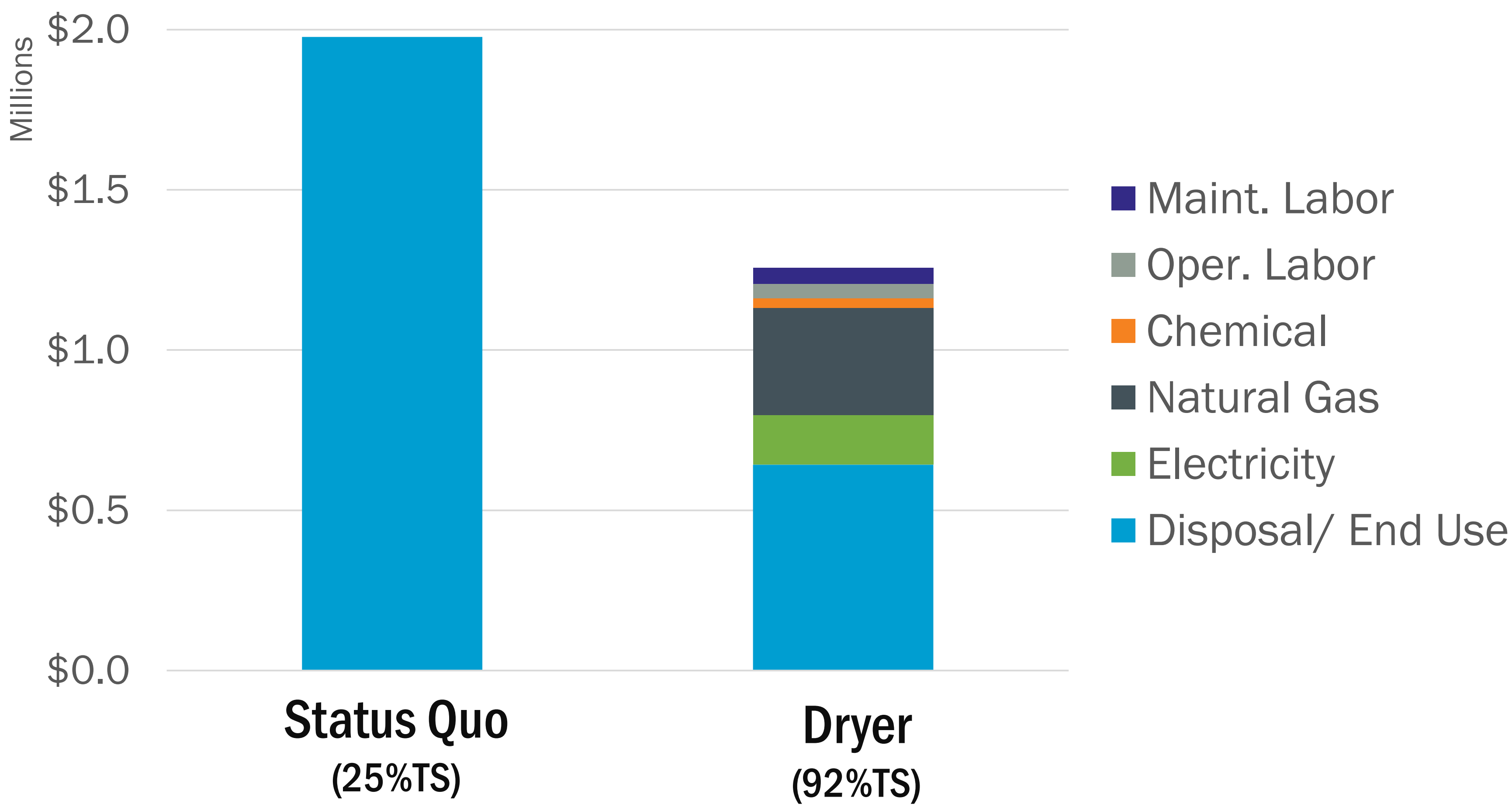
Additional Utility Inputs

	Cake Feed	Dryer	Exhaust Treatment	Storage	Loadout
Power	X	X	X	X	X
Gas		X	x		x
Water	x		x	x	
Chemicals	x	x	x	x	x

X = Required x = Potential

Dryer Economics – Net Savings

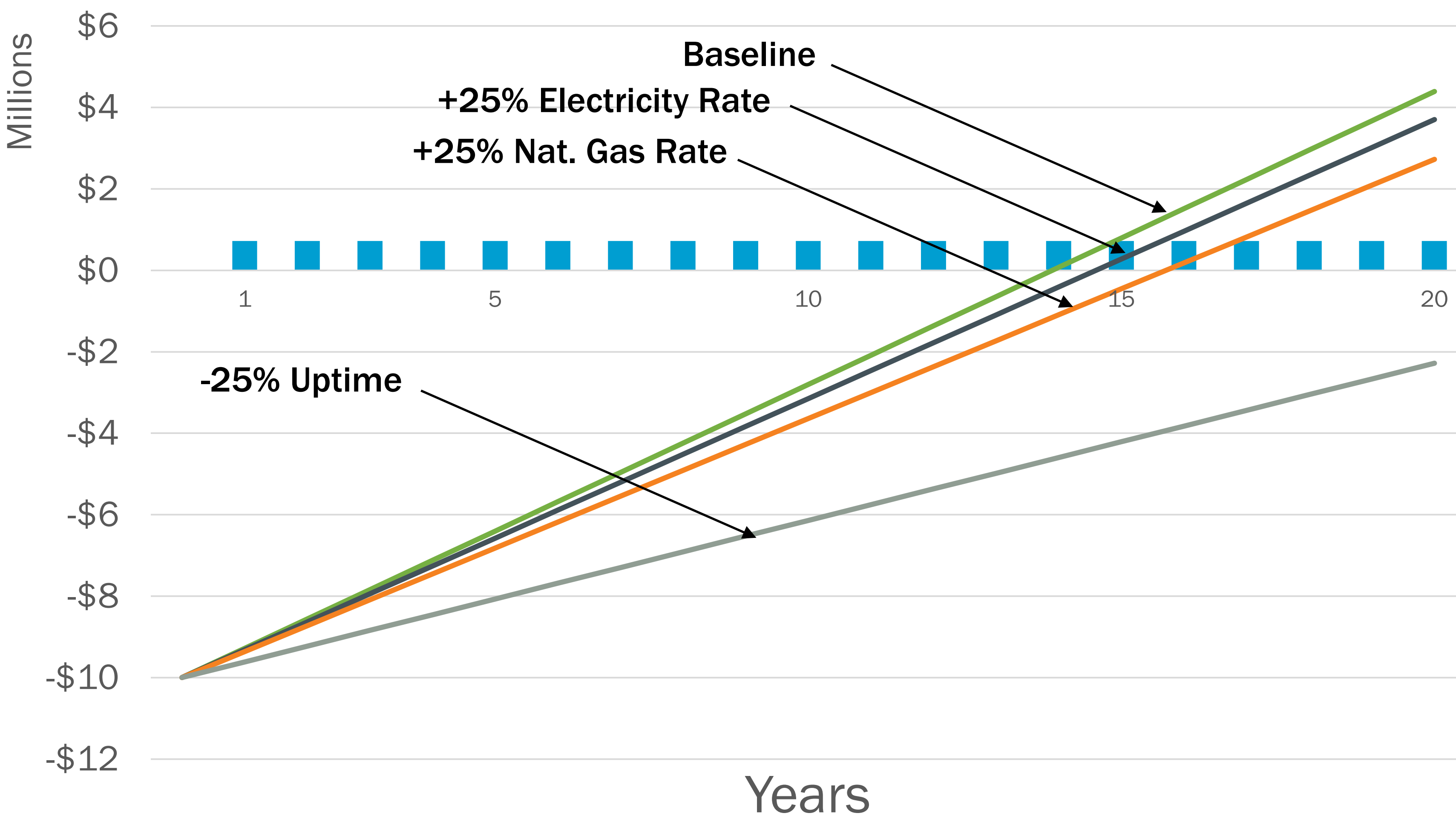
10 Dry Tons Sludge per Day @ $130/ton



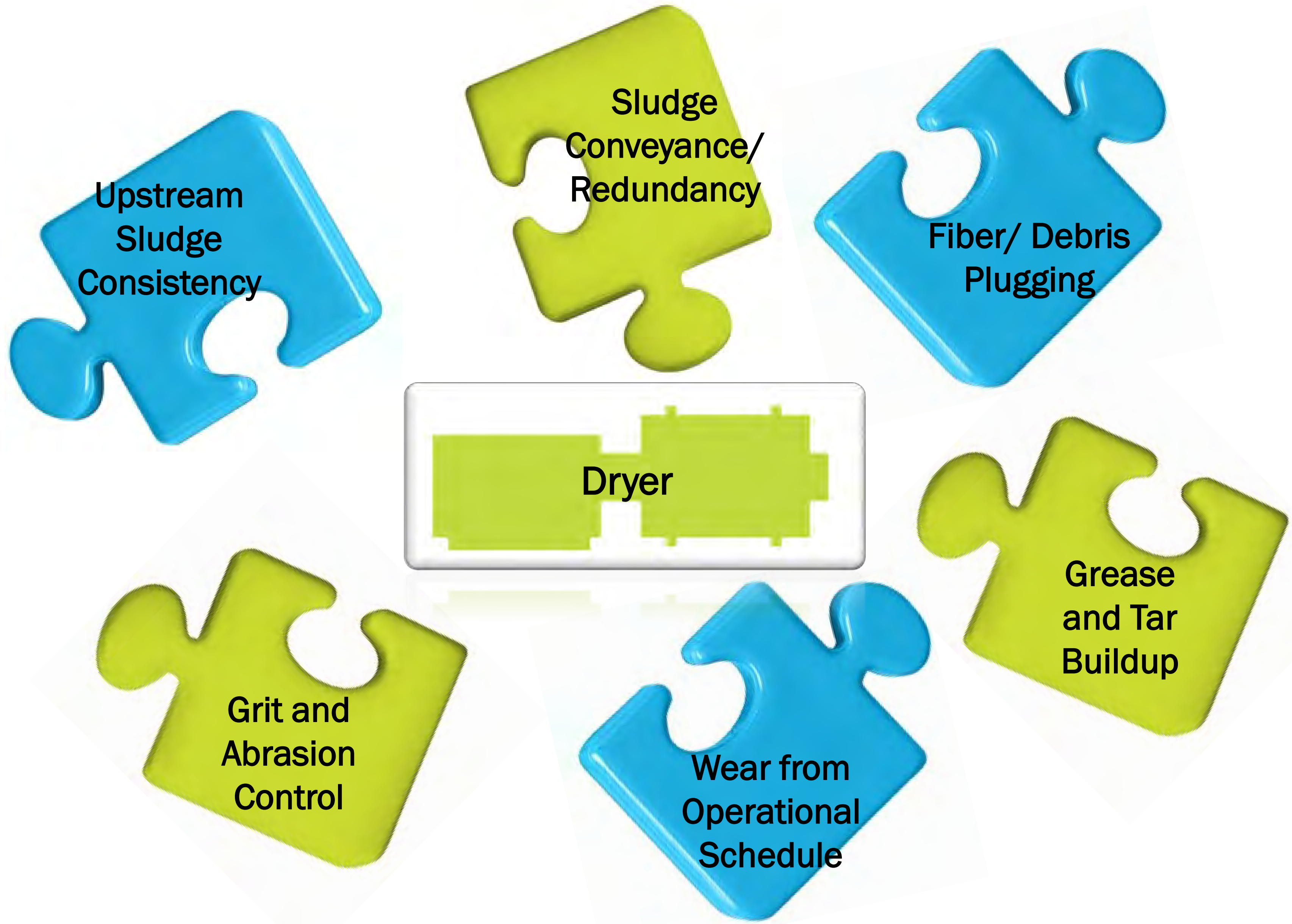
- Assumes: $0.10/kWh ($14/kW demand), $12/MMBtu, $45/hr labor

Simple Payback Sensitivity

10 Dry Tons Sludge per Day @ $130/ton

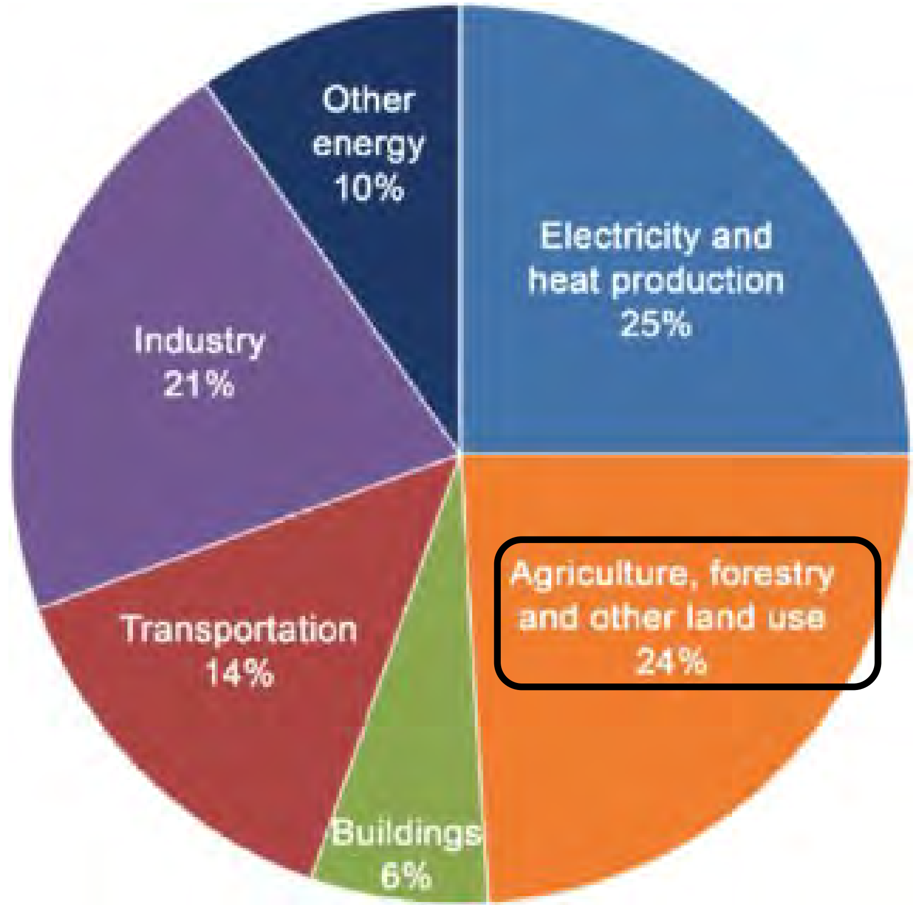


Putting the Pieces Together to Maintain Uptime



Future Trends

Global GHG Emissions



Source: IPCC (2014)

Take Home

Dryers differ in operation, but upstream and downstream processing impacts energy efficiency most

Dryers are energy hogs, but its solids disposal that drives economics

Sensitivity of utility costs is incremental compared to uptime

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Thank you.

Questions?

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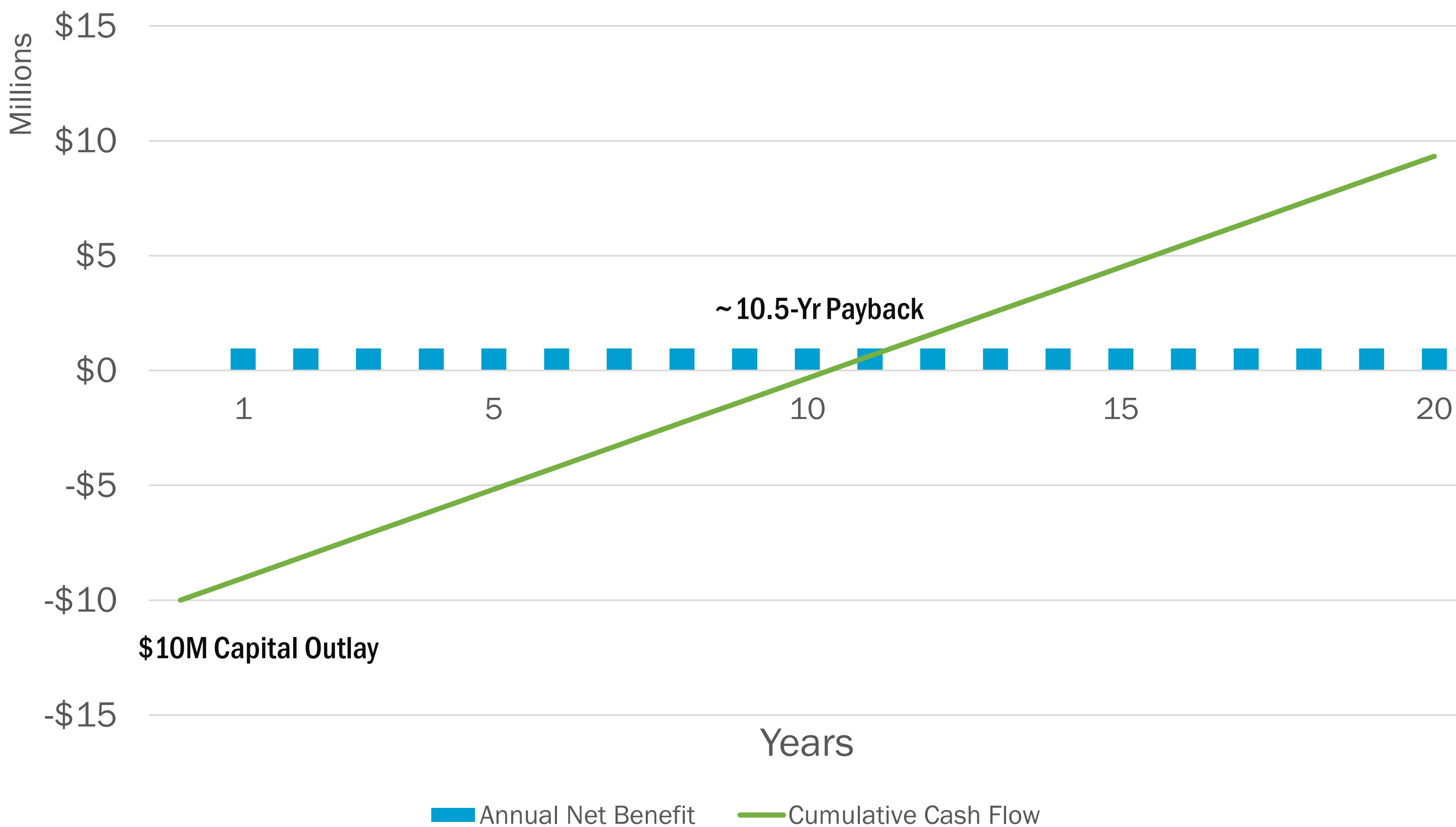
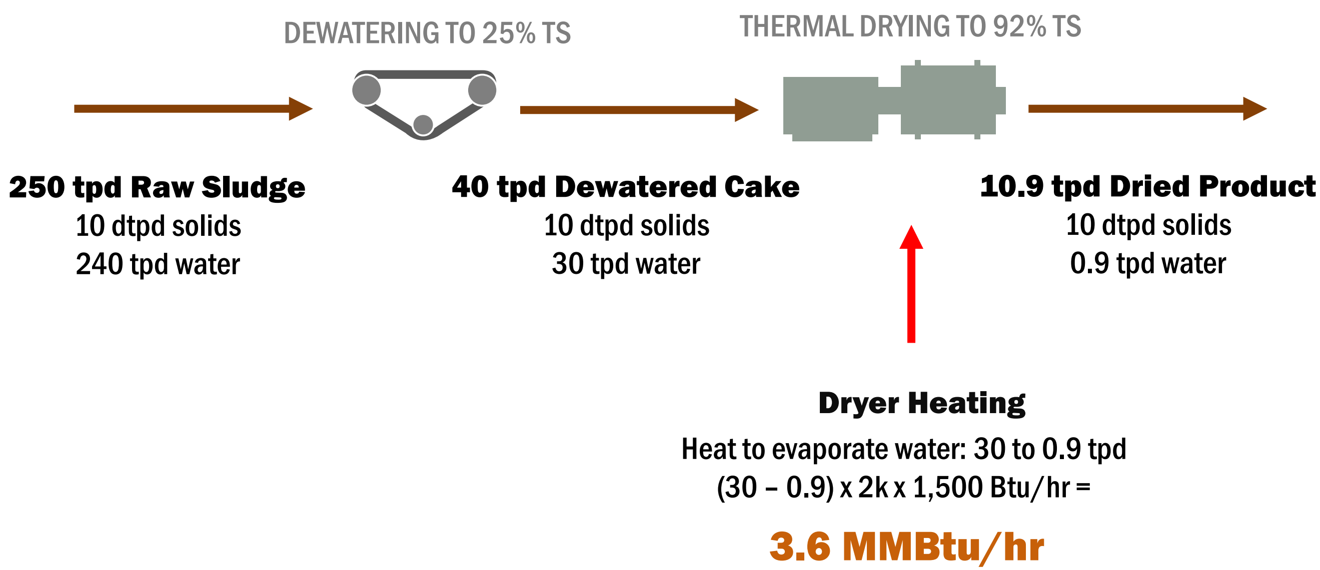
Example Simple Payback



Theoretical Energy Balance

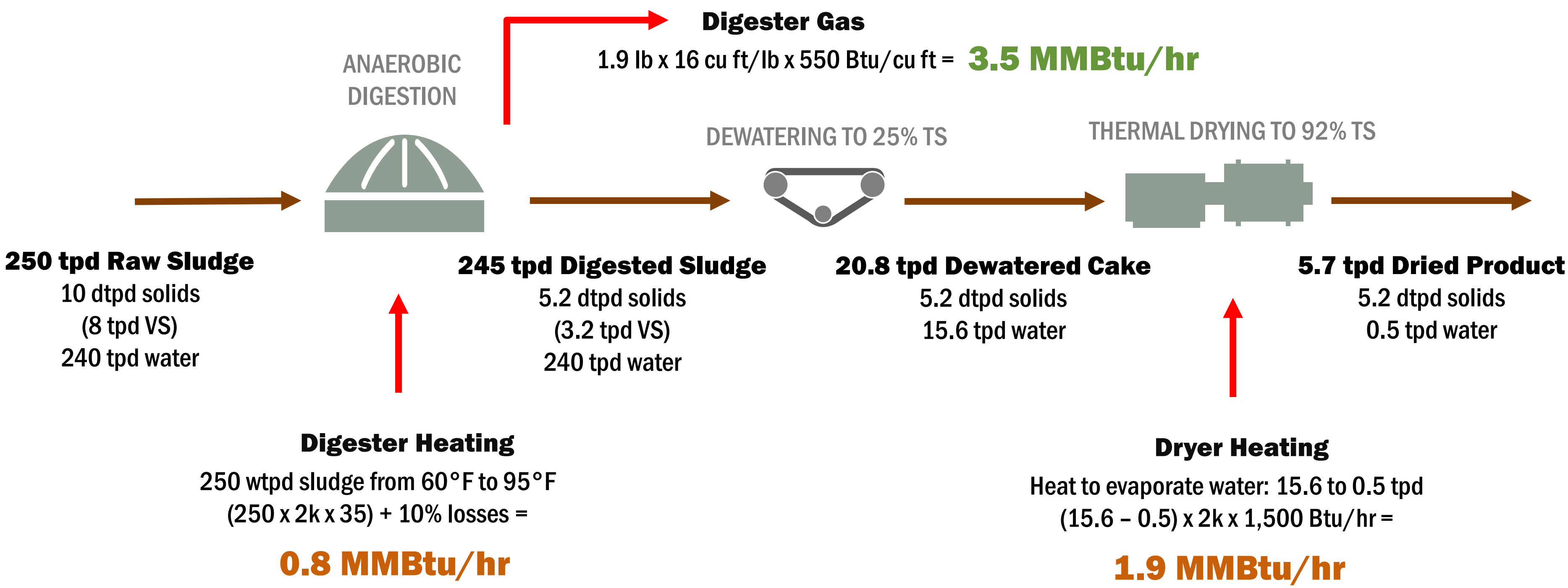
10 Dry Tons Sludge per Day @ 4% TS



- Assumes:
    - Dryer evaporation rate: 1,500 Btu/lb water

Theoretical Energy Balance w/ Digestion

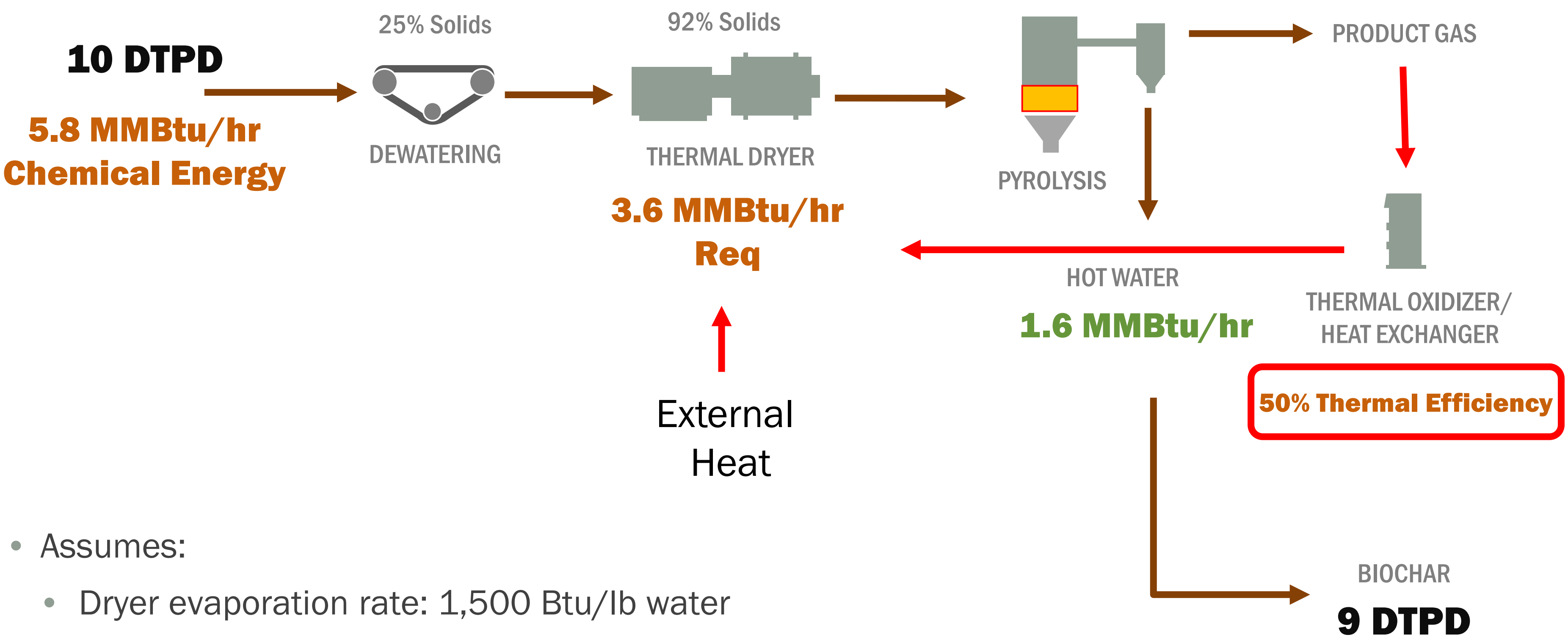
10 Dry Tons Sludge per Day @ 4% TS, 60°F, 80% VS



- Assumes:
  - Digestion VSR: 60%, DG generation: 16 cu ft/lb VS, DG Heat Content: 550 Btu/ cu ft
  - Dryer evaporation rate: 1,500 Btu/lb water

Theoretical Energy Balance w/ Ther. Proc.

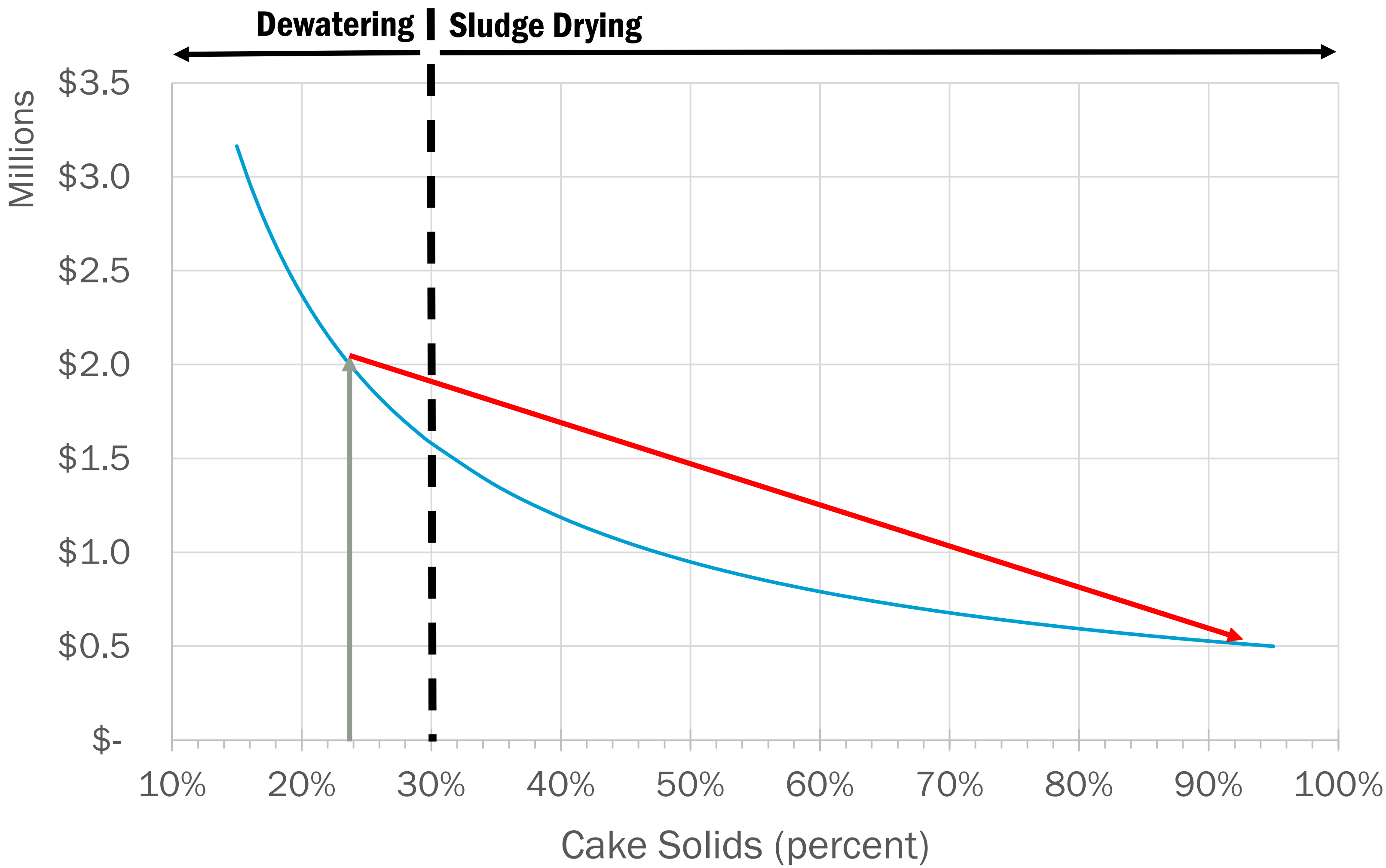
10 Dry Tons Sludge per Day @ 7,000 Btu/lb



- Assumes:
  - Dryer evaporation rate: 1,500 Btu/lb water

Annual Disposal Costs (Recent NYS WRF)

10 Dry Tons Sludge per Day @ $130/ton



Example Simple Payback Sensitivity