A Household Sanitation Process Based on Integrated Diversion/Dewatering, Drying/Smoldering of Solid Waste, and Pasteurization of Liquid Waste

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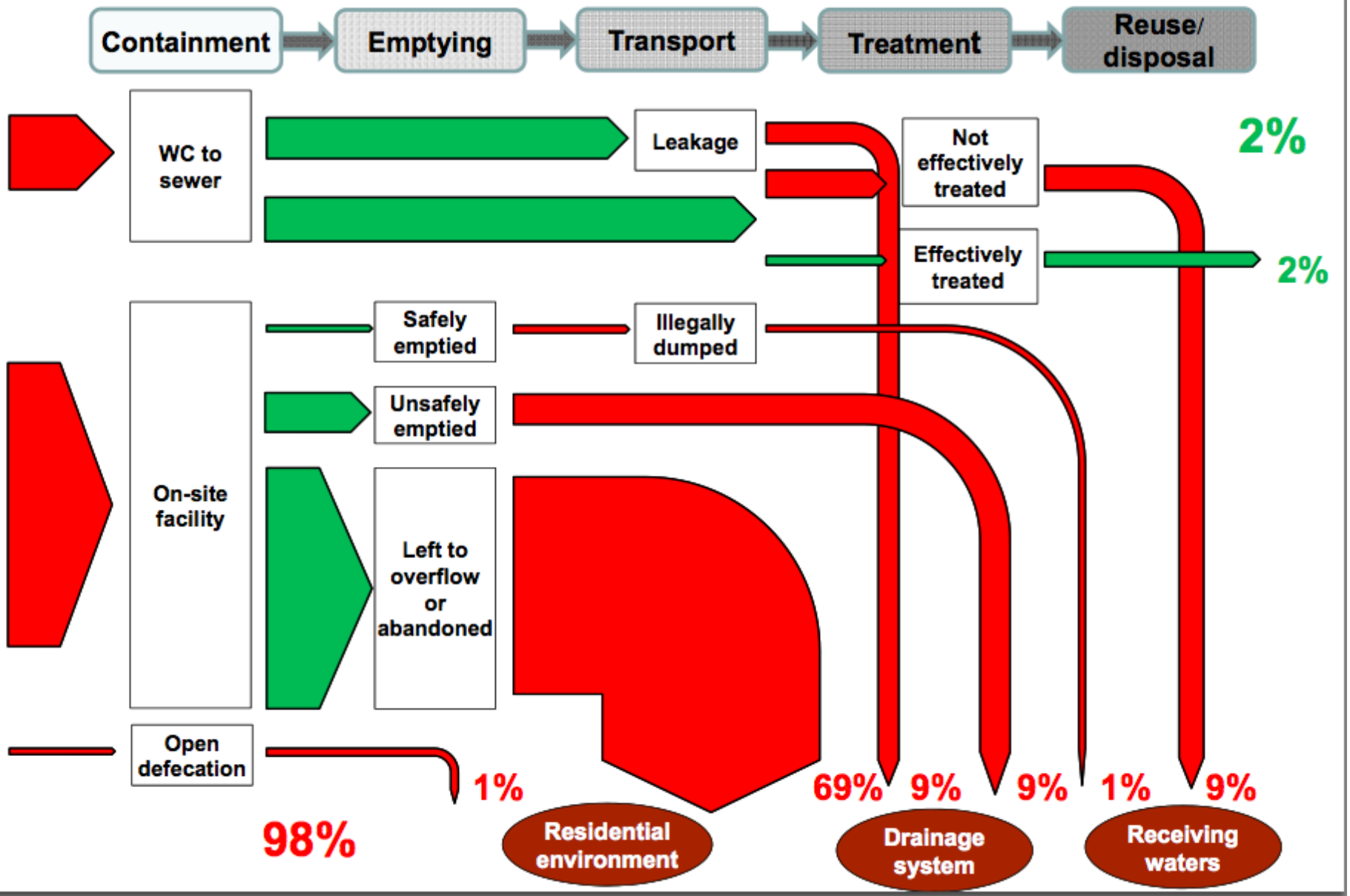
Poor FSM: Institutional Open Defecation

Sludge direct to the environment: no service chain



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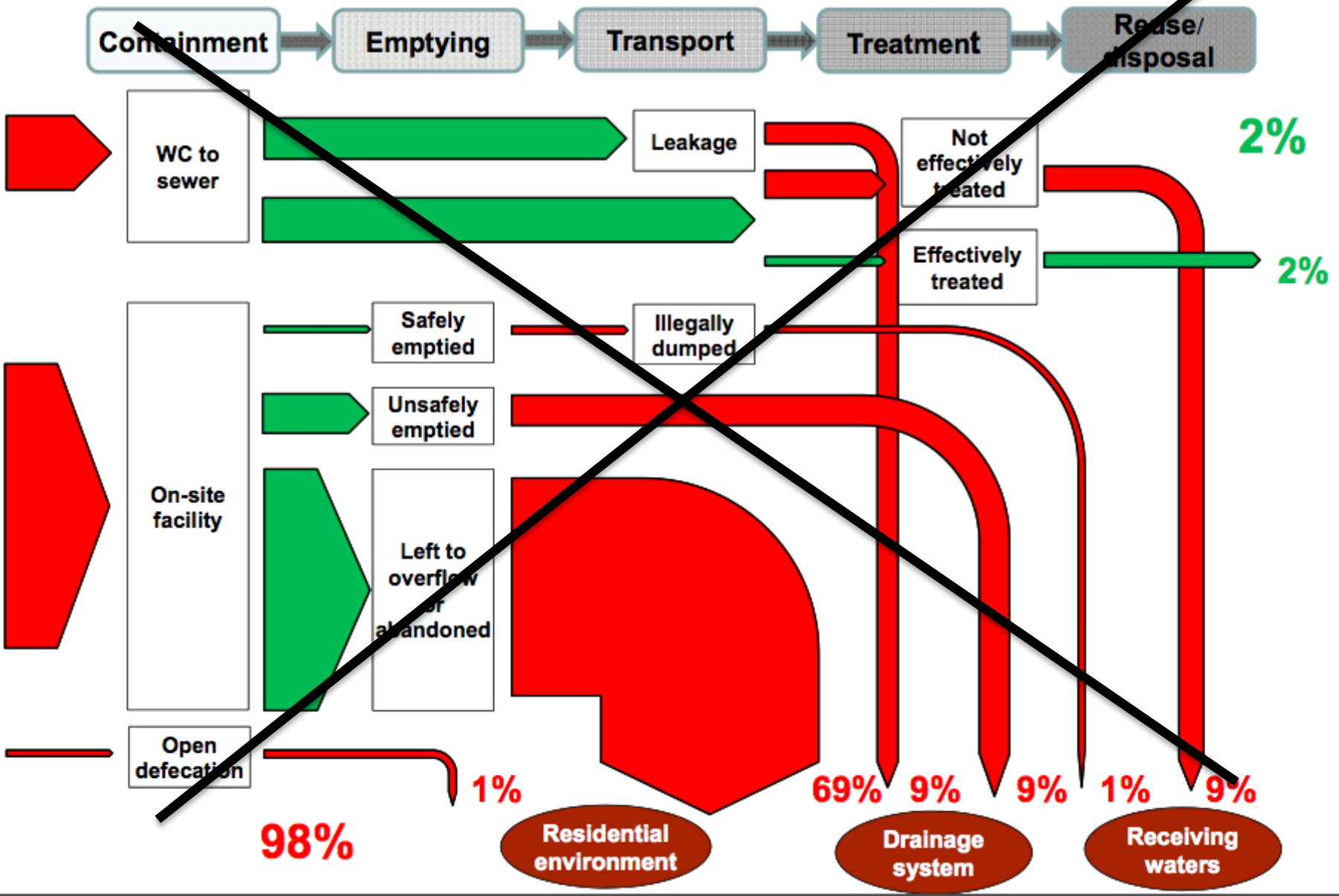
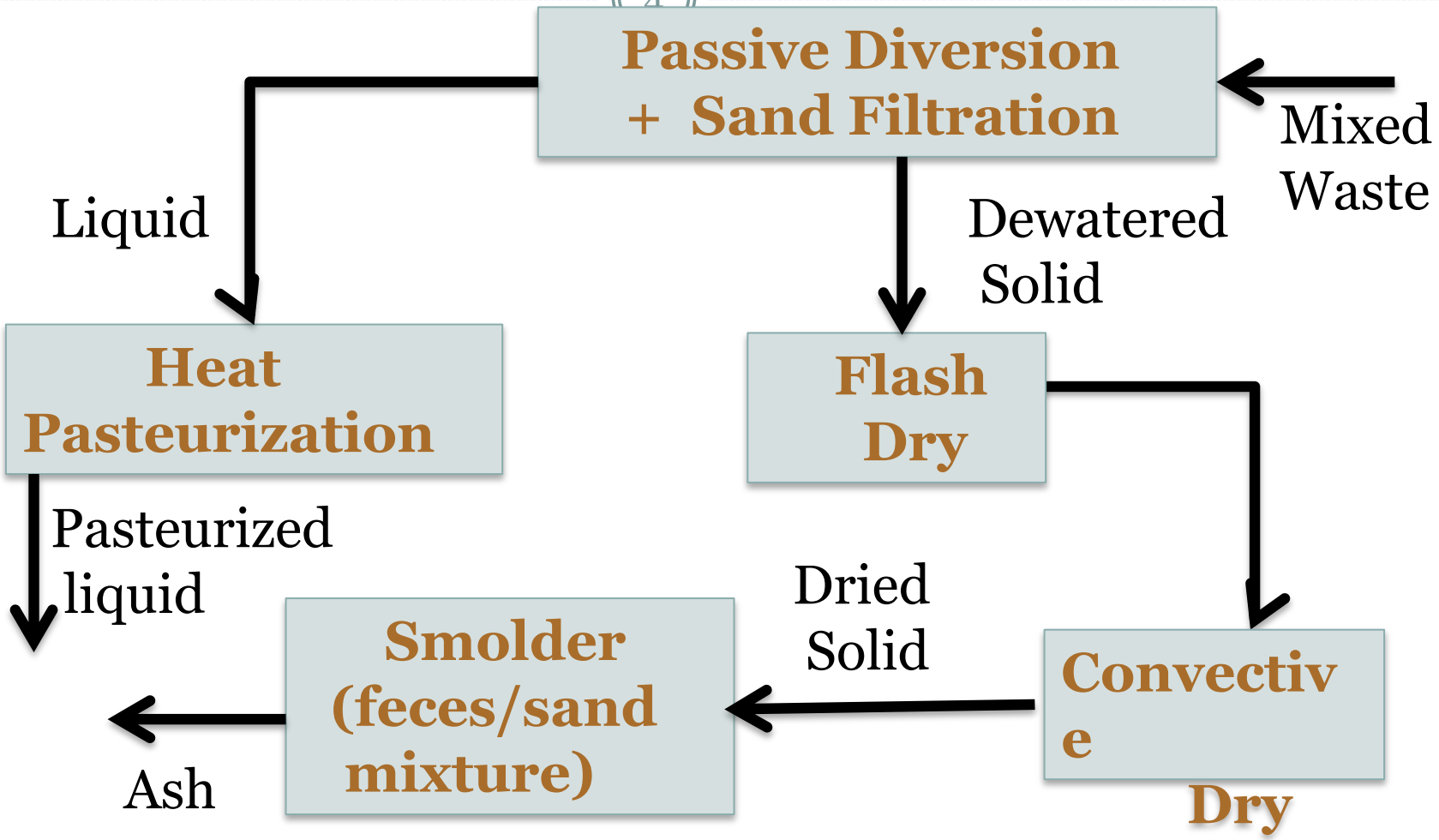


Process Overview
1 day batch/10 person scale



Video: ttps://www.youtube.com/watch?v=-J2App5OrXI

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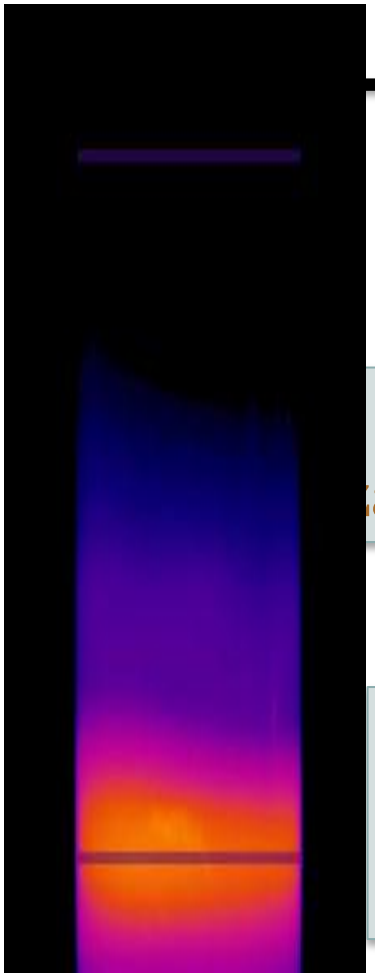

Passive Diversion + Sand Filtration

Mixed Waste

Dewatered Solid

Flash Dry

Convectiv e Dry

Dried Solid

Smolder (feces/sand mixture)

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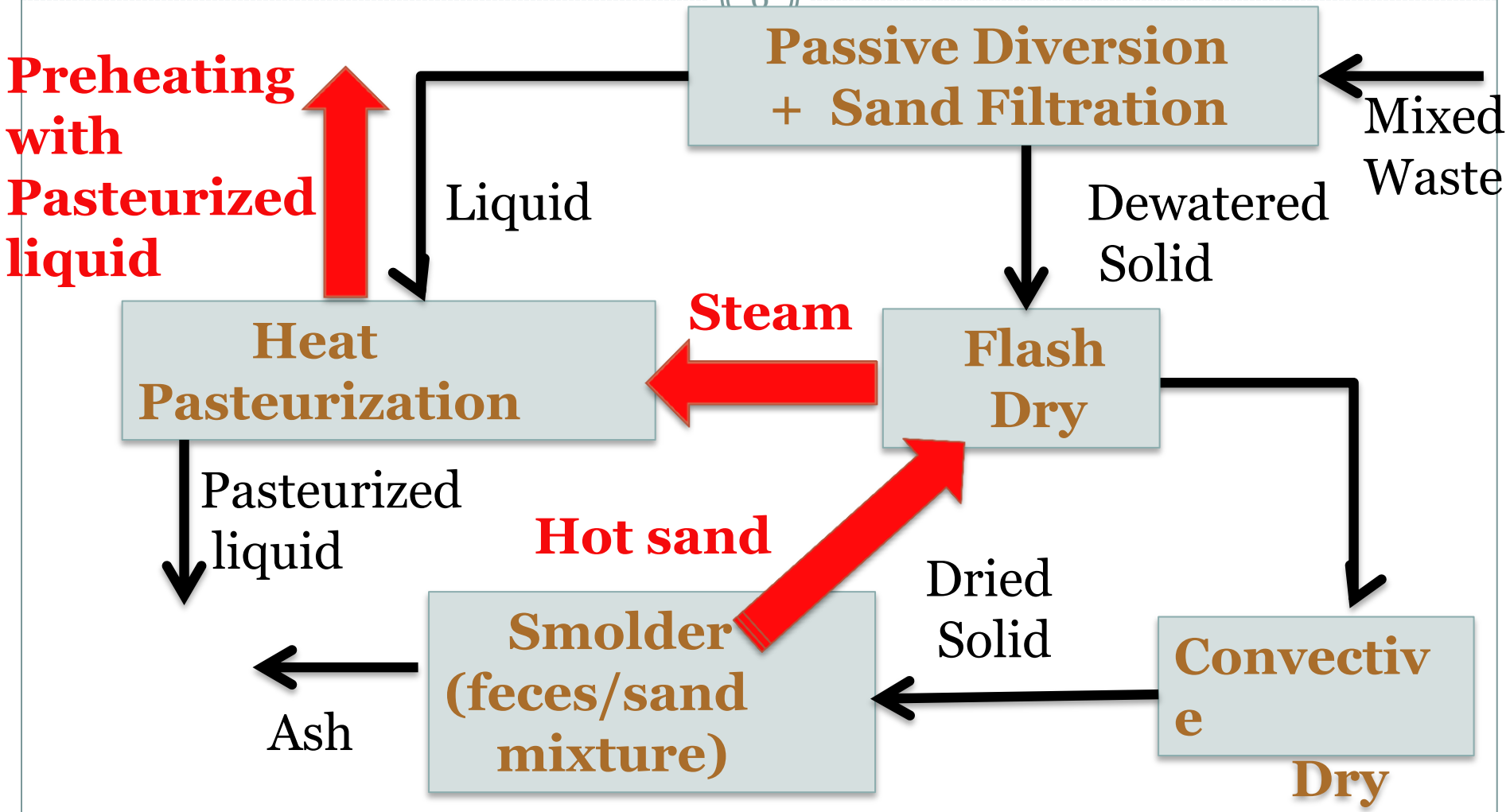
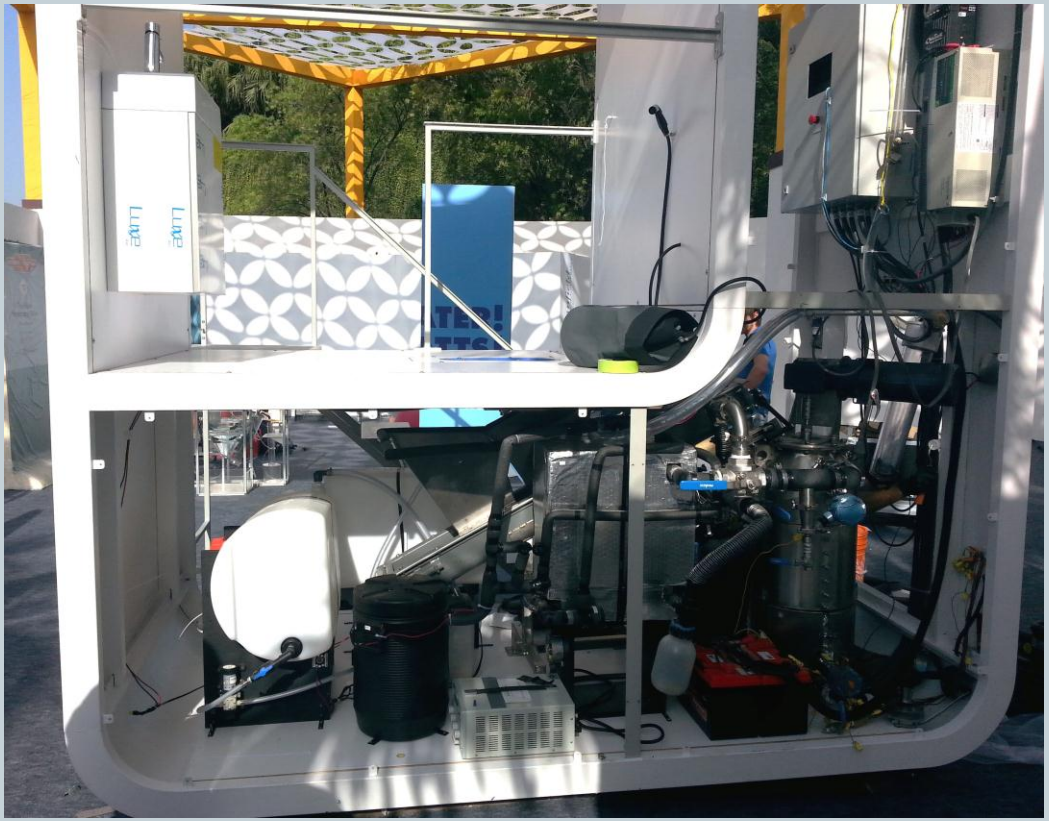
Process Overview: Energy Use



Delhi Prototype

- Fully integrated
- Many single day and multi-day cycles run successfully
- Energy use ~ 4 MJ per day
  - **1.6 MJ for daily ignition**
  - **1.4 MJ for convective drying**



Lessons Learned

What we liked

- Smoldering
  - Robust operating window
  - Controllable rates
  - Sand as thermal battery
- Efficient use of residual heat in smoldered sand
  - Flash dry
  - Condense in kill tank
  - Pre-heating via counter current heat exchanger
- Flash drying - fast
- Modified Sato pan diversion

What we wanted to improve

- Remove daily ignition in batch process
- Remove convective drying
  - Energy intensive; and uses electricity instead of heat
  - Ambient condition dependent
- Mixer in the reactor
  - Reduces smoldering operating window
- Size and cost

Dewatering/Drying : Removing convective drying requirement

	Total water/fuel	Free water/fuel
Healthy feces	3:1	0
Smoldering target	1:1	
Input	50:1	47:1
Delhi Prototype		
Dewatered solids	~ 4:1	~ 1:1 (~98% free water removed)
Drying requirement	**3:1**	
Optimal dewatering		
Dewatered solids	3:1	0
Drying requirement	**2:1**	

Flash AND convective drying

Flash drying would be enough

Since Delhi Toilet Fair

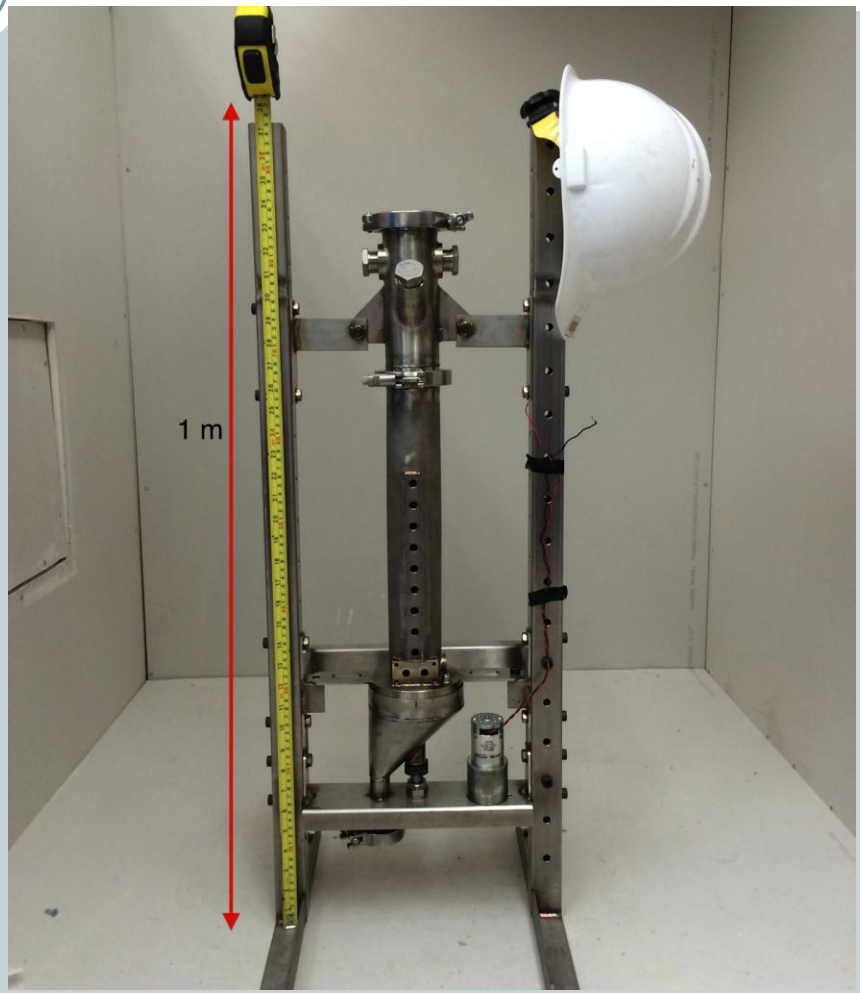
Goals	Progress

• Develop continuous smoldering process
  ○ ↓ ignition energy
  ○ ↓ size, and cost
	• Demonstrated
	  ○ Smaller reactor (6 cm vs 25 cm diameter)
	  ○ Slow fecal destruction rate achieved

• Dewater to ~ 75% MC (~ no residual free water)	• Achieved for “healthy feces” – free flowing free water ○ Working on diarrhea
• Optimize energy management	• In progress

Prototyping Progress and Plans

- All subsystems have been built at least once
  - Continuous reactor multiple times
  - Iterations ongoing
  - Run with surrogate and dog feces
- P1 integrated prototype – March
  - To be tested with human waste
- P2 integrated prototype – July
  - User functionality trials planned near Toronto



If/when all this works:

- Compact system
- Relatively low electricity requirement
  - estimate: < 0.5 MJ per day (< 0.15 kWh per day) for 10 person scale
- Energy management key to making off grid feasible:
  - Capture caloric content of solid waste
  - Design process to make efficient use of generated heat
  - Thus minimize additional energy requirement

Beyond process functionality

- Emissions
- Odor
- Control systems
- Addressing input variability

Thank you