J. ANDREW LANGE, INC.

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Energy Reduction with Thermal Dryers

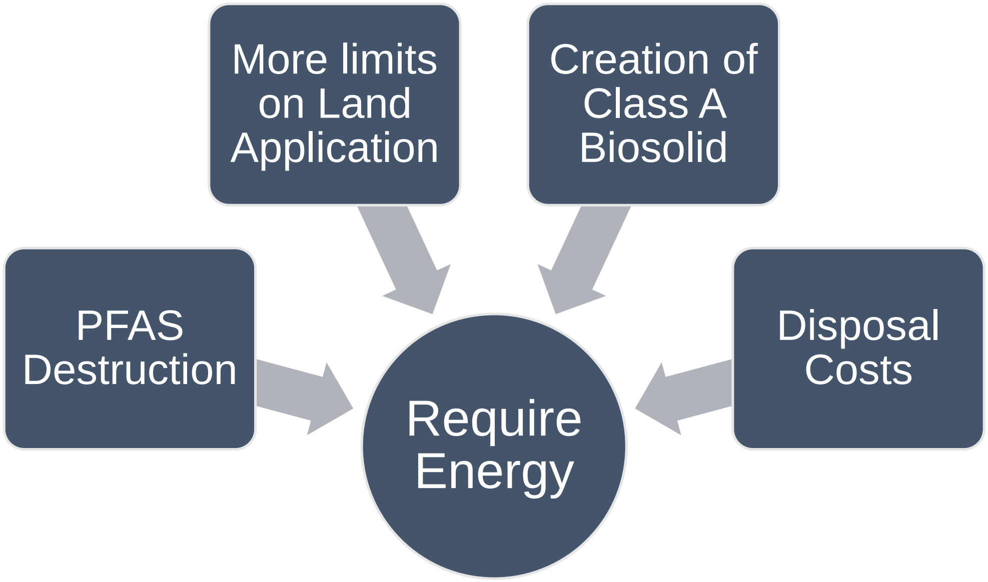
NYWEA/NEWEA Joint Spring Technical Conference

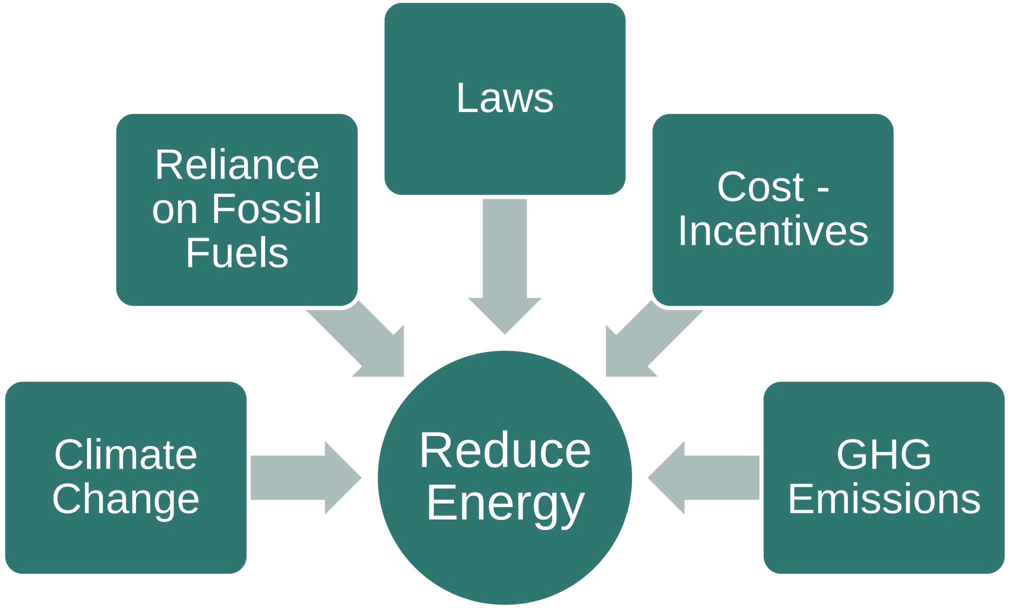
Chip Pless – LCI Corporation

NYWEA
LEADING THE WAY IN WATER QUALITY MANAGEMENT

NEW ENGLAND WATER ENVIRONMENT ASSOCIATION
NEWEA
WORKING FOR WATER QUALITY

Biosolids - Between a Rock and a Hard Place!





Drying Theory

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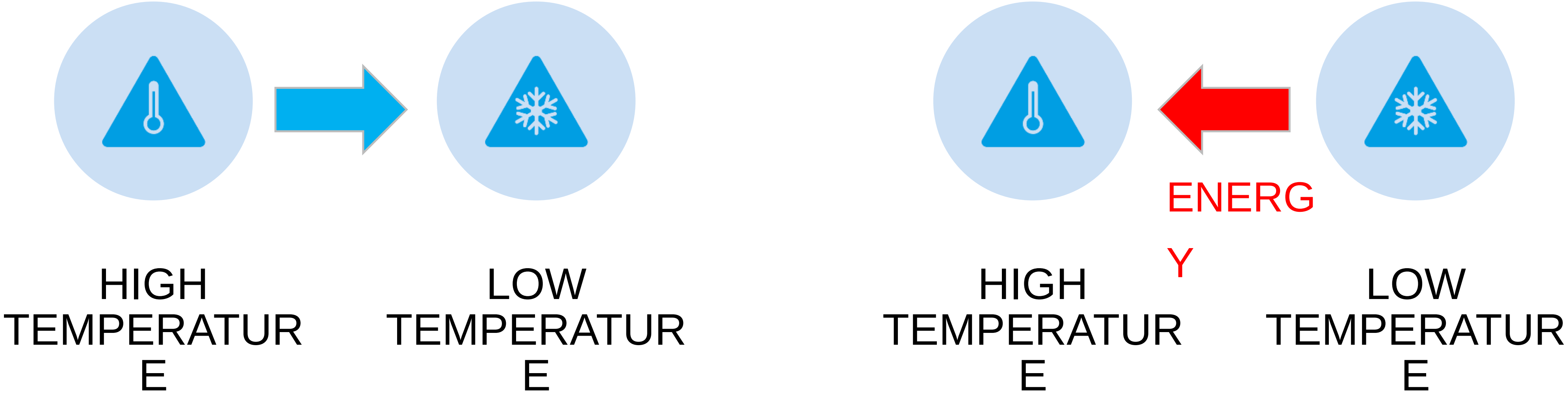
Heat Transfer - What Runs Faster, Hot or Cold? Hot, Everyone Can Catch a Cold!



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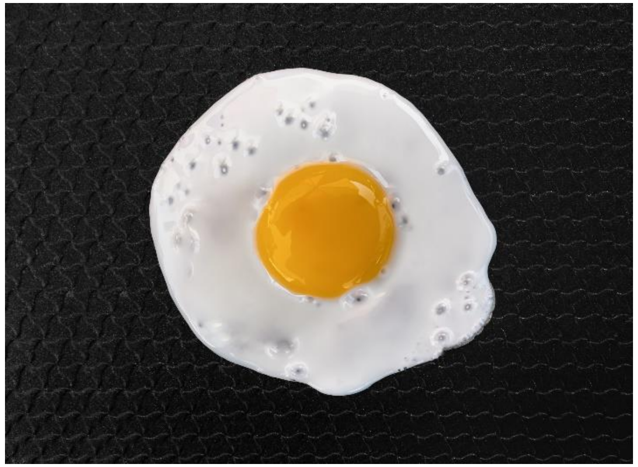
Hungry? Types of Dryers

Convection/Direct – Heated Air

- Belt Dryer
- Drum Dryer (Most)
- Solar/Bio Dryers
- Can Evaporate Below Boiling Temperature
- Less Efficient – Transfer Heat to Air

Conduction/Indirect – Heated Surface

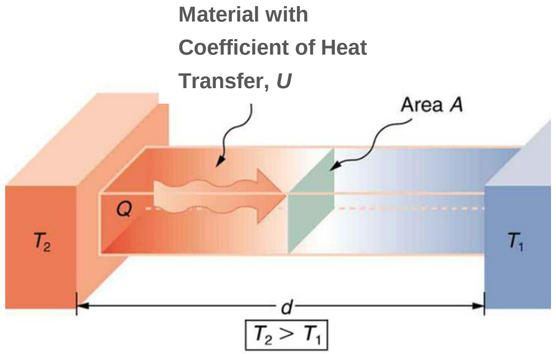
- Paddle/Screw Dryer
- Thin Film Dryer
- Disc Dryer
- Evaporate Above Boiling Temperature
- More Efficient – Transfer Heat to Surface



Indirect Drying Theory – Simple Heat Transfer

- Q=U*(A x ∆T)
  - Q – Heat (W or BTU/hr)
  - U– Coefficient of Heat Transfer [BTU/(hr·ft^2·°F) or W/(m^2·K)] — Fixed
  - A –Heat Transfer Area (ft^{2}or m^2) — Variable – Dryer Size
  - ∆T – Temperature Delta (°F or K or °C) — Variable – Heating Temp

Heating Fluid



Sludge

Image: Heat conduction occurs through any material, represented here rectangular bar, whether window glass or walrus blubber. (Image Credit College Physics)

Heat Transfer
[What is thermal conductivity? (article) | Khan Academy)]

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Indirect Drying Theory - Evaporation

Sensible Heat

- Temperature Increase - $Q=m \times c_p \times \Delta T$
- Specific Heat (c_p)
  - **Water - 1.0 BTU/lb•°F – 80% of Mass**
  - **Solids - 0.34 BTU/lb•°F – 20% of Mass**

Latent Heat

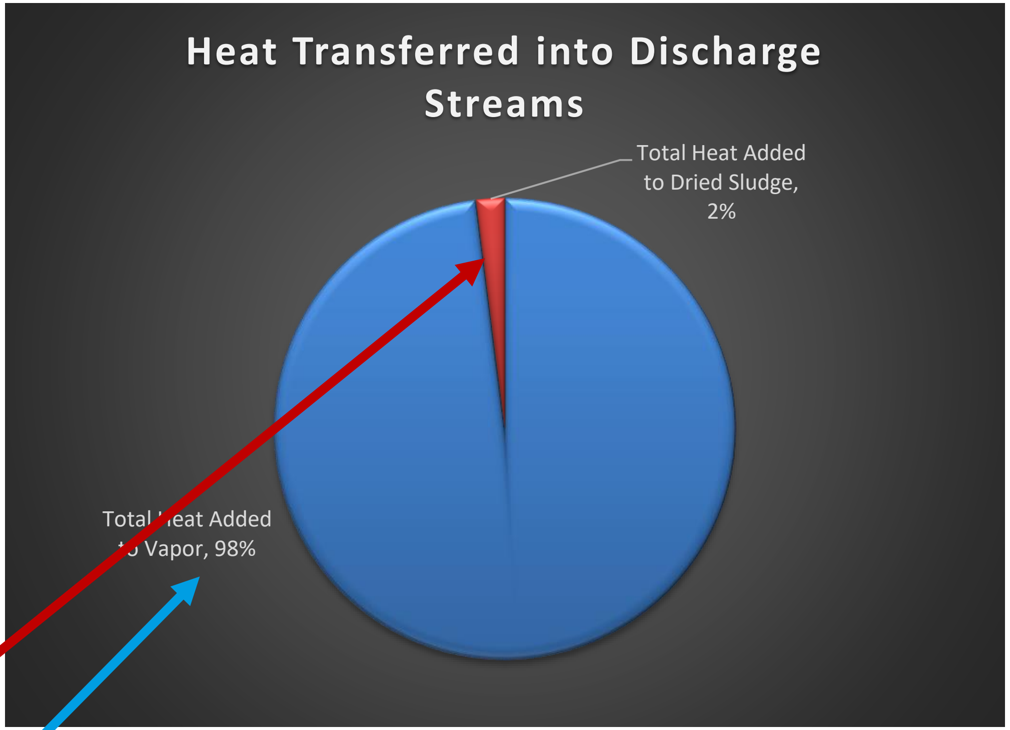
- Phase Change - $Q=m \times H_v$
- Heat of Vaporization (H_v) – Atm Pressure -
  - **Liquid Water to Vapor – 970 BTU/lb**

Theoretical Heat/ 1lb Water Evaporation

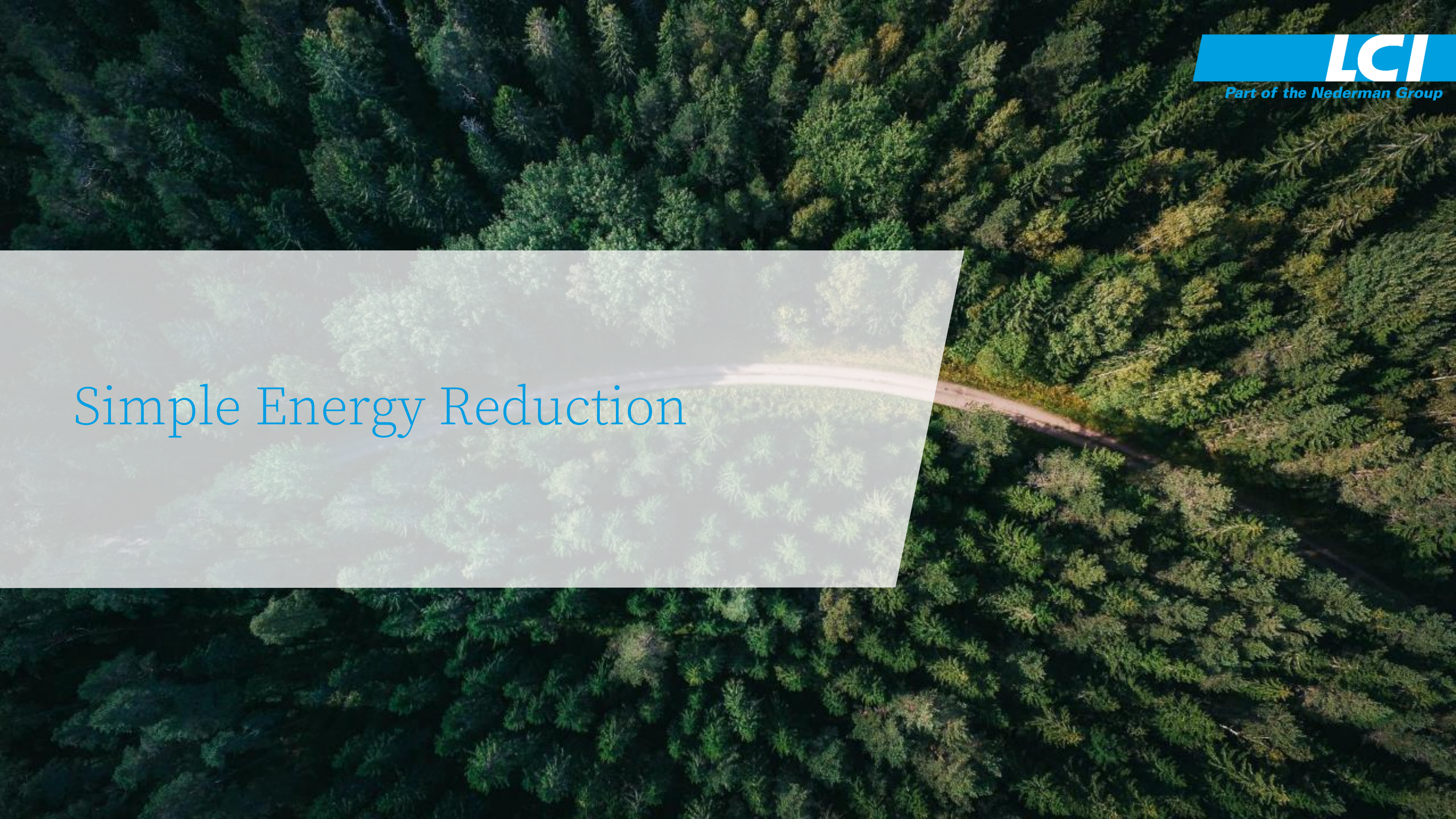
- SH Water = 1 BTU/lb°F x 1.03 lb x (212-68°F) = **148 BTU**
- SH Solids = 0.34 BTU/lb°F x 0.26lb x (212-68°F) = **13 BTU**
- LH Water = 970BTU/lb x 1lb = **970 BTU**
- **1132 BTU/lb water to Evaporate**

Where does the Heat Go

- **Discharged Sludge**
  - 10% Water + 100% Solids = 15 BTU + 12 BTU = **28BTU**
- **Discharged Vapor**
  - 90% water + 100% Vapor = 142 BTU + 970 BTU = **1104 BTU**



Most Energy to Heat and Evaporate Water



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Simple Energy Reduction

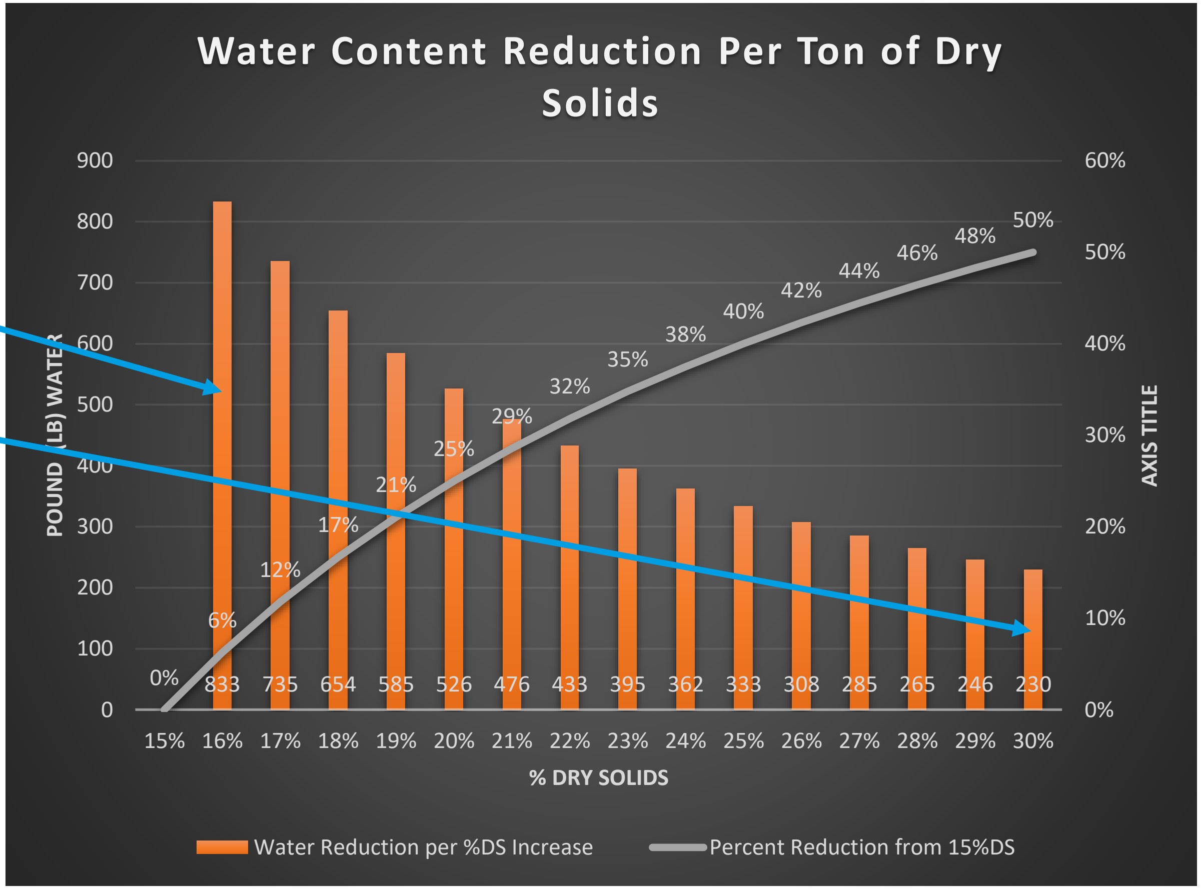
First Things First – Improved Dewatering/Efficient Drying

Decreased Water Content

- Lowers Required Dryer Evaporation Rate
  - Smaller Dryer
  - Less Heat – >1130 BTU/lb water
- 15%-16% - 833lb Water Mass Reduction
  - **6% Energy Reduction**
- 29%-30% -230lb Water Mass Reduction
  - **3% Energy Reduction**

Efficient Dryer

- 1150-1600 BTU/lb water evaporated
  - **30% more efficient**
- Heat Recovery
  - **Up to 85% of Input Heat**



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(Not) Everyone Can Do It! – Partial Drying

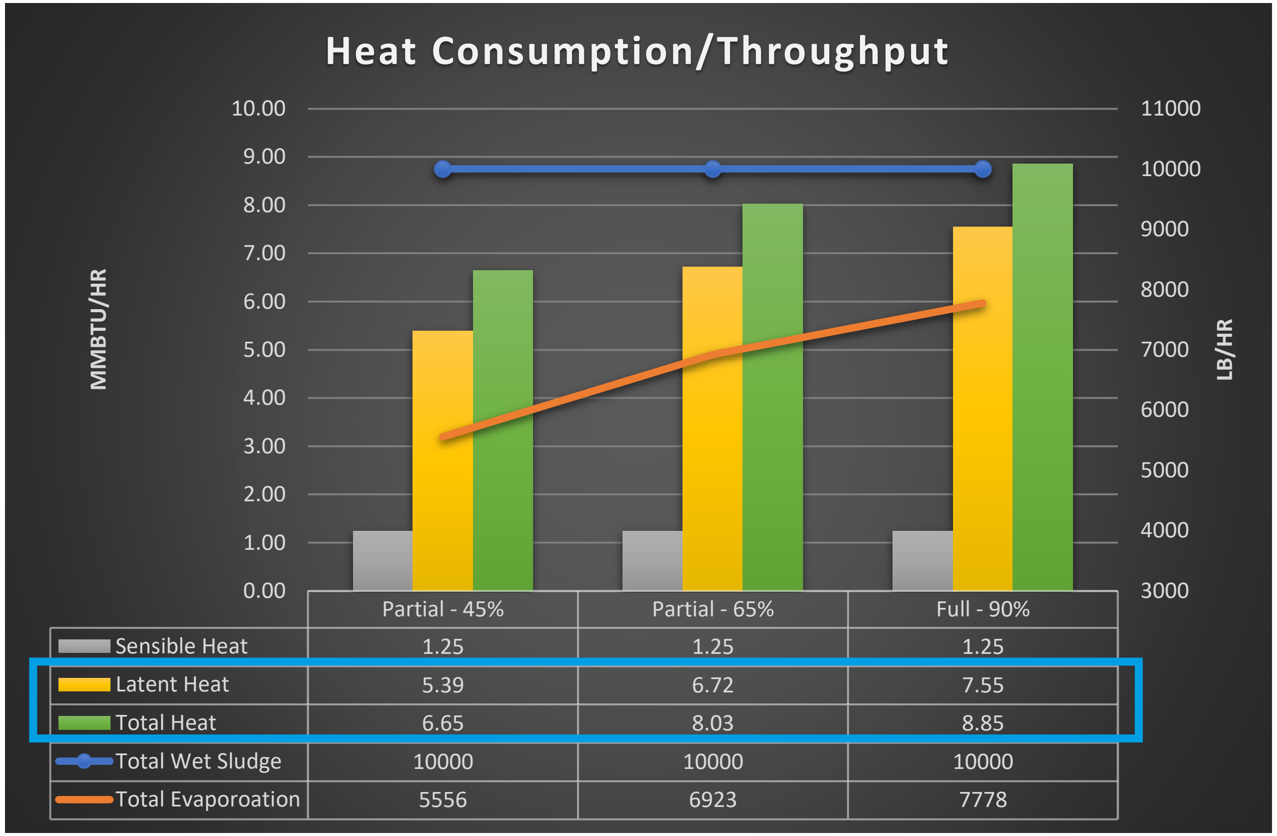
Dry to what you need!

- Applications Don’t Require 90%DS
  - Thermal Destruction
  - Landfill

Decreases Heat

- Sensible Heat remains the same
- Lower Latent Heat
- **Up to 25% Less Heat vs. Full Drying (90%DS)**

Not All Dryers Can Partially Dry



	Partial - 45%	Partial - 65%	Full - 90%
Sensible Heat	1.25	1.25	1.25
Latent Heat	5.39	6.72	7.55
Total Heat	6.65	8.03	8.85
Total Wet Sludge	10000	10000	10000
Total Evaporoation	5556	6923	7778

Easy as Pie! - Heat Recovery

Heat

Thermal Fluid 400°F (205°C)

Heat Water – Add Sensible Heat

Water to Vapor – Add Latent Heat

Vapor at 212°F (100°C)

Vapor to Water – Remove Latent Heat

Cool Water – Remove Sensible Heat

Hot Water 185°F (85°C) - 85% Maximum

Condenser

Dryer

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Easy as Pie! - Heat Recovery

Thermal Energy Savings

- Reuse Wasted Heat
- Reduce Energy

Process Improvements

- Heat Sink
- Lowers Cooling Water Requirement
- Less Wastewater to Treat

Simple Addition

- Heat Exchanger/Condenser
- Future Addition

Useful

- Digester Heating
- Building Heat
- Sludge Heating

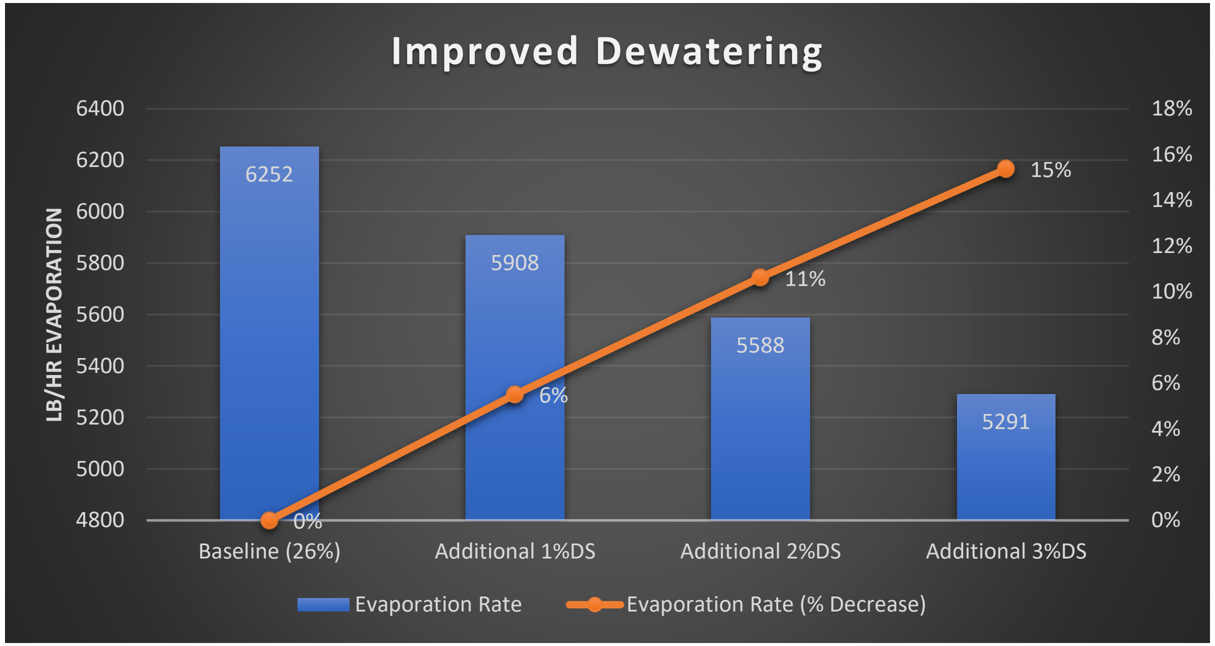
Heat Recovery Examples

Neuberg, Germany - 2003

- 185°F (85°C) Hot Water
- **Used to Heat the Facility’s Buildings**

Inegöl, Turkey – 2016

- Dryer– 440°F from Incineration
- Feed Sludge - Heated to 100°F (38°C)
  - Recovered Heat from Dryer
  - **Lowered Polymer Consumption**
  - **Increases Dewaterability 2-3%DS**
  - **Decreases Dryer Energy 10-15%**



Energy Flow in Biosolids Processes

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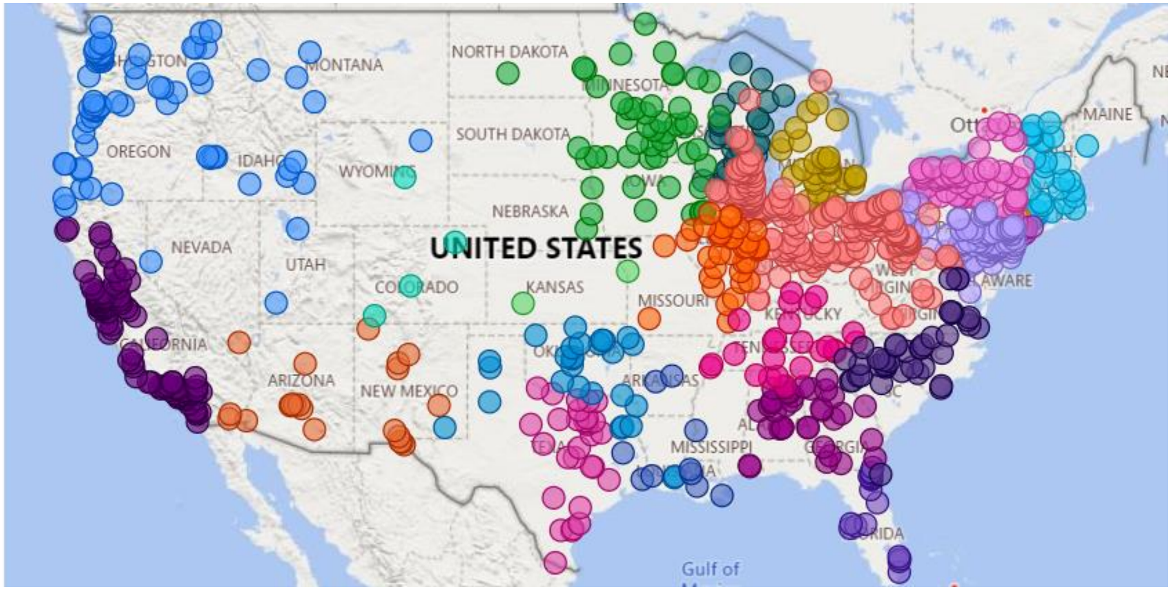
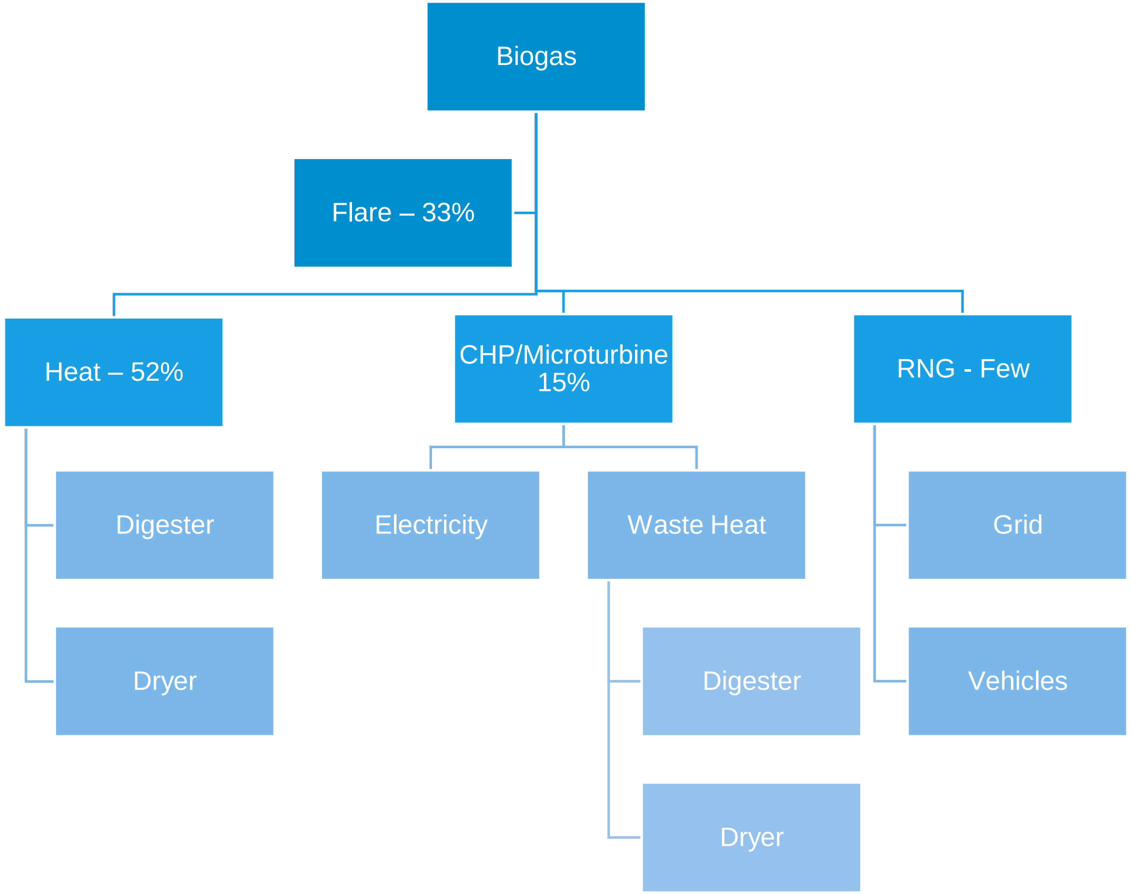
Digestor Biogas Energy Usage

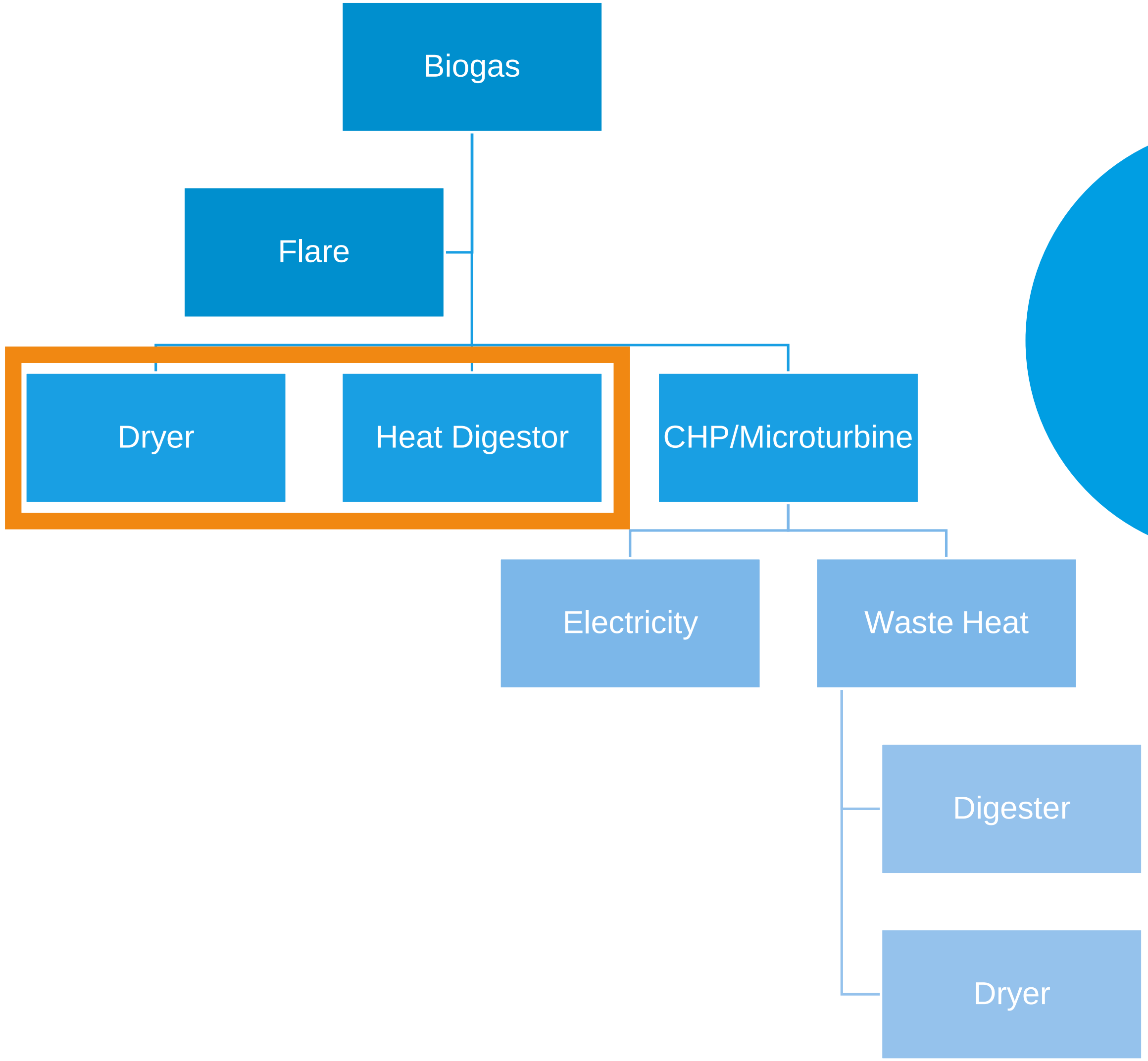


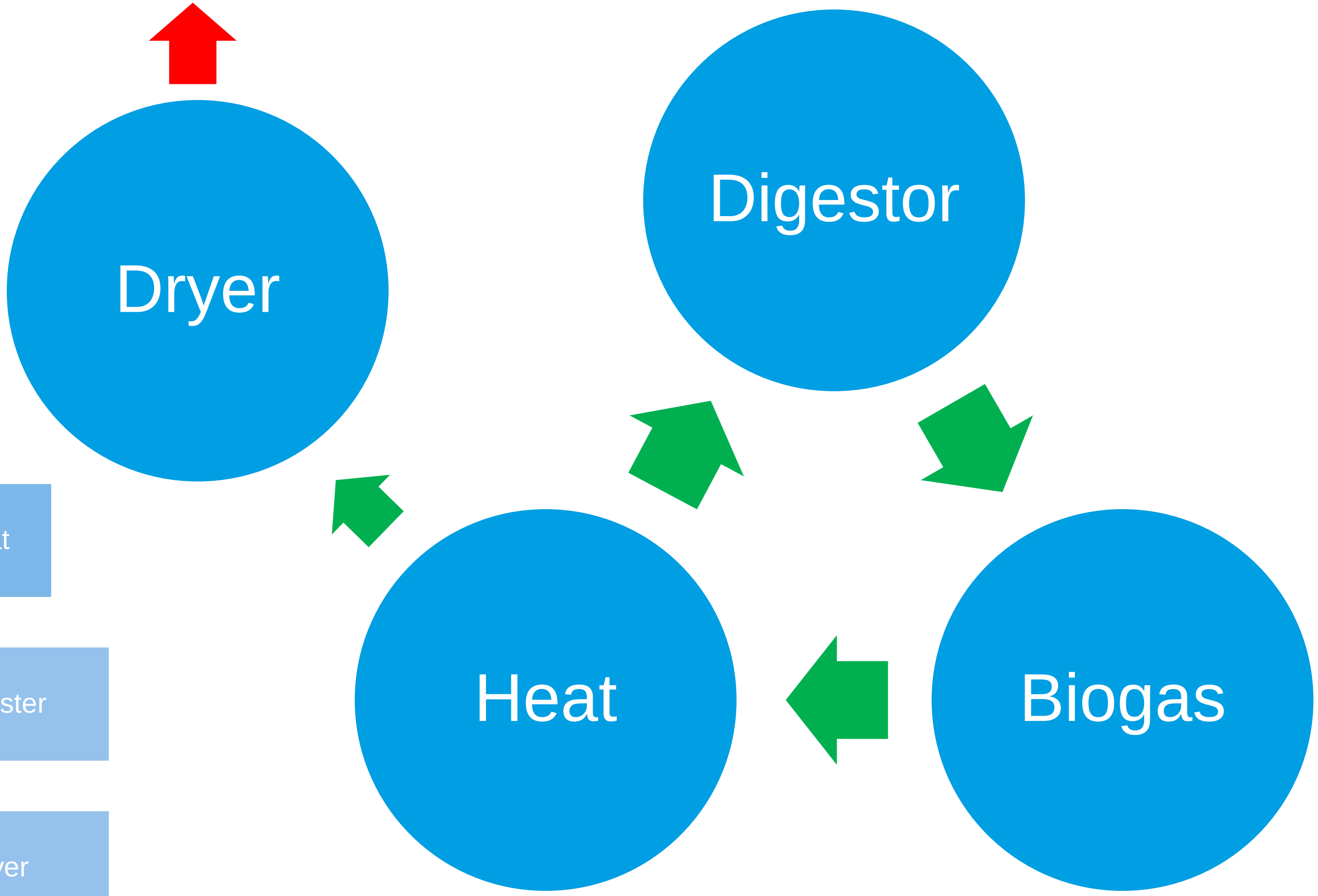


[WEF WRRF - Microsoft Power BI]

[DOE Characterization of CHP Opportunities at US WWTP]

Digestor Biogas Energy Flow – Digester/Dryer





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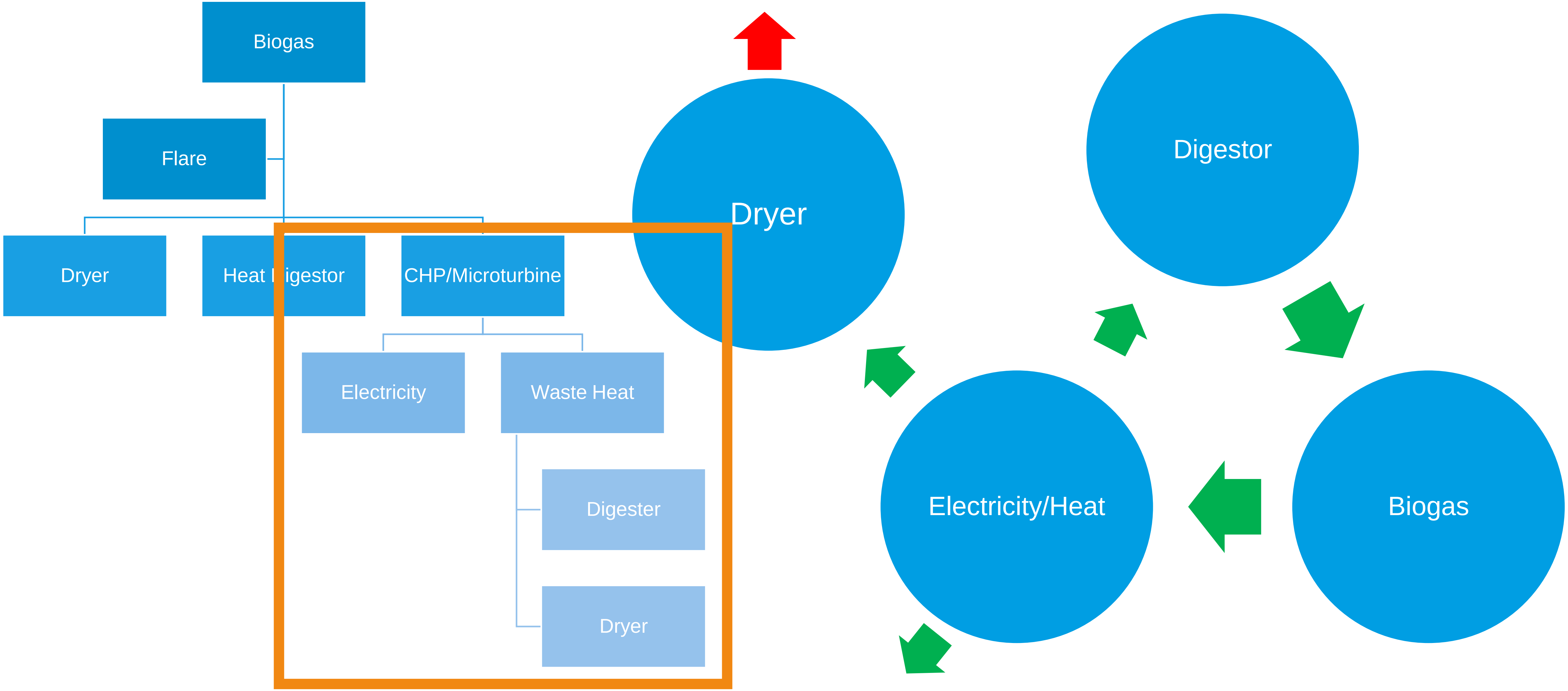
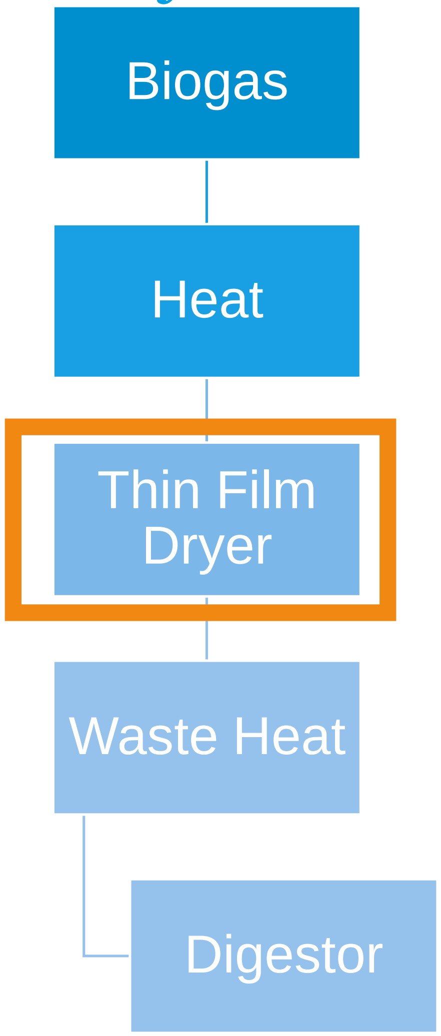
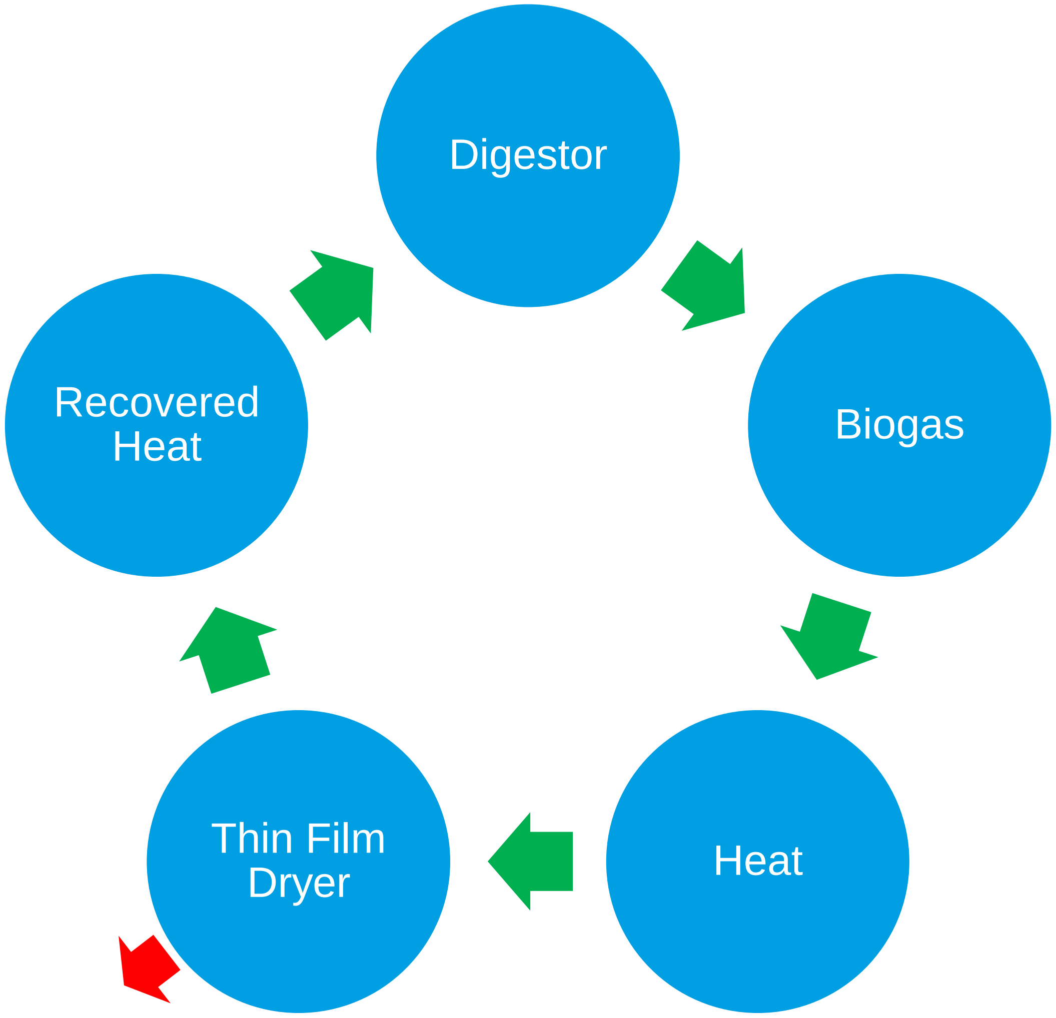
Digestor Biogas Energy Flow – CHP/Digester/Dryer

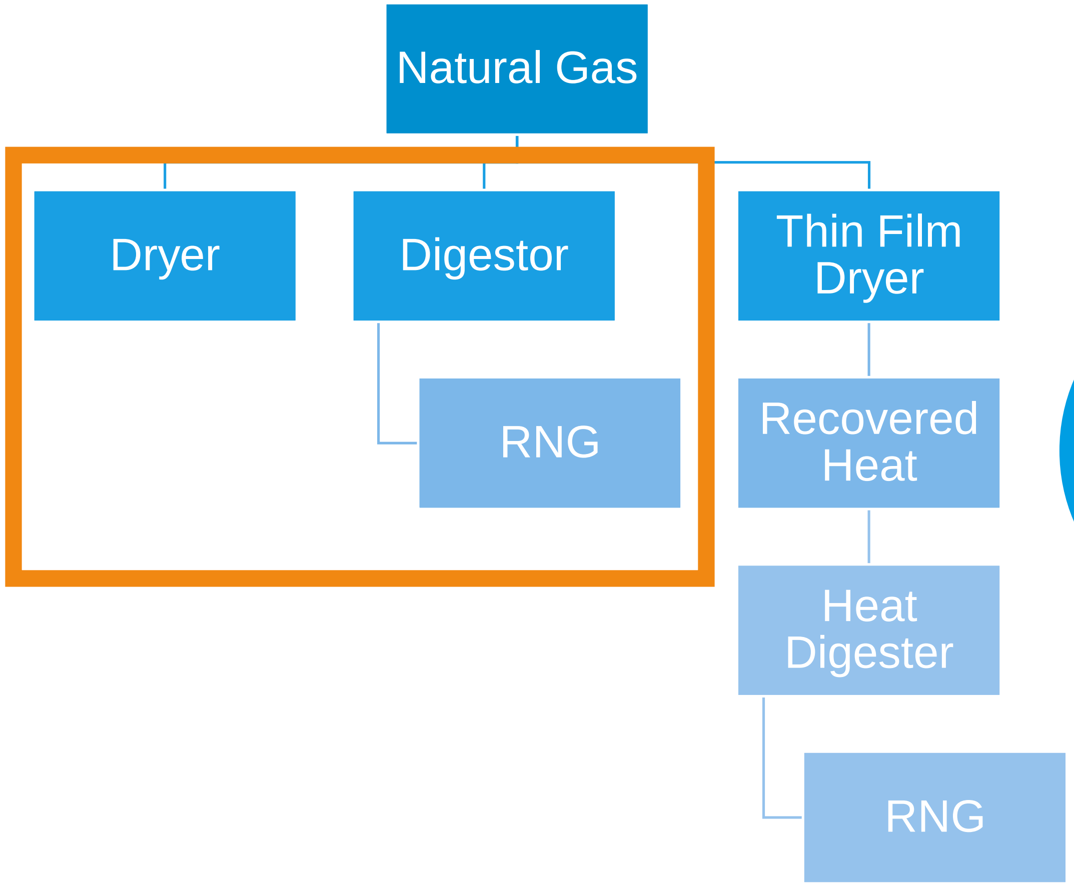


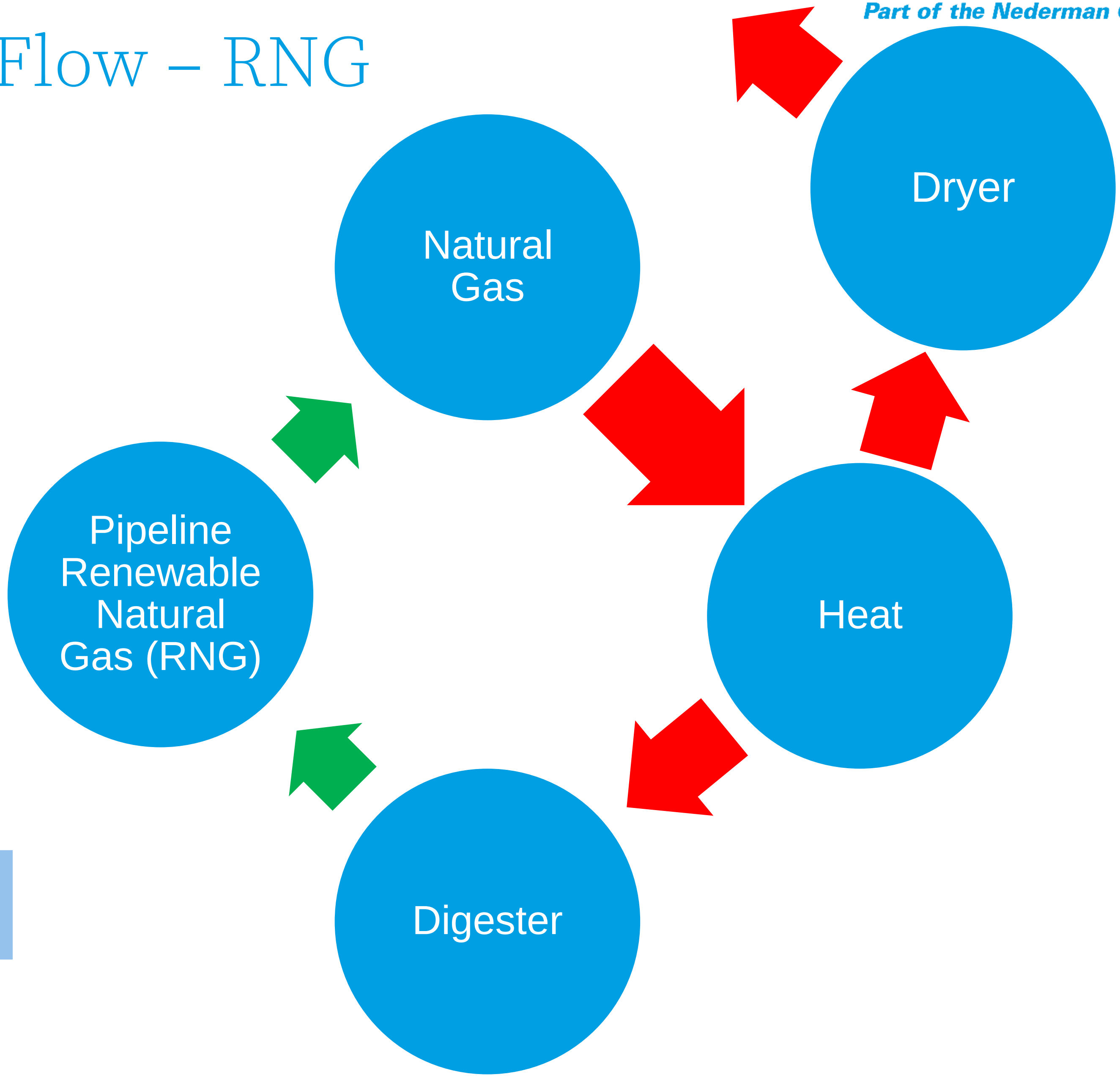
Digestor Biogas Energy Flow – with Heat Recovery



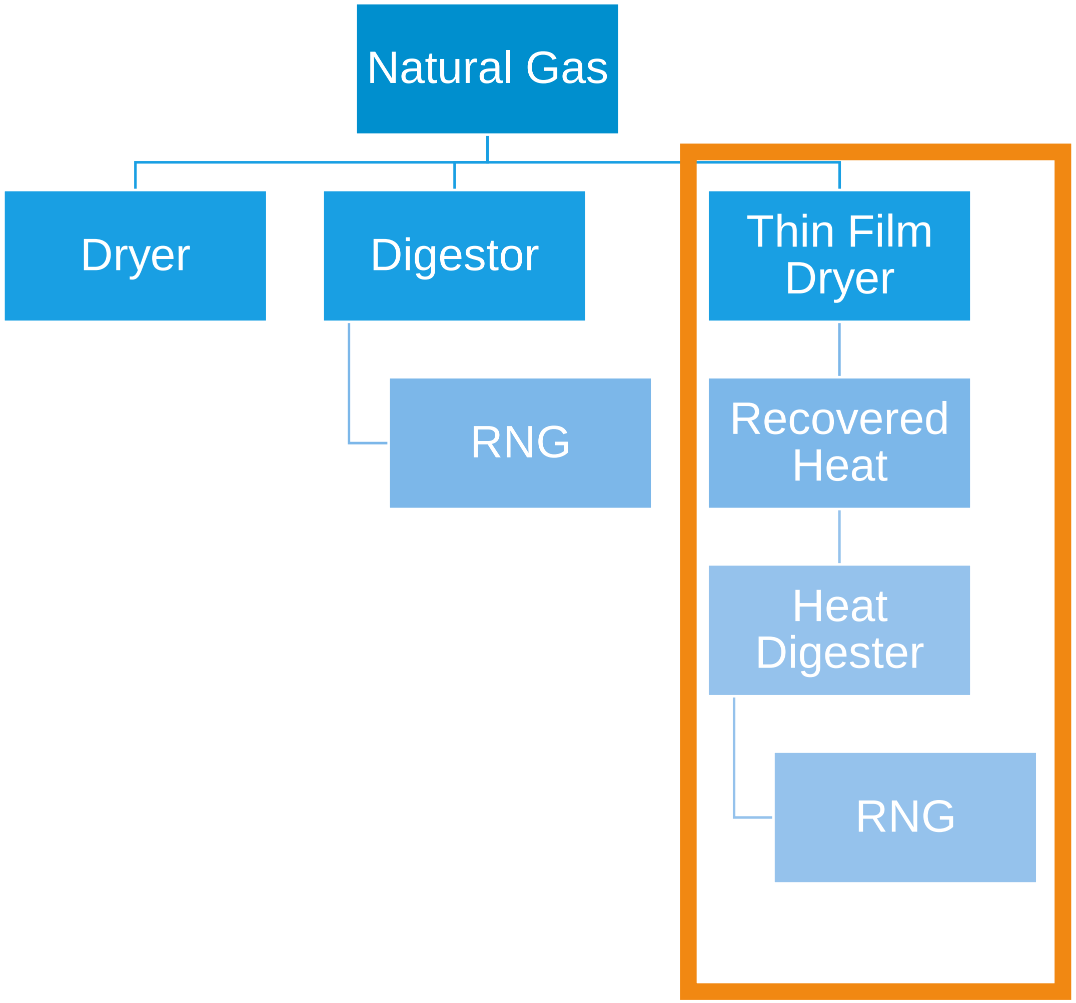


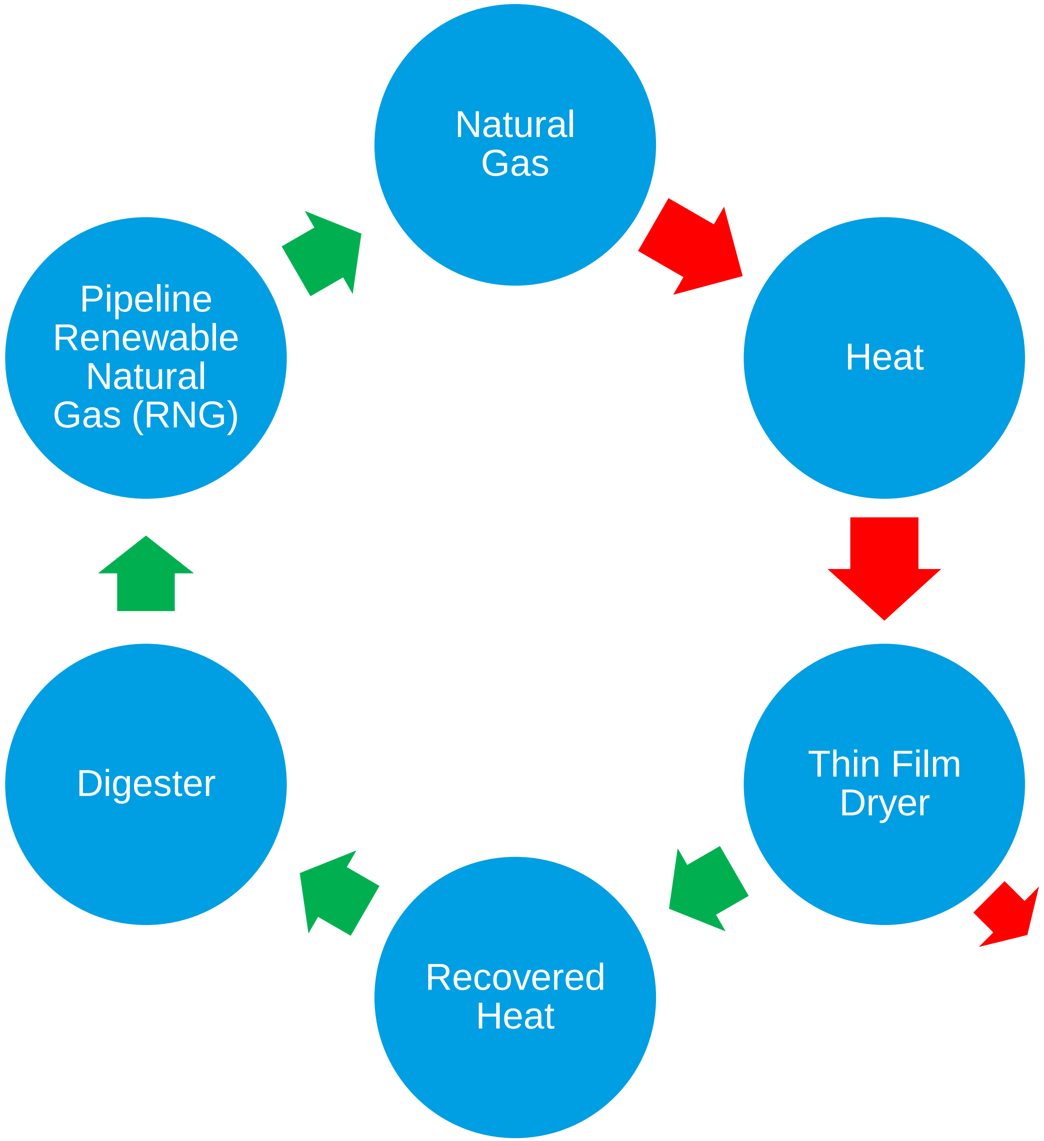
Digestor Biogas Energy Flow – RNG





Digestor Biogas Energy Flow – RNG with Heat Recovery





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Thermal Destruction Technologies

Energy in Sludge

- Primary – 8,000-13,000 BTU/dry lb*
- Blended – 5,000-10,000 BTU/ dry lb*
- **Digested – 5,550 BTU/dry lb***

Processes Requires Drying

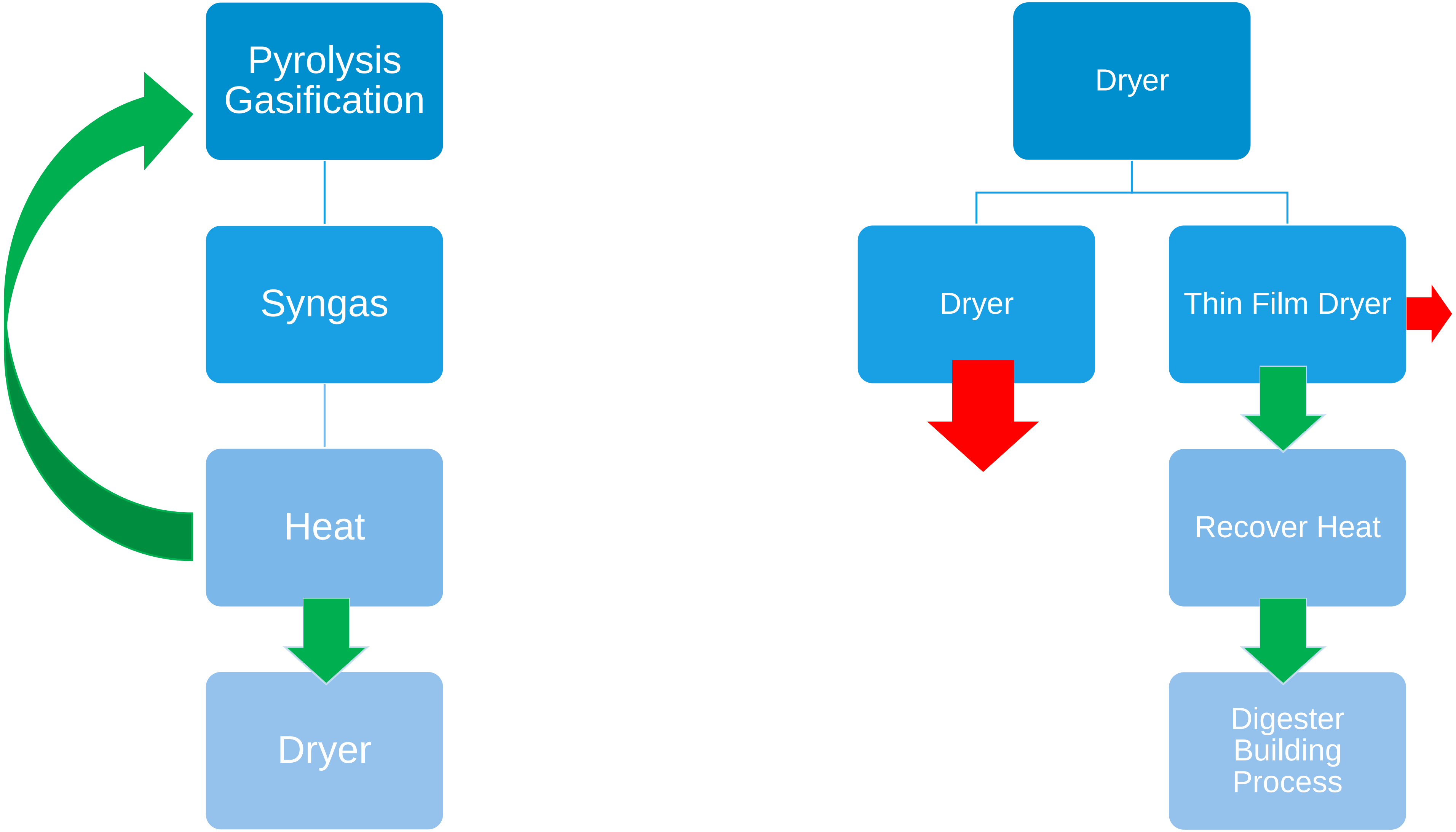
- Pyrolysis/Gasification – 60-90%DS
- Fluidized Bed Incineration – 35-50%DS

Dryer Energy

- Digested Sludge Does Not have Enough Energy
- Efficient Dryer
- Recover Heat for Digester Heating

*- Biosolids Technology Fact Sheet -Use of Incineration for Biosolids Management

Pyrolysis/Gasification Energy Flow



Innovative Energy Reduction

"You Can Observe a Lot by Watching"* – Boiling Point

Operate at "Low Vacuum" ~1.5-3psia (0.1-0.2bara)

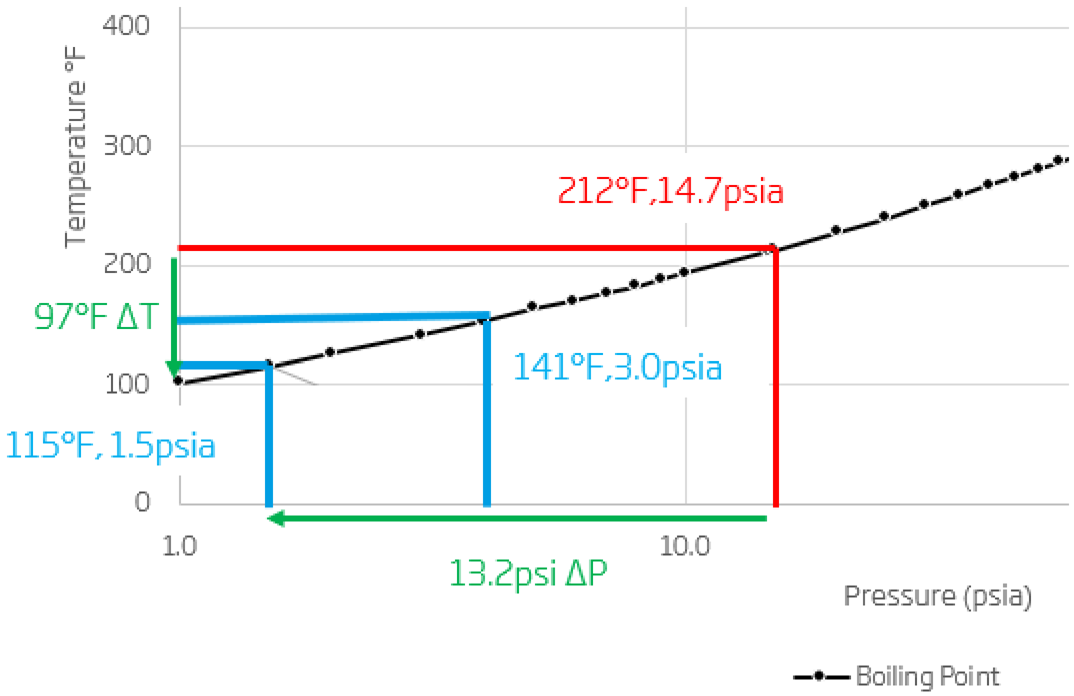
- Vacuum Pump in Place of Exhaust Fan
- LCI has systems as low as 1Torr (0.019psi)

Lowers the Boiling Temp to 45-60°C (114-140 °F)

- Decrease Heat by 5-10% - Sensible Heat Reduction

Indirect Use of Low Temperature Heat

- Down to 195°F (90°C) – Waste Heat more efficiently
- Low pressure boilers under 250°F (120°C) using 15 psig
- Hot water systems



*Yogi Berra

Outside the Box - Dual Stage Dryer

Heat Recovery

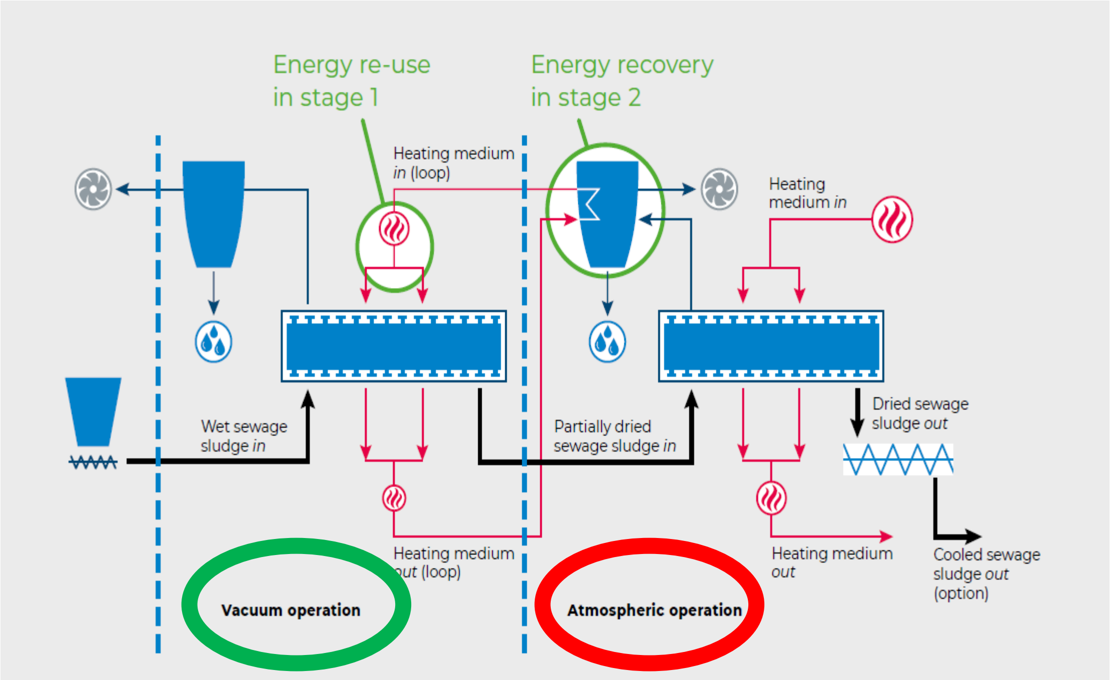
+

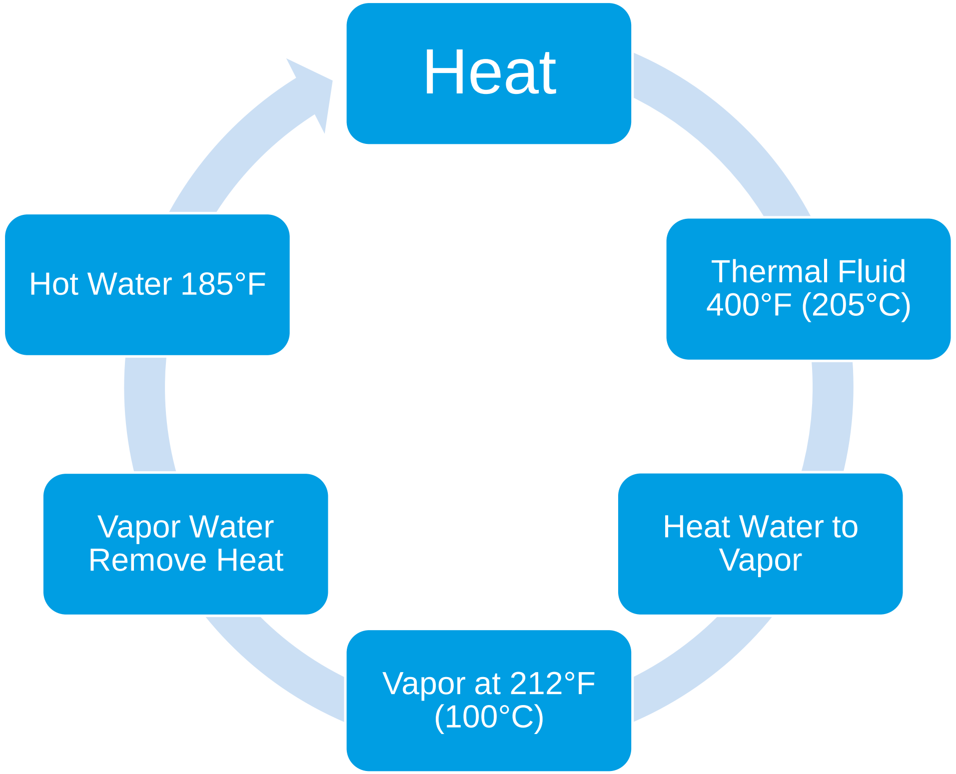
Vacuum Dryer

→

Dual Stage Dryer

Dual Stage Dryer – Vacuum Plus Atmospheric





Up to 45% Energy Reduction

The Future of Energy?

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Holy Cow! Greenhouse Gas Emissions

Measured at Mass	Metric Ton ($MTCO_2e$) •$MTCO_2e$=~2,200 $lbCO_2e$ •Equivalent to 2,500 miles driven
Reported CO_2e Equivalent	Carbon Dioxide - CO_2= $1xCO_2e$ **Methane – CH_4 = $28xCO_2e$** Nitrous Oxide - N_2O = $265xCO_2e$
US 6.34 Billion $MTCO_2e$/yr	**Wastewater 42.0 Million $MTCO_2e$/yr** **3% CH_4 - Anaerobic Conditions** 5% N_2O – Nitrification/Denitrification
Biogenic CO_2e	Cycle Back Naturally **Considered Carbon Nuetral** Biomass - Wood/Paper/**Biosoilds**

EPA Greenhouse Gas 2021
Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021 – Main Report (epa.gov)

MIT
How much is a ton of carbon dioxide? | MIT Climate Portal

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"The Future Ain't What it Used to Be"*

Greenhouse Gas Emissions

Coal
2.26 lb CO_2e/kWh (662 lb/MMBTU) **

Natural Gas
0.97 lb CO_2e/kWh (284 lb/MMBTU) **

Electricity
0.86 lb CO_2e/kWh (173 lb/MMBTU)
Largely Driven By Coal **
Decrease with Renewable Sources

Biofuel –Biogas /Biomass
0.02 lb CO_2e/kWh (6 lb/MMBTU)***

*Yogi Berra

**Frequently Asked Questions (FAQs) - U.S. Energy Information Administration (EIA)

***682-2012 (winnipeg.ca)

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Incentives for Energy Reduction

Water/Wastewater Energy Usage - EPA

- 2% of Total US Energy Usage
- 30-40% of Energy Used by Municipalities
- Energy Available from Solids

Legislation

- Combat Climate Change
- Renewable Energy Sources – Electricity
- Reduce Usage of Fossil Fuels

Funding

- Infrastructure/Inflation Reduction Act
- WIFIA – Enhanced Energy Efficiency Projects
- CWSRF – Energy Conservation Projects

Incentives for Green Energy Production

- RIN’s/eRin’s
- Natural Gas/ Electricity Production

Inflation Reduction Act Gives a Boost to the Biogas Sector | Womble Bond Dickinson

Energy Efficiency for Water Utilities | US EPA

Financial Opportunities: Funding Opportunity Exchange (energy.gov)

Red Light, Green Deal, Yellow Light: Biden’s Energy Roadmap | Baker Institute

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"It's Electric" Heat - Systems Advantages

Advantages

- Heat Quickly, Not Limited by Ambient Temperature
- Simple Installation, Low Maintenance
- Quiet, Compact, Simple
- Near 100% Efficient

Disadvantages

- Small Sizes/Limited Sizes
- Larger Electric Service at Site
- **Cost of Electric Heating**

Small Applications

Less 3MMBTU/hr – 1000kW

Evaporation Rates up to 2,750 lb/hr

Energy Sources

Natural Gas Supply Not Available

Low-Cost Electric Sources Available

Waste Heat Recovery

Up to 85% of Heat Input

Up to 185°F Hot Water

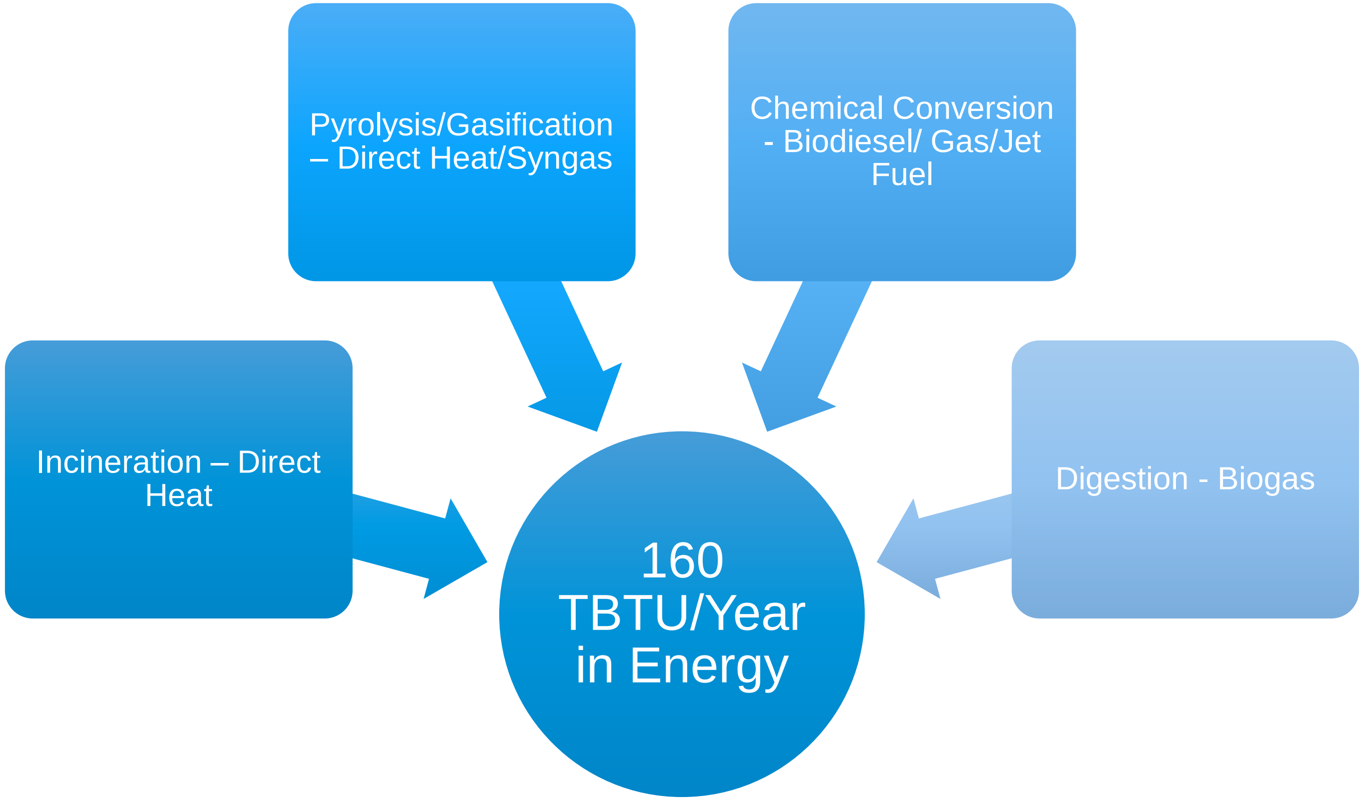
Operational Limitations

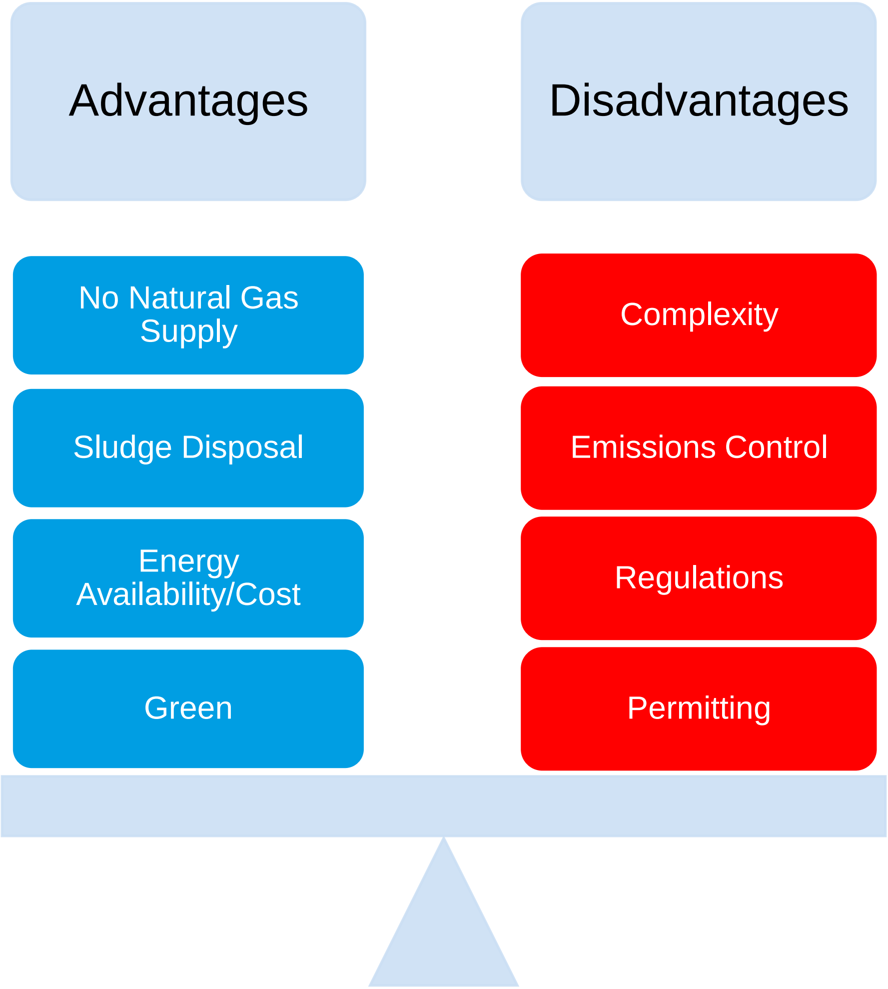
Limited Run Hours

Ease of Maintenance

Gregg Achtenhagen PE, LEED AP and John Lemke , 2022, -Cleaver Brooks - Trends in Decarbonization and the Role of Electric Boilers

BioMass – It's Right Under Your Nose!





Seiple et al., 2020 Municipal wastewater sludge as a renewable, cost-effective feedstock for transportation biofuels using hydrothermal liquefaction, Journal of Environmental Management, [Municipal wastewater sludge as a renewable, cost-effective feedstock for transportation biofuels using hydrothermal liquefaction - PubMed (nih.gov)]

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"If You had a Crystal Ball You Wouldn't Work for Me!"*

We Do Not Know for Certain Where Energy Is Headed

Elections/Administration Changes	Technical Limitations	Energy Cost

↓

Flexibility

Projects Planned Around Energy and Its Future

↓

Energy Conservation is the Right Thing to Do!

*Gary Schamlbach – Former Boss

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Thank you!

Feel Free to Contact Me

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