Hydrothermal Processing in Wastewater Treatment

Overview and Update

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IR^2 Forum August 2017
Manhattan College

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Hydrothermal Processing Overview

- **Hydrothermal Processing (HTP) uses temperature and pressure to efficiently convert wet organic matter to biocrude oil and methane gas in less than an hour**
  - Captures >85% of feedstock energy; uses <14% to run
  - T = 350°C (662°F); P = 200 bar (3,000 psi)
- **Eliminates wastewater solids and operational costs**
  - Significantly reduces CHG emissions from solids
- **Accepts any type of wastewater solids—primary, secondary, both together, or post-digester biosolids**

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Hydrothermal Overview (cont.)

- **Captures phosphorus as a precipitate in the form of a dense solid mixed with other inorganics**
  - Converts to fertilizer in same way as phosphorus ore
- **Effluent water is clear and sterile with COD <100**
  - Contains N as ammonia; currently working to recover as aqua ammonia, a commercial byproduct
- **Fuel products are eligible for incentives such as RINs (Federal) and LCFS credits (California)**

➢ **Solids management, resource recovery, fuel incentives, lower emissions, and small size provides value to the WRRF**

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An Installed and Operating HTP System

Comparison to Other Technologies

- **AD is larger, slower, produces less methane, and leaves significant biosolids for disposal**
  - HTP produces app. 2x as much fuel energy as AD
- **CAMBI Thermal Hydrolysis is a pre-process for AD**
  - Decreases solids but little increased fuel yield
  - Increased yield of AD gas used for CAMBI process heat
- **Incineration disposes of solids but limited resource recovery (heat)**
- **Pyrolysis produces syngas or pyrolysis oil, but at much higher temperature, low yield and low quality**
  - Feed is dried, so not a good fit for wastewater solids

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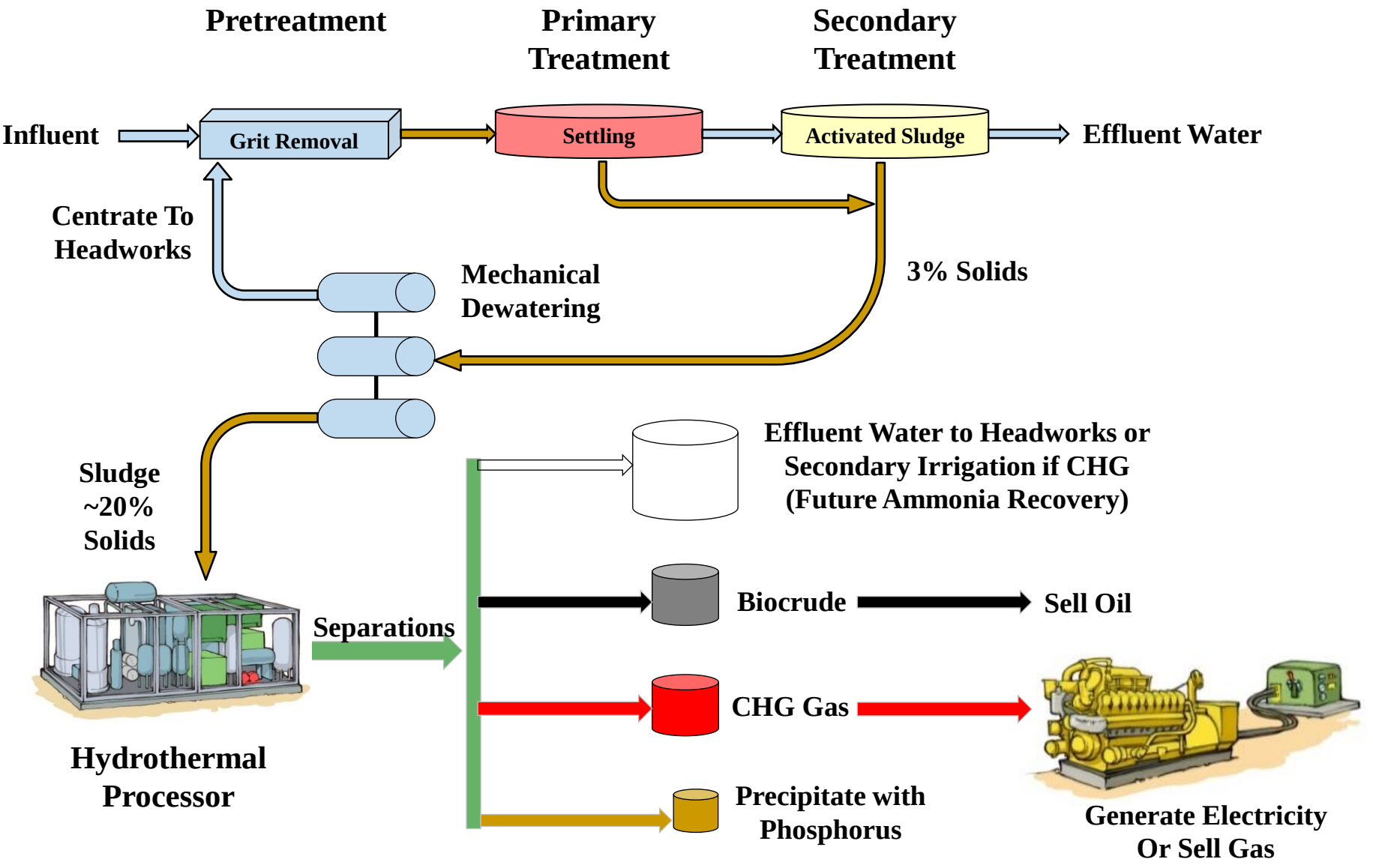
WRRF Process Flow with Hydrothermal Processing



Progress Since 2015

- **At the 2015 IR^2 forum, Genifuel presented an overview of a new technology called Hydrothermal Processing (HTP)**
- **At that time LIFT was in the midst of a test of wastewater solids to assess the performance of HTP with wastewater solids**
- **This year's presentation gives an update of progress in the last two years**

What's New

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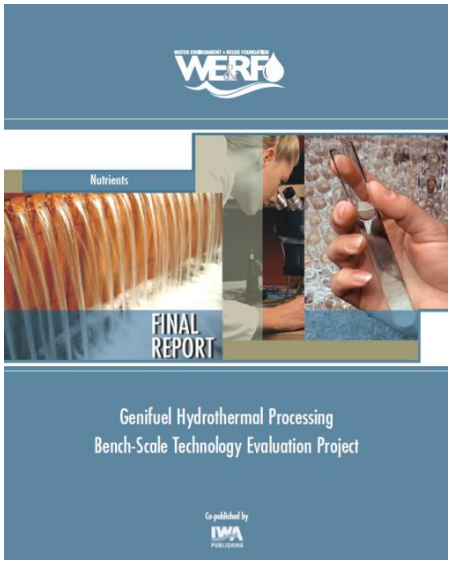
Results from LIFT Study

- **The LIFT study produced a 185-pg. third-party report by Leidos, Inc.**
- **The report was reviewed by utilities and industry experts…**



… and made a number of recommendations

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Recommendations from LIFT Study

- **The LIFT study concluded that the next step should be a pilot-scale installation at a WRRF**
  - Metro Vancouver, who supplied the sludge for testing, has decided to be the pilot-scale site, and has started funding and contracting activities
- **The LIFT study also made 13 other recommendations, and 11 of these are now done**
  - Many of the additional steps were achieved in a follow-up test using sludge from GLWA/Detroit

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More LIFT Recommendations

- **Fill in data gaps for improved modeling**
- **Address key recommendations**
  - Increase feed concentration
  - Longer duration test with single feed
  - Test with representative blend
  - Test with better temperature control
  - Produce more biocrude for upgrading
  - Identify trace constituents in HTL solids
- **Demonstrate operation with high ash**
- **Generate > 500 mL biocrude for upgrading**

Done

➢ **Item not done: Determine CHG catalyst life**

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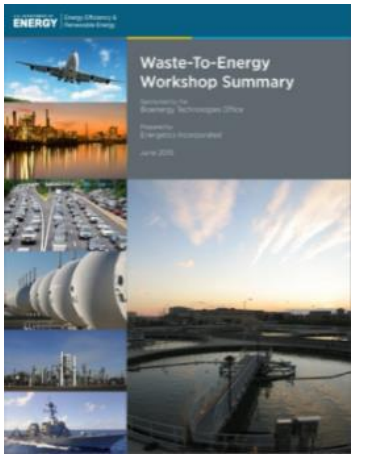
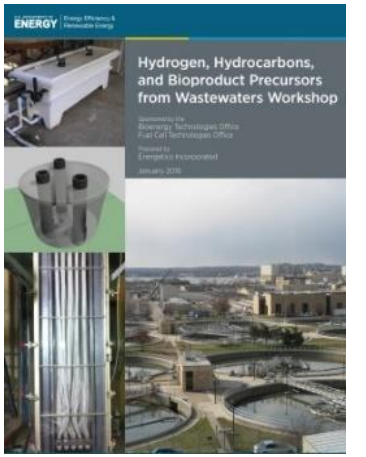
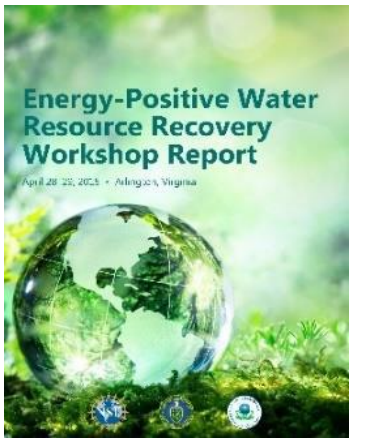
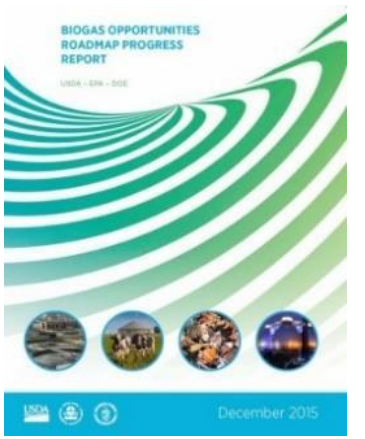
New Developments since LIFT

- **Based partly on the success of the LIFT tests, DOE has expanded its focus on all kinds of Waste-to-Energy (WTE), with extensive workshops and National Laboratory activities**









DOE WTE Reports

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ANNUAL WET AND GASEOUS FEEDSTOCKS

(USA AVAILABILITY AND UNITS)

Feedstock	Millions dry US tons/y	Oil + Gas via HTP Trillions BTU/y	Gas via CHG Trillions BTU/y
Animal Waste	41.0	698.0	568.9
Food & Food Proc. Waste	15.3	284.7	232.0
Wastewater Solids	14.8	286.7	233.7
Organic Portion of MSW	14.3	266.2	217.0
Fat, Oil, Grease (FOG)	6.1	214.3	174.7
TOTALS	91.5	1,749.9	1,426.3

- *Wet wastes can supply 5.9% of US transportation fuel*
- *Wet wastes can supply 5.2% of US natural gas consumption*

New Developments (cont.)

- **And the Pacific Northwest National Laboratory, which ran the LIFT and Detroit tests, has installed major new test equipment**

Medium-Scale HTP System

Oil Upgrading System

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New Developments (cont.)

- **PNNL also ran another set of tests following the LIFT report, using sludge from the Great Lakes Water Authority (GLWA/Detroit)**
- **These tests built on the LIFT experience, and achieved results similar to LIFT but better in almost every category**

➢ **The additional testing provides further confidence at pilot scale in WRRFs**

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Summary Results of LIFT vs. GLWA/Detroit

	Unit	GLWA Prim:Sec 1:1	GLWA Prim:Sec 1:1	WERF-01 Digested	WERF-02 Primary	WERF-03 Secondary	WERF-04 Digested
Solids in Feed	Wt%	15.0%	15.0%	11.5%	11.0%	8.1%	11.5%
Hours on stream	hour	6.3	3.7	0.7	2.0	2.0	2.7
Feed Rate	L/L/h	1.8	3.6	2.1	2.1	2.1	1.2
Mass Yields (Dry, Ash Free, Normalized)							
Mass Balance	%	101%	100%	102%	101%	103%	107%
Oil Yield, Mass (N)	g_{oil}/g_{fd}	45%	44%	31%	37%	25%	35%
Biocrude Gen rate	ml/h	150	290	59	64	24	66
Aqueous Phase							
COD	mgO/L	57,500	61,300	44,600	40,800	73,000	48,200
Nitrogen	wt%	0.74%	0.77%	0.56%	0.26%	0.72%	0.57%
Chloride	ppm	278	280	85	60	102	95
Sulfate	ppm	140	200	190	60	160	200
Phosphate	ppm	ND	ND	87	25	710	66
pH	pH unit	7.7	7.8	8.2	6.4	8.0	8.0

- ***Second test with GLWA showed improvements in yield and processing rate compared to first test with LIFT (WE&RF)***

Metro Vancouver's Interest in HTP

- **After working on LIFT, Metro Vancouver saw the HTP pilot project recommendation as a way to gain experience with solutions to key issues**
  - Rising cost of solids management and increasing distance to disposal sites
  - High cost of installing AD at smaller sites
  - New technology for future system upgrades to improve process and reduce cost
  - A pathway to meet environmental goals for lower emissions and greater energy recovery

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Metro Vancouver's Project

- The MV system will process 10 metric t/d of sludge at 20% solids, which is 5x larger than previous HTP pilot
- Serves satellite site with population of 30,000
- Initially oil only, with gas as later step
- Budget $8.5M CAD for both HTP and site work
- Commission late 2018

Annacis Island System Site

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HTP Size Compared to AD Alternative

MEASURE	HTP	AD
Area occupied	6,727 ft^2 (625 m^2)	15,327 ft^2 (1,424 m^2)
Building Height	20 ft (6.1m)	48 ft (14.6 m)

- ***HTP footprint is 44% of AD***

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GHG Reduction (CO_2 emissions)

ITEM	HTP	AD
Avoided Emissions via HTL Biocrude	860 t/y	N/A
Avoided Emissions via Methane	190 t/y	350 t/y
Total CO_2 Avoided	1,050 t/y	350 t/y

- *HTP reduces CO_2 emissions 3x more than AD*

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HYPOWERS Is the Next New Project

- HYPOWERS is a project partly funded by DOE to support pilot-scale demonstration of HTP in a WRRF
- Size is planned as 20 metric tons/day, or 2x MV
- Host facility is Central Contra Costa Sanitary District ("Central San"), northeast of Oakland, CA

Central San System Site

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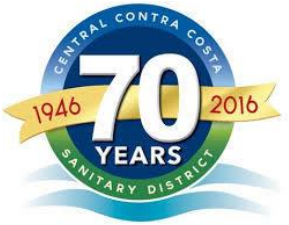
The HYPOWERS Team



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HYPOWERS (cont.)

- **Project is in two phases**
  - Phase 1 is to develop a complete package ready for construction, including design, business plan, regulatory plan, identification of required permits, etc.
    - Cost is $2.5 million, half by DOE and half by the team
  - Phase 2 is awarded for a credible and complete plan
    - Current cost estimate is $14 million, also half-and-half
- **Phase 1 completion date is end of 2018, while Phase 2 completion date is in 2020**

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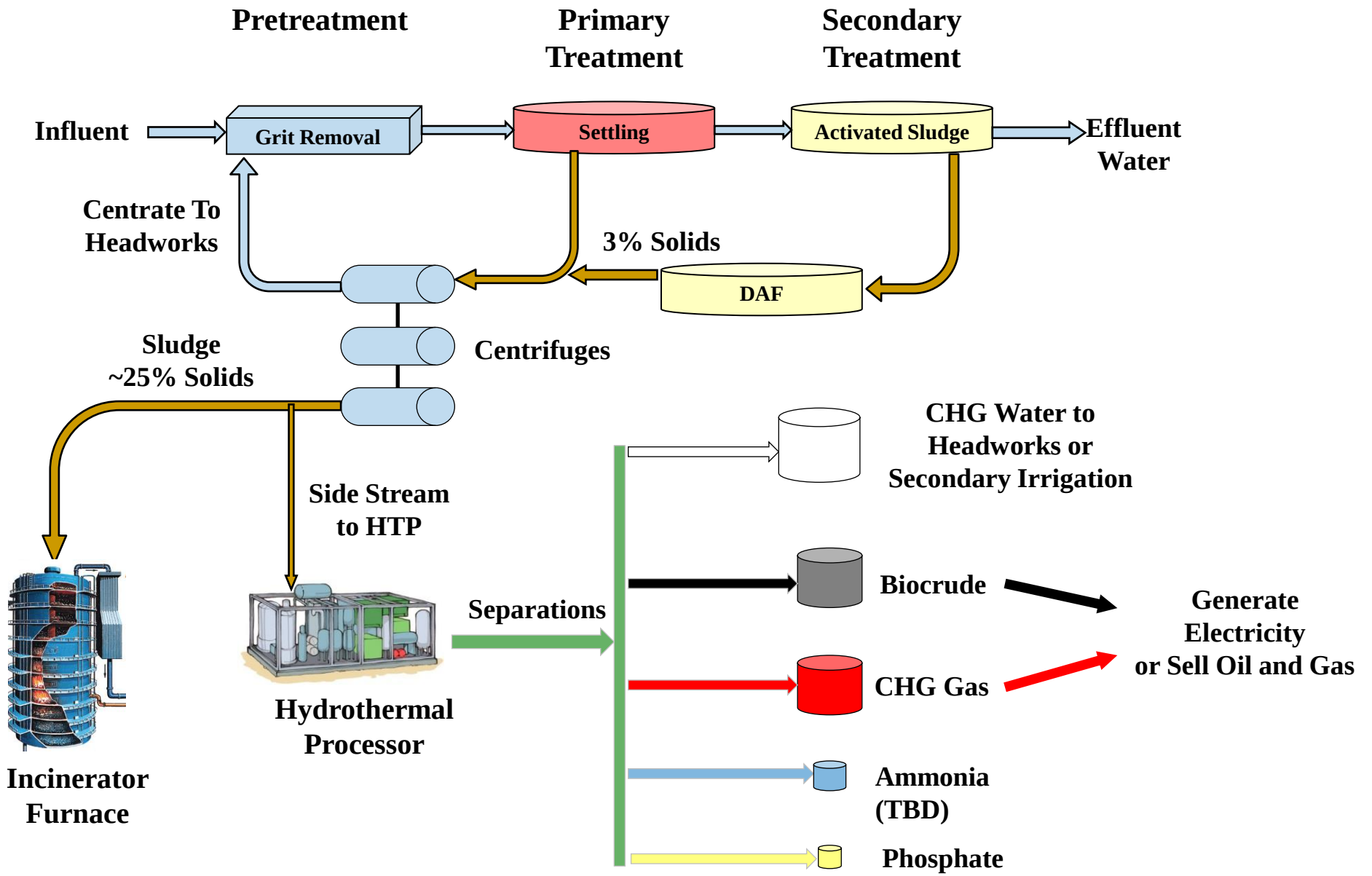
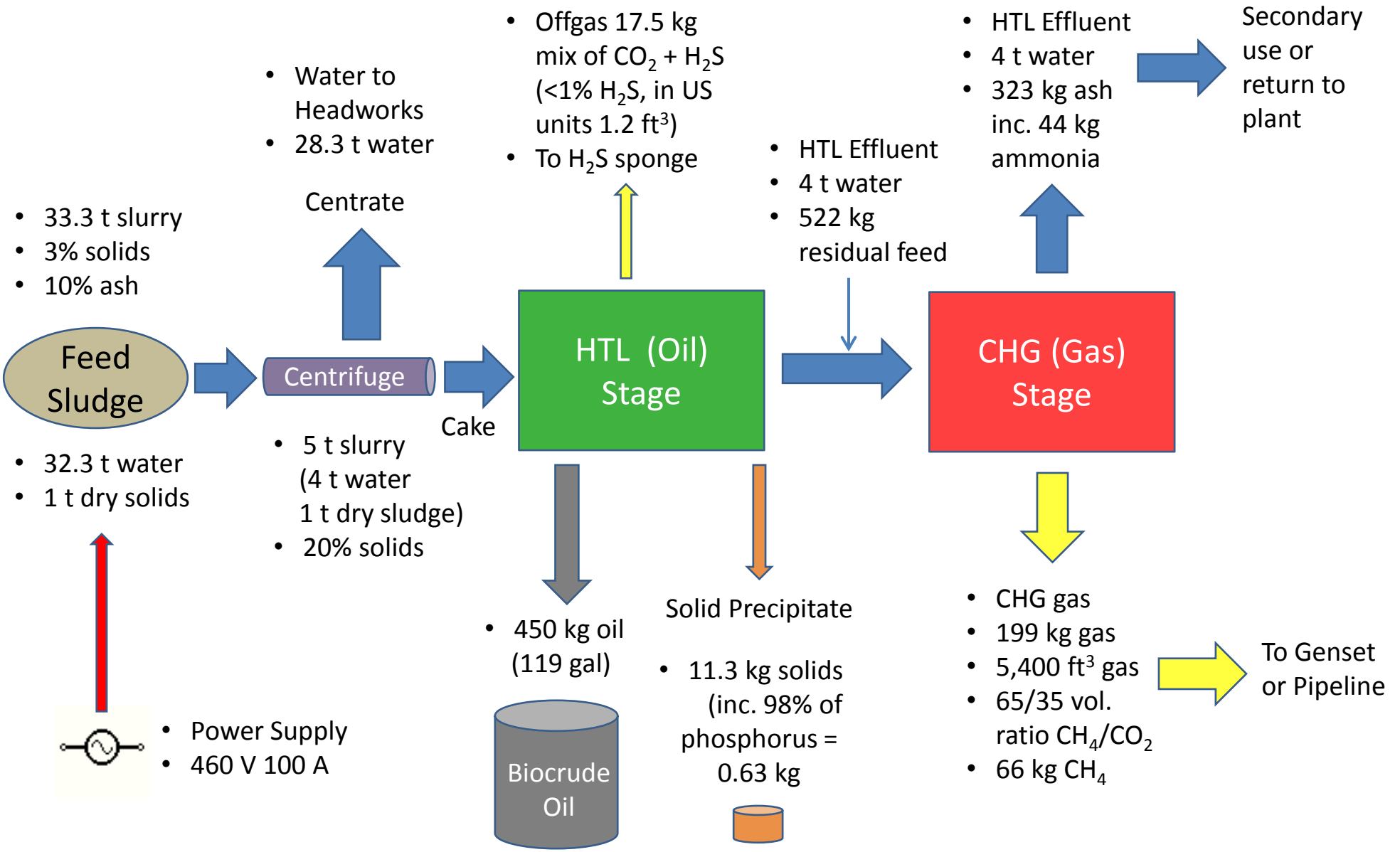
Central San Process Flow with Hydrothermal Processing



Mass Flow Diagram for 1 t/d dry (equivalent) solids*



*All units metric unless shown otherwise. Mass unit of t/d = 1 metric tonne/day

Equipment Installation for HTP

- **HTP system is skid-mount and factory-built**
  - Shipped to site by truck
  - May be containerized for sea shipment
- **Site installation requires pad, utilities (electricity, water, drain), and cover (roof or building)**
- **Need supply of sludge or biosolids**
  - Sludge can be delivered by pipe, biosolids likely not
  - Sludge will need to be dewatered to 20%
- **Need disposition of effluent water and storage tank for oil (weekly pickup)**
- **Odor control simple because very small amounts**

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Potential Commercial-Stage Structures

- **Project can be owned by utility or investor-owned**
- **Utility will likely work with AEC/EPC firm for site work and overall management**
  - Genifuel provides design, fab, and commissioning
  - Utility provides other components and may use outputs to generate electricity onsite
- **If project is investor-owned, then investor will provide a turnkey system**
  - Utility provides long-term supply contract for sludge
  - Investor sells outputs (oil/gas/electricity)
- **Investor could be strategic—e.g. oil or gas company**

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Conclusion

- **Extensive testing with wastewater sludge and biosolids has been successful and has created significant learning for equipment design and expected performance**
- **Critical next step is to demonstrate continuous 24/7 operation at operating WRRF**
  - Planned projects at MV and Central San
  - Sharing of data and results with wastewater industry
- **Need further progress on ammonia recovery and partners in oil & gas industry for output products**

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Hydrothermal Processing in Wastewater Treatment

Thank you!

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