



Shifting the Paradigm: Making Anaerobic Digestion & Combined Heat & Power Feasible for Small WWTFs

**US EPA CHP Partnership Webinar Series
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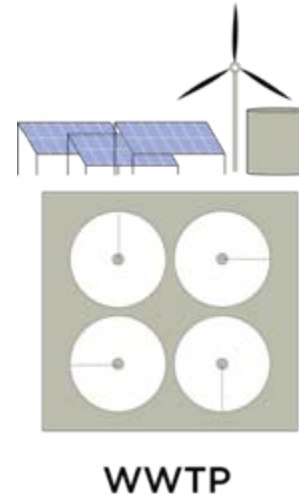
Overview



- Purpose
- Background
- Approach
- Design
- Next Steps
- Takeaway

Purpose: Local and State Support

- **Town of Fairhaven, MA Board of Public Works**
 - Thinking “green”, sustainable, practical
 - Energy project lists
 - Solar PV panels: 115 kW
 - Geothermal wells
 - Sewer PS Efficiency upgrades
 - Digester gas CHP
 - Wind turbines: two 1,650 kW
- **Strong Town support, Sustainability Committee**
- **Encouraged & supported by MA State Grant Programs**
 - Massachusetts Technology Collaborative
 - MA DEP
 - Energy Management Pilot (technical assistance)
 - Green Infrastructure Program (ARRA-funded SRF)



Purpose: Correcting the Paradox

IDEALLY . . .

WWTFs are built to reduce the impact on nature



WWTFs

BUT IN REALITY . . .

WWTFs are energy intensive, and indirectly contribute to negative impact on nature



GHG/Air Pollution

Purpose: Shifting the Paradigm



THE PARADIGM is . . .

Anaerobic digestion and CHP
is feasible only at large WWTFs



WWTFs



BUT IN REALITY . . .

Agriculture/industry have been operating
small cost-effective anaerobic digesters and CHP
for decades . . .



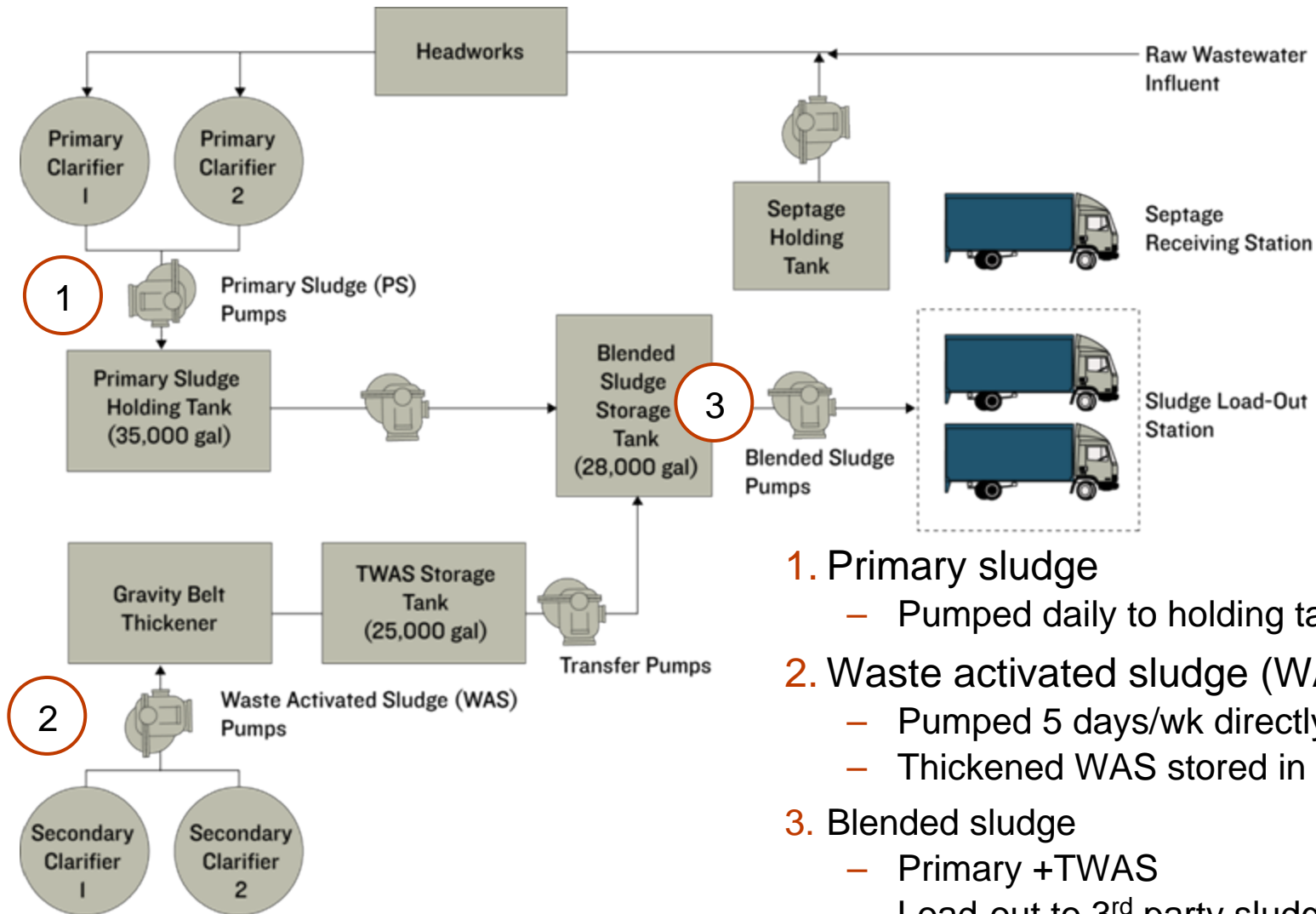
**New renewable energy funding
mechanisms help SHIFT the paradigm.**

Background: Fairhaven WWTF

- Influent Flow
 - Design: 5.0 MGD
 - Average: 2.7 MGD; Peak: 16.0 MGD
- Liquid Treatment
 - Primary clarifiers
 - Conventional activated sludge
- Solids Treatment
 - Gravity belt thickeners (GBT)
 - 3rd party liquid sludge disposal (incineration)
 - No digestion/CHP infrastructure



Background: Current Solids Treatment



1. Primary sludge
 - Pumped daily to holding tank, 1-4 hrs/d
2. Waste activated sludge (WAS)
 - Pumped 5 days/wk directly to GBTs
 - Thickened WAS stored in holding tank
3. Blended sludge
 - Primary +TWAS
 - Load-out to 3rd party sludge haulers

Background: Current Issues



- Annual operating costs
 - Sludge disposal: costs without benefits
 - 2009: \$309,000
 - Contract terms: \$216/truck, \$320/ton
 - Electricity
 - 2006 to 2008 annual average: \$190,000/yr
 - Annual average rate: \$0.16/kWh
- Operational issues
 - Intermittent wasting sludge directly to GBTs
 - No sludge storage
 - Limited process control over activated sludge process

Approach: Holistic View

1. Mitigate sludge disposal & high electricity costs
 - Anaerobic Digestion: solids destruction, reduce volume, produce digester gas
 - Combined Heat and Power (CHP): fuel natural gas generators, produce electricity and heat for use onsite
2. Improve overall WWTF performance
 - Provide continuous solids removal, reduce solids inventory
 - Improve activated sludge process control & flexibility
 - Prepare for potential effluent TN limit

Approach: Timeline

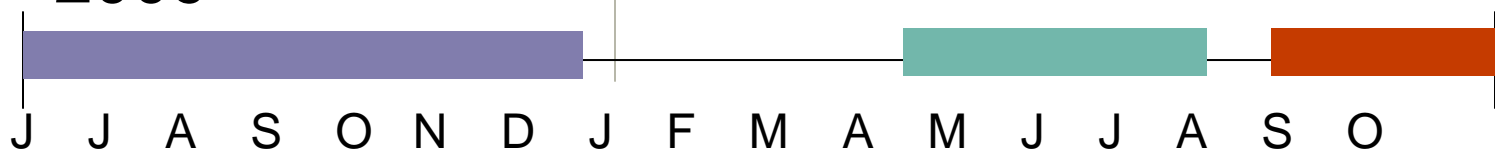
Feasibility to “Shovel-Ready”

1. Feasibility Study: June – December, 2008

- Led to Town approval for design – position for funding

2. Preliminary to Final Design: April – October, 2009

- Notice of MA DEP Green Infrastructure Grant allocation \$7.8M – fast track design
- Required design submittal for review Sept. 15, 2009



2008

US EPA/2009 Partnership Webinar Jan. 21, 2010

2009

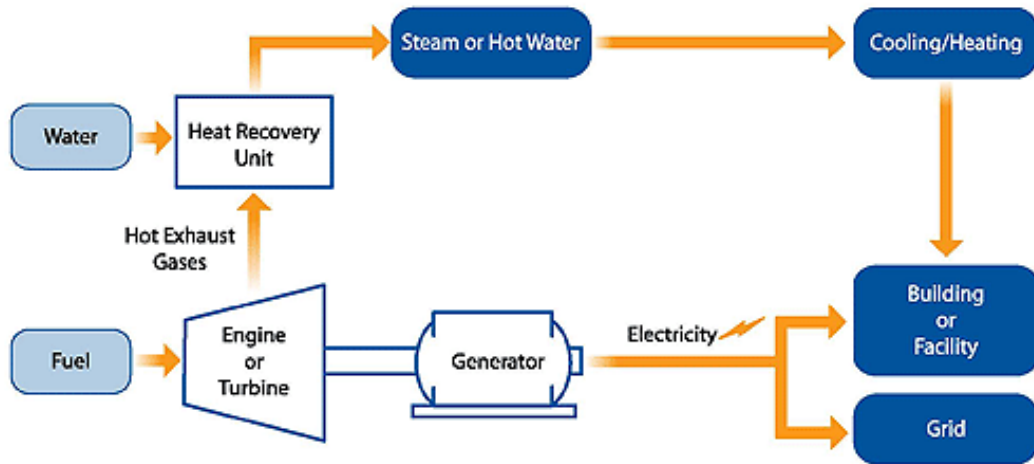
Approach: MTC Feasibility Study



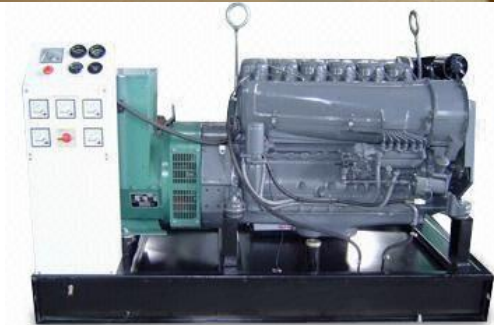
- Evaluated technical & economical feasibility of anaerobic digestion & CHP
- Options included:
 - Digester feedstock
 - Digester configuration, temperature
 - CHP technologies
- Results... Feasible with these elements:
 - Municipal sludge feedstock with FOG
 - Bolted glass-fused-to-steel digester tanks
 - Renewable energy funding
- CHP Evaluation

Approach: CHP Evaluation

- Combined Heat & Power
 - Use digester gas to fuel electric **power** generation equipment
 - Recover **heat** from equipment for use at WWTP

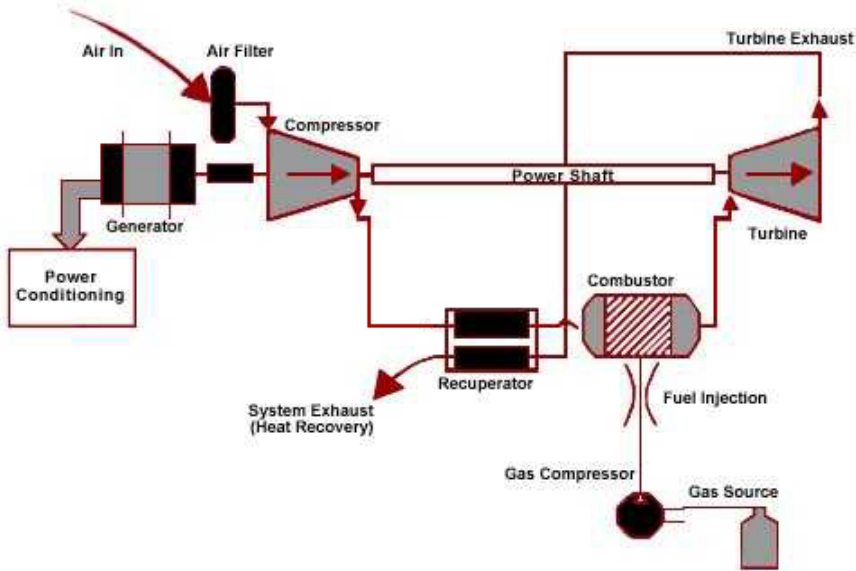


Traditional CHP Technology: IC Engine Generators

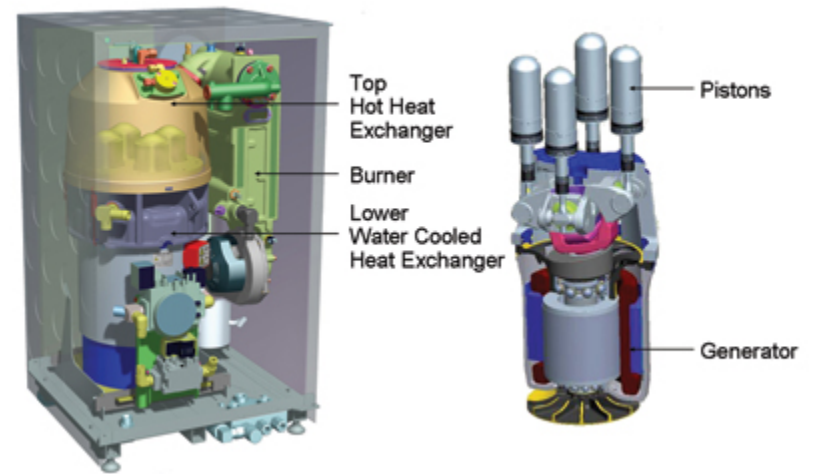


Approach: New CHP Technologies

Microturbines



Stirling Cycle Engines



Approach: CHP Technologies

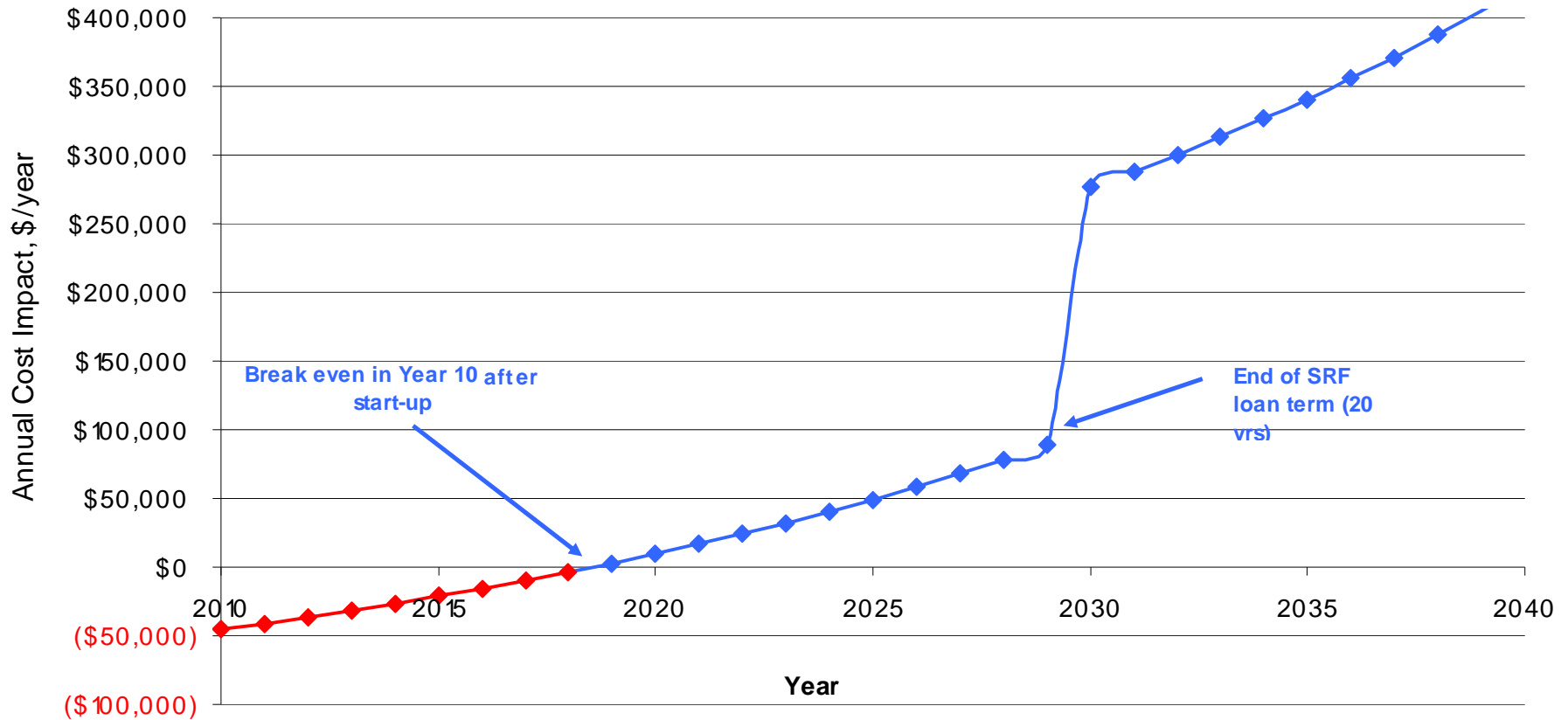
CHP Technology Comparison

Parameter	IC Engine	Microturbine	Stirling Cycle Engine
Power Output Capacity, kW	64 to 150	65	43
Efficiency (Mech.), %	34	26	28
Recoverable Heat	350,000 to 800,000	260,000	240,000
Fuel Pressure, psi	2 to 5	80	25

- With information available at the time of the study, and the needs specific to the Town, the Fairhaven study recommended the IC engine for the CHP technology.
- Note: Each facility has unique requirements and the EPA CHP Partnership recommends an evaluation of all technology options, including others not listed here, to identify one specific to your facility.

Approach: Payback

Payback Analysis for New Anaerobic Digestion & CHP Facility



Approach: Design Basis

- Position for potential stimulus-funded grant programs
- Design Basis
 - Anaerobic digestion process
 - Feedstock: thickened primary sludge + TWAS + local FOG
 - 2-stage mesophilic (95F) digestion
 - Two 145,000 gal tanks, separate membrane gas holder
 - CHP system
 - Small, packaged lean burn IC engine generator, 110 kW
 - Jacket water & exhaust heat recovery
 - Backup boiler
 - DAFT: Co-thicken sludge + scum

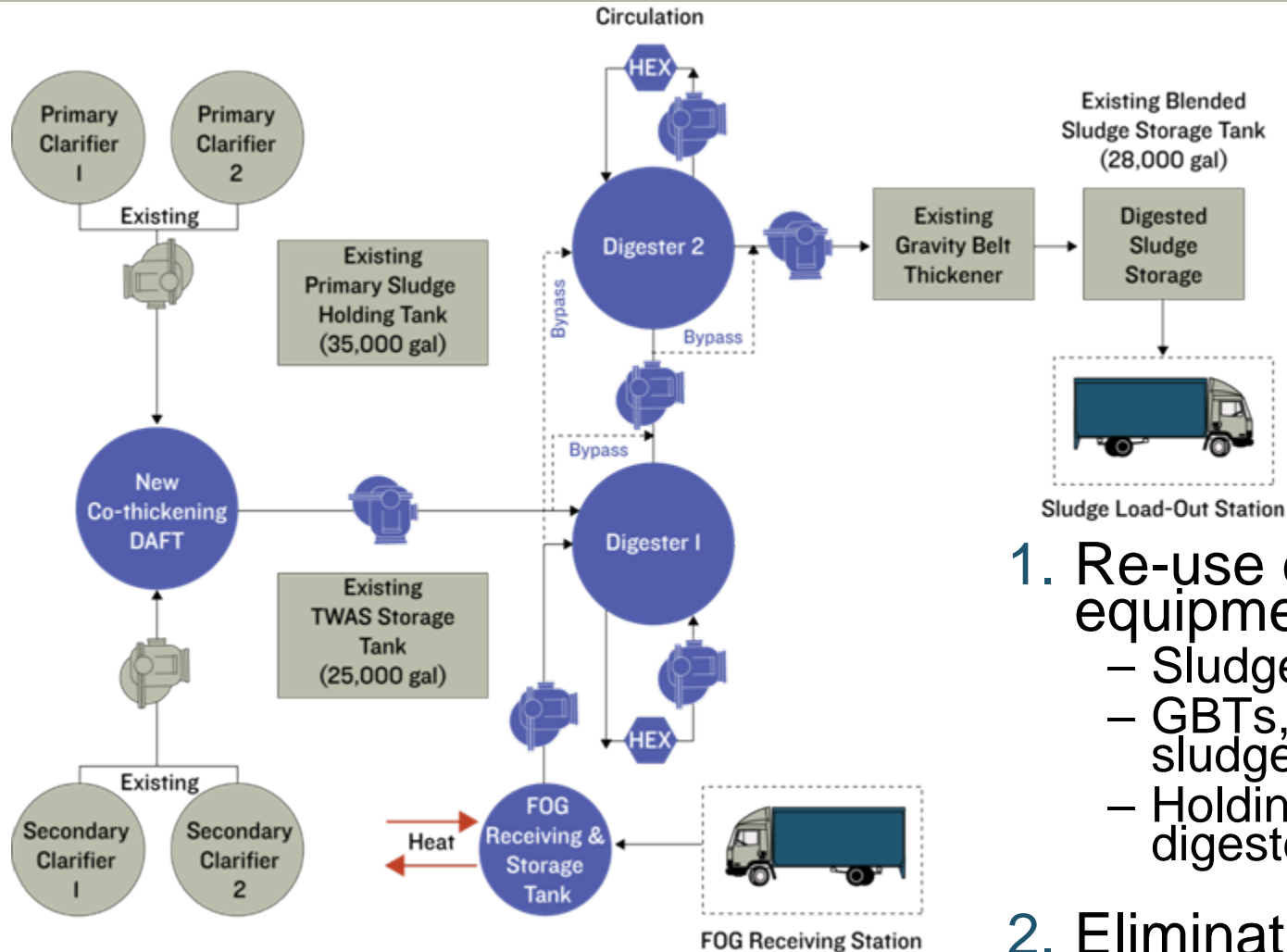
Approach: Design Basis

Basis of Design Projections

Parameter	Condition, Year 2030	Value	
Primary Sludge ¹	Max Month Load	2,900 lbs/d (1.0% TS)	
Waste Activated Sludge ¹	Max Month Load	1,600 lbs/d (0.7% TS)	
Thickened Digester Feed (DAFT)	Max Month Load	4,500 lbs/d (6.0%)	52% Sludge load reduction
FOG ¹	Max Month Load	1,000 lbs/d (10% TS)	
Thickened Digested Sludge (GBT)	Max Month Load	2,600 lbs/d (5.0% TS)	
Digester Gas ^{2,3}	Max Month Production	1,875 ft ³ /hr (65% CH ₄)	
Electric Power ^{4,5}	Max Month Production	100 kW (813,500 kWh/yr)	
Recoverable Heat	Max Month Load	500,000 Btu/h	

1. Volatile solids (VS) content: primary sludge, 84%; WAS, 80%; FOG, 95%
2. Overall VS Destruction: sludge, 65%; FOG, 85%
3. Digester gas production rate: 15 ft³/lb VS destroyed
4. Lower Heating Value CH₄: 550 Btu/ft³
5. Mechanical Efficiency: 34%

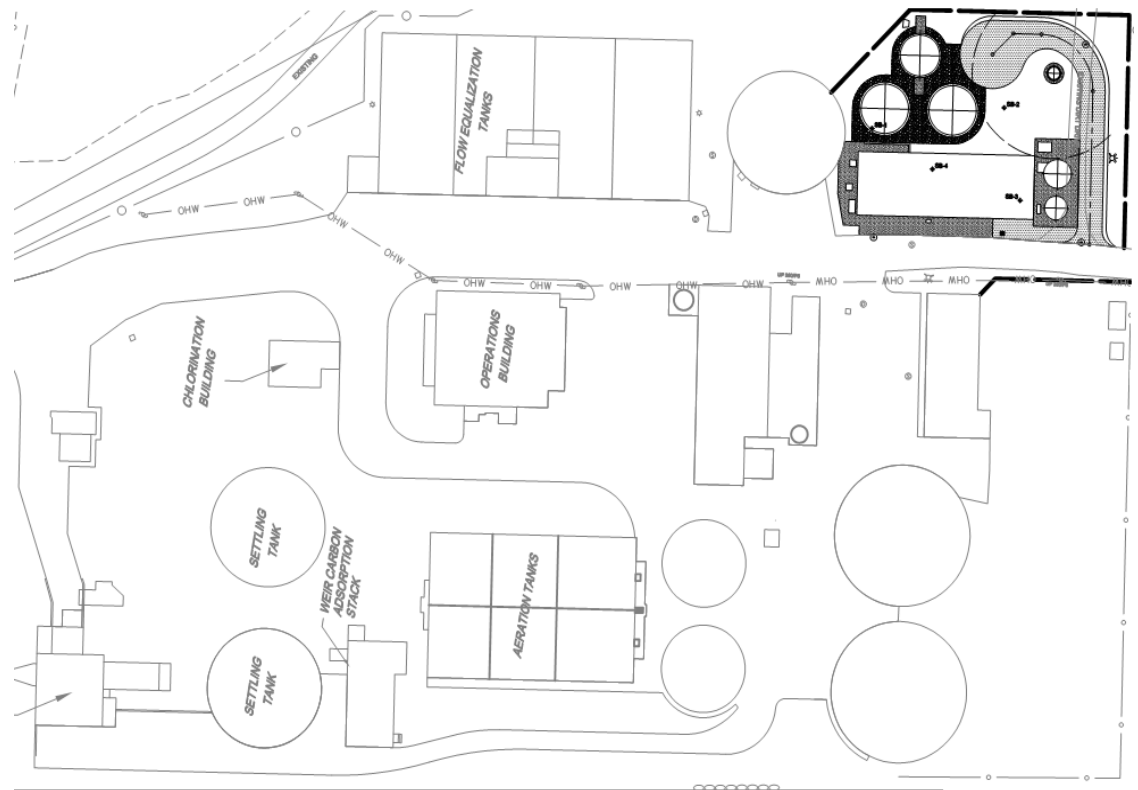
Design: New Solids Treatment



1. Re-use existing equipment & facilities
 - Sludge & scum pumps
 - GBTs, thicken digested sludge
 - Holding tank: thickened digested sludge storage
2. Eliminate use of two sludge holding tanks

Design: New Facility Layout

- 20ft diameter DAFT
- FOG receiving station
- New equipment building
 - 100ft x 80ft
- 2 digester tanks
 - 35 ft diameter
 - 26 ft tall
- Membrane gas holder
 - 26 ft diameter
- Backup gas flare



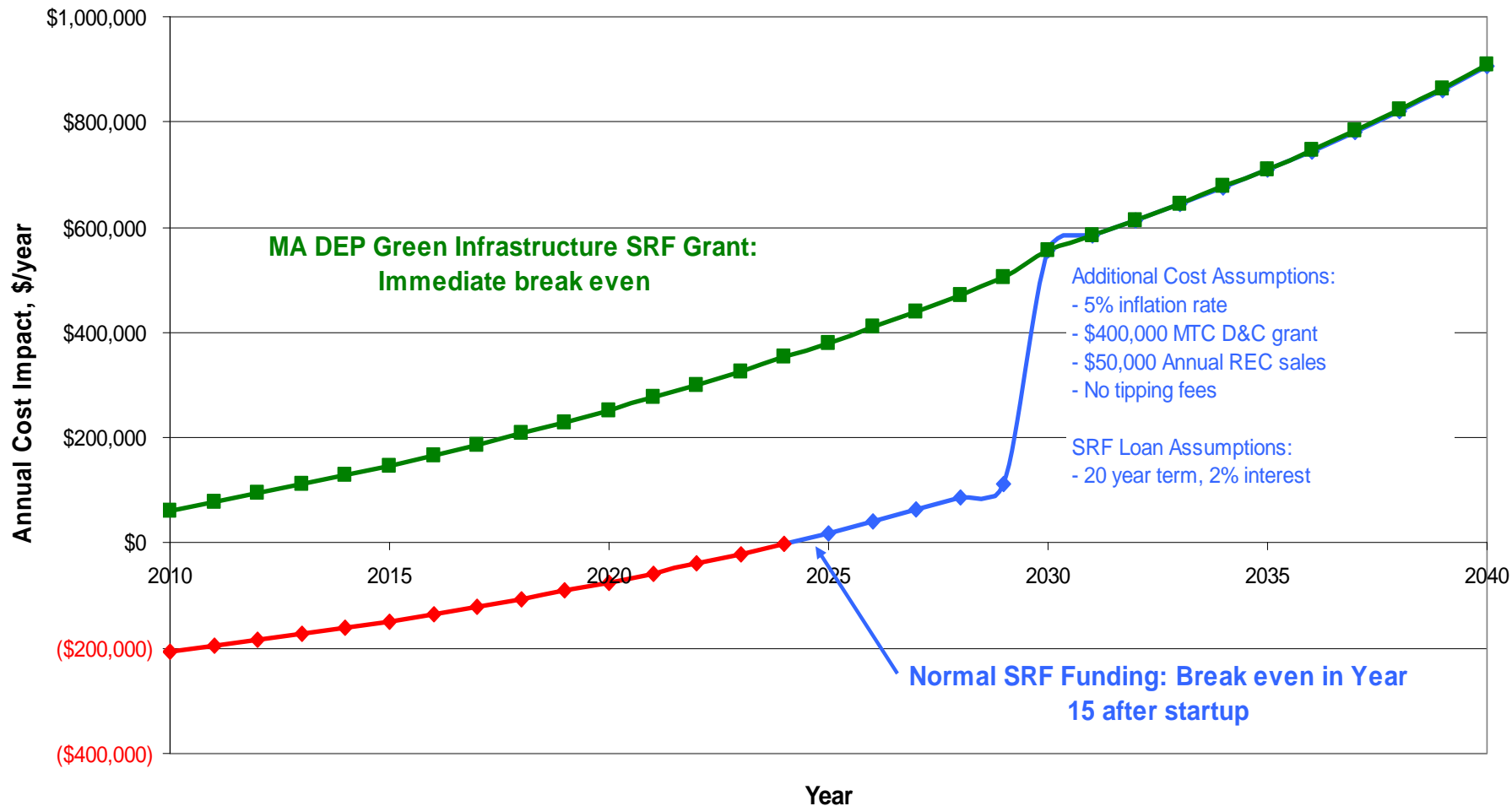
New Anaerobic Digestion and CHP Facility Layout

Design: Costs & Performance

- Contractor low bid: \$7.2 M
- Significant annual operational cost reduction
 - Sludge disposal savings: up to \$135,000
 - Electricity savings: up to \$100,000
 - Potential for additional financial benefits:
 - REC Sales
 - Tipping Fees
- Improved solids inventory control
 - Better clarifier performance with reduction in clarifier blankets
 - Continuous wasting will provide better SRT control

Design: Payback Revisited

Updated Payback Analysis for New Anaerobic Digestion & CHP Facility



Next Steps

- Scheduled
 - Construction: NTP & break ground Jan./Feb 2010
 - Startup: May 2011
- Future Plans
 - Market study on FOG, contracts with FOG haulers
 - High strength thickener return stream management (DAFT, GBT)
 - Performance monitoring
 - Sludge reduction
 - Digester gas, electric power & heat production

Takeaway

- Anaerobic digestion & CHP at small WWTFs is feasible & beneficial
 - Project/WWTF drivers
 - High cost of energy & biosolids disposal
 - Digester feedstock enhancement, availability of volatile wastes, solid waste organics ban
 - Cost-effective design approach
 - Industry/market drivers
 - Renewable energy funding & incentives
 - Market response for small scale systems: availability, costs

Questions?

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- Geoffrey Hayworth, II, Chairman
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Brown and Caldwell

- Jim Schettler, Vice President, Energy & CHP Leader