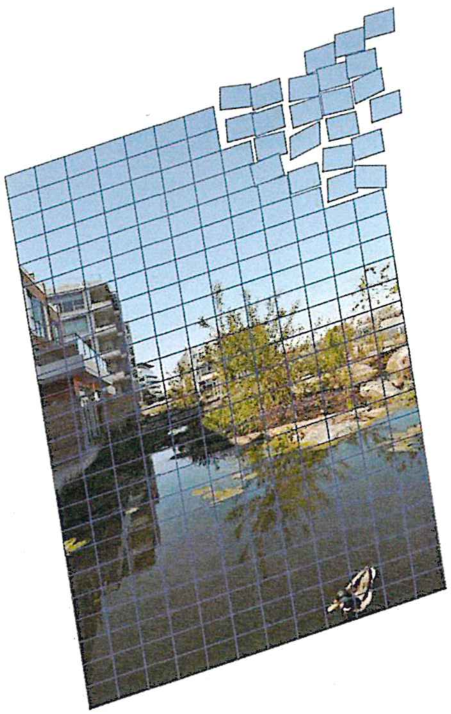


Tertiary Wastewater Treatment & Advanced Gasification

CALWMC

9th June, 2015

Graeme Bethell
Chris Corps

Laura Marcolini
Jack Gardiner
Matt Hart

pivotal

Introduction : Integrated Wastewater Treatment Solutions

- Wastewater Treatment
  - Fixed bed biofilm technology
  - Norwegian
  - Fabricated in US, Canada, Norway
- Biosolids Treatment
  - Advanced gasification
  - US, Austria & Italy
  - Fabricated in Sidney BC & the US
- Integrated Resource Management
  - Optimizes efficiencies & resource recovery
  - Combined business case

pivotal integrated resource management

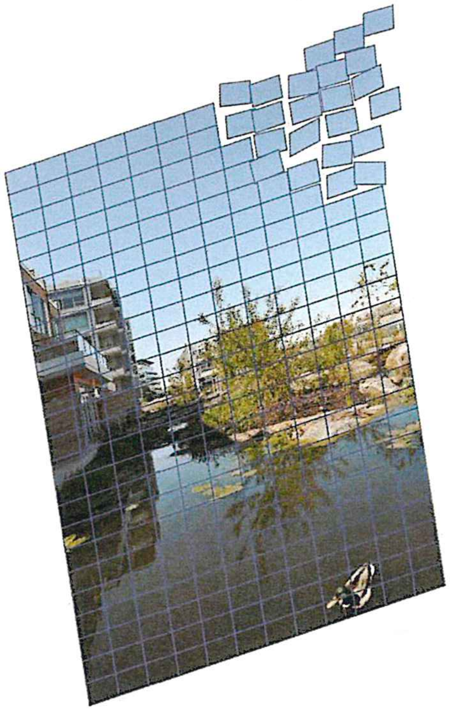
BIOWATER TECHNOLOGY

WESTBIOFUELS

UC San Diego

UC DAVIS UNIVERSITY OF CALIFORNIA

TU WIEN TECHNISCHE UNIVERSITÄT WIEN Vienna University of Technology



Biowater Technology

Continuous Flow Intermittent Cleaning

Liquid Waste Treatment

Proposed System

Primary Treatment

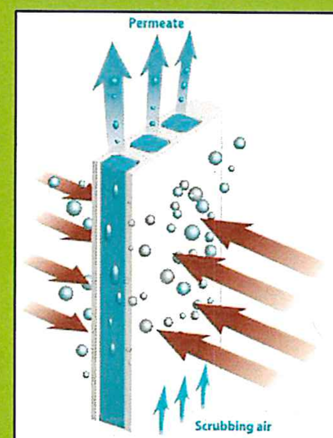
Salsnes Filter

Secondary Treatment

CFIC® System

Tertiary Treatment

Ultrafiltration Membranes



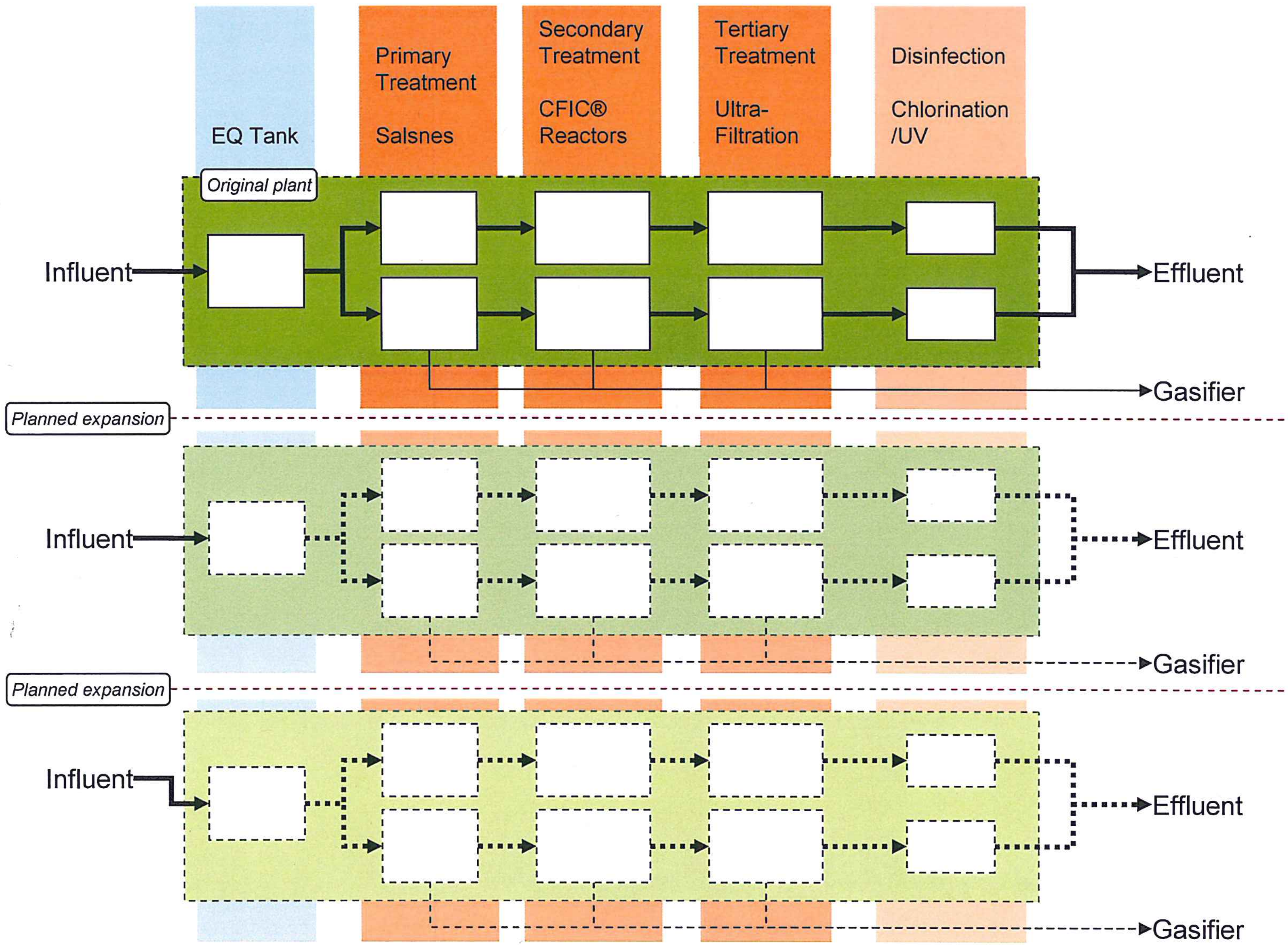
Sludge Management

Advanced Gasifier

Process

- Grit and trash removed
- Primary treatment is screened to separate sludge and water
  - Designed for 4x avg. dry weather flow
- CFIC® biofilm carriers provide secondary treatment to remove organic material
  - Designed for 2x avg. dry weather flow
  - Removes nitrogen
  - Exceeds treatment standards
- Tertiary treatment using ultrafiltration
- Disinfection
- Sludge ➔ thickened ➔ gasifier

Simple Modular Expansion



Project		Client	Nature	New/upgrade	Year/status	Country	Type	ML/day	BOD mg/L	Media Type/ Quantity m^3
1	Vike RA	Hof Kommune	Municipal	Upgrade	2009	Norway	A	1.68 MLd	182	BWT-X/30
2	Kimberly Clark	Haztec	Pulp, Paper	Upgrade	2009	Brazil	B	4.80 MLd	600	BWT35/10
3	Standard Process	Environmental Health	Food & Bev	Upgrade	2009	USA	D	0.77 MLd	1,500	BWT-X/35
4	Trysil RA	Municipality of Trysil	Municipal	New	2010	Norway	E	10.73 MLd	225	BWT-X/252
5	Vigor, Sao Paulo	Acqua Engenharia	Dairy	Upgrade	2010	Brazil	B	1.20 MLd	1,800	BWT35/246
6	Harestua RA	Municipality of Lunnar	Municipal	Upgrade	2011	Norway	F	1.92 MLd	180	BWT-X/58
7	Elverom RA	Norde Land Municipality	Municipal	Upgrade	2011	Norway	B	0.24 MLd	150	BWT-X/8
8	Medite	Evergreen Engineering	Pulp, Paper	Upgrade	2011	Ireland	B	1.20 MLd	2,000	BWT-X/143
9	Pachuca STP	Iberaltec	Municipal	Upgrade	2011	Mexico	D	8.64 MLd	350	BWT15/390
10	Sintek	Eco Digital	Electronics	Upgrade	2011	Taiwan	D	1.49 MLd	400	BWT35/380
11	Nordfjord Kjott	Nordfjord Kjott	Food & Bev	Upgrade	2011	Norway	C	0.58 MLd	1,650	BWT-X/57
12	Aaregau WWTP	JS Umwelttechnik	Municipal	Upgrade	2012	Switzerland	D	2.02 MLd	194	BWT15/84
13	Roros RA	Roros Kommune	Municipal	Upgrade	2012	Norway	A	4.80 MLd	186	BWTX/115
14	Flums	JS Umwelttechnik	Municipal	Upgrade	2012	Switzerland	D	3.60 MLd	200	BWT15/150
15	Wetico	Weitco	Industrial	New	2012	Saudi Arabia	A	2.02 MLd	250	BWTX/232
16	Kan PaK	Kan Pak	Food & Bev	New	2012	USA	A	0.98 MLd	2880	BWTX/300
17	Schoftland	JS Umwelttechnik	Municipal	Upgrade	2012	Switzerland	D	4.01 MLd	168	BWT15/205
18	Bloomingdale	Fleis & Vanderbrink Eng.	Municipal	Upgrade	2013	USA	A	0.46 MLd	575	BWTX/129
19	Barlidalen	Barlidalen Municipality	Municipal	Upgrade	2012	Norway	A	20.40 MLd	120	BWTX
20	Saignelegier	JS Umwelttechnik	Municipal	Upgrade	2012	Switzerland	A	1.44 MLd	233	BWT15/193
21	Langmatt	JS Umwelttechnik	Municipal	Upgrade	2012	Switzerland	D	28.70 MLd	91	BWT15/496
22	Teck Coal	H_2Flow	Mining	New	Under Constrn	Canada	A	7.90 MLd	40	BWTX/141
23	Johanna Foods	Johanna Foods	Food & Bev	Upgrade	Under Constrn	USA	G	1.51 MLd	4500	BWTX/561
24	RPM	H_2Flow	Plastics Recycling	New	Under Constrn	Canada	A	0.20 MLd	737	BWTX/9
25	Wickford Village	Ricci Drain-Laying Co., Inc.	Municipal Package Plant	New	2013	USA	D	0.10 MLd	12	BWTX/9
26	Garcia, Blummenau	Memphis Empreendimentos	Municipal	New	2013	Brazil	A	11.35 MLd	84	BWTX/120
27	Camp Neosa	Stephen Buckley	Municipal Package Plant	New	2013	USA	A	0.10 MLd	250	BWTX
28	Vitasoy	Vitasoy	Food & Bev	Upgrade	Under Constrn	USA	G	0.57 MLd	7,000	BWT-S
29	Givaudan Fragrance	Process Equipment Sales	Pharmaceutical New	New	New/Design	USA	G	0.15 MLd	5,000	BWTX
30	Waste Management	Aqua Tec	Leachate	Upgrade	2013	USA	A	0.04 MLd	500	BWTX
31	Vigor - Lima Duarte (MG)	Memphis	Food & Bev Dairy	Upgrade	2013-2014	Brazil	A	0.50 MLd	2,500	BWTX/108
32	Vigor - Santa Rita de Ibitipoca (MG)	Memphis	Food & Bev Dairy	Upgrade	2013-2014	Brazil	A	0.25 MLd	2,500	BWTX/54
33	Norsk Spesialolje	NSO AS	Industrial	New	2013	Norway	G	0.19 MLd	120	BWT X
34	Saulekilen RA	Sweco AS	Municipal	Upgrade	2014	Norway	A	25.44 MLd	200	BWT15

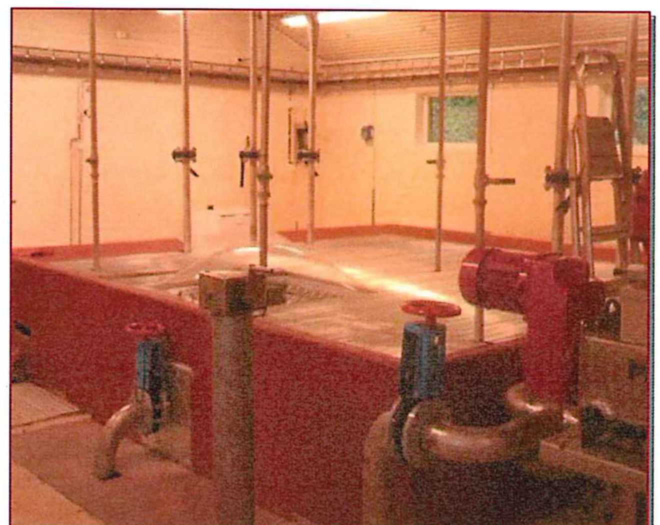
Type of technology

A	CMFF®
B	CMFF®(MBBR)
C	CMFF®(MBBR)/Chemical Precip
D	CFAS®
E	CFAS®/ Flotation
F	CFAS®/ Flotation (turnkey)
G	CFIC®

BIOWATER TECHNOLOGY → pivotal

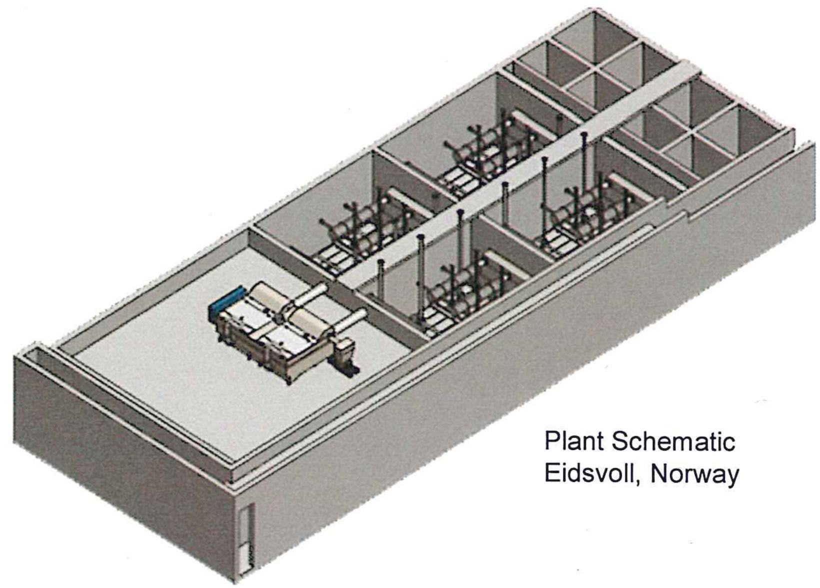
West Side Treatment Example

- CRD specification
  - 2x dry weather flow
  - Secondary treatment
  - Discharge to sea
- Biowater/Pivotal approach
  - 4x dry weather flow
  - Tertiary disinfected
  - Reuse water or recharge creeks
  - 25m x 50m footprint
- Differences
  - 2km outfall
  - Near-waterfront or waterfront siting
  - Footprint, just-in-time expansion
  - Lower capital & operating cost, debt impacts

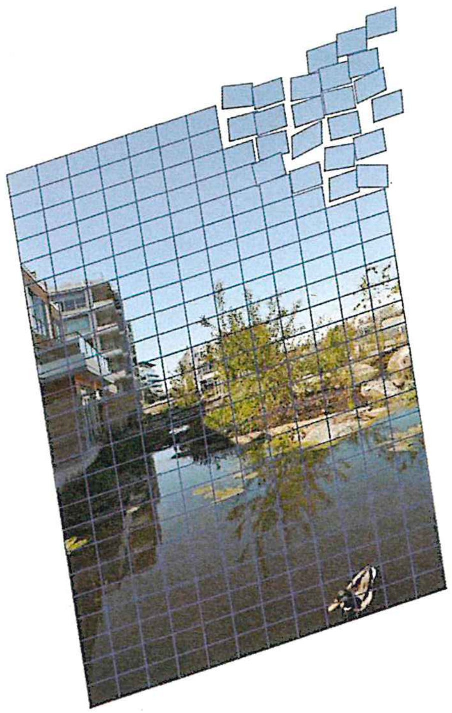


CFIC® System Benefits

- Enables distributed tertiary treatment
  - Low capital and operating costs
  - Highly scalable and compact
  - Modular design
- Avoids over-building large systems
  - Expand as/when/where needed
  - Minimizes taxpayer debt
- Dewaters sludge on-site
- Concentrates & manages hazardous & toxic compounds
- Reduce greenhouse gas emissions
- Maximizes resource recovery



Plant Schematic
Eidsvoll, Norway

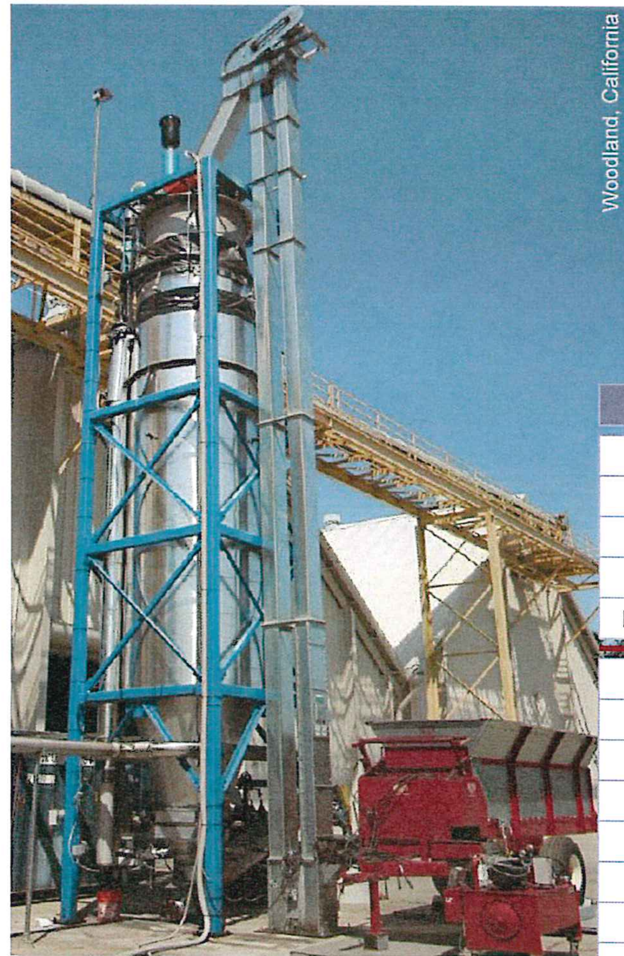


Pivotal IRM

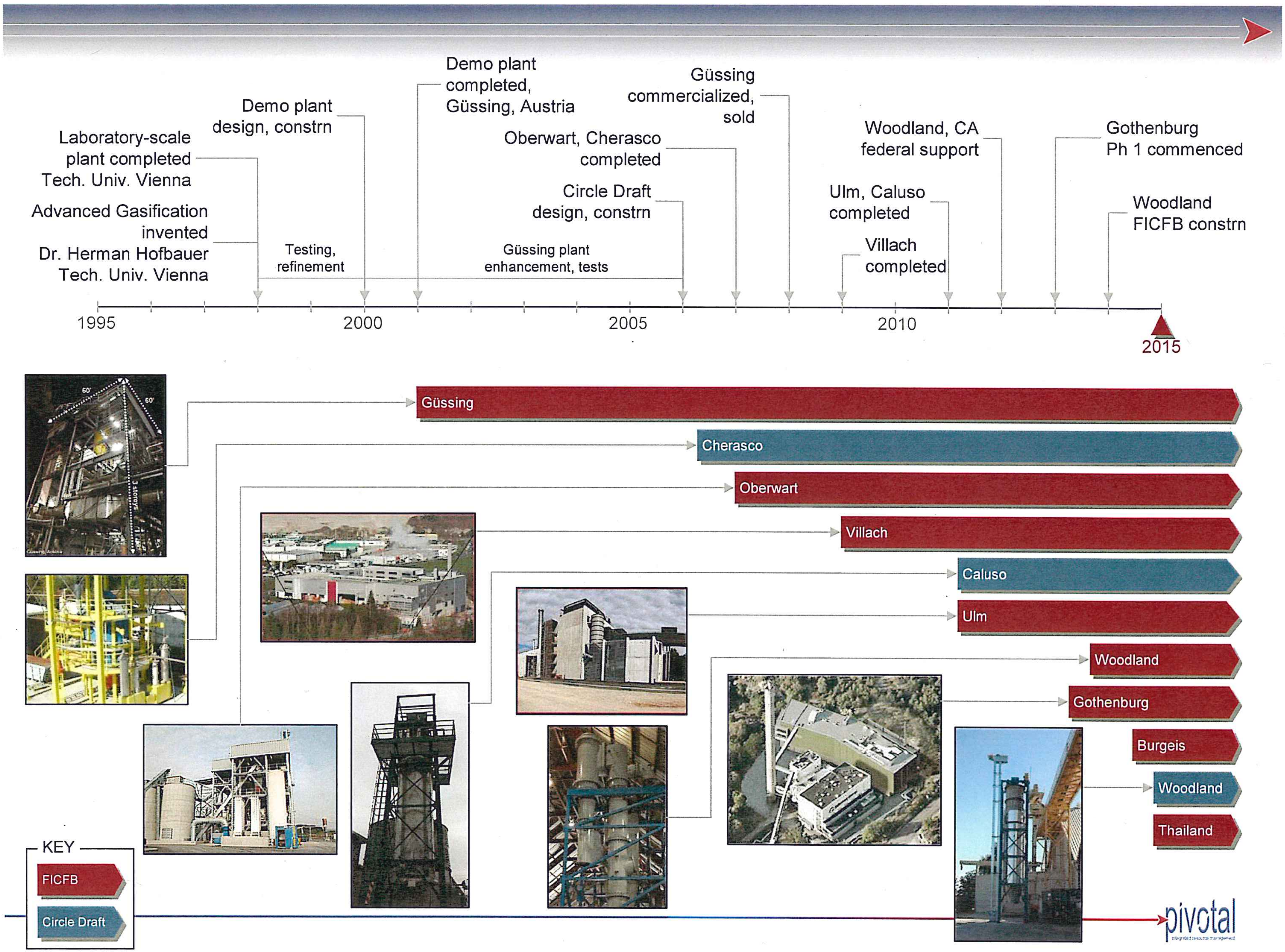
Advanced Gasification

Technology

- Circle Draft Advanced Gasifier
  - Not incineration
  - Modified updraft gasification process
  - Developed since 2007
- Modular system
  - Single unit: 11 tonnes biomass/waste per day
    - Multi-unit systems for CRD
  - Feedstock: wood, MSW/RDF, sludge, etc
  - ≈12 months delivery
- Output
  - Energy
    - Heating, cooling
    - 500 kW electricity and 790 kW heat (ea.)
  - Biochar and ash
  - Distilled water
  - Emissions: ≈natural gas boiler

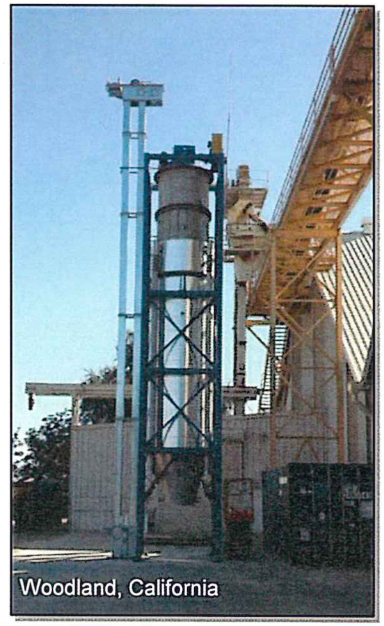


Composition	
H_2	20-33%
CO	16-47%
CH_4	~2-4%
CO_2	~0-14%
H_2:CO	1:1
C_2H_4	2-3%
C_2H_6	~0.5%
C_2H_2	~0.4%
O_2	< 0.1%
N_2	1-3%
C_6H_6	~8g/m³
C_7H_8	~0,5g/m³
$C_{10}H_8$	~2g/m³
TARS	~20mg/m³


Laboratory-scale plant completed Tech. Univ. Vienna
Advanced Gasification invented Dr. Herman Hofbauer Tech. Univ. Vienna
Demo plant design, constrn
Testing, refinement
Demo plant completed, Güssing, Austria
Oberwart, Cherasco completed
Circle Draft design, constrn
Güssing plant enhancement, tests
Güssing commercialized, sold
Woodland, CA federal support
Ulm, Caluso completed
Villach completed
Gothenburg Ph 1 commenced
Woodland FICFB constrn
1995
2000
2005
2010
2015
Güssing
Cherasco
Oberwart
Villach
Caluso
Ulm
Woodland
Gothenburg
Burgeis
Woodland
Thailand
KEY
FICFB
Circle Draft
pivotal

Sludge Options – Circle Draft Advanced Gasifier

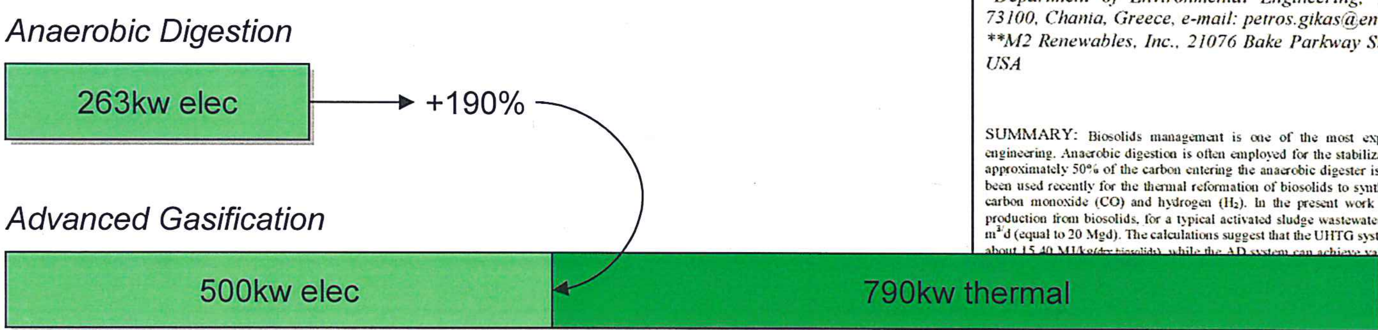
- Three operating plants
  - Cherasco & Caluso, Italy – 2007, 2011
  - Woodland, CA – Under commissioning
  - **50/50 mix of sludge/biomass**
- Benefits
  - Extremely small, nearly silent, safe
  - Low Capital and Operating costs
  - Generate green energy
    - Heating, cooling & power
    - Clean as natural gas
    - Complies with Clean Energy Act
  - Increases recycling
  - Address ≈60% of Hartland's volume

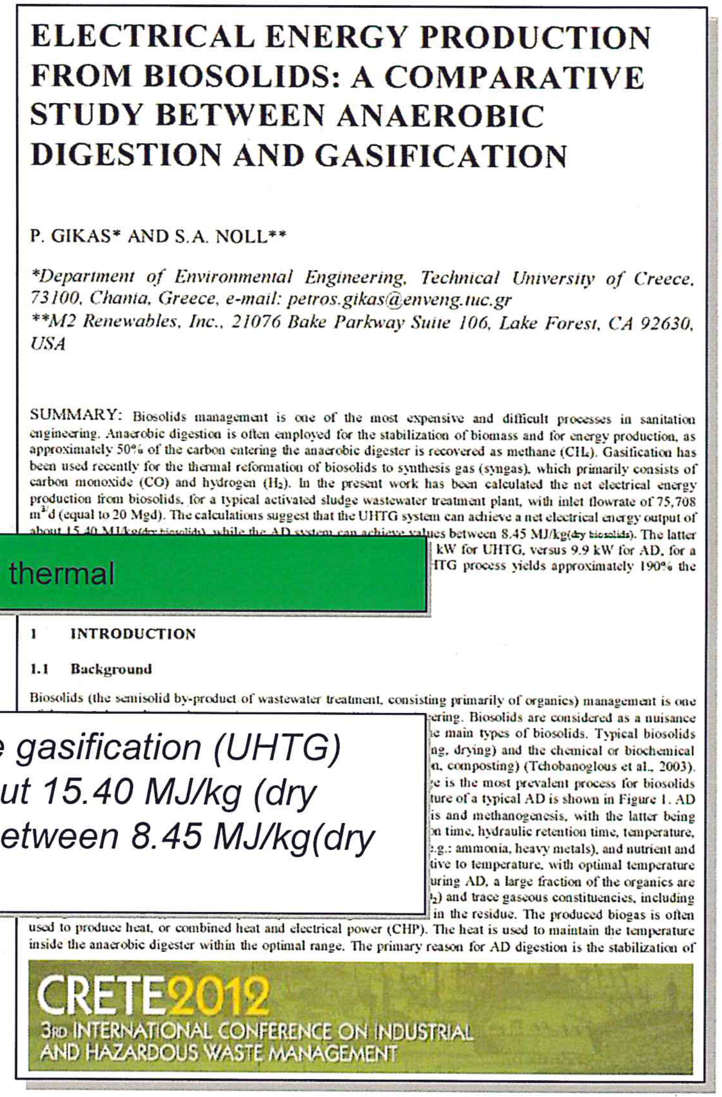


Comparison of Gasification Technologies

Criteria	FIXED BED GASIFIERS				ROTARY KILN	FLUIDIZED BED GASIFIERS	
	Grate	Updraft	Downdraft	Circle Draft Advanced Gasifier	Inclined	Stationary	FICFB
Feedstock variability	limited	limited	limited	multifuel	moderate	moderate	multifuel
Feedstock processing	low	moderate	moderate	high	low	high	high
Gasification agent	air	air	air	air/steam	air/steam	air/steam	steam
Robustness	moderate	moderate	moderate	high	moderate	moderately high	high
Gasifier Temperature	600 °C	550 °C	1000 °C	1050 °C	500 °C	650 °C	850 °C
Energy recovery efficiency	80%	80%	70%	<75%	70%	80%	89%
Tars (mg/m³)	1,000	1,000	1,000	<20	500	50	20
Flyash (Kg/Tonne)	>50	>50	50	N/A	>50	25	8
Pollutant formation	high	high	moderate	low	high	moderate	low
Residual grate ash & biochar	5-20 %	5-20 %	5-20 %	15%	5-20 %	5-10 %	0%
Product gas							
Hydrogen	15	20		21	25	N/A	40
Carbon monoxide	10	10		30	20	N/A	22
Carbon dioxide	20	20		26	25	N/A	20
Methane	4	4		8	5	N/A	10
Other Hydrocarbons	3	0		5	3	N/A	5
Nitrogen	48	46		10	22	N/A	3
Calorific value (mJ/kg)	4	6		10	6	N/A	13

Generation Comparison





ELECTRICAL ENERGY PRODUCTION FROM BIOSOLIDS: A COMPARATIVE STUDY BETWEEN ANAEROBIC DIGESTION AND GASIFICATION

P. GIKAS* AND S.A. NOLL**

**Department of Environmental Engineering, Technical University of Creece, 73100, Chania, Greece, e-mail: petros.gikas@enveng.tuc.gr*
***M2 Renewables, Inc., 21076 Bake Parkway Suite 106, Lake Forest, CA 92630, USA*

SUMMARY: Biosolids management is one of the most expensive and difficult processes in sanitation engineering. Anaerobic digestion is often employed for the stabilization of biomass and for energy production, as approximately 50% of the carbon entering the anaerobic digester is recovered as methane (CH_4). Gasification has been used recently for the thermal reformation of biosolids to synthesis gas (syngas), which primarily consists of carbon monoxide (CO) and hydrogen (H_2). In the present work has been calculated the net electrical energy production from biosolids, for a typical activated sludge wastewater treatment plant, with inlet flowrate of 75,708 m^3/d (equal to 20 Mgd). The calculations suggest that the UHTG system can achieve a net electrical energy output of about 15.40 MJ/kg(dry biosolids), while the AD system can achieve values between 8.45 MJ/kg(dry biosolids). The latter
... kW for UHTG, versus 9.9 kW for AD, for a
...ITG process yields approximately 190% the

1 INTRODUCTION

1.1 Background

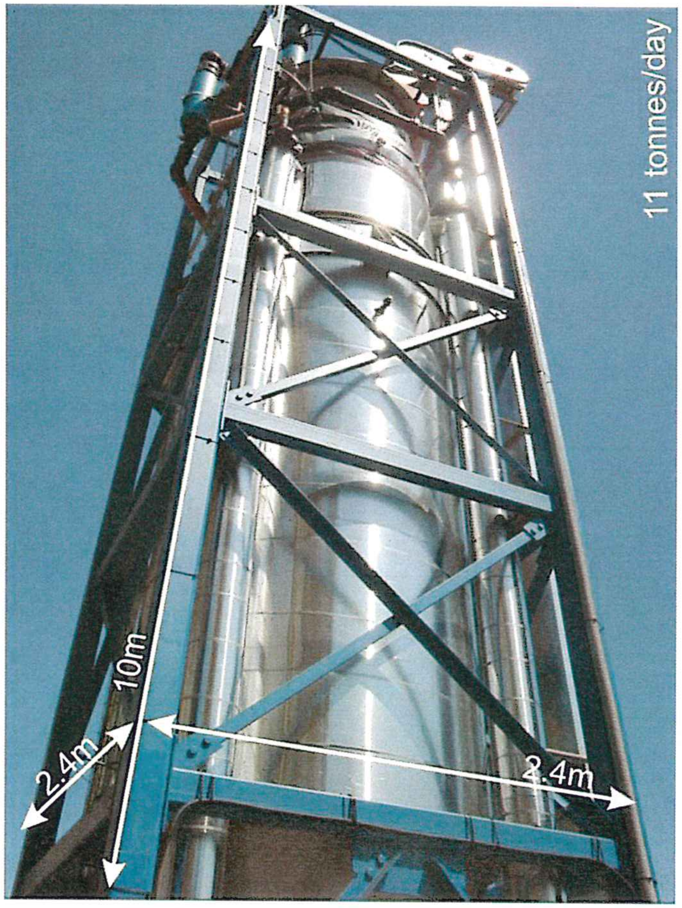
Biosolids (the semisolid by-product of wastewater treatment, consisting primarily of organics) management is one
...ering. Biosolids are considered as a nuisance
...e main types of biosolids. Typical biosolids
...ng, drying) and the chemical or biochemical
...n, composting) (Tchobanoglous et al., 2003).
...e is the most prevalent process for biosolids
...ture of a typical AD is shown in Figure 1. AD
...is and methanogenesis, with the latter being
...n time, hydraulic retention time, temperature,
...g.: ammonia, heavy metals), and nutrient and
...tive to temperature, with optimal temperature
...uring AD, a large fraction of the organics are
...) and trace gaseous constituencies, including
... in the residue. The produced biogas is often used to produce heat, or combined heat and electrical power (CHP). The heat is used to maintain the temperature inside the anaerobic digester within the optimal range. The primary reason for AD digestion is the stabilization of

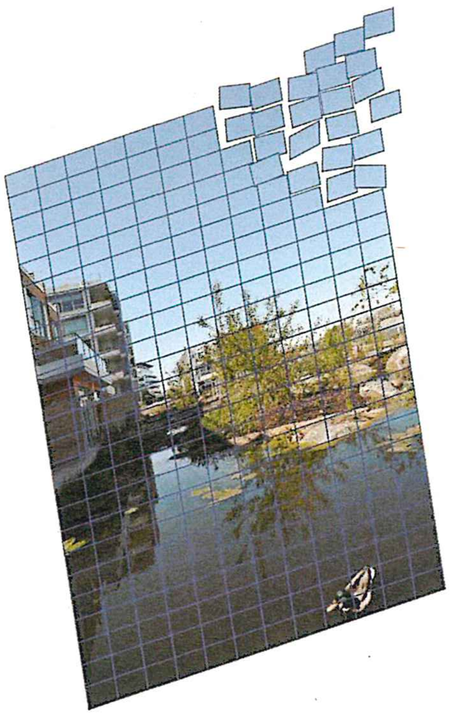
CRETE2012
3RD INTERNATIONAL CONFERENCE ON INDUSTRIAL AND HAZARDOUS WASTE MANAGEMENT

"The calculations suggest that the ultra-high-temperature gasification (UHTG) system can achieve a net electrical energy output of about 15.40 MJ/kg (dry biosolids), whereas the AD system can achieve values between 8.45 MJ/kg(dry biosolids)."

Advanced Gasification Benefits

- Highly scalable, compact & modular, safe and odourless
- More efficient & fraction of the cost of anaerobic digestion
- Destroys harmful materials from entering water and/or land
- Maximizes resource recovery and revenues, improves recycling, maximizes diversion
- Reduces greenhouse gas emissions
- Stimulates economic development
  - Local jobs, R&D, manufacturing
  - Training and education
  - Tourism
- Flagship for green energy/sustainability





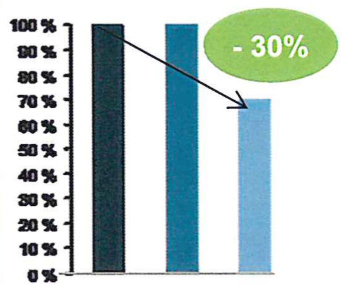
Putting It All Together

Why Integration Pays

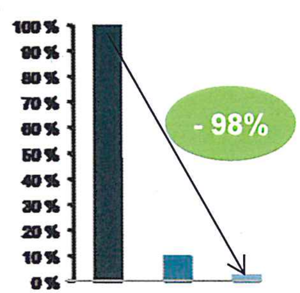
Alternative Approach

Tertiary Treatment

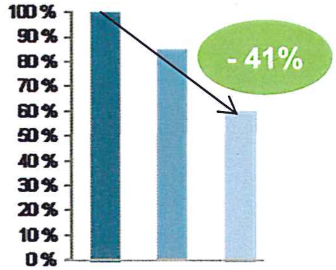
Energy consumption



Solids in effluent



CAPEX



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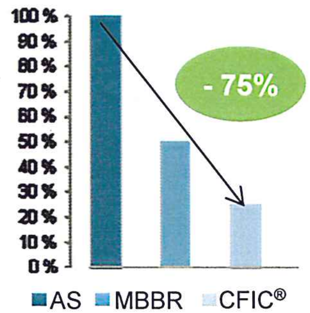
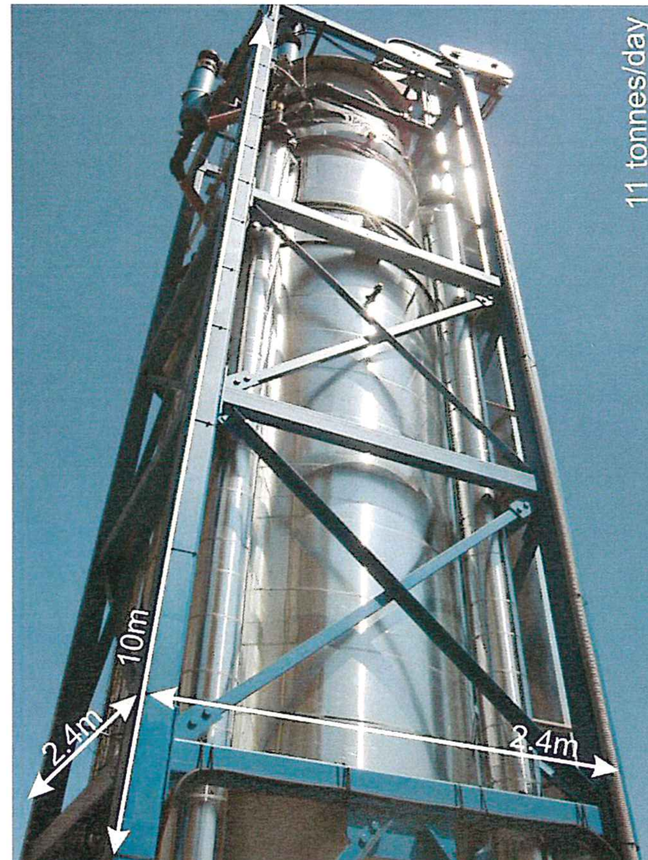
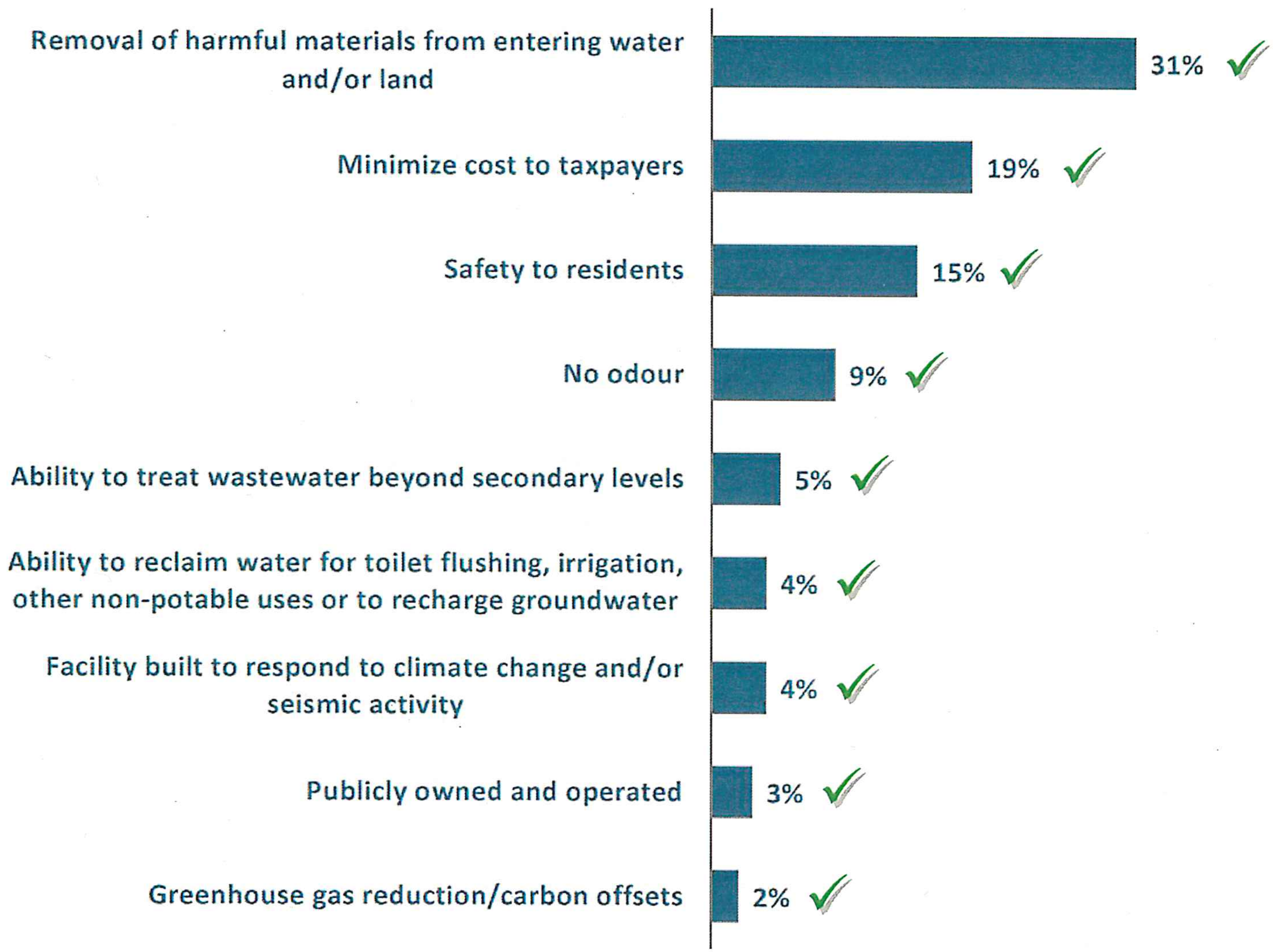


Advanced Gasification



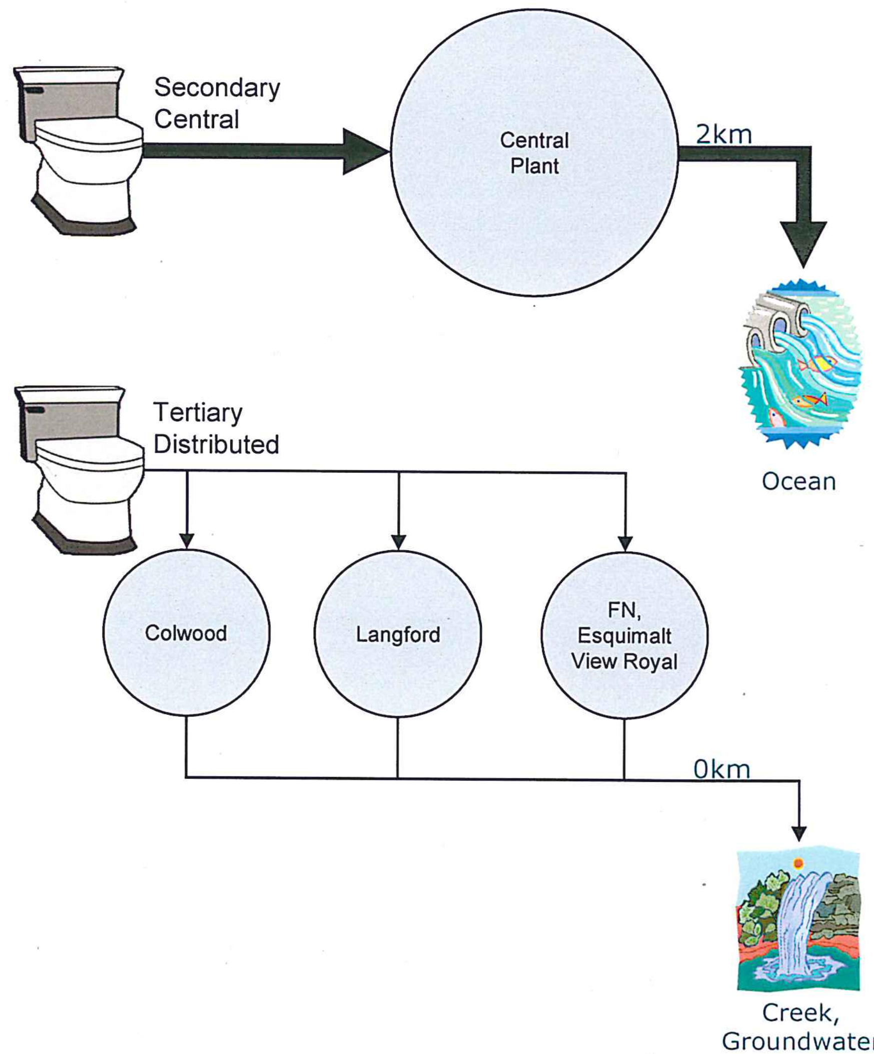
Alignment with Community Objectives

Most Important Criteria



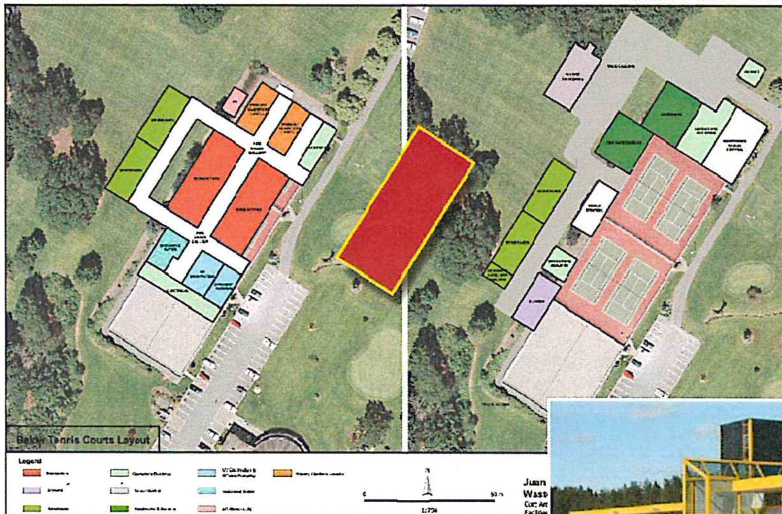
Minimizing Impact, Maximizing Advantages

- Suitable for both distributed & centralized
- Distributed has advantages
  - Cost advantages
    - Avoids new pipes
    - Reduced or similar capital & operating cost
    - Reduced taxpayer charges and debt load
    - Considerably lower developer cost
  - Resilience & risk management
    - Reuse/recycling of heat & water maximized
    - Localized expansion as/when/where needed
  - But: extra public process
- Treatment site comparison
  - 036-DP west side : 38,202 m^2
  - Pivotal/Biowater : ≈2,000 m^2 (<5%)
  - Minimal site impact – locate in spare land

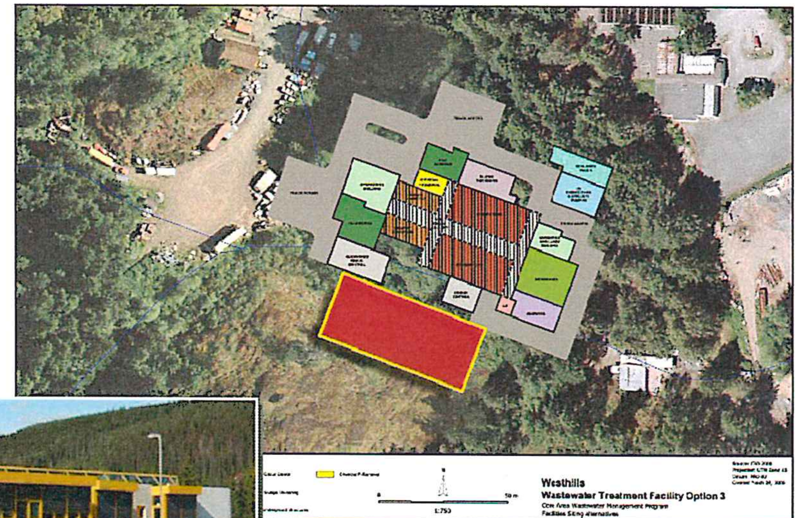


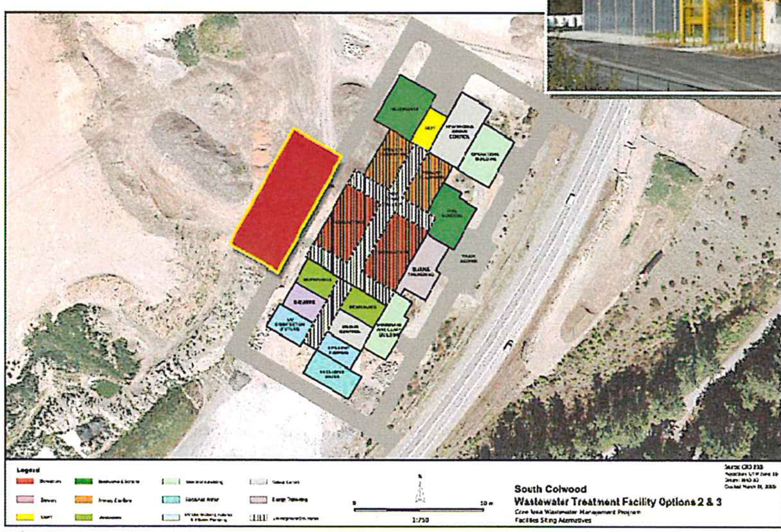
036-DP : Four West Side Sites

Juan de Fuca



Westhills

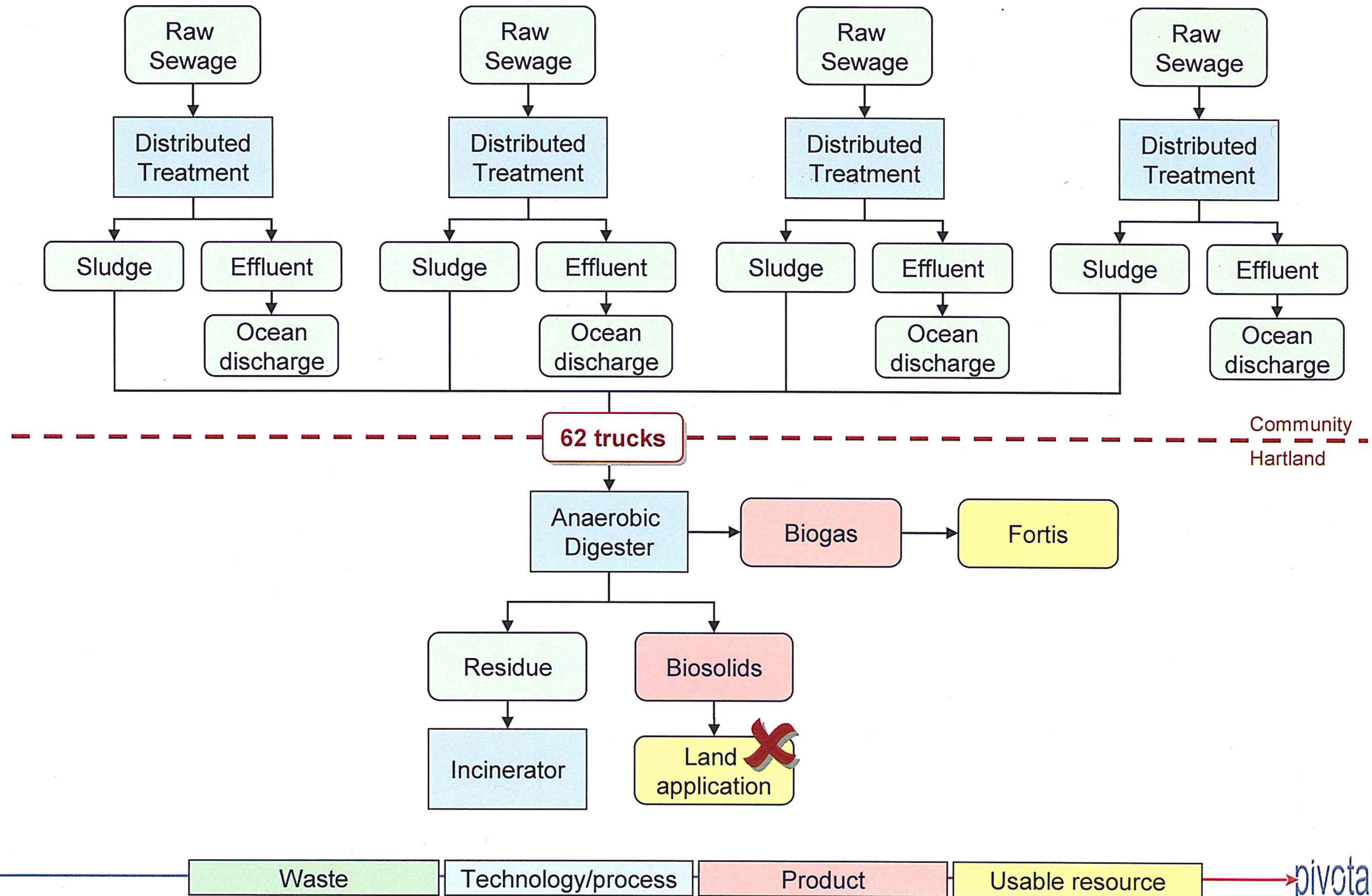




Royal Bay

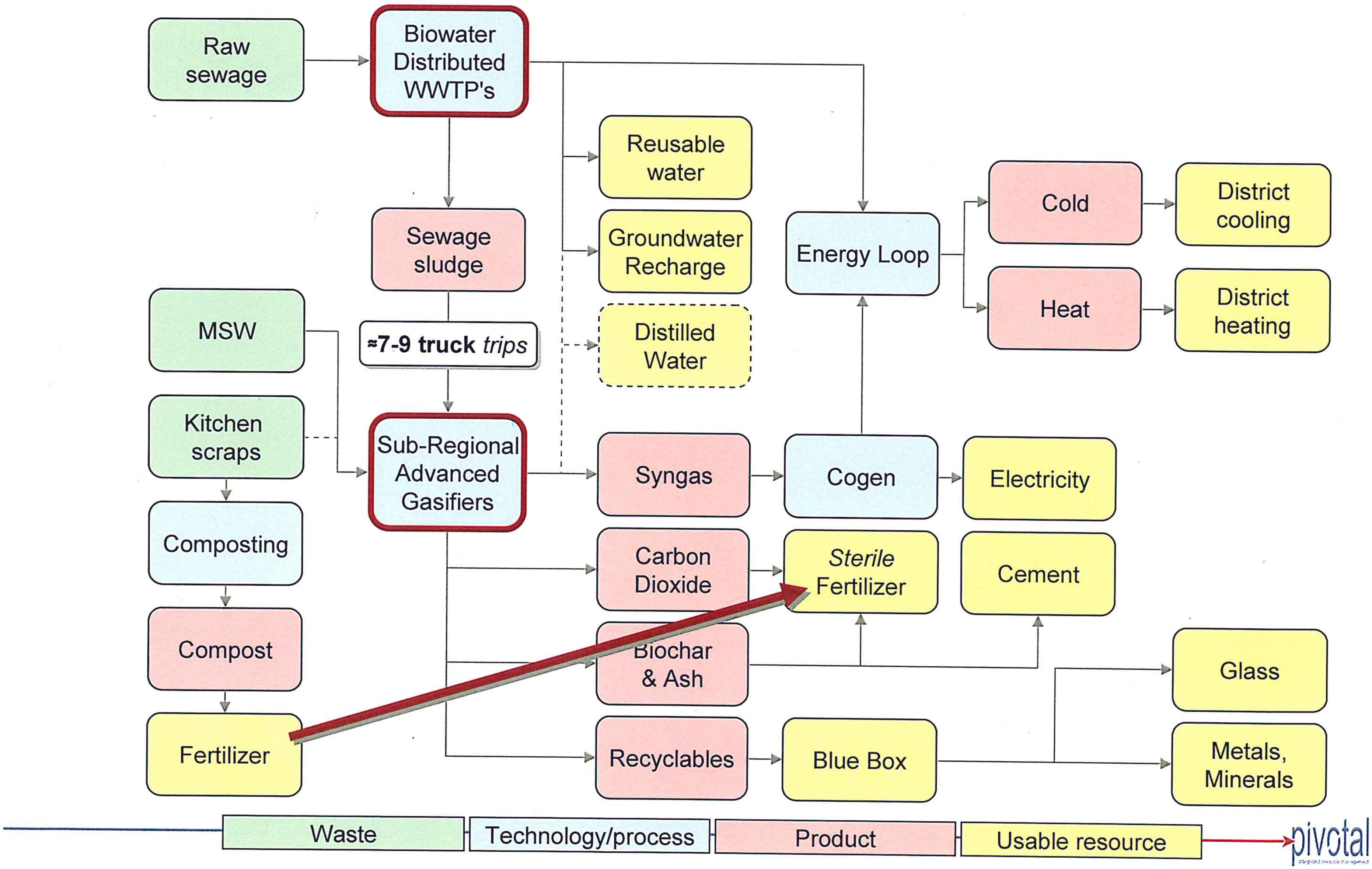
Florence Lake

Trucking Sludge to Gasifier

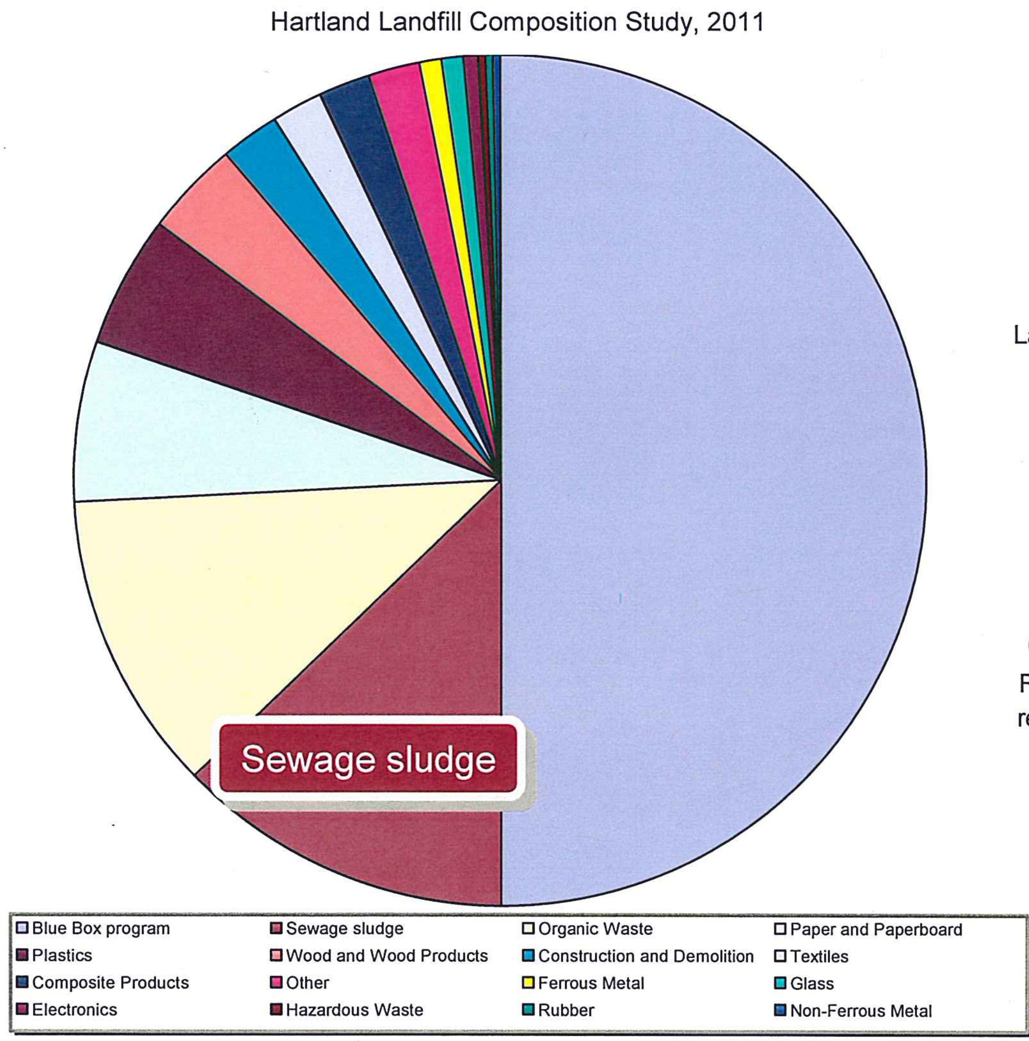


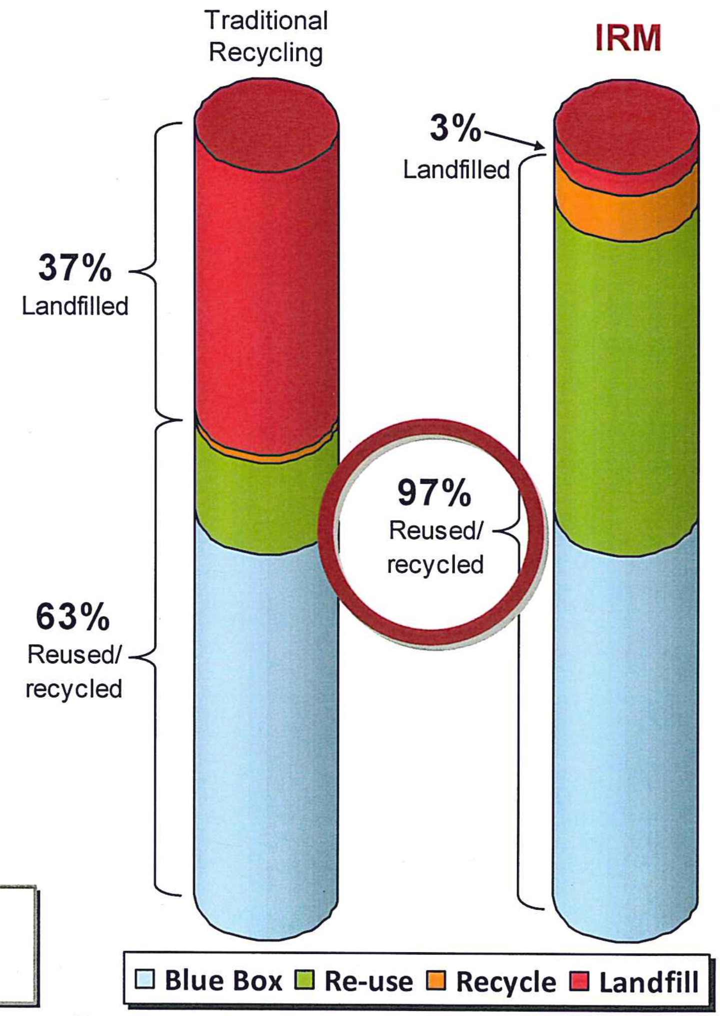
pivotal

Trucking Sludge to Gasifier



Incidental Benefit : 97% Maximum Diversion





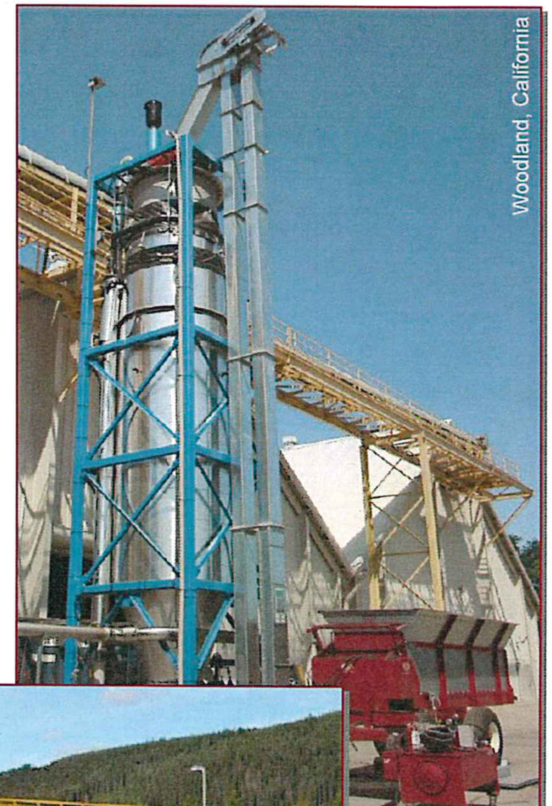
Summary

CRD data	Total	East side	West side
Total projected sewage volume	*108 ML/day*	*83 ML/day*	*25 ML/day*
Total average daily sludge volume	*29 TPD*	*22 TPD*	*7 TPD*
Pivotal/Biowater			
Potential recycled water	39,026 ML/yr	29,968 ML/yr	9,058 ML/yr
Potential distilled water	27 ML/yr	21 ML/yr	6 ML/yr
Potential electrical generation	43,800 mwh/yr	33,634 mwh/yr	10,166 mwh/yr
Potential thermal generation	69,204 mwh/yr	53,142 mwh/yr	16,062 mwh/yr
Potential char production	*3,592 t/yr*	*2,759 t/yr*	*834 t/yr*
Potential GHG CO_2e reduction	*265,841 t/yr*	*204,141 t/yr*	*61,700 t/yr*

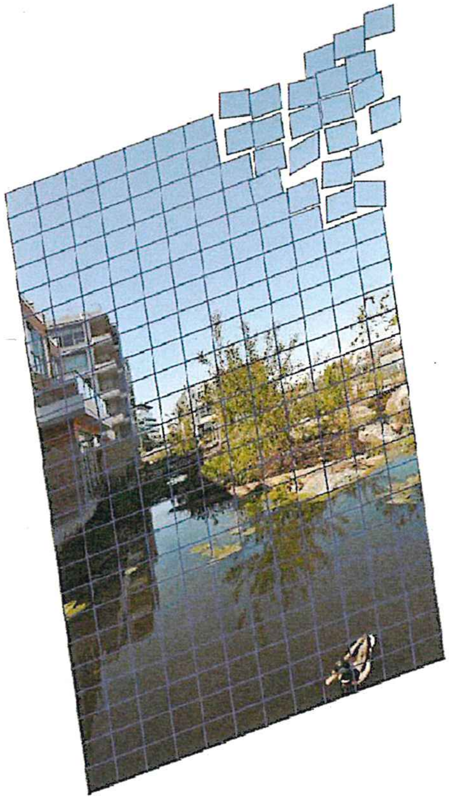
	Total Capital	LCC
CRD Plan	$784m	$3.2bn
Pivotal/Biowater	≈ $250m	???

Summary & Conclusions

- Technologies are proven & stable
- Small plant size empowers & enables options
- "Future proof"
  - Economic modern technologies that exceed all environmental and financial standards
  - Scaleable, J-I-T solutions
  - Simple to expand; reduces both current taxpayer and developers' costs
- Driven by a combined financial & environmental business case
  - *Focus: taxpayer & environmental value*



Questions



Thank you

pivotal integrated resource management

BIOWATER TECHNOLOGY

WESTBIOFUELS

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