Sustainable Treatment
What the Bay Area can learn from the Strass in Zillertal Wastewater Treatment Plant

Enhancing Sustainability Practices of Wastewater Treatment: The Strass Case Study

Dimitri Katehis – CH2M HILL

BACWA
BAY AREA
CLEAN WATER
AGENCIES

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Overview

- Strass WWTP operated by Abwasserverband Achental-Inntall-Zillertal,Strass, Austria
- An Energy-Positive Facility
- Strass's Sustainability Journey
  - Organizational:
    - Defining Sustainability Goals
    - Using Benchmarking Metrics to Target and Communicate Priorities
  - Incorporating Technological Innovation

Defining Sustainability

- Create wealth without impacting the ability of others and future generations' to achieve the same

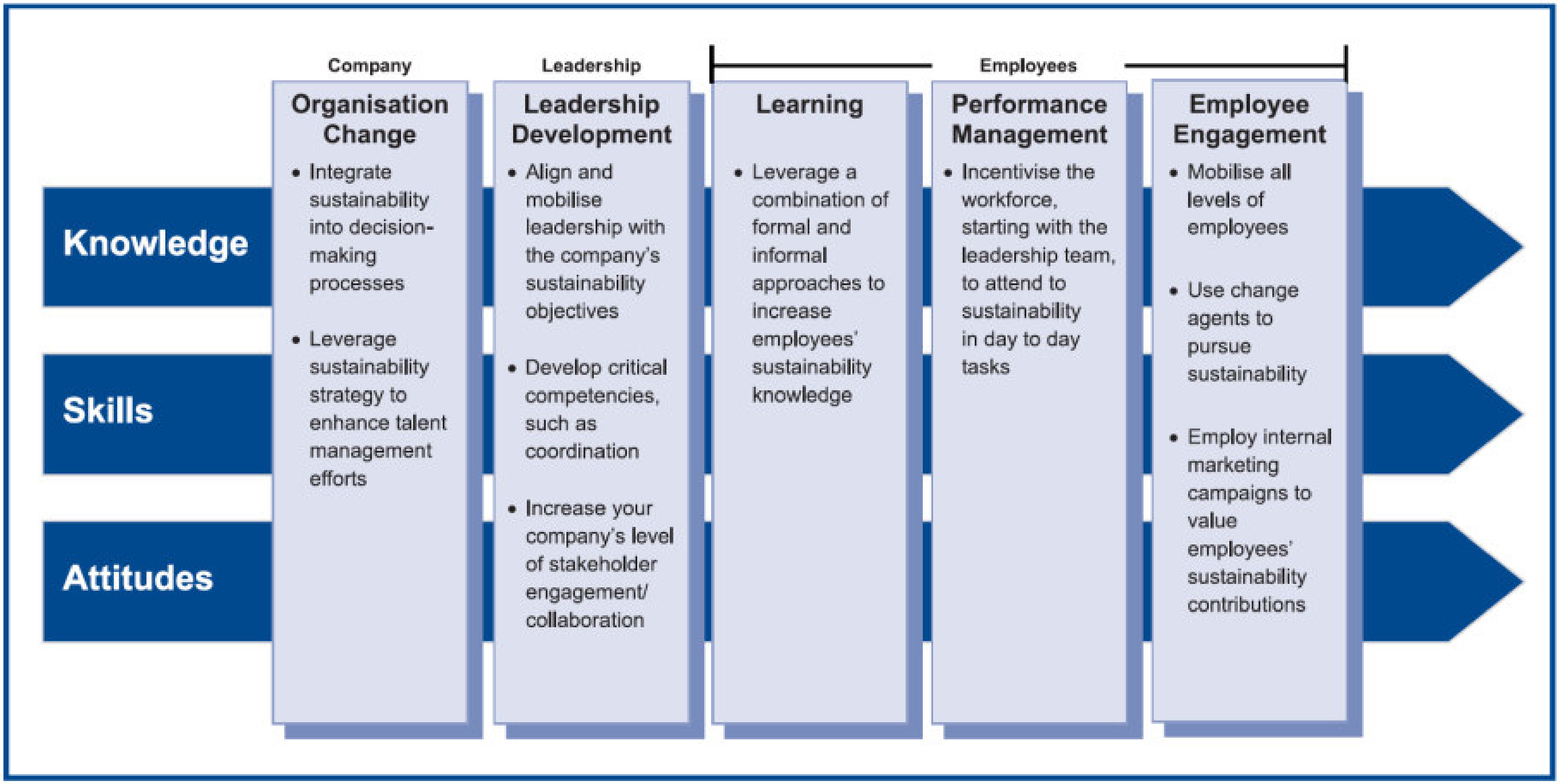
- Mechanism to quantify sustainability
  - People
    - Within the Organization and Beyond
  - Planet
    - Environmental/ Resource Conservation & Management)
  - Profit
    - Financial

Integrating Sustainability

- Sustainability Initiatives Must Be Aligned with Long Term Goals and Utility's Core Mission
  - Compatible with Society's Cultural & Moral Values
  - Environmental Stewardship
  - Financial Stewardship

The Levers of Sustainability

- The 5 Levers (Lacy et al, 2009):

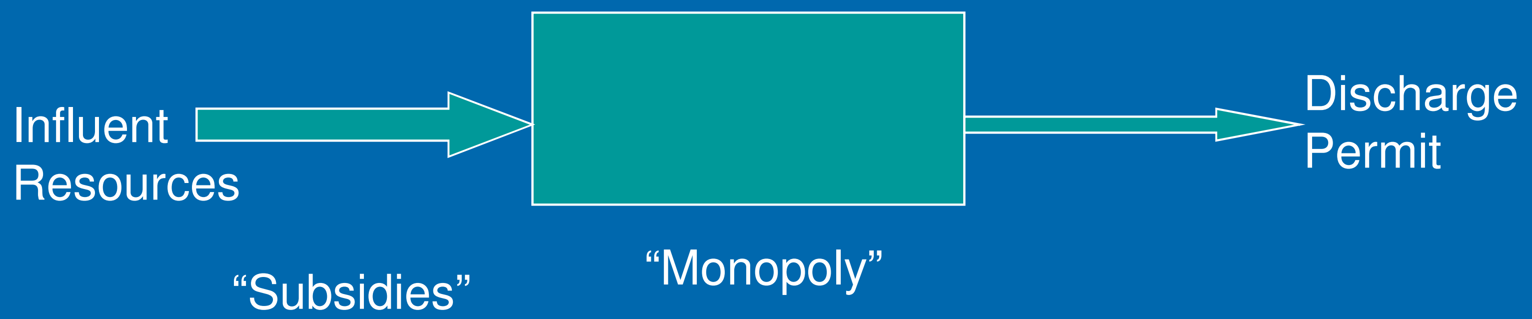


The Levers of Sustainability

- Employee Empowerment
  - Education/Learning
    - Foster the Creation of a Highly Educated Workforce
    - Push for Excellence
  - Performance Management
    - Incorporate Goals that Measure Employee Success Towards the Organizations Sustainability Goals
  - Engagement: Employees as Ambassadors
    - Reinforcing the Image of Public Service In the Community at Large
    - Focus on Material Recovery, High Value Product Generation, Financial Sustainability When Addressing the Business Community

The Case for A More Sustainable Organization

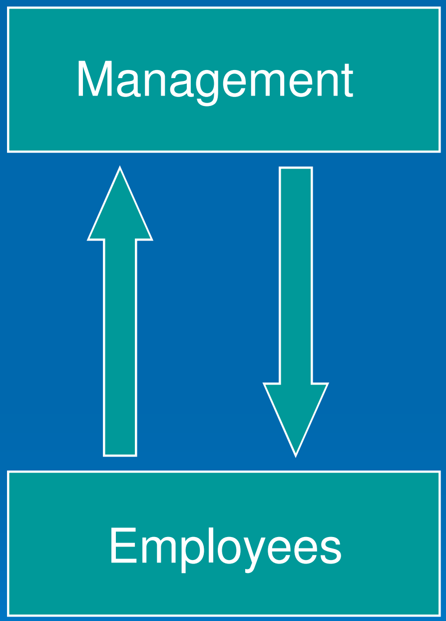
- A Story…



- Drivers for Sustainability at the Strass WWTP
  - Longevity of the Organization
  - Growth
  - Autonomy
  - Recognition

In order to achieve these goals, needed a mechanism to assess where the organization stood at any given point in time

Benchmarking Metrics



- <u>The Challenge</u>:
  - Defining Technically Accurate Metrics that Reflect the Priorities of the Organization

Benchmarking Metrics

Senior Managers Focused on the "Big Picture" →

- $/MG Treated
- kW-h/MG Treated
- kW-hr/lb BOD Removed
- Manhours/MG Treated

Challenge:

1. Can Mask Inefficiencies
2. Directs Attention to Laggards, Diverting Resources From Opportunities
3. Mediocrity is "OK"

Benchmarking Metrics

- Characteristics of Successful Benchmarking Metrics
  - Input Parameters Consistent Across Facilities/Utilities
  - Based on Directly Measurable Quantities
  - Correlate to Core Utility Functions
  - The Proof of a Successful Metric: Employees Monitor Them and Act Upon When Shifts Are Observed

Defining metrics that employees understand and relate to their job functions is the key!

Process Specific Metrics

- Increased Comparative Power:
  - A Greater Degree of Uniformity At the Unit Process Level
- Technically Accurate: Pairing of Parameters with Core Function of Specific Unit Process
- Specificity: Can Drill Down to an Assessment of Core Functions in Job Description (Accountability)
- Acceptance: Users can Relate to Metric and Trend it Because it Supports Mission

Benchmarking Metrics

Process Specificity Can Make the Difference!

Primary Treatment

- ~~kW-hr Consumed/MGD Treated~~
- kg Chemical Consumed/kg BOD Removed
- kg PS Produced/ kg TSS Applied

Secondary Treatment

- ~~kg BOD Removed/MGD Treated~~
- ~~kW-hr Consumed/MGD Treated~~
- kW-hr Consumed/lb BOD Removed

Use Mass Based Process Metrics Will Provide a More Meaningful Measure of Efficiency and Prevent the Proverbial Wild Goose Chase

The European Benchmarking Experience

- Programs in Northern and Central Europe
- Varying Range of Success
  - National Efforts Sparked by a Core Group
  - Increased Transparency for an Otherwise Quiet Sector
  - Opportunity for Exchange of Best Practices during Workshops

Example: The Finnish Approach

Performance Indicators

Performance Indicator	Applicability to Develop Sustainability Matrices
OCP Index	The OCP Index is an indexing parameter developed to measure the efficiency of wastewater treatment. It is calculated based on the influent and effluent pollutant (BOD and nitrogen) loads. This PI, together with the influent and effluent flow data, can be used to estimate the average load of pollutant (BOD and nitrogen) removed per month or per year by the participating wastewater utilities
Operating costs/amount of treated wastewater (euro/cubic meter)	This PI can be used to estimate the average cost of energy and chemicals utilized by the wastewater utilities per year to achieve the desired treatment efficiency. The quantity of energy and chemicals utilized can be approximated from the cost of these resources.

Recognized that the Greatest Opportunities in Wastewater Lay in Energy Utilization

Energy Manuals

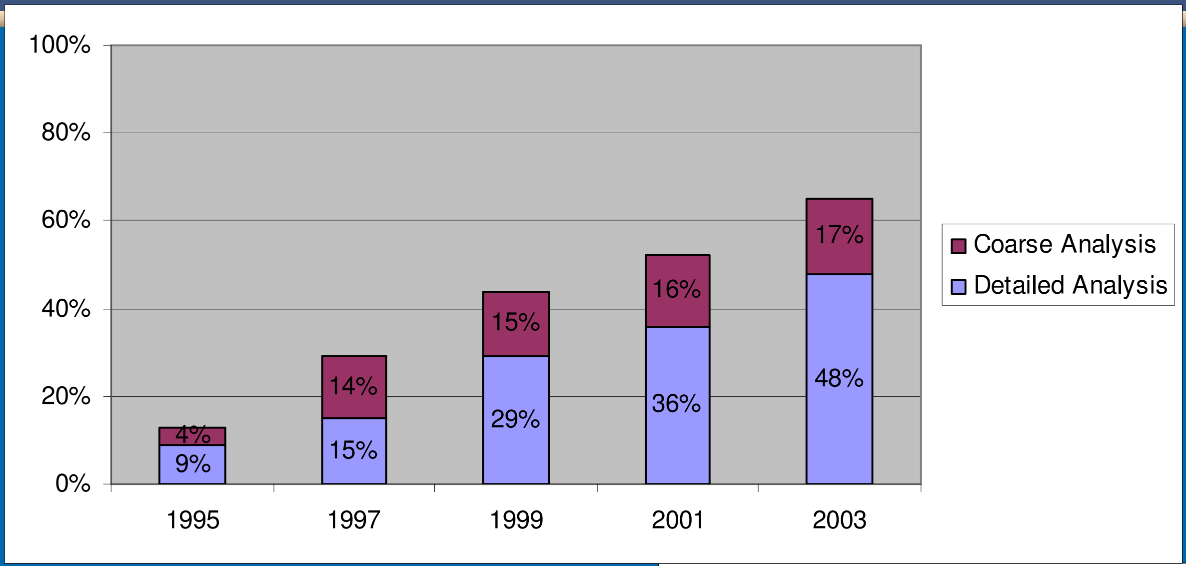
- Swiss Energy Manual, 1994
- North Rhine, Westphalia Energy Manual, 1999
- Austrian Program Based on Swiss Program
  - Two Stage Process
  - Plant Wide and Process Specific Screening
  - Detailed Evaluation if Screening Criteria Met
  - Analysis Software Included

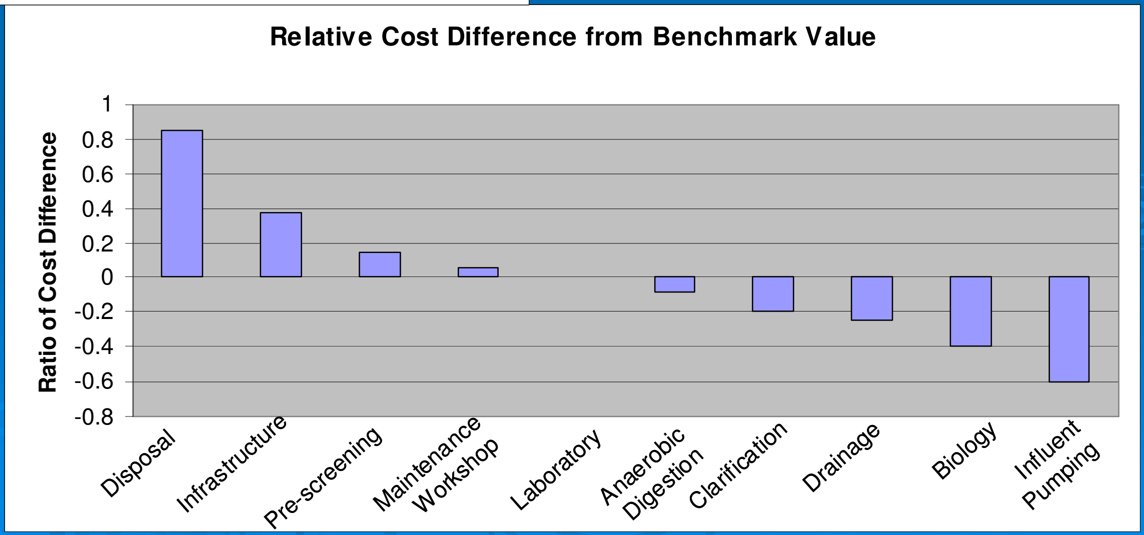
Preliminary Screening Criteria

Assessment of e_{BB} According to the Swiss manual *Energy at WWTPs* (1994).

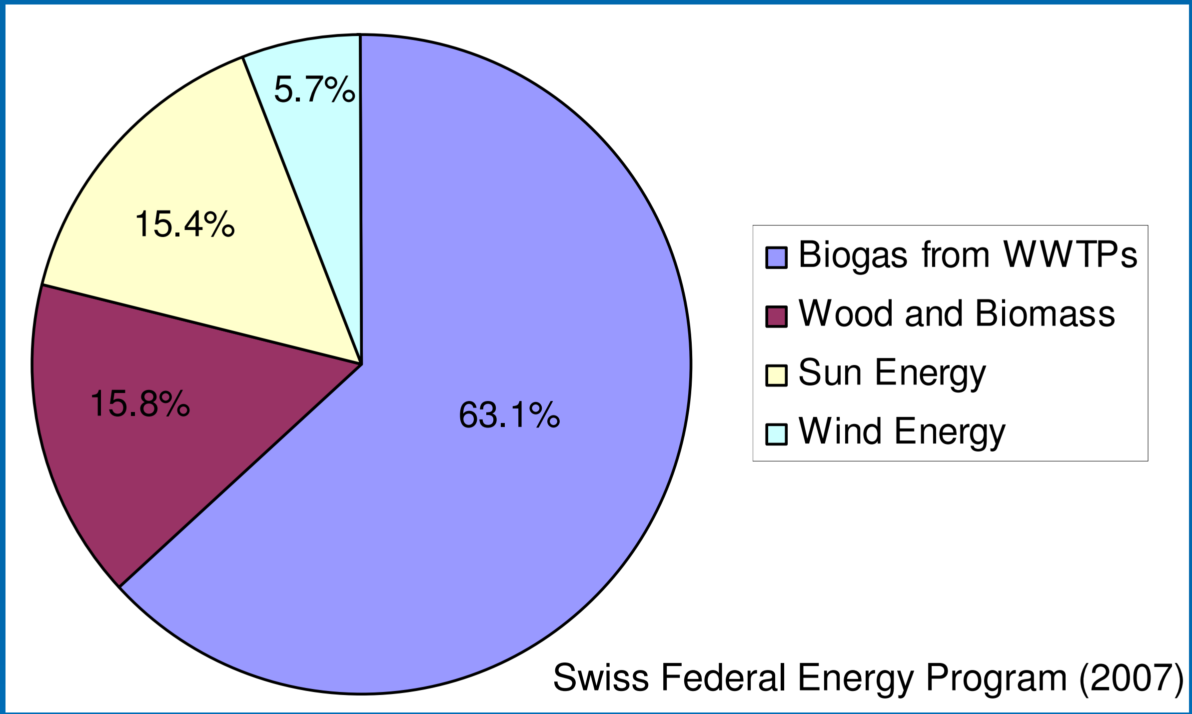
Treatment Target	e_{BB} [kWh per capita-year]	Assessment of Energy Consumption
Carbon removal only	< 10	Low
	10 – 15	Average
	> 15	High
Nutrient removal	< 16	Low
(nitrification at t > 10°C,no denitrification)	16 – 24	Average
	> 24	High

Energy Manual Impact





The Impact of A Comprehensive National Program



- <u>Strass WWTP</u>: An early adopter, drew upon elements of the Swiss and German approach to develop a energy optimization approach prior to the formalization of the Austrian program

Strass: Organizational Characteristics

- A Clearly Articulated and Communicated Vision of What Sustainability Means to Their Organization
- A Highly Educated, Well Paid Workforce
  - Active in the Public Forum
- Strong Partnering with Local Industry
  - R&D, Resource Recovery
- Continuous Internal Benchmarking
  - Quantifying Gains and Missteps
  - Early Adopters of Energy Management Practices
- Tolerance for Managed Risk

Lessons Learned

Organizational		
Strass Key Feature	**Lesson Learned**	**Broader Examples**
Mgt and ops desired a sustainable organization and jointly defined their objective to be cost and energy neutral	Define, and align, your organizational behavior	
Rates are considered to be a temporary subsidy – plant should be cost-neutral!	Consider the customer's perspective	
Employee empowerment	Educate and train operating staff Streamline accountability structure	
Management set objectives based upon kWh per kg COD removed, or per capita	Use the right metrics	
Employed Swiss and German approaches, not just Austrian practices	Try to do the right thing, even if beyond current regulations	

Incorporating Technological Innovation

Strass Data and Results

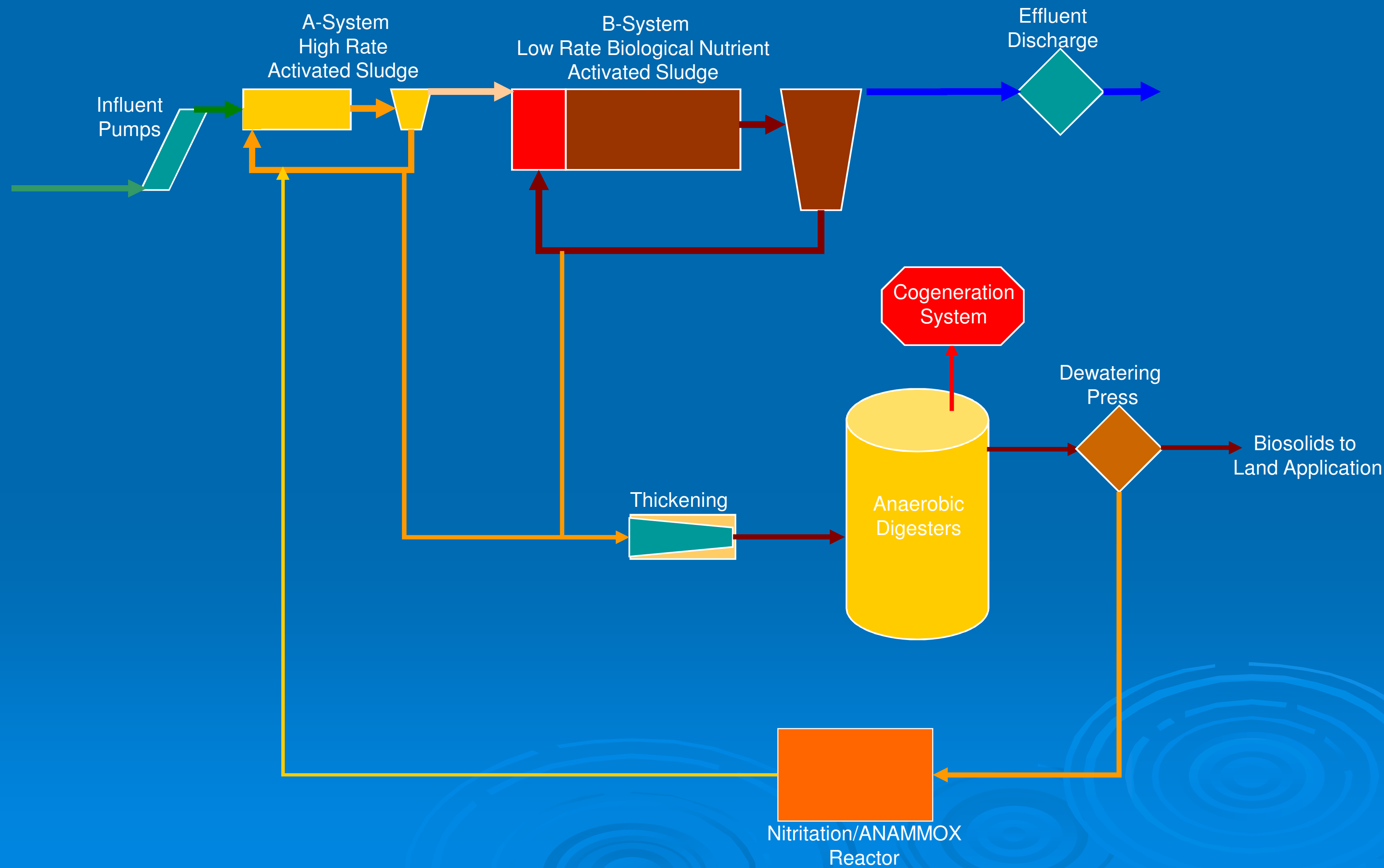
- Strass WWTP operated by Abwasserverband Achental-Inntall-Zillertal, Strass, Austria.
- 10 mgd in the Winter
  - 250K p.e.
- 5-6 mgd in the Summer

Permit Matters!

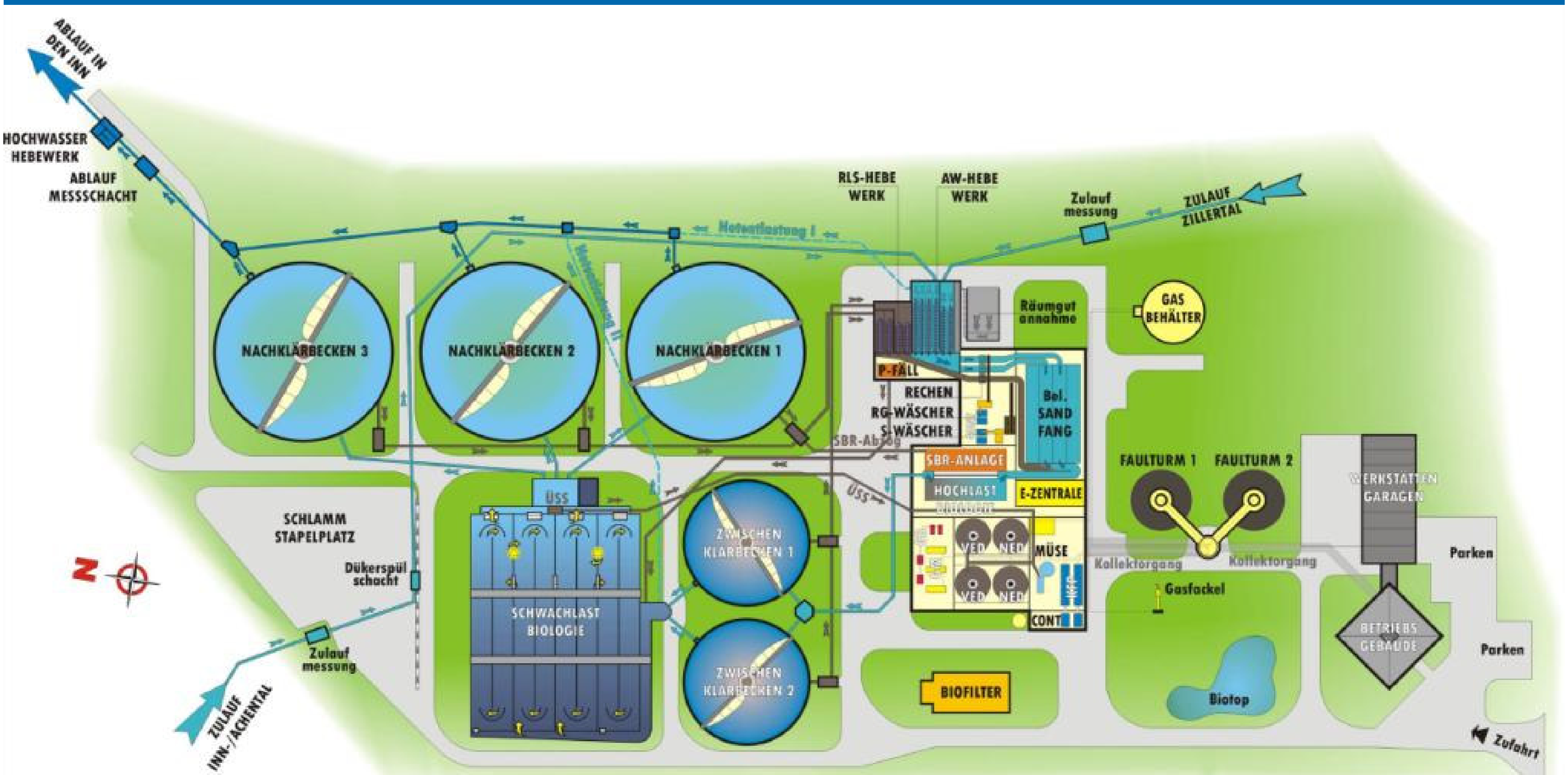
- Discharge Permits Based on the European Directive vs. Typical US NPDES Permits

	ED	NPDES	Comments
BOD5 (mg/L)	20	5-30	
TSS (mg/L)	20	5-30	
Ammonia (mgN/L)	5	1-12+	T>8C
Nitrogen (% rem.)	85	-	T>12C
Phosphorus (mgP/L)	1	0.1 - 2+	

Strass Process Configuration

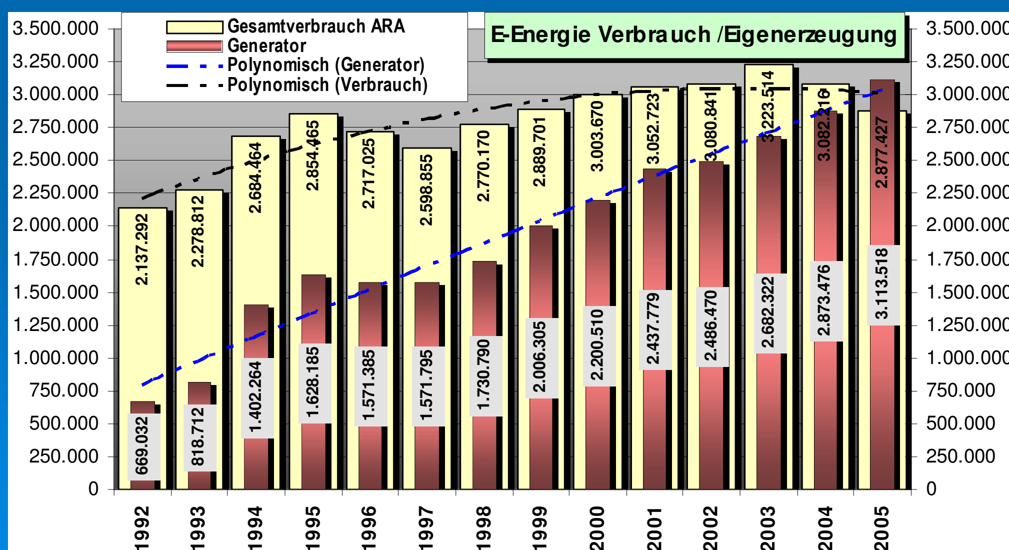


Strass Layout



Strass Data and Results

- Plant produces more electricity than it consumes, an achievement made possible through a program of continuous energy efficiency improvement and co-generation

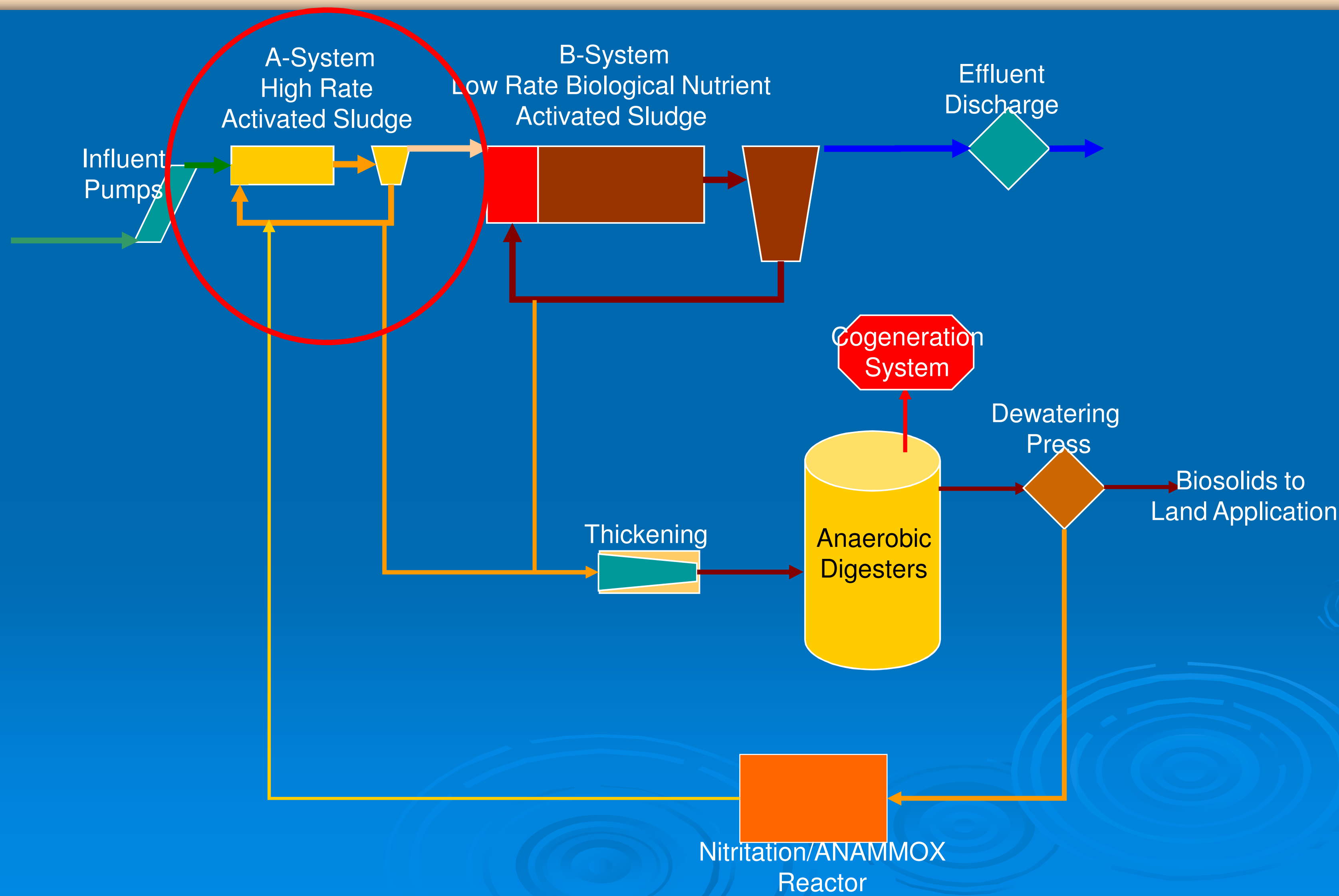


Why Strass ?

- Reduction of chemical costs for sludge thickening by 50%
- Reduction in sludge dewatering costs by 33%
- Reduction in energy consumption on mass treated basis from approximately 6.5 euro/kg NH4-N removed in 2003 to 2.9 euro/kgNH4-N removed in 2007/2008
  - active management of dissolved oxygen (DO) setpoints
  - conversion to ultra-high efficiency strip aeration
- Sidestream treatment
  - 350 kWh/d to 196 kwh/d by implementing Nitritation/anammox (DEMON®)
- Digester gas utilization
  - cogeneration unit, boosting electrical efficiency from 33% to 40% and overall usage efficiency from 2.05 to 2.30 kwh/m3 of digester gas

In a relatively small WWTP; normally considered to be lacking the critical mass necessary to demonstrate innovation

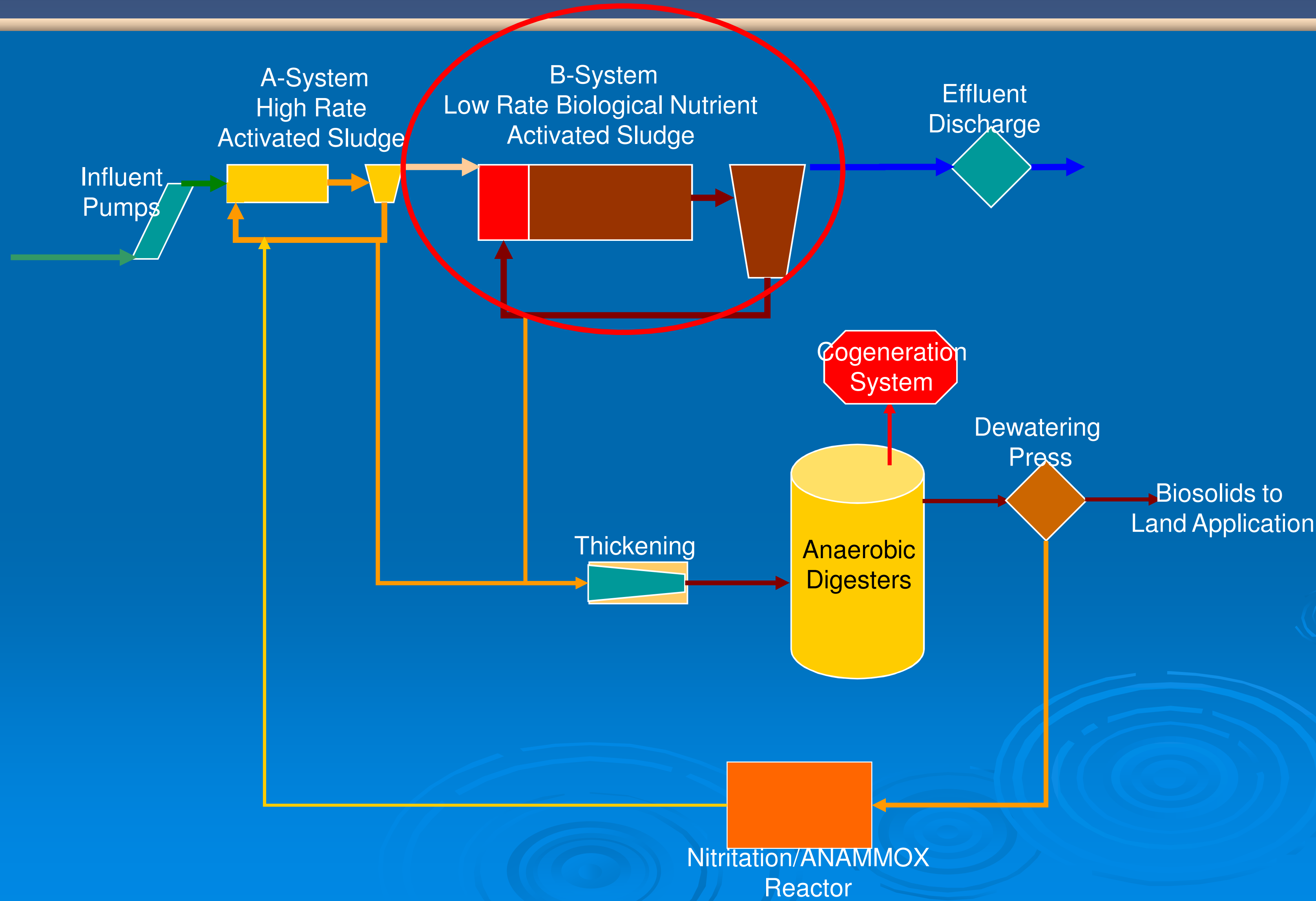
Strass Data and Results



Goal: Maximize Organics to Digestion

- The A-B Process for Primary & Secondary Treatment
- The A Process:
  - High Rate Activated Sludge
    - 0.5 Hr HRT; 12-18 Hr SRT
    - Particulate, Colloidal & SOLUBLE Organics Removal Without Chemical Addition
  - Rapid Transfer from Aerobic Conditions to Anaerobic Conditions for Thickening Preserves Organics

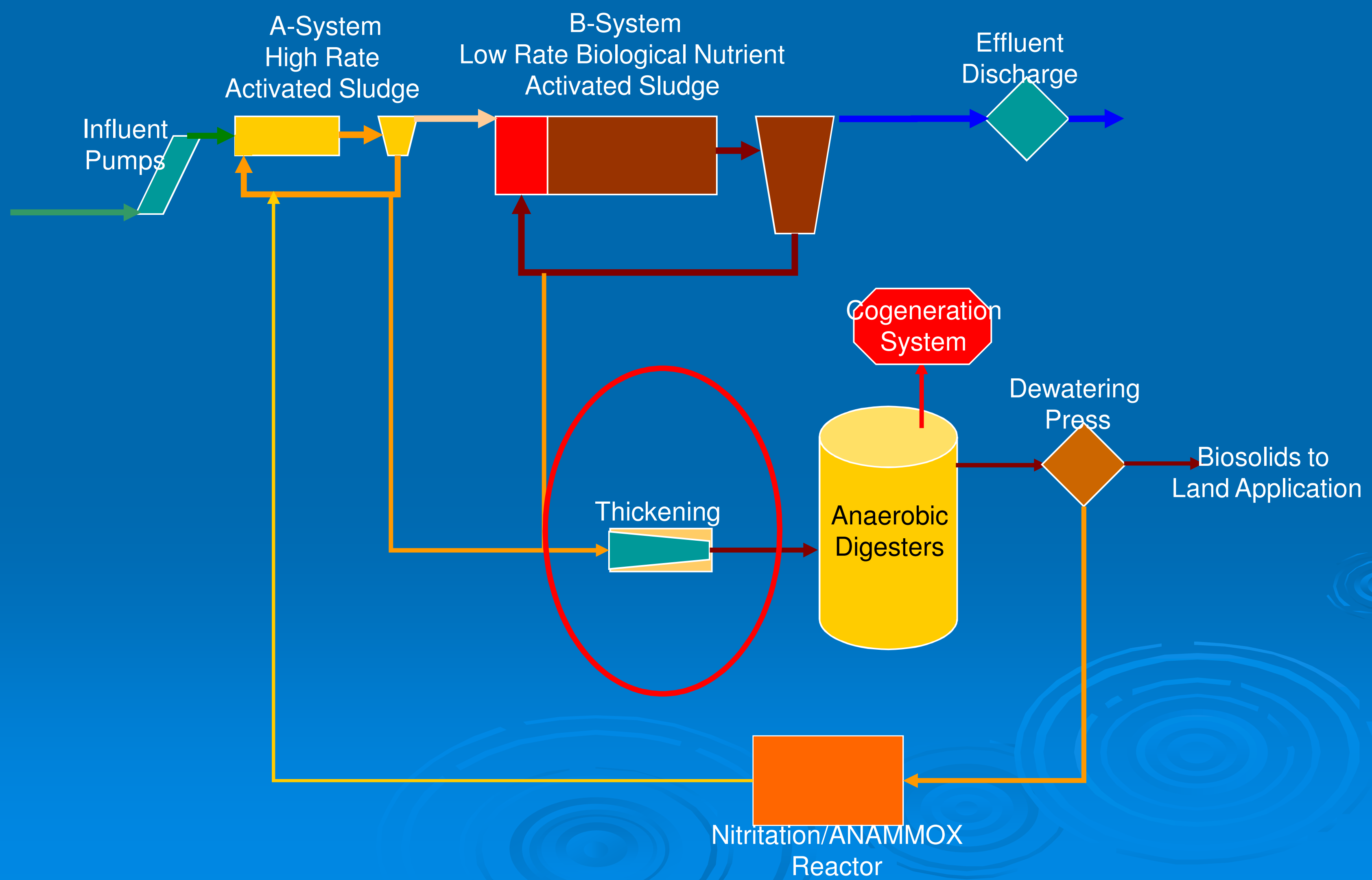
Strass Data and Results



Achieving Sustainable Nitrogen Removal

- High Efficiency Strip Panel Aeration…..
- Ability to Remove Nitrogen Cost Effectively
- Effective Control of the Mass Loading Diurnal

Strass Data and Results



The Key Role Played By Thickening

Thickening reduces volume….

Process	Best at %TS
Storage	< 6
Pumping	< 8
Digestion	4-6
Dewatering	> 4

- Reduces capital and O&M costs of processing facilities
- Increases performance of downstream processes

Sludge Type Plays an Important Role in Determining Best Thickening

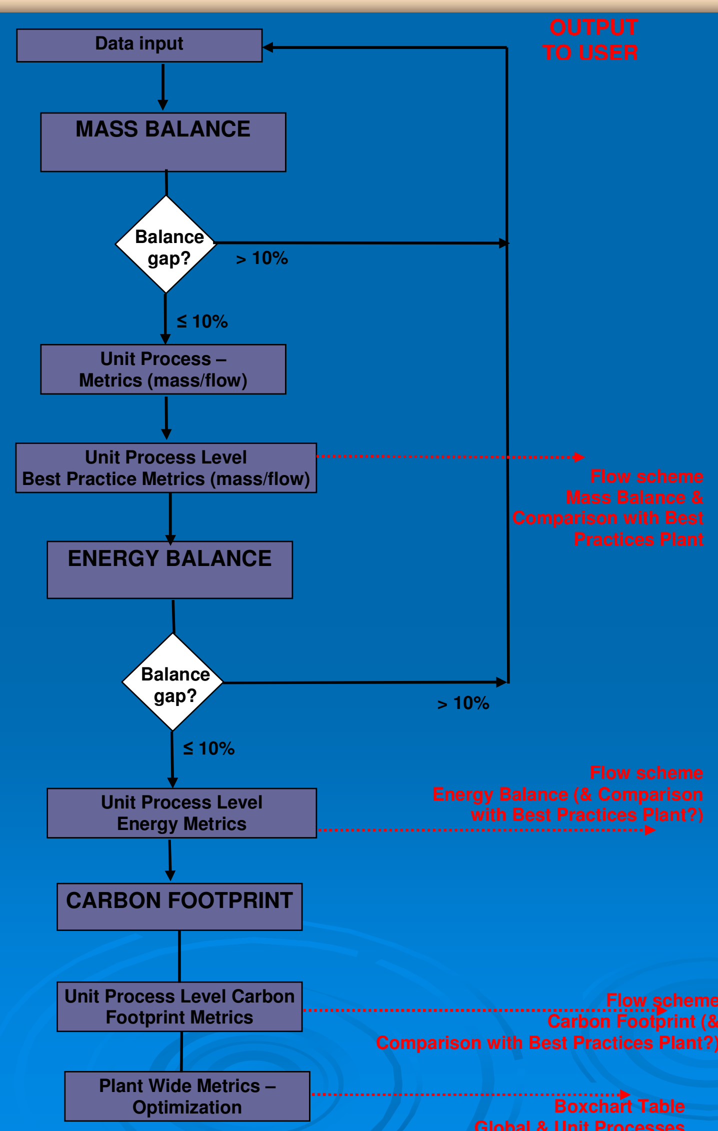
Gravity Thickeners

Centrifuges

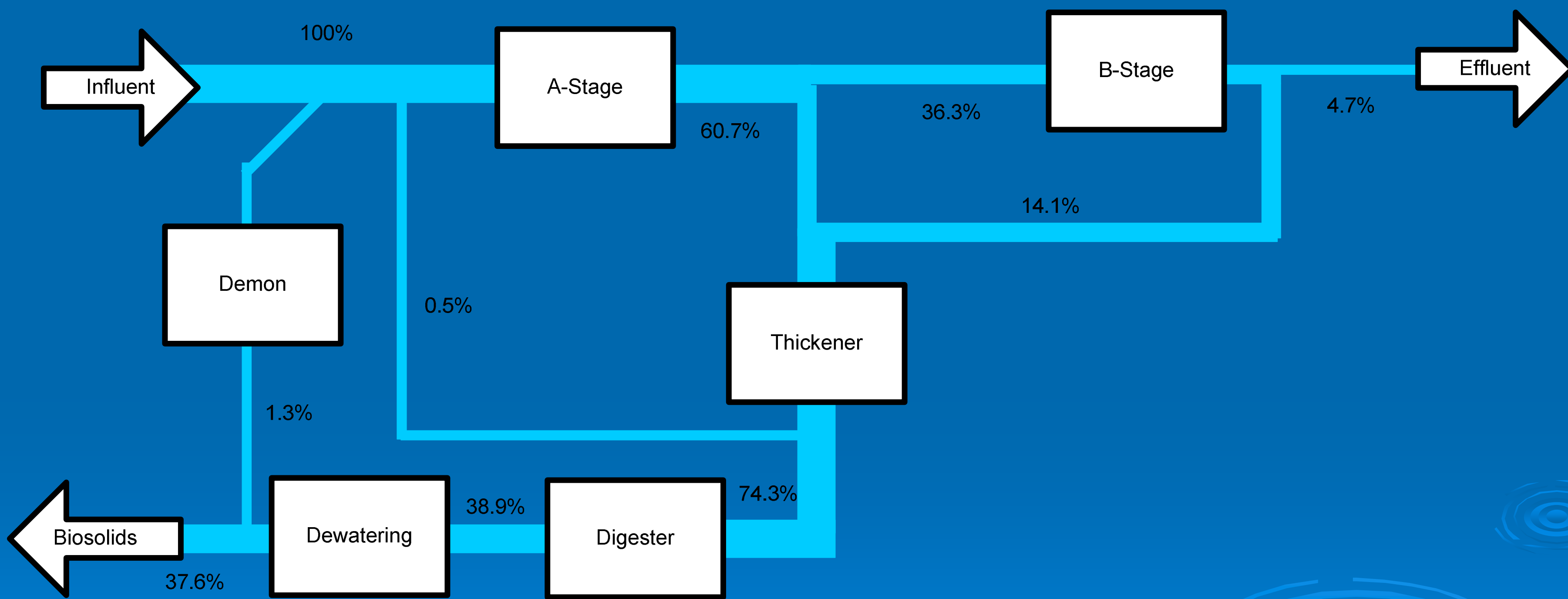
Gravity Belt Thickeners

Use of Advanced Process Analysis Tools

- Conduct COD, Calorific and Electrical Consumption/Generation Balance
- Identify Sinks, Potential Sources of Energy and Opportunities
- Graphical Format for Operations Team to Consult/Interpret
- Trending of Balances Over Time to Assess “Minor” Tweaks

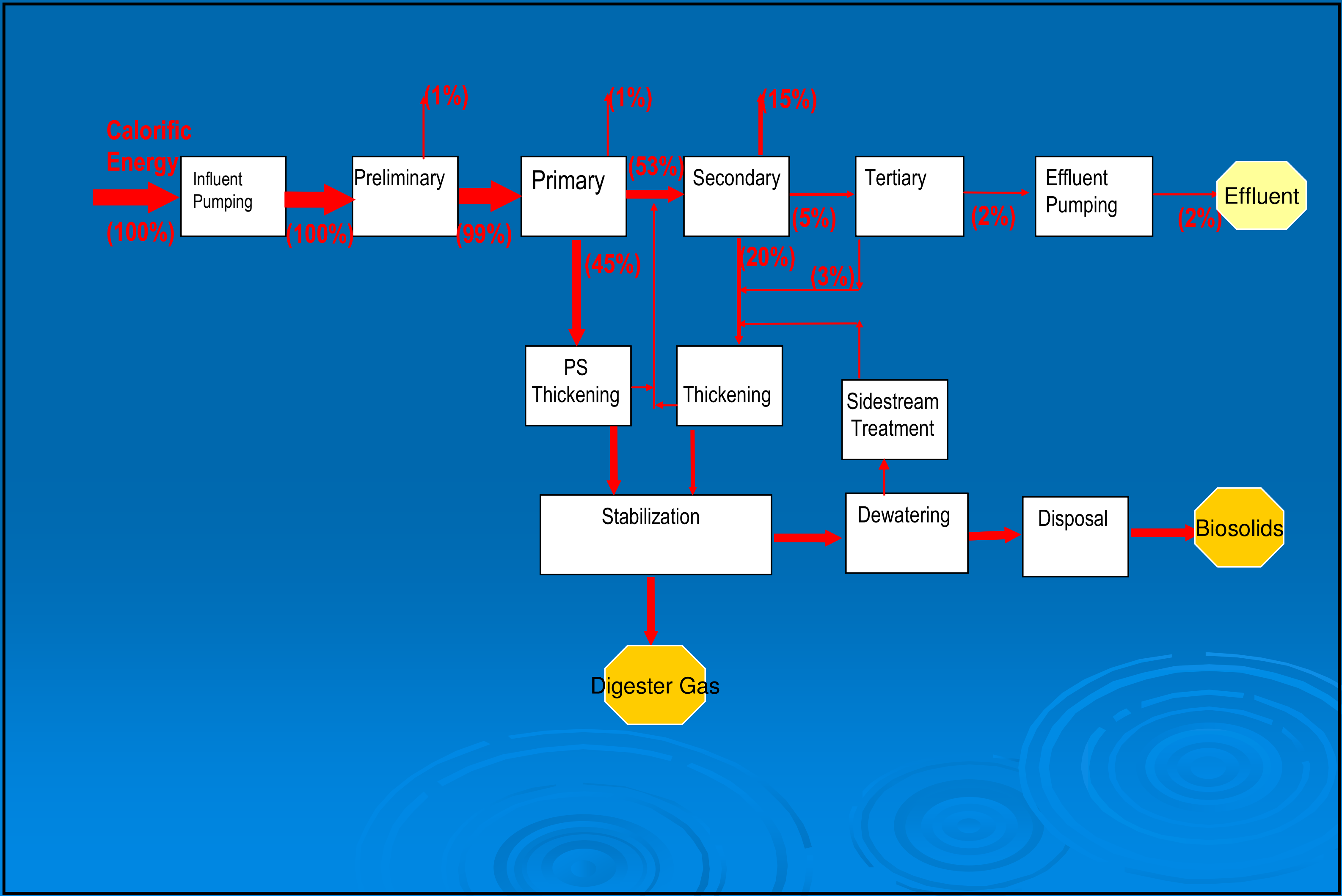

OUTPUT TO USER
Data input
MASS BALANCE
Balance gap?
> 10%
≤ 10%
Unit Process – Metrics (mass/flow)
Unit Process Level Best Practice Metrics (mass/flow)
Flow scheme Mass Balance & Comparison with Best Practices Plant
ENERGY BALANCE
Balance gap?
> 10%
≤ 10%
Unit Process Level Energy Metrics
Flow scheme Energy Balance (& Comparison with Best Practices Plant?)
CARBON FOOTPRINT
Unit Process Level Carbon Footprint Metrics
Flow scheme Carbon Footprint (& Comparison with Best Practices Plant?)
Plant Wide Metrics – Optimization
Boxchart Table Global & Unit Processes

COD Balance

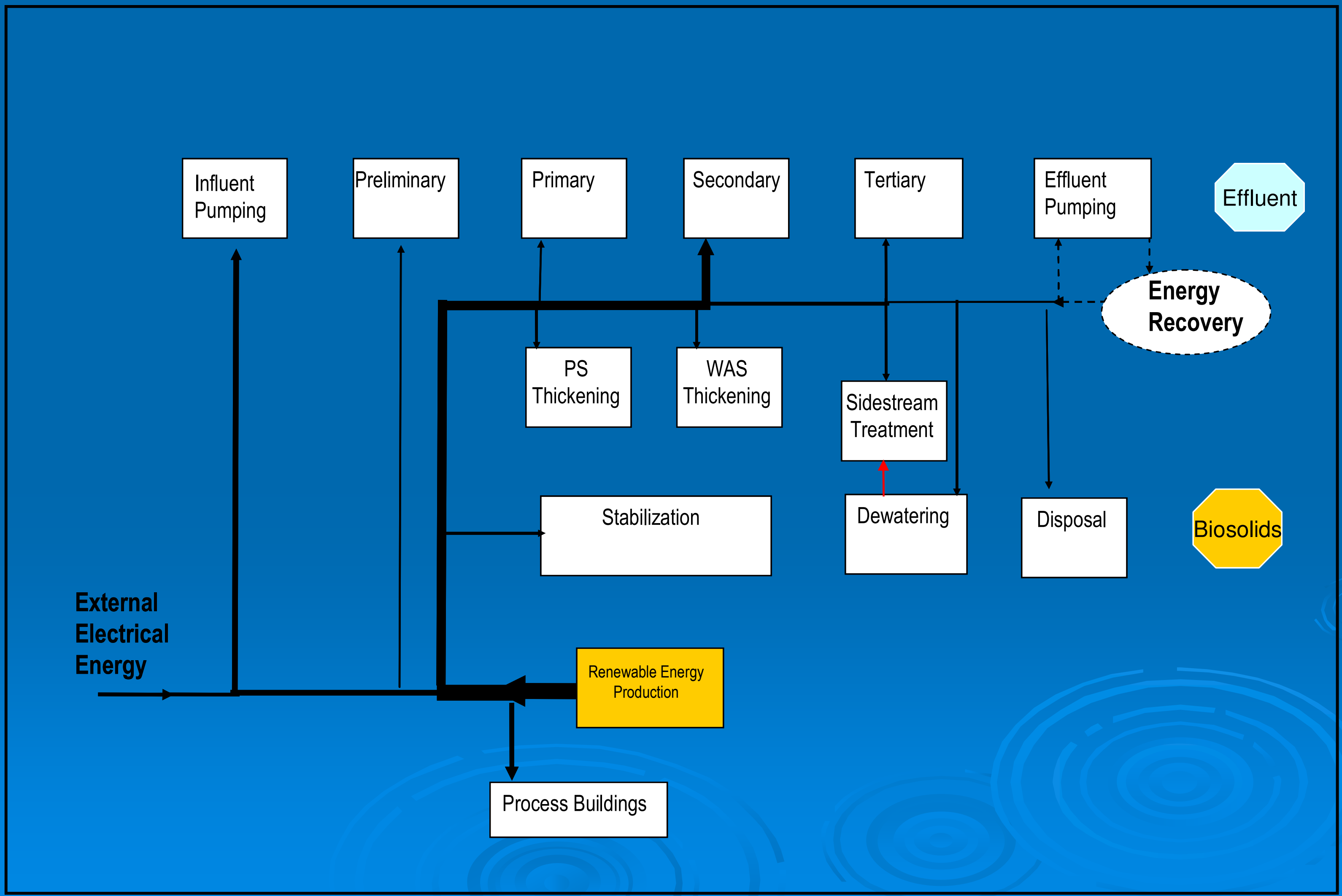


Influent
100%
A-Stage
60.7%
36.3%
B-Stage
4.7%
Effluent
14.1%
Demon
0.5%
Thickener
1.3%
Biosolids
37.6%
Dewatering
38.9%
Digester
74.3%

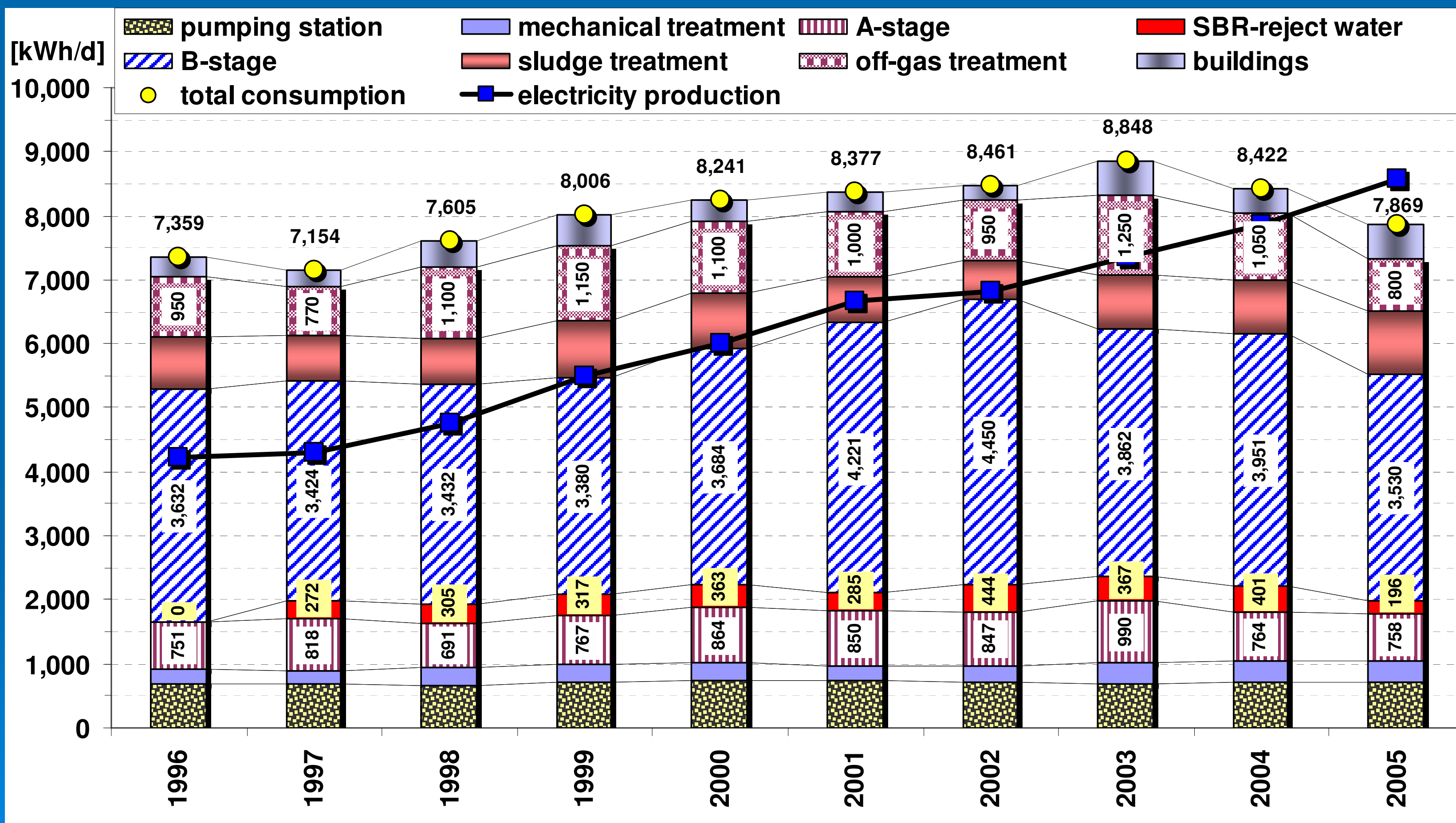
Calorific Energy Balance



Electrical Energy Balance

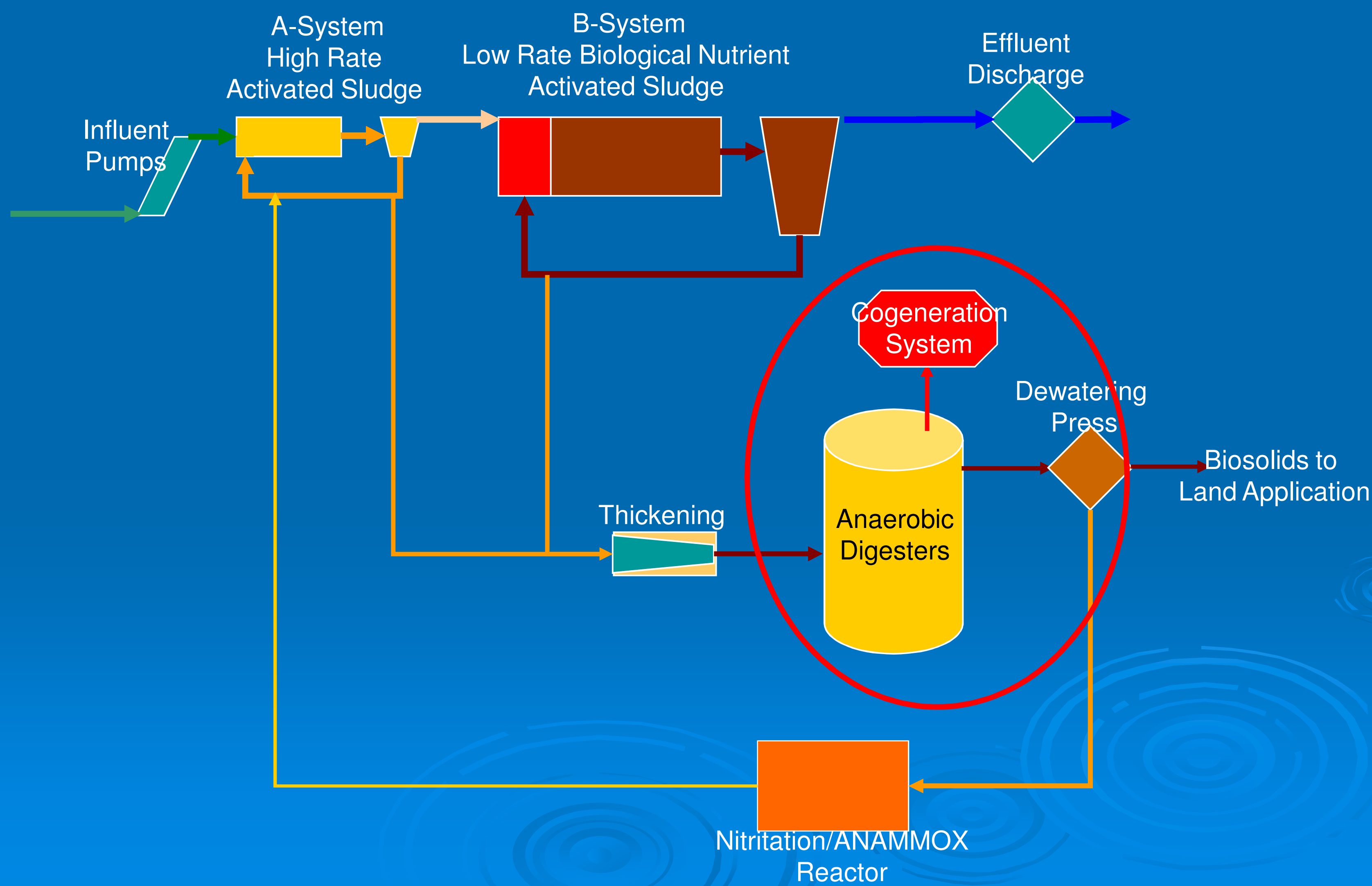


Achieving Energy Neutrality



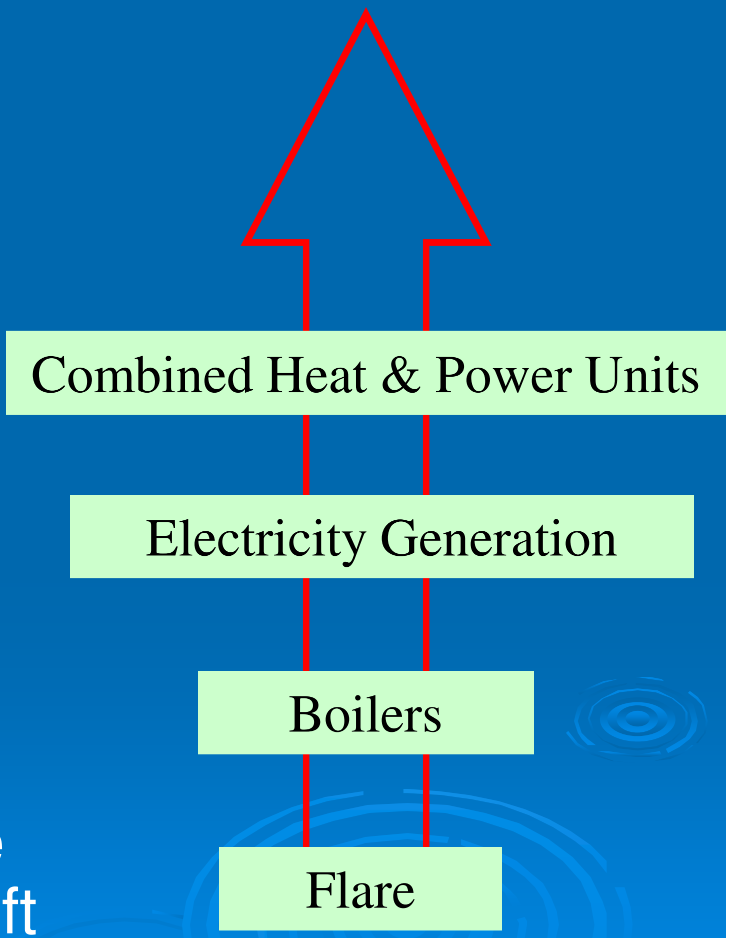
Renewable Energy Production from Digester Gas

Strass Data and Results



Energy Production - Biogas Utilization

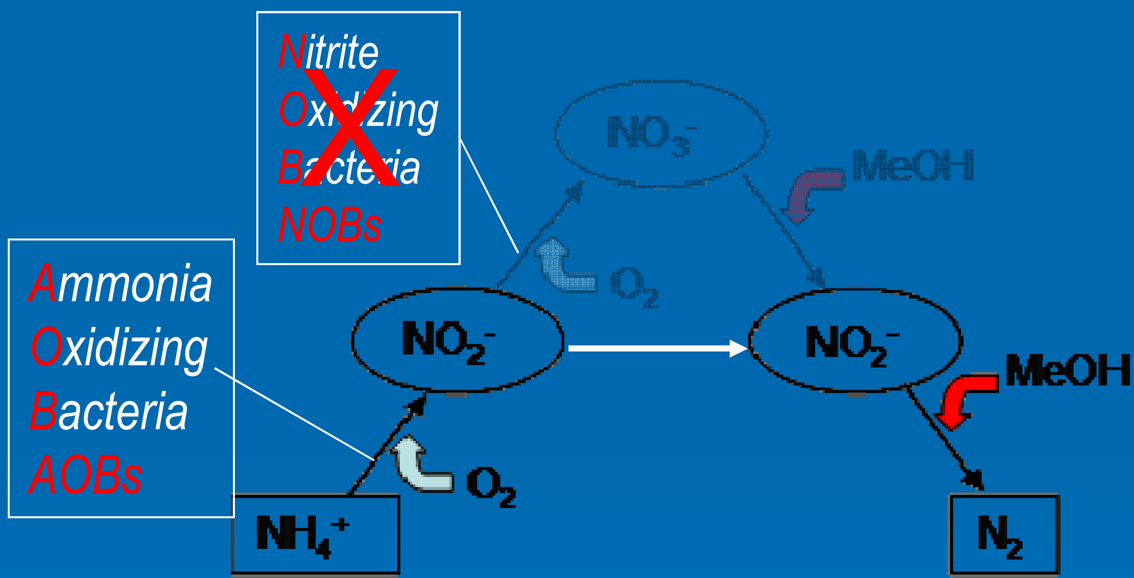
- Best Use Of Biogas
  - Term Can Mean Different Things for Different Plants
- Typical Paradigm for Energy Efficiency:
  - 20-30% Reduction in Energy Consumption
  - CHP: Can Meet **50-100+**% of Plant Energy Demand
- Use of Digester Gas in a High Value Application Opens the Door to A Shift in the Relationship with Local Industry



Energy Production - Biogas Utilization

- Recognition of Wider Range of BioFuel Sources
  - Trap Grease
  - Glycerol from Biodiesel Production
  - Industrial Biological Processing Waste (Antibiotic Production)
  - And More Recently ….Food Waste
- By Producing a High Value Product, the Costs to Local Industry are Offset by Minimizing Costs for Disposal

Incorporating Nitritation/anammox

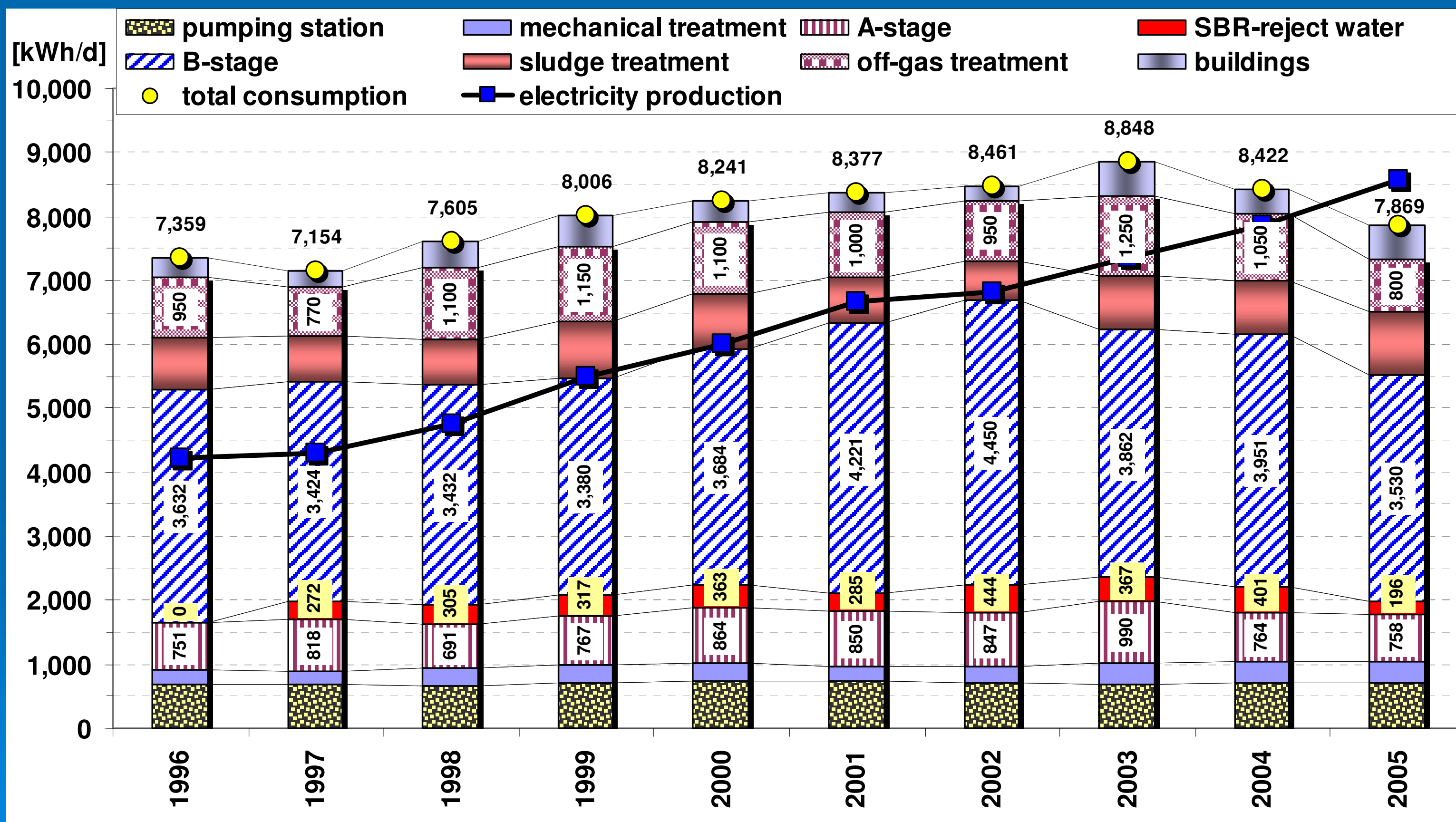


Reduced Costs and Environmental Impacts for Eliminating a Byproduct - Ammonia

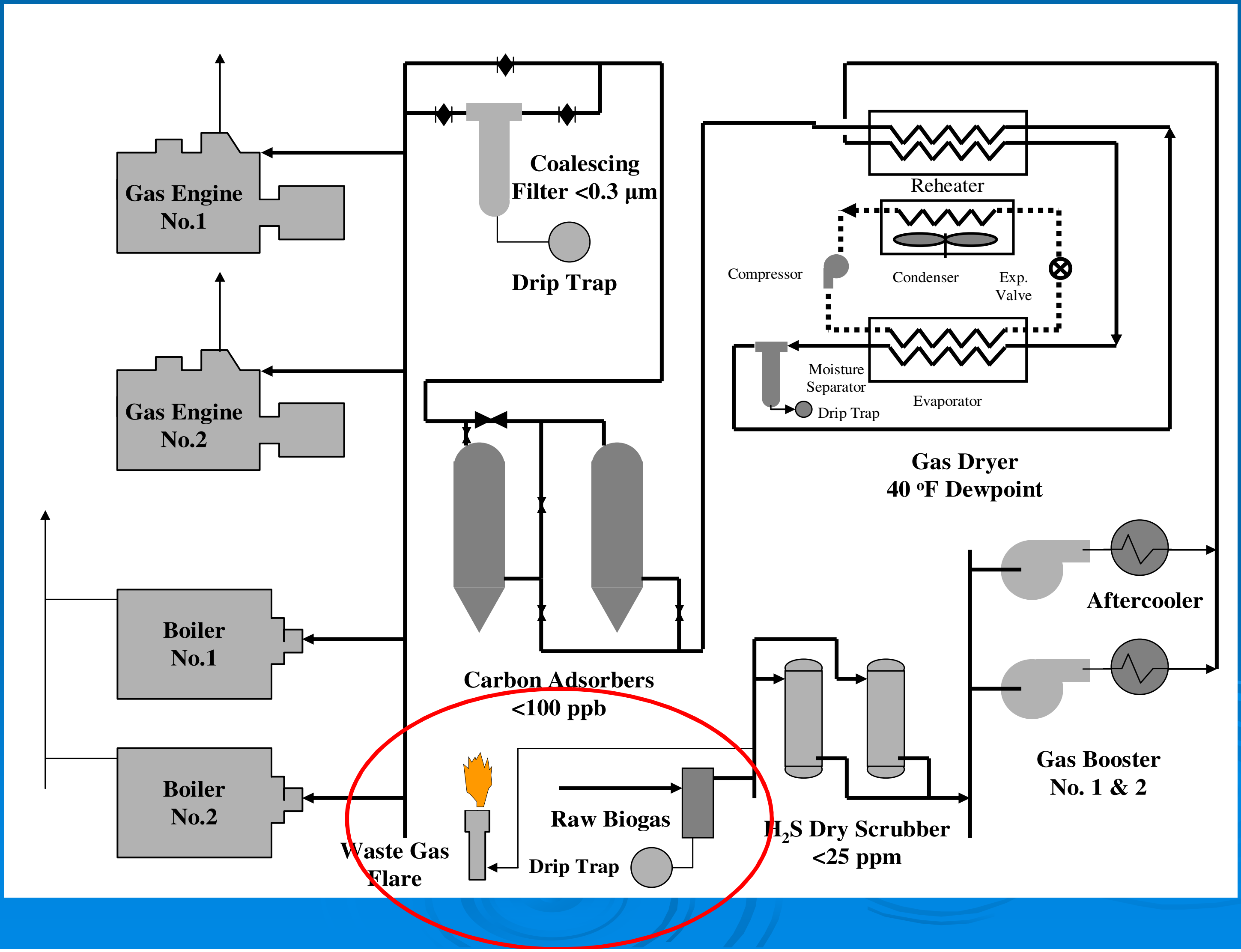
vs.

The Risks of Being An Early Adopter

Achieving Energy Neutrality



Example Biogas Utilization System



An Incremental Approach to Electrical Self Sufficiency

- 2001: Deployment of the new GE-Jenbacher Co-Gen Plant (JMS 208 GS)
  - 340 kW Electrical
  - 744 kW Total
- Increases Electrical Efficiency to 38% from 33.2% - almost a 20% Increase
- Overall Digester Gas Utilization Efficiency Increases to 2.3 kW-Hr/m^3 digester gas from 2.0 kW-Hr/m^3

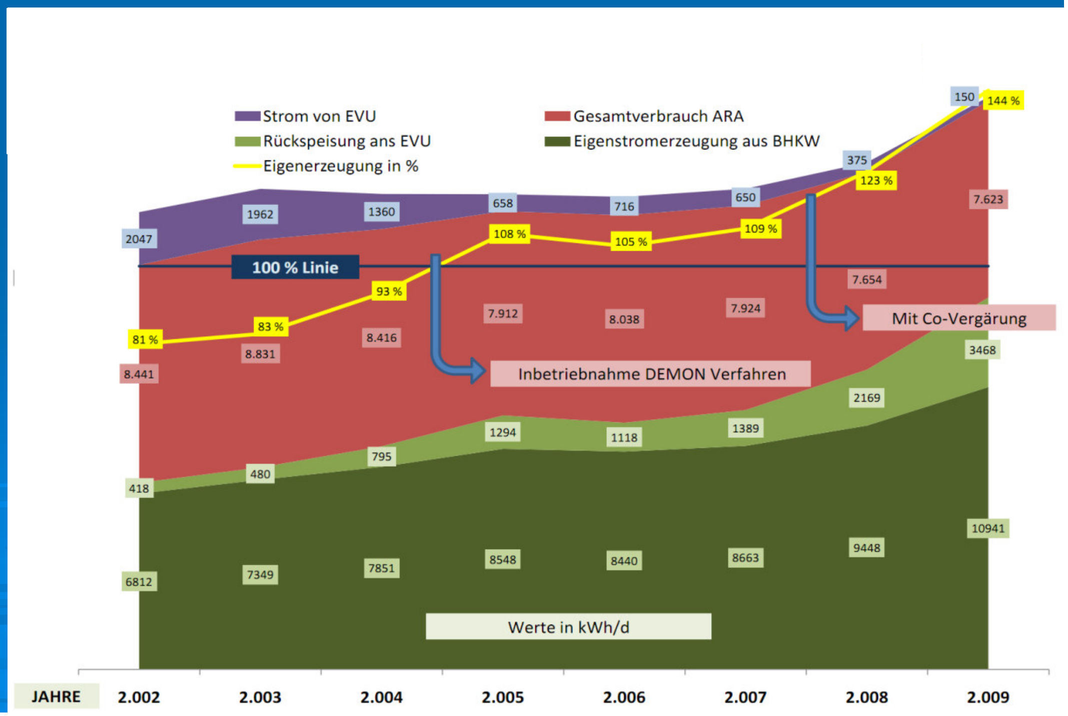
An Incremental Approach to Electrical Self Sufficiency

- 2005: First Year Where Net Electrical Production Exceeds Consumption (108% of Consumption)
  - 2008: Currently Production at 120% of Consumption
- Key Contributors:
  - anammox sidestream nitrogen removal process (2005)
  - high efficiency strip-aeration system (2001-2004)
- Reduced Overall Energy Consumption for Nitrogen Removal from 6.5 kW-hr/kg NH3-N Rem.

  to

  2.9 kW-hr/kg NH3-N Rem.

Food Co-Digestion: The next stage



Co-Digestion Provides the Next Bump

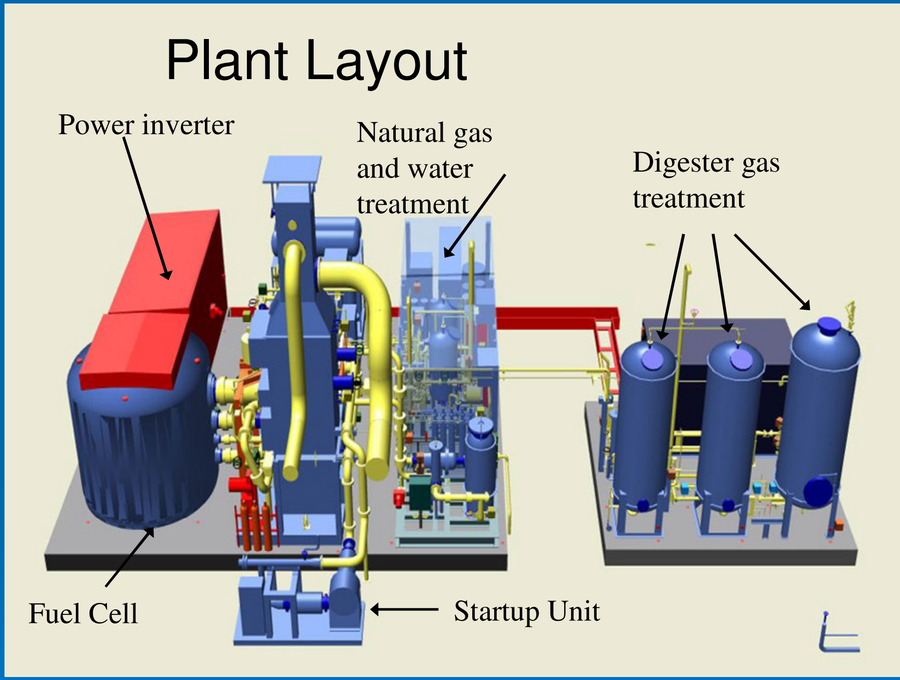
- 330 KW @ 38% e.e.
- 625 KW @ 39.7% e.e.

Cogeneration Summary Table

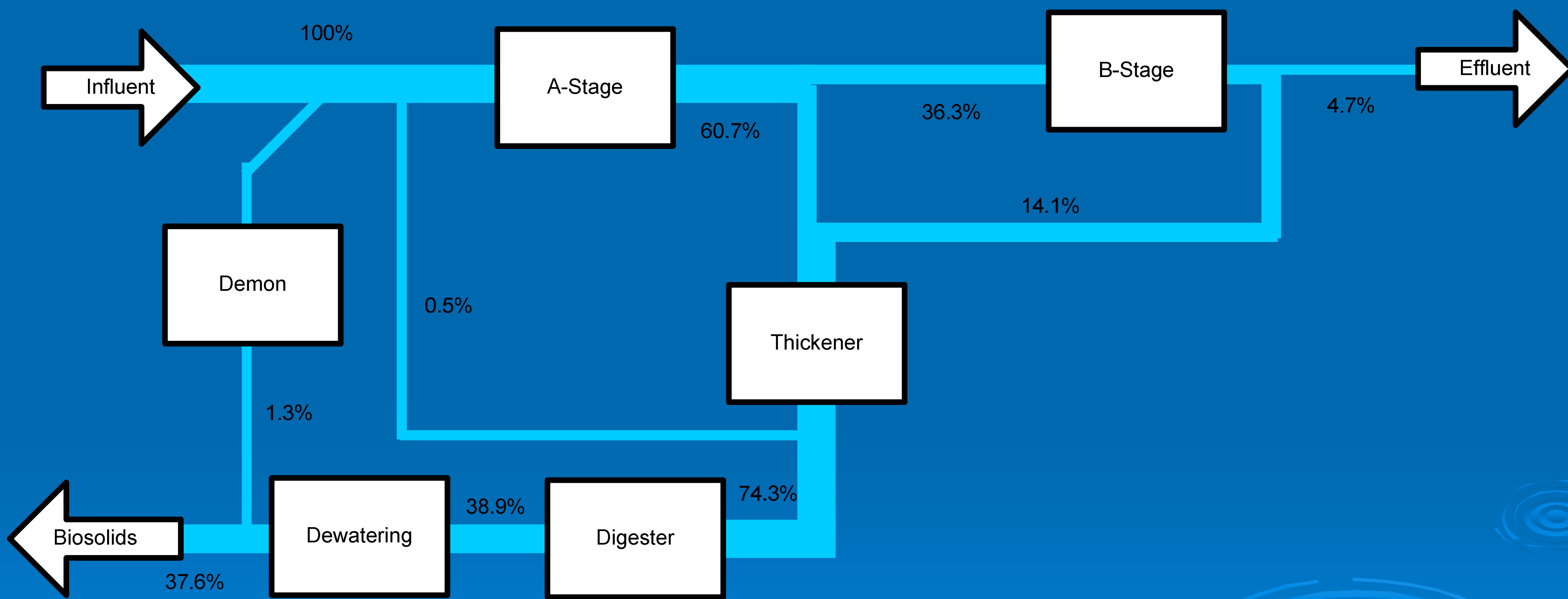
	Engine Generator	Turbine Generator	Micro Turbine	Fuel Cell
Unit Size, kW	150 to 5,000	Over 1000	30-250	100-1000
Current Plant Size	Small to Large	Large	Small	Small to Medium
Efficiency, %	30 - 42	24 - 30	25-30	30-50
Thermal Efficiency, %	40 – 50	45-50	45-50	40-50
Overall Efficiency, %	80 – 90	75 - 80	75-80	85-95
Typical Costs				
Maintenance, $/kWh	0.005 to 0.02	0.005 to 0.008	0.005 to 0.01	0.005 to 0.015
Installed, $/kWh	800 to 1500	1500 to 2000	1000 to 1500	3000 to 5000

Kings County, WA 1 MW Fuel Cell Demo

- Fuel Cells Have Grown UP!
- Raw and scrubbed digester gas, and natural gas sources
- Very low emissions
  - CO < 13 ppm
  - NOx < 0.2 ppm
- Methane Emissions Is the Exception…..
- Economics poor without grant funding



COD Balance


Influent
100%
A-Stage
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Effluent
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14.1%
Demon
0.5%
Thickener
1.3%
Biosolids
37.6%
Dewatering
38.9%
Digester
74.3%

Biosolids to Energy Processes

Gasification and Cogeneration

- Leading Edge Technology for Biosolids
- Large Experience Base in MSW and Biomass
  - Wood Waste
  - Municipal Solid Waste
  - Multiple Privately Funded Ventures

- Production of Syngas
- Cleanup and Utilization of Syngas for Cogeneration

Key Challenges

- Achieving Critical Mass to Make Facility Cost Effective
  - Biomass Resource Availability
    - Biosolids
    - Fats Oils and Grease
    - Wood Waste
- Vendor Qualifications
  - Need to Focus Vendor Efforts to Their Expertise
- Costs
  - Currently at ~$3M per MW for Large Scale Facilities
  - Opportunity to Reduce to ~$1-2M per MW by Simplifying Feedstock Requirements

Some Common Threads

- Utilization of Cutting Edge Technologies
  - Decision-Making & Consensus Building Critical

- Mechanically Complex Retrofits
  - Design Tools Up to the Task
    - 3D Design Tools
  - Development of O&M Expertise

- Competitive Procurement of Proprietary Innovative Technologies
  - Balancing Need for Product Quality and Owner Protection with Maximizing Competitiveness of Similar, But Unique Systems

Key Project Drivers

- Stamford WTE Project, CT
  - Stamford is in an electric congestion zone
  - Impeding development
  - Increase in landfill disposal costs
  - Generate local power to meet WWTP needs
  - Meet sustainability goals

Stamford Waste-to-Energy Project
Stamford, Connecticut

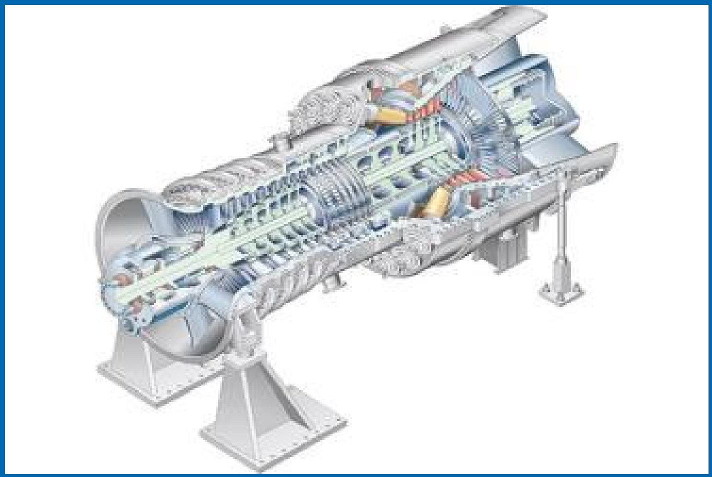
Stamford WPCA – Waste to Energy Project

Stamford WTE Project, Stamford, CT

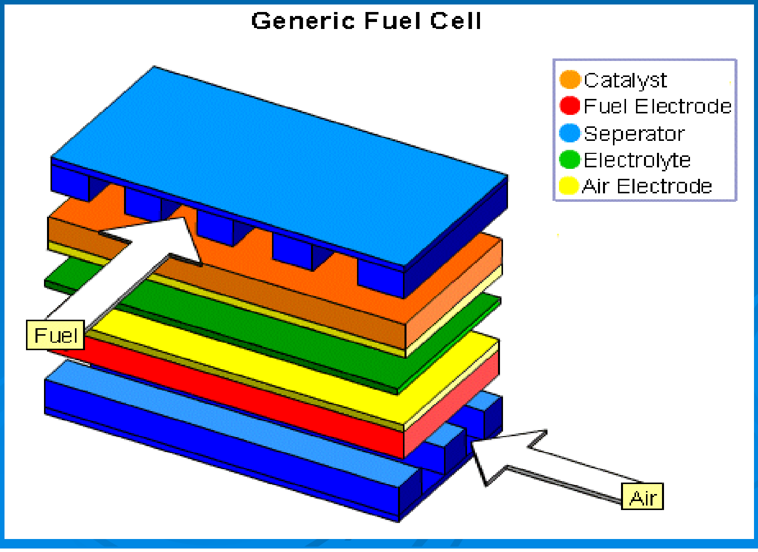
- Project Objective:
  - Design and build a full-scale demonstration facility at the Stamford WPCF to show that dried and pelletized wastewater residuals can be converted to renewable fuel (syngas) which can then be converted to electricity
- Project Description:
  - Facility throughput: 25 dry tons per day (DTPD)
  - Two (2) process trains; 12.5 DTPD / train

Syngas to Electricity

Internal Combustion Engines



Gas or Steam Turbines



Fuel cells

Lessons Learned

Technical		
Strass Key Feature	**Lesson Learned**	**Broader Examples**
Two stage CAS minimizes energy requirements while maximizing digester gas production	Plan long term; implement short term (aka ensure each step takes you toward a long term goal)	
Short SRT first stage CAS, particulate, colloidal and soluble organics capture with little endogenous decay	Conserve COD for diversion to digestion and biogas	
1. High efficiency strip aeration 2. DO setpoint control	Minimize aeration costs for BOD and ammonia oxidation	
Whole plant energy balances used for decision analysis	Use tools that allow comparison of alternatives	
1. Screw press instead of centrifuge for dewatering 2. CHP generator replaced with higher efficiency units	Select equipment and controls with the overall objective in mind	
1. Grease waste augmentation. 2. Also glycerol from biodiesel and select pharmaceuticals. 3. Minimal/No Cost to High value waste contributors	1. Maximize COD to digestion and biogas – codigestion. 2. Partner with industry!	
Anammox on hot high-N sidestream	Treat wastes at their highest concentration to unlock additional cost savings	