WWTP Energy Management Solutions and Case Studies

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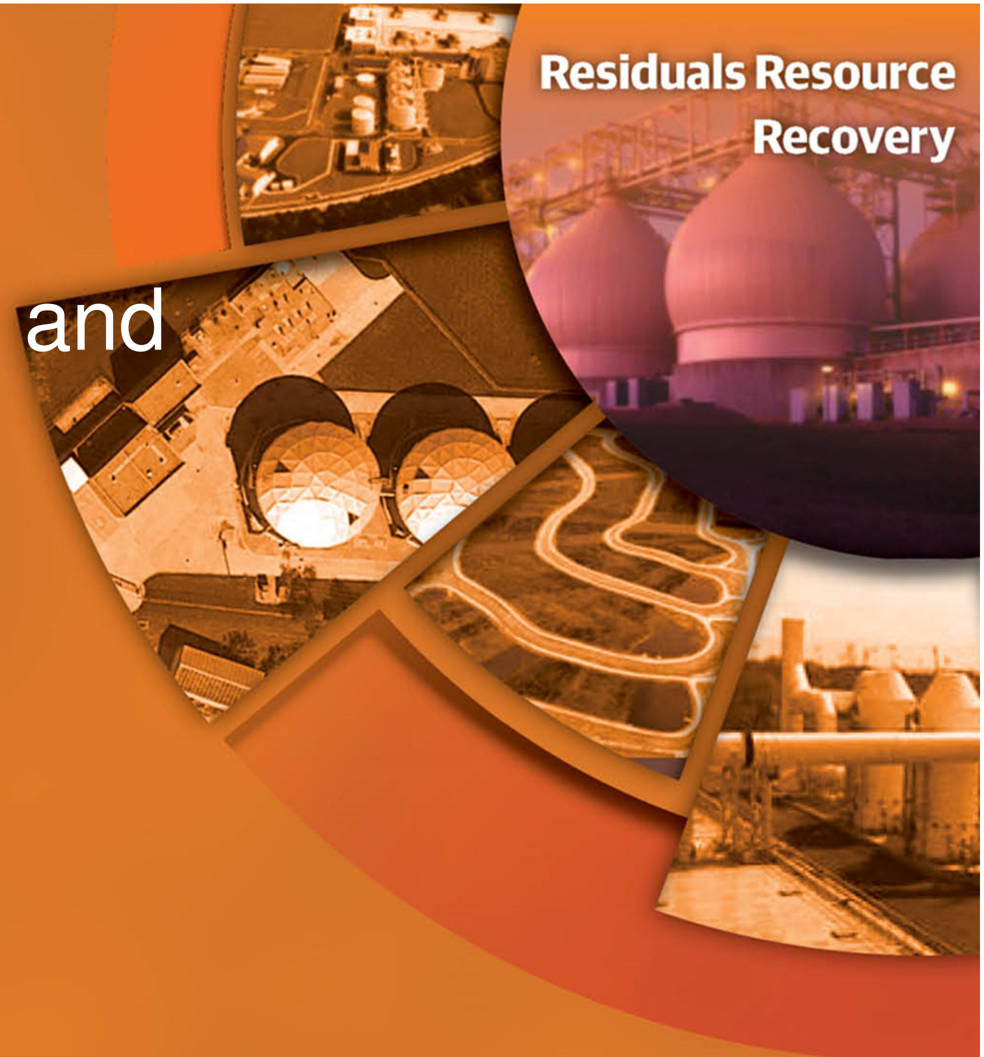
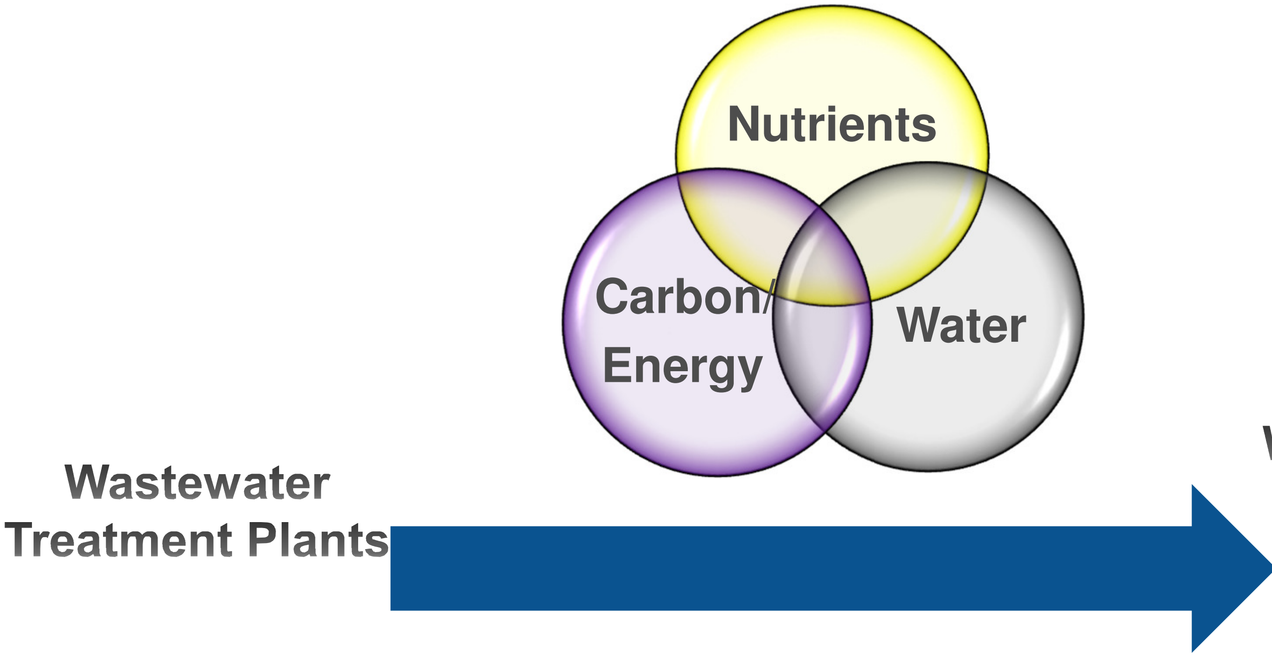


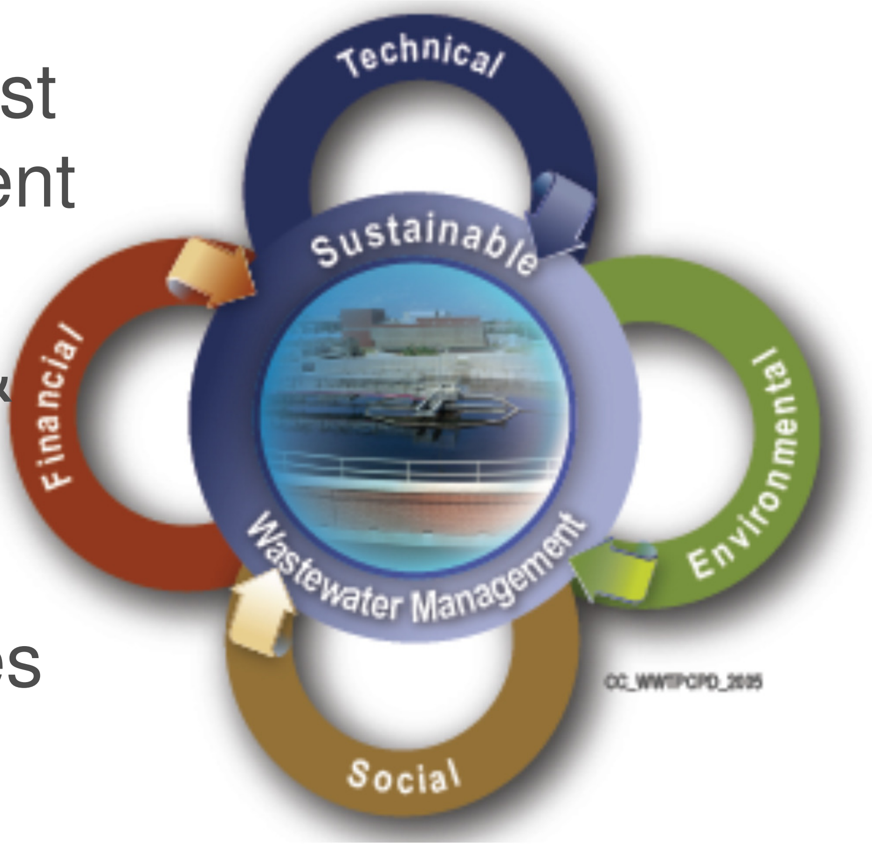
Residuals Resource Recovery

"N.E.W." PARADIGM - *The Future!*



Energy optimization: essential for sustainable resource recovery

- Energy is 2nd to labor in cost of “used” water management
- Energy consumption has significant environmental & social impacts
- Energy requirements limit recovery of some resources
- Energy optimization = *f*(reducing consumption; increasing recovery)

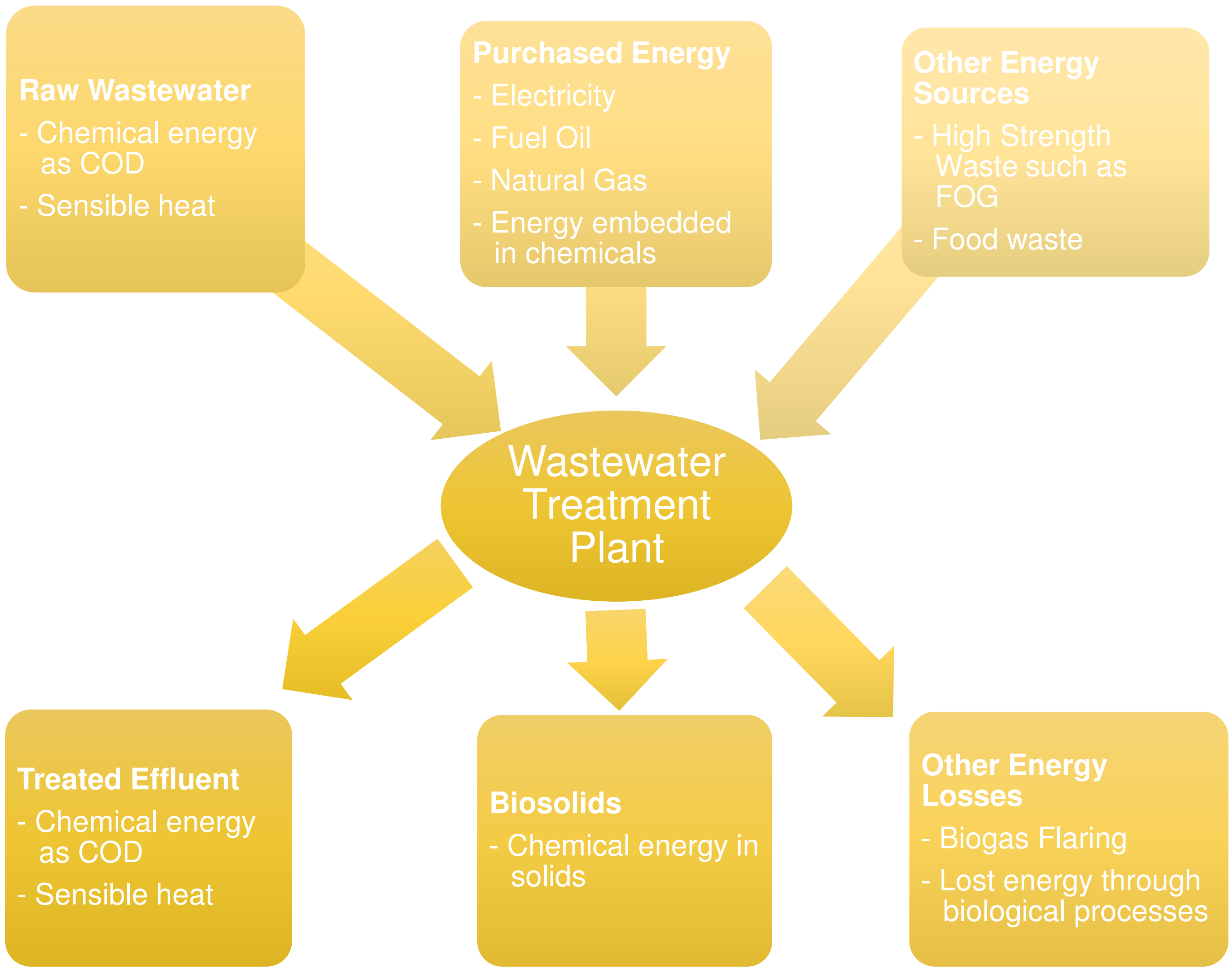


Energy Management Drivers

- Increase in energy costs
  - Water and wastewater treatment typically accounts for 30 to 60 percent of municipal government energy usage
- Increase in resource demand and prices fueled by growth in emerging markets
- Geopolitical pressure on resources worldwide and impacts locally
- Pressure to reduce O&M costs and financial burden on end users
- Stringent discharge standards
  - Nutrient removal
  - Complex and energy intensive treatment processes
- Need for reclaimed water in certain US geographies
- Growing concern of human activity impact on the environment – climate change!

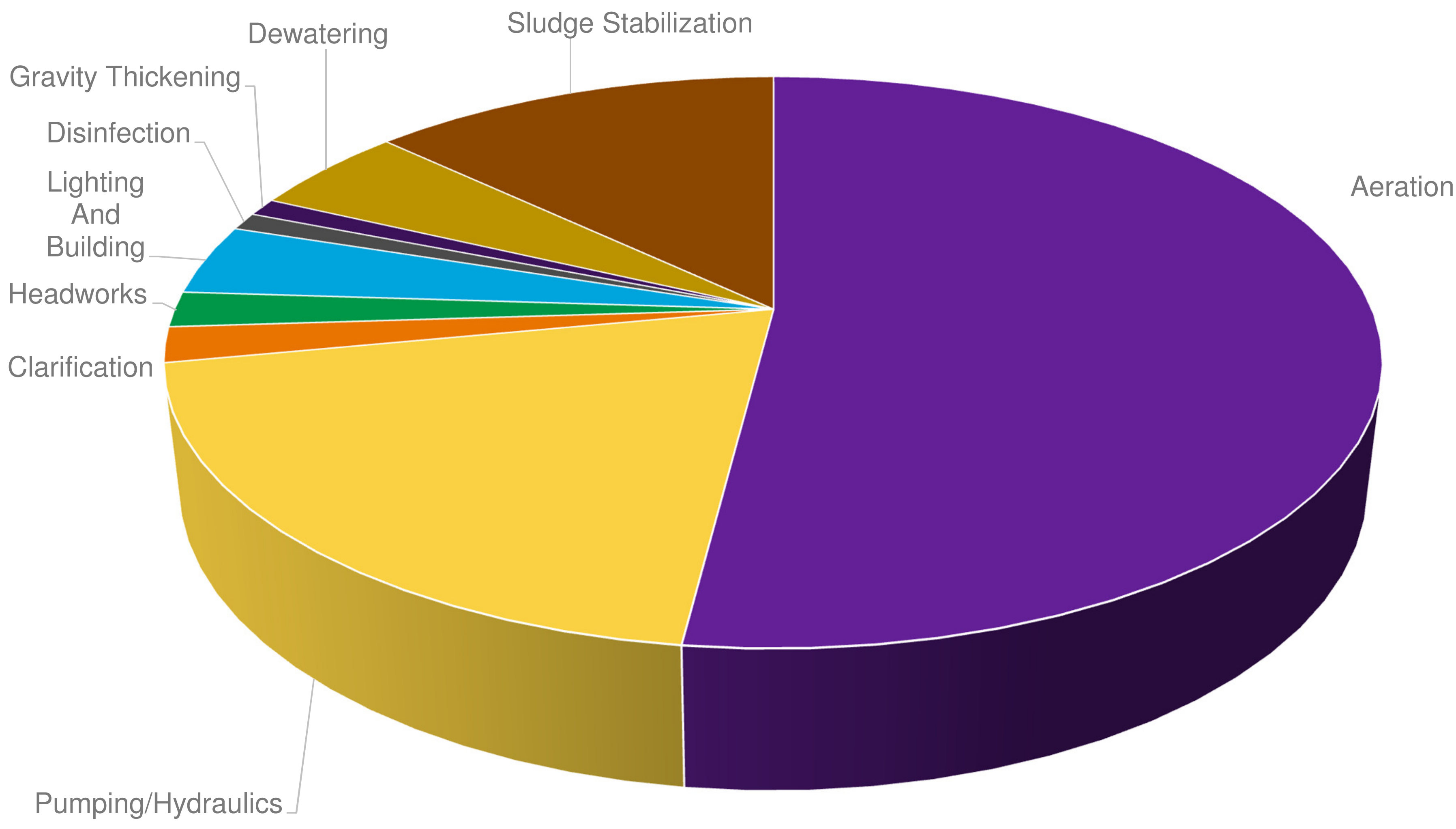
Residuals Resource Recovery

A "Holistic" Approach to Energy Management



Residuals Resource Recovery

Typical Energy Use Profile of WWTP



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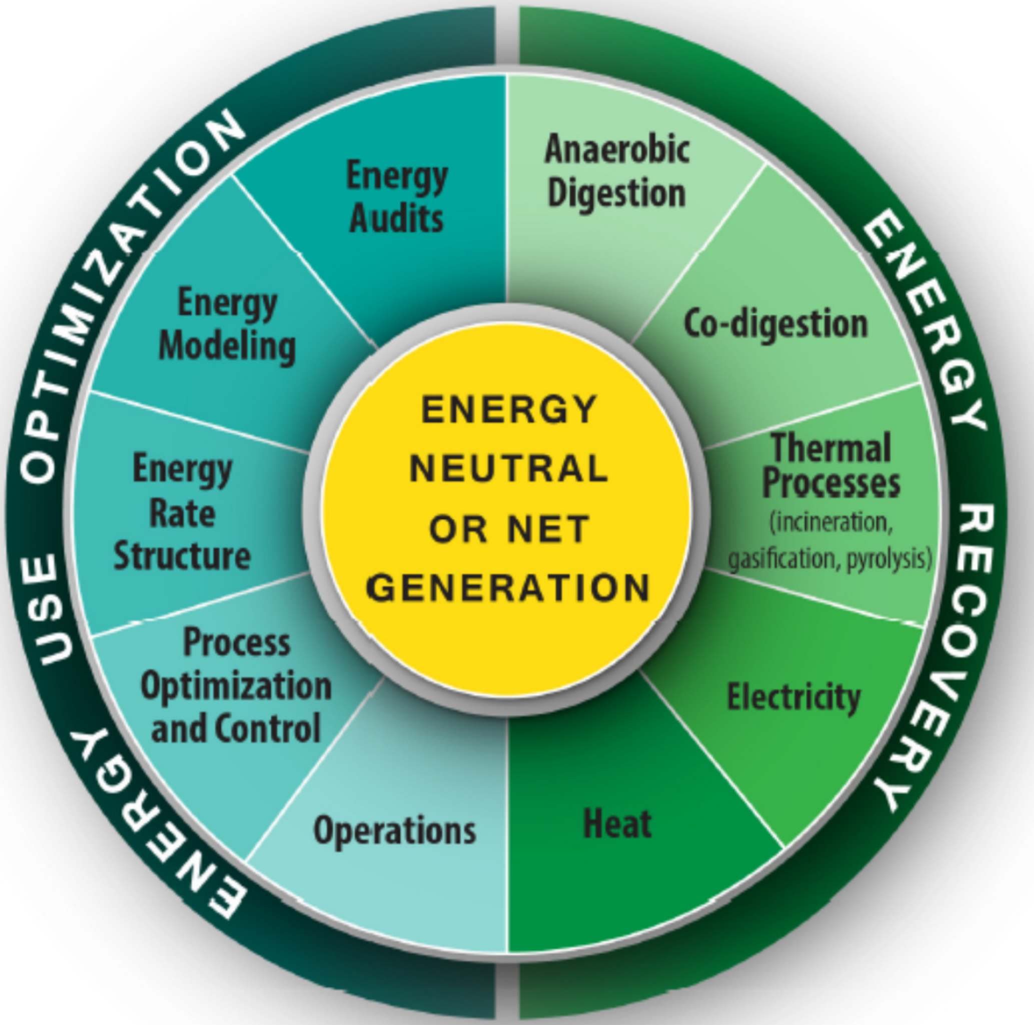
Energy Management

- A multi-pronged approach to energy management
  - Energy Use Optimization
  - Energy Recovery



Residuals Resource Recovery

Silver Bullets for Energy Efficiency

- Treat pollutant load by the lowest energy metabolic pathway possible
- Operate existing pumps/equipment at its optimum (best efficiency) point
- Select equipment for new plants or replacement of existing equipment with energy efficiency in mind
- Treat side stream recycles for nutrient removal instead of recycling to the mainstream liquid treatment process
- Supplement anaerobic digestion with other high strength wastes, e.g. FOG, when practical and available
- Consider low energy natural treatment systems when feasible

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Residuals Resource Recovery

Impact of Process Sophistication on Energy Demand

No activated Sludge, Trickling Filter Based Systems

~ 1,000 kWh/MG

Activated Sludge Based Systems with nutrient removal

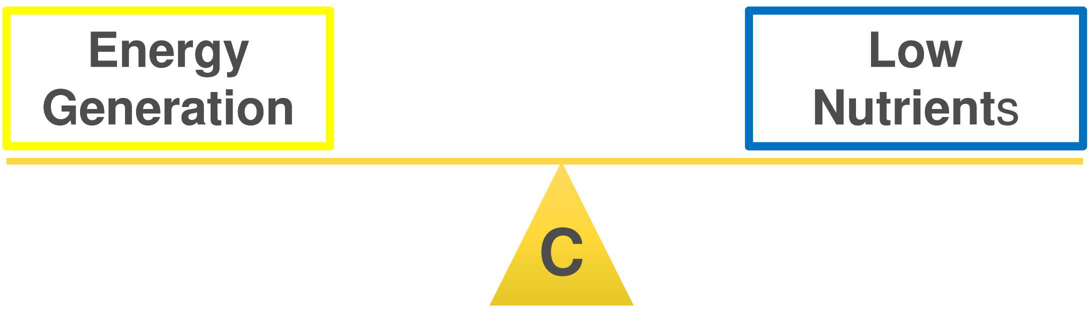
~ 1,400 to 1,600 kWh/MG

Activated Sludge Based System with nutrient removal and advanced treatment

~ 1,700 to 1,900 kWh/MG

Balancing Carbon in the Wastewater Holds the Key to Energy Optimization

- Effective primary treatment reduces carbon load to subsequent processes reducing energy consumption
- Redirected carbon offers potential of significant energy recovery
- Conventional BNR relies on carbon for nitrogen and phosphorus removal.
- Mainstream deammonification and anaerobic processes are alternatives to current energy intensive carbon driven processes



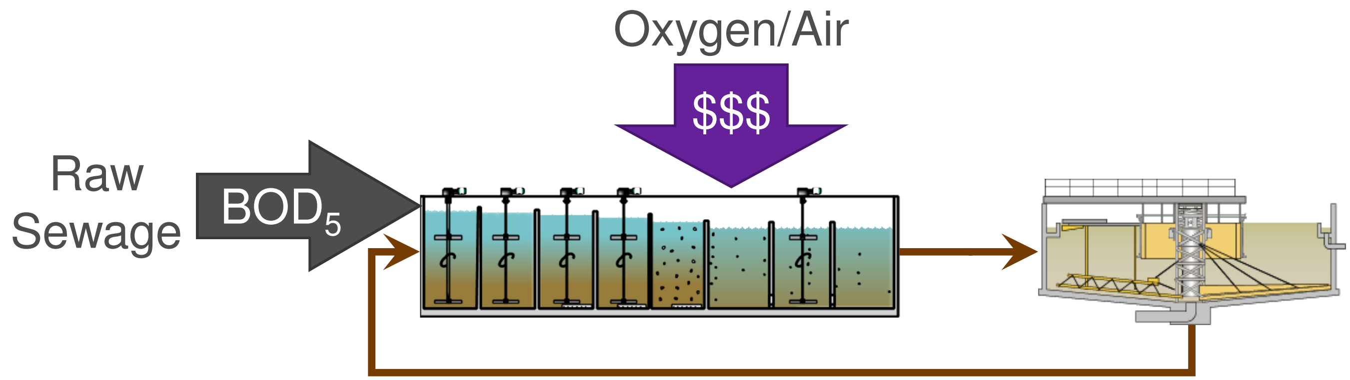
Effective primary treatment: reduces carbon load to subsequent processes and facilitates energy recovery from sludge

- Chemically Enhanced Primary Treatment
- Microscreens
- Dissolved air flotation
- “A” stage of A/B Process
- Anaerobic treatment (UASBs, AnMBR)

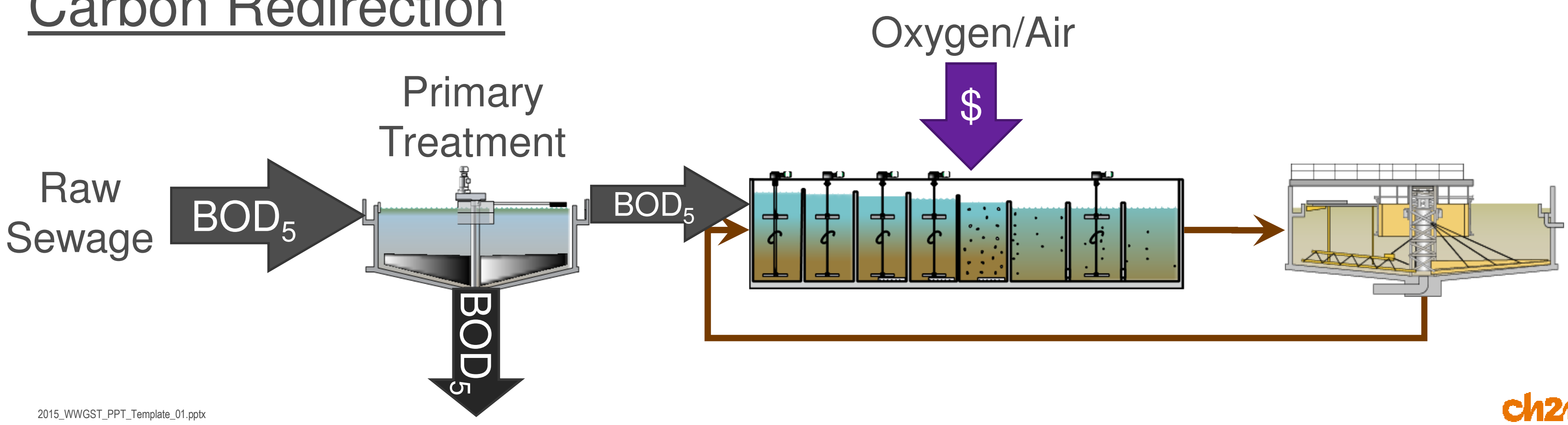
What is Carbon Redirection?

- The diversion of biodegradable material away from the influent to a secondary treatment system

Conventional

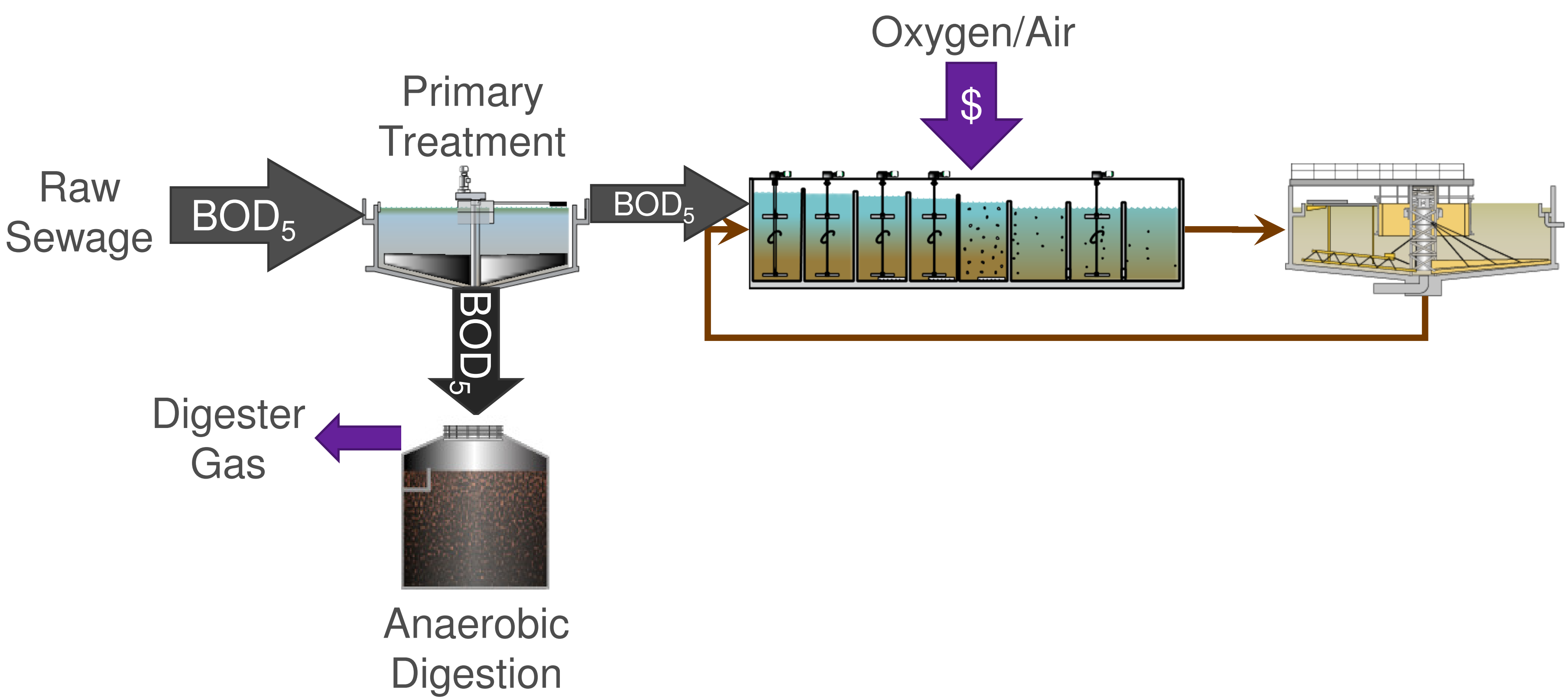


Carbon Redirection



What is Carbon Redirection?

- Realizing energy savings requires anaerobic digestion, or no digestion
  - Aerobic digestion would just move power from the liquids to the solids train



Why Would a Utility be Interested in Carbon Redirection?

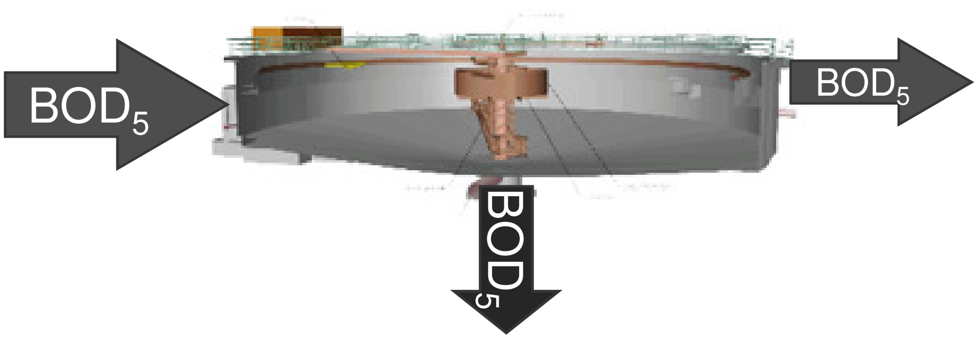
- The Good:
  - Lower Energy Usage
  - More biogas for beneficial use
  - Lower Biosolids Production
  - Smaller Bioreactors/More Bioreactor capacity
  - Sets plant up for future technologies like Mainstream Anammox
- The Bad:
  - Makes conventional nitrogen removal in secondary treatment more difficult. Less carbon is available for denitrification

How do I do Carbon Redirection?

- There are currently three primary ways to redirecting carbon away from secondary treatment
  - Conventional Primary Treatment
  - Chemically Enhanced Primary Treatment
  - High Rate Biological Contact or A-Stage Treatment

Conventional Primary Treatment

- Normally provides between 25% and 45% BOD_5 removal
- This is accomplished through the removal of settleable solids across the primary clarifier

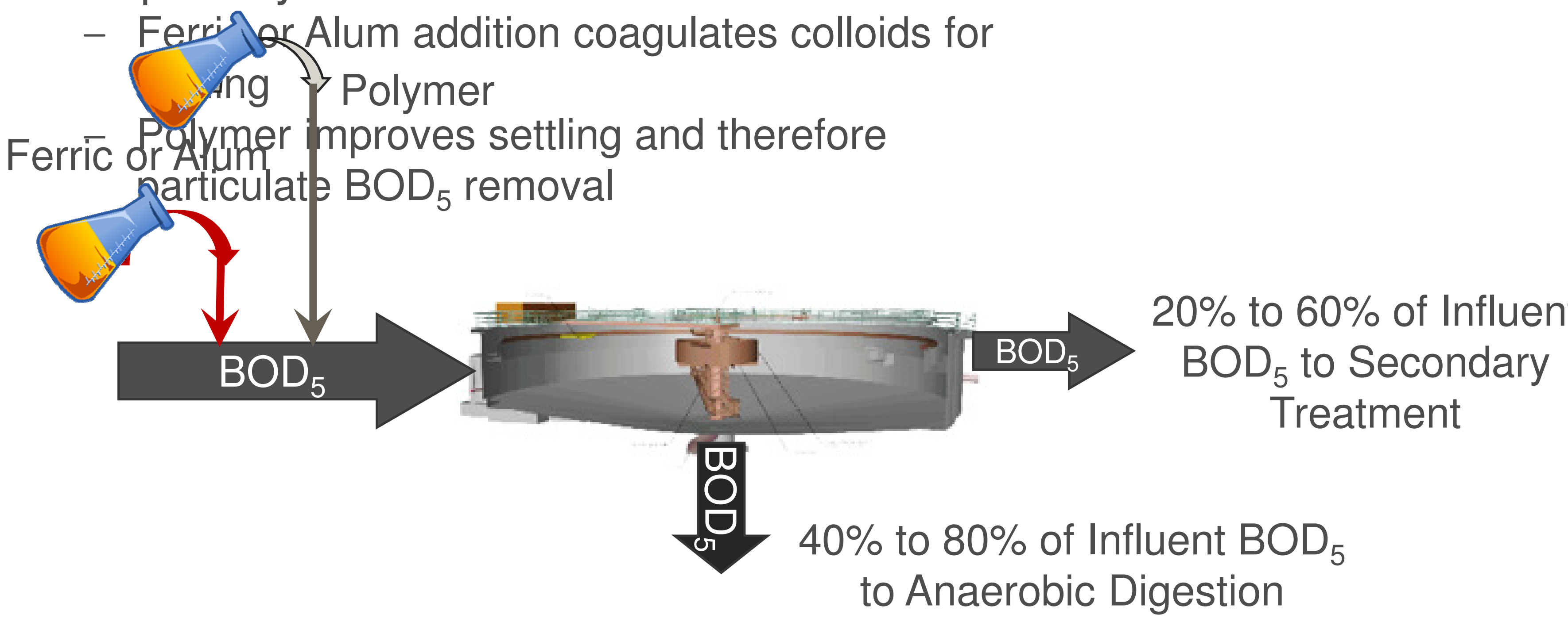


55% to 75% of Influent BOD_5 to Secondary Treatment

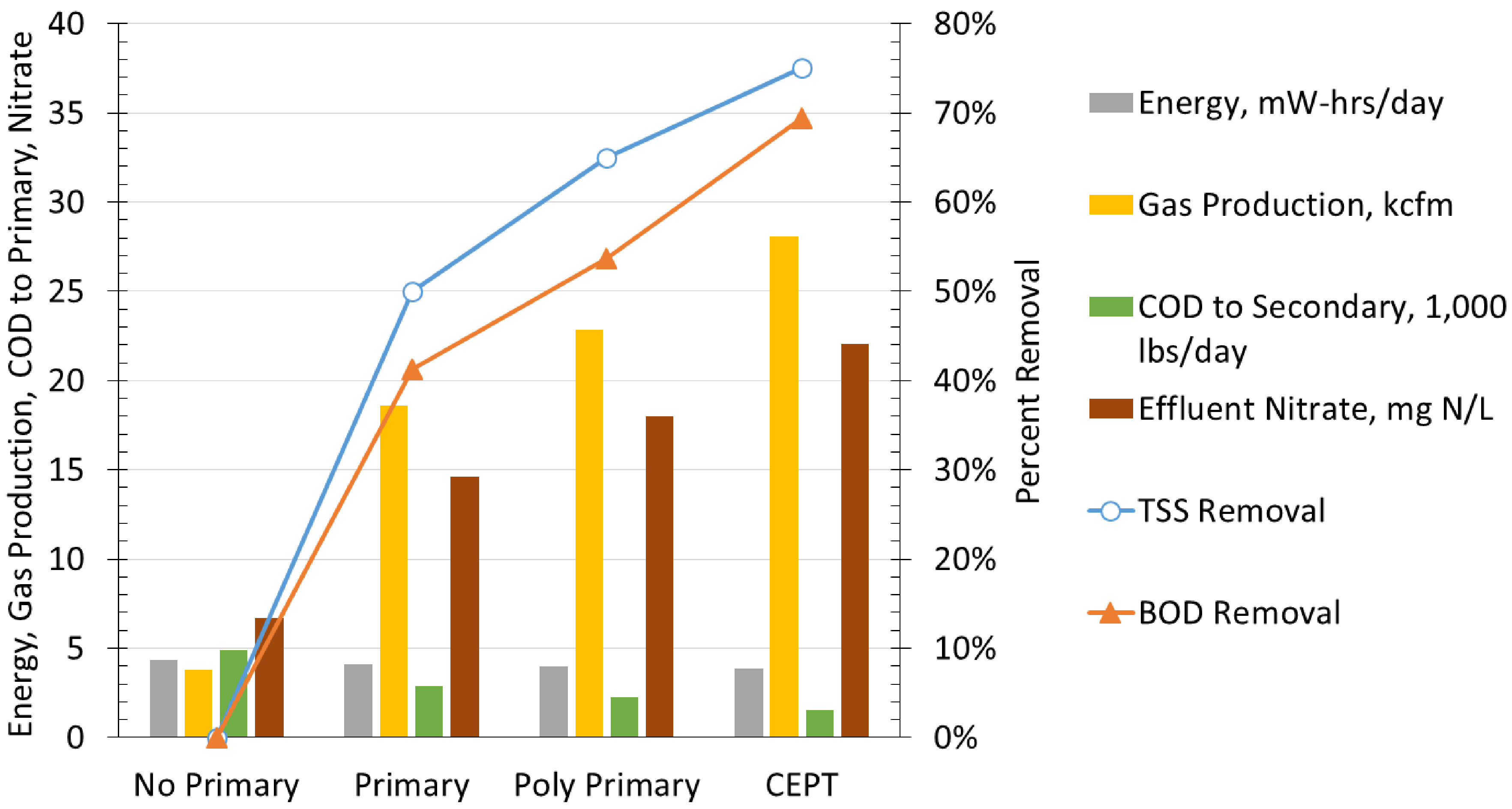
25% to 45% of Influent BOD_5 to Anaerobic Digestion

Chemically Enhanced Primary Treatment

- Normally provides between 40% and 80% BOD_5 removal
- This is accomplished through the removal of settleable solids and colloidal material across the primary clarifier
  - Ferric or Alum addition coagulates colloids for settling
  - Polymer improves settling and therefore particulate BOD_5 removal

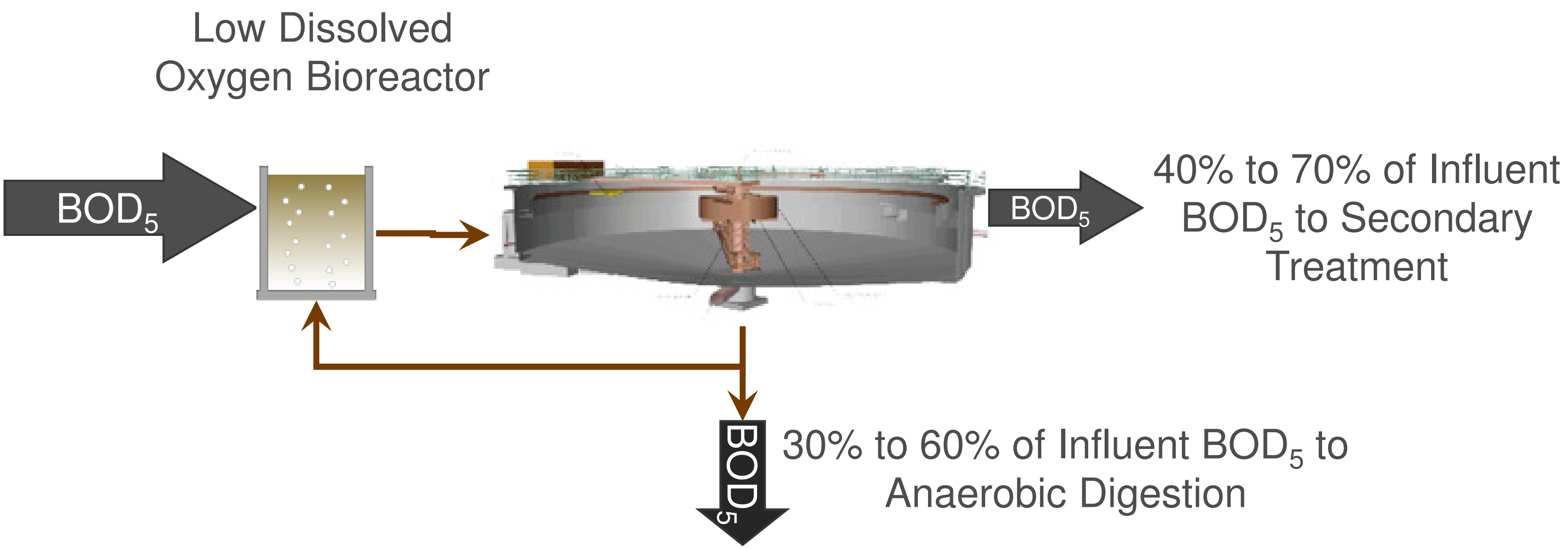


Impact of Primary Clarification (1 MGD Facility)

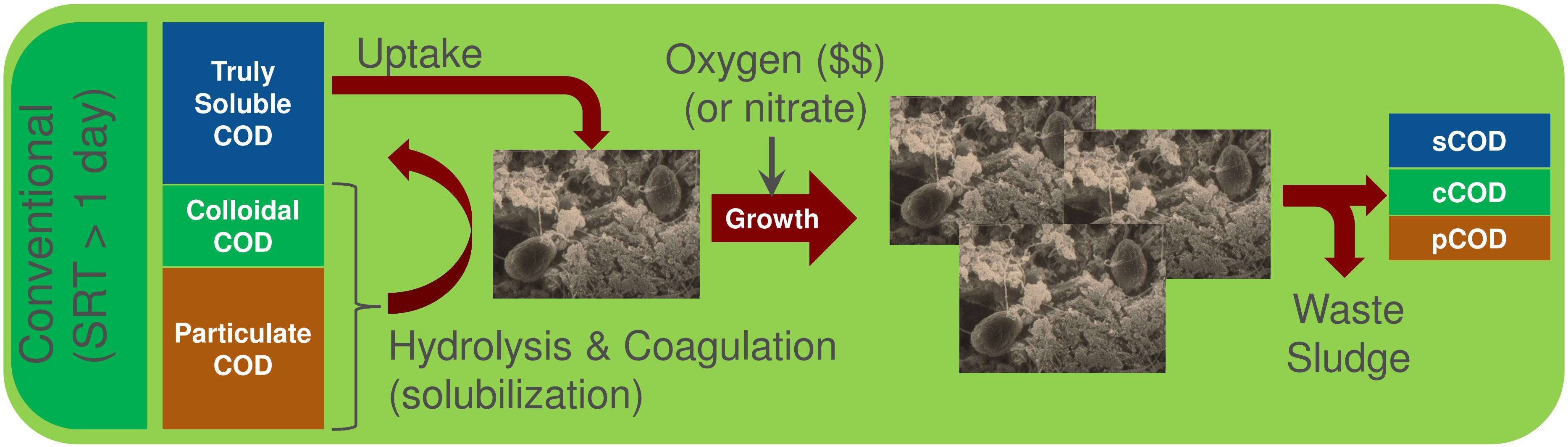


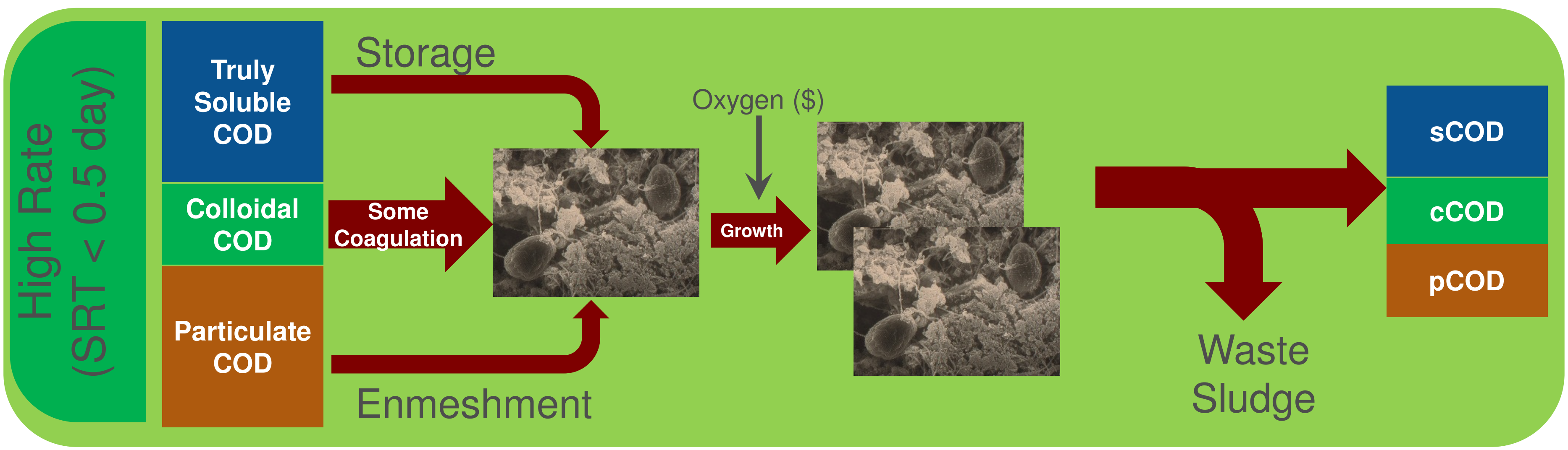
High Rate Biological Contact or A-Stage Treatment

- Very low SRT system (0.25 days to 0.5 days sludge retention time)
- This is accomplished through the removal of settleable, colloidal, and soluble BOD_5 across the primary clarifier
  - No chemical usage!

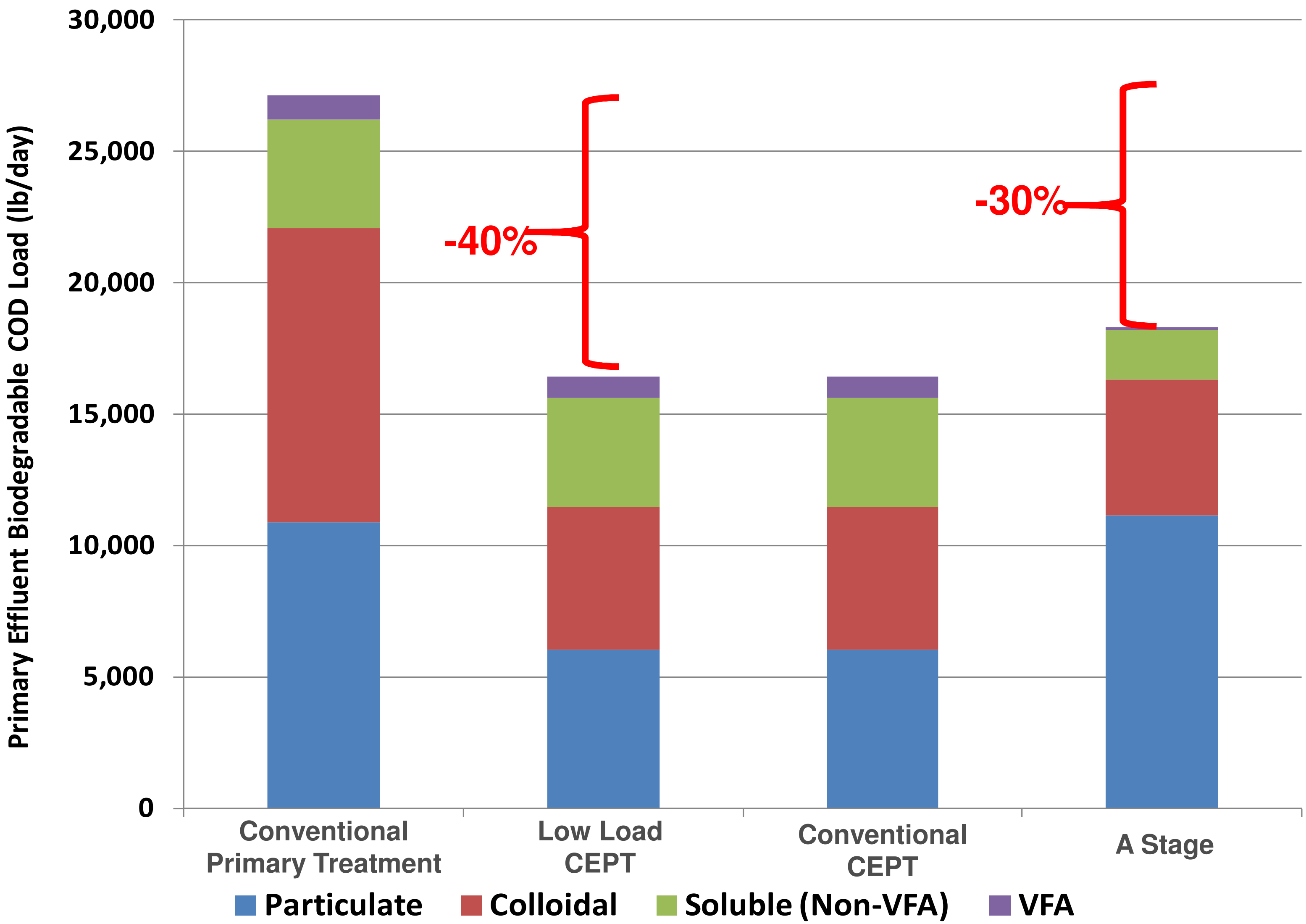


Biological Contact Mechanisms of COD (or BOD) Removal



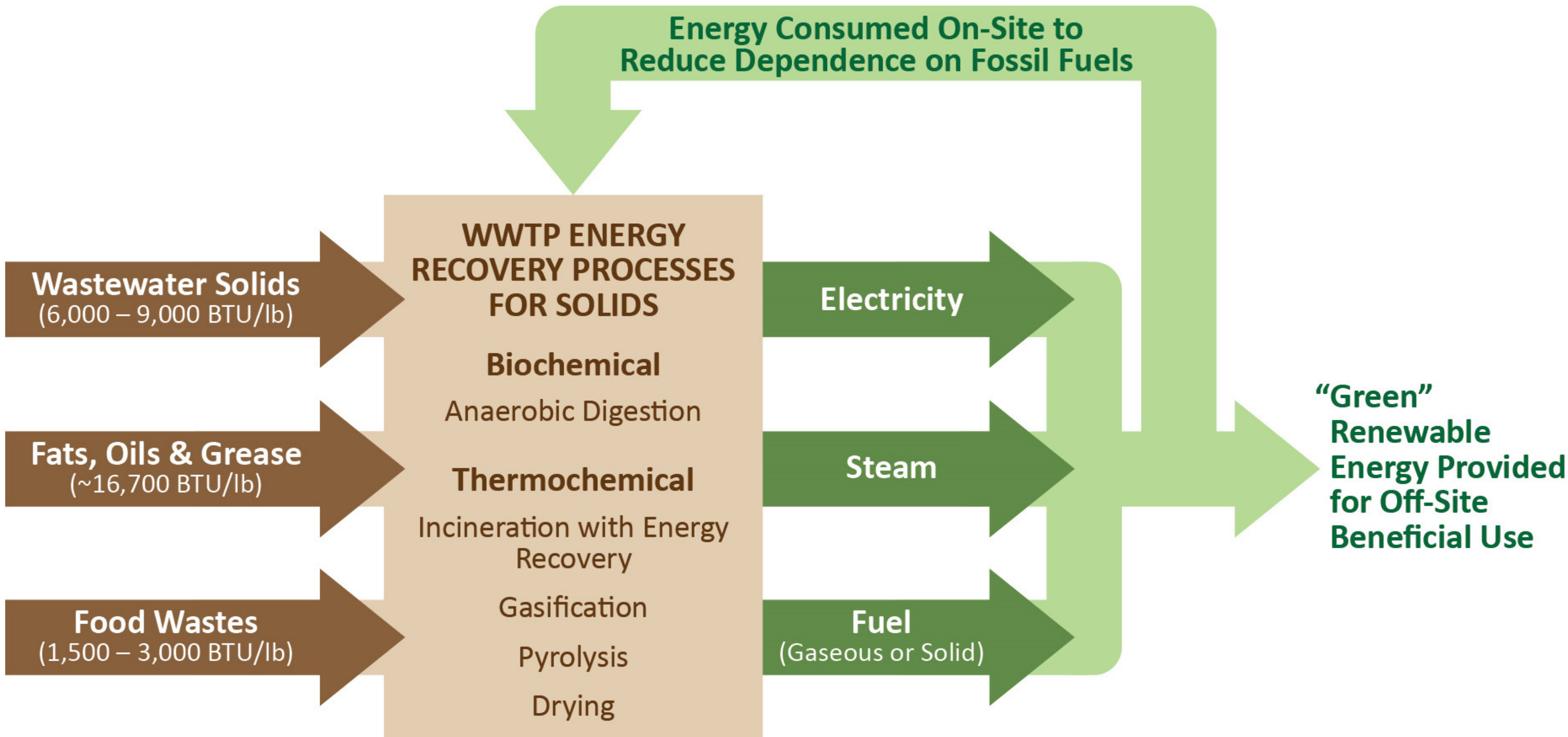


Typical Carbon Diversion System Performance



Residuals Resource Recovery

The Realm of Energy Recovery Opportunities



Utilization of redirected carbon as a renewable energy source: Residuals to energy

- Direct conversion to energy (incineration)
- Preparation and utilization as a fuel
  - Sludge to biogas (cogeneration)
  - Sludge to syngas (gasification)
  - Sludge to oil
  - Sludge to solid fuel (carbonization)
- Status
  - Direct conversion proven but not widely used
  - Some technologies proven, lack of markets
  - ***Biogas cogeneration most widely used***

Carbon redirection and biogas cogeneration in combined heat & power schemes

- Proven energy recovery scheme
- Qualifies as a renewable fuel for green power programs
- Reduces greenhouse gas and other air emissions
- Enhances facility power reliability
- Further gains from sludge pre-conditioning and co-digestion
- Next generation: higher conversion efficiencies (fuel cells?)

F. Wayne Hill Water Resources Center

Douglas L. Smith Middle Basin WWTP

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Elements of an Energy Management Plan

Energy Management Plan

Energy Use Baseline

- Energy benchmarking e.g. kWh/MG, kWh/lb BOD treated, kWh/lb N treated.
- Electrical sub-metering
- Utility billing rate structure
- Current and future energy costs

Non-Process Energy Use Optimization and Generation

- Lighting, building and HVAC Improvements
- Renewable energy such as solar, wind and/or hydroelectric

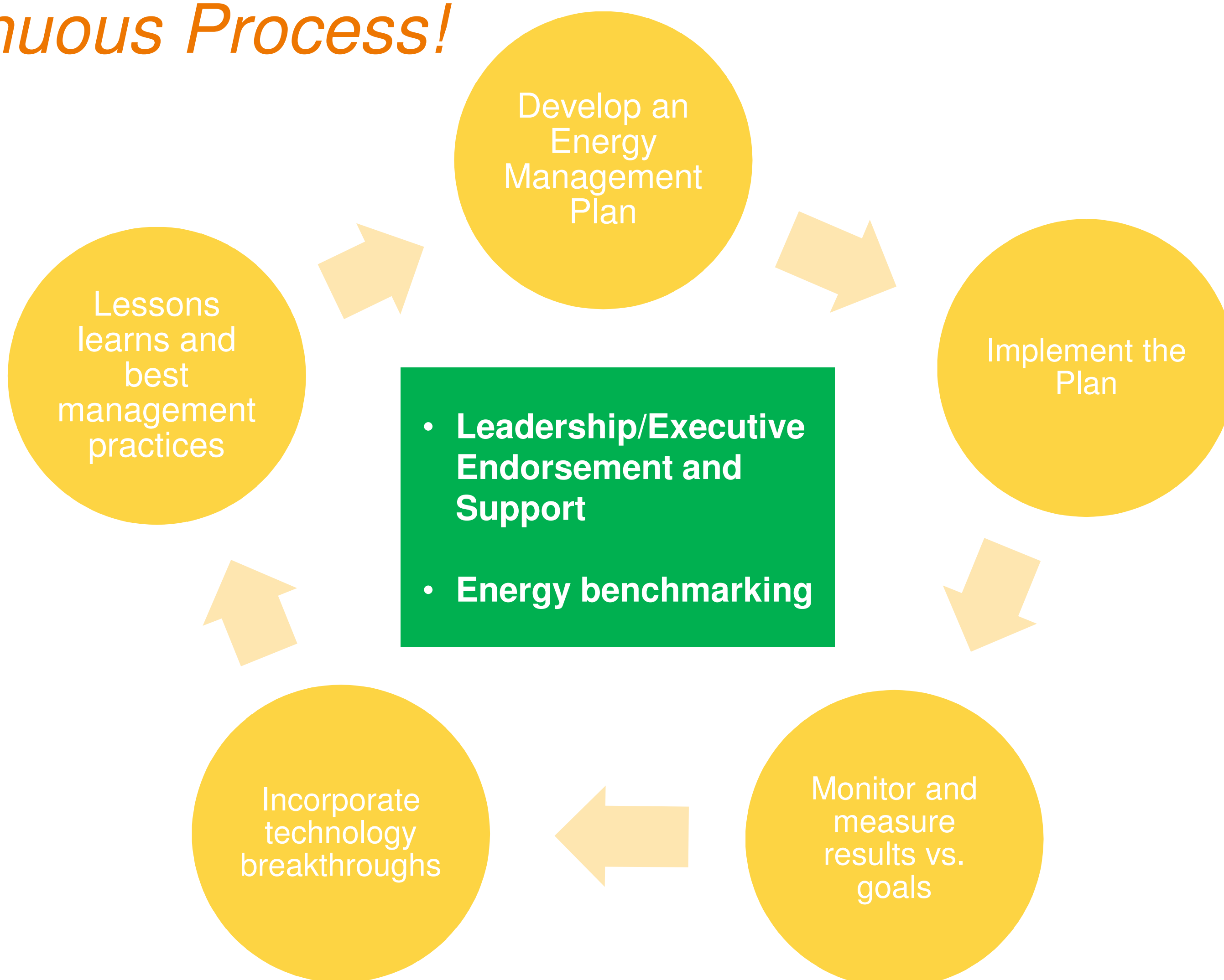
Process Optimization

- Process control optimization and improvements
- Process modifications or upgrades (low metabolic pathway)
- Energy efficient equipment

Process (Calorific) Energy Recovery

- Biochemical processes
- Thermochemical processes
- Treatment of other high energy dense waste materials e.g. FOG

Energy Management – *A Continuous Process!*



- **Leadership/Executive Endorsement and Support**
- **Energy benchmarking**

CASE STUDIES

Case Studies

- Greater New Haven Water Pollution Abatement Facility – New Haven, Connecticut
- VandCenter Syd’s Ejby Mølle Wastewater Treatment Plant - Odense, Denmark
- Crooked Creek Water Reclamation Facility – Gwinnett County, Georgia

Case Study 1 – Greater New Haven WPCF

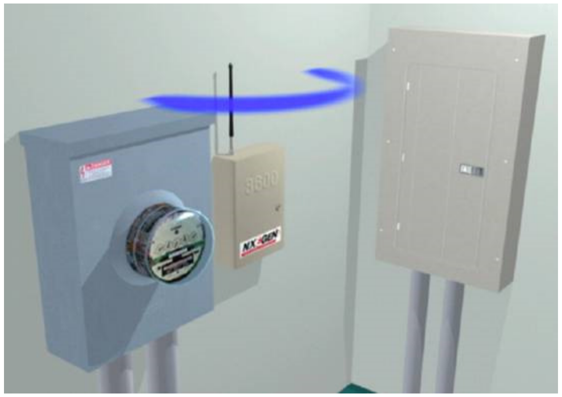
- 60 mgd facility
  - Nutrient Removal: 5 mg/LTN annual average

Energy audit and monitoring lead to energy optimization opportunities and process control enhancements!

Residuals Resource Recovery

Case Study 1 - Power Mapping and Energy Model

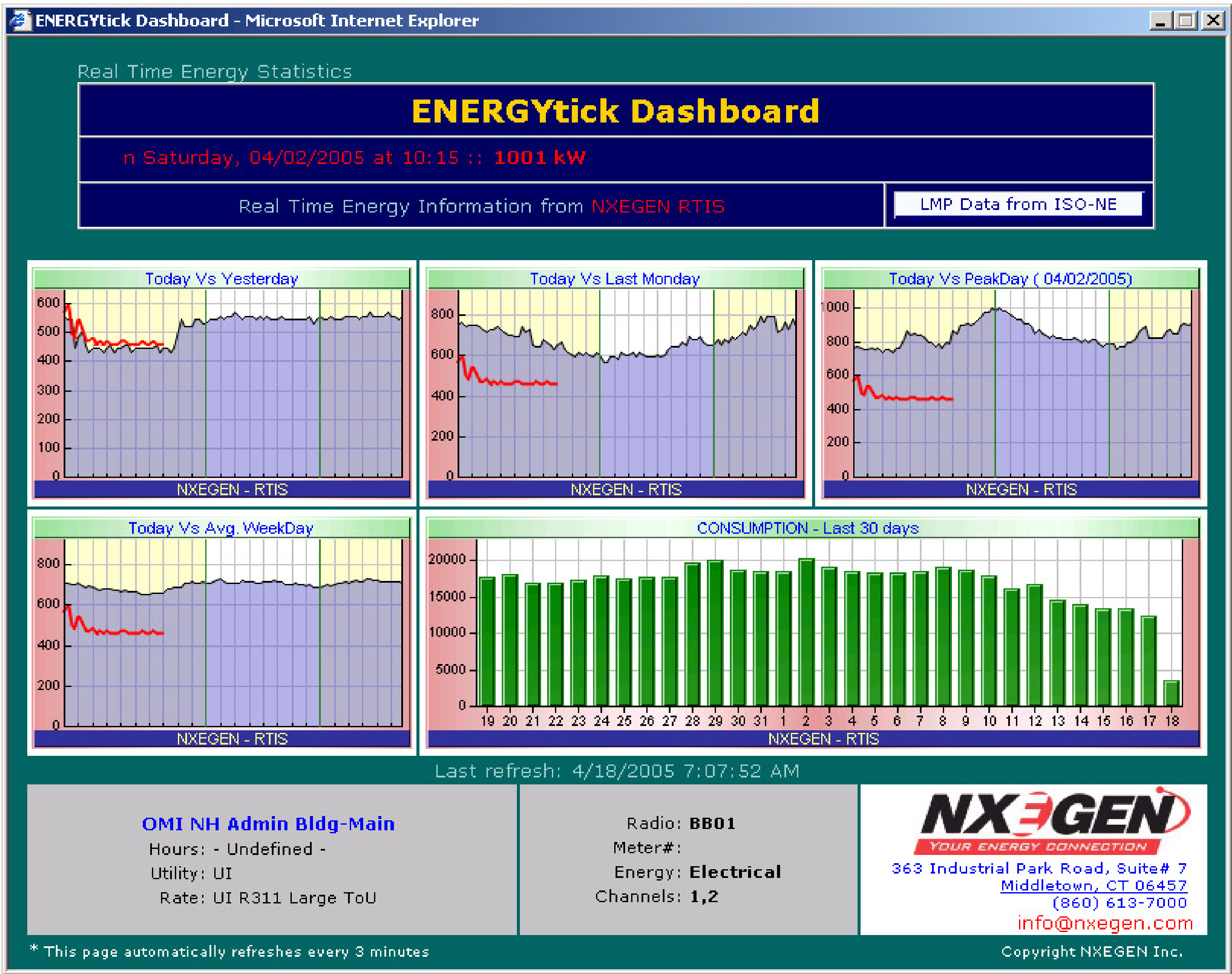
- Detailed mapping of power systems, MCCs, etc.
- Static energy model to account for unit process energy consumption
- Model calibration through online power monitoring of key load centers



OMI Electricity Baseline End Use Budget
East Shore Facility
Month: December 31

	No. of Motors	Operating Motors	Power Factor	Motor H.P.	KW per Motor	Run Hours per Day	Billed KW	Monthly KWh
Large Motors:								
Influent Pumps	3	0.0	90%	250.0	186.5	24.0	0.00	0
Influent Pumps	2	1.8	90%	125.0	93.3	24.0	151.07	112,392
Centrifugal Blowers	5	1.5	90%	700.0	522.2	24.0	704.97	524,498
Totals								636,890
Small Motors:								
Bar Screens	2	1	90%	2.0	1.5	24.0	1.61	1,199
Primary Clarifiers	3	3	90%	1.0	0.7	24.0	2.01	1,499
Secondary Clarifiers	8	8	90%	1.0	0.7	24.0	5.37	3,996
RAS (NRCY)Pumps	8	8	90%	25.0	18.7	24.0	134.28	99,904
Secondary Scum pumps	4	4	90%	5.0	3.7	12.0	13.43	4,995
Primary sludge pumps	6	3	90%	30.0	22.4	12.0	60.43	22,478
Thknd Primary sldg pmps	2	1	90%	5.0	3.7	12.0	3.36	1,249
Primary sludge thickeners	2	2	90%	1.0	0.7	24.0	1.34	999
WAS Pumps	10	5	90%	15.0	11.2	24.0	50.36	37,464
BLEND TANK	4	4	90%	7.5	5.6	24.0	20.14	14,986
Totals								744,071
Total Motor Loads								**1,380,961**
Other Loads:								
					KW Load	Run Hours per Day		
Lighting					207.2	20.0	207.20	128,464
Lighting Upgrade					(75.0)	20.0		
Air Conditioning	# of Tons				KW Load	Run Hours per Day		
	65				78.0	0.0	78.00	0
Heating					KW Load	Run Hours per Day		
					32.6	14.0	32.60	14,148
Computer Loads	# of Work Stations	KW per Work Station	Power Factor			Run Hours per Day		
	30	0.5	95%			18.0	14.25	7,952
Miscellaneous Receptacles		KW per Sq. Ft.	Sq. Ft.			Run Hours per Day		
		1.5	32000			24.0	48.00	35,712
Totals								186,276
Total Baseline Electricity Loads								1,567,237

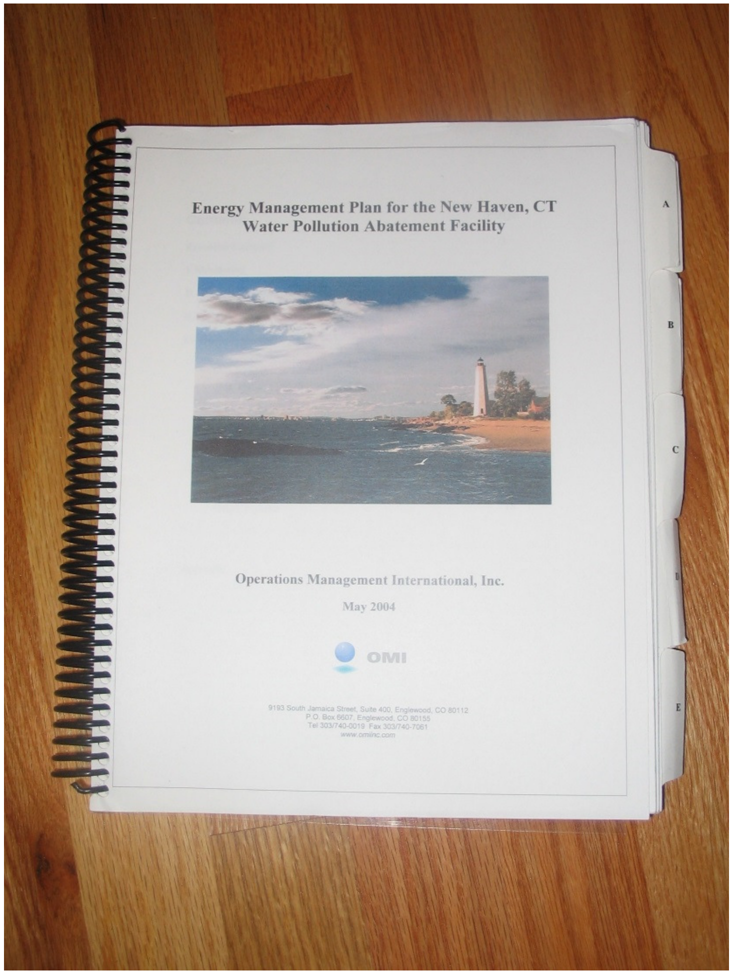
Case Study 1 – Energy Monitoring Dashboard



Residuals Resource Recovery

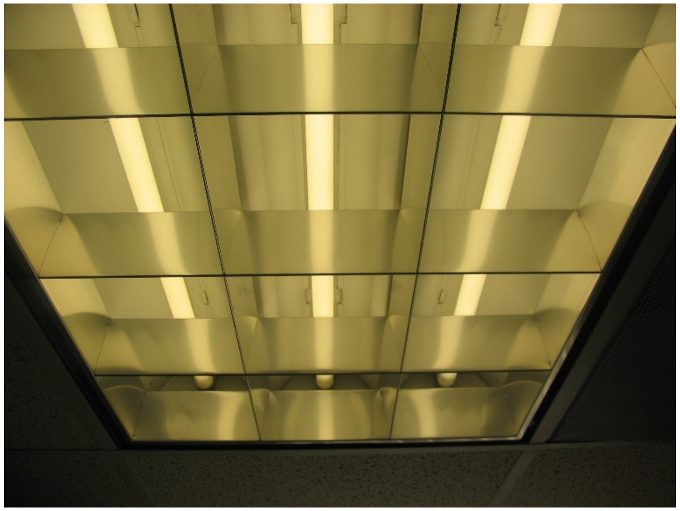
Case Study 1 – The Energy Management Plan

- Power mapping and energy model served as cornerstones for development of the Energy Management Plan
- Mapping, Modeling & Monitoring Outcomes
  - Found 600,000 kWh/year of power used by 3rd party contractor
  - Identified weaknesses in emergency power supply setup
  - Found discrepancies between utility bills and on-line metering
- Energy Management Plan focused on projects with high return on investment



Case Study 1 – Greater New Haven WPCF

- Energy Management Plan Implementation:
  - Instituted light improvements resulting in 658,000 kWh/yr electrical savings and a 2.7 year payback on investment
  - Instituted ISO NE demand response program to generate revenue and reduce power load by 1.7 MW
  - Modified SCADA system, new DO control, installed new instruments to optimize aeration basin blowers
    - Retrofitted blowers helped save 1 million kWh/yr
- Reduced overall power use by 3 million kWh/yr



Case Study 2 – VandCenter Syd (VCS)

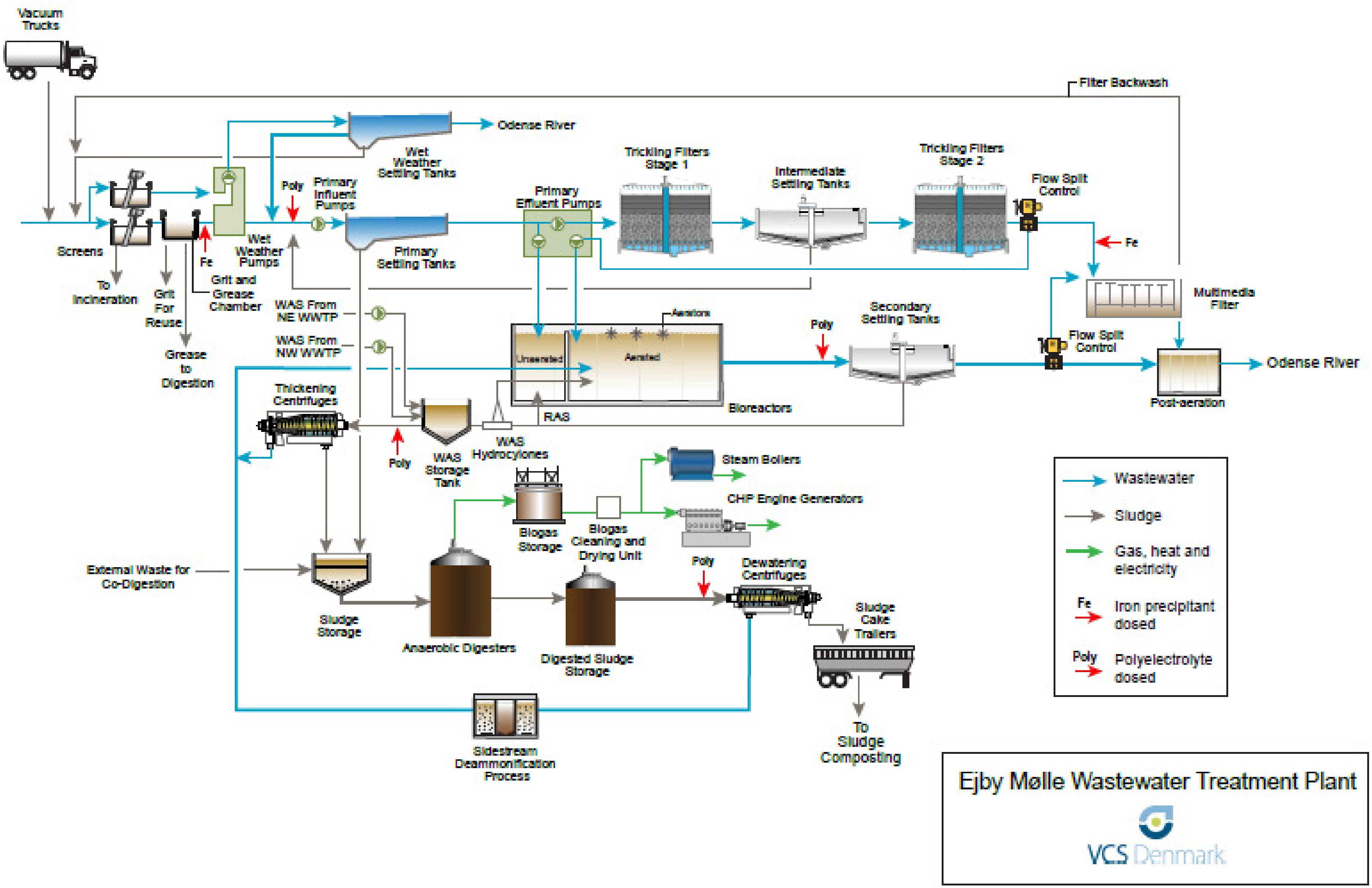
- 3rd largest water and wastewater company in Denmark. Headquartered in Odense.
- Operates 7 WTPs and 8 WWTPs with 2,125 miles (3,400 km) of conveyance
- Ejby Mølle WWTP:
  - 385,000 PE BNR facility
  - 76 percent self-sufficient in 2011

Achieving Energy Self-Sufficiency in a Nutrient Removal Facility Through Operational Optimization!

Case Study 2 - Ejby Mølle WWTP Energy Optimization Project Objectives

- Contribute towards achieving VCS's corporate goal of energy self-sufficiency and carbon neutrality by 2014
- Identify energy optimization opportunities (EOOs):
  - Short-term, readily implementable scenarios to reduce energy consumption and/or increase energy generation, and decrease greenhouse gas emissions
- Identify and document all options, including longer term opportunities for future consideration

Residuals Resource Recovery



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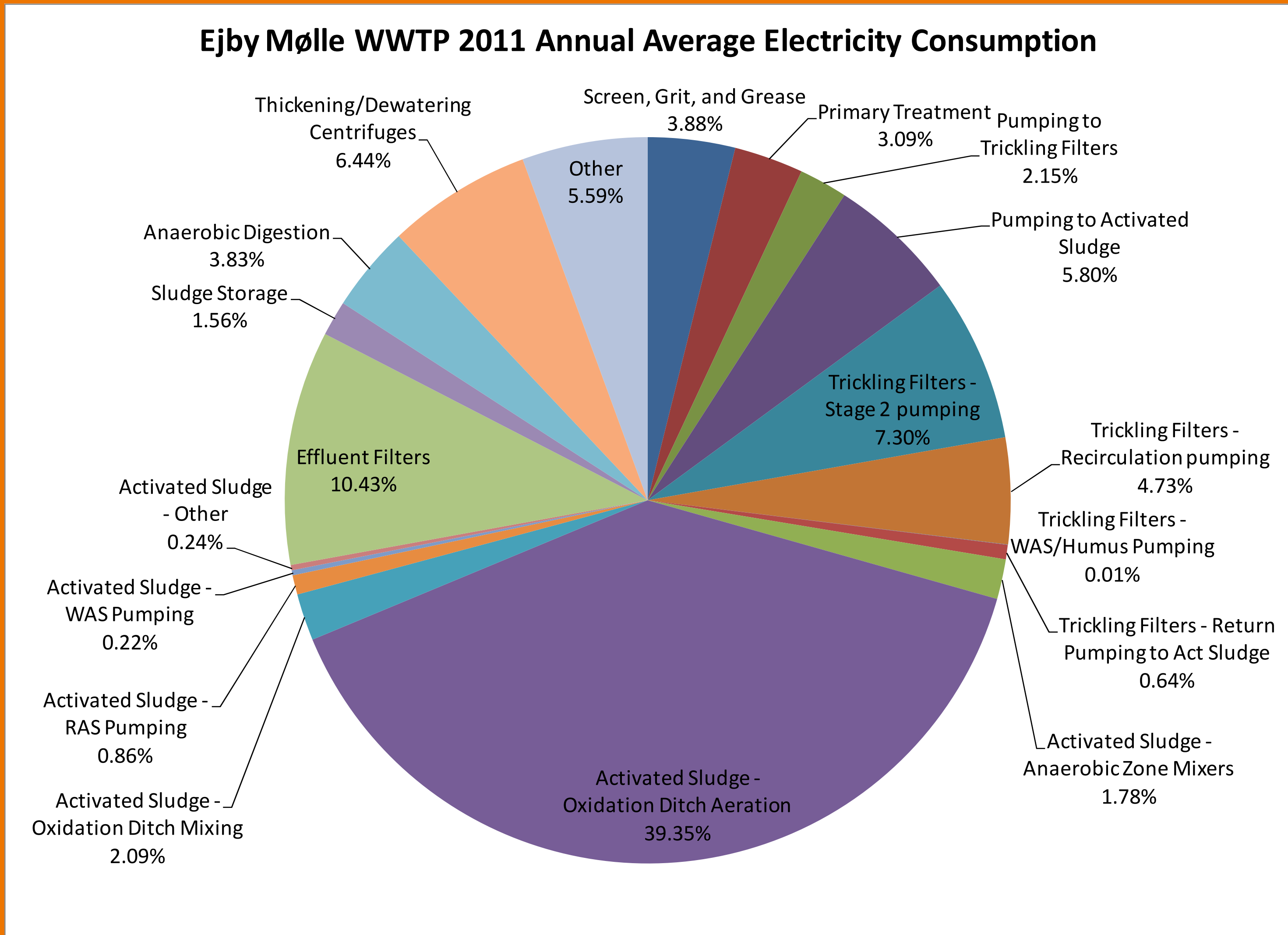
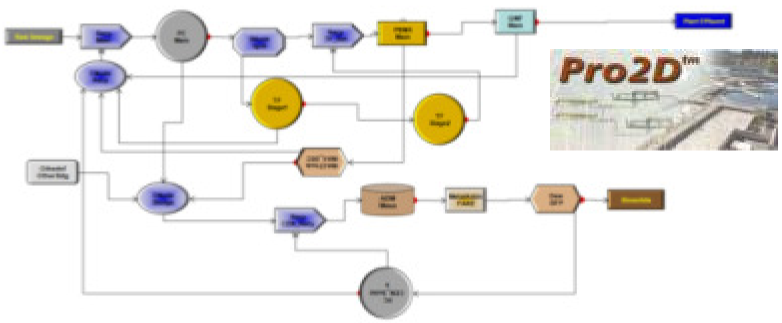
Case Study 2 – Availability of detailed historic energy consumption and generation data was key in the evaluation of optimization opportunities



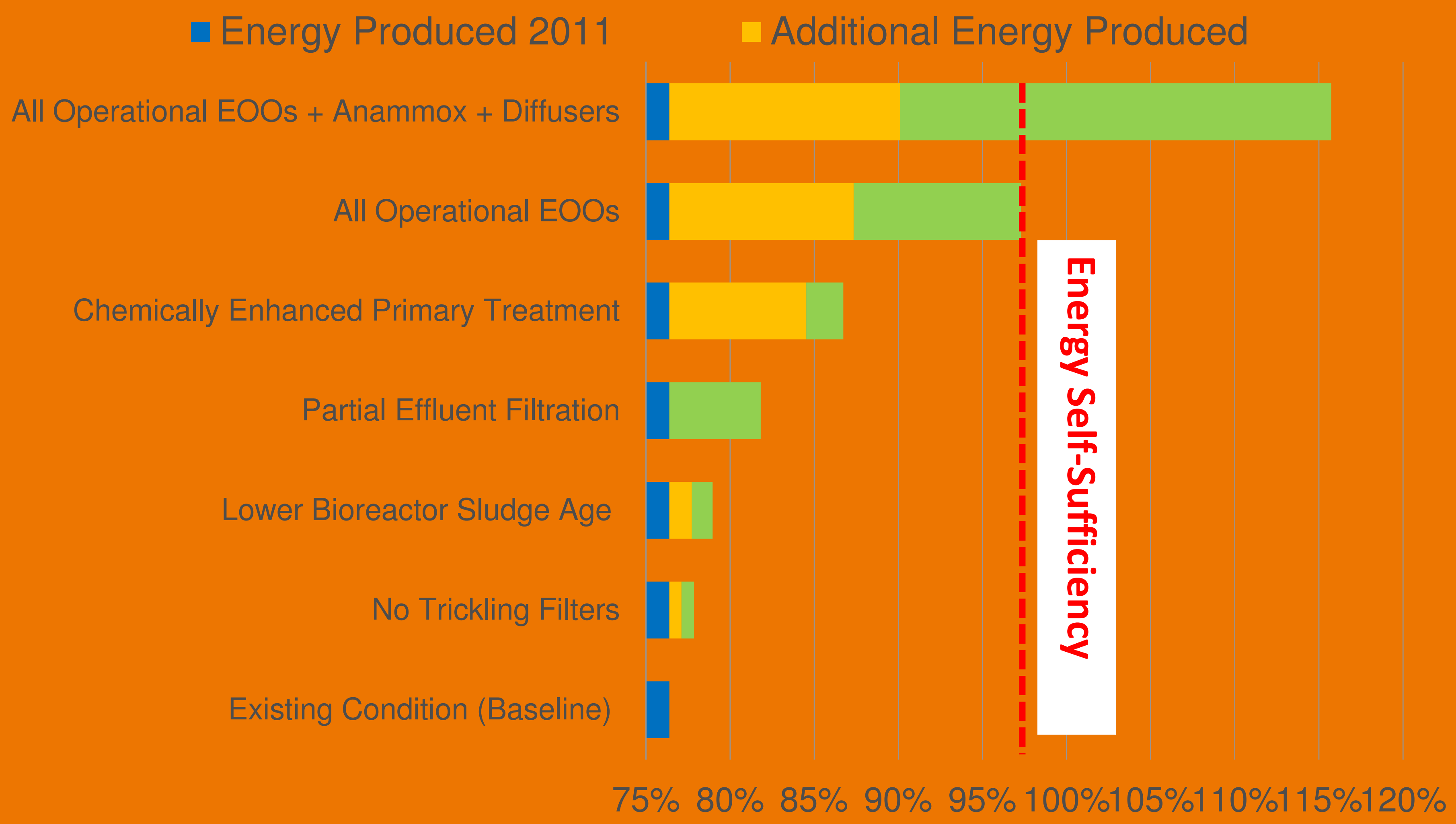
Case Study 2 - A whole plant mass/energy model and screening criteria lead to an EOO short-list

- **Adopted screening criteria**
  - Readily implementable; Primarily process modifications
  - Significant impact on energy profile; Proven elsewhere
- **Short-listed EOOs**
  - Implement chemical enhanced primary treatment (CEPT)
  - Operate at shorter BNR system solids retention time (SRT)
  - Decommission TFs and convert TF clarifiers to CEPT for wet weather treatment
  - Reduce effluent filtration operation to 12 hours per day



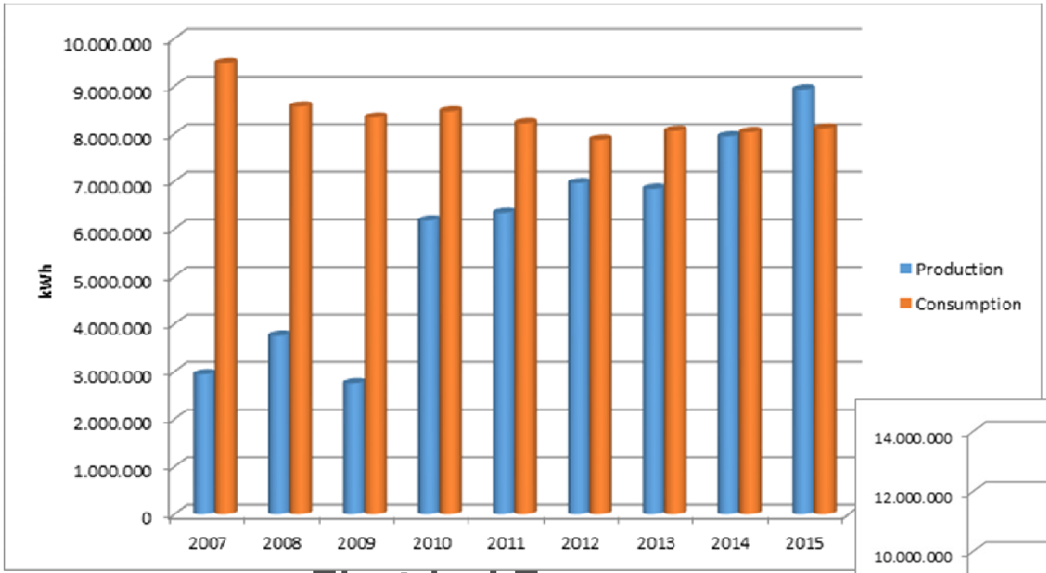
- **Longer term Improvements for positive net energy status**
  - Co-digestion of high strength waste in 2014
  - Implemented deammonification for N removal in sidestreams in 2014; mainstream in 2015
  - Replace oxidation ditch mechanical aerators with fine bubble diffused aeration

Case Study 2 – Path to Energy Self Sufficiency

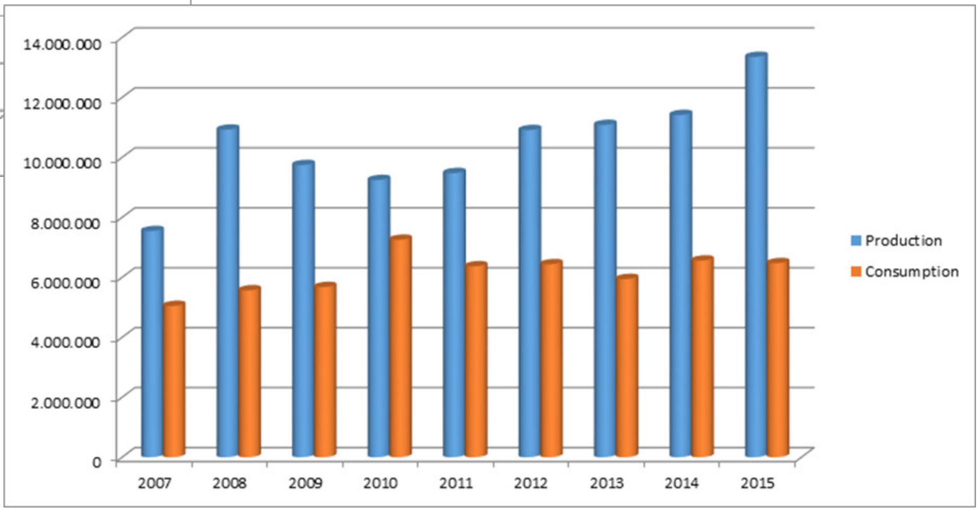


Residuals Resource Recovery

Implementation of several EOOs achieved energy self- sufficiency in 2014



Electrical Energy



Electrical + Heat Energy

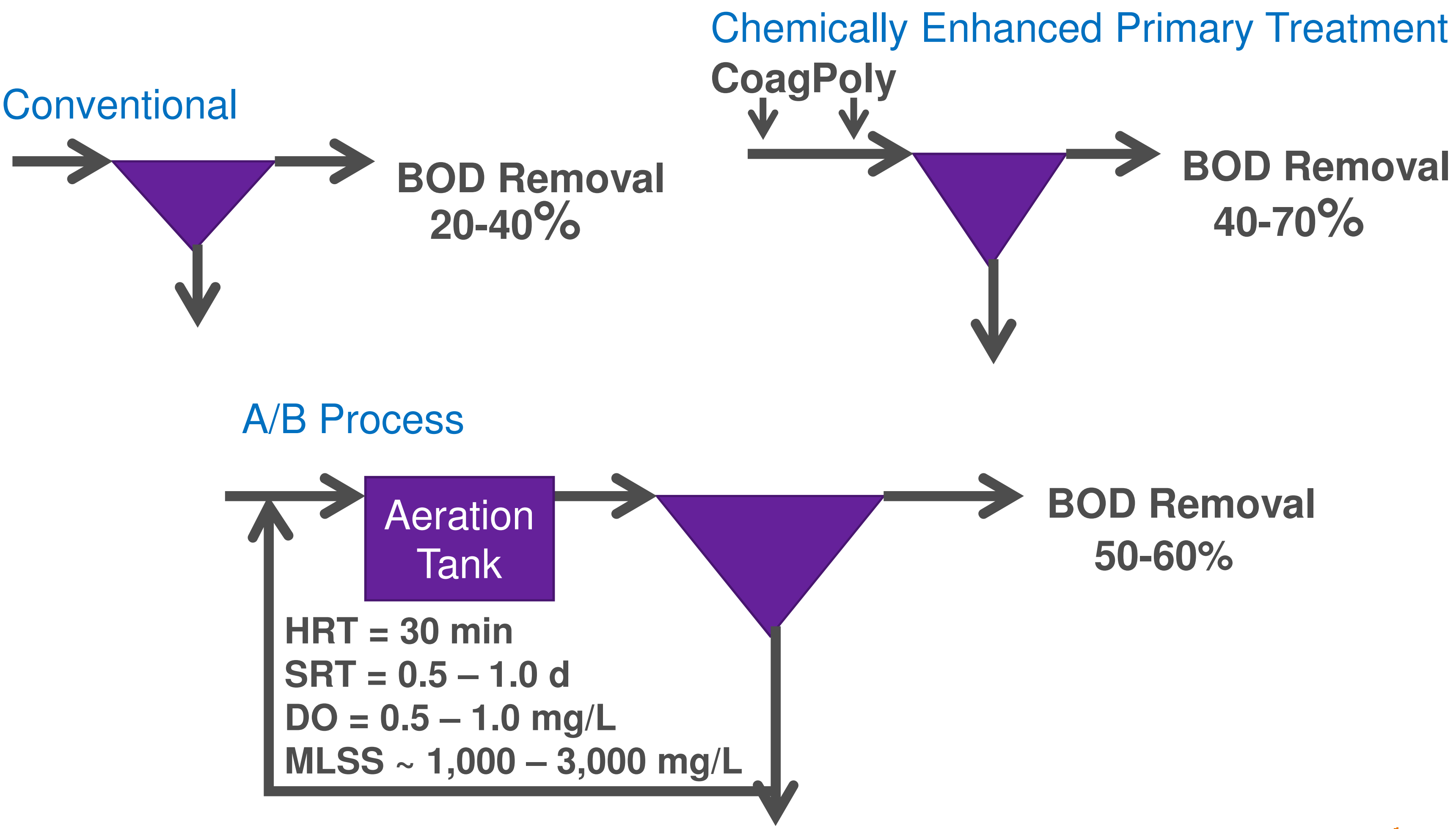
Case Study 3 – Crooked Creek WRF

- 16 mgd design capacity
- Process study of potential future improvements focused on whole plant process modeling to examine relative energy and carbon benefits of different configurations
- Solids stream evaluations focused on anaerobic digestion and biogas production for combined heat and power production

Process Optimization to Reduce Energy Consumption!

Case Study 3 – Crooked Creek WRF

- Primary Treatment Approaches Investigated:

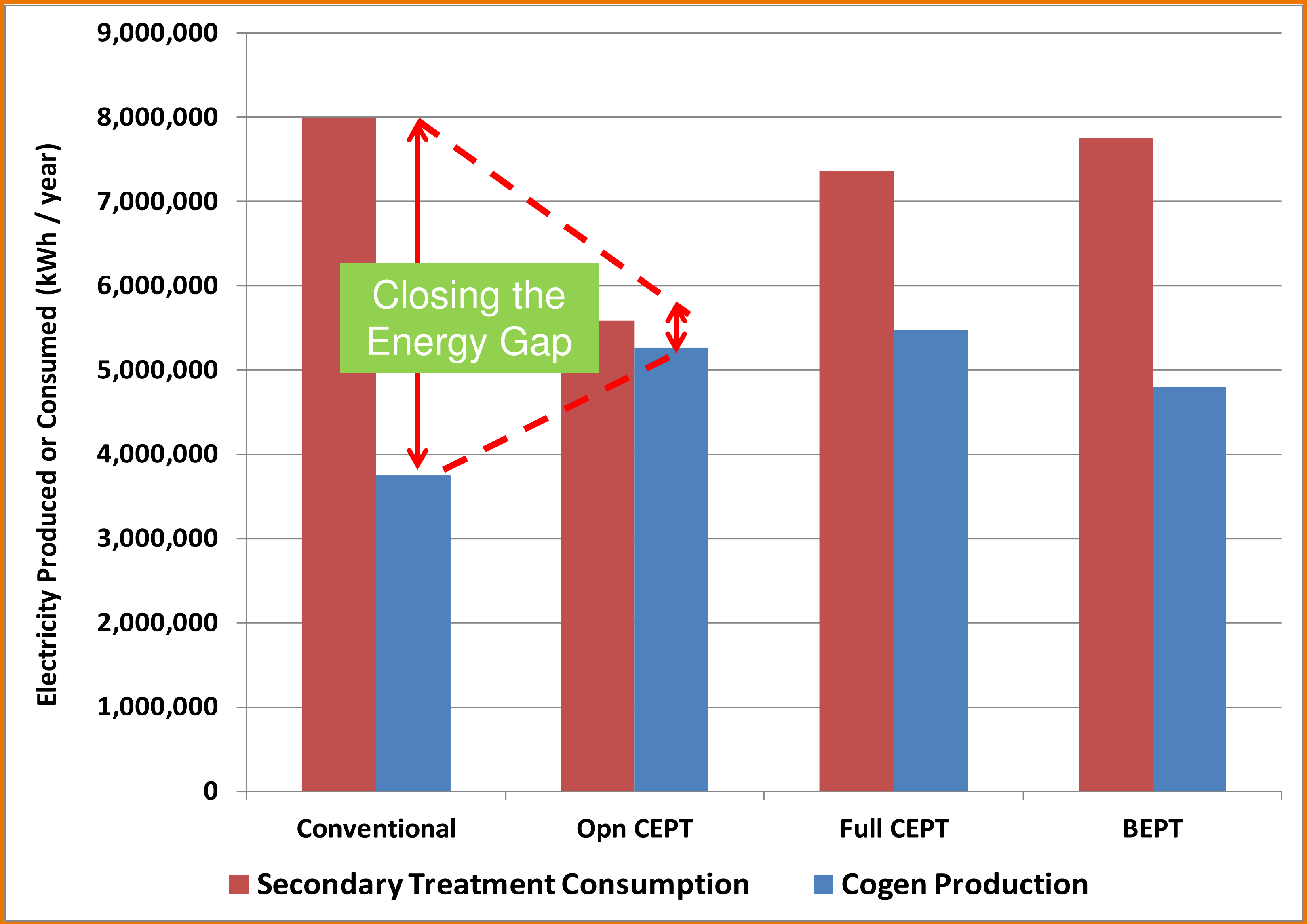


Case Study 3 – Crooked Creek WRF

- A/B Process
  - Currently of interest as a “low energy” process
  - Variation of 2-stage activated sludge
  - Biologically Enhanced Primary Treatment (BEPT)
- Primary Treatment Approach

Scenario Name	Plant Sizing	Plant Operating Mode
Conventional	Conventional	Conventional
Operational CEPT	Conventional	CEPT
Full CEPT	CEPT	CEPT
BEPT	BEPT	BEPT

Case Study 3 – Secondary Treatment Energy Use vs. Cogeneration Production



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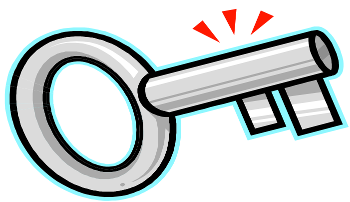
Conclusions

- Typical municipal wastewater theoretically has more energy in pollutants compared to energy required for its treatment
- Energy benchmarking and monitoring is essential to evaluate potential improvement scenarios
- Energy management is a continuous “cyclical” process



- Two pronged approach to energy management
  - Energy use optimization
  - Energy recovery
- A holistic approach to energy management is critical due to interrelationships between energy use optimization and recovery
- Energy self-sufficiency possible with significant generation as well as reduction measures
- Net energy-positive condition achievable with external carbon (codigestion)
- Balancing nutrient removal, carbon management, energy production, energy conservation and water reclamation requirements are key to striving for energy neutrality

WWTP ENERGY MANAGEMENT SOLUTIONS AND CASE STUDIES

Questions?