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U.S. DEPARTMENT OF ENERGY

Just Add Water!

Quick Wins on Energy Efficiency in Wastewater Treatment Plants

May 16, 2017

11:15 am – 12:30 pm

U.S. DEPARTMENT OF ENERGY

Panelists

- John Smegal (Moderator), U.S. DOE, Advanced Manufacturing Office
- Jim Newton, Kent County Delaware, Public Works Department
- Glenn Cunningham, Tennessee Tech University Industrial Assessment Center

John Smegal, Moderator

U.S. Department of Energy, Advanced Manufacturing Office

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Industrial Assessment Centers

Energy Efficiency in Wastewater Treatment Plants

John Smegal, Advanced Manufacturing Office

May 16, 2017

IAC Program

Overview

- The IAC program focuses on generating energy savings, productivity improvements, and water use and wastewater reductions at small and medium-sized manufacturers
- The program also provides significant workforce development benefits

Approach

- Center Directors are typically tenured engineering faculty interested in practical applications
  - Mentor and evaluate student performance on assessments
- Assessments are a teaching tool and the backbone of the real-world IAC experience
  - Normally consists of a one day site visit at an industrial plant
- Assessment reports (60 days) and implementation follow-up (9 – 12 months)

Results

- Average identified savings opportunities are approximately $140,000 annually
- IAC clients typically saves more than $47,000 per year
- Costs to DOE are less than one-fourth of energy savings
  - Savings do not account for persistence
  - Savings do not account for activities associated with IAC graduates

IAC Assessments

- IACs typically focus on serving small and medium-sized manufacturers
  - More than 17,500 assessments conducted
  - More than 133,000 energy savings recommendations made
- Each year, IACs have conducted a limited number (1-2 per center, per year) of “non-traditional” assessments, including water supply and wastewater treatment facilities
  - These facilities include many industrial-type systems (e.g., motors, pumps, fans, compressed air)
- The most recent group of IACs (FY 12 - 16) placed an increased emphasis on serving water and wastewater facilities
- Going forward, this increased emphasis will continue or grow

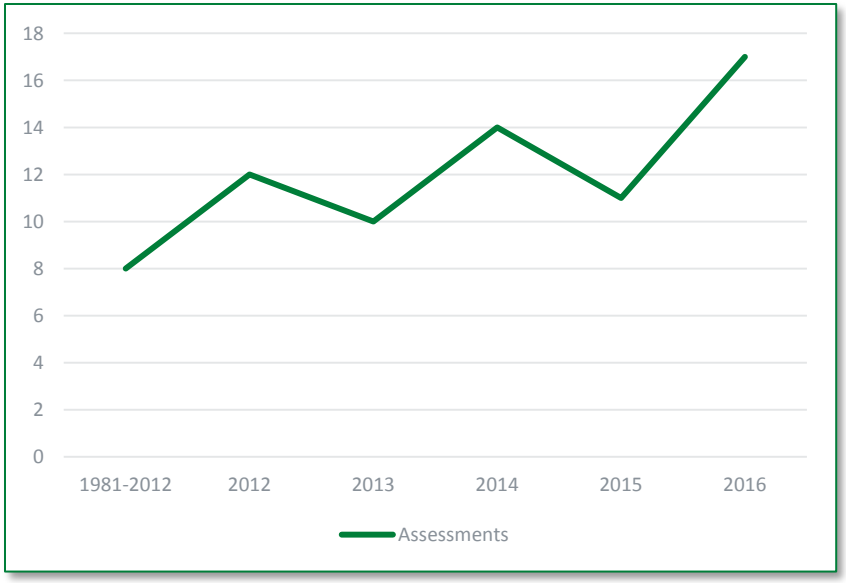
IAC Water and Wastewater Assessments

Location of IAC Water Assessments

(Since 1981)

Number of IAC Assessments

(Since 1981)



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IAC Assessment Results: Water/Wastewater

State	Assessments	Recommendations	Recommended Savings
AK	1	6	$111,304
AL	1	3	$245,530
AZ	6	33	$2,435,148
CA	21	150	$4,372,429
CT	4	27	$139,041
DE	2	9	$246,025
FL	1	7	$130,626
HI	2	23	$4,088,330
IA	1	6	$11,338
ID	1	6	$101,786
IN	3	23	$144,697
KY	3	13	$297,916
MA	5	21	$165,021
MD	7	51	$2,143,911
NC	1	8	$63,618
NE	1	4	$25,821
NV	1	6	$31,291
NY	1	5	$8,469
OR	3	11	$128,839
PA	4	26	$904,147
VA	2	13	112,314
WA	4	25	$732,862
WI	3	22	$293,051
WV	1	8	$80,947
TOTAL	79	506	$17,014,461

IAC Assessment Results: Recommendations

- Typical recommendations include:
  - Install equipment to use waste fuel
  - Install high-efficiency lamps and ballasts
  - Reduce space conditioning during off-peak hours
  - Balance use of high efficiency equipment at peak times and lower efficiency equipment at off-peak times
  - Install occupancy sensors
  - Upgrade compressor controls
  - Optimize motor and pump size
  - Turn off equipment when not in use

IAC Assessments: Emerging Priorities

- Beginning in FY 17, newly selected IACs (28 primary, plus 6 satellites) have been specifically tasked to engage in more water/wastewater treatment assessments
  - Targeting 1-2 facilities per center, per year
- DOE and the individual IACs have been actively engaging with EPA Regions and state water authorities to identify potential opportunities to conduct assessments

- IAC Field Manager, in collaboration with more experienced centers and key stakeholders will be providing training and sharing lessons learned with new centers in conducting such assessments

Questions?

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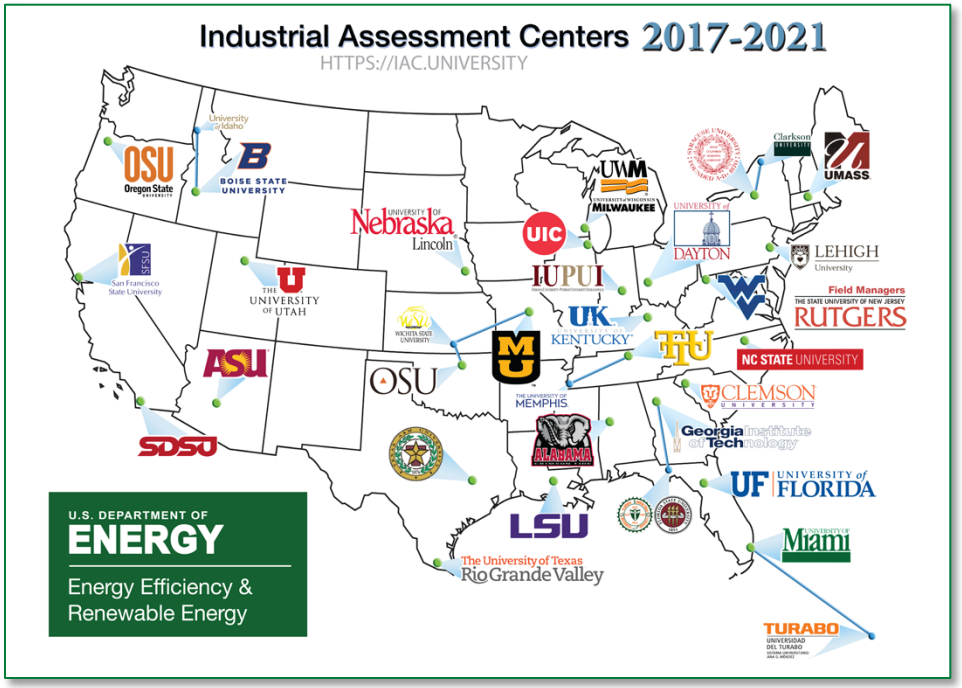

Jim Newton

Kent County Public Works Department – Milford, DE

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Energy Efficiency at Resource Recovery Facilities

Jim Newton, P.E., BCEE, ENV SP
Kent County Public Works
Milford, DE

Understand Where You're At

- Determine Significant Energy Sources
  - Electricity (grid supplied, onsite generated)
  - Natural Gas
  - Diesel
- Determine Energy Uses
  - Pumping
  - Aeration
  - Drying
- Determine Baseline Energy Consumption
  - Total energy in from all sources
  - Add in onsite renewables
  - Estimate all consumption

- Determine Basic Design and Operating Criteria
- Take advantage of DOE programs
  - Industrial Assessments
- Develop an Energy Management System
  - ISO 50001
  - Superior Energy Performance (SEP)

Begin by Making A Plan

- Look at establishing an ISO 50001 Energy Management System (EnMS)
- Look at incorporating DOE's Superior Energy Performance (SEP) program
- Submeter where necessary

Monitor Energy Consumption

Electric Meters

	Filter MCC	UV-A & B	UV-C	Bio Substation	Bio MCC	RPS -1	RPS -2	Blower -1	Blower -2	Solar Incoming	DEC Incoming
Van	285.72	213.13	283.42	279.89	282	285.67	283.97	273.24	273.42		
Vbn	282.85	120.75	282.70	277.42	276	282.54	285.40	271.57	275.57		
Vcn	284.02	120.78	280.33	279.44	281	286.31	286.48	273.59	275.92		
Vab	490.00	242.91	490.22	480.63	482	491.88	492.87	471.61	475.22	12,686	12,675
Vbc	490.65	241.13	485.22	479.91	481	492.51	495.13	472.00	477.47	12,790	12,782
Vca	493.04	244.09	485.34	484.13	490	495.24	493.91	473.44	475.61	12,725	12,711
Ia	125.50	55.06	42.66	233.81	195	57.85	52.67	841.5	491.1	0	76
Ib	117.14	67.41	44.25	187.13	169	60.39	33.45	1042.3	460.6	0	77
Ic	107.92	90.77	32.06	220.44	186	54.34	22.41	771.0	448.3	1	77
In	5.53				0	5.83	8.83	260.5	21.0		
TPF	0.969	0.945	0.617	0.867	0.696	0.880	0.624	0.934	0.915	0.005	0.939
kVAR	23.4	10.1	26.5	89.4	111	23.2	-24.2	258.0	159.9		
kVA	99.6	30.8	33.7	179.3	154	48.9	31.0	723.6	380.4		
kW	96.9	29.1	20.8	155.4	108	43.03	19.3	676.10	345.2	3	1,586
kWH	826,277.9	217.4	326.3	3,884,969.3	1,724,885.9	63,015	24,325	316,789	165,458		

	Filter Bldg	UV A,B,C	BioSolids Misc
kW	96.9	49.9	47.4
kWH	826,277.6	543.8	2,160,083.5

ENERGY

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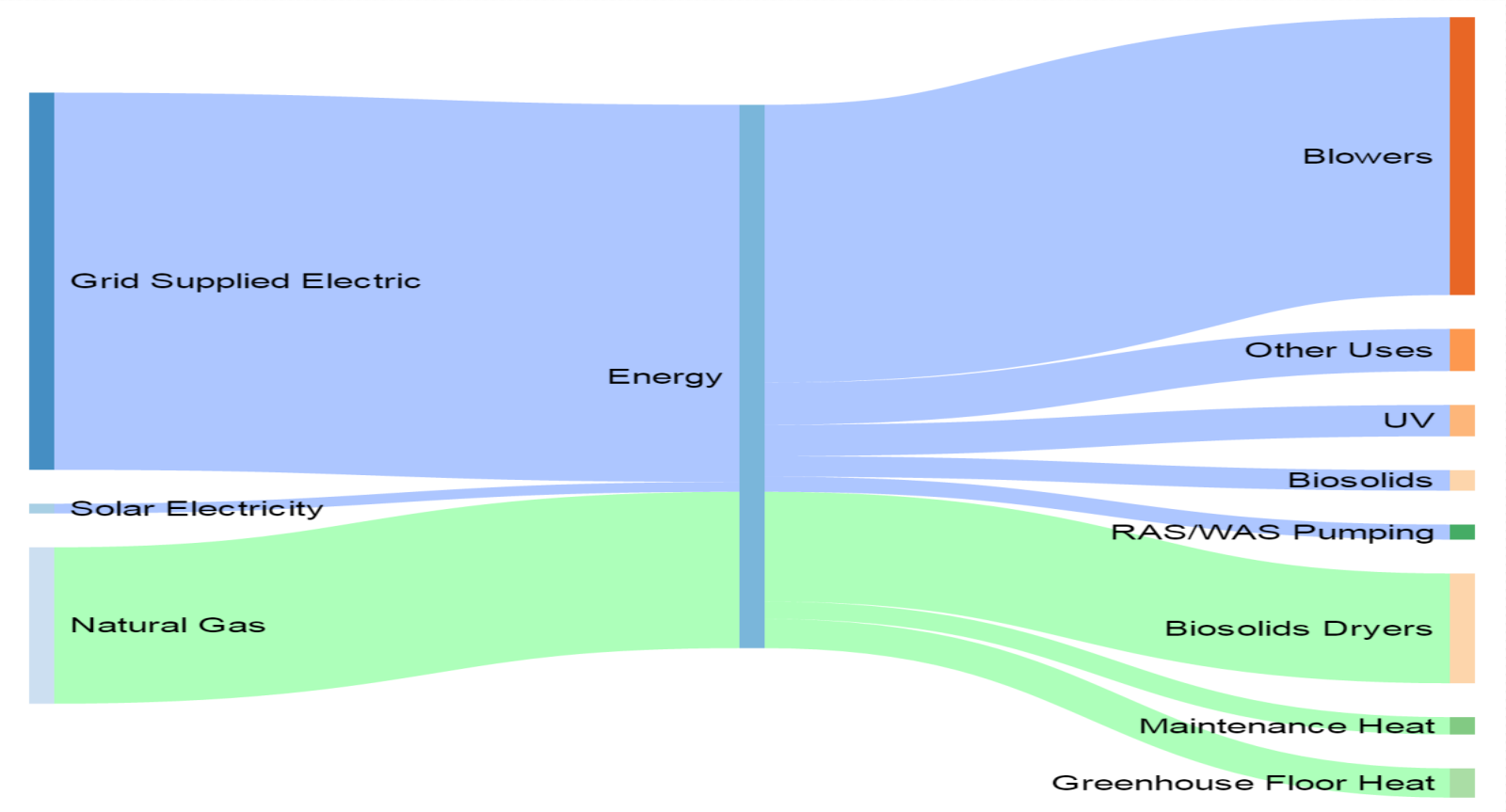
Kent County Energy Balance



Where Can Efficiency Come From?

- Pumping
- Emergency generators
- Water/Wastewater
  - Aeration
  - Disinfection
- Biosolids
  - Thickeners
  - Dryers
  - Digestion
- Plant Support Systems
  - HVAC
  - Lighting

Pumping

- Variable frequency drives
- Operating more efficiently
  - Mechanical efficiency
  - Electrical efficiency
- Reducing pumping head
- Reducing friction losses
- Improving piping systems

Electric Generation

- Distributed generators
- Use digester gas

Aeration Systems

- Improve Oxygen Transfer
  - Diffusers
    - Fine bubble diffusers
- Blowers
  - Multi-Stage Centrifugal
  - Single-Stage Centrifugal
  - Turbo
  - Positive Displacement
  - Automatic Contol
- Measuring DO or N in basin

Disinfection

- Look at chlorination requirements
  - Gas, Liquid, Solid
- Look at dechlorination methods
  - Gas, Liquid, Solid
- UV
- Ozone

Biosolids Thickening

- Polymer addition
- Reduce the volume for subsequent treatment
- Pre-conditioning examples
  - Thermal hydrolysis
  - Ozonation
  - Ultrasound homogenization
  - Shear milling
  - Enzymatic hydrolysis

Biosolids Digestion

- Anaerobic digestion
  - Control temperatures
  - Generate digester gas
  - Add other materials
    - FOG
    - Food waste
    - Yard waste
- Aerobic digestion
  - DO controls
  - Reducing solids concentrations

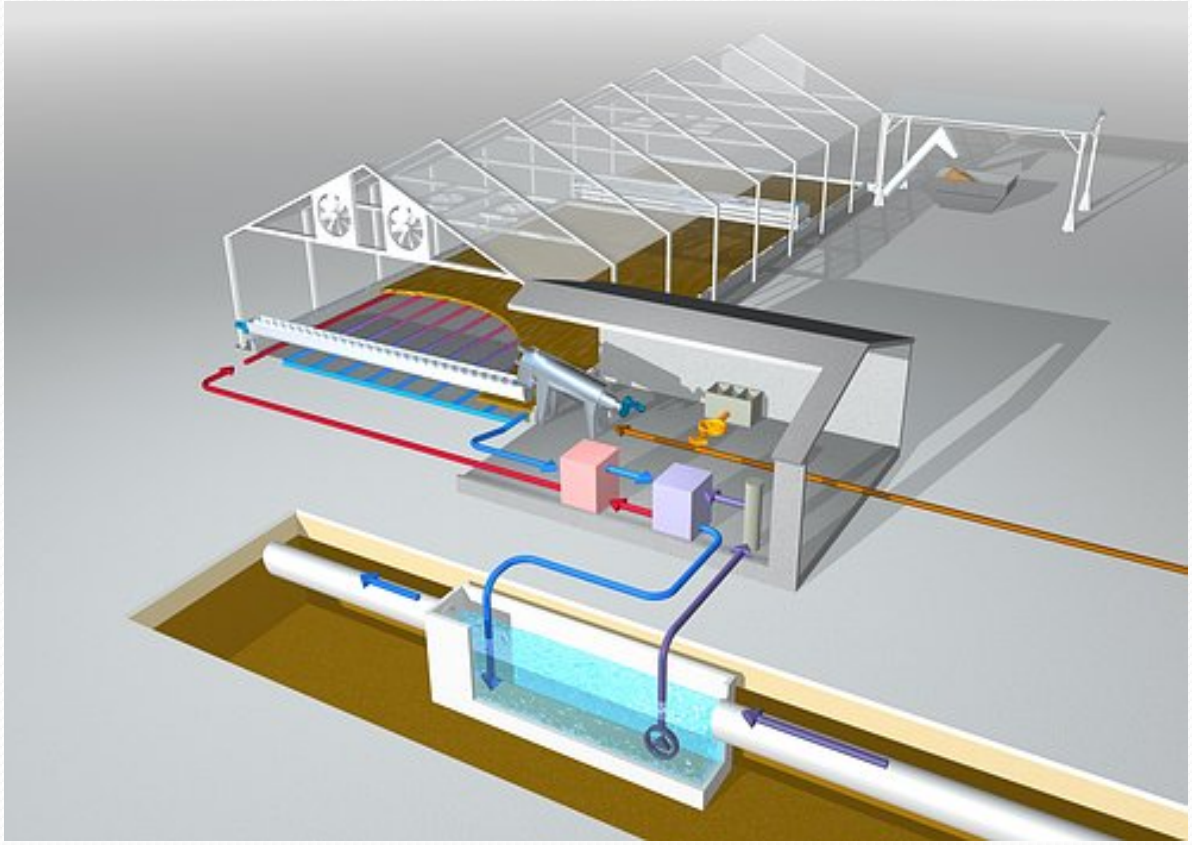
Biosolids Drying

- Incineration
  - Heat recovery
  - CHP

- Thermal drying
  - Drying technique
  - Heat recovery
  - CHP

HVAC

- Geothermal/Thermal energy in water



Lighting

- Switch to LED lights

Reference

- Water Environment Federation:
  - Energy Conservation in Water and Wastewater Facilities

Dr. Glenn Cunningham

Tennessee Tech University Industrial Assessment Center

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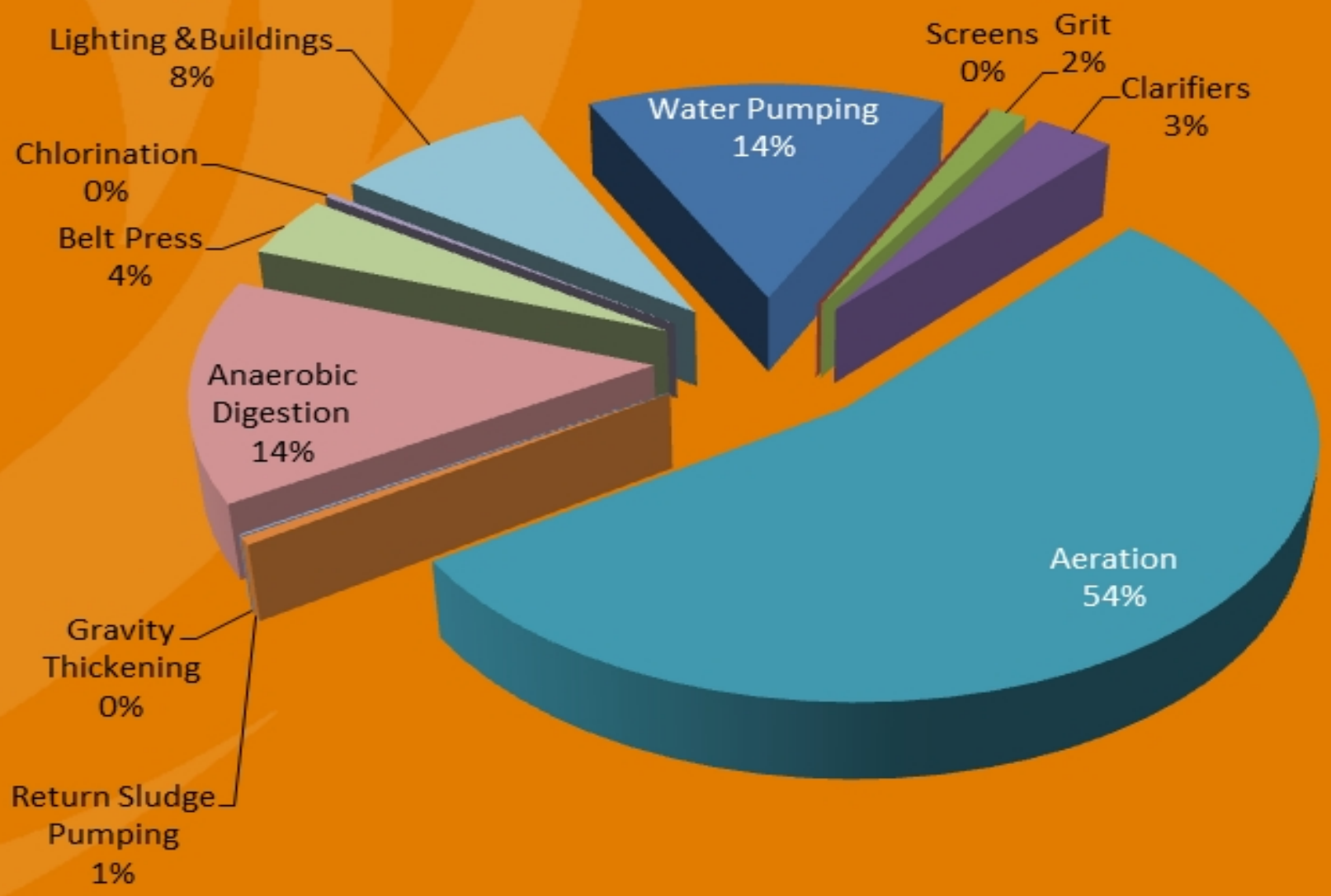
Better Buildings Summit
Wastewater Energy Efficiency

Washington DC
May 15 – 17, 2017

Glenn T. Cunningham, PhD, P.E.
IAC Director
Mechanical Engineering Department
Tennessee Tech University

Areas of Energy Use for Wastewater Plants



Areas of Significant Energy Use

- **Aeration**
  - Blowers
- **Pumps**
  - Inefficient flow control methods: throttling
  - Pumping at higher flow rates than are necessary
- **UV disinfection**
  - Running more lamps than are needed – plant is not operating at its rated capacity
  - Changing lamps out too soon – Plant may change UV lamps every year when they have an expected life of 18 months

Areas of Significant Energy Use

- **Lighting**
  - Turn off when not needed
  - Consider occupancy sensors to shut off lights when no one is around
  - Convert to more efficient fixtures
    - LEDs are becoming much cheaper and dependable
- **Combined Heat and Power**
  - Use biogas to generate electricity and recover heat for digestion and space heat
- **HVAC**
  - Set-back thermostats
  - Avoid electric resistance heat
  - Perform proper maintenance
  - Replace units when their useful life is over

Blowers

Blowers Types

- **<u>Two types of positive displacement and two types of dynamic blowers considered</u>**
  - Rotary lobe blowers (PD)
  - Low-pressure dry screw compressor (PD)
  - High speed single-stage centrifugal blowers
    - Inlet guide vanes
    - Outlet diffuser vanes
    - Can operate with a VFD
  - High speed single-stage turbo blowers
  - Need a wide turndown range in blower capacity
    - 4:1 to 10:1 are typical

Blower Control Scheme

- **<u>Operating Principles</u>**
  - Run the least number of blowers possible
  - Run the largest number of blowers in their most efficient range
  - Avoid idle operation and any bleeding off of air
  - Sequence the operation with longevity and maintenance intervals in mind
  - Blower capacity control method is important for efficient operation

Fans/Blowers

- **<u>Plants often operate at less that design loads</u>**
  - Determine actual BOD and operate only as much aeration equipment as is needed
  - Turn off unneeded blowers
  - If VFDs are installed reduce blower capacity to supply only the required air
  - Example: Newnan Utilities installed one VFD on one of three 125 HP blowers serving the WWTP and saved a reported $24,000/year in electrical cost

Fan Laws

$$CFM_2 = CFM_1 \left(\frac{RPM_2}{RPM_1}\right)$$

VOLUME

VARIES DIRECT WITH SPEED RATIO

$$P_2 = P_1 \left(\frac{RPM_2}{RPM_1}\right)^2$$

PRESSURE

VARIES WITH SQUARE OF SPEED RATION

$$HP_2 = HP_1 \left(\frac{RPM_2}{RPM_1}\right)^3$$

HORSEPOWER

VARIES WITH CUBE OF SPEED RATIO

Fan Laws

*A **10%** reduction in speed (rpm) will result in a **27%** reduction in power*

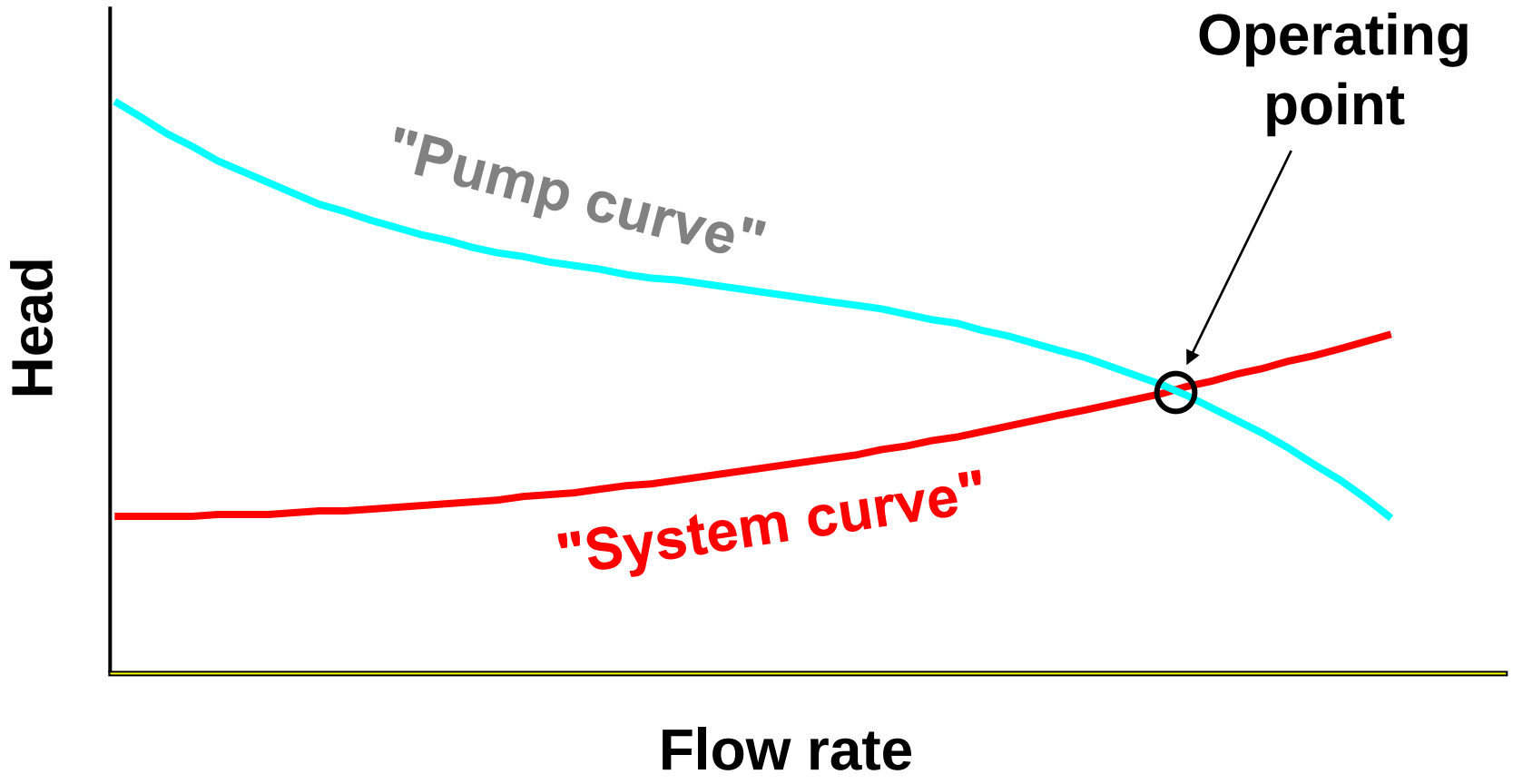
$$\text{Change in kW} = [rpm_2/rpm_1]^3$$
$$= [cfm_2/cfm_1]^3$$

If $rpm_1 = 100$ *and* $rpm_2 = 90$

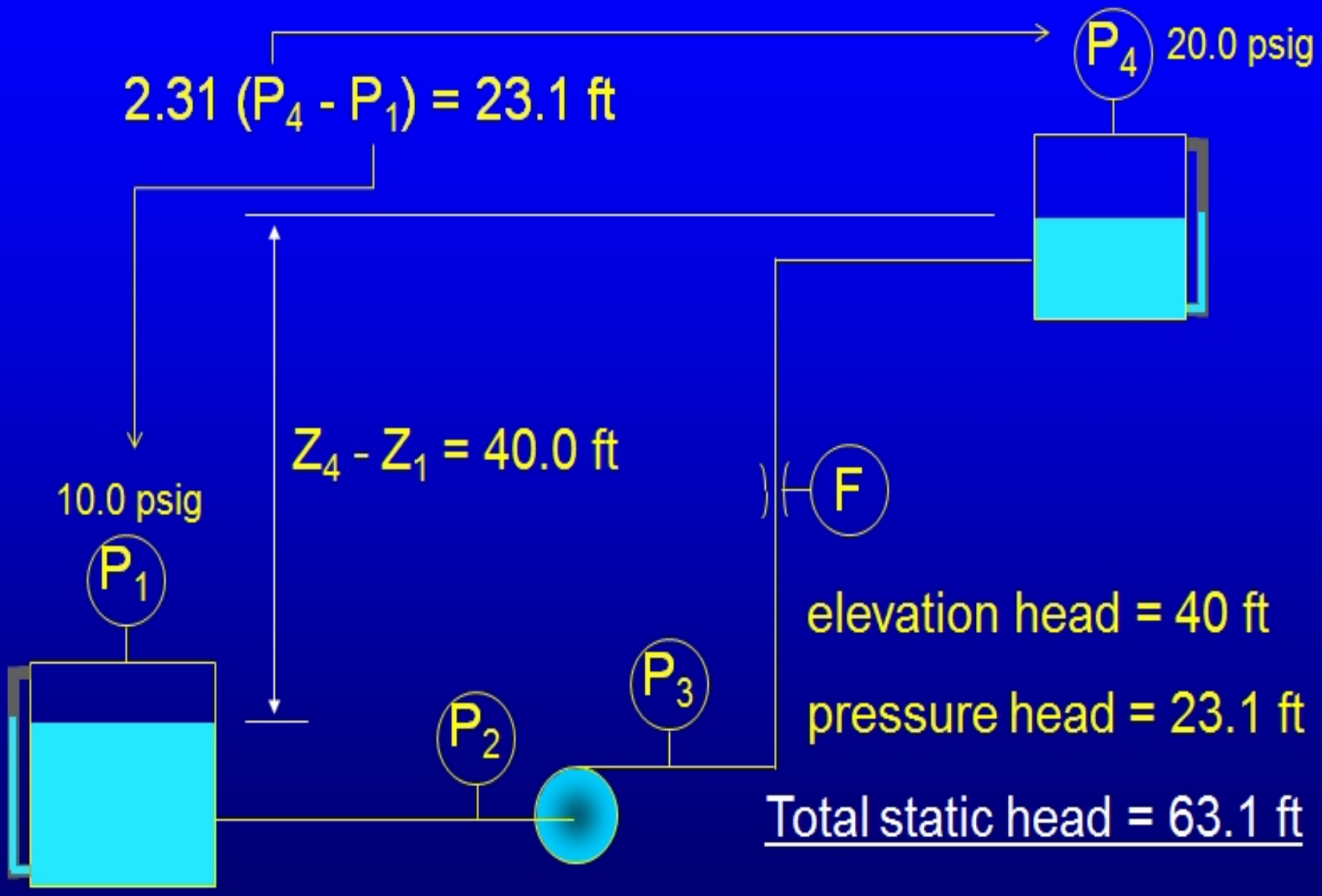
$kW_2 = [90/100]^3 = 0.73$ *or a* ***27% Reduction***

Pumping

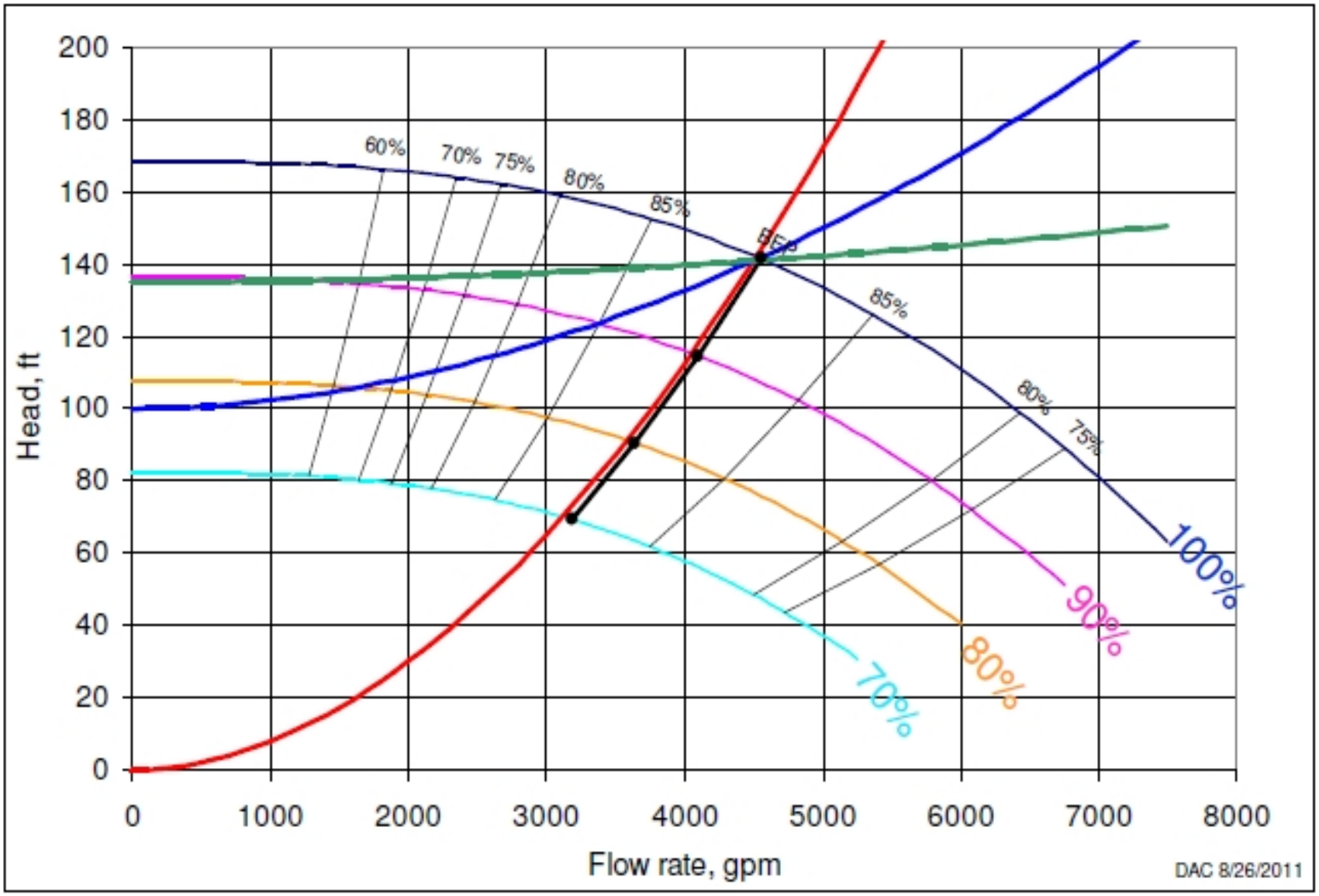
The system operating point is at the intersection of the pump and system head -capacity curves



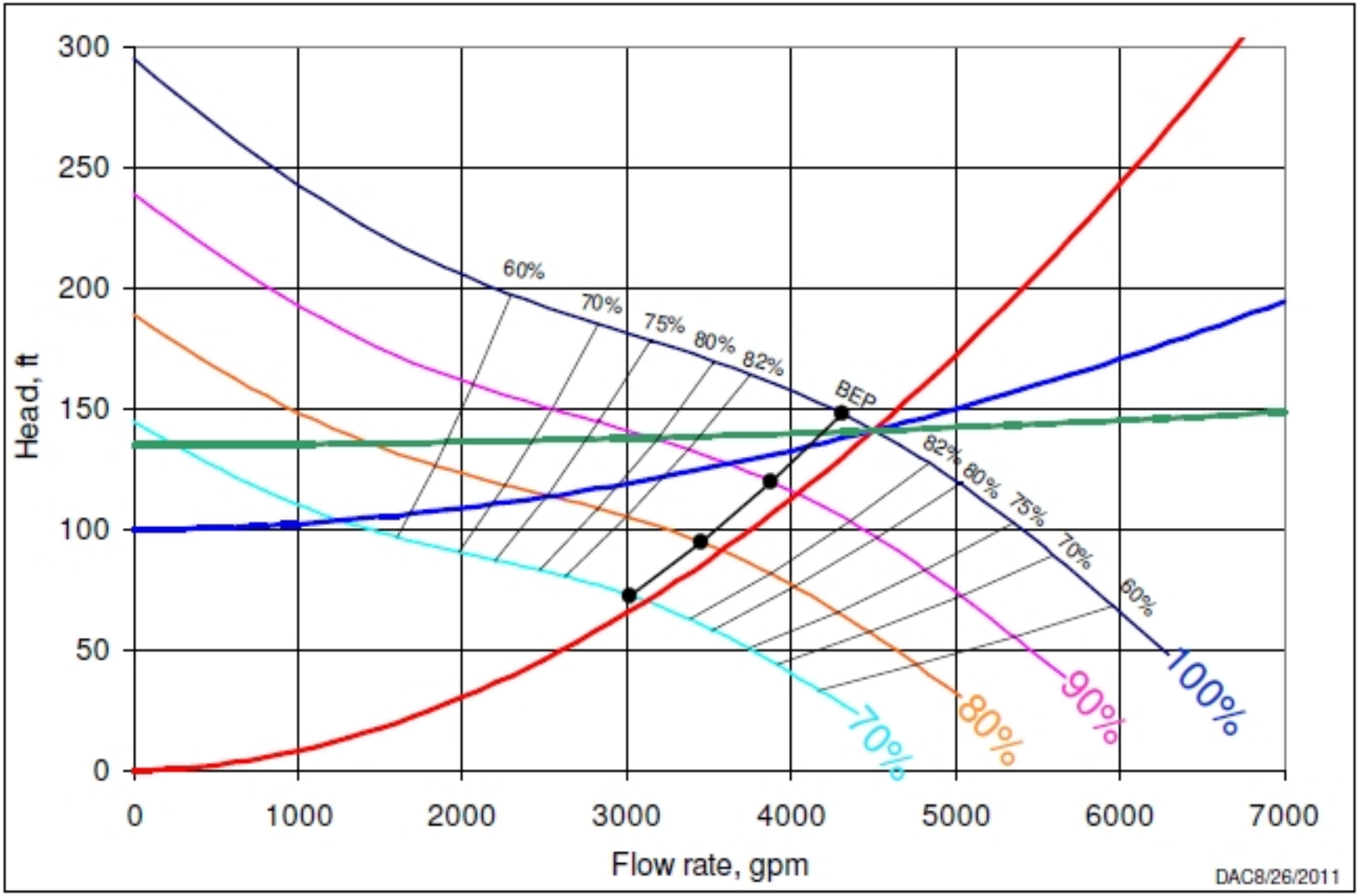
Estimating the Static Head



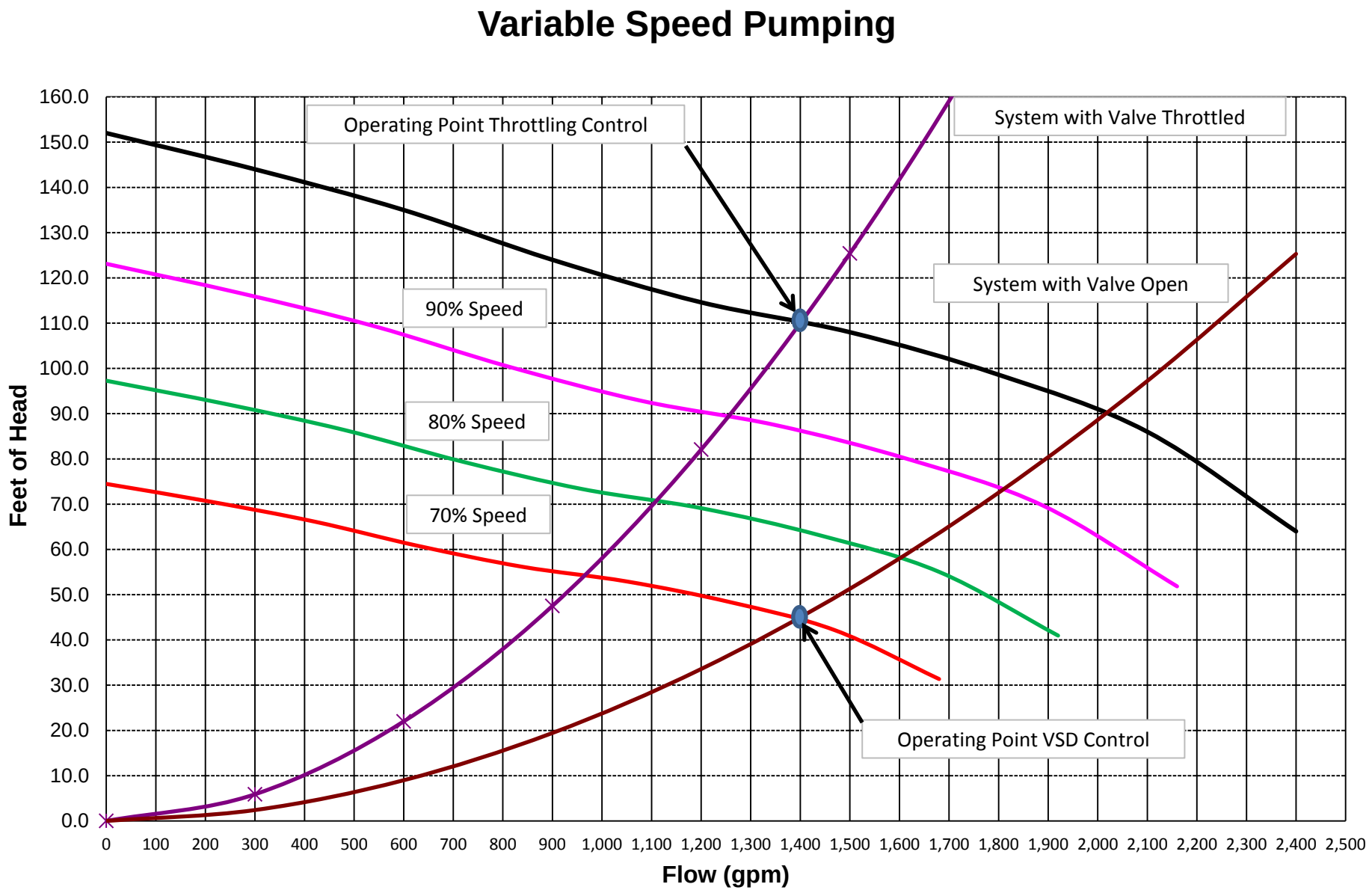
All three system curves with P2, variable speed



All three system curves with P3, variable speed



Actual Pump Study for VSD Operation



Example Water Treatment Plant

- County water treatment facility
  - 200 HP pump
  - 2 100 HP pumps
  - Typically run the 200 HP and one 100 HP
- Peak demand is just under 1.6 MGD
- Demand is less than 1.5 MGD 99.5% of the time
- Would like to operate the plant 12 hours/day or less
- Electric rate has a significant demand charge

City Water System

						Monthly unit costs: 1.2 MGD						
Pump gpm	ft	Required MGD	hrs/ day	operating fraction	PSAT kW optimal	kwhr	Demand charge	Energy charge	Service fee	Tax	annual cost	avg. $/ kWhr
1700	294.1	1.2	11.76	0.490	113.6	40651	$628	$1,809	$9	$147	$31,106	0.0638
1800	298.1	1.2	11.11	0.463	121.6	41096	$707	$1,823	$9	$152	$32,293	0.0655
1900	302.3	1.2	10.53	0.439	129.8	41559	$788	$1,838	$9	$158	$33,512	0.0672
2000	306.8	1.2	10.00	0.417	138.5	42127	$873	$1,856	$9	$164	$34,837	0.0689
2100	311.4	1.2	9.52	0.397	147.4	42699	$961	$1,875	$9	$171	$36,189	0.0706
2200	316.4	1.2	9.09	0.379	156.4	43247	$1,050	$1,892	$9	$177	$37,543	0.0723
2300	321.5	1.2	8.70	0.362	165.9	43879	$1,144	$1,913	$9	$184	$38,995	0.0741
2400	326.9	1.2	8.33	0.347	175.8	44560	$1,242	$1,935	$9	$191	$40,517	0.0758
2500	332.5	1.2	8.00	0.333	185.8	45211	$1,340	$1,956	$9	$198	$42,039	0.0775

						Monthly unit costs: 1.5 MGD						
Pump gpm	ft	Required MGD	hrs/ day	operating fraction	PSAT kW optimal	kwhr	Demand charge	Energy charge	Service fee	Tax	annual cost	avg. $/ kWhr
1700	294.1	1.5	14.71	0.613	113.6	50814	$628	$2,136	$9	$166	$35,270	0.0578
1800	298.1	1.5	13.89	0.579	121.6	51370	$707	$2,154	$9	$172	$36,502	0.0592
1900	302.3	1.5	13.16	0.548	129.8	51948	$788	$2,173	$9	$178	$37,769	0.0606
2000	306.8	1.5	12.50	0.521	138.5	52659	$873	$2,195	$9	$185	$39,152	0.0620
2100	311.4	1.5	11.90	0.496	147.4	53374	$961	$2,219	$9	$191	$40,562	0.0633
2200	316.4	1.5	11.36	0.473	156.4	54059	$1,050	$2,241	$9	$198	$41,973	0.0647
2300	321.5	1.5	10.87	0.453	165.9	54849	$1,144	$2,266	$9	$205	$43,489	0.0661
2400	326.9	1.5	10.42	0.434	175.8	55701	$1,242	$2,293	$9	$213	$45,081	0.0674
2500	332.5	1.5	10.00	0.417	185.8	56514	$1,340	$2,320	$9	$220	$46,670	0.0688

200-hp motor capable of handling loads through 2200 gpm (in service factor for 2200 gpm)

250-hp motor required for 2300 gpm and above

Figure 15. Spreadsheet showing optimal energy cost at various pump flow rates, based on average daily demands of 1.2 and 1.5 million gallons.

Energy charge: First 15,000 kWhr each month @ 6.55 cents/kWhr, remainder @ 3.221 cents/kWhr
Demand charge: $9.87 per kW for all demand above 50 kW, based on maximum 30-minute average during each month
Fixed service fee: $9/month
Sales tax: 6% adder to sum of above charges

Lighting

Lighting

- Most lighting changes today are centered around replacing old fixtures with LED lamps
- In the last couple of years the cost of LED fixtures has decreased dramatically
- The long lamp life reduces maintenance cost significantly

Lighting Retrofit Project

PROJECT:	SOUTHERN FIX #:1	SOUTHERN FIX #:2	SOUTHERN FIX #:3	SOUTHERN FIX #:4
FIXTURES BEFORE:				
Fixture Type	2x4T8 High B	2x4T5 High B	400WHigh Bay	250 HID
Fixture Count	17	69	74	1
Weekly Burn Time Hours	168	168	168	168
Lamp Type	F32T8	54T5	400W MH	250 MH
Lamps per Fixture	6	6	1	1
Lamp Watts	32	54	400	250
Ballast Type	2F32elec	T5/4LMP/	400W MH	250W MH
Ballast per Fixture	3.0	1.0	1.0	1.0
Ballast Waste Watts	-6	22	60	45
Watts per Fixture	174	346	460	295
KWh per Week	496	4,010	5,718	49
KWd	2.9	23.8	34.0	0.3
FIXTURES AFTER:				
Fixture Type	LEDTubeRetro	2x4T5 High B	LED High Bay	LED2x4or1x4
Fixture Count	17	69	71	1
Weekly Burn Times Hours	68	68	68	68
Lamp Type	LED15WTUBE	LED 24W T5 T	LED240whighb	LED156W
Lamps per Fixture	6	6	1	1
Lamp Watts	15	24	240	158
Ballast Type	NONE	NONE	NONE	NONE
Ballast per Fixture				
Ballast Waste Watts	0			
Watts per Fixture	90	144	240	158
KWh per Week	104	675	1,158	10
KWd	1.53	9.94	17.04	0.16
MAINTENANCE BEFORE:				
Total Lamps	102	414	74	1
Replacement Lamp Price	$3.00	$6.50	$55.00	$25.00
Lamp Useful Hours	28,000	24,000	20,000	20,000
Annualized Lamp Changes	32	150	32	0
Total Lamp Change Cost	$180	$1,382	$1,864	$12
Total Ballasts	51	69	74	1
Replacement Ballast Price	$20.00	$120.00	$55.00	$55.00
Ballast Replacement Factor				
Annualized Ballast Changes				
Total Ballast Change Cost				
Annualized Maint. per Fixture	$10.61	$20.03	$25.19	$12.17
MAINTENANCE AFTER:				
Total Lamps	102	414	71	1
Replacement Lamp Price				$1.00
Lamp Useful Hours	50,000	50,000	87,360	50,000
Annualized Lamp Changes	7	29	3	
Total Lamp Change Cost	$19	$78	$8	
Total Ballasts				
Replacement Ballast Price				
Ballast Replacement Factor				
New Ballast (Y/N)	N	N	N	N
Annualized Ballast Changes				
Total Ballast Change Cost				
Annualized Maint. per Fixture	$1.13	$1.13	$0.11	$0.26

Lighting Retrofit Project

PROJECT:	OUTSIDE
FIXTURES BEFORE:	FIX #:5
Fixture Type	Flood/Pole
Fixture Count	2
Weekly Burn Time Hours	84
Lamp Type	1000W MH
Lamps per Fixture	1
Lamp Watts	999
Ballast Type	1000W MH
Ballast per Fixture	1.0
Ballast Waste Watts	81
Watts per Fixture	1,080
KWh per Week	181
KWd	2.1
FIXTURES AFTER:	
Fixture Type	LED Flood/Wa
Fixture Count	2
Weekly Burn Times Hours	84
Lamp Type	LED427w
Lamps per Fixture	1
Lamp Watts	427
Ballast Type	NONE
Ballast per Fixture	
Ballast Waste Watts	0
Watts per Fixture	427
KWh per Week	71
KWd	0.85
MAINTENANCE BEFORE:	
Total Lamps	2
Replacement Lamp Price	$55.00
Lamp Useful Hours	12,000
Annualized Lamp Changes	1
Total Lamp Change Cost	$42
Total Ballasts	2
Replacement Ballast Price	$90.00
Ballast Replacement Factor	
Annualized Ballast Changes	
Total Ballast Change Cost	
Annualized Maint. per Fixture	$21.05
MAINTENANCE AFTER:	
Total Lamps	2
Replacement Lamp Price	
Lamp Useful Hours	40,000
Annualized Lamp Changes	
Total Lamp Change Cost	$1
Total Ballasts	
Replacement Ballast Price	
Ballast Replacement Factor	
New Ballast (Y/N)	N
Annualized Ballast Changes	
Total Ballast Change Cost	
Annualized Maint. per Fixture	$0.30

QUANTITY	DESCRIPTION	PRICE	EXTENSION
1. 26	8' strip - 6 T8 lamp fixtures - retrofit - with 6 new 4' LED T8 frosted Tube (5000 K) 15 Watt Lamps with internal driver	$ 158.80	$4,128.80
2. 140	2x4 - 6 T5 lamp fixtures highbay and lowboy - retrofit - with 6 new 4' LED T5 frosted Tube (5000 K) 24 Watt Lamps	$ 188.80	$26,432.00
3. 138	400W HID fixtures change to 175 new 2x4 - 240 Watt (5000 K) LED fixtures	$ 530.80	$73,250.40
4. 13	250W HID fixtures change to 13 new 2x4 - 156 Watt (5000 K) LED fixtures	$ 299.80	$3,897.40
5. 38	175W HID fixtures change to 38 new flood - 120 Watt (5000 K) LED fixtures	$ 604.80	$22,982.40
6. 32	1x4 - 2 T8 lamp fixtures office and plant floor areas - retrofit - with 2 new 4' LED T8 frosted Tube (5000 K) 15 Watt Lamps	$ 58.80	$1,881.60
7. 14	2x4 - 4 T8 lamp fixtures office and plant floor areas - retrofit - with 4 new 4' LED T8 frosted Tube (5000 K) 15 Watt Lamps	$ 78.80	$1,103.20
8. 33	8' strip - 4 T8 lamp fixtures office and plant floor areas - retrofit - with 4 new 4' LED T8 frosted Tube (5000 K) 15 Watt Lamps	$ 80.80	$2,666.40
9. 30	1x4 - 2 T8 lamp fixtures office and plant floor areas - retrofit - with 2 new 4' LED T8 frosted Tube (5000 K) 15 Watt Lamps	$ 78.80	$2,364.00
10. 22	2x4 - 4 T8 lamp fixtures office and plant floor areas - retrofit - with 4 new 4' LED T8 frosted Tube (5000 K) 15 Watt Lamps	$ 88.80	$1,953.60
11. 64	2x4 - 3 T8 lamp fixtures office and plant floor areas - retrofit - with 4 new 4' LED T8 frosted Tube (5000 K) 15 Watt Lamps	$ 67.80	$4,339.20
12. 3	2x2 - 2 T12 lamp fixtures office areas - retrofit - with 2 new 2' LED T8 frosted Tube (5000 K) 9 Watt Lamps	$ 65.80	$197.40
13. 201	UEA fixture occupancy sensors	$ 44.80	$9,004.80
14. 10	UEA wall occupancy sensors	$ 128.00	$1,288.00
15. 22	UEA LED EXIT SIGN CONVERSION, LESS THAN 4 WATTS	$ 58.80	$1,293.60
outside fixtures			
16. 11	400W HID flood fixtures change to 11 new 187 Watt flood (5000 K) LED fixtures	$ 880.80	$9,688.80
17. 89	175W HID flood fixtures change to 89 new 120 Watt flood (5000 K) LED fixtures	$ 604.80	$53,827.20
18. 8	250W HID flood fixtures change to 8 new 187 Watt flood (5000 K) LED fixtures	$ 604.80	$4,838.40
19. 2	1000W HID flood fixtures change to 2 new 427 Watt flood (5000 K) LED fixtures	$ 1,238.80	$2,477.60

REPORT TO INCLUDE :

ECONOMIC LIGHTING SURVEY, AND TURN-KEY PROPOSAL

SUBTOTAL	$227,614.80
SALES TAX	$ NA
SHIPPING AND HANDLING	ALLOWED
TOTAL	$227,614.80

LIGHTING ENERGY SAVINGS SUMMARY

SAVINGS SUMMARY

ANNUAL CASH SAVINGS	CAPITAL RECOVERY	RETURN ON INVESTMENT
$71,957	37.96 Months	31.61 %

CONVERSION SUMMARY

EFFECTIVE COST PER KWh: 0.0600
AVERAGE WEEKLY LIGHTING HOURS: 133

KWd RATE:

	BEFORE CONVERSION	AFTER CONVERSION
TOTAL FIXTURES:	697	694
TOTAL LAMPS:	1,917	1,980
TOTAL BALLASTS:	734	26
LIGHTING KWh PER MONTH:	126,763	41,192
LIGHTING KWd:	188	84
WATTAGE PER SQUARE FT:	**********	**********

ESTIMATED IMPROVEMENT COST AND SAVINGS

ESTIMATED COST:	$227,614
NET IMPROVEMENT COST:	$227,614
SAVINGS FOR FIVE YEARS:	$359,785
SAVINGS FOR TEN YEARS:	$719,570

ANNUAL KWh SAVINGS:	$61,610
ANNUAL KWd SAVINGS:	N/A, ,
ANNUAL HVAC SAVINGS:	$0
ANNUAL MAINTENANCE SAVINGS:	$10,347
TOTAL ANNUAL SAVINGS:	$71,957

ANNUAL ENVIRONMENTAL SAVINGS

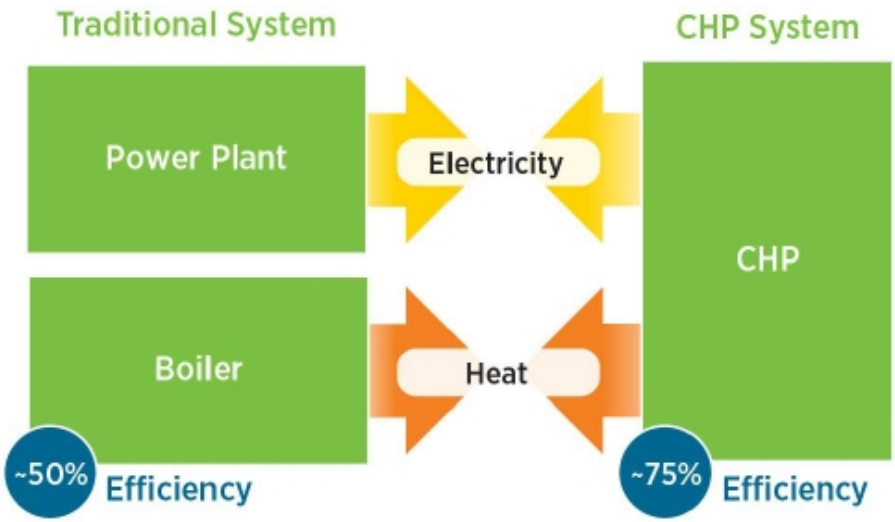
POUNDS OF CARBON DIOXIDE:	1,540,278
POUNDS OF SULFUR DIOXIDE:	10,884,631
POUNDS OF NITRUS OXIDE:	2,669,815

Combined Heat & Power

Opportunities for Combined Heat and Power

CHP: A Key Part of Our Energy Future

- Form of Distributed Generation (DG)
- An integrated system
- Located at or near a building / facility
- Provides at least a portion of the electrical load and
- Uses thermal energy for:
  - Space Heating / Cooling
  - Process Heating / Cooling
  - Dehumidification



CHP provides efficient, clean, reliable, affordable energy – today and for the future.

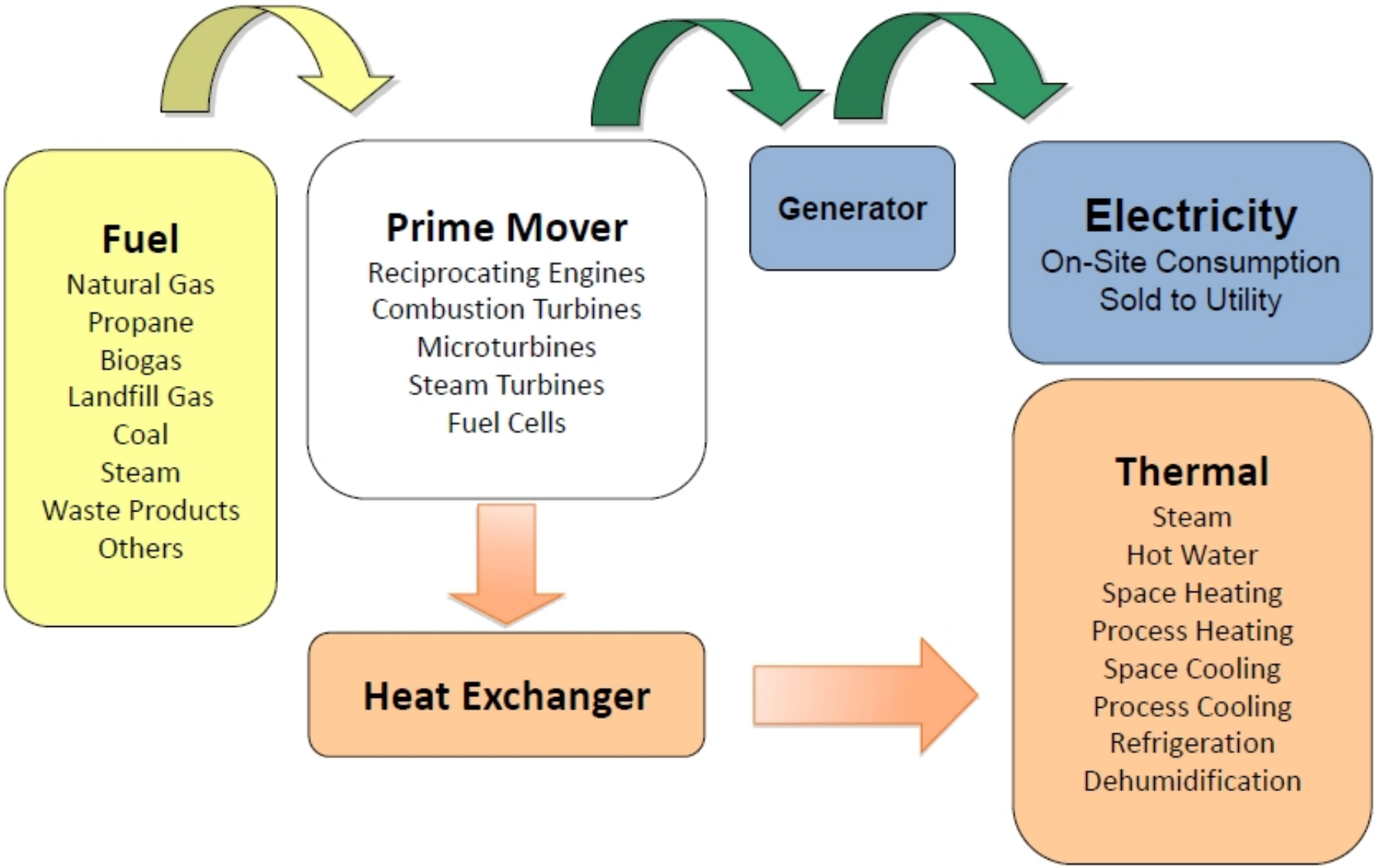
Opportunities for Combined Heat and Power

- Biogas from the digester can be used as fuel to generate electricity and produce useful heat for the digester or space heating
- Natural gas costs about $4.00 to $6.00 per MMBtu, depending on where you live and how much you purchase
- At $0.08/kWh, electricity costs $23.44 per MMBtu
- By burning biogas in an engine/turbine/boiler and producing electricity first the waste heat from the power generation can be used in the digester or as space heat producing overall efficiencies in the 65% to 80% range

Opportunities for Combined Heat and Power

- CHP systems can use a variety of prime movers
  - Reciprocating engines
  - Microturbines
  - Fuel cells
- A typical WWTP processes 100 gal/day of wastewater for every person served
- About 1 ft^3 of digester gas can be produced by an anaerobic digester per person per day
- Anaerobic digester gas from WWTP's is usually 60 to 70% methane with the rest primarily CO_2
- HHV is 610 – 715 Btu/ft^3 and LHV is 550 – 650 Btu/ft^3
- For natural gas the HHV is ~1024 Btu/ft^3

CHP System Schematic



CHP Installation Status in U.S. WWTFs

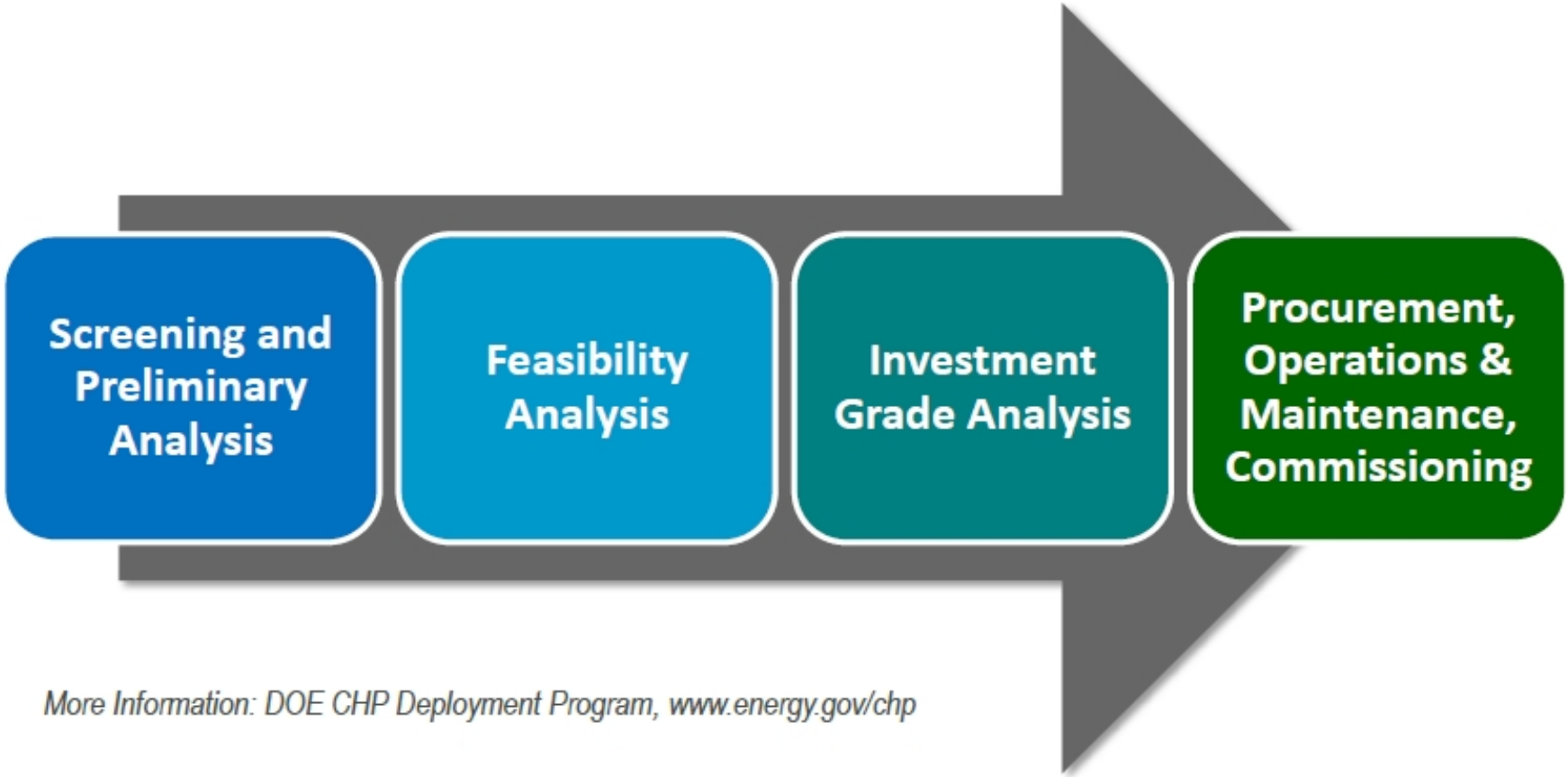
211 WWTFs are operating CHP today

CHP capacity in WWTFs totals ~707.4 MW

Table: Prime Mover Type in WWTFs

Prime Mover Type	# of CHP Systems	CHP Gen. Capacity (MW)
Combustion Turbine	16	349.3
Reciprocating Engine	134	266.0
Boiler/Steam Turbine	5	44.6
Microturbine	38	6.8
Fuel Cell	16	12.1
Combined Cycle	1	28.0
Organic Rankine Cycle	1	0.6
Total	**211**	**707.377**

What is the Project Development Process for a CHP Project?



More Information: DOE CHP Deployment Program, www.energy.gov/chp

Following the Project Development process can help reduce risk later down the road.

Project Snapshot:

Flexibility Between Boilers and CHP System

Rochester Wastewater Reclamation Plant

Rochester, MN

Application/Industry: Wastewater Treatment

Capacity (MW): 2-1 MW engines

Prime Mover: Reciprocating Engine

Fuel Type: Biogas

Thermal Use: Heat for the Digestion Process, Feed Gas Preheat, Building Heat

Testimonial: The facility produces upwards of 338,000 cu. ft. of biogas daily. By burning these in lean-burn engines, the facility has been able to achieve annual energy savings of $650,000.

Aerial View of Rochester Wastewater Reclamation Plant

One of the two 1 MW engines

Project Snapshot:

Partnering with local utility

Albert Lea Wastewater Treatment Facility

Albert Lea, MN

30 kW Capstone Microturbines

Application/Industry: Wastewater Treatment

Capacity (MW): 4-30kW Engines

Prime Mover: Microturbines

Fuel Type: Biogas

Thermal Use: Heat for the Digestion Process, Building Heat

Installation Year: 2004

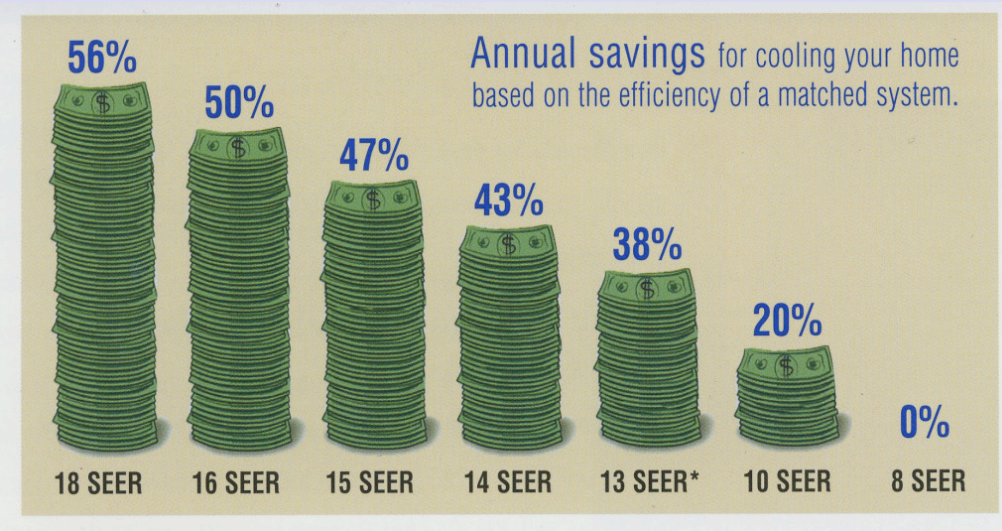
Testimonial: "It gives us the ability to use the methane gas already generated at the plant. We are able to take a waste product and use if for something beneficial." – Steve Jahnke, City Engineer

"We are impressed with the effectiveness of the technology, and hope to encourage other Minnesota cities to consider capturing methane biogas to not only protect Minnesota's environment, but to save energy. The possibilities of the turbines don't end with energy production; they could also bring new businesses, and businesses are looking for cities that have vision." - Lois Mack, Minnesota Department of Commerce

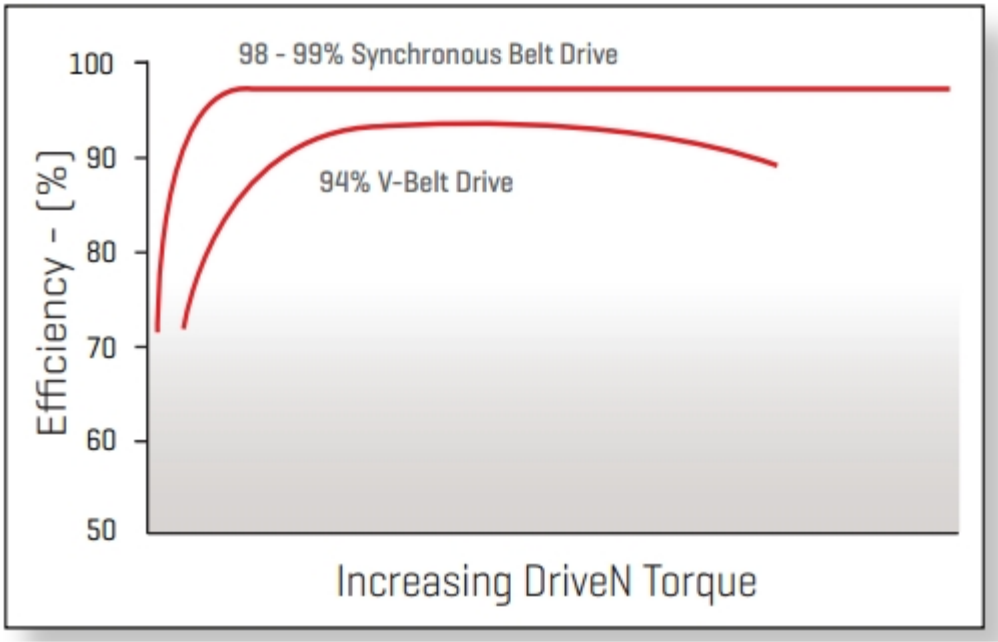
HVAC

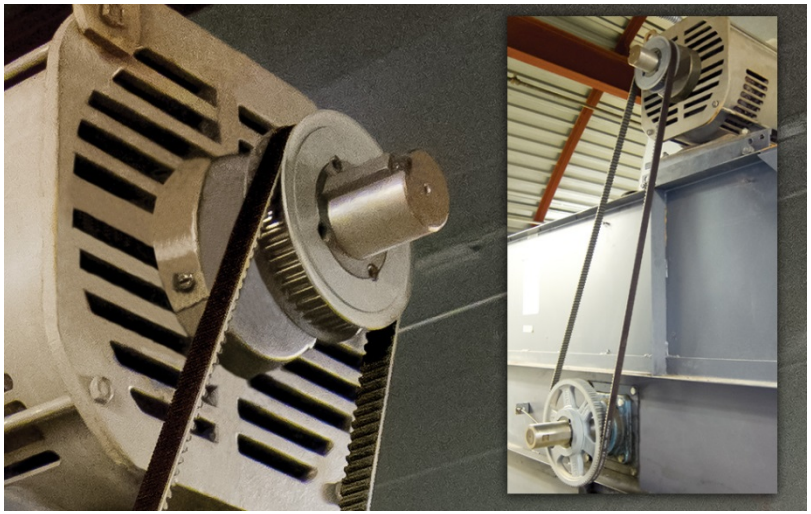
Energy Management Techniques

1. *Preventive Maintenance*
2. *Minimizing ventilation air*
3. *Free Cooling – air side economizer*
4. *Premium efficiency motors*
5. *Use of VFDs for capacity of pumps & fans*
6. *Replace V-belts with cog belts*
7. *Replace old HVAC equipment with more efficient new units*

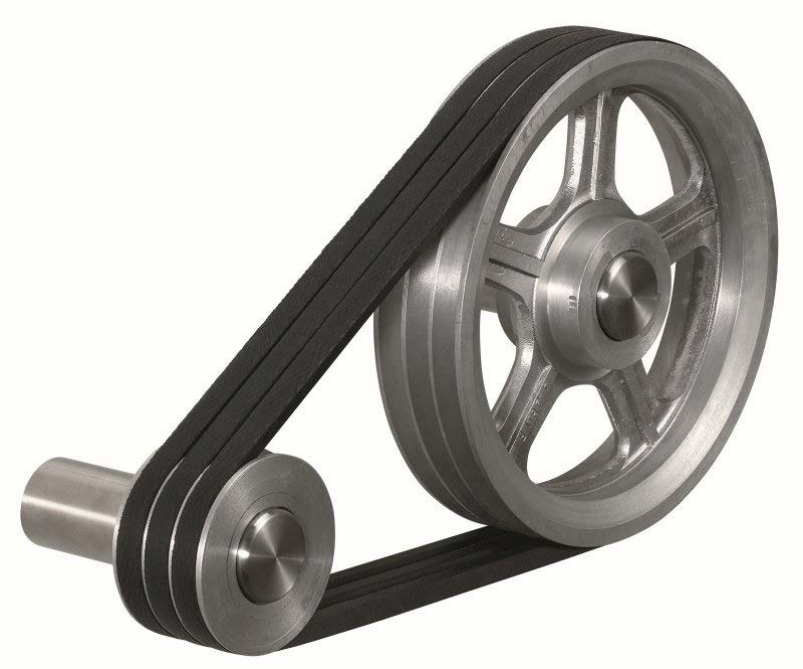


Belt Drive Losses





On average, a synchronous belt drive is 5% more efficient than a standard V-belt drive, eliminating excess energy consumption.



Comparison of Belt Drive Costs

Assume a 75 HP fan drive is converted to Synchronous Belts from conventional V-Belts

- Approximate cost of a system with V-Belts
  - One four-groove B13.6 inch sheave $ 102
  - One four-groove B18.1 inch sheave $ 130
  - Four B 136 V-Belts $ 108
  - Total Cost $ 340
- Approximate cost of a system with Synchronous Belts
  - One P52-14M-85 sprocket $ 220
  - One P72-14M-85 sprocket $ 320
  - One 3150-14M-14M-85 belt $ 478
  - Total Cost $1,018

- Assuming 5% belt slip for V-Belts and an energy cost of $0.08/kWh and the fan operates continuously, predicted savings for the Synchronous Belt over the V-Belts is $2,152/year
- Estimated total conversion cost is $1,500 and the simple payback is 8.4 months

Questions ????

Thank You

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