ENERGY EFFICIENCY PLAN
KINGMAN DOWNTOWN WWTP
ENGINEERING REPORT

Prepared for
Water Infrastructure Finance
Authority of Arizona

On behalf of
City of Kingman

June 2010

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EXECUTIVE SUMMARY

Brown and Caldwell (BC) is preparing this report for the Water Infrastructure Finance Authority of Arizona (WIFA) in reference to City of Kingman Downtown Wastewater Treatment Plant (WWTP) to receive WIFA green funding project status for energy efficiency.

BC intends to demonstrate a minimum 20 percent savings in energy usage required for plant operations. This can be accomplished with the photovoltaic solar power system during daylight hours.

The Leadership in Energy and Environmental Design (LEED) concepts for energy savings addressed herein, contributes to the goal.

The energy saving technologies utilized are as follows:

1. Photovoltaic Solar Power System
2. Premium Efficient Motors
3. Variable Frequency Drives
4. Energy Efficient Lighting
5. Solar Lighting
6. Point of Use Water Heater
7. Motion Detection Lighting Controls
8. Process Systems Optimization

LEED Background

LEED is an ecology-oriented building certification program run under the auspices of the U.S. Green Building Council (USGBC).

LEED concentrates its efforts on improving performance across five key areas of environmental and human health: energy efficiency, indoor environmental quality, materials selection, sustainable site development and water savings.

LEED has special rating systems that apply to all kinds of structures, including schools, retail and healthcare facilities, not typically to wastewater treatment plants.

The program is designed to inform and guide all kinds of professionals who work with structures to create or convert spaces to environmental sustainability, including architects, real estate professionals, facility managers, engineers, interior designers, landscape architects, construction managers, private sector executives and government officials.

State and local governments around the United States are adopting LEED for public buildings of all kinds, and LEED initiatives at the U.S. Departments of Agriculture, Defense, Energy and State drive activity at the federal level.

A typical example that is applicable to a wastewater treatment plant is the use of aluminum, which is recycled, for many items such as ladders, grating, handrailing/guardrailing, hatch covers, and miscellaneous structural elements. These measures are not easily quantified, but they contribute to the desired environmental sustainability.

Various energy conserving building design aspects that will be used for this project include appropriately selected roof and wall insulation, low-flow plumbing fixtures, energy-efficient double pane windows, and placement of windows including translucent panels in process buildings such that outdoor light is available inside buildings while excess heat is excluded.

1. PHOTOVOLTAIC SOLAR POWER SYSTEM

With the available land at the Downtown WWTP project site, it is estimated by BC and the Construction Manager at Risk (CMAR) that about 50kW of photovoltaic solar arrays panels will be installed.

The WWTP 460 volt process equipment connected load is approximately 464 horsepower at the current 50 percent design status level. The WWTP coincident running load that will continuously operate daily, at plant build-out flow, is estimated by BC at 250kW.

The WWTP has installed spares for most equipment such as the Ultra Violet (UV) System, blowers, and most of the pumping systems that reduces the calculated connected loads to the coincident running operational loads.

The WWTP has equipment such as the Belt Filter Press with its associated feed pump and filtrate pump station that operates from 8 to 12 hours per week that also reduces the calculated connected loads to the coincident running operational loads.

50kW / 250kW for optimum solar day, the day time power output of the PV solar system is about 20 percent of the power source for the WWTP.

Table 1. Major Process Equipment

Equipment Tag Number	Major Process Equipment	Volts	HP	Coincident Use Factor (1)	Coincident Running Load (HP)
Auxiliary Systems					
PMP-061	Grit Area Sump Pump 1	460	3	0.4	1.2
PMP-062	Grit Area Sump Pump 2	460	3	0	0
PMP-066	Permeate Pump Vault Sump Pump 1	460	3	0	0
PMP-067	Permeate Pump Vault Sump Pump 2	460	3	0	0
Headworks/Screening					
SCN-111	Stair Screen	460	10	1	10
MME-121	Grit Tank Paddle Drive	460	1	1	1
PMP-131	Grit Pump 1	460	15	0.33	4.95
PMP-132	Grit Pump 2	460	15	0	0
GCW-143	Grit Washer/Classifier	460	10	0.5	5
SCN-151	Rotary Drum Screen 1	460	2	2	4
SCN-152	Rotary Drum Screen 2	460	2	0	0

Table 1. Major Process Equipment					
Equipment Tag Number	Major Process Equipment	Volts	HP	Coincident Use Factor (1)	Coincident Running Load (HP)
SCW-171	Screenings Washer Compactor	460	5	1	5
FAN-191	Foul Air Fan	460	10	1	10
PMP-195	Biofilter Drain Pump	460	3	0	0
Membrane Bioreactor (MBR)					
MIX-301	Anoxic Basin 1 Mixer 1	460	3.5	1	3.5
MIX-302	Anoxic Basin 1 Mixer 2	460	3.5	1	3.5
MIX-311	Anoxic Basin 2 Mixer 1	460	3.5	1	3.5
MIX-312	Anoxic Basin 2 Mixer 2	460	3.5	1	3.5
BLW-331	Pre-Aeration Blower 1	460	30	1	30
BLW-332	Pre-Aeration Blower 2	460	30	0.5	15
BLW-335	MBR Blower 1	460	25	1	25
BLW-336	MBR Blower 2	460	25	0.5	12.5
BLW-337	Common Stand-By Blower (Swing Spare)	460	25	0	0
PMP-381	Permeate Pump 1 & VFD	460	10	0.75	7.5
PMP-382	Permeate Pump 2 & VFD	460	10	0.75	7.5
PMP-383	Permeate Pump 3 & VFD	460	10	0	0
PMP-501	Mixed Liquor Recycle Pump 1 & VFD	460	20	1	20
PMP-502	Mixed Liquor Recycle Pump 2 & VFD	460	20	0.5	10
PMP-503	Mixed Liquor Recycle Pump 3 & VFD	460	20	0	0
PMP-508	WAS Pump 1	460	7.5	0.08	0.6
PMP-509	WAS Pump 2	460	7.5	0	0
CRN-500	Bridge Crane (single girder, top running) - Cl 1 div 2	460	10	0	0
Sludge Holding Tank and Dewatering					
MOV-601	Sludge Equalization Tank Agitation Air Control Valve	460	1	1	1
BLW611	Channel Agitation Blower	460	5	1	5
BLW612	Eq. Basin Agitation Blower	460	5	1	5
BLW613	Swing Spare Agitation Blower	460	5	0	0
Dewatering					
PMP-621	Sludge Feed Pump 1	460	20	0.5	10
PMP-622	Sludge Feed Pump 2 (uninstalled spare)	460	20	0	0
BFP-631	Belt Filter Press	460	10	0.7	7
PMP-632	BFP washwater booster pump	460	3	0.7	2.1
CON-633	Sludge cake screw conveyor	460	5	0.7	3.5
CFR-641	Polymer Blender (part of BFP scope of supply)	460	3	0.7	2.1
PMP-651	Filtrate Pump 1	460	3	1	3
PMP-652	Filtrate Pump 2	460	3	0	0

Table 1. Major Process Equipment					
Equipment Tag Number	Major Process Equipment	Volts	HP	Coincident Use Factor (1)	Coincident Running Load (HP)
Disinfection and Plant Water System					
UVR-801	UV Reactor 1	460	22	1	22
PMP-051	Plant water pump 1 (lead)	460	5	0.4	2
PMP-052	Plant water pump 2 (lag)	460	5	0	0
		hp	**464**		**246**
		amps	**580**		**491**

(1) Estimated % running time & % HP draw for variable speed equipment. Some equipment will be infrequently operated & is not included.

2. PREMIUM EFFICIENCY MOTORS

Premium energy efficient motors are typically 2 to 8 percent more energy efficient than standard motors. For example: over a 10-year operating life, a motor can typically consume more than 50 times the initial purchase price in energy costs.

This makes the decision to invest in premium efficiency motors a good investment, even if the initial premium efficient motor cost is approximately 10 to 15 percent higher than a standard efficient motor.

Annual Savings from Selecting Premium over Energy Efficient Motors

	Motor Efficiency Standard		
Horsepower	EPACT EE full-load efficiency, %	CEE PE full-load efficiency, %	Annual Savings of using Premium Efficiency over Energy Efficient Motors, $
10	89.5	91.7	60
25	91.7	93.6	124
50	93.0	94.5	191
100	94.1	95.4	324
200	95.0	95.8	393

Note: Based on 1800 RPM ODP motor, operated 8,000 hours per year, 75% load, and an electrical rate of $0.05/kWh.

Figure 1. Motor Efficiency

2.1 Federal Legislation and Premium Efficient Motor Savings Example

On December 19, 2007, U.S. President George W. Bush signed the Energy Independence and Security Act of 2007 (EISA) as public Law 140-110.

The National Electrical Manufacturers Association (NEMA) focused on increased motor efficiency levels and recommended new motor efficiency regulations covering both general purpose and some categories of definite and special purpose electrical motors.

The Motor and Generator Section of NEMA established the "NEMA Premium Program" for these reasons:

1. Electric motors vary in terms of energy efficiency
2. NEMA Premium Program identifies higher efficient motors that save money and improve system reliability
3. NEMA Premium labeled electric motors optimize motor systems efficiency in Utility power supply and utility cost saving issues
4. NEMA Premium motors reduce electrical consumption thereby reducing pollution associated with electrical power generation.

The table below lists comparisons for the cost of owning and operating premium efficient motors of various sizes versus standard-efficiency motors.

- Comparisons use average efficiency values for standard-efficiency motors and nameplate efficiency values for motors that qualify for the NEMA Premium designation.
- The motors listed are 208-230V/460V, general-purpose, 4-pole, TEFC, T-frame, NEMA Design B types.
- Cost comparisons are based on 8000 hour per year at 75% of rated nameplate horsepower, and a $0.075/kWh utility rate.
- Potential savings are even more based on Kingman Downtown energy cost of $0.105/kWh utility rate.

Table 2. Standard Efficiency Versus Premium Efficiency Motor, Payback Period

HP	Std Efficiency Motors, Average Efficiency		Provide NEMA Premium Motors			
	% Eff. at 75% load	Annual Energy Use (kWh), cost	% Eff. at 75% load	Annual Energy Use (kWh), cost	Annual Savings, kWh, $	Payback Period
5	84.0	26,644 $1,998	90.5	24,729 $1,855	1,914 $144	2.10
10	86.75	51,653 $3,874	92.2	48,547 $3,641	3,106 $233	2.22
15	87.55	76,771 $5,758	92.6	72,815 $5,461	3,955 $297	2.11
20	89.3	100,206 $7,515	93.4	95,846 $7,188	4,360 $327	2.52
25	89.9	124,457 $9,334	94.0	119,043 $8,928	5,415 $406	2.62
50	91.6	244,211 $18,316	94.5	236,825 $17,762	7,386 $554	2.42

1) Motor Efficiency payback and Return on Investment

NEMA premium motor increases the savings and decreases the payback period. The nominal payback for this example is 2.4 years is equivalent to a **34 percent return on investment**.

2.2 Kingman Analysis

Based on the Figure 1 example, the Kingman Downtown WWTP power rate is 10.5 cents / kilowatt-hour which would approximately double the Annual Savings for the premium efficient motors that are specified for the new wastewater treatment plant project.

The connected load rating is 464 horsepower or 346 kilowatt – as a bench mark, with the coincident running load about half of these ratings.

Refer to the prior Table 2 that indicates the at the efficiency improvement for 5-50 horsepower and Table 3 for the percentage improvement.

Much of the connected equipment for this project is in the 10 to 30 horsepower range, so a conservatively estimated of 4 percent efficiency savings may be available through using the premium efficient motors.

Table 3. Efficiency Gain Percentage of Premium Efficient Motors

5 hp	84.0	90.5	6.5%
10 hp	86.75	92.2	5.45%
15 hp	87.55	92.6	5.05%
20 hp	89.3	93.4	4.1%
30 hp	89.9	94	4.1%
50 hp	91.6	94.5	2.9%

The 246 horsepower coincident operating load is 183 kilowatts. For a year (8,760 operating hours), using the $0.105/kWh utility rate and the 4 percent energy efficient motor savings, is approximately $6,750 per year.

3. VARIABLE FREQUENCY DRIVES

The following graphs (Figure 2) show the power efficiency difference when comparing variable frequency drives to mechanical throttling means.

Utilizing variable speed drives in this example, power consumed is proportional to the cube root of the shaft speed. If shaft speed is reduced by 10 percent, flow is reduced by 10 percent, while power consumption is reduced by 27 percent.

If speed is reduced by 20 percent, power consumption and energy use is reduced by 49 percent.

The speed range of pumps typically is from 50 to 100 percent when adjustable speed / variable frequency drives are used. The following process equipment used for the Kingman Downtown WWTP will have variable frequency drives:

- Permeate pumps (these draw the final effluent through the membranes)
- Mixed liquor recycle pumps
- Aeration blowers
- MBR cleaning/air scour blowers
- Belt filter press feed pump

The power use reduction from running at less than full speed has not been accounted for in developing the coincident running load table in Section-1; it is anticipated that all of this equipment will run between 60 and 90 percent of its maximum speed under normal circumstances.

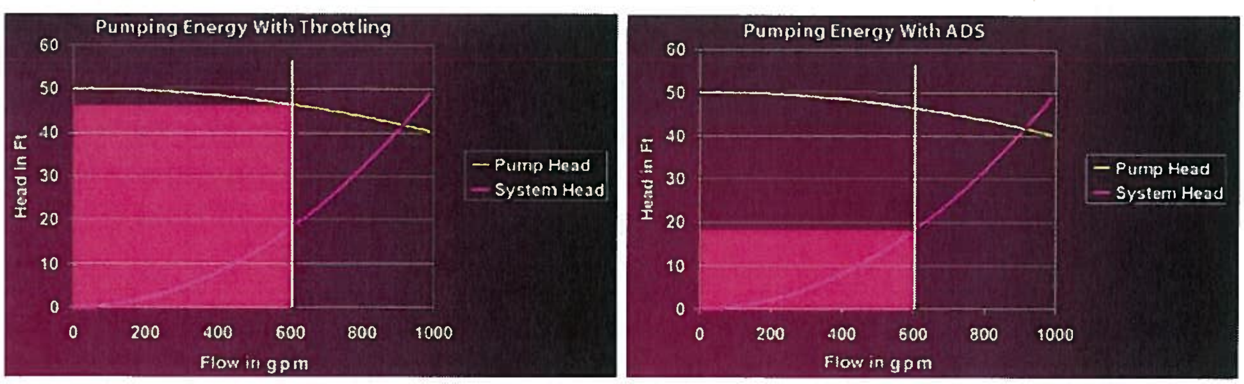

Figure 2. Variable Frequency Drive Energy Savings Versus Mechanical Throttling

4. ENERGY EFFICIENT LIGHTING AND DAYLIGHT SYSTEMS

The Downtown plant design for saving lighting energy is to reduce electricity consumed by the light fixtures (luminaries) and reduce the length of time that the lights are on.

This is accomplished by:

- Reducing the amount of time that lights are on.
  - Accomplished by using dimmers
  - Lighting controls
  - Educating employees to turn off unneeded lights
- Lowering wattage.
  - Replacing bulbs or entire fixtures with bulbs and fixtures that provide the same amount or greater amounts of light with but with reduced electricity usage.
  - Accomplished by replacing inefficient incandescent bulbs with:
    - incandescent/halogen bulbs
    - compact fluorescent bulbs
    - LED light sources.
- Installation of Day Light Systems.
  - Skylights reduce the need for day time lighting.
  - Wall type windows at higher elevations reduces the need for day time lighting while maintaining security. Panels will be translucent, and designed to minimize loss of heat in winter.
  - Building windows sized no larger than required for viewing process areas and plant entry points while maintaining security; windows will be energy-efficient and located primarily on north and east walls.
- Installation of Task Light Systems.
  - Provide multiple switched lighting areas for large buildings so that only the area where light is actually needed is illuminated.
  - Provide outlets for task lighting for times when night-time maintenance of equipment is required.
  - Providing motion sensing lights for gates and driving areas for safety and convenience at night, with timers to turn off the lights after the need has passed.

5. SOLAR LIGHTING

For areas having no available power sources, small solar-based power systems can be used to supply various localized needs. For the Kingman Downtown project, the entrance gates are somewhat isolated from the rest of the facility. A pre-engineered solar panel powered lighting system will be provided to light both entrance gates and the facility nameplate/sign.

The system will consist of photovoltaic modules producing 12 volt DC power, battery storage, and energy-efficient lights capable of operating on the power supplied by the batteries. The batteries will charge during the day, supplying sufficient power for up to 10 hours of night-time operation. System will include a timer and daylight sensor to turn off the lights during daylight or at operator-selected times.

Estimated power savings for the lights is 110 kW hours per year; additional project cost savings are realized by not having to provide conduit and wiring to the location of the entry gates.

6. POINT OF USE WATER HEATERS

Point of use water heater do not waste hot water compared to hot water from a facility hot water system with piping to the locations of use. With these systems, hot water stays inside the pipes after use and cools thus the heating energy is wasted and water may continue to be wasted until the hot water is available. In addition, between periods of use, the water heater may need to re-heat its contents to maintain its temperature setpoint.

Point of use hot water heating system replaces the standard water heating system on this project. Although minimal hot water will be required for this facility, some savings will be achieved in this way, particularly since natural gas is not available for water heating.

Point-of-use water heaters will be provided in the operator's building at the lavatory and at the operators' lunchroom.

7. MOTION DETECTION AND LIGHTING CONTROLS

Lighting controls are installed for turning lights on / off or for dimming. The lighting controls for increasing lighting energy-efficiency in a facility are dimmers, photocells, vehicle motion detections, and occupancy sensors.

- Dimmers reduce the wattage and output of fluorescent lamps and increase the service life of lamps.
- Dimming fluorescents requires special dimming ballasts and fixtures with out reducing efficiency.
- Photocells turn lights on and off in response to appropriate natural light levels.
- Photocells switch outdoor metal halide lights on at dusk and off at dawn.
- Occupancy sensors activate lights when an Operator is in the area and then turn off the lights after the Operator has left.

Photocells will be installed on exterior lighting, which will be switched so that only those exterior lights which are necessary for safety and security are used. Strategically located switched task lighting and/or outlets for work lights will provide for night-time emergency work that may occur at the facility.

Occupancy sensors will be employed within buildings to ensure that when personnel are not present in an area the lights do not needlessly waste energy.

The dried sludge waste materials that are hauled from the WWTP by trucks that drive into the facility and along the building wall past a motion sensor that turns on task-flood lights that are on a five minute timer, then turn off after the truck passes the building allows for less lighting luminaries on the side of the WWTP closest to the highway in Kingman.

The two swing gates that allow vehicles into and out of the WWTP will have LED lights embedded into the block wall near the gates and the WWTP signage mounted on the center of the block wall between the two swing gates will have two LED lights. The lights operate on a timer and are powered by small photovoltaic system with battery/battery charger to provide low level illumination in the 8 watt range per fixture but with the higher lumen output that LED light source provides and the extended life cycle duration compared to other light sources.

8. PROCESS SYSTEM OPTIMIZATION

The Kingman Downtown WWTP design includes a Plant Control System that will optimize the use of the process equipment and sequence the operation to limit the energy consumption to the minimum required for facility operation.

The BC Process Engineers and Control Engineer develop Control Descriptions for each of the processes at the plant with the goal of optimizing the energy usage.

The BC Control System Group implement the Control Descriptions in the form of programmable logic controller (PLC) software code that is loaded into the Plant Control System controllers.

The BC Construction Management Team verify that the Process / Mechanical Systems operate as developed and specified in the Control Descriptions.

The goal is for the Design staff, Control System staff, and Construction Management team to implement the plan to optimize the energy use at the plant.

REFERENCES

Washington State University Cooperative Extension Energy Program, 2003

American Lighting Association (ALA)

United States Environmental Protection Agency (EPA)

Green Energy Efficient Homes