An *Efficient* Water and Energy Efficiency Handbook

A Small but Comprehensive Review of Methods and Technologies Used To Conserve Energy and Power In the Water Utility Industry

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Introduction

Water and Energy share a unique, yet necessary "nexus". They are tied together in ways we often fail to fully realize. We commonly hear how vital water resources are to the exploration and development of critical energy resources. Water, typically in very large quantities, is necessary to facilitate most forms of energy development, production and delivery. But, we often fail to think about how necessary energy is to the development, production, and delivery of our essential irrigation and domestic water resources. This document is designed to help us understand better the interactions of the latter, or the relation of energy and power to water development and delivery – an ever continuing challenge in our purview and responsibility as water suppliers.

To begin with - the art of energy and power conservation in a water supply system finds its roots in the proper development and implementation of a comprehensive water conservation program. They are both tied together in a relationship that plays out when water conservation is more fully understood and extended further into the conservation of energy and power. The rewards which may be realized through the applications of the two strategies can bring about not only a significant environmental benefit, but also substantial fiscal savings.

As a supplier, we understand that one of the largest direct costs associated with the delivery of water involves the cost of pumping. Simply stated - every foot of pumping head, between the dynamic drawdown levels of a water well, to its delivery end point, say an elevated reservoir, serving one or more customer zones costs money. The higher the head, the greater the cost per Equivalent Residential Connection (ERC), at a standardized ERC volumetric demand. Pressure head is also increased on a water system by any process that imposes unwanted resistance to the flow of water, i.e. improper pipe sizes, corrosion, pipe age, improper system or pump designs, poorly maintained pressure regulation valves (PRV's), and other valve issues, etc.

Further – the timing issues (or lack thereof) of pumping cycles during peak electrical utility loads increases costs even further and reduces the reliability or peak capacity of the electrical delivery service or system(s). These costs are ultimately passed on to the system as additional power and energy costs. Pumping at a high capacity for even a short period of time increases the power load and accompanying power demand charges. Pumping at unnecessarily high flow rates for short periods of time also increases head losses and consumes more energy. These costs are also passed on to the water utility as an additional energy charge. Running a water distribution system inefficiently (leaks, loops, and re-pumping) also imposes more charges and costs to the water utility.

In summary – and as you will discover below, there are numerous ways (simple and more complex) to save water, energy, power, and money. But it should be noted, that a properly designed and implemented energy management system is in reality, an ongoing or dynamic process, and begins appropriately with one or more inspections and comprehensive energy audits. This effort should, at a minimum, include an extended period (rather than a more typical steady state) water system computer model.

I have written this paper through both rough and rewarding experience, primarily as a water system operator and manager for nearly 40 years. I have learned from many and do not profess to know all the answers. My real intent was to provide ideas that would spur further internal discussions and allow for the possible study and applications by water managers and their consulting engineers. I do not intend for this process to become burdensome (both fiscally and mentally) or overly complex. Nor do I want these ideas and projects to enslave you to become *efficient* to the point where you are truly *inefficient* in your diligence and capacity as a safe water provider. We never want to lose the public trust in our efforts. We do however want to demonstrate our triumphs and fiscal and environmental responsibility to our customers and constituents.

Finally - while this document appears, as its title suggest, brief or "Efficient" in size, it is fairly extensive in scope. While the list below appears rather large, it is still not inclusive of everything, and as such, do not become overwhelmed. The rewards of this exercise, or more properly, this exploration, could be small in some areas, but can also be great in others. Remember that implemented as a whole, these efforts can show significant economies in operational performance and costs. So - go about your efficiency work initially in a spirit of learning, and then teach or mentor others in this rewarding process. Also - don't forget to have some fun as you progress in this course!

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The Levels of Effort and Resource Requirements

To facilitate an easier initial scan or filtering of the subject matter, the following energy conservation inventory and ideas are divided into sections or groups of processes which possess similar efficiency characteristics. Each inventory item is further classified by a unique *Tier* symbol, indicating the potential degree of difficulty or involvement needed to assess and remedy. The items are classified into three (3) energy auditing *Tiers* alongside a corresponding project, or group of projects, indicating the possible resources needed to accomplish the tasks. The *Tier* indicator or symbol applies to all projects adjacent and below it, up to the next symbol indicator presented. Be advised that the listed *Tier* level may change depending on the proficiency of the water system. Some systems may be able to accomplish more tasks internally, and others may need more assistance than indicated. Each auditing *Tier* is detailed below:

1. **TIER 1**. The round ❶ one symbol signifies that the local water system personnel can most likely accomplish the evaluation or task. If not – the system should look to other entities such as the Rural Water Association(s) of the local state for training and/or assistance (see Tier 2 below).
2. **TIER 2**. The round ❷ two symbol signifies that a professional organization such as the local Rural Water Association can assist water system personnel with this extended effort. If they feel they cannot assist – they will recommend that the utility proceed to the next tier (see Tier 3 below). Tier 2 projects would be found more readily in an *energy assessment*.
3. **TIER 3**. The round ❸ three symbol signifies that the level of involvement will most likely involve a paid consulting engineer or other similar professional who can more readily assist with a thorough *energy audit* and evaluation. These evaluations typically involve much more complex levels of study, and are likely needed to receive construction funding and or fiscal

assistance from programs associated with local electric utilities, State water regulation authorities, and other funding agencies, etc.

The symbols listed below are added in addition to the 3 above if a special effort is also indicated:

1. The 🛠 tool symbol is attached along with one of the above symbols, and signifies that the project will likely require some equipment replacement and/or newly constructed or modified capital facilities.
2. The 🔒 combination lock symbol signifies that this project may be much more complex or more difficult than others, and may require more time, study, and other resources to access. The rewards may be greater however.
3. The 💰 money bag symbol indicates the project could be significantly more costly than others – but, with the cost high, the savings could be just as significant.

ENERGY and POWER – What am I Really Trying to Save?

We often use the terms Energy and Power interchangeably, and each term becomes ubiquitous. However they each define a distinct and important physical electrical characteristic utilized and conserved in varying water processes. As such, they each need a more concise explanation and an understanding as to how they are different, and how they are related, since each will often present different or unique conservation strategies. This discussion is also needed to better understand the electrical utility rates or tariffs as discussed later in this document.

What is Power?

Power is what is needed to supply a mechanical or electrical device with energy. Power can also be thought of as the peak or set output capacity of a mechanical device – such as an electrical motor, or gasoline engine.

We think of power often in Watts (w) or more often Horsepower units (hp), where one horsepower would equal 746 Watts. Power is very similar to the *Flow* of water in a distribution piping system. You measure water flow with a meter at one instance, in units such as – Gallons per Minute or per Second, (GPM or GPS). You measure Power in a similar way – with a meter on a wire at one instance, in units such as – Watts or Horsepower.

If you graphed power in kilowatts (kw) with your SCADA system, for say a pump station over a one month period, it would resemble a flow chart in gallons per minute (gpm) of water pumped. The peak power for the month would be the highest peak of the chart during that displayed period.

What is Energy?

Energy on the other hand is the useful Power derived from the utilization of physical or chemical resources, such as providing light or heat, or to work various motors and machines. Energy can be thought of as *Power* multiplied by *Time*, or a measurement of the amount of power consumed over a given time period (such as hours, months, or years). Likewise, this can be a measurement of the energy consumed by a mechanical device.

We think of energy often in Kilowatt Hours (kwh) units. Energy therefore is a primary billing component used by Electrical Utilities. Energy is also similar to *Volume* in a water system. You measure water volume over a billing time period with a meter in units such as – Gallons. You also measure Energy the same way – with a meter over a billing time period, in units such as – Kilowatt Hours per Month.

Again, if you graphed energy in kilowatt hours (kwh) with your SCADA system for say a pump station over a one month period, it would really be the same kilowatt chart for power as described above, however the energy would be the *total area below* the kw line, or the integration of the kilowatt curve. Using a water comparison, this area would equate to the total water pumped for the same period (month).

More simply stated - Power is related to how fast a car can go (assuming an Equivalent mass of all cars compared). And Energy is related to how much fuel that car consumes in gallons (assuming an equivalent distance or time of all cars compared).

How are we billed?

Energy provided by an electrical utility, is billed in a similar fashion to how we bill customers for water. We pay so much per month for the total kilowatt hours of energy consumed during any given monthly period. The meter keeps a running total – just like a water meter. Power on the other hand, is a one-time instantaneous charge for the peak power kilowatt demand hit each month. It is reset to zero at the beginning of each billing period. This is why a high power demand, incurred for even minutes, can result in such a large cost. The power charge revenue of an electrical utility is used to help offset the cost of capital improvements needed to deliver that peak capacity, such as generation plant and transmission line capacities. In the water business, this is more comparable to our one time tap or impact fee, charged up front to any given customer, based on what we calculate their peak capacity or impact on the water system will be. The electrical industry does not make this capital charge up front, but assesses it monthly, based on the peak capacity you need in their system.

In the water industry – we need to remember that it is very common for Power to make up as much as half or even more (in an inefficient system) of the total electrical bill cost. Both of these deliveries and charges play a significant role in our efficiency strategies.

For each conservation effort listed in this document, a third symbol has been appended to represent whether the idea or project is primarily an *energy efficiency* or saving effort, or a *power efficiency* one, or as is found in many cases, both *energy and power efficiencies* are possible. Therefor we use an Ⓔ symbol for *Energy* efficiency projects, or a Ⓟ symbol for *Power* efficiency projects. If no symbol is used, the project or idea can be attributed to *Both Energy and Power* efficiency projects.

And Finally – the Usual DISCLAIMER:

Always review and discuss any proposed or desired ideas, projects or testing procedures herein with qualified professionals before arriving at a final decision or implementation. No two water systems are alike and many systems require very unique solutions. This document is only a guide and does not negate further detailed investigations and study. Also follow all electrical safety rules and regulations. Different electrical facilities also require very specific safety and protection measures. When in doubt – call a professional.

The Energy Saving Audit and Implementation Process

Here is where the real hunt for Energy and Power conservation and efficiency opportunities begin. Listed below are nearly five hundred ideas and places and resources to search, learn, and evaluate for your efficiency prospects. It should be remembered that not all of the efforts listed will be applicable, viable, or even economically feasible for your particular water utility. Some are better than others, and some require significant efforts and costs. All opportunities are listed within general categories and some points may be duplicated in multiple sections where appropriate.

As a rule of thumb, energy and power efficiency projects, especially those which require significant capital to implement, should demonstrate clearly a five to seven year payback period or less. Many of these projects simply require a behavioral, operational, or workflow modification (i.e. pump timing or electrical utility rate modification), and may not require much money at all to implement. Other fairly simple projects will not even begin to become visible to system personnel until some computer modeling is performed on the system. This effort, performed by a qualified engineer can often open up opportunities never thought of before. It will also paint a clear picture of how your water system really functions, which may have been hidden, often since its inception.

It is always advisable when implementing an energy management program to begin with a plan. In such a plan you should prioritize your efforts by simplicity, costs, skill levels required, and capital investment recovery, etc. Look carefully at the life cycle costs when evaluating larger projects. Due to the diversity, geography, and complexities encountered within the water industry - a project or task which works with one system, does not always mean it will work the same on another system. Through this ongoing and dynamic process, you should be able to make informed decisions, choices which most typically begin with what we in the business often refer to as the "Low Hanging Fruit", or the simplest and most cost effective projects.

One last point – in all your efforts, you need to remember to protect your people and your water system. Some efficiency projects, if not implemented carefully or studied properly could unsuspectedly impose some negative effects on a water system. For instance, adjusting a treatment plant process control scheme for only energy efficiency goals may impose a water quality issue you never anticipated. Or, turning down a well output to a very low (or very high) flow level could create groundwater quality issues. Always remember to pursue projects which <u>do not</u>:

1. Risk the safety of any personnel. For example, selecting medium and high voltage motors for larger pump systems are generally more energy efficient, but if your organization is not equipped to maintain such higher risk equipment, safety may be severely compromised.

2. Jeopardize ANY federal, state, and local water quality standards and regulations.

3. Diminish established levels of service standards of your system, i.e. low distribution system pressure levels, or reservoir emergency storage levels, etc.

4. Create financial burdens, including staffing levels, which can easily exceed any savings.

5. Result in what I call the *Efficiency Paradox*. In this odd but real irony - some projects may contradict each other without a careful and thorough analysis. For example, the *Power* cost savings achieved by configuring a pump station to run at higher flow rates during off-peak (night) periods, may be easily offset by an additional cost of *Energy* if the distribution system

it pumps into was not designed for the additional flows. This Energy loss is the direct result of unanticipated new head losses. Was a possible pipeline(s) project factored into the real or potential savings? All efficiency efforts must be presented in a holistic setting that looks at all possible *precedents* and *dependents* created by an operational strategy or system modification and improvement.

So - in harmony with the many and some burdensome philosophies discussed above – we should again remember to always begin our efficiency research by evaluating the efficacy of our own water conservation programs, including our potential and quantified water losses. In any energy efficiency effort, it is always easier to save energy and power by simply avoiding the known and the unknown losses or undue wasting of our most precious resource - water.

I. Conservation Related Efficiencies

Energy conservation almost always begins with water conservation, including the methods of improving our accurate accounting for water losses within the various and complex delivery systems:

A. **Water Conservation Processes**. Encouraging water conservation always has a direct linkage with energy conservation. Not only does it save energy resources, it also frees up water that can be used as a future (virtual) water source, reducing the dependence on higher price s involved with source development, whether capital costs, water rights costs, or operational costs. Any conservation planning effort should at least look at the following basic strategies and include any related implementation plans as practical:

1. **The Plan** – Develop a comprehensive Water Conservation Plan and review the relationships between water and energy conservations therein. ❷
2. **Implementation** – Implement ordinances, rules, and regulations which effect the strategies and goals contained within the Conservation Plan. ❶
3. **Measure Accurately** - all water use, including separate meters for irrigation and domestic uses, if necessary. ❶
4. **The Standards** – Know what the real supply and demands of your water system are. Know what a typical Equivalent Residential Connection (ERC) uses in a year, an average month, and a peak month and day if possible. Also determine a peak daily flow rate per ERC for source development standards. Use these standards to compare conservation performance over time. If you cannot determine this information initially, begin with State Division of Drinking Water ERC standards. ❶❷
5. **Price water to recognize its finite nature** - Pricing mechanisms should provide incentives to water users who conserve water as well as penalties for those who waste it. At a minimum, adopt and effectively utilize increasing block rates. ❷
6. **Hold Responsible** - all water users for protecting the quality and quantity of water resources at their disposal. ❶
7. **Incentives** - Create financial or publicity incentives to reward users for efficient irrigation systems. Key elements to observe are system design, operation, and maintenance, combined with effective scheduling and management practices. ❶
8. **Education** - Create or assist in educational programs, which emphasize to all water users the absolute necessity of supporting regulatory policies, which reward conservative and efficient water use. ❶

9. **Reclaim** - Support water reclamation initiatives if feasible, particularly for irrigation, including the use of reclaimed water from municipal, industrial, and other available sources, where practical. ❸ 🛠 💰
10. **Prioritize Water Development** - Give increased support to developing new water resources, conveyance, and storage facilities, which enhance dependable water supplies for urban and agricultural use, with proper consideration given to legitimate environmental and efficiency concerns. ❶
11. **Buy-In** - Participate in water conservation planning as an ongoing program. These plans must be in place prior to a critical need and must provide for each water user's acceptance of a fair share of any water conservation effort. ❶
12. **Manage the Resource** - Institute studies to identify water use and misuse by all segments of the water using industry to provide data on which to base decisions regarding equitable water distribution during periods of drought or other shortage or water quality event. ❷
13. **Manage the Peak** - Investigate innovative water storage projects, to allow the supplier to better manage its water resources during peak periods of the year. ❸🛠Ⓟ
14. **The Water and Energy Nexus** - Meld Water and Energy Conservation into a unified strategy. Water and Energy share many of the same conservation strategies and should be looked at conjunctively in any conservation programs. ❶
15. **Water Loss Reduction Programs** - are very necessary to demonstrate to customers that the water supplier is doing everything possible to minimize water loss on the supply side of the equation while promoting conservation programs to the end users on the demand side. ❶
16. **Legislative Actions** – City or County Landscape Ordinances can save considerable resources when properly applied in the initial project planning and design phases. ❷
17. **Source Protection –** Involve local and county jurisdictions in the development and enforcement of area, regional, and watershed groundwater and surface water source protection plans. Protecting the resource from development constraints or hazards is much cheaper than treating or replacing a water source. ❷❸

B. **Water Accountability**. Accounted and unaccounted water losses waste significant energy, resources, and money, and can be at least partially remedied through a regular water audit and thorough investigation using many of the processes below. Most types of water losses fit into one or more of the following categories. Each system should develop a program to regularly or even continually (using SCADA) investigate, quantify if possible, and mitigate as much water loss as possible. (NOTE: leak detection instruments may be required in many of the tests needed for this program. The Rural Water Association may be of assistance in this area if needed). The categories of water loss are:

1. **Unbilled Metered Consumption:** ❶
   a. This is usually a water revenue loss (if the meter is read) resulting typically from a defect in the accounting and billing systems and internal controls of the utility (also see 5 below).
   b. This can also be a loss from special agreements, judgments, or other special treatment of customers who are metered (at least making a demand reading usable in a water audit - if read).
   c. This can further be a water and revenue loss if the meter is simply NOT read.

d. The water utilities own water consuming facilities can often fall into this category, i.e. offices, plants, flushing, etc. which meters are not included in a regular accounting of demands.

2. **Unbilled Unmetered Consumption:** ❶
   a. This category consists mainly of forgotten customers, or
   b. Often users that are some of the earliest connections which might be forgotten or were believed to be terminated in the billing system but not disconnected.
   c. Firefighting and other emergency water uses fall into this category.
   d. Again – often the water utilities own facilities and uses which are un-metered can fall into this category (see 1d above).

3. **Unauthorized Consumption**: ❶
   a. This is typically the water thief, illegal users; or
   b. Connections that have been unauthorized in the past and not disconnected.
   c. Unauthorized construction water users will often be found here (i.e. a meter by-pass) if not regularly checked up on.

4. **Customer Metering Inaccuracies**. These errors result usually from: ❶❷
   a. Lack of a meter testing and replacement program.
   b. Meters that are not designed for the particular application or installation configuration, i.e. a propeller meter on a low flow application.
   c. Meter that are too old, obsolete, or are reaching their end of life.
   d. Meters that are damaged or partially or completely plugged.
   e. Meters that have failed.
   f. Meters that have lost their power source (if applicable) or their electronic read system batteries have been depleted.
   g. Meters damaged or stopped due to freezing conditions.
   h. Meters that cannot be tested or verified due to their inaccessible conditions, i.e. in the basement or crawlspace of a home, etc.
   i. Lost meters.
   j. Vandalized meters or reading equipment.
   k. Oversized meters, particularly on services where the meter was designed to handle fire flow demands from a fire sprinkling system.

5. **Systematic Data Handling Errors**. This category is where errors in data processing occurs, namely: ❶❷
   a. Clerical data entry errors.
   b. Meter data configuration errors, i.e. types, size, units billed, wrong multiplier units, unrecognized meter roll-overs, etc.
   c. Meters coded to the wrong customers.
   d. Billing system rate entry and testing errors.
   e. Errors or "bugs" in the actual firmware of the reading equipment or the software used for reading equipment and billing.
   f. Errors due to the lack of maintained reading software updates.
   g. Lack of an accounting control system to review or check up on billing reports, meter work orders, etc.

6. **Leakage on Distribution System Mains**:
   a. Leak detection audits should be performed on a regular schedule, starting with older and less reliable infrastructure. ❷
   b. The establishment of a system typical water loss baseline aids in the identification of new leaks as well as performance of your water loss programs. ❶
   c. Meter performance and testing. A regular testing program should be implemented. Many residential meters have an accuracy curve that drops significantly after 10 to 15 years. As much as a cup per minute or more can pass undetected through some ¾ inch meters. Larger systems should consider purchasing or constructing their own meter testing benches. ❷
   d. Master metering should be provided where practical, when a large user base is fed off of one or two line(s), and mass balance tests reviewed regularly (supply in, less summed user meter demands out). ❷
   e. Fire hydrant leak tests should be performed regularly, particularly on hydrants used for construction water. ❶
   f. Operational leaks, i.e. flushing and testing should be metered and accounted for if possible. ❶
   g. Fire department tests – if unmetered, an estimate should be maintained by the fire department and submitted to the utility. ❶
   h. Sewer system flushing programs should utilize hydrant meters. ❶
   i. Construction water should be metered. Investigate the installation of metered bulk water stations if construction water places a regular heavy demand on a system. This can reduce significantly wear and losses on fire hydrants. ❷❸
   j. Fire hydrant meters should be tested regularly. They fail or can be damaged fairly easily, especially if used for construction water. ❷
   k. Can the SCADA system be provisioned to monitor for water losses on a real time basis? ❸ 🔒
   l. Investigate the implementation of automatic PRV pilot adjustment systems which can adjust pressures for high and low demand periods. Lower pressures at low demand periods can significantly reduce water losses on the distribution system. ❷🛠
   m. Regularly check for water losses at PRV stations and other distribution system regulation valves. ❶
   n. Air-Vac and air release valve stations are an often overlooked source of water losses. Many of these are lost and hidden, but can result in significant losses if damaged from freezing or other problems. ❶

7. **Leakage on Service Lines (laterals):**
   a. If a leak is found on a service line after the meter, due to corrosion or age – there is a very good chance there is a leak on the service line feeding the meter. ❶
   b. Know where all service line valves are using maps, GPS, GIS, etc. Most of the time these are covered over (buried in landscaping) by the customer. ❷
   c. If a customer has a fire sprinkling system, does it have a regularly tested flow detection system? ❶
   d. Know the soil conditions in areas that are prone to leaks. ❶

e. Use service line materials and depths which are more suitable to your environment and soil conditions. ❸
f. Automated Meter Read (AMR) systems can aid in the locations of service line leaks by observing trends throughout the night or unoccupied seasons or times. They can also detect leaks from freezes etc. ❷ 🛠 💰

8. **Leakage on Tanks and Overflows**: ❷ or ❸
   a. Leaks in tanks can be found through regular internal and external inspections.
   b. On metal tanks – inspect for corrosion, and cathodic protection issues. Recoat the tank if necessary.
   c. Check for leaks in tank control vaults and valve systems, including tank level regulating altitude valves.
   d. Excessive water overflow and other losses in tanks can be caused or remedied by the following:
      i. Proper Placement of Reservoirs and PRV's. Keep pressures feeding an altitude valve at a minimum if possible.
      ii. If feasible - use PRV's less and reservoirs more for pressure control.
      iii. Investigate the use of reservoir inlet and outlet detection devices.
      iv. Investigate reservoir emergency or seismic control valves which close to protect storage in an emergency water loss situation.
      v. Investigate reservoir overflow detection systems.
      vi. Watch for reservoir level transducer failures or improper level calibrations.
      vii. Ensure that reservoirs are properly vented and protected.

9. **Leakage within Plants and Equipment**:
   a. Check for leaking pump surge anticipator or pressure relief valves which discharge water to the atmosphere. ❶
   b. Check for leaking pump control valves (deep well type) which may discharge water to atmosphere. ❶
   c. Check pumps for excessive leaks in pump seals. ❶
   d. Check for leaking air-vac and air release valves in pump stations and treatment plants. ❶
   e. Regularly check for water losses at regulation valves including altitude valves, electric and pneumatic actuated valves, pump to waste PCV's, and PRV's. ❷
   f. Ensure that filter to waste cycle times are not overly excessive. ❷
   g. Investigate the feasibility of backwash water re-use, either internally or for irrigation etc. ❸ 🛠
   h. Inspect sedimentation, mixing, clarifier, filter basins, systems and the like regularly for leaks, performance issues, etc. ❸
   i. Monitor for leaking well foot or other check valves on sources. ❸
   j. Optimize the backwashing and purging of all filter systems to avoid unnecessary waste. ❸

II. System Modeling Efficiencies

One of the first steps necessary to the properly develop a comprehensive energy audit of a system is to perform an extended period computer model to evaluate the source, distribution, and pumping system(s) function and performance. While the modeling can be somewhat complex, system personnel and others can assist with the data gathering and mitigation or repairs necessitated thereby. Modeling – particularly "Extended Period" modeling is also a dynamic process which needs to be regularly reviewed and "fine-tuned" as needs arise, new data becomes available, and system conditions or improvements change. As a part of this evaluation, the following energy demanding scenarios (including others, such as water quality conditions) should be studied in detail. We will begin with what I refer to as the "4-L's", or the primary efficiency modeling "red-flags": ❸ 🔒

A. **Looping**. The process of unwarranted or repeated boosting of the same water. Ask this question: Could a pump or system of pumps be boosting water, or any portion thereof in one or more continuous loops? Such loops can be found, among other possibilities, within the following locals: ❸ 🔒 Ⓔ

1. In the distribution system piping through inter-zonal connections, where a booster station pumps water from a lower zone to a higher zone, and water can be routed back down (around the booster and back to the pump suction side) through one or more locations or devices, such as: ❶ Ⓔ
    a. PRV stations – where one or more station(s) are designed to be normally closed (open only in very high flow or fire flow situations), but failures occur through:
        i. Improperly maintained PRV's, Failed Solenoid Controls, or Relief Valves and related PRV pilot control systems.
        ii. Leaks in a PRV valve diaphragm or across valve seat.
        iii. Leaks in a standby or larger backup fire-flow PRV.
        iv. Leaks in a by-pass gate or butterfly valve.
    b. Leaking through normally closed zone isolation valves. Often these are also accidentally opened when their purpose is not understood. A normally closed valve should be marked as such in a valve box with an inserted pole, labeled 2x4 board, flag, etc.
    c. An improperly designed or applied PRV station (due to various future distribution modifications), which should be kept closed or could be simply eliminated.

2. In pumping stations where failures may occur through: ❶ Ⓔ
    a. Leaking pump check valves, when one or more pump(s) are off.
    b. Leaking surge anticipator or pressure relief valves, which discharge to the pump suction zone.
    c. Leaking pump by-pass PRV or solenoid valve systems used to deliver fire return flows from the higher pressure pumped zone to the pump suction zone.
    d. Water cooled chiller, fan coil, or air-handling systems used to cool a pumping plant, where a solenoid or control valve feeding the coils fails to close or leaks from the higher pumped zone back to the suction side.

3. Source and Treatment Facilities through: ❶ Ⓔ

a. Chemical (i.e. chlorine gas) feed systems or ejection systems, i.e. leaking pump check valves, solenoid valves, etc.
b. Leaks from corroded or damaged source well pump lines or well columns, where the water flows or circulates back into a well casing annular space. This can also involve screen and corrosion issues.

B. **Leaping**. The process of unnecessarily pumping a source, such as a well, or lower zone around (or "leap-frogging" over) a higher PRV separated pressure zone (often through a separate pumping line) to a tank, when the pump would be using significantly less energy by simply pumping the necessary demand pressures (or a portion thereof) directly into the pressure zone in which it is located. The problem can best be remedied if there are other sources or pumps that can supply the actual higher tank zone. The PRV's are now only used for high flows, emergency backup, or when the well or pumps cannot meet the necessary supply. Leaping can be mitigated by: ❸ Ⓔ

1. Well or booster pump station(s) pumped exclusively into the hosted pressure zone, with flow controlled by zone pressure, i.e. VFD's or multiple pumps.
2. Well or booster pump station(s) pumped into upper tank zone pipeline only when needed by an automatic diverting valve, but used in lower zone as much as possible.
3. A combination of 1 and 2 above, achieved by adding a separate or smaller pump(s) (or dividing up pumps) to keep the hosted zone in water, with the others used to supply the upper zones.
4. Performance can be monitored by metering the pumps AND the inter-zone PRV's.

C. **Losing Head.** The process of unnecessarily dropping or breaking a usable water supply head pressure, which could have been utilized in a local or adjoining zone without the drop. These conditions may be found in the following situations: ❸ Ⓔ

1. Breaking a spring or flowing well pressure, or wholesale supplier delivery point pre-maturely just to re-pump the same water unnecessarily.
2. Underutilization of the pressure delivery of a flowing well, even if it is seasonal in nature.
3. Breaking a high pressure zone in a pumped system – just to be pumped up again to that zone or another higher pressure zone.
4. Remediation of this problem often involves re-provisioning or installing new pipelines to bring the pumping systems into a more efficient condition.

D. **Loading**. The processes involved to better facilitate the efficient timing and efficient capacity loading or control of pumping systems. If configured properly – significant savings can be realized, but if pump operations are random or uncontrolled or not optimized, the costs can be excessive. These problem(s) are remedied in more detail as described in sections further down in this document, but it is mentioned here because it is often discovered in the computer modeling processes. It is realized in a pumping and energy model by one or more of the following: ❸ Ⓔ

1. Well and booster pumps which pump a very high flow of water to a tank or user demand zone for short periods of time, i.e. less than 20 percent of the day.
2. Pumping systems engineered for some distant build-out capacity, but the current operational needs are only a fraction of the limit.

3. Pumps that only reach their optimum efficiency when loaded with one or more parallel pumps. They typically operate to the right of the curve when run alone.
4. Pumping cycles which create an excessive head loss on the system.
5. Pumping systems which do not perform in their most efficient pump curve zones, or have an inadequate or poorly designed suction head.
6. Well drawdowns which have changed significantly since the initial pump sizing. This is common in aquifers which are producing beyond their safe yield or are simply "mined out".
7. Tanks and reservoirs which are sized too small to allow for a more custom timed (i.e. off-peaking or extended load factor) pumping cycle.
8. Pumping systems which model well if run in "off-peak" scenarios, but are not run as such, and vice versa.
9. Pumping systems utilizing an ineffective or efficient electrical rate tariff.
10. Pumping systems which are artificially restricted to control flows, such as valving, etc.
11. Pumps not prioritized and operated by efficiency constraints.
12. Pumping systems which could be operated or sequenced better on a seasonal basis.
13. Pumps driven by inefficient or poorly designed electrical drives, starting, and control systems.
14. Worn or improperly maintained pumps.

III. Water Source (or Supply Side) Efficiencies

These efficiency processes and projects are related to a water suppliers sources and represent supply side (or production) type improvements.

A. To begin with – ask yourself: "Is the source water actually making it to a tank? Does it really need to?" (See "Leaping" above). This activity can be actively modeled and monitored in a SCADA system setting. ❷ Ⓔ
B. Run sources (or prioritize them) based on energy costs per unit of water (also known as Specific Energy), and choose the most efficient sources first – given water rights and other water quality and safe yield implications and considerations. This figure would be presented in a unit such as kWh / Acre-foot, or kWh / MG, or kWh / 1000 Gallons, etc. ❷ Ⓔ
C. Monitor well Specific Capacity (standard flow per standard drawdown unit, such as gpm / foot) on a real time basis using SCADA to test for changing well efficiencies over time or by season. ❸
D. Using the data derived above, and through a change application process with the State Engineer, determine whether water rights could be transferred from an expensive source to a less expensive one. Or could multiple sources or points of diversion share the same water rights, allowing you to have greater flexibility in how you operate sources. ❸
E. Monitor in real time with SCADA, and log sources and pumping systems for not only Specific Energy, as discussed above, but also Specific Power. This process allows you to see the effect of the demand component of your power bills and take steps to minimize its impact (i.e. should I use off peak peaking, or load factor extension strategies). This calculation is typically expressed as kw/gpm or gpm/kw. This figure, along with Specific Energy, as described above, is also often used as a seconday comparison and to check for the trending of pump efficiencies over time, and possible needs for well and pump maintenance. ❸ Ⓟ

F. Remain current on all water source protection plans and work to mitigate any possible threats to said source(s). Ensure that each source has an approved and recorded protection zone. Work with City or County officials to assist in the adoption of a source protection element to a zoning code or regulation. Losing a source, either temporarily or permanently can cost the public and the environment significantly. ❷

G. Monitor total source production monthly and daily if possible. Tie source capacity to the number of standardized ERC's to establish a running trend of capacity utilized and available, as well as overall efficiency. ❶

H. Well Source Energy Issues – check for the following and remedy as necessary: ❸ Ⓔ

1. Well screen maintenance issues (i.e. corrosion, scaling, plugging, iron bacteria tuberculation, etc.) creating a greater draw-down than the well was originally equipped for.
2. Excessive VFD Harmonics or inadequate filtering, along with issues associated with excessive cable lengths between the VFD and motor.
3. Improper well power cabling used for a VFD controlled motor.
4. Well pump and/or motor sizing errors or condition changes over time.
5. Line drive well pumping systems are typically more efficient than submersible pump systems, if the well can be equipped for such and has the proper characteristics.
6. Undersized well casing, preventing more efficient pump and motor selections.
7. Corroded or leaking pump column piping.
8. Investigate in-situ chemical treatment systems for problematic water quality wells, where a chemical feed lines are installed in the well for scale and/or bacteriologic treating of the well on a regular basis. The well can be designed to recirculate chemicals during this period then flush. This can significantly maintain or improve well performance.
9. Properly screen and develop and test pump new sources to optimize well performance and create a valid base line of data for future tests and comparisons.
10. Clean, and re-develop older wells as necessary.
11. If feasible - run wells often with iron bacteria issues to prevent fouling of screens and casing perforations, etc.
12. Avoid under sizing of casings on new wells.
13. In VFD well pump systems, investigate the feasibility of using an across-the-line starter after a VFD reaches 60 Hz to reduce inefficiencies imposed by the VFD system.
14. Size a well pump system for the optimum or most likely drawdown levels encountered in the well. If this level changes over time, either modify pump speed (i.e. speed up when levels drop) or change the pump to keep the operating point as close to the peak in the efficiency curve as possible.
15. Typically a well pump will run on the right side of the curve efficiency point on start-up and move left to its optimum point when the dynamic drawdown reaches its "sweet spot". The left side of the curve uses more energy and power demands when pumping these higher flows. If using a VFD, it could be more efficient to start the motor at a lower speed, keeping the efficiency point at its peak and slowly speeding up to maintain that position as the drawdown point drops and stabilizes. Ⓟ
16. On well pump to waste cycles, either slow the VFD speed down to the anticipated finished flow rate (this may entail another flow meter or the re-positioning of the current one), or put an orifice on the waste line to hold back pressure just below the normal system operating pressure. This prevents the pump from running

inefficiently on the far right side of its curve, costing considerable energy and unwanted power demands, as well as pump damage from possible cavitation. Ⓟ

17. See the ***Pumping System Efficiencies*** section below for more pump related ideas.

I. Spring Source Issues: ❷

1. Loss of flows due to roots or damaged collection systems.
2. Lack of vegetation control in the spring collection areas.
3. Lack of protection (i.e. fencing) from animals etc.

IV. Water User (or Demand Side) Efficiencies

These efficiency processes and projects are related to a water suppliers end users and represent demand side (or customer) type improvements. Most of these projects are indicative of cumulative energy savings.

A. Implement increasing block water rates (with many tiers), including possibly surcharges to higher demand customers. Doing this is the first step to actively encourage customers to be more involved in water conservation measures. ❷
B. Investigate zero based rates which provide no water allowances in the base charges. ❷
C. Review the feasibility of high elevation rates or the establishment of high elevation surcharges to assess customers who place a higher pumping demand with related higher energy cost on the system. ❷ ❸ Ⓔ
D. Review and update the water conservation plans and strategies as necessary (See conservation section above). ❷
E. Review your system Rules and Regulations – to ensure that they promote conservation and penalize users for unnecessary water use and waste. ❶ ❷
F. Demonstrate resource conservation strategies and water education by participating in or developing annual school or community water fairs. ❶
G. Provide public education and assistance when possible to help conserve water or find known water losses. ❶
H. Investigate possible customer "Adopt a Hydrant" programs to alert the utility when water theft occurs or a leaking hydrant is found. ❶
I. Reduce system leaks and water losses by implementing fixed based meter read systems, which read meters daily and hourly. Tie customer water meter reading system to work in conjunction with a carefully implemented master meter system(s). Generate daily reports, pinpointing areas where a water leak or break may be occurring. Use this system to assist customers in troubleshooting leaks on their side of the meters. Provide customers with daily water use statistics on company web pages to promote their own usage understanding, patterns, early leak detection, and conservation. ❸ 🛠 💰 Ⓔ
J. Regularly test and calibrate meters and perform regular upgrades as necessary. ❷
K. Follow AWWA Water Audit standards or your own standards, and perform annual water audits. ❶
L. Consider secondary water system metering, if you provide such, to save higher quality and treated water sources, and helping to avoid the often used term, "you better use it or lose it" water consumption philosophy. ❶
M. Consider customer culinary irrigation metering systems or the metering of pools or large water features, separate from customer meters with high use customers. ❶

N. Consider ET Irrigation Control Systems, or providing ET data to customers to assist in the proper programing of their irrigation systems. ❷ ❸

O. Provide customer – On-Site conservation and leak evaluations and audits. ❷

P. If you utilize a fixed base and hourly customer meter read system – investigate and consider an additional demand surcharge based on peak daily flows, which have a larger impact on a distribution or pumping system than annual or monthly volume usage (similar to what power utilities do with a demand charge). This could possibly eliminate the need of an impact fee, or compensate for a possible under assessed one. ❸

Q. Investigate installation of real time leak detection monitoring equipment. ❸ Ⓔ

R. Master Meter new developments where practical to assist in area or regional mass balancing calculations. ❶❷

S. Investigate wastewater re-use systems and possible Membrane Bio-Reactor (MBR) scalping plants to facilitate the irrigation of large institutional, agricultural, or private irrigation needs in adjacent areas. ❸ 🛠 💰

T. Provide optimum lawn watering and irrigation schedules to customers. ❶

U. Implement water theft regulations and provide the policing of such. ❶

V. Provide annual water loss reports to your public and board. ❶

W. Track what a system ERC standard really is, and trend regularly its claim on your water source capacity and water demand capacity. ❶

X. Understand better what water use is in the middle of night in the winter to estimate more accurately the background or passive water losses, etc. ❷❸

Y. Develop a system wide or area specific diurnal curve of water demands to assist in continuing computer water modeling efforts. ❷ ❸

Z. If possible – install meters in the low flow PRV by-passes which are constructed around larger PRV's, and are used more at low water use periods to help establish a system or regional base leakage rate. ❶

V. Pumping System Efficiencies

These efficiency processes and projects are related primarily to booster pumping facilities. Much of these projects and improvements can also be applied to pumping systems found in various types of treatment plants.

A. Pumping system efficiencies (primarily energy) are decreased if one or more of the following situations exist: Ⓔ

1. The pump is operating outside of its pump curve efficiency range. ❷
2. The pump is worn or not of a proper design. ❷
3. The flow of water is restricted or throttled on the suction (and/or) discharge side. ❶
4. The flow of water is controlled by by-passing a portion of the water around the pump. ❶
5. The electrical control system, i.e. VFD is not designed for the application. This is common in high head pumping systems where a VFD controls the whole flow range in a relatively small band of Hz. VFD's are not always efficient in these cases. ❸
6. The Distribution System is not routing and controlling the flow of pumped water properly to its destination, i.e. re-pumping or short circuiting, faulty PRV's, etc. (see Looping in Modeling above). ❸

7. Other Distribution System Problems, i.e. storage issues, leaks, corrosion, pipe age and quality, under sizing, etc. ❶❷
8. Pump station pipe materials and fittings are corroded or tuberculated, increasing the friction coefficients. ❶
9. The electrical Load Factor is too low and the head losses on the distribution system are excessive. Load Factor (LF) is a fractional number or percentage indicating the average amount of time per day a motor or pump runs. i.e. a Load Factor of 0.25 or 25% means the pump runs on average 6 hours per day. ❷❸
10. The Electrical System Power Factor (PF) is not efficient or too low. ❸ ⓟ
11. The Water System Peaking Factor is too high (above 2.0). ❷ ⓟ
12. The Pumping Systems are not cooled properly. ❷❸
13. The pump motors are old or worn, or are not of a high efficiency design, or designed for a VFD, etc. ❸

B. Pump Curves and pump performance should be regularly reviewed and tested. Test each pump on at least 4 points on the curve. Have a VFD curve available if the pump is on a VFD and test at several speed points. ❶

C. If you use the correct utility power rate for your pumping systems, significant money can be saved. ❶❷

D. If you pump during the designated off peak periods of the Electrical Utility – you can also save money, by completely eliminating or reducing the Power Demand Charge. Proper storage capacity is essential to follow this strategy. ❷❸ⓟ

E. If you use Variable Frequency Drives (VFD's) to increase your Load Factor, or use jockey type pumps – you can significantly reduce your costs – by reducing your demand and energy charge. ❷❸

F. If you have a high head loss on a pump plant, a VFD can reduce your energy cost by reducing the total dynamic pumping head. ❷ 🛠 ⓔ

G. If you are charged a power factor penalty – you can eliminate that charge by implementing power factor correction strategies. ❸ⓟ

H. Pump cycles and operation should always be selected for efficiency, yet be prepared for any emergency operation scenario. ❶

I. Always match the VFD to the proper pump and pump curve. ❷

J. Never, ever use a restrictor valve to control the flow rate of a pump. ❶ ⓔ

K. Run pumps more often (prioritize) based on their costs per unit of water pumped, also referred to Specific Energy. If possible - choose the most efficient pumps first in a system for pumping. ❶ⓔ

L. Carefully develop effective multiple pump rotation and lockout strategies. ❶

M. Provide for pump back-up strategies. ❸🛠 🔒 💰

N. Carefully review the necessity for pump trimming when using a VFD. Many times the VFD can act as the pump trim. ❸

O. Evaluate multiple and smaller pump designs, vs. one or 2 large pumps in a pumping plant. ❷❸🛠

P. Review well and pump designs to evaluate if a line drive pump is more efficient than a submersible pump system. Submersible motors are typically less efficient. ❸🛠ⓔ

Q. Implement SCADA and control system lockouts to prevent operators from running multiple pumps when not needed, or bumping pumps unnecessarily during a more costly on-peak pumping period. ❸ⓟ

R. Provide engineered pressure and surge protection systems to better protect distribution infrastructure and pumps from wear, breaks, leaks, etc. ❸

S. Typically small jockey type pumps should run first and as long as possible to extend the load factors as much as possible. A load factor above 80 % is not unrealistic, in fact it is preferred. ❸🛠

T. Jockey pump(s) can run on a different energy strategy than the larger pumps. For example – the jockey can run as much of the time as possible (high load factor), and can be controlled from the highest levels of a tank. The other LAG series of pumps kick in in series when the jockey pump cannot meet demands. These pumps could be programed as well to run off-peak. This hybrid strategy can be quite efficient. ❷

U. See if it is possible to divide a pump plant into 2 services (2 meters), with the smaller jockey pumps on a lower cost small commercial rate, and the larger pump on the commercial or industrial rates. ❸🛠💰

V. Regularly evaluate for service or replacement any old and worn pumping equipment. ❶

W. Provide or specify motor shaft grounding brushes to protect bearings on VFD operated pumps. ❷

X. Use high performance lubricants on motors for extended performance and lower operating temperatures, and maintain levels. ❶

Y. Well "pump to waste" cycles often run pumps at their highest energy and power demands. Provide a back pressure or pressure sustaining valve in line with the pump control valve (on the waste line only), or add a sustaining pilot on the pump control valve, to hold waste discharge pressures closer to the efficiency point on the curve. Ensure that these valves are not oversized. They should provide some back pressure simply as a function of their size. An alternative for a VFD controlled pump would be to run the waste cycle at a lower speed. ❶❷Ⓟ

Z. Evaluate your pump exercise and water testing strategies. Avoid running a pump for a short period just to exercise it. If a pumping system needs this, evaluate running it in an off-peak period or on a generator regularly. The same applies to running well pumps for a simple water test, when they would normally be idle for a month or more. It is usually not as necessary to regularly exercise pumps as many operators believe. Check with the pump suppliers for guidance. ❶❷Ⓟ

AA. Ensure that your well and well pump performance matches its design characteristics and pump curve. Also monitor well static and dynamic drawdown and specific capacity over time. If there are irregularities – the pump may be worn, or the pumping column may be leaking into the well annular space. When changing or servicing well pumps, perform a video inspection to ensure that the well casing is in good condition. A corroded or malfunctioning casing and screen system will restrict flow into the well casing and lower drawdown levels, thus increasing energy and power requirements. ❸

BB. On larger pumping systems, investigate the application of medium or high voltage motors. Typically these motors are smaller, require less copper, run cooler, and are more energy efficient. The motors and control equipment, i.e. starters, VFD's, etc. can be more costly however. ❸🛠💰

CC. Review your pumping LEAD/LAG logic and tune it to be more efficient. For instance – if you are utilizing Jockey Pump(s), you may need to modify your LEAD/LAG logic from the typical AND logic, where a lead pump starts (i.e. the Jockey Pump), AND then a larger Lag pump is added if necessary, to an OR logic scenario. In an OR logic, the Lead pump runs first, then if a larger Lag pump is needed, the Lead pump shuts off first, then the larger Lag pump(s) run. In this system you Lead OR Lag, instead of the common Lead AND Lag. This prevents the jockey pump(s) from wasting energy and power when the larger Lag pump(s) operates. A system may have 2 jockey pumps, where the Lead logic performs an AND operation on those first, then the OR logic on the larger pumps after. LAG logic can also have an option to favor the off-peak periods for further savings if desired. This logic design can save a significant amount of energy and power. ❷ Ⓟ

DD. If you are considering a VFD, always request and analyze VFD pump curves from the manufacturer to evaluate whether a VFD is efficient in the given application. If you don't have this information (particularly on a current installation), generate your own VFD curves based on operating conditions and the Pump Affinity Laws. Understand these laws when designing a new installation and avoid VFD systems where the static pressure is so high that it takes 85 percent or more of the 60Hz frequency range just to get the water moving. ❷ ❸

EE. On new pumps - always request pump test curves from the manufacturer and compare the results to the published specification curves. Pay particular attention to the efficiency curve performance. If the curves are not equal or better than the published curves, consider rejecting the pump(s). ❷❸Ⓔ

FF. In summary, implement water pumping and operational management strategies similar to the following:

1. Reduce Energy usage on pumping facilities by ensuring that pumps are not running at a level or in a configuration which increases head losses in the pumping or piping systems. ❶Ⓔ
2. Eliminating a possible return flow loop or leak in a pumping station through relieve/surge anticipator valve(s) or emergency fire flow PRV's. ❶Ⓔ
3. Review pump curves to better limit Variable Frequency Drives (VFD's) to their optimum frequency range settings. ❶
4. Avoid "across the line" starters for motors where possible. Reduced Voltage Soft Starters (RVSS) and VFD's are usually better, depending on the application, and offer far better motor protection strategies. ❸
5. Monitor temperatures and environmental variables better in all pumping and other remote facilities to get better controlled energy use for heating and/or cooling. Use Motion detectors for lighting controls and install more efficient fluorescent (T5 or T8) or LED lighting. ❶❷Ⓔ
6. Evaluate and implement better and more efficient cooling systems for the larger pumping facilities, to not only save energy but extend pump life. ❸ 🛠 Ⓔ
7. Improve the efficiency and reliability of larger HVAC heating and cooling systems by, monitoring air pressures, humidity, and other parameters. And to better control operation in the winter months, using the heating systems only when needed. Integrate HVAC controls into PLC's and integrate with system SCADA equipment. Investigate using the water itself for heat transfer medium (i.e. geothermal or geo-exchange technology) in a more efficient heat pump system. ❸ 🛠 Ⓔ
8. Ensure where feasible, that pumps controlled by Variable Frequency Drives (VFD's) do not have their impellers trimmed – thus allowing for a wider range of operational flows and pressures. ❸ 🛠
9. Large pump motors can be wound with RTD's (temperature sensors), and associated motor protection relays, to better monitor motor winding conditions. ❸ 🛠
10. Establish Power Quality meters on larger facilities with daily SCADA logging capabilities. ❸ 🛠 Ⓔ

VI. Storage System Efficiencies

Often we don't thing of a storage reservoir in terms of energy or power efficiency, but we need to remember that a reservoir functions just like a very large battery in an electrical system. Often, just a better understanding of how the tank functions in the overall operation of the system provides many ideas on the proper optimization of the related source, distribution and pumping systems.

A. Know all tank dimensions, including elevations of floor and overflow points. ❶
B. Verify tank capacities and the capacity per foot. ❶❷
C. Know the equalization, fire, and emergency tank levels and capacities. ❶
D. Know your tanks typical and unusual rate of level changes +/- at all times with the SCADA system. ❶
E. With the above information, make informed decisions, instead of relying on the classic "saw tooth" decision (pump fill and drain cycle), for determining leaks, etc. ❶
F. With our unique ability to store water in tanks, we should think more of a tank as an energy storage battery, and utilize it accordingly and run pumps as such. ❶❷ Ⓟ
G. Storing Water is very similar to storing energy, which in turn allows us: ❶

    1. The ability to run high energy and power motors and other equipment at controlled rates, and
    2. During controlled periods of time. Ⓟ
    3. This is unique in the world of commercial and industrial power users.

H. Size all new tanks for: ❷❸

    1. Required ERC Demands as per State DEQ Standards, plus
    2. Fire and Emergency Storage, plus
    3. Energy Storage volumes (for Off-Peak Pumping) if possible. Ⓟ

I. Inspect and clean all reservoirs regularly, check for leaks and security issues. ❶❷
J. Have a reservoir back-up plan in case a reservoir needs to be taken down, w/ PRV's, pressure regulated pumps on VFD's, etc. ❶❷
K. Install backup floats in reservoirs in case of transducer failures. ❶❷
L. On new tanks, ensure that it is designed with water tight measures and leak detection through visible foundation drain systems. ❸ Ⓔ
M. Implement storage tank security measures to protect it from vandalism and possible contamination. ❷❸
N. Investigate possible ASR (Aquifer Storage and Recovery) projects to reduce the Seasonal Peaks, and better optimize the usage of water sources or treatment facilities. ❸ 🛠 🔒 💰

VII. Distribution System Efficiencies

These efficiency processes and projects are related primarily to the water distribution piping and transmission piping facilities. Much of these projects and improvements can also be applied to the pressure regulation facilities located throughout the system. These improvements and reviews are primarily energy efficiency related.

A. Ensure that all PRV's are properly maintained and tuned to provide optimum pressure levels which may in turn reduce accompanying distribution system water losses. ❶ Ⓔ
B. Review fire hydrants annually and test for possible leaks. ❶ Ⓔ

C. Keep a centrally accessible and well maintained set of pipe location and leak detection instruments to ensure rapid and accurate assessments of infrastructure. ❶❷Ⓔ

D. Investigate installing a centrally located and efficiently accountable bulk water filling station for construction water – minimizing water losses and unauthorized use by contractors. ❸Ⓔ

E. Develop and implement a distribution system flushing program to ensure that water quality is maintained as well as friction losses minimized. ❷Ⓔ

F. Review and maintain key air-vac and air release devices in the distribution system to ensure that they are functioning properly with no build-up of air. This will maximize flow of water and can significantly decrease energy demands. Ensure that high points of distribution piping have air regulation devices. Even a partially air locked pipe can use significant energy in pumping. ❶Ⓔ

G. Where practical, install customer services in the top zone of distribution piping (and at pipe high points) to ensure air is kept out of the piping systems, and reduce the need for air-vac devices. ❶Ⓔ

H. To optimize energy efficiency on any raw un-treated water transmission lines – implement pipeline pigging programs to ensure that pipe wall friction coefficients are maintained at a minimum, thus reducing pumping energy costs. ❷❸Ⓔ

I. Model the distribution system using a steady state AND extended period models, to evaluate possible undersized piping systems and networks, including water flow patterns, water quality characteristics, and energy demands over different scenarios. (See Modeling above). ❸ 🔒 Ⓔ

J. Test water for possible tuberculation and corrosion (iron and sulpher reducing bacteria, and langler index) issues which can impose energy inefficiencies. ❷Ⓔ

K. Be careful not to crush PE piping in new piping installations. ❶Ⓔ

L. Investigate the installation of real time pressure transducer monitoring at key distribution sites and use the data to calibrate system models. ❶❷Ⓔ

M. Implement and monitor Backflow testing programs to protect water quality, and ensure that these protection devices are not leaking. ❶Ⓔ

N. Check the distribution system(s) for partially closed or lost isolation valves. Know the valve rotation counts for various diameters of pipe. Verify these diameters with the piping models and record drawings. ❶Ⓔ

O. Investigate pipe network looping and additional network upgrades in the system to reduce head losses on pumping systems, etc. ❷❸Ⓔ

P. Specify pipe materials which have a higher "C" coefficient in future upgrades and/or expansions. ❶Ⓔ

Q. Incorporated pressure management PRV control valve systems where practical. These systems can drop the pressure from say, 110 psi to 70 psi during low demand periods, which helps to reduce water use and lower the leak rates. It also limits the wear and tear on the water system. But when higher flows are needed in that zone, the pressure automatically increases to the higher pressure for such use as fire-flow or heavy demand. When demand subsides, the valve automatically returns to the lower settings. ❷❸Ⓔ

R. Develop an upgrade master plan for piping systems which are deficient in size, materials, or quality. ❸Ⓔ

VIII. Plant or Treatment Facility Efficiencies

This section could be very extensive, but because plants are so unique, it is difficult to list improvements and ideas that would apply to all. Most of the concepts addressed in the other sections of this paper will apply readily to a process or sub-process in any treatment plant, i.e. pumping is ubiquitous. Therefore, I am only listing some generalized concepts that may be common to all plants.

A. Upgrade key chlorinating disinfection units to more efficient systems, utilizing less energy either in production and/or transportation and handling of product. ❸ Ⓔ
B. Investigate chlorine generation systems. We live in a State with accessible and cheap salt deliveries, making the electrolytic generation of chlorine much more efficient. ❷ ❸
C. Implement more natural and energy efficient systems to reduce algae growth in raw water systems, i.e. covered basins, ultrasonic mitigation equipment, etc. which could reduce the costs and amount of chemicals used for treatment. ❷ ❸ Ⓔ
D. Improve treatment plant process control and efficiency through proper utilization and dosing of chemicals to reduce chemical waste, etc. ❶ ❷ Ⓔ
E. Improve chemical storage where feasible, to increase bulk purchase discounts and reduce delivery frequency thus saving energy and costs. ❶
F. Monitor electrical facilities for inefficient heat dissipation or cooling, through increased building insulation, etc. ❸ Ⓔ
G. Ventilate properly or look to other methods to control humidity and condensation, and enemy to electrical equipment and motors. ❶ ❷
H. Use more efficient lighting in plants (i.e. T5 Florescent or LED). ❶ ❷ Ⓔ
I. Carefully evaluate the processes and determine if motors or other energy hungry equipment (i.e. heating loads) overlap unnecessarily, creating a higher demand than may be needed. See if various process can be timed or scheduled in the SCADA systems to limit these possible overlaps in power loads. ❷ ❸ Ⓟ
J. Are filtering, backwash, and purging or filter-to-waste cycles optimized to reduce water waste and filtration efficiency? ❸ Ⓔ
K. Are there any normally wasted process or backwash waters that can be properly recycled for re-use, either in the plant or externally, i.e. irrigation systems, etc.? ❷ ❸
L. Can the plant or any sub-units of the plant be run during off-peak cycles? ❶ ❷ Ⓟ

IX. Technology and SCADA Related Efficiencies

A question often asked us in the water industry is, "Do you run the system, or does it run you?" This section looks at the ever increasing importance of a SCADA or automated control system(s) in our water industry. It is often, the real brains behind our brains, and is greatly needed if a system is to implement many of the water efficiency and conservation programs addressed elsewhere in this paper.

A. Key to the operation of a successful advanced energy management strategy is the close and persistent review of pumping and energy data. While many SCADA systems are adept at general plant operations, an advanced system requires more analysis of the situations at hand, and must make more complex decisions, as well as provide more comprehensive reporting and alarming features. I refer to this process as SCADA 2.0. Presented below are some of the SCADA 2.0 process and related control strategies: ❸ 🛠

   1. **Typical** - SCADA operation based on the usual reservoir set points
   2. **Off Peak Mode** – Run everything off-peak if reservoirs allow (can eliminate or reduce power charge – Rocky Mountain Power (RMP) Rates 6B, 8, 9, Ⓟ, or reduce energy charge – Rate 6A). Ⓔ

3. **Off Peak – High Load Factor Mode** – Run everything off-peak if reservoirs allow, but pump the entire off-peak period at lower flows (can eliminate power charge – RMP Rates 6B, 8, 9, Ⓟ AND reduce energy charge for all rates. Ⓔ)
4. **High Load Factor Mode** – Fill the entire day with as few of pumps as possible (or run smaller "jockey type" pumps) or reduce Hz on VFD's (can significantly reduce energy charge AND power charge). Depending on the size of the Jockey Pump(s), you may need to modify your LEAD/LAG logic from the typical AND logic, where a lead pump starts (i.e. the Jockey Pump), AND then a larger Lag pump is added if necessary, to an OR logic scenario. In an OR logic, the Lead pump runs first, then if a larger Lag pump is needed, the Lead pump shuts off first, then the larger Lag pump(s) run. In this system you Lead OR Lag, instead of the common Lead AND Lag. This prevents the jockey pump(s) from wasting energy and power when the larger Lag pump(s) operates. A system may have 2 jockey pumps, where the Lead logic performs an AND operation on those first, then the OR logic on the larger pumps after. LAG logic can also have an option to favor the off-peak periods for further savings if desired. This logic design can save a significant amount of energy and power.
5. **Efficiency Failover Mode Option** – Have a lower emergency set point to allow for failovers. For example - if #2 or #3 fails – then switch to #4, Additional Option - If #4 fails –then switch to #1.
6. **ALERTS** - The SCADA system reviews continuous pump efficiency, with GPM per KW, and Gallons per KWH (or KWH per MG), as well as Power Factor monitoring data and presents historical trend charts and alerts. (Note: some power and energy monitoring equipment upgrades may be necessary). The system also alarms key personnel when a water loss is determined.
7. **REPORTING** - Provides detailed and advanced reports to alert for possible water loss, other problems, as well as supply and demand data in certain areas (by day and even by hour), etc.

B. Implement energy and power monitoring reporting (i.e. Specific Energy and Power) into the SCADA system to better monitor the performance of pumping systems. This will allow for more rapid reporting of pump failure or blockage by rocks or debris in an impeller or impeller or bearing wear, significantly reducing its efficiency, or motor malfunction. ❸

C. Through the proper implementation of an Asset Management system and a GIS system – provide geographically accurate infrastructure information and maintenance history to empower staff with the data necessary to make timely repairs, reduce travel, and improve maintenance decisions. ❷❸🔒

D. Have proper power backup generators and equipment available so key infrastructure can be operated in an emergency. Backup all SCADA, security, and critical control systems at key locations using a small backup generator and/or UPS system if necessary. ❸🔒 💰

E. Move more critical computer server applications into the "cloud" as they become available and more mature, reducing local costs of hardware management, software maintenance, as well as energy costs, and providing better data backups. ❶❷🔒

F. Install "water bug" type water leak detection devices on all SCADA sites to enable staff to react quickly to any type of facility leak or water loss promptly. ❷❸

G. Develop and practice backup procedures for failed SCADA system(s) (i.e. communication loss plans), etc. ❶

H. Basic SCADA reports to be provided in any system should include at a minimum the following: ❶

    1. Daily Consumption – net of reservoir levels, etc.
    2. Hourly Consumption as above.
    3. Pump performance data (i.e. specific energy and specific well capacity).
    4. Power quality data.
    5. USE the SCADA data gathered efficiently and properly in operation and maintenance decisions (asset management).

I. Listed below are some of the most important SCADA efficiency and data parameters to gather at plants and pumping facilities: ❷❸

    1. Amps
    2. Volts
    3. VAR's
    4. Kilowatts
    5. Kilowatt hours
    6. KVAR hours
    7. Power Factor
    8. THD (Total Harmonic Distortion)
    9. Well drawdown
    10. Well Specific Capacity Calculation; gpm / foot
    11. Specific Power Calculation; Kw / gpm or MGD
    12. Specific Energy Calculation; Kwh / gallon or KG or MG
    13. Possible electrical utility rate cost data – i.e. what does a pump cost per day, month, year, etc.?

J. Tie real time SCADA data into a dynamic water computer model. ❸ 🔒 💰
K. Tie real time SCADA data into an asset management or work order system, where work orders are issued automatically based on equipment run metrics, i.e. run hours, gallons pumped, etc. ❷❸ 🔒
L. Record system pressures at key points and in PRV stations, etc. See real time performance in emergencies, pipeline breaks, etc. pinpoint trouble areas for potential cross connections, etc. ❸
M. Provide higher levels of infrastructure security and intrusion detection. Use IP video in high risk areas. ❸🛠🔒
N. Using the above data and resources - predict areas for future improvements and repairs. ❶
O. Be careful with communication issues and the possible "Unwanted Lag" occurrence. If the SCADA system starts lag pump(s) when the lead pump cannot raise reservoir levels properly, be sure that it does not just occur with a simple reservoir level sensor or communication or power system failure. A delay may be appropriate, or a lower set point may be necessary. Monitor communication failures of any type by alarm and ensure that they do not start unnecessary equipment. This unwanted result can be quite costly! ❷❸🔒
P. Allow for a real time or dynamic Mass Balance Process with your SCADA systems to detect and locate leaks and losses. ❷ ❸
Q. Synchronize or schedule energy demands better. Prevent overlaps of loads if possible, i.e. pumping and resistive heating, etc. ❶ ❷
R. Allow SCADA to become the facility thermostat by monitoring environmental and weather variables better. ❸

X. Internal or Operational and Behavioral Efficiencies

This section describes energy efficiency strategies that can simply be achieved by management through operational changes and the way we function day to day in the workplace. Many of these strategies, if feasible, require very little money or effort to achieve a savings.

A. **Sustainability** - Review State and EPA Standards for capacity development in the following areas and implement the following standards or improvements: ➊➋

1. Managerial Capacity
2. Financial Capacity
    a. Develop Effective Rates
    b. Develop Impact Fees
    c. Implement Levels of Service Standards
3. Technical Capacity

B. **Train and Educate** – Provide training opportunities for administrative, office, and operational staff at regular intervals. Ensure that all personnel are certified at levels at least at their required proficiency requirements. The Rural Water Association of Utah, AWWA, and the State Division of Drinking Water offer many courses and testing opportunities. ➋

C. **Administrative**: ➋

1. Know who to call when help is needed. Have a ledger distributed to all departments of who to contact in an emergency or if technical assistance is needed. Again, the Rural Water Association of Utah and the State Division of Drinking Water have resources in place to help with any type of problem or assistance needed.
2. Develop a realistic capital improvement program to replace old systems with more efficient systems.
3. Implement efficient Utility Billing and related financial data systems.
4. Develop sound emergency management programs, including redundant communication systems for SCADA and personnel access.
5. Join the UT-WARN cooperative agency to provide resources in an emergency or other problem.
6. Implement Asset Management Systems for:
    a. O&M
    b. Capital Improvements

D. **Operational**: ➊

1. In large utilities, distribute operational personnel where practical. Create possible small satellite offices or shops and equipment stores, with SCADA access to more efficiently position operation staff across the service area.
2. Train operators regularly in the efficient and proper diagnostic procedures used to determine system water losses.
3. Reduce paper output by providing work orders, system maps, O&M manuals, and system photos digitally to remotely accessible computers and mobile devices (iPads, smartphones, etc.).

4. Optimize and centralize spare parts and other inventory in key locations to reduce energy and time related travel needed for the proper operation and maintenance of the systems assets and services.
5. Ensure that all operations and management staff have reliable access to relevant SCADA, security systems, and server data and resources to minimize the amount of travel need to check systems in person.
6. Encourage telecommuting with certain staff where practical.
7. Compile and regularly train with employees or operators "Water Operations Manuals" or "Standard Operating Procedures" (SOP's) – compiled with emergency and energy management procedures, etc.
8. Practice "table top exercises" and drills and tests, etc. in company operation and emergency procedures.
9. Teach operations staff to be creative and innovative, and provide new ideas and designs in efficiency. Reward for such!

E. **Office Facilities**: ➊

1. Implement Energy management strategies in water system offices – i.e. programing thermostats effectively and using low energy lighting, motion controlled light switches, etc.
2. Install a backup generator for the administrative office if needed.

F. **Public Relations and Education**: ➊

1. Make the water system's WEB Page more public friendly, usable, and efficient.
2. Education (start early to instill a conservation ethic in children):
3. Conservation Resources
4. School and Community Water Fairs
5. Back-flow and cross connection prevention
6. Groundwater protection
7. Conservation Garden(s) and xeriscaping displays
8. Public Educational Press Releases
9. Educate the public to assist in the recognition of a water leak, possible security breach, or water theft, etc.

G. **Materials and Equipment Recycling**: ➊

1. Recycle paper and other appropriate office items. Provide accessible bins for such purposes.
2. Recycle used metal scrap, copper, brass, (meters) and bronze, from old water facilities, equipment, and meters.
3. Re-use older electrical and water distribution equipment where feasible.
4. Recycle all SCADA and UPS system batteries.
5. Implement the proper re-use of used materials in bone yards, etc.

H. **Fleet and Transportation**:

1. Reduce fuel usage by operations staff through the proper implementation and use of a field accessible customer service order, asset management system, and inventory control system. This will significantly reduce the need to return to the office frequently to gather work orders, directives, etc. ➊🛠
2. Procure more energy efficient vehicles and equipment in system operations where practical. ➊🛠💰
3. Investigate CNG conversions for viable equipment. ➊ 💰
4. In very large systems, investigate the use of GPS tracking on company vehicles to assist in the most timely and efficient dispatch of personnel to customer needs or equipment problems. ➊

I. **Multi System Regionalization and/or Cooperation Efficiencies**: ➌ 💰 💰

1. Can provide some economies of scale.
2. Allows for the shared source and storage facilities and extends capacities.
3. Can lower the staffing levels per customer.
4. Can provide a more efficient use of heavy equipment and repair parts inventories.
5. Regionalizing can sometimes be inefficient however, regarding energy due to the interconnection of systems that were not designed for such.

XI. Energy Supply Systems, Control, and Backup Efficiencies

This section looks into more detail the proper provision and sizing of energy supply systems, the timing and control of such, as well as efficient backup supplies. NOTE: much of the data gathering and work field necessitated by this section should be performed by qualified personnel, who are adept at electrical safety and arc-flash procedures:

A. Carefully select the appropriate utility energy rate for the pumping application (See section XII below). ➊➋
B. Pumping Selections should be based on unit water costs. Know the Specific Power cost per ac-ft/year, mgd or gpm Ⓟ. Also know the Specific Energy cost per k-gal, ac-ft, or mg Ⓔ. ➊➋
C. If it is not an emergency - make all motor operation selections for efficiency rather than convenience. ➊
D. Evaluate Conventional vs. Off-Peak Pumping systems using the following thoughts and criteria: ➊ Ⓟ

1. Electrical Power systems size power generating and delivery systems using the same concepts of a water system.
2. Power plants are sized to meet the peak daily energy and power load of their users, even if for a very short time.
3. The art of energy conservation is based on reducing the overall peaking factor of a system, thus reducing peak generating demands, brown outs, rolling blackouts, and minimizing the carbon footprint of a power system.
4. The SMART energy grid is an attempt to reduce adverse peaking impacts.
5. Peak water demands like power deliveries are the most costly.
6. Peaks require the greatest usage of resources.

7. Peak demands rob a system of customer growth capacity – whereas reducing the peak through conservation allows for the economic servicing of more customers with fewer upgrades.
8. Peak demands increase O&M on a system.
9. Peak demands also have a greater impact on the environment.

E. Evaluate the pumping plant Load Factor – using the following thoughts and criteria: ❶

1. Load Factor (LF) is a measurement of the amount of time a facility runs during the billing cycle or during the average day. A large part of an electrical bill is the demand or peak power charge, and if a pumping system runs at a high capacity for a short time – the peak power (kw) charge is assessed – on as little as a one minute pumping period.
2. The Load Factor (LF) on a pumping system also has a big impact on monthly power rates.
3. If the pumping system can run longer – say 80% or more of the time, at a lower capacity – the same amount of water is pumped during a day or month, but the peak power charge is much less.
4. LF is expressed as a fractional number or a percent (%), where 100% means the pumps run 24/7. 50% means they run half of the time during the billing period, average day, etc.
5. Most pumping facilities are designed inefficiently to run for short periods normally, around 25% LF or less, and cost considerably more to run.
6. They are also designed so longer run periods are saved for emergencies or build-out.
7. A VFD can have a big impact on Load Factors if run correctly, and can save on motor maintenance and efficiency as well.
8. A small jockey type pump or pumps can also increase the Load Factor.
9. An ideal Load Factor would be 80 percent or above.

F. Low Power Factor (as opposed to Load Factor), which is caused by an inefficient pumping system can also significantly increase electrical inefficiencies and may result in an electrical utility penalty. The power factor decreases as more reactive power is utilized in a system (VAR's). Reactive energy can be reduced generally by adding capacitors to a circuit or utilizing VFD's. ❸ 🛠 Ⓟ

G. Energy Savings and a VFD: ❶

1. Besides saving Power in a pumping system as previously explained, VFD's can also be utilized to save energy (kwh). This can be a significant savings in some systems.
2. Many pumping systems are pumping too great of a flow in a restricted piping system and the head losses can be significant, i.e. improperly sized pump to pipe system.
3. Other pumping systems are using a valve to restrict the flow in a pumping system to accomplish the above.
4. Imagine driving down the road at 100 mph, and while keeping your foot at the same position on the accelerator, stopping or slowing down your speed with your brake. You consume the same amount of energy but instead of using it, you are burning it

up in your braking system. This is similar to the energy losses in a system that restricts flow with a valve.

5. A VFD can save considerable energy by replacing the valved system or restricted distribution piping. It can run pumps for a longer period at a lower flow (similar to the power savings above).
6. This solution can result in energy savings as well as power savings.
7. VFD's do not ALWAYS save energy however, and are not always ideal for some pumping systems, namely high head systems which have a large static head to overcome before a variable flow can be realized.
8. VFD's can also add extra heat to a pumping system, which heat can increase further if users try to raise the carrier frequencies of the VFD's (a way to help reduce the noise generated by the motor). Noise may be reduced, but efficiency is also reduced.

H. Soft Start's or Reduced Voltage Soft Starters – (RVSS) can be a viable alternative to a VFD, where a VFD is not an efficient alternative. RVSS reduce the peak loads and stress on a starting pump, and also contain valuable motor energy and power data, which is useful in an advanced SCADA monitoring and control system. They also run cooler and can significantly outlast an across the line starter. ❸ 🛠

I. Smaller and more pumps can also be a viable alternative to a VFD, by simulating a VFD by through the sequence or combinations in which they are operated. ❸ 🛠

J. Regularly review plant Wire to Water Efficiencies. ❷

K. Test for Harmonics on VFD pumping systems and remedy with properly sized filtering systems. Many newer VFD's come with these features. ❷❸

L. Ensure that plant motor and VFD equipment is properly and efficiently cooled. ❸

M. Have a Back-up Power System program and optimize any generator efficiency. Conserve potential generator use. Generators should start remotely, based upon one of the following selector switch positions provided in the control system: ❸ 🛠

1. Auto Lock Out - meaning that the generator and fuel will not be used,
2. Auto Start in Outage - meaning that the generator will switch on whenever the power goes off, and
3. Auto Start Pump Call - meaning that the generator fuel will only be used when the reservoir calls for water, and the generator will automatically shut off when the reservoir is full. This is designed to conserve fuel during emergency situations. Diversify generator fuels, with some using diesel fuel, and some using natural gas and propane. Have a diversity of types, stationary and mobile, and do not oversize them. VFD pumps take less starting capacity. If feasible - some starting capacity can be saved by starting a pump at shut-off heads against a closed valve, then slowly opening it.

N. Utilize Solar Cells and battery (UPS) on SCADA systems to keep the data transmitting during a power outage and protect security. ❸ 🛠

O. Implement security systems to protect water quality and quantity. ❷❸🛠

P. Incorporate energy management and operation of back-up systems into your emergency preparedness and response systems. ❶

Q. Investigate using a small solar powered DC/AC well for long term emergency water (if only 1 gall per person per day), with a portable tank if needed, i.e. a 10 gpm well, run for 12 hours per day will supply 7,200 people. ❸ 🛠

R. Provide a good backup supply of key equipment to promptly implement repairs and save water, i.e. transducers, SCADA equipment, pumps, valves, repair parts, etc. ➊

S. Provide advanced Power Quality Monitoring equipment at pumping plants (on either a per pump basis or per plant) to assist in the diagnosis of pump problems, etc. ➌ 🛠

T. Perform regular Infra-Red (IR) camera tests on electrical facilities to determine any potential thermal electric problems with motors, transformers, breakers, electrical connections, etc. ➊➋

U. Building and plant design and energy efficiency: ➌ 🛠

1. **Insulation**. Remember that concrete is not a good insulator in and of itself. Insulate the outside buried portions thereof with protected insulation. Where the wall is above ground, insulate the inside.
2. **Louvers**. Louvers can let in a lot of cold during winter months. Do you have a system in place to insulate and cap unnecessary ones, at least seasonally? Also – investigate some of the newer more efficient and insulated lovers for replacements or new applications.
3. **Lighting**. Review HO-T5 and LED lighting options. Standardize on one system. Skylights can be valuable in certain situations. Security may be a concern with these however.
4. **HVAC** – This can be very significant. Electrical resistive heating systems can often have kilowatt loads higher than even some of the pumping systems (3-20kw per heater!). If this is the case – seriously look at other alternatives for heating and/or cooling, such as:

    a. A small loop of water run through a fan coil and supplied around a pump system can supply significant cooling potential, and even possibly some geothermal heating solutions. Resistive heating elements can be installed in many of these systems to provide for heating if needed. Remember to use NSF approved systems or heat exchangers if the water is returned to the distribution system.
    b. Review shallow geothermal (sometimes referred to as geo-exchange) options where you use the water itself for heat transfer medium, similar to a heat pump. Water utilities do not need the expensive geo-thermal well drilled for typical geo-thermal systems. We can simply use our water supply. Again, remember to use NSF approved systems or heat exchangers if the water is returned to the distribution system.
    c. Review solar thermal systems which incorporate heated water or air for day-time heating. These can be coupled with geothermal systems as well.
    d. Investigate possible solar photovoltaic systems which can power small resistive heaters. Some resistive heaters (and electric water heaters) can run on straight DC power as well as AC, eliminating the need for a photovoltaic inverter.
    e. Avoid running a heating system when the pumps are running, this can significantly reduce the peak power demands on the system. Make the SCADA system the controlling thermostat of the plant(s) if possible.
    f. If you are investigating geothermal or geo-exchange systems keep in mind the following points:

i. First - to use the pumped water itself as the heat transfer medium, there needs to be installed a secondary loop with another heat exchanger that is NSF (National Sanitary Foundation) approved for drinking water. As far as I know currently, there is no geothermal unit manufacturer who makes an internal exchanger which meets NSF regulations, meaning it cannot come in contact with drinking water. The State Division of Drinking Water requires this certification. This second loop adds a significant amount to the cost of the units, making the payback on these systems outrageously high.

ii. Second - There is a lot more maintenance required with these systems, and they are very complex. Some drinking water system personnel may not be prepared to take on equipment that has this much of a learning curve and challenge.

iii. Third - While they are "green", capital wise - they are typically the most expensive heating and cooling systems you can find.

iv. As an alternative - If you can lay a closed loop pipe coil in something like a water tank, a pond, or can bury it along a new pipeline in the ground (providing a pipe project is part of the new pump station). The costs could be much cheaper and you only need the one exchange loop. If you have a mine tunnel as a source – this is also a good source of water for a geothermal type system. You could lay a loop of pipe up the tunnel, in the water drainage ditch and then back and you could probably completely heat and cool a plant or pumping facility with such an arrangement.

v. Again – an often preferred alternative (which in a way is partly geothermal) which would function in most pump stations is to simply install a cheap air handler or fan-coil unit using a culinary system loop of water (around the pump) directly for cooling, and installing an electric element heater in the unit for heating. This is not as efficient, but it is more efficient than a regular heater, and it can be economical to install. Currently I can only find one manufacturer which makes a coil that is NSF approved. And that is Williams Furnace Company.

5. **Humidity** - Moisture from condensation can become a serious problem, especially if a pump or plant air is over heated. Review economical humidity control systems (i.e. de-humidifiers). Proper ventilation can be important as well. Air to air heat exchangers can be used in some situations. Know the purpose and proper operation of you ventilating systems. Simply plugging a system can cause other humidity problems if not carefully monitored. Investigate adding humidity and temperature sensors to you SCADA system for continuous monitoring.

V. Keep all electrical and control equipment clean. ➊

W. Keep accurate records for daily, monthly, and annual water use at source and demand facilities, also calibrate to correspond to energy billing periods. ➊

X. Large energy accounts should be subscribed with the power company for on-line access, for daily review, reports, etc. ➊

Y. If you uses off-peak power strategies, check utility energy meters regularly to ensure that they are synchronized with the correct time. Always leave a small time buffer on your start and stop times. ❶

Z. If you use small jockey type pumps AND large pumps in a common facility, investigate the feasibility of connecting each system to its own power service, meter, and rate. This could allow each pumping system to run on its most efficient and economical rate structure. This may not be allowed in some areas. ❸🛠

AA. Avoid energy and load overlaps and redundancies. Time loads to be off-set where possible to avoid higher power demand charges. (see above) ❶

BB. External Energy Service Provider Strategies:

1. Ensure key facilities are accessible to outside utilities in all seasons to guarantee that meters are read in an accurate and timely fashion and not estimated. Estimates eliminate much of the benefits to off-peak strategies or low load and high load factor strategies. ❶
2. Know the meter codes and multipliers displayed on your electrical utility meter, especially if you have a "time-of-day" meter, and understand how to read these and use them in an audit. ❷
3. Perform regular utility bill audits. Record and log power and gas consumption data as needed to ensure accuracy in billings as well as facilitating reliable budgetary projections. ❶
4. Graph energy and gas use to demonstrate success of conservation and management strategies. ❶
5. Eliminate small unnecessary or redundant electrical accounts – replace with solar systems if and where feasible (i.e. small SCADA only accounts). ❶
6. Investigate net metering opportunities on smaller accounts using solar, wind, or energy recovery generation devices or other similar and authorized equipment. ❸🛠

CC. Investigate the Rocky Mountain Power (RMP) WattSmart program for possible incentive funding of energy saving and management projects. This requires an analysis – performed and funded by a RMP authorized consultant, but if a real and verifiable energy savings can be obtained, the WattSmart program will provide financial assistance to achieve the same. These projects can provide a significant savings on high energy projects such as pumping systems as described in this document. A not insignificant part of your monthly electrical bills fund this program. Don't let that payment go to fund other customer's projects. ANY future energy saving project you anticipate should be reviewed with your RMP customer service representative prior to its design and implementation. ❸🛠

DD. As a general rule of thumb - If your current or future pumping project or plant will consume one or more megawatts of peak power, and if your project is located within a mile of an electrical suppliers high voltage transmission lines, you should seriously investigate the feasibility of becoming a rate 9 customer (Rocky Mountain Power) and connecting directly to that transmission system with your own sub-station. ❸🛠🔒💰Ⓔ Ⓟ

EE. Investigate potential energy sources and Net-Metering opportunities on certain key facilities. This will allow the power meter to run backwards when you generate more power than consumed. This uses the Power Utility in essence as an annual storage battery where you can use your net metering credits as you consume power. This is not feasible in all situations. Also – investigate the new Rocky Mountain Power rate 32, which allows for renewable energy facilities to be placed in more optimum locations of the State, and allows the power to be transferred to its end use. Cooperative projects can also be provided under this tariff. Sources of energy to investigate may include, among others: ❸ 🛠 💰

1. Natural Gas / Propane generation:
2. Diesel generation with proper air quality equipment
3. Solar Electric
4. Solar Thermal
5. Geo Thermal
6. Wind
7. Energy Recovery at PRV's, i.e. Small or Micro Hydro, etc.

XII. Energy and Power Utility Rate Dynamics

This section describes many of the key energy and power tariffs, regulations, and operational opportunities available to Rocky Mountain Power (RMP) customers. These regulations may be similar to those water utilities which are supplied by local Municipal Power Systems. Check with their local tariffs and regulations to properly review any differences.

A. Commercial tariffs commonly used in the water supply industry (NOTE: Rate selections can be changed by you, but not more than once per year): ❶

1. **Rate 23** – Small Commercial – low demand < 30kw, this is typically the highest unit cost rate for water production, but can be very economical on small loads (less than 15 kw) because there is not a demand charge on that portion.
2. **Rate 6** – Commercial – medium demand < 1 mw (most common default pumping rate).
3. **Rate 6A** – A commercial time of day *energy* rate. If you have a low load factor – you can save on this rate. It also has an off peak rate built in to it. Ⓔ
4. **Rate 6B** (see note *) is the Rate 6 *power* time of day off-peak rate. Ⓟ
5. **Rate 8** – Large commercial / industrial rate > 1 mw. Slightly lower rates but the off-peak period DOUBLES in the summer months from 8 hours to 16 hours per day! Ⓟ
6. **Rate 9** – Large industrial transmission rate. Should be considered if loads are consistently above 1-2 mw. Considerably lower rates and off peak periods are the same as rate 8, but you need to take the service from a transmission line at the high voltage side, 46kv and above, and you must construct, own, and operate a sub-station. ❸ 🛠 🔒 💰 Ⓟ
7. **NOTES** *: Rate 6B has a 12 month averaged minimum Kw (look-back) – prior to the 6B Election. Be careful and practice for a year before electing this rate (try to get on-peak loads as low as possible)! OR – start a new facility with this rate if you are going to go Off-Peak.

B. Off-Peak Power periods: ❶ Ⓟ

1. 11:00 PM to 7:00 AM all year
2. All day on weekends and major holidays.
3. For Rate 8 and 9 Customers they are:
4. 9:00 PM to 1:00 PM in the Summer Months, and

5. 11:00 PM to 7:00 AM in the Winter Months.
6. All day on weekends and holidays
7. Summer months are May through September
8. Remember that you lose most of the power demand savings if you go on peak for even a minute (except Rate 6A).

C. Off-Peak Considerations and Implications: ➊Ⓟ

1. Beware of Rate 6B –with Great Savings comes Great Responsibility.
2. Carefully control water source tests or pump exercise schedules.
3. Check power meter clocks at least annually and provide a small time buffer in your run schedules.
4. Study the Rate Tariffs REGULARLY! They change without notice.
5. Understand the fine print in the tariffs regarding the "Daylight Savings Time" Challenge! This requires several more schedule changes than you think because RMP still programs their meters using the OLD Daylight Savings Time annual schedules. A mistake here can be costly. The current wording is as follows: "Due to the expansions of Daylight Saving Time (DST) as adopted under Section 10 of the U.S. Energy Policy Act of 2005 the time periods shown herein (Off-Peak) will begin and end one hour later for the period between the second Sunday in March and the first Sunday in April, and for the period between the last Sunday in October and the first Sunday in November."

D. Larger User Implications. The Off-Peak rate for rate 6 and the rates 8 and 9 look similar, but the following needs to be remembered: ➊Ⓟ

1. The Off-Peak periods for the number 6 rates (6A and 6B) can never go more than 8 hours per day.
2. The Off-Peak periods for the 8 and 9 rates go to 16 hours per day in the summer.
3. Many pumping systems may need to go partially ON-PEAK in the peak months to meet the daily and monthly demands of the system when the limitation is only 8 hours per day.
4. If you have the ability to use 1 MW – you may want to consider a forced change to Rate 8 (pay a large power penalty at first) to enjoy the benefits of a longer off peak summer period (study carefully). This trick would need to be done at least once annually, preferably in the winter months before May.
5. The extended off peak period makes the savings for rate 8 and 9 larger than may appear, since the Off-Peak periods will likely be maintained in the peak months.

E. A Conservation - Savings Management Example (The greater the effort – the greater benefit): ➊

1. **Easy** – If you have low LF, (<50%) move to rate 6A.
2. **Moderate** – Stay on rate 6 and Increase your LF or pumping efficiency by:
   a. Managing your control scheme better (SCADA)
   b. Installing VFD's on pumping systems (RMP may help pay!)

3. **Harder** – Move your rate to 6A and shed your energy loads to Off-Peak periods.

4. **Hardest** – If you are a large user –Move to rate 8 or 9 and go Off-Peak as much as is possible. Use high pump loads Off-Peak and reduce loads On-Peak with large Load Factors. Investigate ASR or Energy Recovery. ❸ 🛠 🔒 💰

F. The Energy Rate and Load Factor Dynamic. Using current RMP rates, the following should be noted: ❶

1. Rate 6A is more economical for a low Load Factor (<40%).
2. Rate 6 or 6B is more economical for a higher Load Factor (>40%).
3. *However*, the savings for rate 6 beyond 40% load factor is not as great as the savings for 6A below 40%. If in doubt – you are safer to error using 6A.

G. Estimated utility energy reads (where a power utility cannot read a meter due to access or weather conditions) can kill any off peak pumping strategy. They do not account well for uses at differing periods of the day. They also can have an impact on high load factor strategies. If this becomes common, particularly in the winter months, see if a continuous remote read system is available from the utility. It may cost a little more a month but the savings can be much more significant. ❶ Ⓟ

XIII. Common Engineering and Design Efficiency Goals

These ideas are in essence a generalized summary of all of the above – directed more fully to the engineering and professional science fields. Most all of the above concepts, at least the more complex ones, can be a derivative of the real goals and objectives and strategies listed below. ❸ 🛠

A. Ensure that all new water storage and pumping facilities are designed and sized with off-peak pumping demands in mind.
B. Remember a high or gradually climbing system peaking factor (usually over 2.0) can be an indication of one or more inherent inefficiencies of the system.
C. Study potential ASR programs (Aquifer Storage and Recovery), including possibly other similar groundwater programs to reduce the peak pumping and treatment load on the company facilities in the summer months.
D. Study other possible major surface water storage projects to reduce the peak capacity impacts of secondary systems if applicable.
E. Study where hydro-electric energy recovery may be implemented at large pressure reduction locations or other storage locations. Situate key PRV's near power infrastructure if possible. Also – locate PRV's in plants or pumping stations if they are adjacent to the same. PRV energy recovery is still in its infancy, and as of late, is still not as feasible on small PRV systems.
F. Investigate the possibility of incorporating wind and/or solar energy systems to facilitate net metering or energy sales opportunities near plants or other facilities.
G. With mature GIS data – computer model the distribution systems to find areas or facilities that may be inefficient of undersized, decreasing possible water losses and pumping demands.
H. Provide workable and dynamic water models to staff and train in the proper use thereof, i.e. simple EPANET systems.
I. Study water sources and pumping facilities to find the actual energy and power costs per acre foot or MG or KG. The company can then develop a strategy to pump water from more

efficient pumping systems and also shut down or mothball facilities that are inefficient or redundant.

J. Assist in the possible water right modifications to best facilitate the pumping prioritization strategies derived from above.

K. Make the SCADA system smarter. Monitor areas for real-time water losses and pressure changes. Look at supply AND demand numbers.

L. Model the system to test for efficiencies in pumping, distribution, and storage systems.

M. Automate meter reading and billing systems, upgrade meters if needed.

N. Choose the correct power rates for each service and design the facility for such.

O. Enlarge water storage systems if possible (require more of new developers).

P. Pump OFF-PEAK as much as practicable.

Q. Improve the water distribution system where needed.

R. Design pumping plants with more and smaller selectable pumps and motors, or with larger motors on VFD's.

S. Never underestimate the power of "jockey pump(s)". Consider also a Seasonal 2 Stage pumping system with smaller pumps in the winter and larger pumps in the summer.

T. Design the highest efficiency point of a pump curve around immediate pumping needs and have a strategy to modify that with future pump changes or VFD program modifications as future build-out pumping needs warrant. Don't design the best efficiency for a point way out in the future – which in many instances may not even come.

U. Use a VFD rather than a restricting valve or a by-passing strategy – or simply change out the pumps.

V. Increase sizes of transmission lines or loop distribution lines if pumping head is too high on a pumping plant.

W. Avoid VFD's on high pressure pumping systems. Use more and smaller pumps if needed to simulate a VFD system if needed.

X. Cool pumping systems properly and efficiently.

Y. Correct power factor issues on accounts that are penalized with capacitor banks.

Z. Investigate the Industrial Rate 9 feasibility on large projects (i.e. greater than 1 megawatt).

AA. Train and assist in the implementation of a regular water and energy audit program.

BB. Prioritize pumping systems based on efficiencies.

CC. Pump or deliver lower priced water in critical high use areas if possible.

DD. Keep expensive water in the highest zone(s) as much as possible. Prevent it from unnecessarily flowing down into lower zones.

EE. Improve pressure zone control.

FF. Incorporate a mass balance system in key areas if possible (supply less demand) to promptly detect leaks, etc. This could be automated by SCADA in certain areas, especially with newer fixed read customer water meters.

Definitions of Terms Used in this Document

Abbreviation	Definition
A/C	Air Conditioning
AC	Alternating Current
ac-ft	Acre Feet (a volume of water covering an acre of land a foot deep (43,560 cubic feet)
ASR	Aquifer Storage and Recovery
AWWA	American Water Works Association
C	the discharge coefficient used in the Hazen Williams equation of flow (the higher the C value the higher the flow through a pipe)
CNG	Compressed Natural Gas
DC/AC	Direct Current / Alternating Current
DEQ	Department of Environmental Quality
ERC	Equivalent Residential Connection
ET	Evapotranspiration
gal	gallons
GIS	Geographic Information System
gpm	gallons per minute
HGL	Hydraulic Grade Line
HVAC	Heating, Ventilating and Air Conditioning
Hz	Hertz (a measure of the cycles per second -used with electrical equipment)
IR	Infrared
k-gal or KG	1,000 gallons
kw	Kilowatts - the primary unit of Power
kwh	Kilowatt Hours - the primary unit of Energy usage.
KVAR	1,000 VAR's. See VAR below.
KVARHr	The portion of energy usage attributed to reactive energy.
kwh	Kilowatt Hours
LF	Load Factor (the measure of time a facility runs during a billing cycle)
mg or MG	million gallons
mgd	million gallons per day
O & M	Operation and Maintenance
PCV	Pressure Control Valve
PE	Plain End or Professional Engineer
PLC	Programmable Logic Controller
PRV	Pressure Reducing Valve
RMP	Rocky Mountain Power
RVSS	Reduced Voltage Soft Starters
SCADA	Supervisory Control and Data Acquisition (Water system operation automation)
SMART Energy Grid	A method by which energy suppliers can monitor and control energy loads, such as reducing AC loads during the peak periods of the day.
THD	Total Harmonic Distortion
UPS	Uninterruptible Power Source
VAR	Volt-Ampere Reactive, a unit of reactive power in an electrical system. Reactive power exists in an AC circuit when the current and voltage are not in phase.
VFD	Variable Frequency Drive

Conclusion

As can be seen from the above presentation – this is definitely a work in progress. It was written in more of an outline format to help generate better thought and ideas for energy assessments and audits that may be performed on your system(s). It is not a source of all answers, there is a very long and arduous path to continue to explore and pursue. In my opinion - the water utility industry as a whole has been seriously lacking in a worthwhile quest for more real energy efficient facilities and operational practices. My hope is that this work presents at least a start to that quest. I would be more than happy to receive any comments or suggestions for improvement, including any recommendations for more energy efficient ideas and projects.

Thank You.

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