Water and Wastewater energy checklist

6 Steps to improve efficiency and save money for Energy Managers

Growing water demand requires better energy efficiency

Water use continues to increase as the global population grows. Clean water is required by people for drinking, cooking, and washing, and by industrial facilities for cleaning and other processes. Wastewater treatment is an essential part of modern life, ensuring sustainability throughout the water usage cycle. This checklist looks at ways to reduce energy use and improve efficiency across the water industry, identifying opportunities and offering energy saving solutions.

The water and wastewater industry requires significant amounts of energy to produce and provide clean water, and to process the subsequent wastewater. It is estimated that between 3.5% to 4% of the world's electrical energy is consumed by the water and wastewater segments.[1)] However, it has been calculated that energy consumption in the water sector could be reduced by 15% by 2040 if the right energy efficiency and energy recovery measures were adopted.[2)]

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Water and wastewater utilities use 4% of the world's energy, which is almost as much as the entire energy demand of Australia[1)]

Utilities in the water and wastewater industry are increasingly looking for ways to improve their energy efficiency. This trend is driven by several things including new sustainability legislation. In the EU, for example, the European Green Deal sets out targets and policies that require businesses to reduce emissions and minimize their energy use, as well as to eliminate water pollution. Pressures on water tariff prices are also a big factor. It is estimated that in most cases water revenues do not cover the cost of production and operation due to high energy costs. The high energy consumption and costs are in large part to mechanical water flow control methods and oversized pumps and motors.

Different processes throughout the water and wastewater cycle consume different amounts of energy, however, the prevalence of these processes varies by region. For example, the amount of wastewater processing varies around the world. As a result, globally, water distribution networks still consume by far the most energy even though wastewater processing uses more energy per cubic meter of throughput.

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On average, energy accounts for 45% of the cost of water production.[3)]

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Connectivity panel installation for ACQ580 variable speed drives / variable frequency drives (VSDs / VFDs).

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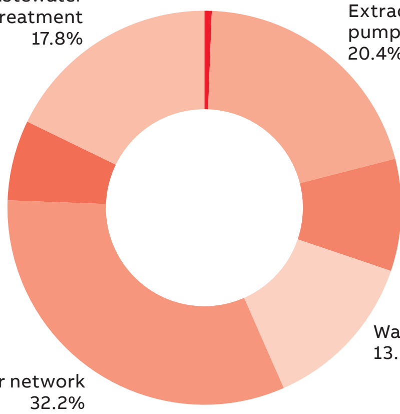
Global water utility energy consumption by process[4)]



A brief overview of energy use
in the industry

Below is an overview of the processes that consume the most energy at each stage of water and wastewater handling.

Clean water
Water treatment facilities pump and process water to make it drinkable. It is estimated that pumping consumes around 80 to 85% of the energy used during water treatment, with centrifugal pumps being the most commonly used type of water application. [4)] The amount of energy needed for treatment varies by location and water source, and on the level of contamination in the water.

The energy required to extract water, transport it to treatment facilities and to subsequently distribute the treated water to customers also varies significantly by location. Water sources and reservoirs can be many miles from the end customers. In some cases, like the South-North Water Transfer Project in China and the State Water Project in California, USA, water is transported well over 1000 km. Globally, most consumers are located in towns and cities and, as a result, around 70% of the electricity used for water supply and treatment is used to supply people in urban areas. [5)]

Irrigation
Irrigated agriculture consumes most of the world's fresh water, and it accounts for roughly 70% of total global freshwater withdrawals. [6)] In irrigation, the majority of the energy is consumed by the pumps used to pump ground or surface water. Both electric and diesel pumps are used around the world for irrigation applications.

Wastewater
Wastewater treatment involves a number of energy intensive processes. In advanced wastewater treatment systems, which provide the most comprehensive water cleaning, the wastewater goes through three stages of treatment: Primary treatment to remove solids, Secondary treatment to remove dissolved organic matter and Tertiary treatment to remove nutrients like nitrogen and phosphorous as well as any remaining suspended solids.

Typically, about 50% of the energy used for wastewater treatment is consumed during secondary treatment. [7)] One of the most energy intensive process in this stage is aeration during the biological processing. Pumps also consume a significant amount of energy, and these are used for wastewater collection and other processes throughout the plant. Together, aeration and wastewater pumping can account for more than 60% of the energy consumed by a wastewater plant. [8)]

Sludge treatment
Due to its high solid content, pumping sludge uses a significant amount of energy, and processes like drying and thickening using centrifuges are the most energy intensive.

Desalination
Desalination is one of the most energy intensive areas of the water and wastewater industry. Although it produces less than 1% of the world's fresh water, it accounts for around 5% of the water sector's electricity use. [9)]

Pumping processes use the most energy during desalination, for example, raising sea water to the level of the facility, high-pressure desalting with semi-permeable membranes and high-pressure pumping for reverse osmosis. The energy required to run high-pressure pumps accounts for approximately 25 to 40% of the overall cost of desalinated water. [10)]

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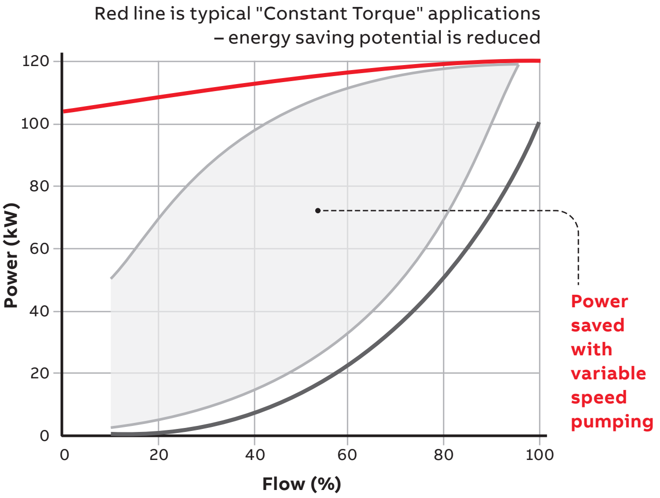
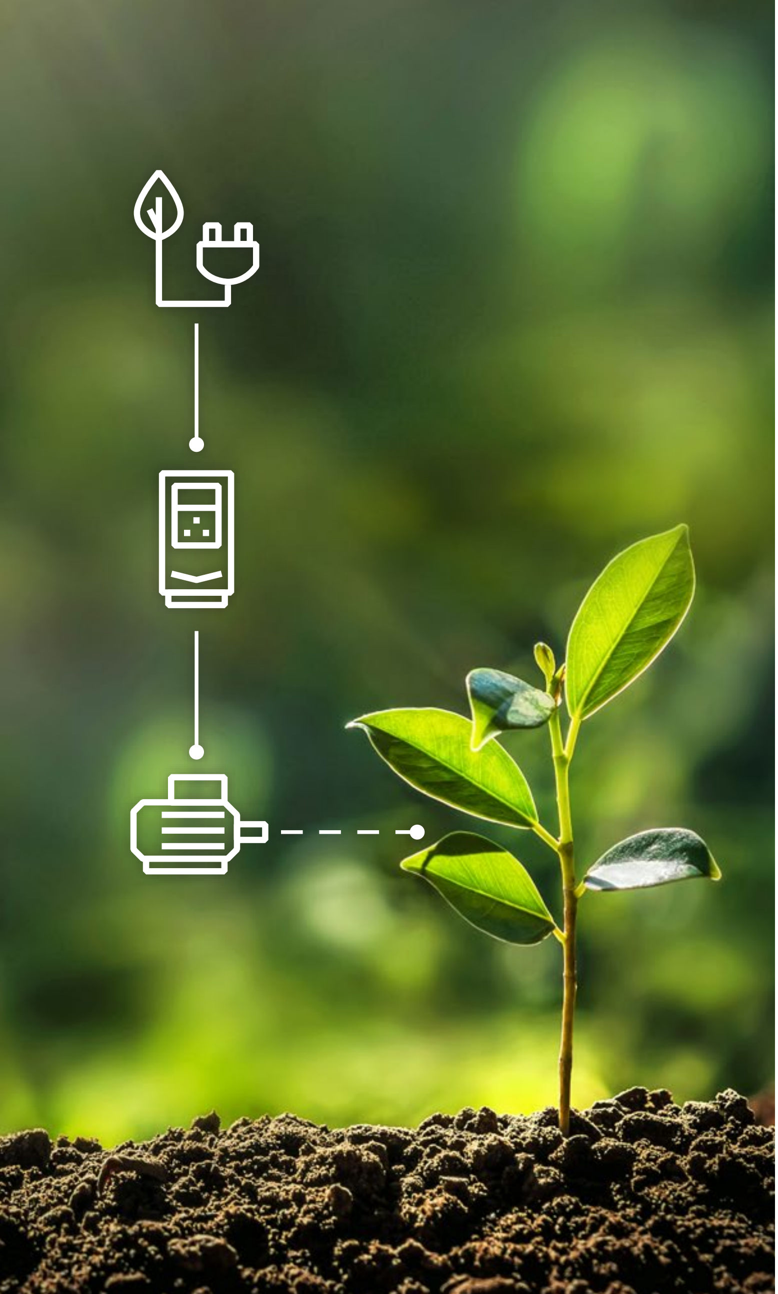
If the flow can be reduced by 20% then by using a VSD/VFD controlled motor, the power drawn by will be only 51% of its nominal power. [11)]



Three different perspectives

Purchasing decisions aren't always just made by one person. Within the ABB 6-step plan, each stakeholder in the decision-making is considered and their goals met, as well as saving energy.

"Utility managers are concerned with how much of their operating budget is associated with electricity, which is normally 25 to 40%."



Energy efficiency

"We need to cut our energy bill and carbon footprint."

Energy Manager

Know where to look…
In every stage of water and wastewater treatment process, there are opportunities for improvement while also saving large amounts of energy at the same time. This checklist will help to identify the areas with the quickest payback in your water processes.

… and how to unlock the saving potential…

Pumps and aerators are the largest water and wastewater energy consumers. Practices of pump oversizing due to reasons such as catchment area characteristics and life horizon consideration offer opportunities for savings. Reviews of overall electrical system efficiency (comprising transformers, variable speed/frequency drives (VSDs/VFDs), motors and load) can be made and design improvements considered.

… by unlocking the hidden story using this checklist

- Provide credible, impartial analysis of current plant performance, and potential savings for motor-driven applications.
- Financial controllers need to have the facts at their fingertips – without getting bogged down in the technical jargon. Savings are presented using the context of payback vs investment.
- The magnitude of energy savings available depends on the type of treatment and delivery system in use, the age and condition of the equipment in use, and the capital available to implement major changes, if necessary.

Productivity and resilience

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"We must avoid supply interruptions and deliver high customer outcomes."

Production Manager

Build in resilience…
Water and wastewater plants need to run without interruption and in the most efficient and environmentally conscious way. Ensuring the reliability of plant assets is the best way to reduce supply interruptions, lower environmental impact and keep your business efficient and effective.

… with flexible motor-driven solutions

Using an ultra-low harmonic (ULH) drive will not intensify harmonics in the power network. Instead, it reduces the losses in the mains supply, improves the mains quality and reduces the risk of disturbance of other equipment connected to the mains. Using ULH drives in combination with generators will reduce the generator size required, compared to a similar standard drive.

A variety of flow rate conditions need to be achieved for most design codes. As a result, most pumps are selected to meet peak conditions but also with redundancy to be able to cope with emergencies or unforeseen peak flows. This often results in oversized pumps and motors that lack efficiency in day-to-day operation.

Pump efficiency management considers current operating conditions and startup low flows which determine the power consumption of the pumping system (motor, drive and pump) across the range of pumping rates. From current flow up to design flow you can achieve best efficiency point (BEP) pumping through VSD/VFD control.

Operation and maintenance

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"Uptime is our number one priority."

Maintenance Manager

Lower operational overheads…
Wastewater pumps suffer a higher wear rate because of grit, rags, debris, and other solids. Managing these issues saves energy by avoiding pumping against partial blockages.

… by utilizing smart functionality

Temperature, load, under/overvoltage protection and warning features help anticipate breakdowns.

A real-time clock allows timed tracing of faults, so you know what happened and when.

ABB Ability™ Condition Monitoring services support remote pumping stations by delivering accurate, real-time information about drives and motors, ensuring equipment is available, reliable, and maintainable.

Blockage protection / pump cleaning function keeps the pump's impeller clean by running a sequence of ramps between minimum and maximum pump speed, depending on configurable triggers. This feature avoids the high costs associated with removing the pumps to manually clean and the health and safety implications of the lifting operations.

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ACQ580 water and wastewater industry drives

Finding energy saving opportunities every step of the way in water treatment

In every stage of water treatment there are opportunities to improve processes while also saving large amounts of energy. Identify the areas with quickest payback in your clean/potable water process.

1 RIVER WATER PUMPING/ABSTRACTION

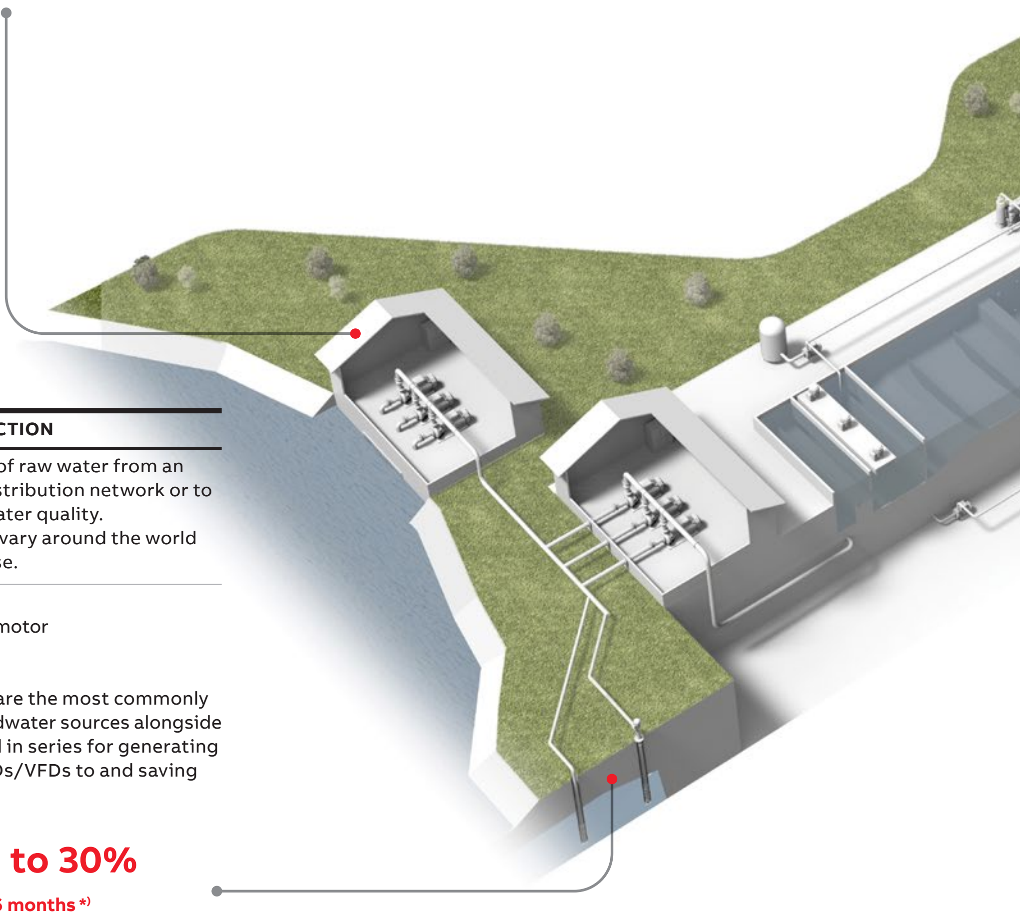
River water extraction involves extraction of raw water from the source and conveying it to a distribution network or to a treatment facility, depending on the raw water quality.
Raw water sources include lakes, reservoirs and rivers.

Applications:
- Centrifugal and submersible pumps

Energy saving opportunities:
From lakes, reservoirs and rivers, the choice of pump depends on pump location and height that is needed to be lifted. Close-coupled end-suction pumps are a typical solution for everyday pumping applications controlling their speed via a VSD/VFD, replacing valve control and saving energy. Horizontal split case is suitable for higher flow rate applications at low pressure, and it's not uncommon to find pumps installed from the 1960s still in operation. With typical minimum speed: 20-25 Hz opportunities for energy saving with VSDs/VFDs is a high.

Potential savings: Up to 30%

Potential payback period: 6-36 months *)



2 GROUNDWATER OR WELL PUMPING/EXTRACTION

Groundwater extraction involves extraction of raw water from an underground source and conveying it to a distribution network or to a treatment facility, depending on the raw water quality.
The depths of the underground aquifers can vary around the world and, as they get depleted, the depths increase.

Applications:
- Multi-stage pump with special submersible motor

Energy saving opportunities:
Borehole/well or the vertical turbine pumps are the most commonly used pumps for extracting water from groundwater sources alongside vertical multi-stage pumps. Often connected in series for generating high pressure and are suitable for fitting VSDs/VFDs to and saving energy.

Potential savings: Up to 30%

Potential payback period: 12-36 months *)

3 **MAINS PUMPING STATION**

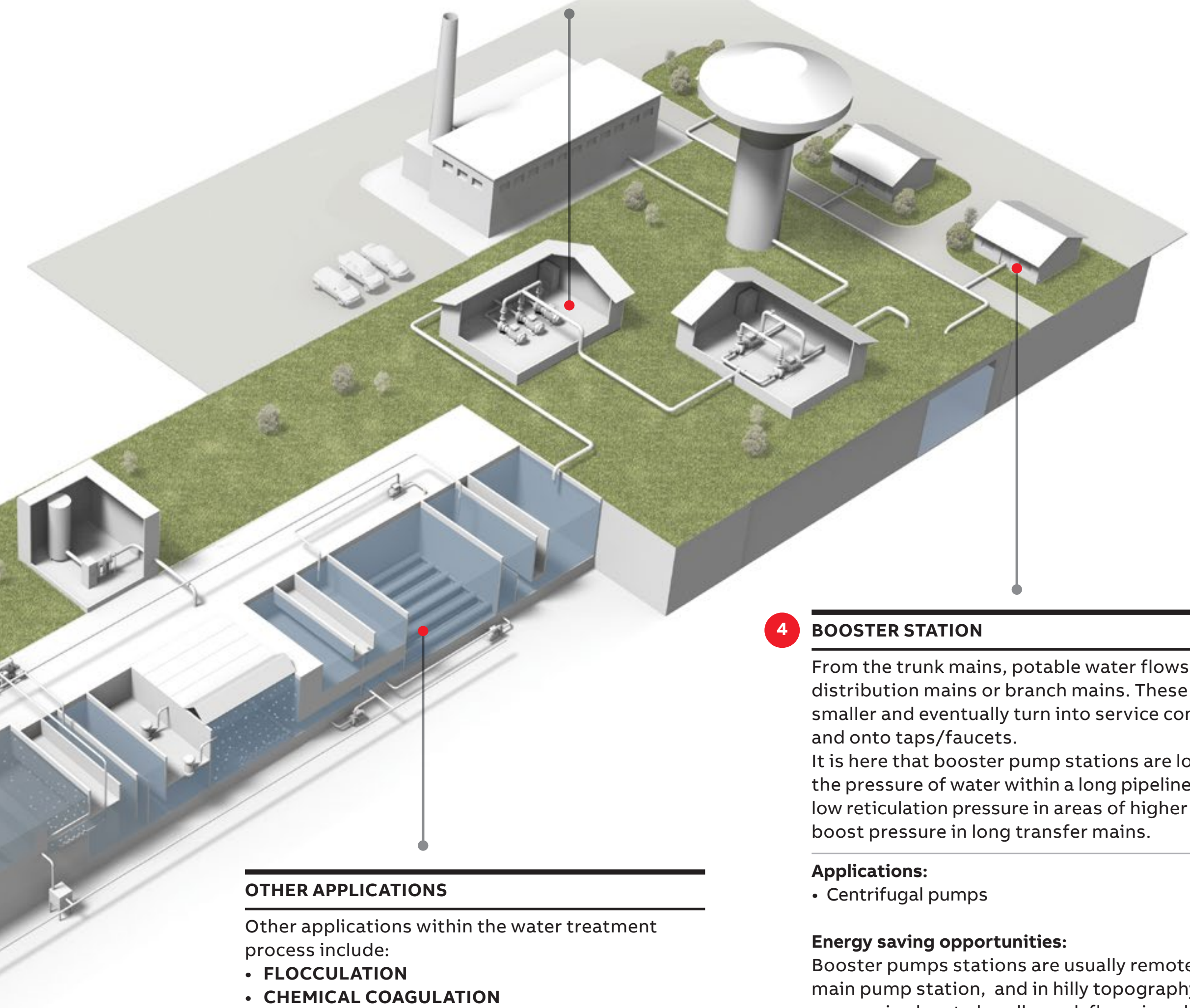
After the raw water is processed through the treatment facility, the now potable water moves into distribution systems which consists of a network of pipes, canals, and sometimes even aqueducts. When gravity flow is impractical, pump stations are needed. Large mains pumping stations are usually custom made and typically have split case pumps to move high volumes of water through large diameter pipes (or trunk mains).

Applications:
- Centrifugal pumps and vertical turbine pumps

Energy saving opportunities:
Typically, horizontal split case centrifugal pumps (which are single-stage centrifugal pumps) are suitable for higher flow rate applications at low pressure, offering large energy saving potentials.

Potential savings: Up to 50%

Potential payback period: 6-24 months *)



4 **BOOSTER STATION**

From the trunk mains, potable water flows into smaller pipes called distribution mains or branch mains. These become progressively smaller and eventually turn into service connections outside homes and onto taps/faucets.
It is here that booster pump stations are located, designed to boost the pressure of water within a long pipeline. Typically, they would boost low reticulation pressure in areas of higher elevation but can also boost pressure in long transfer mains.

Applications:
- Centrifugal pumps

Energy saving opportunities:
Booster pumps stations are usually remotely located away from the main pump station, and in hilly topography where high-pressure zones are required, or to handle peak flows in a distribution system that otherwise handles normal flow requirements.

Potential savings: Up to 45%

Potential payback period: 6-18 months *)

OTHER APPLICATIONS

Other applications within the water treatment process include:
- FLOCCULATION
- CHEMICAL COAGULATION
- DISINFECTION
- SEDIMENTATION
- FILTRATION

These applications have energy saving opportunities but due to power sizes haven't been addressed in the plan but still benefit from the application VSDs/VFDs for improved process control.

Best practice would promote pumping at rates to meet water demand (rate of change), avoiding peak power periods where possible (refill storage tanks only when necessary), ensuring all storage tanks are full prior to peak demand periods by monitoring on/off levels.

*) Typical paybacks based on case study measurements available from ABB.

Finding energy saving opportunities every step of the way in wastewater treatment

In every stage of wastewater treatment there are opportunities to improve processes while also saving large amounts of energy. Identify the areas with quickest payback in your wastewater process.

1 WET WELL / LIFT STATION

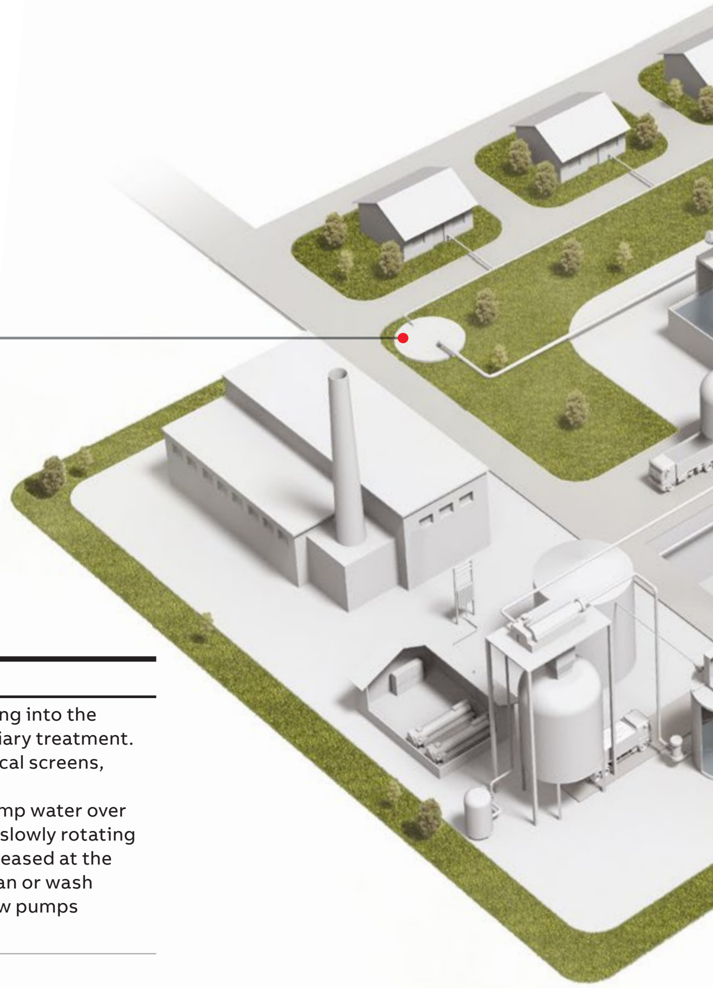
Wet Wells (sewer pumping stations / lift stations) are used to move wastewater to higher elevations in order to allow further transport to the wastewater works via gravity flow. Sewage feeds into, and is sometimes stored in, a sealed underground pit/well.
Level instrumentation determines when a pump is started to lift the sewage upward through a pressurized pipe system (force main or rising main).

Applications:
- Submersible, dry well or suspended pumps

Energy saving opportunities:
While prioritizing reliability above energy efficiency was past practice, the increasing distances between catchments and treatment works and high energy costs presents saving opportunities. Over-sizing is a common practice in the design cycle, the use of ABB VSDs/VFDs can reduce energy costs significantly.

Potential savings: **Up to 53%**

Potential payback period: 6-36 months *)



2 HEADWORKS

The headworks are where wastewater enters the treatment plant prior to moving into the preliminary treatment, primary treatment, secondary treatment, and then tertiary treatment. Equipment in the headworks may include pumps, Archimedes screws, mechanical screens, screening compactors, grit removal systems, and grit washing systems.
Archimedes screws are suitable for any application where there is a need to pump water over a short distance. The principle is an inclined tube, fitted with flights or blades, slowly rotating inside a trough. Water at the base is carried by the blades up the trough and released at the highest point of the pump. Wash water is a term used for any water used to clean or wash equipment on a wastewater plant. Washing equipment such as screens or screw pumps requires a lot of water and often is cleaned by pre-pressurized wash water.

Applications:
- Pumps
- Archimedes screws

Energy saving opportunities:
Wash water pumps system and Archimedes pumps are potentially the largest energy users with a high potential for energy saving. This can be realized by fitting an ABB VSD/VFD to optimize for idle periods and better pressure control for the wash water equipment.
Although the efficiency of the Archimedes screw is often high, the determination of flow control versus sump well depth can lead to further energy savings.

Potential savings: **Wash-water up to 50%**
Archimedes screw up to 25%

Potential payback period: 6-36 months *)

3 AERATION

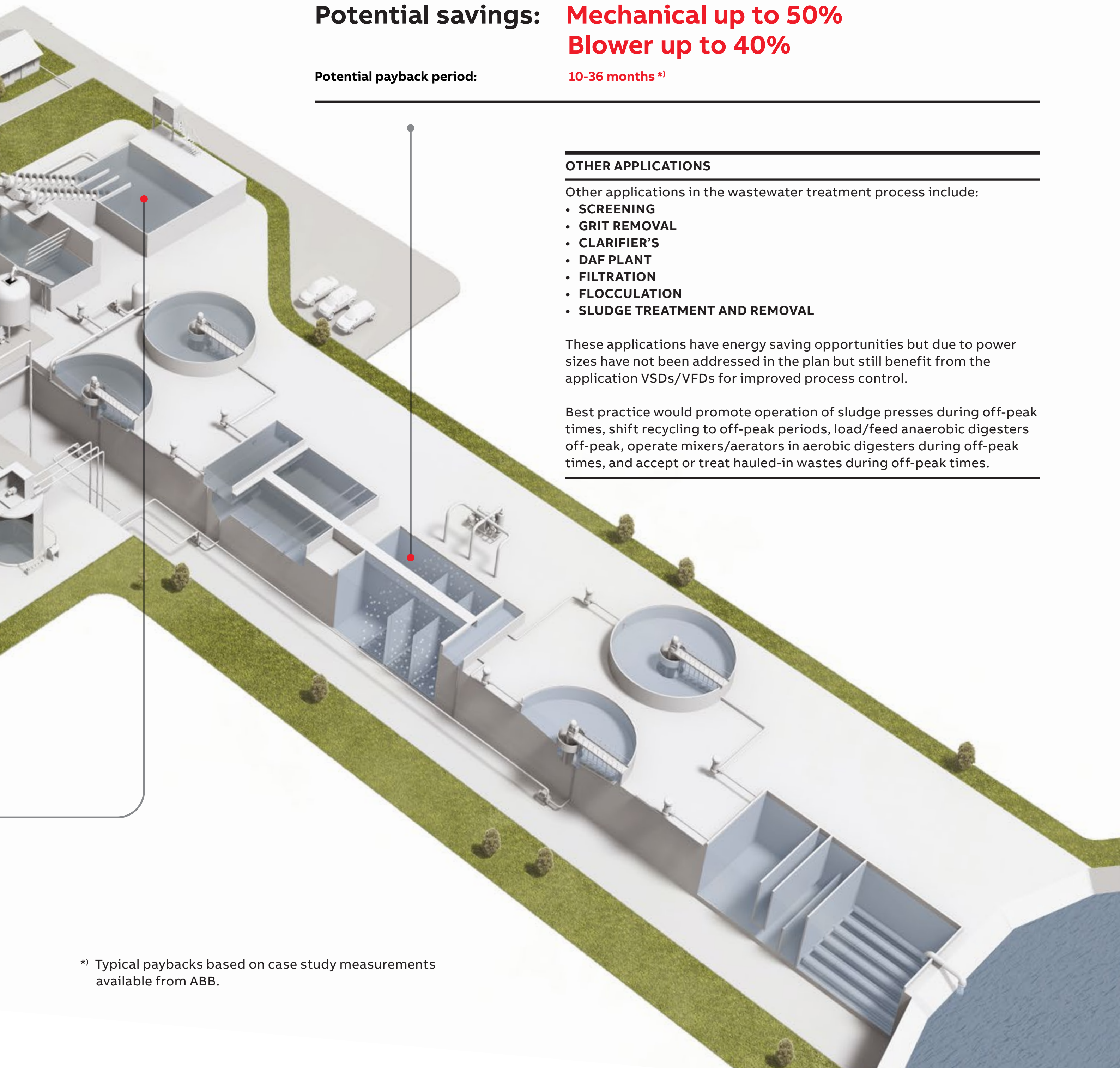
Aeration is the process of adding air into wastewater to allow aerobic bio-degradation of the pollutant components. Loading of the treatment plant varies continuously and uncontrollably due to population activity, seasonal rains, industrial loads etc. These variations and their time scales vary from hours to months, making it a challenge to optimize, so a common approach in the past was to oversize equipment.
There are several approaches to aeration and energy requirement varies considerably for each approach. Activated sludge uses the most amount of energy but treats more gallons/liters per kWh compared to aerated lagoons. Oxidation ditches favor areas with larger land and less flow, but in all cases, aeration is a major energy consumer.
Aeration approaches depend on many factors, including the age and size of the plant. The water-into-air method produces small drops of water that fall through the air, and the air-into-water method creates small bubbles of air that are injected into the water stream.

Applications:
- Blowers, fans
- Surface aerator mixers

Energy saving opportunities:
Removing dampers and restrictions and controlling motor speed with an ABB VSD/VFD can significantly reduce energy usage. Further control via dissolved oxygen and ammonia levels can improve overall efficiency.

Potential savings: **Mechanical up to 50%**
Blower up to 40%

Potential payback period: **10-36 months *)**



OTHER APPLICATIONS

Other applications in the wastewater treatment process include:
- **SCREENING**
- **GRIT REMOVAL**
- **CLARIFIER'S**
- **DAF PLANT**
- **FILTRATION**
- **FLOCCULATION**
- **SLUDGE TREATMENT AND REMOVAL**

These applications have energy saving opportunities but due to power sizes have not been addressed in the plan but still benefit from the application VSDs/VFDs for improved process control.

Best practice would promote operation of sludge presses during off-peak times, shift recycling to off-peak periods, load/feed anaerobic digesters off-peak, operate mixers/aerators in aerobic digesters during off-peak times, and accept or treat hauled-in wastes during off-peak times.

*) Typical paybacks based on case study measurements available from ABB.

The 6-step checklist

1

Develop a baseline

Gather readily available energy use information to provide a baseline against for future comparison.

2

Understand the savings

Review best practices and understand how speed control of centrifugal pumps and blowers can offer large energy saving potential.

3

Identify and assess your plant

Identify your focus pumping and aeration systems as motor driven loads within these offer the greatest scope for saving significant amounts of energy.

4

Implementation

List and define each of the opportunities, objectives, and expectations, plan the implementations and pass to engineering team to deliver.

5

Track and report progress

A successful project is measured by tracking performance against objectives.

6

Continually update the plan

Learn where there have been successes or failures so future adjustments can be made and monitor the KPI and process performance indices to look for additional improvements.

1. DEVELOP A BASELINE

Collect the data needed to provide an energy baseline.

- The data needs to be available and easy to collect from existing meters etc., and should be time/date stamped.
- Data may include the facility/plant production data and corresponding energy use and demand trends. Production data may include millions of gallons per day (MGD) of biochemical oxygen demand (BOD) treated.
- Interview supervisory, operations, and maintenance staff to verify understanding of energy use, stakeholder suggestions and feedback on approaching energy saving, as well as potential roadblocks and limitations.
- It's important to verify that the recorded equipment and asset lists are accurate. Walk through your facilities and process flows to check size, capacity, and operating status for major assets.

2. UNDERSTAND THE SAVINGS

Pumping systems and blowers used throughout the water and wastewater process offer significant opportunities for saving energy.

- It's estimated that upgrading to new pumping technology can lead to energy savings of 3 to 7%. Using VSDs/VFDs with high-efficiency motors can result in around 25 to 30% energy savings.
- Upgrading existing IE3, IE2 or even IE1 efficiency motors to IE4 and synchronous reluctance motors, like ABB's SynRM IE5 and Baldor Permanent Magnet NEMA motors, lowers losses and improves overall efficiency.
- Review best practices such as energy monitoring techniques, power cycling non-essential equipment, maintenance, standards etc.
- Understand the basic theories of saving energy using ABB VSDs/VFDs.

3. IDENTIFY AND ASSESS YOUR PLANT

Each energy saving opportunity must succeed as a stand-alone project, alongside the whole processes specific needs.

- Create your team's facility assessment plan, including system walk through and focus application identification.
- Using this checklist, you will be able to focus on the highest value applications for return on investment.
- If the expertise to analyze the opportunities does not exist in-house, ABB experts will help you recommend a list of priorities and an implementation plan.
- An energy efficiency opportunity can be any system change (equipment or operations) reducing energy consumption or power demand.

4. IMPLEMENTATION

This step ensures that the energy plan involves and includes all stakeholders, and the execution effectively returns the expected returns.

- Key actions include creating schedules and timelines, project budget planning, task management and analysis of results versus expectations.
- The implementation plan also will illustrate how existing processes, potential shutdowns or other changes in processes or schedules interact with the overall plan to give early warning of risks to core plan activities.
- Tracking and reporting must form part of the plan to ensure that results and progress are measured once each element of the overall plan is installed and becomes operational.
- Ultimately, any part of the project that is implemented and operational must show expected returns and impact on the facility's overall energy performance, aligned with identified and designated Key Performance Indicators (KPIs).

5. TRACK AND REPORT PROGRESS

Ensuring projects progress to completion and provide feedback is key.

- Success should begin to be measured upon installation, focusing on the previously identified KPIs and performance metrics, including installation statuses, impacts on facility energy use, operations and productivity impacts, process performance, and employee engagement.
- It's critical to share performance and monitoring results with all stakeholders, including anyone who has had involvement in the energy plan, operations and maintenance staff who will run and maintain the systems, and other management functions within the organization.
- Make sure you don't overlook the track and report step. It's critical to the success and sustainability of the energy program, allowing you to gain in-depth insights into ways of improving the plan, guidance for future plans and adjustments, as well as providing motivation to staff to help achieve the goals.

6. CONTINUALLY UPDATE THE PLAN

Opportunity to improve does not always end with a successful project implementation.

- As the plan progresses towards your goals, lessons will naturally be learned from successes and failures along the way. The team will want to take these lessons and apply them in reordered priorities, changes to parts of the plan, new application opportunities and much more. This becomes a lesson in itself for continual improvement of the plan, by agile reaction, identifying more opportunities, better workflows and adjusting to new economic and legislatory demands.
- This step serves as a reminder to all the stakeholders that energy management and energy saving plans are not one-time projects. They should be part of a continuous business process that seamlessly integrates into the utility/firm's business practices to provide ongoing efficiencies and savings.

The 6-step checklist

Use this checklist to ensure that your plant operates at its optimum level

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There are several technologies available that can help water and wastewater plants improve their energy efficiency.
The most notable of which are VSDs/VFDs and upgrading motors to more efficient models.

Step 1 – Develop a baseline		Check ✓
Planning		
Reduction goal	• Define the timescales that you intend to achieve your goals in and the type of goal for your organization (energy, cost, CO_2).	☐
Establish organizational commitment	• A successful energy strategy should involve collaboration from the whole organization to meet the goals of the project. • Involve and gain buy-in from all levels of your organization for your energy management initiatives and goals.	☐
Energy Assessment Team	• Assemble a team of key stakeholders for your 6-Step plan, the 'Energy Team'. • Include as many as possible who have a stake in energy cost and management, including but not only leadership, management, administrative, engineering, operations, and maintenance.	☐
Baseline data	• Determine the Energy Performance Indicator (EPI) data to be used to create your baseline, including current energy usage measurements and production data such as millions of gallons/liters per day (MGD) per kWh or kWh per 1000 kg (2204 lbs) of biochemical oxygen demand (BOD) treated.	☐
Create a model for the data	• A simple data model can consist of plots of energy costs over time (i.e., total kWh by day or month) versus flow and/or treatment rates, and a more complex model could include all of facility's major energy using processes and power data. • Plotting average data over a period allows for seasonal variations and enables easier Key Performance Indicator (KPI) target definitions.	☐
Consider process changes	• Ensure you have a way of measuring the impact of new equipment or process changes throughout the measurement period as these could affect your baseline measurements.	☐
Verify your equipment lists	• Verify the accuracy of your equipment lists by walking through your facilities to check each asset by size and capacity, operating and process status, and sizes of motors applied to major systems.	☐

Step 2 – Understand the savings		Check ✓
Review best practices		
Real time energy monitoring	• Understand usage peak versus off-peak energy periods so tanks can be filled off-peak, digester load/feeds or backwash cycles can be carried out at lower cost off-peak tariffs.	☐
Power off non-essential equipment	• If a process is intermittent or not essential, leaving equipment powered off or cycling off may offer instant savings.	☐
Maintenance	• Poorly maintained motors and equipment may be operating inefficiently and will benefit from preventative maintenance plans. • Consider installing new high efficiency motors in place of rewinding when motors fail.	☐
Correctly size motors	• When installing new, or retrofitting, correctly sizing and using high efficiency motors has an instant impact on energy costs.	☐
Flexible system design	• Flexible system design allows you to adjust and operate more energy efficiently during peak loads (such as tourist season) as well as during the “off-season.” • In many areas, tourism-related loads can be as much as ten times larger than off-season loads. These variable conditions may require idling treatment units during the off-season.	☐
Automate processes	• Using automation allows for better control of processes, for example Dissolved Oxygen (DO), Pressure and Flow, which in turn can help save energy by controlling to real time demands. • Applying VSDs/VFDs with process control feedback capabilities is a low-cost method of giving improved control with energy saving paybacks.	☐
Identify the focus facilities and applications	• Using the guidance on pages 6-9, list the key facilities where energy saving opportunities are at their greatest. • Create a project plan to follow for the next step; identifying and assessing each facility and application.	☐
Standardize	• Standardizing on VSD/VFD/motor supplier allows you to benchmark and repeat savings based on standard sets of metrics, such as matched pairing of equipment.	☐
Understanding the theory of VSD/VFD energy saving		
Cube/pump affinity law and energy saving from speed reduction	• Understand the relationship between a pump/fan/blower speed and their energy requirement - This is known as the cube/pump affinity law because the need for power and energy reduces with the cube of the speed. • The law can be used to calculate the energy consumption and energy savings potential of related applications. • For example, water and wastewater applications most commonly require flow control. If the flow is reduced by 20% using a VSD/VFD controlled motor, the power drawn by will be only 51% of its nominal power. Remember, you cannot reduce flow without reducing pressure, and that will limit the savings, check with your ABB engineer.	☐
Motor sizing	• Many motors are larger than necessary for average loading conditions, thereby wasting energy when a smaller motor could be used. • Oversized motors can also result in a lower power factor that can affect your utility billing and power quality. • Motors oversized by more than 50% should be replaced with correctly sized, high-efficiency or premium-efficiency motors. It is not always possible to change to a smaller size motor in many pumps due to flange size and shaft diameter, etc. But you can change to a higher efficiency motor at the same physical size.	☐
The effects of valves and throttling vanes	• Look for scenarios where pump flow is moderated with a valve, or where excessive air flow from a fan/blower is controlled with vanes. • By forcing the flow through a constriction, energy is wasted through friction. • In some installations, particularly where throttling is used to control flow, savings of up to 50% are possible.	☐
Use VSD/VFD speed reduction in place of restrictions	• VSDs/VFDs apply to most processes in water and wastewater systems where loading conditions fluctuate. • They can replace throttling valves on discharge piping, control the pumping rate of a process pump, control pressure in distribution/force mains, control airflow rates from blowers, and control the speed of oxidation ditch drives and many more applications.	☐
What are the savings?	• Savings vary with application and technology, many VSD/VFD retrofits can result in savings from 15% up to 53%.	☐
Look for legacy VSD/VFD installations	• Aging VSD/VFD technologies are less efficient and often require more cooling than modern solutions, it's important to identify where overall system efficiency gains can be made by replacing lower efficiency solutions (such as legacy 18-pulse drive systems).	☐
Engage your ABB VSD/VFD energy experts	• Take advantage of ABB's energy experts to explain and train your team on the physics of energy saving.	☐

Step 3 – Identify and assess your plant		Check ✓
Planning		
Create your team's facility assessment plan	• Project manage the delegated members from your energy assessment team to visit each facility and carry out the assessments.	☐
Engage your ABB VSD/VFD energy experts	• Engage your ABB VSD/VFD energy experts and their partners to leverage VSD/VFD and motor experience within the water/wastewater industry.	☐
System walk through	• Using the previously identified asset lists, revisit at each facility to further verify the accuracy of size/capacity data, operating status and motor sizes. • Note any additional applications/pumps/blowers that were not noted in your master lists.	☐
Identify focus applications	• Review the reference information provided on the following pages. • Clean water: - Lake and River water pumping/abstraction, Borehole/well Pumping, Mains Pumping Stations, Booster Stations. • Wastewater: - Wet Wells/Lift Stations, Headworks, Aeration.	☐
The assessment process		
Data collection	• For each application, note all the details including but not limited to: - Motor kW/Hp rating, and all available nameplate data. - Motor control and starting method - Valve/throttle vane position (% open or closed) - Available meters/displays reading motor running current (make sure to note the operating conditions – high flow, low flow, etc.?). - Run-time meters to see how pumps cycle on/off when staged, etc. - Logbooks or maintenance schedules showing down time or unplanned maintenance, etc. - Fan and pump curve data, head, operating points, etc., - SCADA or operator interface flow/pressure/kW traces etc. - Weather station data • Tip: back up notes and documentation with photos for later reference. • ABB experts can supply templates and guides to data collection.	☐
Data analysis	• ABB provides software tools that help you analyze data, record energy consumption and calculate potential energy savings with payback estimates – guided by one of our application experts. • Local utilities often offer guidance and tools to supplement the ABB software and can often build in additional rebates and incentives.	☐
Report	• ABB's software tools can take the data analysis and generate a customized report for each pump/fan/blower with payback and recommended product information • Local utilities often allow integration of ABB provided data to supplement build in additional rebates and incentives into the investment payback calculations.	☐
Recommendations	• An action plan is prepared, comprising an Executive Summary and a detailed engineer's report, highlighting applications that can benefit the most from using VSDs/VFDs. The figures will be translated into monthly savings, and there will be detailed recommendations for fitting VSDs/VFDs and motors, including costs and payback times. The ABB Energy & Productivity Appraisal report can be used to assist end users in identifying potential energy saving opportunities and satisfy the requirements of local schemes.	☐

Applications to focus on in Clean Water facilities

Lake and river water pumping and Abstraction
River abstraction is a critical to ensuring an adequate and reliable water supply. When in combination with a pump strategy using the latest VSD/VFD technology, you can lower your energy costs and reduce over abstraction pumping.

Pumping from a river to the raw water pumping station often requires overcoming a head. In most cases, the pump was chosen for a specific load point, called the design duty point. This is typically close to the Best Efficiency Point (BEP) of the pump and in most cases, pumps are NOT running at their BEP, but at a lower load.

A throttle valve often sets this lower load, which creates inefficiency and losses, and is where adding a VSD/VFD adds a tremendous advantage to a pumping strategy, since it adapts the speed to the actual need, minimizing the losses.

Groundwater/Well pumping and abstraction
The water level in a borehole/well is not constant over the year, typically at lower levels during the summer compared to autumn/fall and winter months. They often need higher speeds during the summer to overcome the increased static lift (just to get the water out of the borehole/well) and this seasonal change needs to be accounted for in the recording of savings.

Cavitation is a risk in borehole/well pumping, with a vortex being created if the level in the borehole is low, risking turbidity or pump damage. The vortex will go from the water level and down to the inlet of the pump, the pump will be getting a mixture of air and water, and this will lead to cavitation (a vortex will NOT be created if there is sufficient water above the pump inlet). A VSD/VFD can help to avoid this issue as well as saving energy.

Typically, the pumps are multi-stage pumps with special submersible motors. The motors tend to have long, narrow configurations (often being less efficient than a standard IEC/Nema motor) commonly they are two pole motors running at 2800 rpm at 50 Hz and 3400-3500 rpm at 60 Hz. They are suitable for VSDs/VFDs but consideration needs to be taken on long cable runs and insulation classes.

Mains pumping station
Water distribution systems take several forms around the world, from pressurized municipal water supplies that can deliver water directly into homes, to tanker trucks that distribute water to community access points.

These systems differ mainly because of the type of water source used and the topography. A topography suited to a gravity system has potential gains including supply continuity and low energy costs. When gravity flow is impractical, a pump station is required and when there are flow demand changes, the opportunities for fitting VSDs/VFDs for energy saving reasons are bigger.

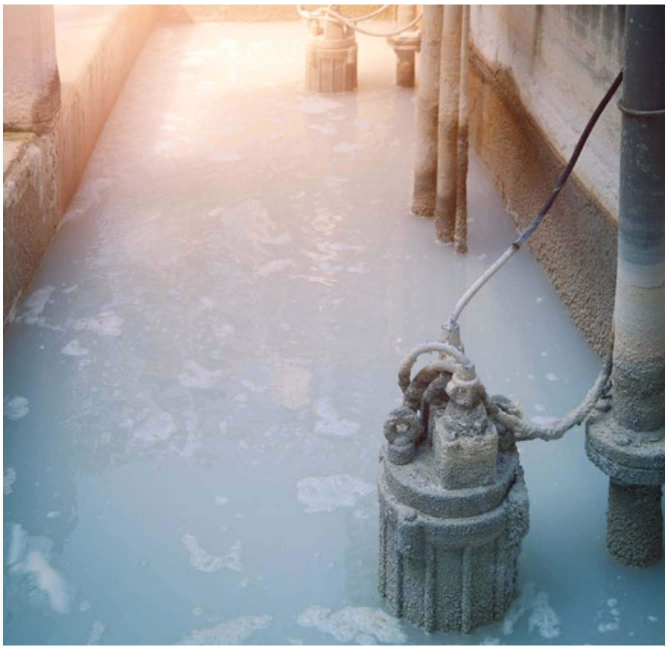
Another case for introduction of VSDs/VFDs is where there are pressure transients in a water network. Sometimes being caused by a valve being opened or shut too fast, a pump inducing suction instantaneously, or a large water user such as an industrial plant opening or shutting it's supply. In these cases, the kinetic energy of the water transfers into strain energy on the network. It sends a shock wave through the system, putting undue and potentially damaging pressure on the assets. Using VSDs/VFDs can, through controlled accelerations and deceleration, reduce this shock and help to calm the network.

Booster Stations
Booster stations are designed to boost the pressure of water within a long pipeline. Typically, they would be used to boost low reticulation pressure in areas of higher elevation but can also be used to boost pressure in long transfer mains. Booster pumping stations should be designed for optimal control of energy but historically energy wasn't at the forefront of decisions in the design stages. The correct control system could schedule pump operations so that station electrical consumption is minimized at the same time adequate storage for fire protection and system pressures is maintained.

The design of pumping equipment and drives can be evaluated regularly using several factors of consideration: frequency of routine maintenance and adjustments, energy savings, proper alignment of pump and motor, as well as support of suction and discharge piping, noises, and vibration checks (noise is minimized by choosing pumps to operate near the point of best efficiency and proper suction conditions).

Other areas for investigation include increased vibration as this affects the life of bearings, stuffing boxes and their effectiveness, and checking mechanical seals. Reducing the number of partially closed valves will not only decrease noise but also radial thrust leading to lowering stresses in shafts and bearings of centrifugal pumps and adding resilience to the system.

Applications to focus on in Wastewater facilities



Wet Wells, sewer pumping stations or lift stations
Wet Wells, also known as sewer pumping stations or lift stations, account for around 14% of a wastewater plant's energy demands.

Wastewater pumping in the past prioritized reliability above energy efficiency to ensure uninterrupted operation, but with increasing distances between catchments and treatment works, combined with the cost of energy, this is slowly changing.

Since catchment characteristics change daily and hourly, and flow estimates can be inaccurate at design stages, pump selection can be difficult, making oversizing of pumps and motors a common practice.

Wastewater pumps also suffer a higher wear rate because of grit, rags, debris, and other solids, so managing these issues saves energy by avoiding pumping against partial blockages and allowing higher efficiency from a less worn pump impeller.

Headworks

A variety of pumps are used to pump wastewater from an influent wet well to the headworks facility. Screw pumps are most common, because of the uncomplicated Archimedes water lift principle. Open or enclosed, they are used for their high capacity and non-clog benefits. They are better at handling larger solids compared to traditional centrifugal pumps.

In most cases, they pump from a sump where there is very little variable capacity, and the rate of discharge is naturally controlled by the fluid level at the screw inlet. Traditionally, speed control was considered unnecessary, but case studies show large energy savings with the application of VSD/VFD control is possible.

Wash water is a term used for any water used to wash any equipment, such as screens or screw pumps etc and requires a large volume of water. Pumps pressurize wash water and send it through filtration processes that remove contaminants. Wash water then returns to the cannon or pressure nozzle, and the cycle continues.

Typically wash water pumps are multistage or booster sets to achieve the high pressure, operated either manually, or by an on-demand system. On-demand systems traditionally monitor and turn on when there is an increased need for more water/pressure however this 'always on' is more energy intensive than applying VSDs/VFDs to constantly control pressure through the wash cycles.

Aeration

The aeration process stage in wastewater treatment accounts for around 53% of a wastewater plant energy demand. Activated sludge uses the most amount of energy but treats more gallons/liters per kWh compared to aerated lagoons. Oxidation ditches favor areas with larger land capacity and less flow, but in all cases, aeration is the major energy consumer.

Variation in loading of the treatment plant is continuous and largely uncontrollable because of changes in population activity, seasonal rains, or industrial loads, etc.

This variation of the process and disturbances combined with varying time scales from hours to months, makes it a challenge to optimize the plant at installation.

A common approach, was to oversize equipment, opening up the benefits of the VFD/VSD as a retrofit solution. Energy saving possibilities with VFDs/VSDs in aeration is up to 70% reduction in energy usage by removing dampers/restrictions and controlling motor speed. Further savings can be achieved through controlling dissolved oxygen levels with in-built process controllers.

Step 4 – Implementation		Check ✓
Targets and timelines	• Review and redefine goals and targets identified in the assessment stage. • Set timelines and reporting stages for implementation to ensure project completion.	☐
Determine roles and resources	• Consult with your key facility management and engineering teams to review the key implementation roles and responsibilities within each function. • Engage and use your ABB contacts expertise in your implementation plan.	☐
Create a communication plan	• Ensure you develop relevant and targeted information for each of the key stakeholders in the plan. • Communicate progress and results regularly. • Create basic graphics and reports to communicate initial findings.	☐
Create the installation plan	• Start with the quick-win no, or low-cost, control or process changes that are easy to implement with minimal engineering effort. • Review the Step 3 recommendations that identify the highest impact applications and/or quickest return on investment opportunities. • Work with your key stakeholders to plan the supply, installation, and commissioning of the identified applications. • ABB can help to identify the correct VSD/VFD and motor for each respective application. • In many instances, ABB and/or their partners can help with the installation and start-up or commissioning of the drive and motor.	☐
Trial and verify	• Often, it's valuable to choose a high value application to trial an installation in order to verify the expected savings to offer evidence to justify the investment in VSDs/VFDs and/or new motors. • Prior to the installation, ensure you have pre-trial energy usage data for the chosen application. • In many instances, ABB and/or their partners can help with the pre and post installation measurements as well as the installation start-up of a trail VSD/VFD. • Post-trial, repeat the measurements using the same operating conditions. • Energy savings = (pre-trial energy use) ± (adjustments) - (post trial energy use).	☐
Calibrate and improve	• As part of the commissioning process, ABB can help you set the correct parameters to ensure that the VSD/VFD or motor is operating at its optimum energy efficiency.	☐
Operations and Maintenance	• ABB provides life cycle services to ensure that the VSD/VFD and/or motor is looked after throughout its working life. • For example, during the operation and maintenance stage, ABB can continually monitor the energy consumed by the motor and compare this with the original specification. • ABB VSDs/VFDs and remote motor/pump sensors can be connected to online software services to monitor equipment and notify if unusual operating conditions are detected.	☐
Productivity impact	• Starting with simple data available, you can gradually increase the complexity as goals, needs and available resources expand. • Using these initial sets of findings, you can expand the scope of data gathering and use the results to justify additional investment.	☐
Further actions	• During an energy appraisal, ABB's engineers may also review existing business operations and technology to identify the scope for improvements in energy efficiency and reduced CO_2 emissions. • Availability of suitable energy loans and grants and specific technologies (depending on local knowledge). • Review of current preventive maintenance schemes, replacing old/obsolete VSD/VFD or motor components as part of a preventive maintenance plan. • Retrofitting existing drives with modern technology.	☐
Upgrades and interventions	• Every time an upgrade, intervention or change is made to a process (new equipment, upgraded technology or maintenance) the time of the change should be recorded in tracked data so it's impact can be determined. • KPIs will help show changes in operations, influent/effluent flows, effects of weather, and even how facility energy usage changes with equipment changes, additions, or upgrades.	☐

Step 5 – Track and report progress		**Check ✓**
Measure Success	• Once you have established key performance metrics, focus on these - as well as the energy measurements you should also review installation, operations and maintenance, treatment process performance, etc. • Tracking will provide historical documentation of project interventions, with patterns and trends becoming evident. • Depicted graphically, they can show dramatic results arising from Energy Team efforts. • Communicate performance measurements regularly to your key stakeholders involved in the planning, implementation, and management of the facility and energy plan.	☐
Perform regular updates	• Tracking and reporting is only effective if the information it records is current and comprehensive. • Data needs to be collected and incorporated into the tracking system at an interval of time effective to your baseline studies. • Perform weekly and monthly updates to your tracking systems.	☐
Conduct periodic reviews	• Periodic reviews of your progress with milestones should be conducted with the management team, the energy team, and your selected groups of employees. • Arrange meeting frequency to match the audience's needs. These reviews must focus on project progress, roadblocks or problems and potential successes.	☐
Identify necessary corrective actions	• Tracking systems are the best way of measuring and determining if an energy saving program is working well. • It helps to identify when specific activities are not meeting performance expectations and are in need of review.	☐
Keys to success	• Use reliable, measurable performance metrics. • Follow up on data analysis, e.g., investigating when data appear irregular or celebrating when success is indicated.	☐

Step 6 – Continually update the plan		**Check ✓**
Review action plan	• Once progress is under way towards achieving your energy management plan goals, lessons can be learned and adjustments made. The energy team may need to react to reordered priorities, changes in procedures and other assignments to ensure that the long-term plan is successful. • Identifying what is working well, and what didn't, so you can build best practices. • Carrying out regular reviews and evaluations of the effectiveness of the plan allows energy managers to: - Measure the effectiveness of implemented projects and programs. - Make informed decisions about future pump, motor and VSD/VFD energy saving projects. - Document additional savings opportunities that have been identified, as well as non-quantifiable benefits that can be leveraged in future.	☐
Feedback is the breakfast of champions	• Solicit feedback and ideas for planned improvements or changes from the energy team or wider implementation and stakeholders. • Gauge awareness of the energy plan by assessing employee and organizational understanding of energy issues. • Identify the critical factors that contributed to either meeting or missing targets. • Quantify the additional benefits of energy management activities, such as reduced operation and maintenance costs, enhanced PR and image, community engagement, and employee's comfort, as well as overall energy cost reduction. • Although the energy plan involves commitment of resources and manpower it also has the advantage of: - Providing employees with the opportunity to engage, contribute and understand energy management. - Allows introduction of new technologies into the water treatment process. - Avoids failures by creating new processes and programs that learn from previous mistakes. - Assesses existing and new tracking tools/systems to better administrate ongoing projects. - Provides financial results along with success stories that illustrate the worth of the energy plan to inside and outside stakeholders.	☐
Continual Improvement	• Continual improvement of the energy plan is a key process, driving identification of new application opportunities, modifying the plan as needed and changing actions based on evolving business needs. • As industry and regulatory needs change, the energy plan should also be a continuous process and not a one-time project. • Since energy projects have large impacts of both system performance and business costs, factors such as economic and regulatory changes need to be factored into future needs. • Also, renewable energy opportunities and new process technologies should be added to future revisions. • The energy plan should ultimately become an integral part of the business needs of the utility.	☐

Education and development

ABB offers a wide range of training from Lunch 'n' Learn sessions to hands on, instructor-led skills development courses. A range of e-learning modules is also available.

Previous knowledge
There are no prerequisites for these training topics. However, it would be helpful if the student had a basic understanding of water industry applications.

Objectives
To alert energy managers of the merits of using VSDs/VFDs to improve process efficiency, reduce energy use and lower carbon dioxide emissions.

Location
The courses can be presented at customer premises or an ABB facility. Online content can be served using online conferencing software.

Booking
To book training, or for more information, contact your local ABB office.

Bespoke training courses
Contact your local ABB office for any training opportunities tailored to your custom needs.

Lunch 'n' Learn topics	Duration	Reference	Check ✓
Drives Basics – Theory	15 mins	EN154	☐
Pumps Basics – Theory	15 mins	EN155	☐
Best Efficiency Point Pumping	20 mins	EN156	☐
Wastewater – Wet Wells – Understanding the application	20 mins	EN157	☐
Wastewater – Headworks – Understanding the application	20 mins	EN158	☐
Wastewater – Aeration – Understanding the application through energy case studies	20 mins	EN159	☐
Clean water – River Abstraction – Understanding the application through energy case studies	20 mins	EN160	☐
Clean water – Groundwater abstraction – Understanding the application through energy case studies	20 mins	EN161	☐
Clean water – Distribution network – Understanding the application through energy case studies	20 mins	EN162	☐
Clean water – Reservoir – Understanding the application through energy case studies	20 mins	EN163	☐

References

1) IEA World Energy Outlook 2018, Page 122,
https://iea.blob.core.windows.net/assets/77ecf96c-5f4b-4d0d-9d93-d81b938217cb/World_Energy_Outlook_2018.pdf

2) Water-Energy Nexus, World Energy Outlook Special Report, 2016, page 6,
https://iea.blob.core.windows.net/assets/e4a7e1a5-b6ed-4f36-911f-b0111e49aab9/WorldEnergyOutlook2016ExcerptWaterEnergyNexus.pdf

3) Water-Energy Nexus, World Energy Outlook Special Report, 2016, page 30,
https://iea.blob.core.windows.net/assets/e4a7e1a5-b6ed-4f36-911f-b0111e49aab9/WorldEnergyOutlook2016ExcerptWaterEnergyNexus.pdf

4) Water-Energy Nexus, World Energy Outlook Special Report, 2016, page 33,
https://iea.blob.core.windows.net/assets/e4a7e1a5-b6ed-4f36-911f-b0111e49aab9/WorldEnergyOutlook2016ExcerptWaterEnergyNexus.pdf

5) ABB, Water treatment plants, Providing clean and safe drinking water, page 2,
https://library.e.abb.com/public/37a912f8291c4647abee3e3e05078d52/Cleanwater_brochure_3AXD50000483624_REVB_EN.pdf

6) Water-Energy Nexus, World Energy Outlook Special Report, 2016, page 11,
https://iea.blob.core.windows.net/assets/e4a7e1a5-b6ed-4f36-911f-b0111e49aab9/WorldEnergyOutlook2016ExcerptWaterEnergyNexus.pdf

7) Water-Energy Nexus, World Energy Outlook Special Report, 2016, page 35, https://iea.blob.core.windows.net/assets/e4a7e1a5-b6ed-4f36-911f-b0111e49aab9/WorldEnergyOutlook2016ExcerptWaterEnergyNexus.pdf

8) ABB, Wastewater treatment plant, Building resilient, safe and sustainable facilities, page 2, https://search.abb.com/library/Download.aspx?DocumentID=3AXD50000421060&LanguageCode=en&DocumentPartId=&Action=Launch

9) Water-Energy Nexus, World Energy Outlook Special Report, 2016, page 30-31, https://iea.blob.core.windows.net/assets/e4a7e1a5-b6ed-4f36-911f-b0111e49aab9/WorldEnergyOutlook2016ExcerptWaterEnergyNexus.pdf

10) U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Chapter 7 Desalination, Powering the Blue Economy: Exploring Opportunities for Marine Renewable Energy in Maritime Markets, April 2019, page 90. https://www.energy.gov/sites/prod/files/2019/09/f66/73355-v2.pdf

11) For an example of the calculations involved, see “Program Insights: Variable frequency drives,” Consortium for Energy Efficiency, 2019, https://cee1.org/content/variable-frequency-drives.

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