



Wastewater treatment plants Recommended electrical network design for efficient plant and energy operations*

*IEC standard compliance

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Introduction

Wastewater Treatment Plants (WWTP) operators face major challenges

Water is the world's most widely consumed product. Everywhere it is a strategic resource. Everywhere it needs to be carefully stewarded and managed to meet the challenges of:

- access to clean drinking water for all,
- water pollution and sustainable treatment,
- regulatory and environmental issues, even more stringent (exacting standards and regulations for water quality, energy conservation and reduced waste and emissions).

WWTP designers and operators are at the forefront of the two first challenges. And they have to confront these challenges on a fiercely competitive, cost-constrained water market. Labor costs are rising. So are energy costs – and at an even faster rate. While the water prices remain unchanged.

Electrical network designers have an important role to play for continuous quality and energy efficiency of wastewater treatment

WWTP require an electrical network that fits in with their continuous quality wastewater processes while cutting operating costs and, in particular energy costs. Therefore a plant's electrical network must be reliable, easy to operate and maintain throughout the plant's lifetime, and scalable to facilitate future expansion and process overhauls. In addition, energy, mainly electricity, accounts for up to 30% of a plant's operating costs, and makes the plant's electrical network a crucial factor for cost effective wastewater treatment.

Schneider Electric provides design recommendations, productivity tools and services to support efficient electrical network design, proven and ready-to-go for WWTP

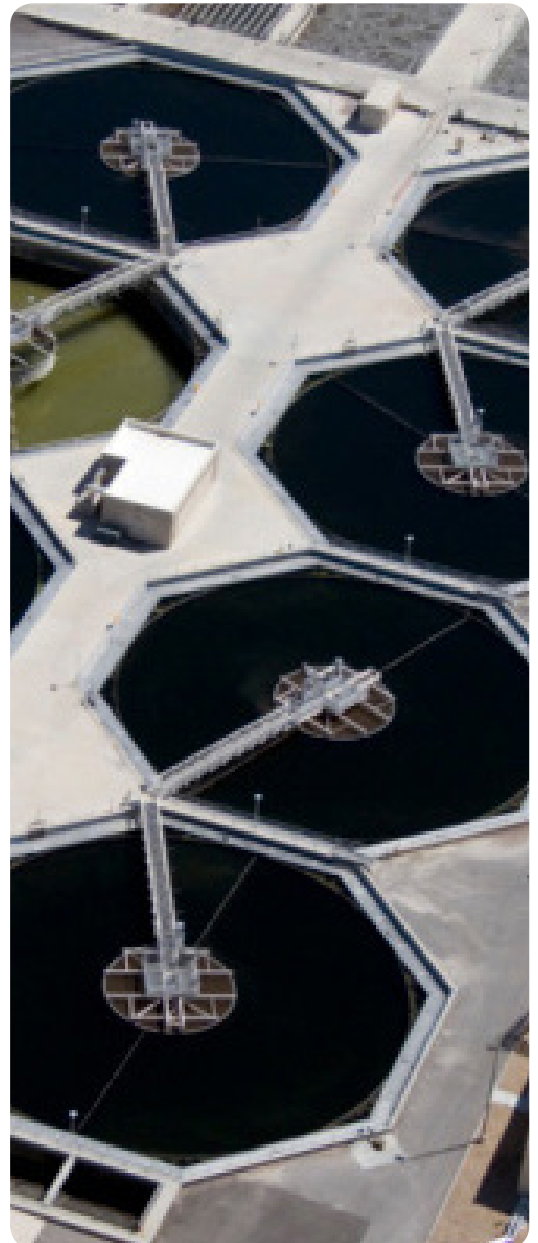
A similar and consistent approach has been developed by Schneider Electric concerning control system architectures, for the design and build of integrated power and control solutions. Please refer to the dedicated documents. The recommendations are provided for structured preliminary and final design which helps to establish suitable configurations, based on cost effectiveness, structural efficiency, fast and easy implementation, operational performance and sustainability criteria. It describes preferred solution architectures by plant type and size. Each solution architecture is presented with a single-line diagram for medium voltage and low-voltage configurations, key design principles, and the recommended equipment and technologies.

All of the architectures have been developed to meet WWTP performance requirements in areas like:

- Safety of people and property
- Compliance with codes, regulations, and standards
- Availability, operability, and maintainability
- Sustainability and energy efficiency
- Scalability and retrofit suitability
- Project implementation time and risk mitigation
- Cost – in particular the total cost of ownership, broken down into capital expenditures and operating expenses

Also included are ways to reduce both design and operating costs over the entire plant lifetime by addressing issues like power quality, motor control, secure power, power monitoring and control, and energy efficiency.

Last but not least, the available productivity tools and services support electrical network designers for structured preliminary and final design, for specification for tender, and sometimes up to design implementation and electrical network modernization, when they are involved.



Electrical network design challenges on the rise for Wastewater Treatment Plants (WWTP)



Electrical engineers face increasing challenges when designing systems for WWTP.

A rapidly-changing regulatory environment

Today's engineers must go beyond meeting health and environmental regulations—they must also ensure that their systems will be compliant with, or easily upgradeable to potential future requirements.

The advent of new technologies

When it comes to WWTP design, the state of the art is constantly shifting with the emergence of new technologies that make existing processes more efficient and cost-effective—or open the door to totally new ones.

Membrane-based technology is one such example. It improves water treatment, but uses more energy. Another example is local power generation—whether from biogas, heat exchangers, water turbines, or solar panels—which can reduce a plant's energy consumption and carbon footprint.

Finally, advancements in information and communication technology are paving the way to vastly improved WWTP monitoring and control systems.

An evolving energy market

Increased privatization and the broad implementation of smart grids have rocked today's increasingly global energy industry, making both plant operations and decision-making processes more complex.

Today's energy market is also being shaped by demand/response, an approach backed by local government officials and utilities. Demand/response provides an opportunity for WWTP to play a key role in streamlining power grid operations by reducing or shifting their electricity consumption to off-peak hours in exchange for lower utility rates and other financial incentives.

The technology that WWTP use to improve energy efficiency and process control can also help them become successful contributors to demand/response systems by enabling them to coordinate and schedule load shedding and shifting, so as to reduce energy demand during peak hours.



Key success factors for WWTP efficient electrical network design and architectures



Performance of a standard compliant electrical network is key for continuous, safe, cost-effective and sustainable wastewater treatment services throughout a plant's lifetime

The top priority for a WWTP's electrical network is to minimize downtime and to be safe. Cost effectiveness throughout the plant's lifetime is next in line. A WWTP's electrical network typically accounts for 5% to 10% of the total plant construction cost. WWTPs are usually permanent facilities. The average WWTP is more than 25 years old, up to 50 years in some countries where some plants have been operating for more than a century. Therefore, investing in high-quality electrical network, equipment and wiring, is generally cost effective. The electrical network design process should be iterative, taking into account the overall WWTP design, any process-related considerations, overall architecture, equipment, security, and HVAC. Finally, electrical network specifications, design, installation, and commissioning should meet all applicable codes, regulations, and standards, and help shorten project implementation times, plus mitigate risk.

A WWTP's electrical network typically accounts for 5% to 10% of the total plant construction cost.

WWTP electrical network designers will have to consider:

Availability, operability, and maintainability

WWTPs require high process uptime, which necessitates a reliable power supply. To achieve this, engineers must:

- Choose a network architecture that strikes the right balance between risk mitigation and return on investment (ROI)
- Select reliable equipment configured for each process and load
- Implement an appropriate maintenance policy with corrective, preventive, and predictive measures
- Install a power monitoring and control system with the following features, to help operators make the right decisions and take the appropriate corrective actions:
 - Real-time monitoring of the entire electrical network
 - Alarming, data logging, event tracking, fault analysis, and root cause analysis
 - Automatic medium-voltage loop reconfiguration, automatic transfer switch control, and automated system generator testing
 - Remote troubleshooting of power equipment and some related loads like motors

Operability and maintainability have become more crucial than ever due to the scarcity of skilled workers for the operation and maintenance of electrical networks, and to increasingly complex and technology-driven monitoring and control systems.

Scalability and retrofit suitability

With an average age of 25 years, most WWTPs have clearly been designed and built to last. However, plant processes and equipment change over time to allow for increased capacity, integrate new technology, and comply with new regulations. Therefore, a plant's electrical network architecture must be scalable, compatible with third-party equipment, and employ standard protocols.

For new plants, it is important to ensure that equipment and systems will be properly maintained and upgraded regularly to minimize obsolescence.

For plant expansions, new electrical networks must integrate seamlessly with existing equipment—with minimal effect on process uptime. New electrical networks should also meet existing criteria for reliability, operability, and maintainability.

Plant managers should make sure that new electrical networks, systems and equipment receive the same services as the installed base, including retrofit services.

Safety of people and property

Above all, a WWTPs' electrical network must be safe. A tested, validated, and documented architecture is an excellent way to ensure system safety. Next, the selected equipment should be standards-compliant, backed by the appropriate certifications. Finally, engineering studies on issues like protection, availability, and coordination are a must.

And, to ensure safe operations and maintenance, it is important to request mechanical and electrical interlocking early on in the design phase, and to use electrical network monitoring and control features like alarming, root cause analysis, and crisis management support—all to help ensure that non-expert operations and maintenance staff make safe decisions.

Cost

When designing electrical networks for WWTPs—especially for design-and-build projects—engineers should consider the total cost of ownership (TCO), which includes capital expenditures (CapEx) and operating expenses (OpEx) over the plant's entire lifetime—25 years on average. A WWTP's electrical network typically accounts for 5% to 10% of the total plant construction cost.

Energy consumption accounts for on average up to 30% of a WWTP operating cost.

Sustainability and energy efficiency

In addition to the many water-related environmental issues they must address, WWTPs' operators are, to a growing extent, seeking sustainable, energy efficient processes with low CO₂ and other pollutant emissions. These concerns are also reflected in the regulations and standards with which WWTPs must comply. A plant's electrical network must be designed for immediate integration with energy and waste monitoring systems.

Compliance with codes, regulations, and standards

Electrical network designers must also take into account the rapidly-changing codes, regulations, and standards with which WWTPs must comply in order to ensure public health and safety and promote sustainable development.

Project implementation time and risk mitigation

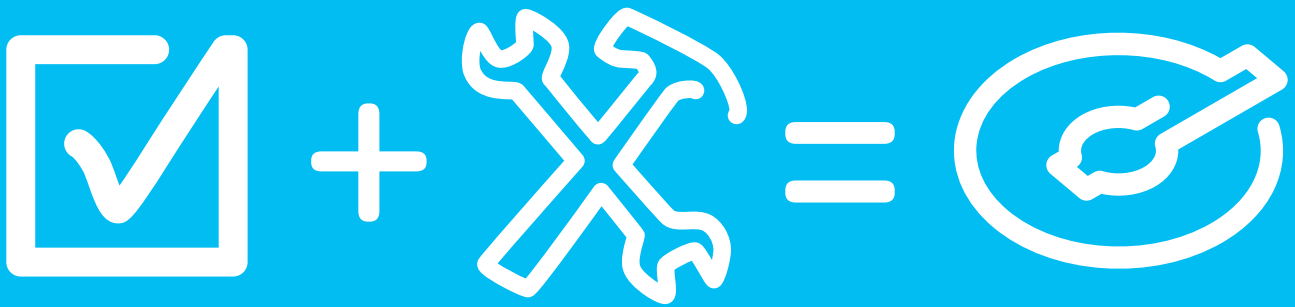
Several factors can help shorten project implementation times and mitigate risk.

These include:

- tested, validated, and documented architectures developed specifically for different types and sizes of WWTPs
- productivity enhancing design and calculation allowing for easy comparisons
- careful equipment selection, well-drafted specification for tender.

It is also important to factor in equipment delivery, installation, commissioning, and modernization times.

Recommended electrical network design for efficient WWTP and energy operations



Schneider Electric recommended electrical network architecture, proven and ready-to-go for WWTP.

Schneider Electric productivity tools and services to support efficient electrical network design and specification for tender.

A reliable, safe, cost-effective and easy-to-implement electrical network design, that enables continuous quality and energy-efficiency of wastewater treatment, over the plant's lifecycle.

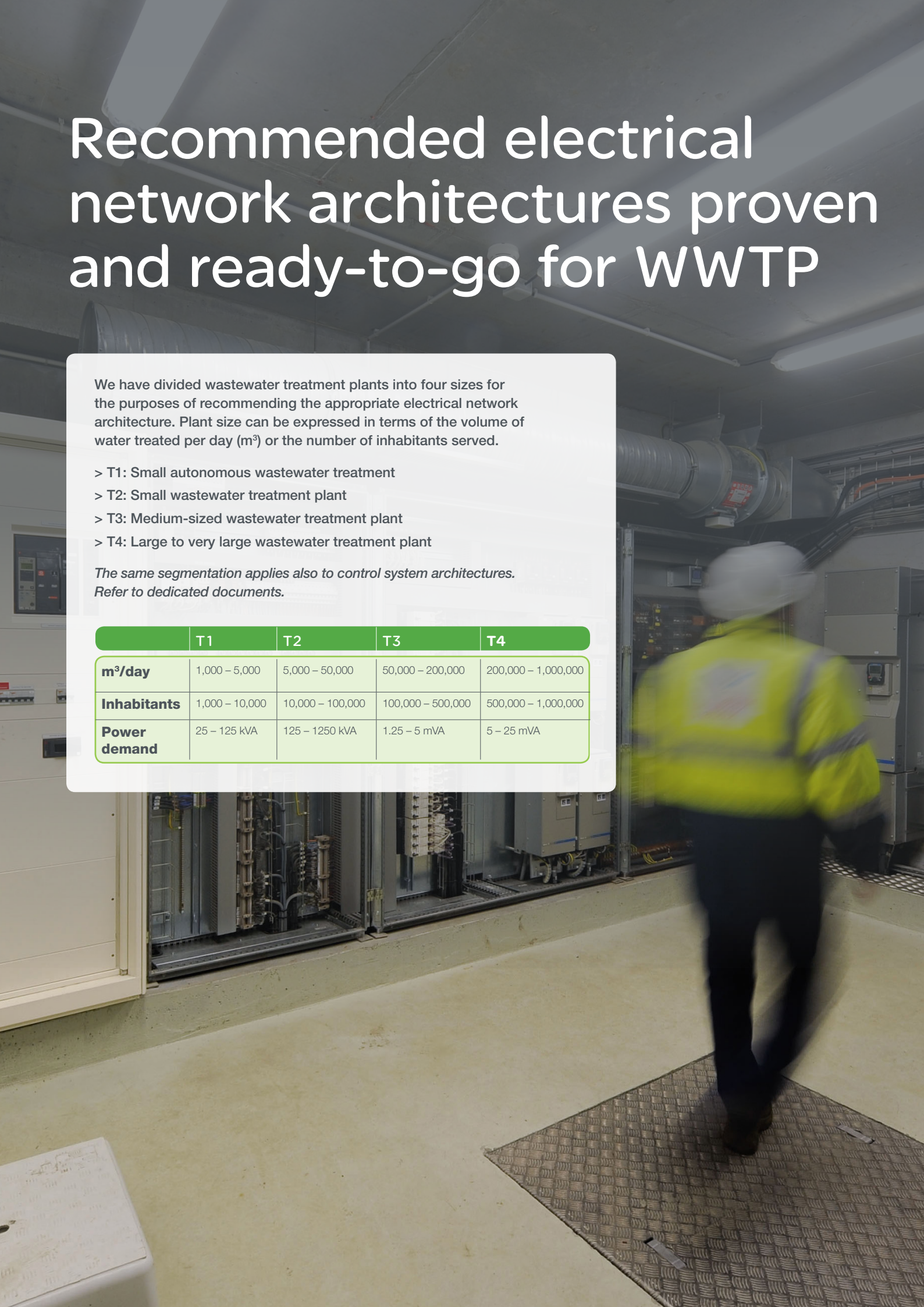
Recommended electrical network architectures proven and ready-to-go for WWTP

We have divided wastewater treatment plants into four sizes for the purposes of recommending the appropriate electrical network architecture. Plant size can be expressed in terms of the volume of water treated per day (m³) or the number of inhabitants served.

- > T1: Small autonomous wastewater treatment
- > T2: Small wastewater treatment plant
- > T3: Medium-sized wastewater treatment plant
- > T4: Large to very large wastewater treatment plant

The same segmentation applies also to control system architectures. Refer to dedicated documents.

	T1	T2	T3	T4
m³/day	1,000 – 5,000	5,000 – 50,000	50,000 – 200,000	200,000 – 1,000,000
Inhabitants	1,000 – 10,000	10,000 – 100,000	100,000 – 500,000	500,000 – 1,000,000
Power demand	25 – 125 kVA	125 – 1250 kVA	1.25 – 5 mVA	5 – 25 mVA



Recommended architecture for small autonomous WWTP (T1)

Scope

Water treatment plants with power demand of less than 125 kVA, IEC.

Main design principles

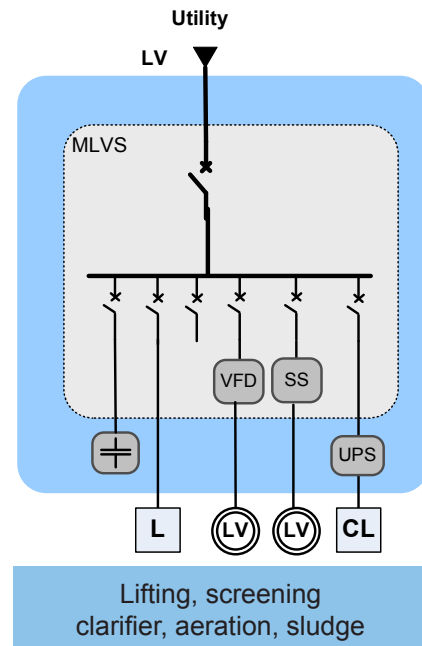
For T1 plants, the electrical network architecture must be simple and cost-effective while helping to reduce OpEx.

Because of the low power demand, we recommend a radial single feeder configuration with low-voltage power supplied by an electric utility.

In this configuration, all process units are supplied from a single low-voltage switchboard and motor control is performed using conventional wired systems (protection + thermal relay + contactor), variable speed drives and soft starters.

Power meter can be linked to local Remote Telemetry Unit (RTU), for transmission of power consumption and basic power quality indicators to remote control center.

Single line diagram



Abbreviations

MLVS: Main Low-Voltage Switchboard
VFD: Variable Frequency Drive
SS: Soft Starter
LV: Low-Voltage Motor

Recommended equipment

- > **ATV 61/71** variable speed drives
- > **TeSys U** motor starter or **Altistart 22 or 48** soft starter for fixed-speed pumps
- > **Prisma Plus** LV switchboard
- > **PM700** power meters

Recommended architecture for medium-sized WWTP (T2)

Scope

Water treatment plants with power demand of 125 to 1250 kVA, IEC.

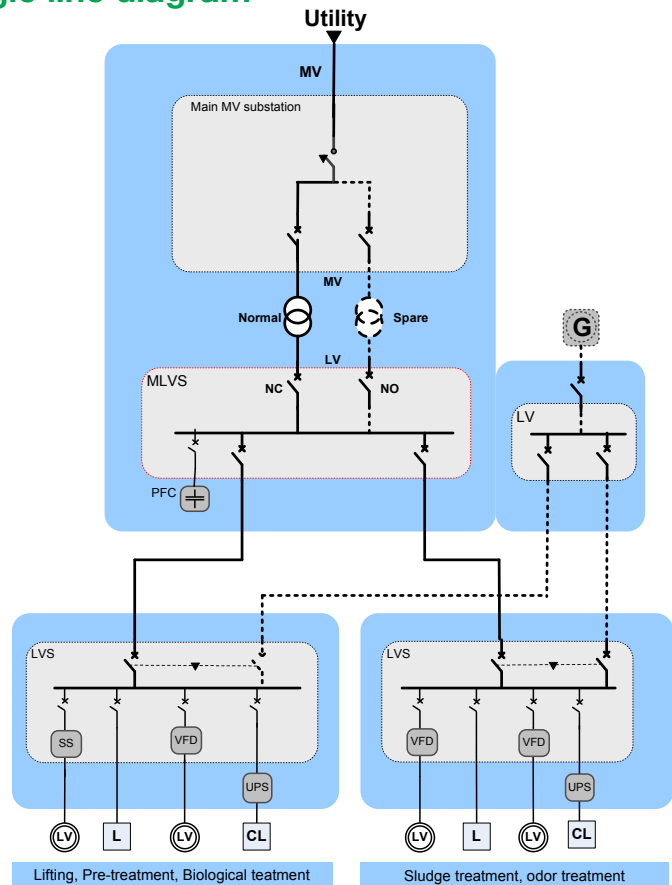
Main design principles

At this treatment capacity or power demand, a medium-voltage supply is part of the electrical network. These plants have more motors (with and without variable speed drives), resulting in greater harmonics and degrading the power factor. The separate low-voltage switchboards improve availability.

Our recommended architecture includes:

- A single-line power grid connection
- A simple medium-voltage configuration (radial double feeder)
- Optionally, two redundant transformers in parallel to improve availability and facilitate maintenance
- One to three low-voltage switchboards (LVS) to supply the process units; in the architecture shown, one LVS feeds the water treatment processes (lifting, pretreatment, and biological treatment), and the other the sludge and odor treatment processes
- A fixed low-voltage capacitor bank for power factor correction
- A motor control center (MCC) integrated devices with communication capabilities for motor control
- An optional backup generator with fixed or mobile configuration for load shedding from the process power supply. Uninterruptible Power Supply (UPS) is used to protect the critical loads
- Power meters with communication capabilities to send data to a local Supervision Control and Data Acquisition (SCADA) system or to a remote energy management information system.

Single line diagram



Abbreviations

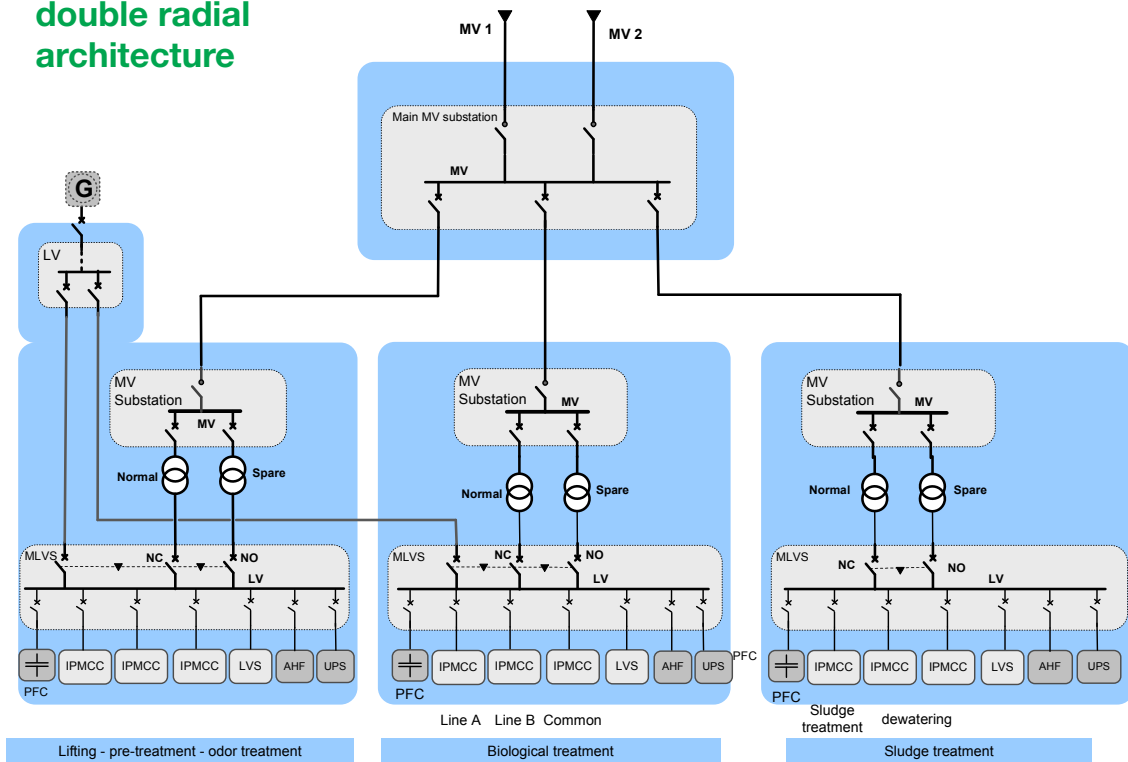
- LVS:** Low-Voltage Switchboard
- MLVS:** Main Low-Voltage Switchboard
- PFC:** Power Factor Correction
- SS:** Soft Starter
- VFD:** Variable Frequency Drive
- LV:** Low-Voltage Motor

Recommended equipment

- > **SM6** MV switchboard
- > **Trihal MV/LV** transformer / Alternative: **Minera** oil-immersed transformer
- > **Prisma Plus** LV switchboards
- > **TeSys U** motor starter (protection + thermal relay + contactor)
- > **ATV 61/71** variable speed drives
- > **Accusine** active harmonic filters
- > **Masterpact UA & UB** modules for LV ATS
- > **ATS48** soft starter
- > **Smart-UPS** : UPS system

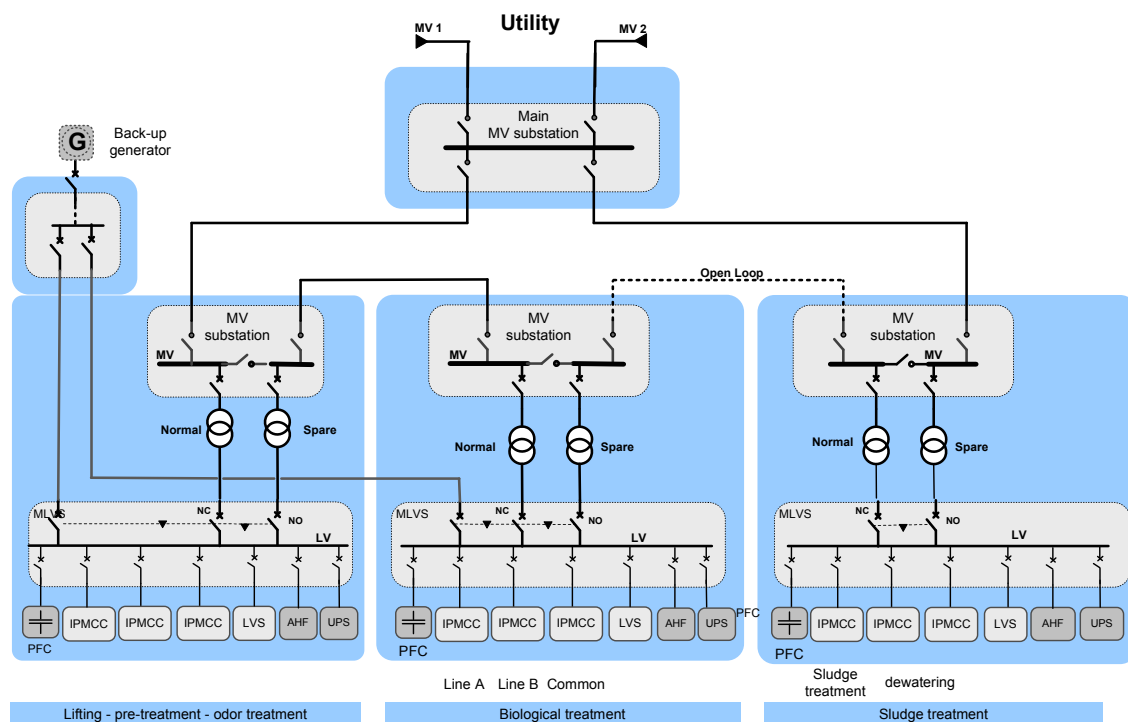
Recommended architecture for large WWTP (T3)

Single line diagram: double radial architecture



• The radial single feed architecture is simpler and more cost effective but offers lower power availability.

Single Line Diagram : open medium-voltage loop



• The open MV loop architecture is more suitable for larger plants and offers better availability.

Abbreviations

- AHF: Active Harmonic Filter
- IPMCC: Intelligent Power & Motor Control Center
- MLVS: Main Low Voltage Switchboard
- PFC: Power Factor Correction
- VFD: Variable Frequency Drive
- SS: Soft Starter

Scope

Water treatment plants with power demand from 1.25 to 5 mVA, IEC.

Main design principles

Plants of this size typically have high operating costs and a significant environmental impact due to the large volume of water they treat and their installed power. The medium-voltage (MV) electrical network—which extends down to the shop floor—should incorporate more redundancy.

For optimal performance, power availability and monitoring should be managed with specific systems. Large plants like these contain many motors, which often use variable speed drives and thus need intelligent motor control systems.

We recommend a ring-main service from the plant's electric utility to feed the MV system.

The primary MV switchboard should be located in a main electrical room to supply each workshop. Depending on the plant's layout and local regulations and habits, we recommend either a radial single feed or an open MV loop architecture:

- The radial single feed architecture is simpler and more cost effective, but offers lower power availability.
- The open MV loop architecture is more suitable for larger plants and offers better availability.

Since MV/LV transformer failure can cause extended plant downtime—and in order to facilitate maintenance—we suggest either partial redundancy (to allow for downgraded operation in the event of a transformer failure) or total redundancy (to allow for normal operation in the event of a transformer failure). Installing several MV/LV transformers—preferably of equal power—as close as possible to the distributed loads can reduce the low-voltage (LV) connection distances.

Process units should be supplied by several LV switchboards.

Recommended features

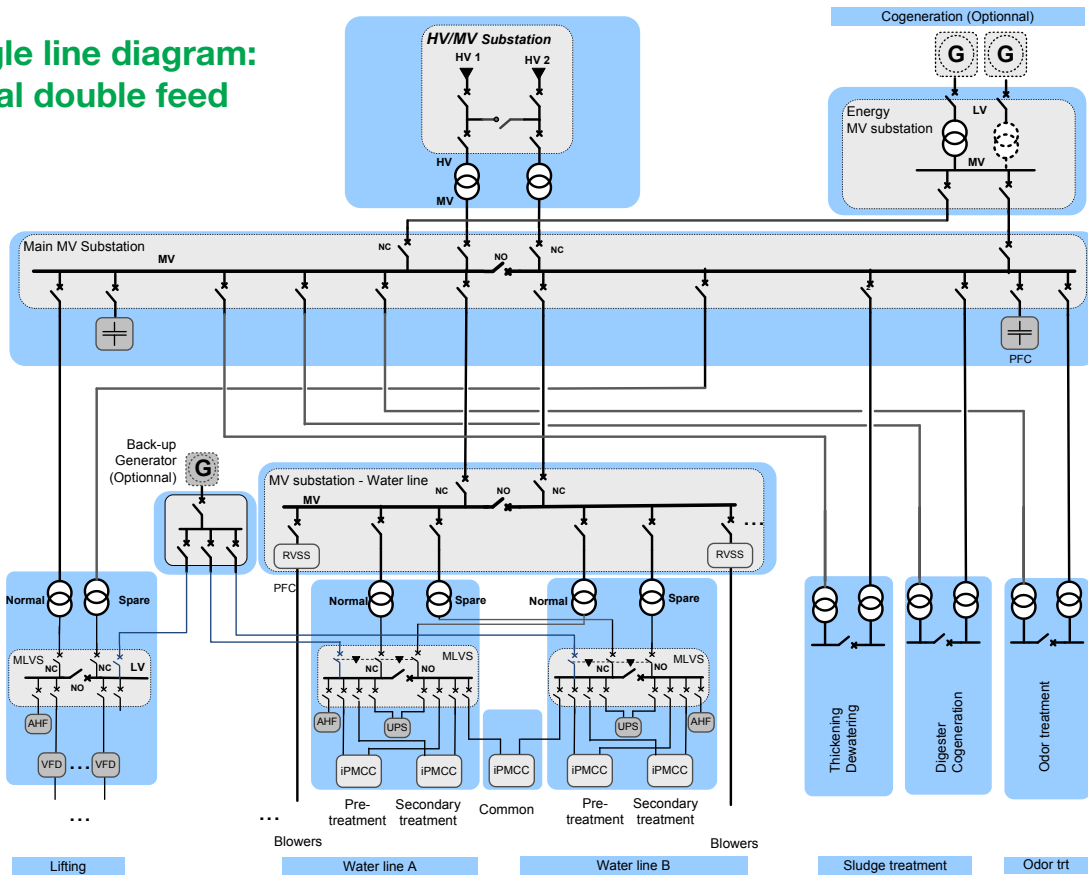
- Power factor correction can be managed by stepped capacitor banks, which are suitable for large motors with fluctuating loads. Another option would be to provide power factor correction through a MV capacitor bank.
- Harmonic filters are recommended to improve power quality (since they mitigate variable speed drives disturbances).
- Given the large number of motors, we recommend motor control via an intelligent Power & Motor Control Center (iPMCC) to improve availability, facilitate maintenance, and limit operating costs.
- Power monitoring is also crucial to maintaining a plant's overall energy efficiency. This can be achieved through power meters linked to an Energy Management Information System (EMIS), which could either be part of a Supervision Control and Data Acquisition (SCADA) system or a dedicated system with advanced features (for integration with multisite systems, for example).
- Backup generators should be used for critical process units. A mobile generator could be added for emergency backup. Uninterruptible Power Supply (UPS) is used to protect the critical loads.

Recommended equipment

- > **SM6** MV switchboard
Alternative: **RM6** ring main unit (for harsh environments)
Alternative: **MCset** MV switchgear (for high short-circuit current)
- > **Sepam** MV protection relays
- > **Trihal** MV/LV transformer
Alternative: **Minera** oil-immersed transformer
- > **Motorpact RVSS** for MV motors
- > **Motorsys Okken** intelligent power and motor control centers (iPMCC)
Alternative: **Motorsys Blokset** iPMCC
- > **VarSet** capacitor banks
- > **ATV 61/71** variable speed drives
- > **ATS 100** for MV ATS
- > **Masterpact UA & UB** modules for LV ATS
- > **Accusine** active harmonic filters
- > **Smart-UPS:** UPS system
Alternative: MGE Galaxy
- > **PM 700/800:** power meter

Recommended architecture for large to very large WWTP (T4)

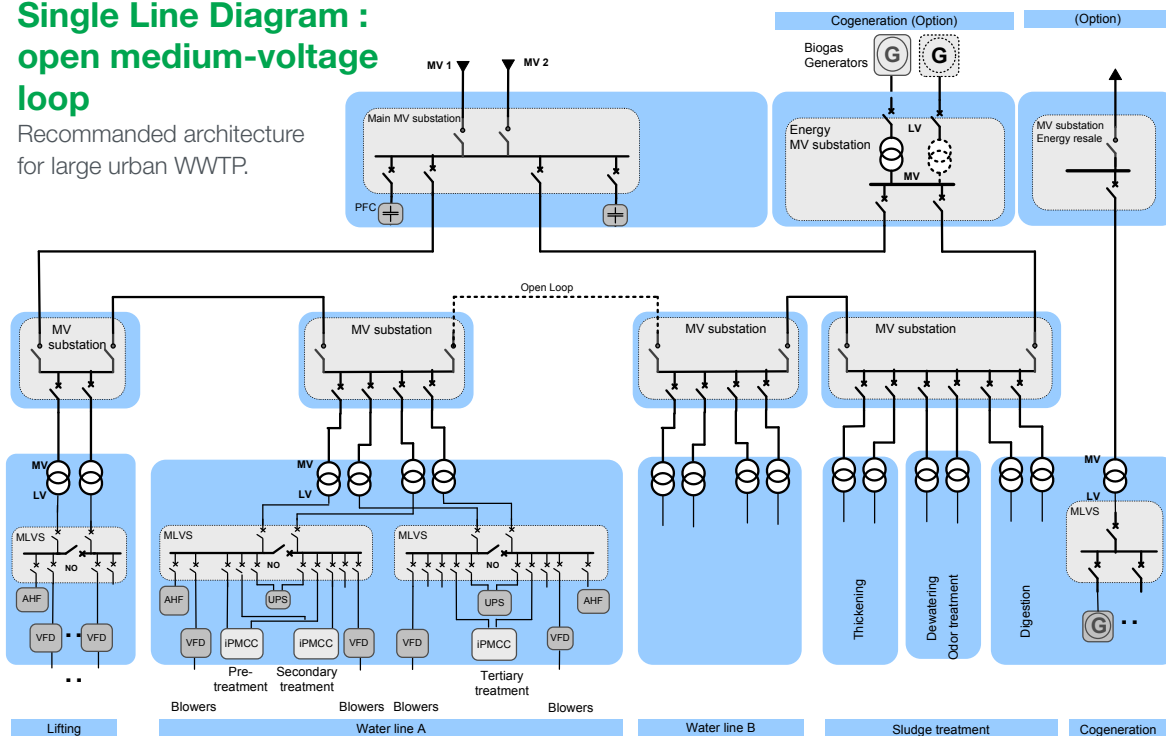
Single line diagram: radial double feed



• The radial double feed electrical network architecture is simple and offers high power availability but is less suitable for extended sites.

Single Line Diagram : open medium-voltage loop

Recommended architecture for large urban WWTP.



• The open MV loop architecture is more suitable for larger plants since it limits cabling and infrastructure work; it can also be upgraded or expanded cheaper and more easily by "cutting" the loop and adding new loads.

Abbreviations

- MLVS: Main Low-Voltage Switchboard
- VFD: Variable Frequency Drive
- RVSS: Reduced Voltage Soft Starter
- iPMCC: intelligent Power And Motor Control Center
- AF: Harmonic Filter
- PFC: Power Factor Correction

Scope

Water treatment plants with power demand between 5 and 25 mVA, IEC.

Main design principles

Plants of this size treat large volumes of water, which requires a large installed power base. Operating costs for these plants are high, and must be managed carefully.

The medium-voltage (MV) electrical network—distributed down to the shop floor—should incorporate a high level of redundancy. For optimal performance, power availability and energy efficiency have to be managed with specific systems. Large plants like these contain many motors, which often use variable speed drives (VSD), and thus need intelligent motor control systems.

We recommend a double supply service from the plant's electric utility to feed the MV system.

Both architectures allow processes to be powered by a second supply in the event of a malfunction, ensuring service continuity.

The primary MV switchboard should be located in a main electrical room to supply each workshop. Depending on the plant's layout and local regulations and habits, we recommend either a radial double feed or an open MV loop architecture:

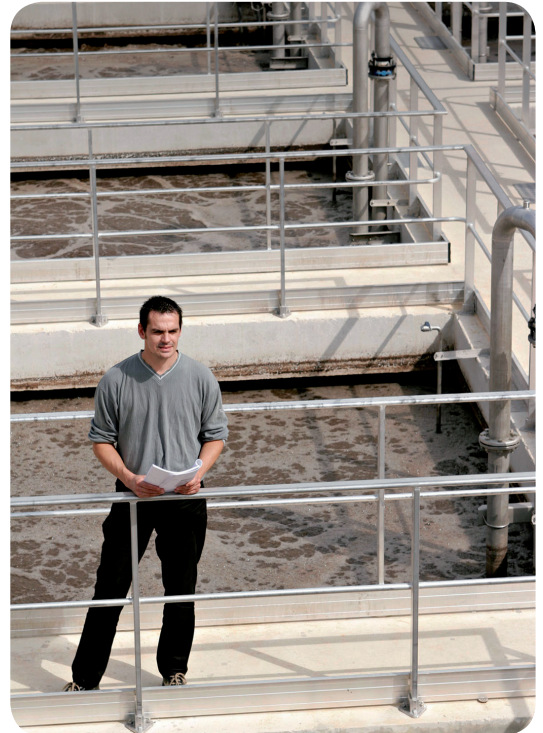
- The radial double feed electrical network architecture is simple and offers high power availability, but is less suitable for extended sites.
- The open MV loop architecture is more suitable for larger plants since it limits cabling and infrastructure work; it can also be upgraded or expanded cheaper and more easily by “cutting” the loop and adding new loads.

The open MV loop architecture can also be controlled by an automatic reconfiguration system offering several benefits:

- Automated service recovery for enhanced personnel safety and maximum service continuity
- Fast, automated, and safe operation to minimize the risk of human error in stressful or new situations
- All network configuration scenarii taken into account
- Limited downtime during electrical fault elimination.

Since MV/LV transformer failure can cause extended downtime—and in order to facilitate maintenance—we suggest either partial redundancy (to allow for downgraded operation in the event of a transformer failure) or total redundancy (to allow for normal operation in the event of a transformer failure). Installing several MV/LV transformers—preferably of equal power—as close as possible to the distributed loads can reduce the low-voltage (LV) connection distances.

Each LV and MV switchboard busbar should be split into two half busbars linked with a bus tie. This configuration improves power availability by providing a dual supply, and lets maintenance be performed without stopping the process: one of the half busbars can be disconnected from the power supply while the other continues to supply the process. This configuration also improves operator safety since only limited maintenance is performed on powered equipment.



Recommended features

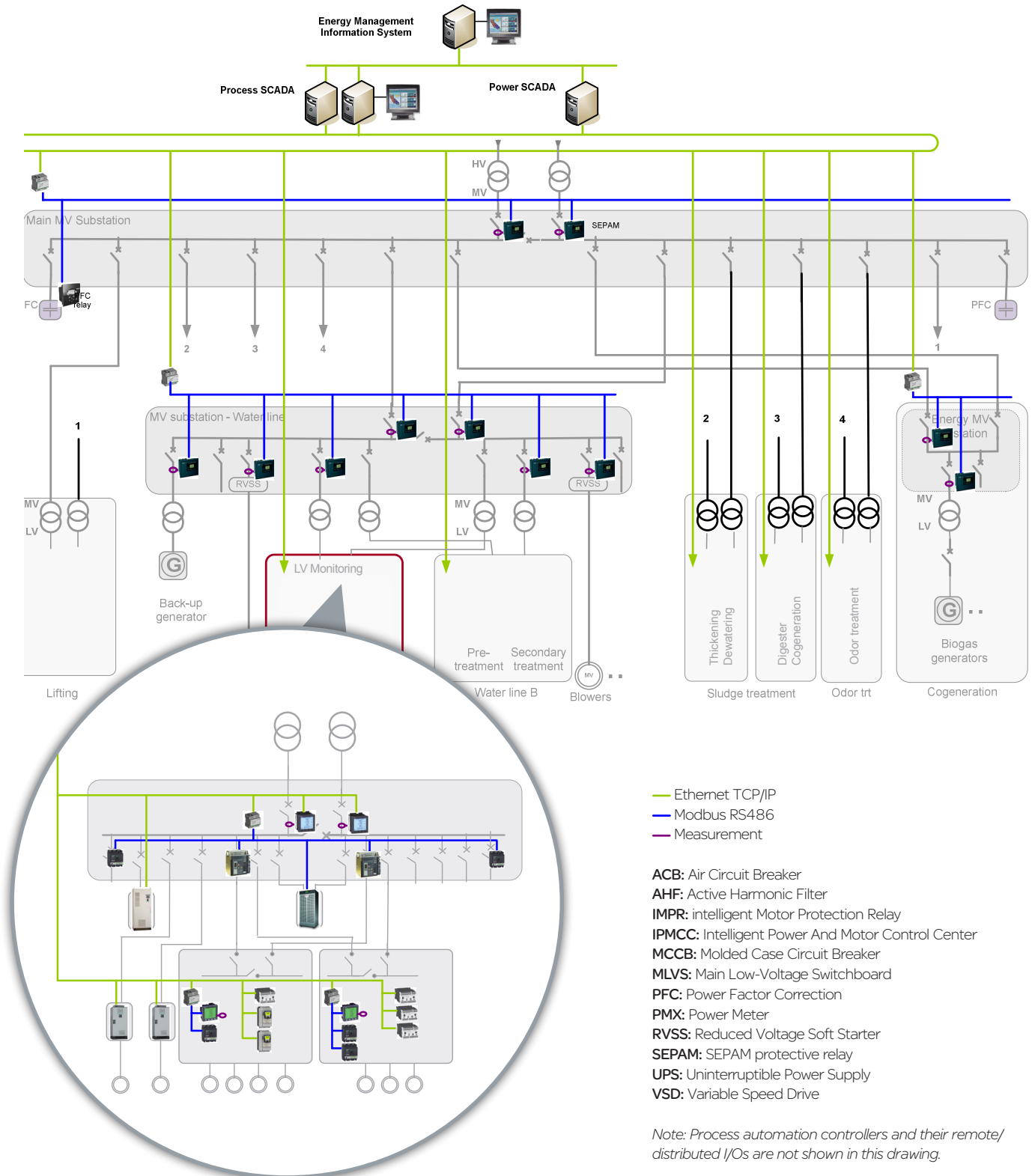
- Power factor correction (PFC) can be managed by stepped capacitor banks, which are suitable for large motors with fluctuating loads. Another option would be to provide PFC through a MV capacitor bank.
- We recommend harmonic filters to improve power quality (through the mitigation of VSD disturbances), which can be implemented in several ways:
 - Compensation of several VSDs using a network compensation structure, based on one active filter per group of drives
 - VSD (ATV61/71 plus) in combination with a dedicated multi-winding transformer using a 12-, 18-, or 24-pulse rectifier structure for very high power LV drives (>400 kW)
 - A low harmonic drive system, based on active front end technology (ATV61 plus LH 55kW – 630kW)
- Given the number of LV motors, we recommend motor control via an iPMCC to improve availability, facilitate maintenance, and limit operating costs. The larger motors—such as high-power blower motors—can be supplied directly from the MV system and fitted with direct online, reduced voltage auto transformers, or reduced voltage soft start motor starters.
- Power monitoring is also crucial to maintaining the plant's overall energy efficiency. This can be achieved through communicating devices or power meters linked to an Energy Management Information System (EMIS), which could either be part of a process SCADA system or a dedicated system with advanced features (for integration with multisite systems, for example).
- Power control can be provided through the process SCADA system, but for larger plants, a dedicated electrical SCADA would offer more advanced features, such as MV loop reconfiguration and automatic transfer sources.
- Backup generators should be conveniently connected to the MV system via MV/LV transformers, making it possible to distribute power over a large process area.
- If the sludge treatment process includes local power generation from biogas (co-generation using biogas generated from sludge digestion), the energy produced can be sold back to the grid or re-used within the plant.

Recommended equipment

- > **SM6** or **GMA** cubicles (depending on country)
Alternative: **RM6** ring main unit (for harsh environments)
- > **MCset** or **PIX** MV switchgear (for high short-circuit currents)
- > **Sepam** or **Micom** MV protection relays
- > **Trihal** MV/LV transformer and **Canalis KTA** prefabricated busbar trunking, providing direct connection to Okken switchboards
Alternative: **Minera** oil-immersed transformer
- > **Motorpact RVSS** for MV motors
- > **Motorsys Okken** intelligent power and motor control centers (iPMCC)
Alternative: **Motorsys Blokset** iPMCC
- > **DVI•••** MV capacitor banks
- > **ATV 61/71** variable speed drives
- > **Accusine** active harmonic filters

Recommended architecture for electrical power monitoring in all WWTP (T1, T2, T3, T4)

Single line diagram



An efficient metering architecture is crucial to both the Power Monitoring and Control System (PMCS) and the Energy Management Information System (EMIS).

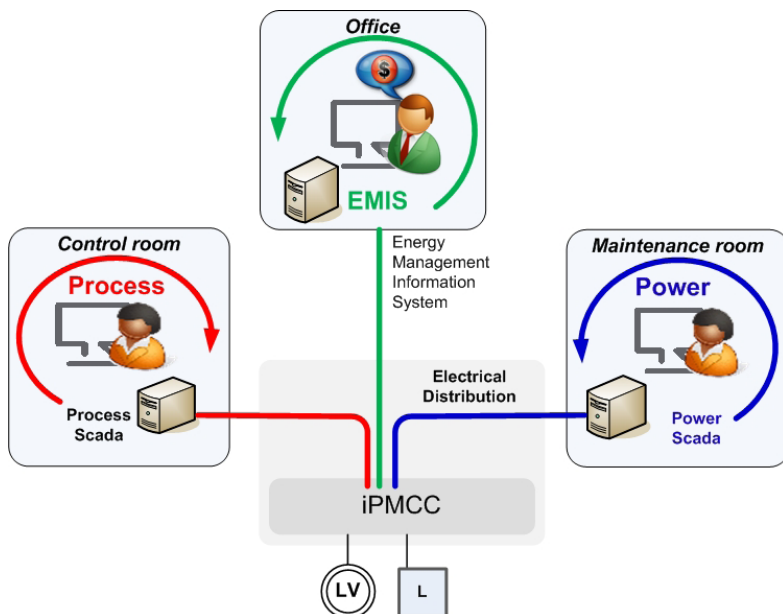
Scope

All WWTP. The metering architecture should be adjusted to plant size and needs.

The example shown page 18 is for a large to very large water treatment plant (T4).

Metering data are sent to three main control systems

Intelligent electrical devices—meters, switchboards, sensors, and other devices—serve as the primary data collectors. Data are sent to the PMCS, the EMIS, and the power control system. The intelligent electrical devices and the plant's communications network determine how consistent, accurate, and reliable the data are.



Process, power, and energy-efficiency data are collected by intelligent electrical devices and sent to the various information systems.

Process control

A process is made up of many components, including motors; the process control system controls the motor starters. Generally, a process control system or distributed control system controls and monitors one or more processes.

Energy Management Information System

An EMIS is designed to facilitate decision making. The system aggregates data from intelligent electrical devices and sensors, and uses the data to generate tables, graphs, and reports.

Power control

Data collected by intelligent electrical devices can also be sent to a PMCS, which uses a power SCADA system with both basic and more advanced features. A PMCS typically covers the entire electrical network.

Main design principles

In the example shown, power measurement devices are located at the plant, process, and load levels. All of the equipment shown have communication capabilities and are linked to the plant's communications network. Data collected by the devices can be integrated into a site-wide monitoring and control system.

In a MV system, measurement devices are typically located:

- At the point of delivery
- At the main processes (lifting, aeration, sludge treatment, odor treatment, and co-generation)
- At major loads (blowers).

MV protection relays are generally used to provide power measurements. They offer good accuracy and eliminate the need for additional current and voltage transformers to connect power meters to the network.

In a LV system, measurement devices are typically located:

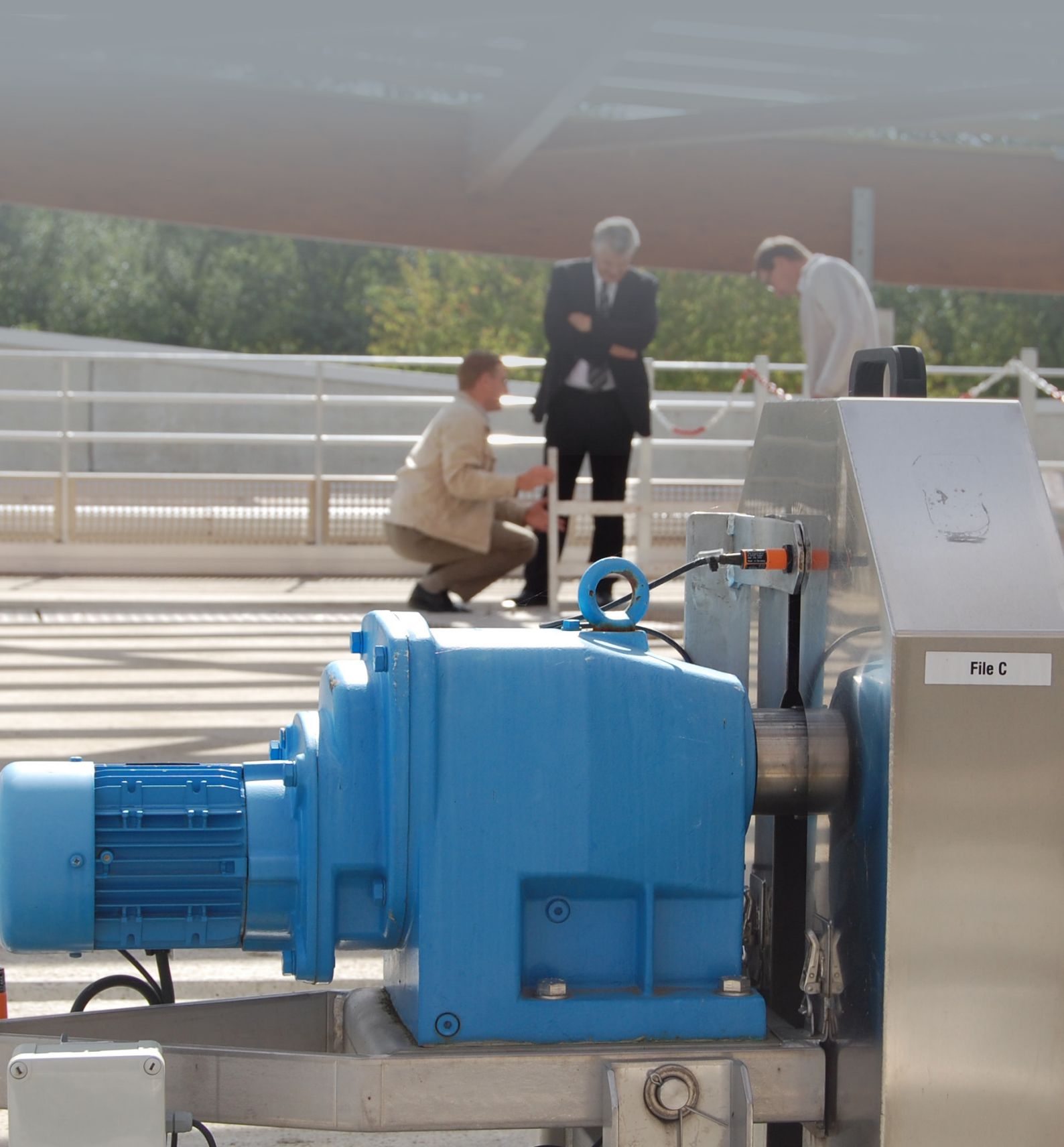
- At the sub-process level (water line A, for example)
- At the load level.

In a LV system, several types of equipment—intelligent motor protection relays, variable frequency drives, circuit breakers, and active harmonic filters—can be used to provide power measurements. The use of intelligent devices (like CBs) incorporating metering and communication capabilities ensures that the right data are sent to the system. However, when better accuracy and advanced power quality analysis are required, we recommend using dedicated power meters.

Recommended equipment

- > **Sepam** MV protection relays
- > **ATV 61/71** variable speed drives
- > **Accusine** active harmonic filters
- > **Masterpact** and **Compact** with **Micrologic Trip Unit** circuit breakers
- > **PM8xx** series, **PM7xx** series, and **PM1200** power meters

Recommended features for WWTP



Power quality

Introduction

Power quality refers to both voltage and current quality determined according to criteria like magnitude, frequency, waveform, and symmetry. Disturbances to any of these factors are considered power quality problems, which can be of several types:

- Harmonics (waveform)
- Voltage sags and swells or voltage interruption (magnitude)
- Voltage unbalance (symmetry)
- Voltage frequency fluctuation.

Impacts and applications

For wastewater treatment plants (WWTP), the main power quality issues are voltage interruptions and harmonics.

Voltage interruptions

For WWTP, long voltage interruptions may result in the discharge of untreated water into public waterways, creating a public health hazard and resulting in fines for the plant. Secure power equipment like generators and uninterruptible power supply systems can be used to ensure a continuous power supply.

Harmonics

WWTP also frequently encounter harmonics issues since variable speed drives account for a significant proportion of their total power. Harmonics can increase the RMS current in the different circuits and deteriorate supply voltage quality. Correcting harmonics can help:

- Reduce overloading of the electrical system, thereby releasing useable capacity
- Lower system losses and demand power
- Limit the risk of an outage and
- Extend equipment lifetime.



Recommended solutions

This section treats the solutions for harmonic mitigation only. The solutions for voltage interruptions are treated in the Secure Power Supply section.

Harmonics can be corrected in several ways and in different levels of the electrical installation.

At the installation and/or equipment level, harmonics can be corrected by:

- Passive filters, which consist of reactors and capacitors set up in a resonant circuit configuration and tuned to the harmonic frequency; a system may be made up of a number of filters to eliminate several harmonic orders.
- Active filters, which comprise power electronics and are installed in parallel with the non-linear load, to compensate the harmonic current or voltage drawn by the load.
- Hybrid filters, which include a passive filter tuned to a given harmonic frequency and an active filter for the rest of the harmonics in a single unit.

At the equipment level only, harmonics can be corrected by:

- Multi-pulse arrangement for variable speed drives; requires a dedicated transformer directly supplied from the medium-voltage system. The standard configuration is based on a 3-winding transformer providing a 12-pulse supply for the drive. This limits harmonics considerably; no further mitigation is generally necessary.
- AC-line or DC-link chokes for drives (one for each drive), recommended when an installation includes many drives. The use of chokes increases drive lifetime and enables the use of cost-effective mitigation devices like active filters.
- An active front end, which is connected upstream to the standard frequency inverter and consists of three components: an active infeed converter; a line filter module; and a line filter choke. An active front end is the best-performing equipment-level harmonics-reduction solution, bringing THDi to under 4%.

Guidelines for choice of harmonics mitigation solution:

- If harmonics mitigation is necessary, installation-wide mitigation should be considered first, as one installation-wide device is usually more cost effective than several smaller devices installed at the equipment level.
- When large drives are used ($\geq 400\text{kW}$), local (equipment-level) mitigation is recommended. Typical mitigation techniques include multi-pulse configurations, active front end, and active filter systems.
- When a large number of drives are used, chokes are recommended (ACline or DC-link chokes).
- When PFC capacitors are used, detuned banks are preferable, with active filtering if further attenuation is needed. This will ensure capacitor protection and avoid resonance.
- When PFC capacitors are not used, an active filter is recommended.

➤ **Learn more:** [Harmonic Mitigation – Solution Handbook](#)

Schneider Electric offers

- **VarSet** detuned capacitor banks and passive filters
- Active harmonic filters:
AccuSine SWP and **AccuSine PCS**
- Hybrid filter:
Custom design available on request
- **Altivar ATV61**
with optional active front end
- **ATV212** range
with anti-harmonics technology

Power factor correction

Introduction

A plant's power factor has a direct effect on its energy efficiency and electricity costs.

The power factor is the ratio of the real or active power flowing to a load divided by the apparent power in the circuit, and is a unitless number between 0 and 1. A power factor close to 1 means that the line current is at a minimum for the given active power.

Impacts and applications

Wastewater treatment plants (WWTP) typically have a low power factor due to the many inductive devices they employ (like motors and transformers), meaning that power factor correction is often necessary.

Power factor correction consists of increasing a plant's power factor so that it approaches 1, usually with a target of 0.92 to 0.95. Power factors lower than this may incur a surcharge by the electric utility supplying the plant.

Recommended solutions

Power factor correction is generally done by installing power factor correction capacitors that maintain a plant's power factor above a value agreed upon with the electric utility. These capacitors also enhance the performance of some of a plant's electrical system components such as cables and transformers.

At low voltages, compensation is provided by:

- Fixed value capacitors, usually applied at motor terminals
- Or automatically-controlled capacitor banks, connected for example to the busbars of a general power distribution board.

In an electrical installation, compensation is performed using low-voltage capacitors, either for the entire installation, partially (section-by-section), locally (at each device), or some combination of the latter two. When the installed compensation power exceeds 800kvar and the load is continuous and stable, it is usually cheapest to install capacitor banks for medium voltages.

➤ **Learn more:** [Electrical installation guide](#)

Schneider Electric offers

Medium-voltage equipment:

CP capacitor banks with **Propivar NG** capacitors

Low-voltage equipment:

VarSet range of fixed and automatic capacitor banks

Motor management

Introduction

Motors constitute the primary power load of a wastewater treatment plant (WWTP) and link a plant's processes to its electrical network.

Today's plants face new challenges to boost efficiency and increase their returns on both CapEx and OpEx. Intelligent motor starters (LV and MV) and motor control systems are one way to achieve this goal.

Impacts and applications

Because a single motor failure can mean costly downtime for a plant, plant managers need to ensure that their motors are adequately protected and have reliable control systems.

Although most motors are small and relatively cheap, a failure can mean lost production, increased maintenance costs, and a major risk if the process is critical. Therefore, better protected motors mean a better protected plant.

Motor protection and control is a plant-wide issue. It concerns not only a plant's motors and processes but also operator safety, electrical technician safety (at the motor starter, electrical feed, and load levels via isolation and lockout), and the protection of the plant's electrical network.

Recommended solutions

Conventional motor protection systems based on thermal overload protection cannot communicate with higher-level process control systems and consequently fail to meet the needs of today's continuous process industries.

This is due to several factors:

- First, motor failure can be triggered by a variety of incidents, such as an abnormal power load or supply, an insulation failure, incorrect wiring, or a number of external factors. Such incidents can cause motor burnout or other problems, each requiring a different response. Conventional motor protection systems with a "circuit breaker + contactor + thermal relay scheme protect only against short circuits and overloads—but these account for a mere 35% of motor failures. Therefore, conventional systems are clearly unable to ensure service continuity for critical processes.
- Second, protecting a motor by simply shutting it down is often impractical. Today's plants need intelligent motor protection systems that can identify potential risks and alert operators to take action before a failure occurs.
- Third, motor protection systems must communicate with both process and power SCADA systems.

Motor protection and control systems must be able to send real-time data to control centers and receive the resulting commands.

This data should be transferred via a commonly-used industrial communications protocol— such as Ethernet Modbus TCP/IP, Profibus-DP, DeviceNet, or Modbus—to ensure maximum interoperability with third-party plant control systems and equipment.

That is, motor protection systems should be intelligent enough to get the right information to the right people at the right moment.



Intelligent motor protection and control systems can deliver an unprecedented amount of services to help operators diagnose problems and—for the first time—perform true preventive maintenance.

- Protection fault counts
- Motor control function counts
- Fault history
- Minimum wait times
- Time to trip
- Current maximum and start time of last start
- Motor operating time

LV and MV motor starter solution

A motor starter has four basic functions:

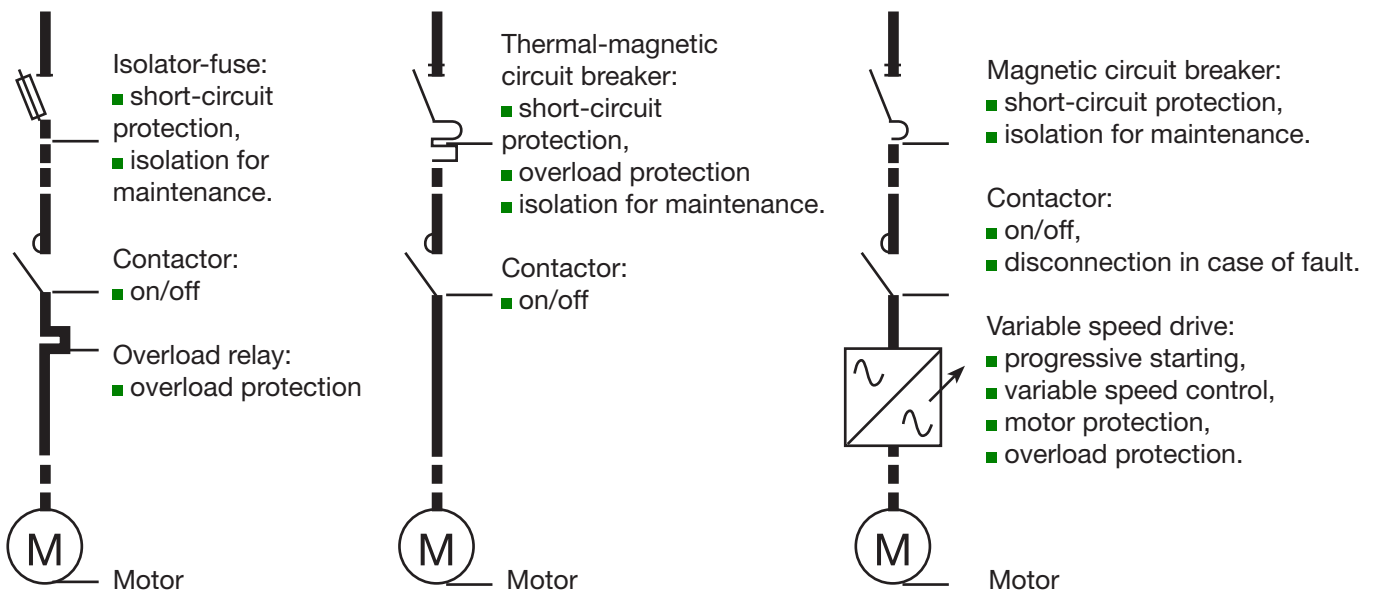
- Isolation
- Short-circuit protection
- On/off control
- Overload protection.

Motor starters can be enhanced with additional features depending on the requirements of a particular motor.

- Power features: speed adjustment, progressive starting, phase inversion, etc.
- Control features: auxiliary contacts, time delay, communication, etc.

A motor starter can be designed in one of three different ways according to the desired function.

Motor starter design and functions



There are several types of motor starters.

Main motor starter types (LV and MV)

Starting type	Starting mode	Description
Direct starting	1 Direct on line (DOL)	The simplest and least expensive starting mode, but can only be used if the load allows a large starting torque. Full voltage is applied directly to the motor; the starting current may be up to 10 times the nominal current (Is max #10 In).
	2 Star-delta starting	A simple and low-cost starting mode that reduces the current peak on starting. But the starting torque cannot exceed 1/3 of the nominal torque. The motor is started by coupling the windings in a star configuration under the line voltage (Is max #3 In).
Progressive starting	3 Soft starting	A high-performance starting mode that allows soft starting and stopping with limited Is. The motor is fed a gradually increasing voltage according to the current and torque limit settings. Is max (#3 to #4 In) is set during starting, but this decreases torque performance.
	4 Variable speed drive (VSD)	The most expensive and complicated mode, used for critical or specific loads like (conveyors or exhaust fans). In addition to the features offered by soft starting, VSDs allow continuous speed variation.
	5 Reverse motion	In addition to all starting mode the reverse motion is achieved 2 phases permutation (except VSDs where the controller handles both rotating directions).

For MV the functions are the same than for LV, but they are performed by specific units where each function is carried out in a separate cubicle or enclosure.

The starting mode names for MV motors are given in the following table.

Starting mode names for MV motor starters	Correspondence to starting mode names for LV motor starters
Full voltage non-reverse (FVNR)	Direct on Line (DOL)
Full voltage reverse motion (FVR)	Direct on Line (DOL)+ reverse motion
Reduced voltage with reactance (RV)	Soft starting (+ reverse motion)
Reduced voltage with autotransformer (RVAT)	Soft starting (+ reverse motion)
Reduced voltage with soft starter (RVSS)	Soft starting
MV drives	Variable speed drive (VSD)

LV Intelligent Power and Motor Control Center (iPMCC)

An iPMCC is a system integrating Intelligent Motor Protection Relays (IMPR) into a reliable Power Control Center (PCC) and Motor Control Center (MCC) switchboard, while communicating with plant control systems through an industrial communications network.



iPMCC offer significant advantages over conventional systems in terms of plant design, construction, and operations.

iPMCC's advantages throughout the plant's lifecycle

Plant design and construction		
Better efficiency	Shorter commissioning time	
Less engineering work since starters are standardized over a wider range. Less on-site wiring time due to the use of field buses. Less set-up time due to remote configuration of motor control devices.	A better understanding of process reactions through detailed troubleshooting and statistics. Faster troubleshooting and bug tracking. Support for resolving process start-up problems. Faster commissioning due to tested, validated, and documented architectures (TVDA).	
Plant operations		
Greater service continuity	Less unplanned downtime	
More accurate sensors. More accurate motor protection models.	Alarms giving operators time to fix the problem before the motor trips. Detailed trip criteria to facilitate corrective actions. Statistics for continuous improvement. Records of all changes to protection configurations.	
Operating costs		
Energy	Maintenance	Upgrades
Lower energy consumption. Benchmarking and cost allocation. Records of all changes to protection configurations.	Less downtime. Faster troubleshooting and repair. Less spare parts inventory. Enhanced preventive maintenance strategy.	Simplified engineering. No wiring required. Easier setup. Easier process tuning and commissioning.

Description of iPMCC's components

Intelligent motor protection relay (IMPR)

An **intelligent motor protection relay**—the key component of an iPMCC—is an electronic device with a microprocessor inside. It protects motors using current and voltage calculations; the device receives data from sensors and calculates potential motor faults and operator risks.

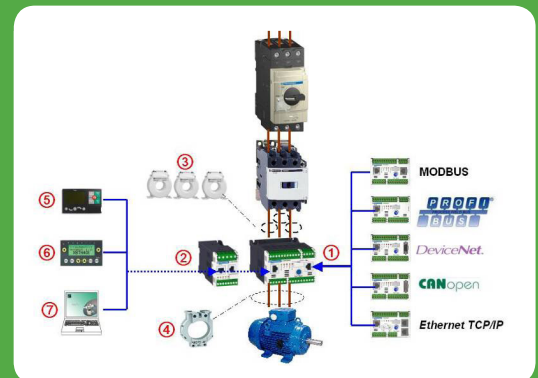
IMPRs can detect many kinds of faults. They are much more effective than conventional thermal relay protection systems, and can incorporate many complementary functions like monitoring, alarms, fault recording, statistics, and communications.

LV motor control center (MCC)

A LV motor control center (MCC) is an electrical switchboard that centralizes all motor starters of a given process. Many industries prefer such centralized control systems to facilitate operations and maintenance.

Critical applications typically employ withdrawable MCC functional units since they allow for easier repair in the event of fault; the faulty motor starter can be replaced quickly without locking out the entire switchboard. Less critical applications usually employ fixed or disconnectable functional units. MCC installation systems should type-tested assemblies (TTAs) to ensure the applications' safety and reliability. Type testing, especially rising temperature testing, is essential in iPMCC applications because the IMPRs in iPMCCs are more heat sensitive. Furthermore, MCCs should provide a reliable bus communications connection. MCCs are different from multi-purpose cabinets, which can group only a few motor starters.

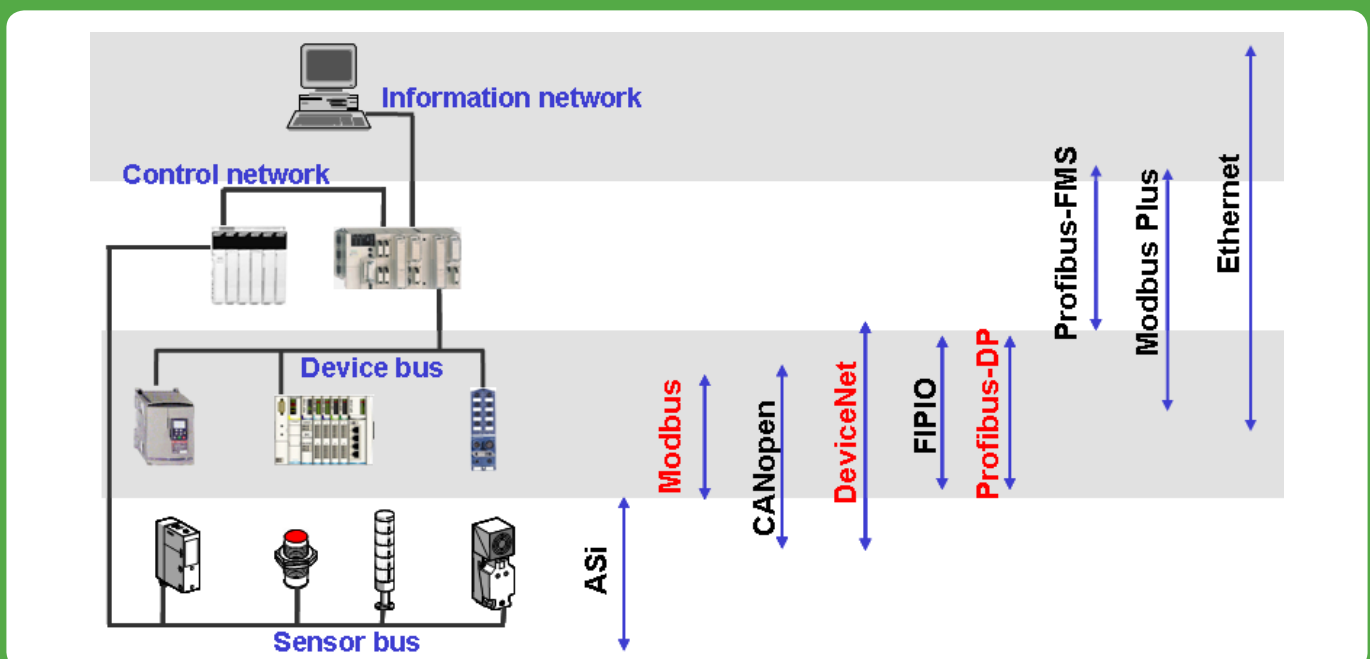
They have few electrical features and do not allow for separation between motor starters' functional units. Multi-purpose cabinets must be completely locked out to perform any starter maintenance or reconfiguration



Communications capabilities

iPMCC applications, typically comprising 50 to 1,000 motor starters, must process large amounts of data including motor status, current value, and any alarms. Conventional wire-to-wire connections are neither efficient nor cost-effective when a great deal of data must be transmitted. Today such data is usually transferred via a communications network.

Such communications networks need the support of a common language, which is the communications protocol. The following chart shows the protocols most commonly used in different levels of industrial communications networks.



Schneider Electric's offers

LV motor starters

Correspondence to starting mode names for LV motor starters	Schneider Electric offerst
Direct on Line (DOL)	Compact / Masterpact circuit breakers LD...thermal relays LC...contactors
Star- delta starting	Compact / Masterpact circuit breakers LD...thermal relays LC...contactors
Soft starting	Compact / Masterpact circuit breakers ATS 48, ATS 22
Variable speed drive (VSD)	Compact / Masterpact circuit breakers ATV 61 /71

MV motor starters

Starting mode names for MV motor starters	Correspondence to starting mode names for LV motor starters	Schneider Electric offers
Full voltage non-reverse (FVNR)	Direct on Line (DOL)	MCset, MV switchgear (for high short-circuit current)
Full voltagereverse motion (FVR)	Direct on Line (DOL)+ reverse motion	MCset, MV switchgear (for high short-circuit current)
Reduced voltage with reactance (RV)	Soft starting (+ reverse motion)	Motorpact RV
Reduced voltage with autotransformer (RVAT)	Soft starting (+ reverse motion)	Motorpact RVAT
Reduced voltage with soft starter (RVSS)	Soft starting	Motorpact RVSS
MV drives	Variable speed drive (VSD)	Altivar ATV 1000, ATV 1100

iPMCC: MotorSys™

MotorSys™ is Schneider Electric's flagship motor control system, available in three models according to the desired size and cost-effectiveness.

MCC and iPMCC positioning for WWTP

	WWTPT1	T2	T3	T4
MotorSys™ High Dependability iPMCC			++	+++
MotorSys™ Easy iPMCC		++	+++	
Conventional MCC	+	+		

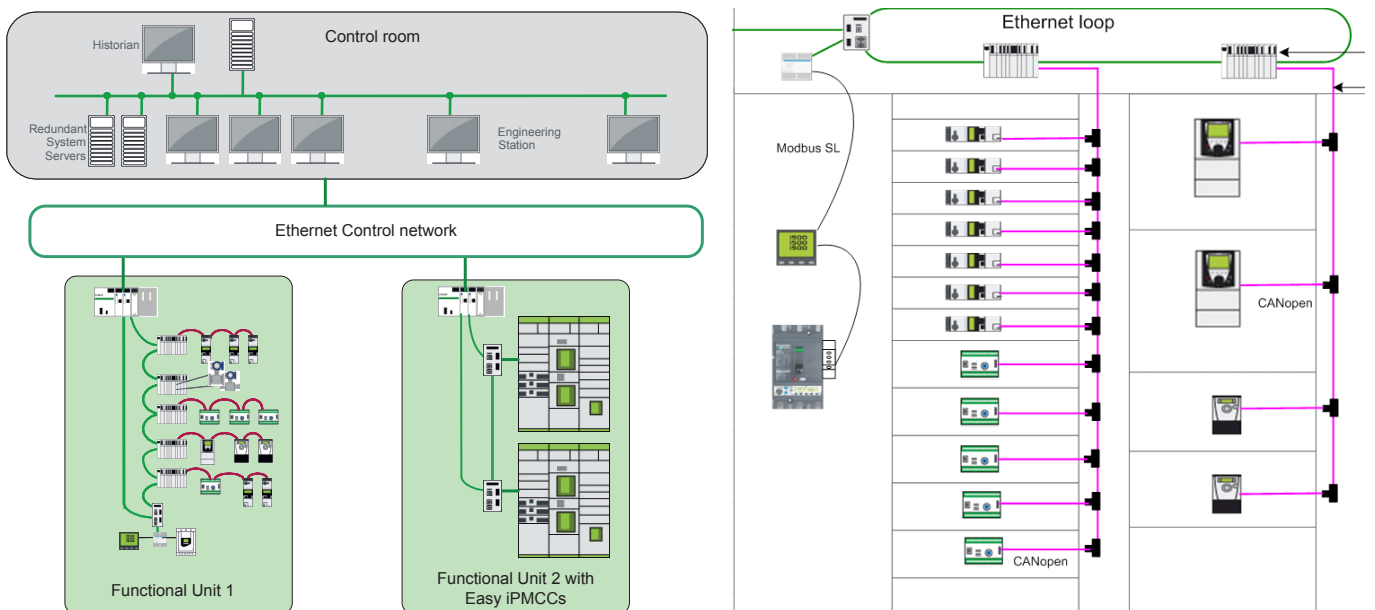
Model 1: Conventional MCC for WWTP T1

This basic system uses conventional overload relays. It is the cheapest system and boasts a very large installed base. However its operational costs rise as the number of motors involved increases, making it less cost-effective for larger applications.

Model 2: MotorSys™ Easy iPMCC

The Easy iPMCC system targets small- and medium-sized applications. Its main benefits are its reasonable overall cost and ease of installation, commissioning, and maintenance. The following diagram shows a PlantStruxure system architecture with several functional units, including the MotorSys™ Easy iPMCC for motor control.

Architecture with MotorSys™ Easy iPMCC



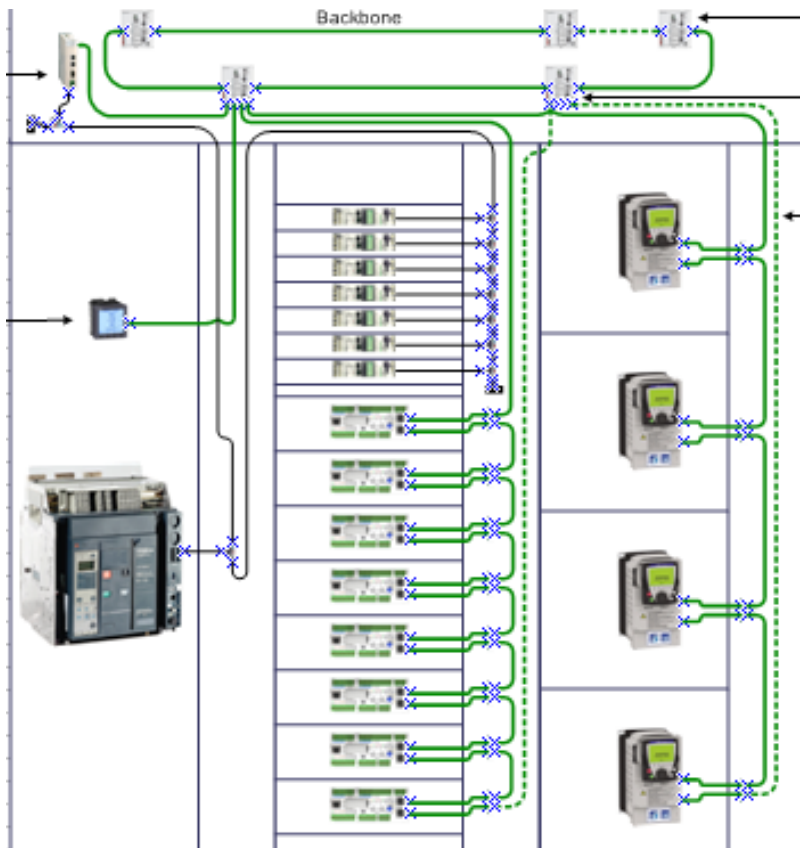
Model 3: MotorSys™ High Dependability IPMCC

The High Dependability iPMCC uses Ethernet-down-to-the-device technology. The main benefits of this system are:

- The ability to provide different levels of reliability according to a plant's needs, with a view to building an architecture with "no single point of failure" for motor control
- Maximum transparency for a high added-value service
- An open architecture due to the use of Ethernet throughout the system.

The following diagram shows a PlantStruxure system architecture with several functional units, including the MotorSys™ High Dependability iPMCC. A high availability PlantStruxure automation system with a dual Ethernet ring can be used to connect all functional units in the architecture to the control room. Ethernet allows for a wide array of network architectures, ensuring a high degree of flexibility

Architecture with MotorSys™ High Dependability MCC



Secure power supply

Reliable power is essential to wastewater treatment plants so they can comply with environmental regulations and avoid costly contamination.

Back-up generators and uninterruptible power supply (UPS) protection—combined with dependable power architecture and intelligent power monitoring systems—lets plants keep their equipment running, protect against data loss, and ensure data transfer among critical systems.

With a secure power supply at every step in a wastewater treatment process, critical systems can be kept running safely for reliable 24-hour plant operation.

Uninterruptible power supply (UPS)

Introduction

UPS systems are designed to protect critical loads from power variations and outages.

- Batteries supply the power in a UPS system, which prevents a total interruption but only for a limited time: from several minutes to several hours. Therefore, these systems are typically combined with a backup generator to ensure a continuous power supply, especially when a power interruption could have serious consequences. A UPS system's back-up time should be compatible with the time needed for the back-up generator to start-up and be brought on line.
- UPS systems are also used to supply power to loads that are sensitive to disturbances by generating a “clean” voltage that is independent of the grid.

Impacts and applications

Secure power via a UPS system is essential at several levels of a plant's operations.

- **At a process level**, to prevent the loss of control over critical processes at pumping stations or treatment units. This typically comprises the following critical loads, located in an electrical room or the plant itself:
 - Communications equipment
 - Process controllers and downstream remote I/O boards
 - Process monitoring instruments, intelligent electronic devices, and local control stations
 - Security systems (fire, access control, and video).

The usual required back-up power time is 30 min., although longer times may be needed in certain circumstances.

- **At a control room level**, to prevent data loss and server shutdown. This typically comprises servers, workstations, and communications equipment, with configurations ranging from a standalone server rack to a complete server room requiring cooling services and management.
- **Other critical loads**
Other equipment can be protected by a UPS system, such as:
 - Ultraviolet (UV) water disinfection systems, due to their sensitivity to variations in power quality
 - Inlet valves.

Recommended solutions

Technology

Double conversion on-line technology is recommended for the sensitive loads and harsh power conditions typical of water treatment applications. This technology provides excellent voltage conditioning (output voltage and frequency are independent of input voltage and frequency) and easy paralleling. The on-line operation means there is no transfer time during an AC input power failure, since the AC input charges the back-up battery supplying power to the output inverter.

N+1 redundancy for greater availability

For critical process data, engineers can install parallel redundant or “N+1” configurations (typically in server rooms). A parallel redundant configuration consists of paralleling several same-size UPS modules onto a common output bus. A system is N+1 redundant if the spare amount of power is at least equal to the capacity of one system module. With this configuration, the failure of a single UPS module does not prompt the transfer of the critical load to the electric utility feed. This configuration also allows for the UPS capacity to increase as the load increase.

UPS system architecture

At a process level, UPS system architecture can be centralized or distributed depending on a plant’s size and layout.

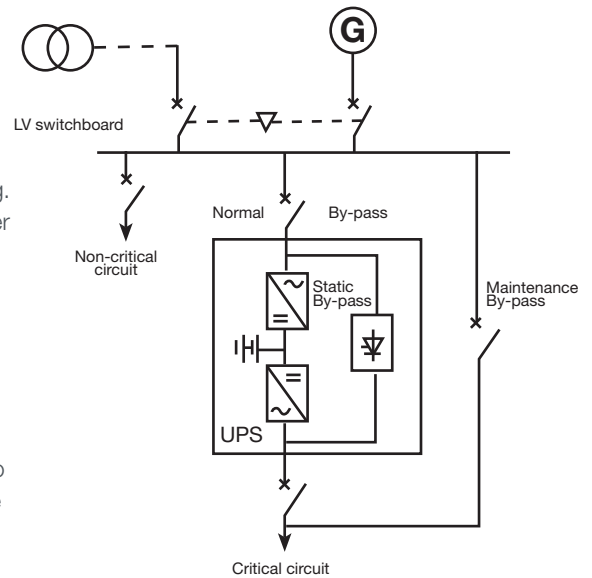
- **Distributed architecture** – One or more single-phase UPS modules are installed in each functional unit’s electrical room to supply critical loads. Standard design practice is to equip local process control panels with feeds from either a dedicated or a common UPS module depending on the panel’s location.
- **Centralized architecture** – Single- or three-phase UPS modules (depending on the power load) are installed in electrical rooms to supply critical loads over a large area or several functional units.

Full integration with monitoring and control architecture

Built-in or optional network management cards provide remote monitoring and control through a simple Web/SNMP interface or an industrial communications network (like Modbus).

Customized designs

System designs can be tailored to specific electrical, mechanical, and /or environmental specifications. Customized UPS modules can also be created for precision engineering.



Example of configuration for a double-conversion on-line UPS unit with standard normal and bypass AC inputs

Schneider Electric offers

Industrial Control Panel UPS® On-Line – Single-phase, 500VA, DIN-rail-mounted, online power protection with fixed runtime (5 min.).

Smart-UPS® RT – Single-phase, 1-20 kVA, high-density, double-conversion online power protection with scalable runtime.

Symmetra LX® – Single-phase, 2-16 kVA, N+1, highly available, redundant, and scalable double-conversion on-line power protection with scalable power and runtime.

MGE Galaxy® 300 – Three-phase (3:1; 3:3), 10-40 kVA power protection with excellent efficiency and reduced footprint. Designed for demanding industrial applications.

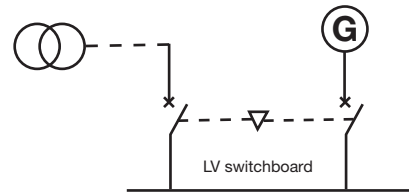
MGE Galaxy® 3500 and 5500 – Three-phase (3:1; 3:3), 10-120 kVA power protection with excellent efficiency and reduced footprint. Designed for demanding industrial applications.

Gutor PEW/PDW – Single- and three-phase, customizable DC and AC UPS.

Backup generators

Introduction

The power supplied by a backup generator is produced by an alternator driven by a thermal engine. A generator's backup time depends on how much fuel is available. A backup generator does not produce any power until it has reached its rated speed. Therefore, these generators are typically coupled with a UPS system to ensure a continuous power supply, especially for critical processes.



Impacts and applications

Backup generators are largely used in WWTP to supply power in the event of an outage. Their use is strongly recommended for medium and large WWTP (T3 and T4) and suggested for small WWTP.

In WWTP, generators are used as well for production of energy from biogas. In this case, the generators supply power to the electrical network or supply partially the WWTP. These generators are part of a co-generation system and are not considered as backup generators.

Recommended Solutions

Generators usually do not run on medium voltage, except in the following situations:

- Co-generation and local bio-gas production, to lower energy costs; or
- When a power grid has little spare capacity or is not available.

Low-voltage backup generators generally operate independently of a grid, so a source switching system is usually necessary.

Full integration with the monitoring and control architecture

Power monitoring and control systems display essential process data for operators, including:

- Generator set running hours
- The temperatures of generator windings and bearings
- The power consumption of particular loads.

These systems can also be used for preventive maintenance, and to provide the data required by a load shedding system. Operators should test their backup power supply systems on a regular basis (e.g., monthly), to prevent power outages. With power monitoring and control systems, key data like generator running times, temperatures, and required power can be easily viewed and printed in a report.

Schneider Electric offers

Emergency Power Supply test solution
able to detect and prevent power incidents taking down the entire plant. This solution ensures correct testing methodology and detailed reports that reduce your risk and liability.

Automatic Transfer Switch

Power Monitoring and Control system

Power monitoring and control systems

Introduction

Power monitoring and control systems (PMCSs) are used to control medium-voltage (MV) and low-voltage (LV) devices on an electrical network. They give operators essential information to keep a plant running, and help plant engineers reduce a plant's energy consumption and carbon footprint.

Coordinated control features can be used to manage the electrical network, demand/response, loads, and generators. PMCSs can also track real-time power conditions, assess power quality and reliability, and help operators respond quickly to alarms to avoid crisis situations.

Plant engineers can use PMCSs to study power usage trends to identify idle capacity or wasted energy, or to evaluate energy efficiency improvements. PMCS software typically includes load aggregation and calculation features, and can be connected to an Energy Management Information System (EMIS) for advanced energy management.

Challenges

A reliable power supply is crucial to ensuring a plant's continued safe operation. Factors such as a harsh climate, site upgrades, and aging equipment can diminish the reliability of a power supply and increase the risk of a power outage. To mitigate this risk, plant operators need to be able to effectively monitor and control a plant's electrical network.

In addition to reliability, power quality is another key issue, especially in terms of sensitive loads. Assessing power quality is a complicated task requiring real-time data, special software, and troubleshooting expertise. With these capabilities, operators can perform a root cause analysis and capitalize on prior experience to determine the best course of action to mitigate risk.

As communication systems become increasingly intricate, operators need more advanced skills and systems to manage power efficiently. Communicating electrical devices give operators essential process data, but these data must be translated into actionable information in order to facilitate decision making for maintenance, energy efficiency, and equipment management. A PMCS can be a valuable tool for aggregating data, making it easy to understand, and helping with plant commissioning and troubleshooting.

Recommended solutions

A PMCS consists of software, hardware, and communications devices assembled into different architectures (like integrated or collaborative) depending on a plant's needs.

The PMCS components are:

- **Software**

- Human-machine interface
- Redundant I/O server
- IEC61850 compliant databases

- **Hardware**

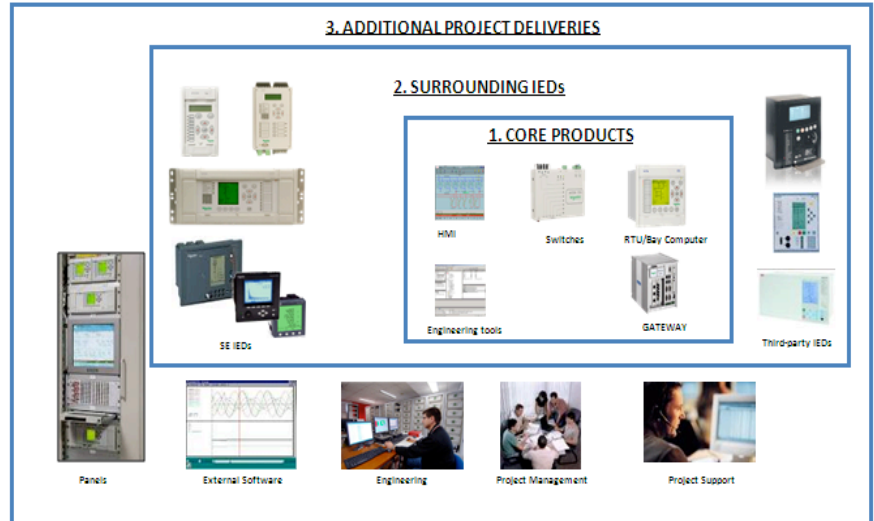
- Remote terminal units (RTUs)
- Programmable logic controllers (PLCs)
- Switches
- Sensors and actuators

- **Communications network**

- IEC61850 compliant databases
- Distributed, multiple server architecture
- Redundant, self-healing ring, double-ring technology

- **Server(s)**

Implementing a PMCS requires outlining specific processes, training operators, and providing support—especially during plant operation.



Schneider Electric offer

Schneider Electric offer, including software, hardware, communication network and server:

PowerLogic SCADA software

- Reliable data acquisition
- Interactive graphics
- Alarm management
- Schneider Electric device support
- Intuitive commands and control
- Software redundancy

Schneider Electric devices

PowerLogic electrical network protection:

- Sepam series 20, 40, 80, SEPAM 2000 (S36)

PowerLogic power and energy meters:

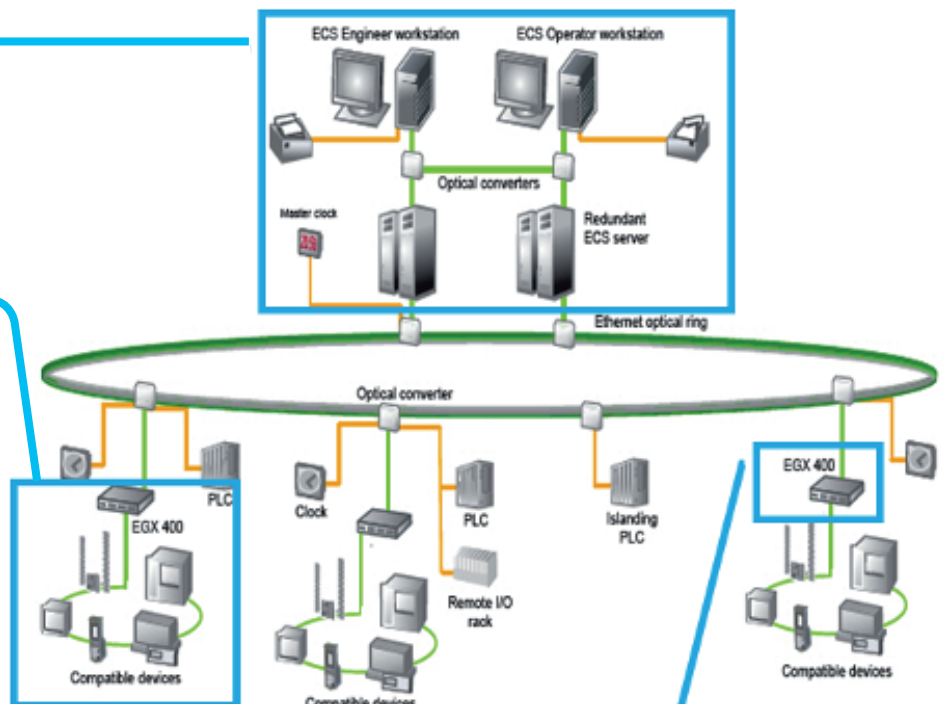
- PM800 series
- PM710, PM750
- CM4000 series
- ION 7650

Circuit breaker control units:

- Micrologic 5.0P and 6.0P
- Micrologic A, and Micrologic A FW v2
- Micrologic H

Branch circuit monitors:

- BCPM, BCM42



Communication hardware products

- Gateways
- PLCs, RTUs

The main features of the Schneider Electric PMCS are:

Data acquisition and integration

PMCSs integrate power supply devices with PLCs, RTUs, controllers, and other intelligent energy devices. They can provide native, out-of-the-box support for all SEPAM Series 20, 40, 80, and SEPAM 2000 (S36), Micrologic 5.0P and 6.0P, Micrologic A,E, Micrologic A FW v2, Micrologic H, PowerLogic CM4000 series, PM800 series, PM710, PM750, ION7650, and BCPM/BCM42 devices. They enable access to meter data, can be used to control protection relays and digital outputs, and allow for remote configuration. They also interface with PLCs, RTUs, and electrical network equipment, as well as with other energy management or automation systems through Modbus TCP/IP. Devices can be added easily and configured rapidly with the easy-to-use Profile Wizard and Profile Editor. A scalable platform allows for remote devices and for user clients to be added as needed.

Alarms and events with 1ms timestamp support

PowerLogic SCADA software sends operators alerts for outages or impending problems that could lead to equipment stress, failures, or downtime. Alarms can be configured to trigger on certain events, power thresholds, or equipment conditions. The software includes an event log for all PC-based and field events and alarms, including related conditions at the time of the event or alarm—all with accurate 1ms time stamping. It can easily discriminate between alarm levels (from less-critical to highly-critical) with a high-speed alarm response.

Operators can sort, filter, and print data by any alarm property, and configure specific alarms to change symbol color or flash an icon on a page. Operators can also view the five most recent alarms from every page, providing detailed information in an easy-to-understand format.

Power equipment control

With a PMCS, operators can perform fast, manual control operations by clicking on trigger buttons, and operate remote breakers, protection relays, and other power distribution equipment.

Real-time monitoring

PMCSs let operators monitor all power distribution points in an electrical network. They can view real-time power and energy consumption data, past trends and data logs, alarm conditions, equipment status (on/off, temperature, pressure, etc.), control triggers, and analysis tools. Single line diagrams allow for real-time monitoring and control of electrical network devices and power distribution points. Point-and-click navigation reveals deeper layers of detail. The software's IEC- and ANSI-standard symbols and templates are fully animated and interactive, combining control and display functionality. Operators can easily configure the software's dynamic coloring with default and user-defined colors and voltage levels.

Analysis

Operators can plot trends on any variable a PMCS tracks, letting them instantly identify patterns that may lead to disturbances. A PMCS displays millisecond-accurate alarm data to help operators determine a particular sequence of events or perform a root cause analysis. By combining trends and alarm data, operators can carry out sophisticated disturbance analyses. The user-defined color coding and overlays show data series, time ranges, thresholds, and limits clearly. Operators can also view waveforms using ActiveX (waveforms from the ION8650 are captured via IEC61850 only), and they can record, save, and export trend data to archives.



Energy efficiency technology

Below is an overview of technology commonly used to lower a Wastewater Treatment Plant's (WWTP) energy consumption—without any significant change in its processes.

Low-loss transformers and motors

A new generation of transformers and motors made with high performance iron sheets and increased cross section copper windings can improve overall efficiency by up to 5%.

High-efficiency UV lamps

Ultraviolet (UV) radiation is a commonly used for disinfection in wastewater treatment plants since it can effectively neutralize most viruses and germs. UV disinfection also eliminates the need to generate, handle, transport, and store toxic, hazardous, or corrosive chemicals. UV radiation is produced by striking lamps containing mercury vapor with an electric arc to generate a charge. Low-pressure, high-intensity lamps are the more energy efficient technology.

Variable speed drives

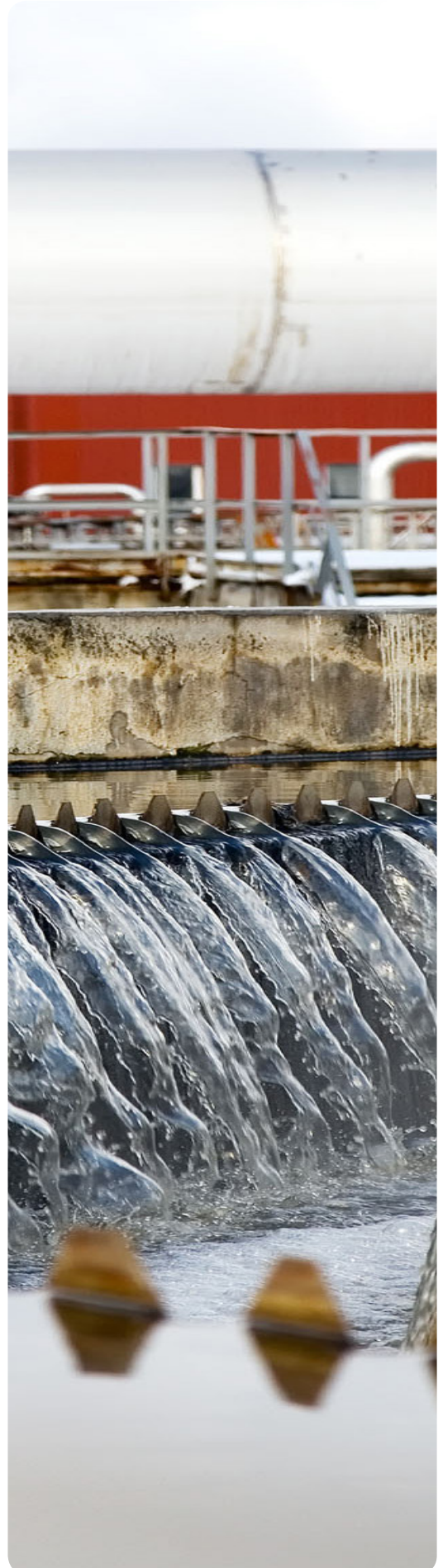
Without a variable speed drive (VSD) pump, the pump's driving motor is typically run at a fixed speed and liquid flow is controlled with a valve or throttle. This means that the power requirement is virtually the same regardless of the liquid flow rate. However, if the valve or throttle is left fully open and the driving motor is adjusted to control the liquid flow rate, the power requirement can be slashed by 50% at an 80% nominal flow rate, for example. Therefore, substantial energy savings are possible wherever a plant uses a variable flow rate. Schneider Electric has developed a line of variable speed drives for pumping and other applications: Altivar 21 and Altivar 61.

MV motor supply

Using a medium-voltage power supply for high-power (> 100kW) motors reduces the line currents, thereby diminishing the Joule losses in transformers, cables, and motors. A low-voltage power supply may be cost-prohibitive for large equipment or when several sets of cables are needed. Two configurations are possible for medium-voltage variable speed drives:

- A variable speed drive operating directly at a medium-voltage; or
- The use of step-down/step-up transformers, so that the power circuits are operating at a low voltage (400V or 690V).

The latter configuration has several advantages: it is easy to install, easy to retrofit, does not require a new motor, allows for easier maintenance, spare parts are more readily available, and it employs proven, widely-used technology. The same inverter can be used if a plant later decides to switch to a low-voltage motor. Schneider Electric has developed a line of medium-voltage motor controllers: **Motorpact** starters and **Altivar** variable speed drives.



Energy management information system (EMIS)

Introduction

An EMIS tracks an organization's energy performance, giving managers the information they need to boost energy efficiency and reduce energy costs.

An EMIS is typically composed of:

- Metering architecture, including a communications network and power meters and sensors
- Software to collect, store, and report energy data, process data, and key performance indicators.

Challenge

Energy is typically the biggest operating expense for a Wastewater Treatment Plant (WWTP). Moreover, plants' energy needs are increasing rapidly due to population growth, stricter discharge regulations, and aging infrastructure. Most WWTP can cut their energy costs by 30% or more with the effective use of energy management information systems, energy efficiency measures, and process optimization.

Recommended solutions

An EMIS should:

- Collect data on energy consumption, process inputs and outputs (like m³ of water treated or kg of dry sludge), and other factors that affect energy consumption (like biological or chemical oxygen demand).
- Consolidate data and track key performance indicators such as kWh/m³ (power needed to treat one m³ of wastewater), kWh/kg BOD (energy required to eliminate 1 kg of Biochemical Oxygen Demand), and t CO₂-eq (equivalent tons CO₂ emissions).
- Generate energy performance tables, charts, and reports.

An EMIS can be implemented:

- At a plant level, to improve the plant's operational efficiency by eliminating energy waste, and cut the plant's production costs
- At a corporate or municipal level, to allocate costs more effectively, boost energy efficiency, and comply with environmental regulations.

An EMIS should bring the following benefits for a WWTP:

- Cut energy consumption without affecting water quality
- Benchmark best practices across plants
- Negotiate more favorable power supply contracts, avoid billing errors, and sub-bill more accurately
- Optimize energy sources
- Improve energy quality
- Enhance CO₂ emissions control for a smaller carbon footprint
- Comply with environmental regulations.

ISO 50001:

An energy management program is typically based on the Plan-Do-Check-Act process recommended by ISO 50001. This process helps plants establish and prioritize energy conservation targets (Plan), implement specific practices to meet these targets (Do), monitor and measure energy performance improvements and cost savings (Check), and periodically review progress and make adjustments to their energy programs (Act). The use of an EMIS is strongly recommended at the Check phase.



Schneider Electric offers

Schneider Electric has developed end-to-end energy management solutions that can be implemented at both a plant and corporate or municipal level.

Our systems help corporations and cities lower their energy bills, shrink their carbon footprint, and underscore their green image by:

- Providing essential data for reducing energy consumption and measuring the effects of energy efficiency efforts
- Consolidating data at a corporate or municipal level for generating reports and benchmarking.

For individual WWTPs, our systems can cut the plant's energy consumption and, subsequently, operating costs by:

- Tracking the energy performance of various processes
- Reducing plant downtime and energy waste
- Enhancing the energy efficiency of plant equipment.

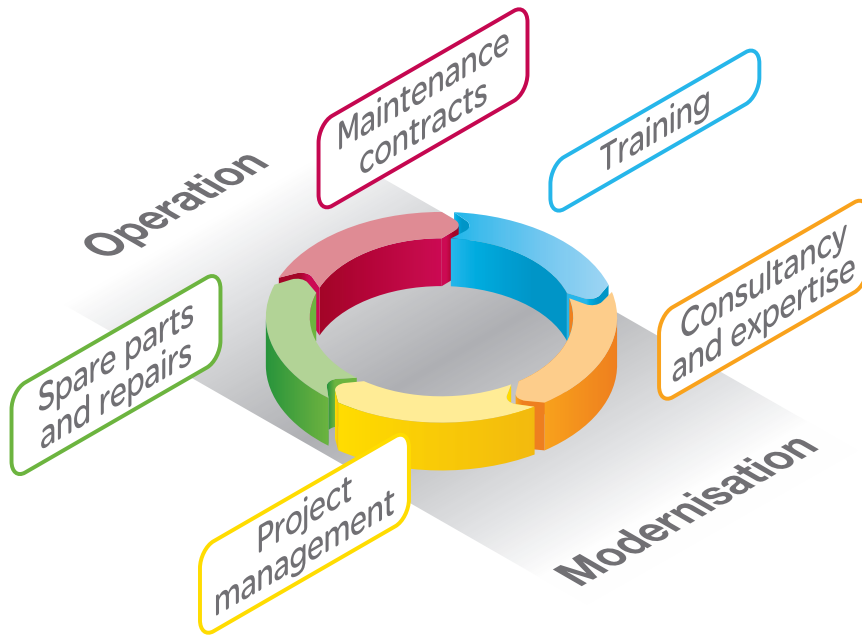
Our systems also provide a high-level, consolidated view of the cost and benefits of energy management and sustainability plans. They let sustainability managers track energy savings and cost control indicators like ROI and GHG emissions—to make sure their organization is on track to meeting its targets.

Our systems include tested, validated, and documented metering architecture that is both modular and scalable, so as to meet a plant's changing needs and capacity for investment.



Productivity software,
tools and services





To support the water process throughout its life cycle, from the electrical network design, during operation and to modernization, we offer various services available in all countries.

Our network of qualified partners and our projects and service centres are able to provide electrical network services.

Design phase services

To ensure efficient solutions for WWTP project and high performance operation, we offer software, tools and services to support for structured preliminary and final design, and for specification for tender:

- Consultancy and expert services
- Energy efficiency solutions
- Critical power solutions

Operating phase services

To avoid unexpected downtime of WWTP application, ensure a constant performance level and to reduce operating costs:

- Maintenance and spare parts management
- Site audits and repairs
- Training

We conduct power quality and harmonic studies to identify previously undiagnosed problems that can reduce equipment life and interfere with reliable operation. As the upgrades come online, our installation services verify that the new equipment is damage-free, properly installed, and ready to meet optimum performance standards.

Modernization phase services

To reduce risks after a long period of WWTP operation and improve the performance of applications:

- Diagnostics and feasibility studies
- Retrofit expertise and consultancy
- Project support

A systematic approach to upgrades and retrofits is the key to extending equipment life at a fraction of the replacement cost. We upgrade or replace circuit breakers with new technology; develop switchgear retrofit solutions; recondition LV and MV power circuit breakers; replace or repair drives.

Commercial reference
samples for designed
and implemented
electrical networks in WWTP
(IEC & Nema)



Wastewater treatment plant, Csepel (Hungary)

Customer profile

Genesis of the project

Some years ago in Budapest, Hungary, 600 000 m³/day of wastewater were discharged into the Danube. 46 % of this water were not treated at all.

In 2002, the Hungarian Program for Treatment of Waste Water specified that the City of Budapest City must to comply in 2010 with the objectives of the 1994 Sophia Convention, which aimed at the protection of the Danube. In addition, the treated water must also meet EU standards.

Customer objectives

The City's two objectives involve the construction of a plant capable of treating effluents generated by a population of 1,5 millions inhabitants.

Veolia and Suez are leading the consortium designing this wastewater treatment plant with a capacity of 350000 m³/ day, the largest in the European Union. To achieve this, the consortium needs a unique partner, Schneider Electric, taking the full responsibility of process automation and delivery of energy management solution.

Customer benefits

- By reaching 95% of wastewater treated instead of 54%, Budapest City will comply with European Union regulation
- The new wastewater treatment plant will allow energy efficiency
- Schneider Electric allowed for a 15% design cost reduction in design cost

Solution overview

A turnkey solution

- Complete study and design of the architecture.
 - Project management
 - Standardization and objects library creation
 - Full delivery and commissioning of motor control, process automation and energy efficient electrical network, from medium voltage to low voltage.

The upstream collaboration with Schneider Electric at the design stage allows standardisation and minimizes the risks all along the project.

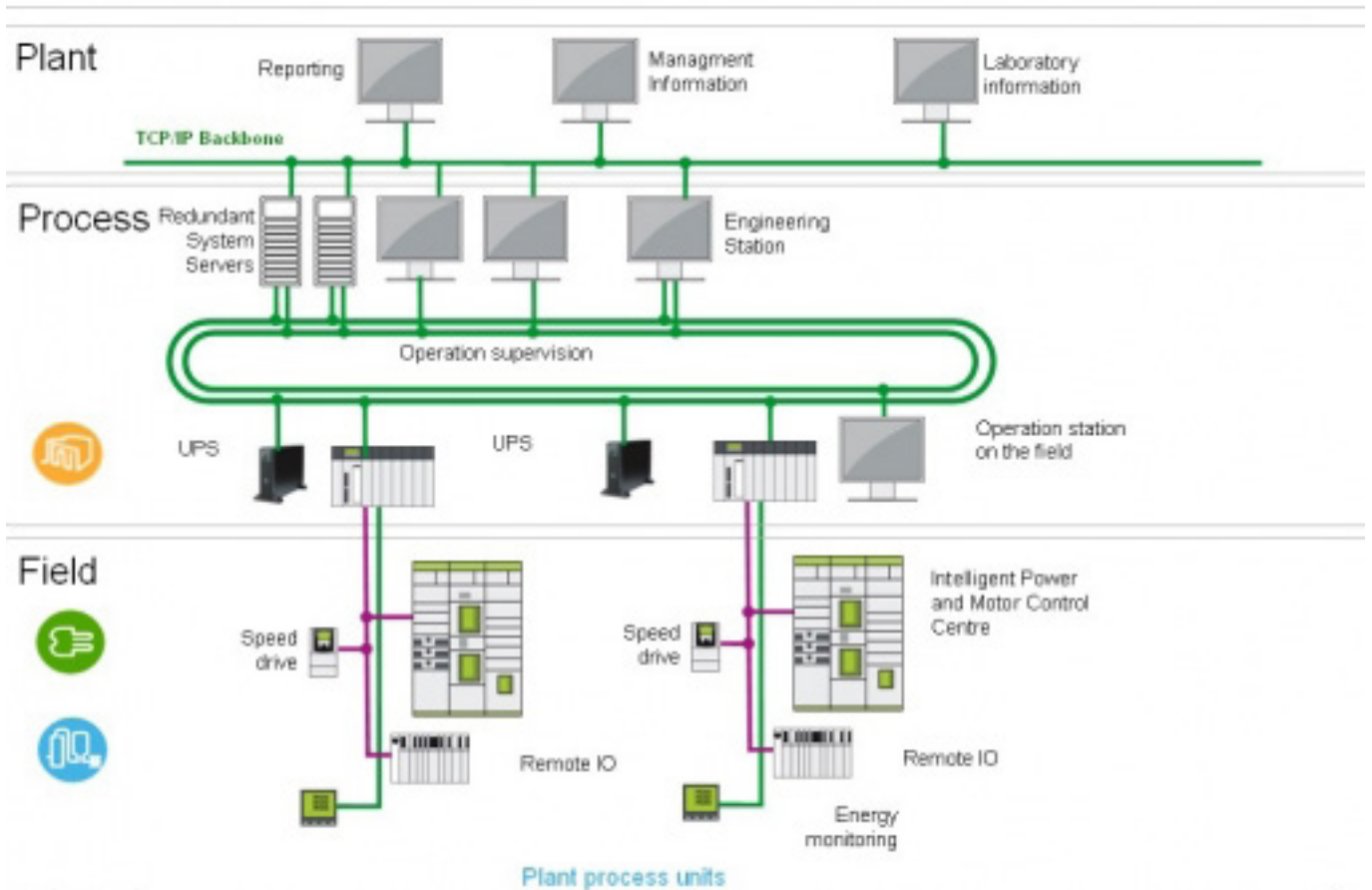
Schneider Electric's added value

- Schneider Electric is a global company well implanted in Hungary. Furthermore, Schneider Electric is a key and regular partner for Veolia and Suez.
- Schneider Electric, ensured a single point of contact for the customer, fully managed the key steps of the project, providing a turnkey electrical network and automation
- Deep technical involvement – not only limited to products but mainly focused on applications and projects.

Key figures

- ≥ 15% design cost reduction
- ≥ 95% of wastewater treated

Csepel WWTP architecture



Wastewater treatment plant, Dijon

Customer profile

- Degremont: Design&Build and commissioning of the plant
- Lyonnaise des Eaux: Plant operation

Both companies are subsidiaries of Suez Environment

- Plant size: 400 000 equivalent inhabitants (70 000 m³/day)

Customer objectives

- No process interruption: this could result in the release of wastewater into the environment
- Energy efficiency: conservation of energy resources
- Environmentally friendly: high quality water released into the environment and no odour nuisance for the neighbourhood (compliance with EU regulations)

Customer benefits

- High level technical support by having a single manufacturer's equipment for the automation and electrical network systems
- Flexible and extendable solution

Solution overview

A full Power & Control solution



- MV supply with open ring
- Each process step managed as a functional unit connected with Ethernet bus

Schneider Electric's added value

- Customer intimacy
- Complete Power and Control solution
- Energy Efficiency expertise

Key figures

- 15% energy savings
- 95% availability

Wastewater treatment plant, Atotonilco (Mexico)

Customer profile

Genesis of the project

The Hidalgo state is one of the principal sources of agriculture in Mexico. Previous irrigation of fields using untreated wastewater has been a cause of major health and environmental concerns. As a part of the Sustainable Water Programme for the Mexico Valley, a water treatment plant in Atotonilco, 60 km from Mexico city, will be built.

Customer objectives

The National Water Commission of Mexico, Conagua, intends to significantly improve environmental conditions and raise the overall water treatment rate in the country. Additionally, the project will provide treated water for irrigation of around 80,000 ha in the Tula Valley of Hidalgo, concurrently improving living conditions of approximately 300,000 inhabitants in the region without access to treated water.

Customer benefits

- Atotonilco project will significantly improve environmental conditions and raise overall water treatment rate of the country from 36% to 60%.
- Improved living conditions for the inhabitants and the quality of surface water bodies and streams that receive the wastewater.

Solution overview

A turnkey solution

Through a consortium led by Impulsora del Desarrollo y el Empleo en America Latina (IDEAL), and other stakeholders including ICA, DYCUSA, Green Gass, Atlatec, the Build-Operate-Transfer (BOT) will take place in two phases over three years.

- **Phase 1:** Reach a capacity of wastewater treatment of 23 m³/sec
- **Phase 2:** Increase the wastewater treatment capacity 12 m³/sec

Schneider Electric's added value

- Schneider Electric's global presence making it a reliable partner with proven practices around the world.
- Schneider Electric has a deep technical knowledge of electrical distribution not limited to products but also focused on applications and project management.

> For more information, go to the Schneider Electric website/Solutions > Water
www.schneider-electric.com

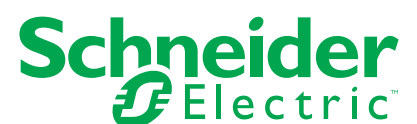
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