

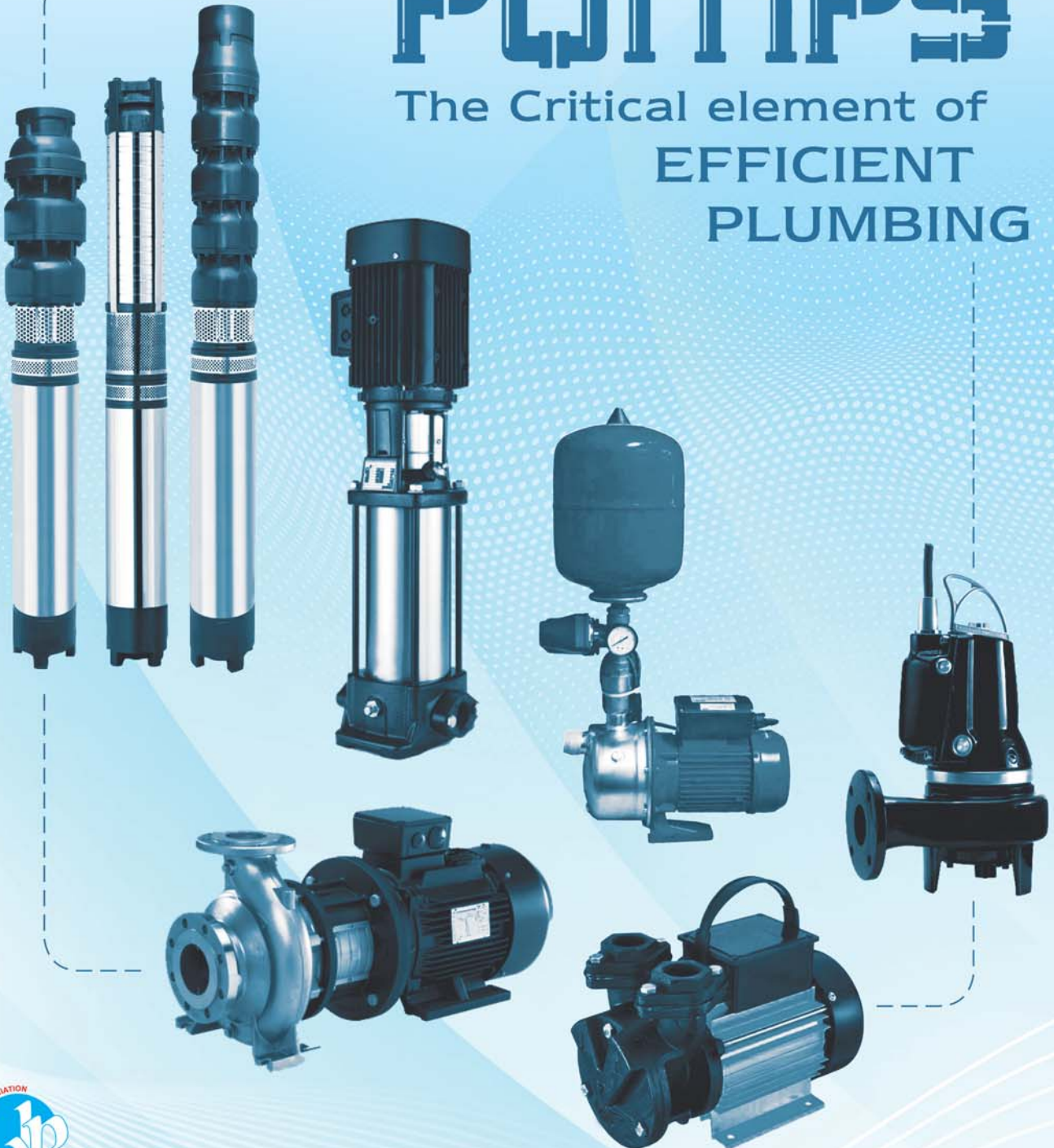
Indian Plumbing Today

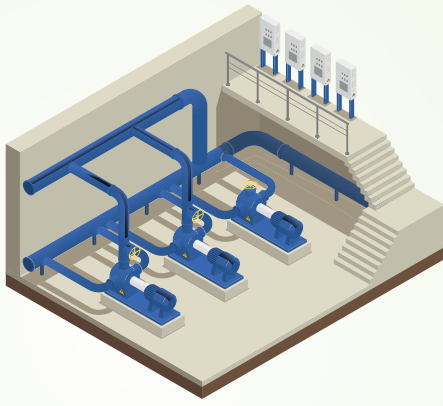
Vol 06/ Issue 05/ August 2024

Annual Subscription : ₹ 240

PUMPS

The Critical element of
EFFICIENT
PLUMBING





Optimizing Water Sustainability and Efficiency: The Vital Role of Hydro pneumatic pumping Systems

- Avinash Mishra & Madhubanti Dutta

Who doesn't enjoy a constant, smooth flow of water at home? While local utilities provide water through their pipeline network, pumps are essential for pushing the water stored in overhead tanks. These pumps ensure that water is consistently available at the desired pressure, maintaining a reliable and steady flow throughout your home.

Introduction

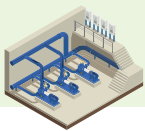
Water resources provide a crucial range of services essential for sustainable development. Their continuous demand is driven by population growth, industrialization, and policies related to food and energy security, along with evolving production and consumption patterns. The United Nations Sustainable Development Goals, particularly Goals 6, 11, and 12, emphasize actions to ensure access to safe water, enhance resource efficiency, and promote sustainable consumption patterns. According to the UN General Assembly (2015), the water sector's energy consumption globally accounted for 120 Mtoe in 2014, mostly in the form of electricity, representing 4% of the total global electricity consumption. Water supply and distribution are the largest energy consumers within the sector (IEA, 2016).¹

New challenges in water systems encompass diverse approaches, ranging from failure analysis and risk assessment to enhancing system efficiency and developing innovative designs. In water distribution networks (WDNs), the risk function measures the network's vulnerability and potential security loss. Analyzing transient flows, which represent the most hazardous operating conditions, is essential for ensuring system reliability in terms of water quantity, quality, and management. Specific equipment like air valves in pressurized water pipes manage the air

associated with the filling process and can serve as control mechanisms, though their reliability is a primary limitation. Advanced tools have been developed for the implementation and operation of smart water grids. Improving water system efficiency and addressing the water-energy nexus involves the use of appropriate pressure control and energy recovery devices, as well as pumped-storage hydropower solutions, to achieve the most technically and cost-effective outcomes. Integrating water and energy analysis supports more reliable, flexible, and sustainable eco-design projects, leading to more resilient systems through innovative concepts.

Improving the management of these systems in terms of energy and resource efficiency is critical for sustainable water use and overall development strategies. Water supply systems (WSS) are extensive infrastructures that transport water over vast areas, leading to significant environmental impacts such as high energy consumption and greenhouse gas emissions due to water pumping processes and water losses. Pumping systems alone can account for up to 90% of the sector's energy consumption (IEA, 2016; Lam et al., 2017; Grundfos, 2004). Retrofitting pumping equipment with more efficient solutions, including variable speed motors and enhanced control systems, can yield substantial energy savings (Marchi et al., 2012). Innovative technological and non-technological

1. UN General Assembly (2015)



techniques are vital to addressing water challenges while keeping solutions cost-effective, as advocated by the Water Supply and Sanitation Technology Platform (WssTP, 2018). Digital tools, such as system monitoring, hydro-informatics, data analytics, simulation, and optimization algorithms, are crucial for improving system efficiency and supporting decision-making within integrated water-energy frameworks.

Why is Pump Efficiency Important?

The efficiency of a pump is crucial because it directly impacts operational costs. An inefficient pump wastes energy, leading to higher electricity expenses to power the pump. Additionally, inefficient pumps tend to wear out faster, increasing maintenance costs. Frequent breakdowns result in production stoppages, increased labour, and more spare parts needed for repairs, all contributing to higher operational expenses. Therefore, using an efficient pump not only conserves energy but also reduces costs and enhances overall system reliability.

The design of pumping systems in commercial buildings adheres to the standard that ensures reliability by requiring the remaining pump or pumps to provide the maximum daily pumping capacity if any pump is out of service, as outlined by the (GLUMRB 1992) guidelines. Water distribution systems can be categorized into systems with storage and closed (dead-end) systems. Systems with storage offer numerous benefits, such as reliability during power outages, damping pressure transients, meeting peak demand during emergencies, and enabling pumps to operate efficiently to minimize energy use. However, these systems can be impractical due to costs, lack of suitable tank sites, or aesthetic concerns. On the other hand, closed systems, which must run at least one pump continuously to maintain pressure, face challenges such as demand variability, over-pressurization risks, and energy waste from throttling or recirculation. While variable-speed pumps can reduce energy waste, their high cost often rivals that of the pumps themselves. Consequently, the initial cost of setting up a pumping station generally favours the use of two constant speed pumps, each capable of delivering the peak design flow. Balancing reliability, efficiency, and cost is crucial in selecting the appropriate pumping system for commercial buildings.

The Importance of Pumping Systems in Commercial Buildings

Pumping systems are vital to the operations of commercial buildings, ensuring the smooth movement of water for various essential functions such as heating,

cooling, pressurized water supply, and wastewater management. These systems are integral to maintaining comfort and functionality across a diverse range of spaces, including office complexes, shopping malls, hotels, and hospitals. The key applications of pumping systems in commercial buildings include:

- **Hydropneumatic Systems:** Providing uniform pressure across all outlets.
- **Plumbing Infrastructure:** Ensuring a reliable water supply and managing wastewater through sewage and drainage systems.
- **Fire Protection Systems:** Supplying water to fire sprinkler systems for emergency fire suppression.
- **HVAC Systems:** Circulating water or refrigerant for heating, ventilation, and air conditioning.
- **Water Features:** Maintaining decorative fountains, waterfalls, and other architectural water features.

Advancements in Pump Technology

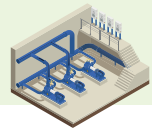
Recent technological advancements have significantly improved the efficiency and performance of pumping systems in commercial buildings. Some of the latest pump varieties include:

- **Variable Speed Pumps:** These pumps offer flexibility and energy savings by adjusting their speed to match varying demand, thereby reducing energy consumption and operational costs.
- **Booster Pumps:** Designed to enhance water pressure in multi-story buildings, ensuring adequate pressure for both domestic and commercial applications.
- **Submersible Pumps:** Commonly used for drainage, sewage, and wastewater management, these pumps operate while submerged in water, making them ideal for basements and underground facilities.
- **Centrifugal Pumps:** Utilized in HVAC systems, these pumps use centrifugal force to circulate water or coolant, providing efficient heating and cooling.

Best Practices for Selecting Pumping Systems in Commercial Buildings

Choosing the right pumping system for a commercial building requires careful consideration of several factors:

- **System Design and Sizing:** Conduct a thorough analysis of the building's requirements, considering flow rate, pressure head, and system dynamics. Work with experienced engineers to design systems tailored to the specific needs of the property.



- **Energy Efficiency:** Opt for energy-efficient pumping solutions to minimize operational costs and reduce environmental impact. Consider variable frequency drives (VFDs) and high-efficiency pumps to optimize energy consumption based on fluctuating demand.
- **Reliability and Redundancy:** Incorporate backup pumps and systems to ensure reliability and mitigate the risk of downtime and system failure. Implement predictive maintenance strategies to detect potential issues early and prevent costly disruptions.
- **Integration and Control:** Integrate pumping systems with building management systems (BMS) for centralized monitoring, control, and optimization. Use advanced control algorithms and sensors to adjust pump operation in real-time based on occupancy patterns and environmental conditions.

Sustainable Water Distribution with Hydro pneumatic Systems

A hydro pneumatic tank contains pressurized air and water without a bladder, allowing direct contact between the two. The compressed air acts as a cushion to exert or absorb pressure. This type of tank serves three main functions:

1. Delivers water within a selected pressure range, preventing the well pump from continuously running.
2. Prevents the pump from starting up with every minor call for water.
3. Minimizes pressure surges (water hammer).

Well pumps and booster pumps work with pressure tanks to maintain consistent pressure. The pressure tank regulates the pump cycle rate to avoid overheating and premature motor failure. Hydropneumatic tanks function best with an air cushion of $\frac{1}{4}$ to $\frac{1}{2}$ the tank capacity. As water absorbs air, the cushion decreases, reducing the tank's ability to pressurize the system. Automatic air replenishment is necessary to maintain proper operation.

If a pressure tank becomes waterlogged, the motor cycles too frequently (more than six times an hour), leading to:

- Higher energy costs due to frequent motor starts.
- Inefficiency, especially in deeper wells.
- Increased risk of equipment failure from overheating.

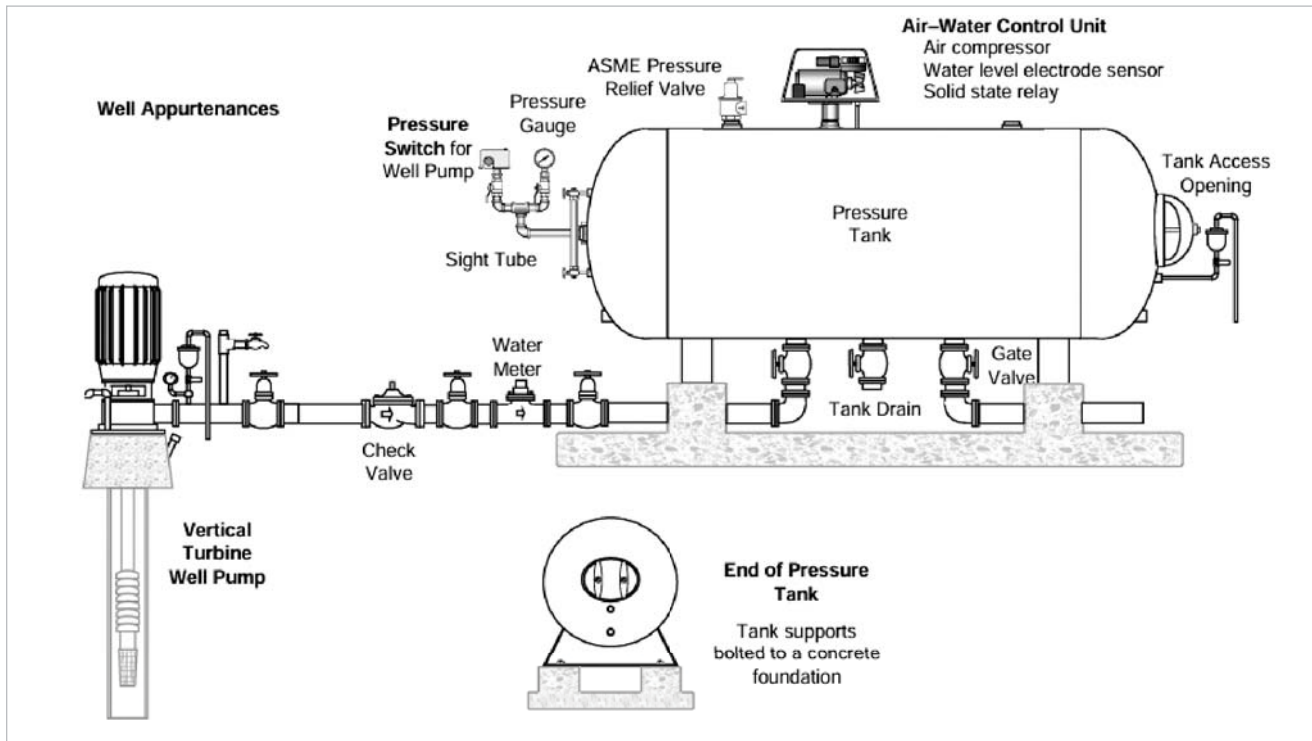
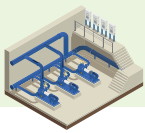


Figure 1: The setup of a hydropneumatic pressure tank system used with a well pump

Source: Washington State, Dept of Health

Diagram Credits: Drinking Water Tech Tips hydro pneumatic Tank Control Systems 331-380, Revised 6/23/2023



Two Ways to Add Air to a Pressure Tank

a) Air Volume Control Systems

These systems use an oilless air compressor, a liquid-level switch, and a pressure switch. The liquid-level switch senses water level, and the pressure switch senses air pressure. Both control the air compressor to maintain the desired water level. A time-delay circuit prevents rapid cycling.

b) Air Charging Systems

Common in older tanks, these systems mechanically add and release air without sensors. One type uses a bleeder orifice and a snifter valve on the pump discharge line to add air during each pump cycle. Check valves prevent backflow, and an air release valve manages excess air. Another type uses a Schrader valve to draw air before the pressure tank, with a release valve discharging excess air.

Energy Efficiency and Environmental Impact

One of the primary benefits of hydro pneumatic pumping systems is their ability to optimize energy use. By maintaining consistent water pressure and reducing the frequency of pump cycles, these systems minimize energy consumption. This efficiency not only lowers operational costs but also reduces the carbon footprint associated with water distribution, contributing to a more sustainable environment.

Innovative Technologies

The advanced technologies integrated into hydro pneumatic pumping systems are key to their efficiency and reliability. Pressure tanks and smart controllers ensure that water pressure is maintained at optimal levels, reducing the need for pumps to operate continuously. Additionally, variable frequency drives (VFDs) adjust pump speed based on real-time demand, further enhancing energy efficiency and operational flexibility.

Design Principles for Sustainability

The design principles behind hydro pneumatic systems focus on sustainability and resilience. These systems are engineered to handle variable water demands and adapt to changing conditions, ensuring a reliable water supply while conserving energy. Incorporating materials and components that are durable and require minimal maintenance also contributes to the longevity and sustainability of these systems.

Benefits for Businesses

By adopting hydro pneumatic pumping systems,

businesses can achieve significant benefits. The reduced energy consumption leads to lower utility bills, while the reliable performance of these systems ensures uninterrupted water supply for various applications. Additionally, the environmental benefits align with corporate sustainability goals, enhancing the reputation of businesses as responsible stewards of natural resources.

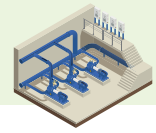
Formation of a Hydro pneumatic System

A hydro pneumatic system is typically composed of 2 to 6 multistage centrifugal pumps designed to withstand high pressure. It includes high-resistance valves and a control panel to regulate the number of operating pumps based on system discharge and pressure rate. Due to the frequent starting and stopping of centrifugal motors and pumps, pressure tanks are incorporated to minimize this frequency. The system also features switches to sense high and low pressure, along with a pressure transmitter.

The pressure tanks, made from rubber bladders, are surrounded by pressurized air, taking advantage of water's non-compressible nature. When a tap is opened, the water level in the tank decreases, reducing the pressure. Once the pressure drops to a specific threshold, the pressure switch activates the pumps to restore the desired pressure level, subsequently turning off the pumps when the target pressure is reached. This mechanism ensures a reliable and efficient water supply throughout the building.

Water pumping machinery plays a crucial role in residential buildings by providing a consistent and reliable water supply. As noted by Taisei, "Depending on the characteristics and scale of each project, select and install a suitable pump system." Here are some specific applications and uses of water-pumping machinery in residential settings:

- 1. Water Supply:** In residential buildings, water is supplied via underground wells, public water mains, or storage tanks and distributed throughout the structure using water pumping equipment. Pumps ensure adequate water pressure for various fixtures such as faucets, showers, toilets, and appliances like washing machines and dishwashers.
- 2. Increasing Water Pressure:** When the municipal supply's water pressure is insufficient, water pumping equipment can be utilized to boost the pressure. This is especially helpful for residences or tall buildings situated in low-water-pressure areas. The pump raises the pressure to ensure proper flow and operation of plumbing fixtures.



3. **Water Filtration and Treatment:** Residential buildings often employ water-pumping machinery as part of their water filtration and treatment systems. These pumps move water through filters, water softeners, and other treatment equipment to remove impurities, improve water quality, and provide clean and safe drinking water to residents.
4. **Sump Pump Systems:** In areas prone to flooding or with a high-water table, residential buildings may utilize sump pump systems. These systems include a pump installed in a sump pit or basin in the basement or crawl space. The pump automatically activates when water levels rise, preventing flooding and water damage by pumping the excess water away from the building.
5. **Hot Water Circulation:** In larger residential buildings or homes with complex plumbing layouts, water pumping machinery can be used for hot water circulation systems. These systems help maintain a constant supply of hot water by circulating it through the plumbing lines, reducing the wait time for hot water at fixtures, and conserving water.
6. **Swimming Pool and Spa Maintenance:** Residential properties with swimming pools or spas often rely on water pumping machinery to circulate and filter water. Pumps move water through the pool's filtration system, ensuring cleanliness, proper chemical distribution, and optimal water quality for recreational use.

The specific type and capacity of water pumping machinery used in residential buildings can vary depending on factors such as the size of the building, water demand, available water sources, and local regulations. Professional plumbing contractors typically determine the appropriate pump size and specifications based on the specific requirements of the residential property.

Advantages of Hydro Pneumatic Pumps

- **Efficiency:** Hydro pneumatic pumps are typically more efficient than traditional pumps, especially when properly sized and maintained.
- **Compact Size:** They are smaller and more compact, making them suitable for tight spaces and mobile applications.
- **Low-Noise Operation:** They operate quietly, which is beneficial in residential and noise-sensitive areas.
- **Energy Savings:** By using compressed air and efficient control systems, these pumps can

significantly reduce energy consumption compared to traditional pumping methods.

Linking Pumps and Water Audits to Enhance Water Use Efficiency

The integration of advanced pumping technologies and systematic water audits creates a powerful synergy that significantly enhances water use efficiency. Pumps, particularly hydropneumatics systems, are designed to ensure the optimal transfer and distribution of water. They maintain consistent pressure, reduce energy consumption, and minimize water loss. On the other hand, water audits provide a comprehensive evaluation of a water system, identifying inefficiencies, leaks, and areas of excessive consumption.

Optimizing Pump Performance Through Water Audits

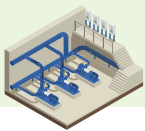
Water audits play a crucial role in optimizing the performance of pumping systems. By thoroughly analyzing the water distribution network, audits can pinpoint inefficiencies that may not be immediately visible. For example, an audit might reveal that certain sections of the network are experiencing pressure drops due to suboptimal pump performance or leaks. By addressing these issues, organizations can adjust pump settings, repair or replace malfunctioning equipment, and fine-tune the system for maximum efficiency.

Reducing Energy Consumption and Costs

Efficient pumps, especially when paired with hydro pneumatic systems, contribute to significant energy savings. Water audits can help identify areas where pumps are operating inefficiently, such as running more frequently than necessary due to leaks or pressure imbalances. By resolving these issues, pumps can operate more effectively, reducing energy consumption and lowering operational costs. This not only conserves resources but also extends the lifespan of the pumping equipment.

Enhancing Water Sustainability

The combined use of efficient pumping technologies and water audits leads to a more sustainable water management system. Efficient pumps ensure that water is distributed effectively with minimal waste, while water audits provide the insights needed to continuously improve the system's performance. This holistic approach helps organizations achieve a balance between water supply and demand, reducing the strain on water resources and promoting long-term sustainability.



A Framework for Continuous Improvement

Regular water audits ensure that water management systems remain efficient over time. As technology advances and new challenges arise, audits can help organizations adapt by identifying new inefficiencies and areas for improvement. This continuous feedback loop ensures that pumping systems are always operating at their best, leading to sustained improvements in water use efficiency.

In conclusion, the link between pumps and water audits is fundamental to achieving water use efficiency. By combining advanced pumping technologies with systematic water audits, organizations can optimize water distribution, reduce energy consumption, lower costs, and enhance the sustainability of their water management practices. This integrated approach is key to addressing the growing challenges of water scarcity and ensuring a reliable water supply for the future.

References:

1. GLUMRB (Great Lakes and Upper Mississippi River Board of State Public Health and Environmental Managers). (1992). "Recommended standards for water works." Albany, NY.
2. AWWA (American Water Works Association). (2015). "Energy management for water utilities." Denver.
3. Walski, T. M. (2001). "Don't forget energy cost when selecting pumps." AWWA Annual Conf., AWWA, Denver.
4. Walski, T. M. (2012). "Planning-level capital cost estimates for pumping." J. Water Resour. Plann. Manage., 10.1061/(ASCE)WR.1943-5452 .0000167, 307-310.
5. Walski, T. M., Wu, Z. Y., and Bowdler, D. (2006). "Finding thieves in your water system." AWWA Annual Conf., AWWA, Denver.
6. King, G. E. (2012, February). Hydraulic fracturing 101: What every representative, environmentalist, regulator, reporter, investor, university researcher, neighbor and engineer should know about estimating frac risk and improving frac performance in unconventional gas and oil wells. In *SPE Hydraulic Fracturing Technology Conference and Exhibition* (pp. SPE-152596). SPE.
7. Ding, R., Yin, H., Cheng, M., Li, G., & Xu, B. (2024). The design and analysis of a hydro-pneumatic energy storage closed-circuit pump control system with a four-chamber cylinder. *Journal of Energy Storage*, 79, 110076.
8. Wang, C., Wang, F., Li, C., Chen, W., Wang, H., & Lu, L. (2022). Investigation on energy conversion instability of pump mode in hydro-pneumatic energy storage system. *Journal of Energy Storage*, 53, 105079.
9. Intriago Zambrano, J. C., Michavila, J., Arenas Pinilla, E., Diehl, J. C., & Ertsen, M. W. (2019). Water lifting water: a comprehensive spatiotemporal review on the hydro-powered water pumping technologies. *Water*, 11(8), 1677.
10. Anferov, V. N., & Bazanov, S. A. (2021). Parameter determination procedure for the ejector pump and hydro-pneumatic accumulator in the enclosed hydraulic drive. *Journal of Mining Science*, 57(4), 607-614.



Avinash Mishra
Chairman, Water Audit Council
Former Advisor, NITI Aayog

Avinash Mishra is having an experience of 33 Years of Water Resources sector. His educational qualifications are B.E. (CIVIL), M. Tech. (Water Resources) from IIT Delhi. He has been working in the National Policy Planning formulation, and Action Plans of the country. He is engaged in the development plans, and proposals of the State Governments relating to major, medium, and minor irrigation, flood control, drainage, command area development, watershed development, drinking water supply & sanitation. Represented the Planning Commission, now NITI Aayog in the various technical advisory committees of the Irrigation & Water Supply Sector. Initiated many schemes i.e. PMKSY, JJM, SVAMITVA Yojana, Atal Bhujal Yojana, Aquifer Mapping, Member of various committee on Water Resources including the Committee of Bureau of Indian Standards. He can be reached on amishra-pc@gov.in.



Madhubanti Dutta
Manager,
Water Audit Council

Madhubanti Dutta has over a decade of experience in Environment, Climate Change, Agriculture, Biodiversity, Water, Land Resources, and Energy. She holds an M.Sc. in Environmental Economics, and her career is characterized by a steadfast commitment to excellence in Fundraising & Financial Management, Research & Analysis, Stakeholder Engagement & Policy Development, and Team Leadership & Collaboration.

Madhubanti has had the privilege of contributing significantly to addressing the challenges posed by climate change during her tenure at NITI Aayog. She is currently working as Manager, Technical at Indian Plumbing Association. She can be reached on info@wateraudit.in.