IoT technology and digital twins

Smart electric pumps

caprari

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IoT and virtual twins: macro trend or revolution? Likely both, given the speed with which this bridge between the physical and virtual worlds is forming and the transformative impact it is poised to have across multiple industrial sectors.

The world of electric pumps is directly involved, as the transmission and intelligent analysis of real-time data bring countless advantages to the design, monitoring and management of machines and systems. Caprari leads the way with an innovation that enables decisions to be made on the basis of concrete data, improving operational efficiency, optimising energy use and predicting potential anomalies. In this context, data-driven decision-making processes become the true catalyst for change, enabling a shift from reactive management to a more proactive, efficient and sustainable approach.

IoT and Digital Twins: figures for a growing trend

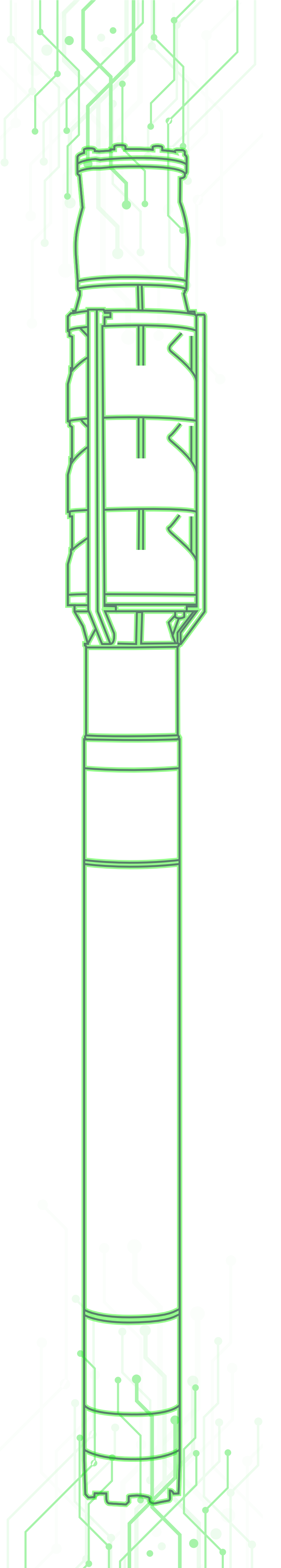
The data reveal how deeply rooted and steadily growing the trend towards progressive digitalisation has become. The digital twin market is projected to reach a value of between $125 and $150 billion by 2032. Looking at the present, and particularly the manufacturing sector, 29% of companies worldwide have already fully or partially implemented digital twin strategies.

But what exactly do we mean when we talk about the IoT (Internet of Things) and digital twins?

First and foremost, it is important to stress that these are two distinct yet complementary concepts. The Internet of Things (IoT) is a network of physical devices connected to the Internet that collect and exchange data in real time. A digital twin is a virtual replica of a physical object, system or process. This digital copy is continuously updated with data gathered from its physical counterpart via IoT sensors. The digital twin allows the functioning of the real object to be simulated, analysed and optimised without directly intervening on it.

The IoT provides real-time data, while the digital twin uses this data to model scenarios and support decision-making. In this way, it becomes possible to:

- ► enhance predictive maintenance;
- ► optimise production processes;
- ► test innovations without risk.



BEST EFFICIENCY POINT

is the digital device developed and patented by Caprari to enable remote control and monitoring of any electric pump, including other brands on the market, with the aim of optimising performance.
The project was conceived within Caprari's research and development department, which has always been strongly committed to finding new solutions to improve process efficiency. It was precisely this dedication to product efficiency that drove the research and integration of digital technology, pioneering the adoption of dedicated software and IoT in pumping system management.
The Green Box project is the outcome of strategic collaboration with two key partners: one specialising in hardware and the other in web portal development. At the heart of the project is Caprari, which laid out the supply specifications in detail and, above all, shared its extensive expertise in the field of electric pumps.

GREEN® BOX caprari

A device designed for maximum energy efficiency

The focus on energy efficiency lay at the core of the project, guiding the conversion of Caprari's expertise into three key components: the portal software, the hardware (electronic circuit board) and the firmware – the software integrated into the electronic circuit board, essential for accurate data transfer to the cloud.
The pursuit of maximum energy efficiency through **continuous monitoring of the electric pump's operating point is what distinguishes Green Box from all other devices on the market**. When installing a pump, the objective is to get as close as possible to the ideal operating curve – the one specified in the catalogue, based on the actual test curve developed in the test room – while accounting for the inevitable head losses that define the actual system curve. This is where the digital twin, a virtual model of the pump based on the actual test curve developed in the test room, comes into play.
The installed sensors constantly record the system data, which is compared in real time with the **digital twin**. This process makes it possible to determine whether the pump's operating point is close to the BEP (Best Efficiency Point) and, if not, to **automatically adjust the operating parameters** (such as speed and flow rate) **in real time, ensuring the pump is consistently operating under optimal conditions**.

BEST EFFICIENCY POINT

The best efficiency point (BEP) of an electric pump is the operating point at which it performs with maximum efficiency, delivering the best ratio between energy absorbed and hydraulic energy transferred to the fluid.

Characteristics of the BEP:

► **Maximum hydraulic efficiency:** minimal internal losses (friction, turbulence, dissipation).
► **Minimal wear:** reduced mechanical stress and cavitation, extending service life.
► **Optimal energy consumption:** lower electrical energy usage for the same flow rate and head.

How is the BEP identified?

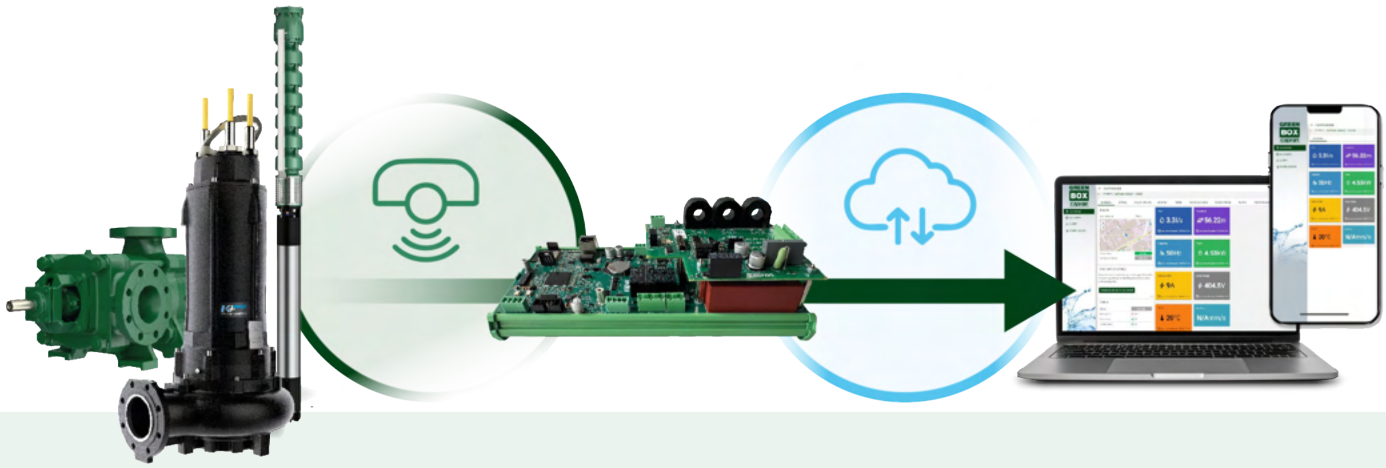
The BEP can be found on the pump performance chart, which shows the efficiency curve in relation to flow rate. It is the point at which efficiency reaches its peak, generally indicated by the manufacturer.

Importance of the BEP

► Operating close to the BEP extends the pump's service life and reduces operating costs.
► Straying too far from the BEP can cause issues such as:
- ► Excessive vibrations
- ► Cavitation
- ► Overheating
- ► Reduced pump service life.

To ensure optimal operation, electric pumps should be sized and adjusted to operate as close to the BEP as possible.

How the Green Box works



ON REQUEST

LTE CONNECTION

STAND-ALONE EXTERNAL TOUCHSCREEN DISPLAY

Another key strength of the Green Box device is its **plug-and-play design, offering exceptional versatility and adaptability to different requirements**.
It can be integrated into an existing panel to make the system smarter, or installed in a completely new context. The sensors inside the pump measure electrical, hydraulic and mechanical parameters: flow rate, pressure, temperature, and vibration. The system has been designed to optimise this initial phase as much as possible, making it more economically sustainable. The Green Box **can communicate with the various types of inverters and soft starters available on the market** for data acquisition, or operate autonomously with dedicated sensors.
In its simplest mode, the Green Box functions as a **stand-alone device with a touchscreen display**.
In its most advanced mode, its full potential of **connectivity** is harnessed for remote management of the electric pump, acting on the digital twin, which remains continuously synchronised with real pump data. The electronic circuit board is equipped with a Wi-Fi module and Ethernet connectivity, and it is also possible to integrate a global LTE module, ensuring continuous and reliable connectivity regardless of geographical location and without reliance on wired or Wi-Fi networks. The data can be transmitted to the **cloud platform** and accessed via the Caprari **web portal** and web app.
The human-machine interface has been designed to be exceptionally simple and intuitive, allowing increasingly detailed information to be extracted as needed. The ability to share data also strengthens our assistance and customer care service, enabling our technicians to respond to support requests or consultations on pump performance more effectively and promptly.
Through an **API system or Ethernet connectivity**, the Green Box communicates smoothly and securely with **SCADA systems and other platforms installed by the customer**, integrating seamlessly with **centralised monitoring** systems.
The Green Box can also operate in **active mode**. By default, the electronic circuit board simply transfers data, with any interventions carried out via the portal. However, the device can also be configured so that the circuit board acts as a master, directly intervening in the pump's operation. This is an option the customer can select at their own discretion, with support from our technical department during setup. In active or pump control mode, once parameters have been set, the Green Box can act as a **machine stop** and secure the system without the need to install any additional devices (warning and stop) inside the panel.

Monitoring of electric motor parameters

The Green Box enables the monitoring of the electric motor's parameters, allowing prompt intervention in the event of failure. Here are some of the parameters monitored:

►**Current asymmetry:** this poses risks such as overheating, abnormal noise, excessive vibration and premature failure. Detecting and correcting asymmetries helps extend motor life.

►**Insulation:** a drop in this parameter indicates deterioration of the winding insulation, allowing predictive maintenance to be scheduled.

►**Phase sequence:** as this determines the motor's direction of rotation, it must be checked to prevent system failures and malfunctions.

►**Phase failure:** this prevents the motor from running under overload conditions.

►**Dry run protection:** the oil level regulators on the K+ pumps indicate the leakage of the mechanical seals.

Reverse pump rotation

The Green Box also includes an **anti-clogging feature** that stops the motor and reverses the direction of rotation to attempt to unblock the pump, then restarts it in the normal direction. This sequence is highly effective in cases of clogging, as it automatically restores normal operation.

A versatile device

Its user-friendliness and plug-and-play design make the Green Box ideal for all applications. It is particularly in energy-intensive production environments that it can make a real difference.
The Green Box adds value to all **industrial processes** involving fluid handling, from hydraulic and cooling system control to hydroelectric power stations and the oil and gas sector. Beyond optimised energy efficiency, the availability of a digital twin for electric pump control means reduced downtime, maintenance only when necessary, improved safety, advanced analysis and data-driven decision-making. The integration of industrial IoT is making plants increasingly autonomous and intelligent, supporting the shift towards a more efficient and sustainable Industry 4.0.
The **multi-utility sector** is also increasingly engaged in this digital transformation, following the "Smart & Digital Water" paradigm identified in the White Paper of the Osservatorio Valore Acqua (Water Value Observatory) as one of the key strategies for efficient and sustainable water supply chain management. Energy consumption in sewerage and purification – two of the most energy-intensive activities in the tertiary sector – could be reduced by up to 30% thanks to new smart solutions. In general, a real-time data-driven approach supports operators in continuously improving processes and maintaining optimal plant performance.
Lastly, there's the **agricultural sector**. IoT and digital twins for electric pump control consistently support precision agriculture and smart irrigation, enabling the optimisation of water and energy use, the simulation of irrigation scenarios, and the reduction of waste and operating costs through predictive maintenance and automation.

Looking to the future

Recognising the importance of new technology for sustainable water resource management, Caprari is already looking ahead, exploring the potential of integration with **Artificial Intelligence** and **Machine Learning**. Digital twins will become increasingly accurate and autonomous. There will be a transition from a single-parameter logic to a multi-parameter comparison logic, paving the way for new predictive and prescriptive tools. These new systems will help achieve strategic objectives, enhancing both efficiency and sustainability.

Source:
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