THE PI SYSTEM AND INDUSTRIE 4.0

OSIsoft®

OSIsoft Technologies Enable Industrie 4.0 Information Architectures

EXECUTIVE OVERVIEW

If you work in a manufacturing industry, it's difficult to escape the ideas and concepts of Industrie 4.0 (I4.0). Germany's I4.0 defines a technology framework designed to revolutionize the manufacturing world. Similar to what the steam engine did in the last century, I4.0 technology, including the Internet of Things (IoT), will enable manufacturers to transform their operations, business models and supply chains. Yet, although I4.0 adoption is high priority for many in the C-suite, many strategies to jumpstart a true "digital transformation" never take shape.

Why? The definition of I4.0 may be vague, but the driving forces behind it are real. For example, IDC predicts that IoT spending will reach $1.7 trillion by 2020. On the other hand, I4.0 is not only about connecting machines to people to processes, which is the focus of IoT. Progressive businesses have prioritized creating new business models, becoming more customer-focused or even building connected supply chains. Often, however, **disconnects between technology adoption and business drivers leave many organizations wondering how to get started.**

A foundational piece of all I4.0 initiatives will include technologies that harness growing volumes of industrial sensor, automation and operational data. For over 35 years, OSIsoft's PI System has been designed to manage large, complex sets of IoT data to create a digital record of both real-time and historical record of industrial operations.

Although I4.0 concepts are relatively new, many leading organizations have worked with OSIsoft to implement strategies that embody the spirit I4.0:

Aurubis - A global leader in copper production and recycling, Aurubis consolidated data from all facets of the copper smelting process to reduce energy by 5 percent at their Hamburg site.

Novartis - After consolidating and standardizing data systems, Novartis' Workcenters of the Future include paperless operations, "lights out" manufacturing and information "cockpits" that display role-based information.

Flowserve - A 200-year old manufacturer of pumps, valves and seals, Flowserve has traditionally described itself as a "big iron" company. By leveraging sensor technology, they have added value-added services to become "a better reliability partner for customers."

As IoT disrupts industrial business models, facilitating I4.0 strategies will be key to enabling digital transformation. This paper describes how OSIsoft technologies support four basic I4.0 design principles that promote safer work environments, increase efficiency and enable customer-focused business models.

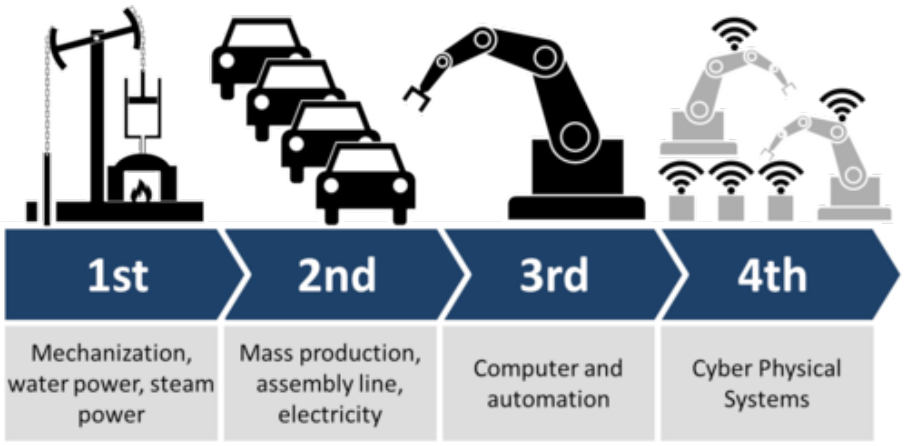


Figure Credit: Christoph Roser at AllAboutLean.com

SETTING THE VISION

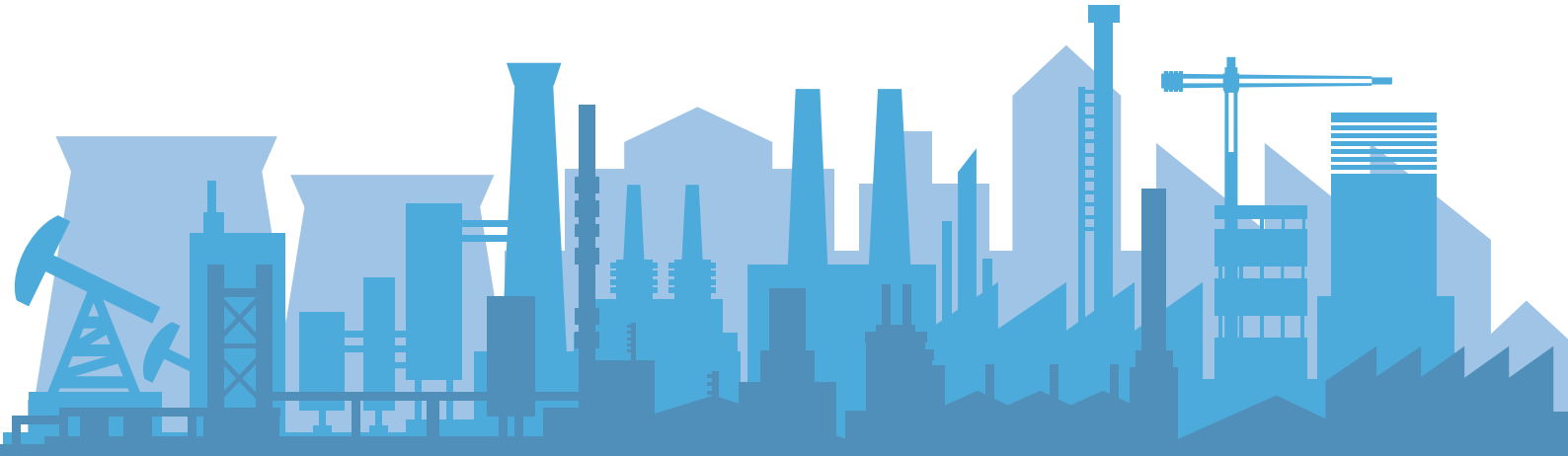
The term “Industrie 4.0” was first coined in 2011 and has grown to become a cornerstone of Germany’s national technology research and innovation policy. Originally associated with discreet manufacturing and “smart factories”, its principles are now being applied across multiple industries and to resolve more global issues like climate change, energy conservation as well as issues associated with growing population and urbanization.

I4.0 technologies include:

- Advanced robotics and artificial intelligence
- IoT
  - Cloud computing and advanced analytics
  - Wireless sensors
- (Semi-)autonomous machines and processes
- Digital manufacturing

In many nascent I4.0 scenarios, these technologies function independently and/or offer local value, but as I4.0 vision and technologies mature, chaining them together will amplify value by creating seamless digital operations and collaborative value chains. As boundaries between digital and physical worlds dissolve, some of the benefits that industries expect to realize include:

- Lower costs as a result of greater efficiency and technological integration
- Producing batches or personalized products as easily as masses
- Tracking products from cradle to grave to improve design
- Growing closer to customers through new digital products and services
- Creating a network of partners and suppliers to optimize supply chain



I4.0 DESIGN PRINCIPLES AND DATA ECOSYSTEMS

For many organizations, knowing how to get started can be one of the hardest tasks. To shape I4.0 technology strategies, four design principles were presented at a recent conference:

1. **Interoperability:** Machines, devices, sensors, and people connect and communicate with each other via the IoT.

2. **Information transparency:** When information systems create a virtual copy of the physical world by enriching digital models with sensor data. This requires the aggregation of raw sensor data to higher-value context information.

3. **Technical assistance:**
Assistance systems support humans by aggregating and visualizing information comprehensibly for making informed decisions and solving urgent problems on short notice.
Cyber physical systems physically support humans by conducting a range of tasks that are unpleasant, too exhausting, or unsafe for human co-workers.

4. **Decentralized decisions:** Cyber physical systems make decisions on their own and to perform their tasks as autonomously as possible. Only in case of exceptions, interferences, or conflicting goals, tasks are delegated to a higher level.

In addition to these four design principles, it is also key to consider that IoT sensors and devices produce data and information relevant to broader ecosystems. Sharing data across these ecosystems will transform communication between customers, businesses and across larger ecosystems. Secure data exchange across these broader data environments will promote customer-focused initiatives and enable new business models and associated revenue streams through opportunities such as expanded service offerings.

MANY FACTORS WILL CHALLENGE I4.0

Sensors and automation systems are the heart of I4.0. Just like vital signals allow a doctor to diagnose a disease, industrial time series data enables engineers to understand the physical behavior of assets and processes underlying operational performance, diagnose problems early on and formulate targeted improvement strategies.

I4.0 technologies will propagate more data, from more locations, in more formats and from more systems than ever before. Even now, a single mining site can generate two petabytes of data in a 16-hour shift. To fully realize the benefits of transparent, interoperable data environments outlined by I4.0 design principles, strategies to address these technical and governance challenges need to be administered now.

MULTIPLE PROTOCOLS - Making sense of machine data is hard. Understanding asset fleets, sensors, devices all speaking different languages can be overwhelming. As the number of devices and sensors grows, increases in the number of data acquisition "protocols" are creating a greater (not lesser) need for new "interfaces."

BIGGER DATA - IDC predicts that 152,000 devices will come online every minute by 2025. The sheer volume of IoT data will exceed the capacities of legacy systems used for operational decision support. Traditional databases are not suitable for the volume and complexity of data emanating from these sources.

DATA VARIETY - Industries rely on multiple types of data, but making them work together often requires substantial human capital for basic data manipulation as well as custom coding. To promote transparency, centralized data management systems should ease integration of multiple data types (e.g. time series, GIS, financials, unstructured).

NEW DATA SILOS? - Historically, purpose-built systems capture and shape data for pre-ordained purposes, preventing information interoperability and transparency. Without foresight, some IoT "solutions" could represent the new silo – undermining the intent to construct architectures enabling broader, interactive data ecosystems.

CONTEXT AND COMMUNITY - As I4.0 continues to enable broader data ecosystems and collaborative business models, several "contextual views" may be needed for data to enable multiple applications, operational scenarios, and services. Linking industrial and IoT sensor data with higher-value context will become much more complex.

LIFECYCLE MANAGEMENT - Compared to traditional SCADA, DCS and PLC systems, many IoT sensors are considered "expendable." To ensure data quality, concentrators, aggregators, gateways, head-end systems are needed to aid in lifecycle management of broadly deployed sensors and devices.

SAFETY AND SECURITY - Expanding the digital footprint and shared data ecosystems offer opportunity but also increase attack surfaces and the need for enhanced data governance. Secure-by-design approaches including encrypted communication, data diodes and identity-as-a-service offerings can help secure I4.0 systems from threats and decrease safety risks.

PI SYSTEM TECHNOLOGIES

Assets such as turbines, reactors, tablet presses, pumps or trains are complex things. Each one of them has thousands of valves, screws, pipes, etc. It's not unusual for complex assets to produce upwards of 1000-5000 signals. The PI System provides the foundation for any I4.0 strategy by delivering a standardized way to acquire, manage and provide data to stakeholders throughout the enterprise. For over 35 years, enterprises with assets like these have implemented the PI System to create digital infrastructures for real-time machine data, operating events and environmental information.

As data systems become larger, more complex and dynamic, OSIsoft's PI System supports system interoperability and information transparency through or by:

PERVASIVE CONNECTIVITY - With over 450 available interfaces that connect to diverse operating systems, sensors and devices, customers create unified data layers that permeates the entire operations

SCALABILITY - The PI System is designed to monitor critical infrastructure and span enterprise systems. One of our largest customers deploys over 29 million data tags. Under test conditions, two PI Servers were able to process 70 million data streams over a 60-minute period.

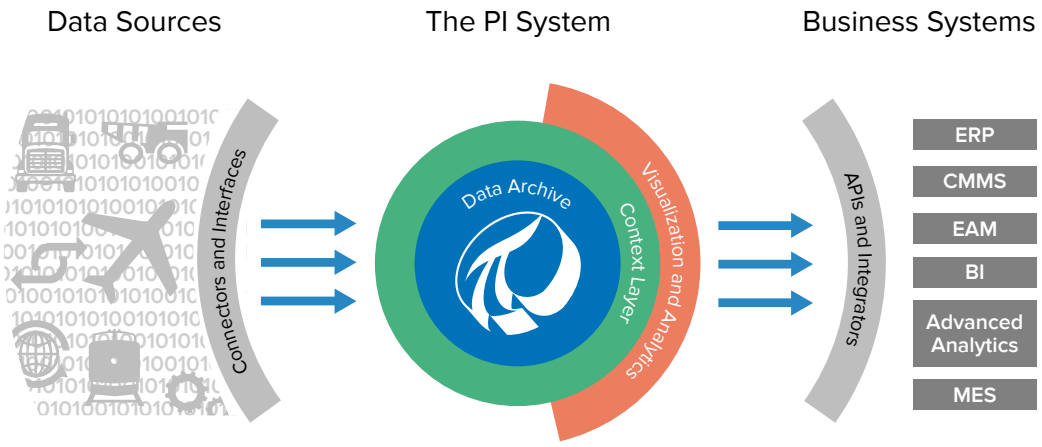
GOVERNANCE The PI System removes the work of ensuring consistent engineering units, a common time scale and creates a shared reference system and provides a traceable data lineage.

INTEGRATION TECHNOLOGIES Getting closer to customers, creating resilient and adaptable supply chains depends on creating information architectures that integrate multiple data types including operational data and other enterprise IT systems like SAP® HANA®, Esri® and data warehouses.

CONTEXT - Configurable asset templates include hierarchies of associated elements, attributes and calculations that organize data streams and related process information by familiar asset and plant topology.

EXTENSIBILITY - Industrial customers can combine legacy equipment with new or upgraded equipment. The ability to group and regroup asset templates, without limits futureproofs systems and enables customers to drive meaningful analysis and innovation.

FLEXIBILITY - OSIsoft offers commercial licensing for enterprise-scale operations, service-based business models and partner-enabled solutions.



1. Aurubis

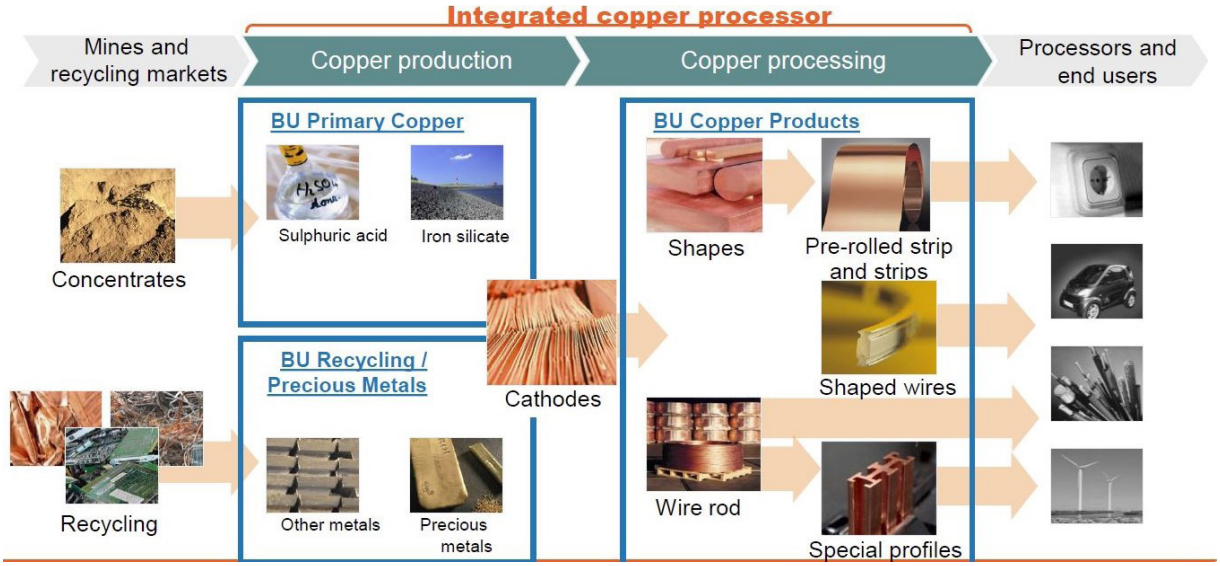
Headquartered in Hamburg, Germany, the Aurubis Group is the largest copper producer in Europe and the world leader in copper recycling. Aurubis' Hamburg copper smelting plant is the largest of its kind in Europe. The plant covers 4 square kilometers, produces 2 million tonnes of copper and consumes 600,000 MW of energy on an annual basis. With energy costs doubling over the last five years, Aurubis wanted to implement an energy management system for cost reduction and compliance purposes.

With only three full-time employees dedicated to calculating and monitoring energy use across its enterprise, Aurubis needed an energy management system that could bring all energy data into a single system.

In 1999, Aurubis had adopted the PI System to optimize operations at the Hamburg site. Because the PI System successfully consolidated data from all facets of the copper smelting process, Aurubis decided install multiple submeters and expand the PI System's footprint to bring high resolution energy data into their pre-existing data infrastructure.

PI System data has allowed operators to identify specific areas of improvement and monitor processes such as cooling water before returning it its source. Aurubis avoids tax penalties when Notifications alert them that their natural gas usage will exceed daily limits. Primary data are rolled up and shared; energy accounting is transparent to all levels of the company and available on demand.

In its first year, Aurubis was able to reduce energy consumption by 5% - the equivalent of 2 million euros - using the PI System infrastructure for performance-based cycles of improvement.



2. EDF-RE

EDF Renewable Energies (EDF-RE) is in the business of producing green energy. In North America, they design, construct, maintain and operate large-scale wind farms and solar facilities. EDF's strategy as a responsible electricity company includes championing low-carbon growth included the following goals:

1. Doubling the size of renewable energy
2. Embracing digital transformation
3. Growing closer to customers

Though EDF and OSIsoft are longtime partners, EDF-RE's North American PI System implementation is still growing rapidly. Recently, EDF-RE added the SAP HANA IoT Integrator by OSIsoft to their infrastructure to enable near real-time reporting of integrated operational, business and geospatial data. Using the integrator to send operational data into the SAP HANA platform enabled EDF-RE to bring diverse data types like contract, lease, geo-spatial and CRM data together to build business intelligence.

EDF-RE's enterprise data platform supports a single source of truth and self-service analytics. **They have already seen a 92% reduction in report run times and an 86% reduction in database size.** Pulling data from SCADA and Excel spreadsheets for curtailment calculations used to take weeks – now it takes minutes. EDF-RE believes that the joint solution will ultimately enable them to grow closer to customers through better performance and service.

3. Novartis

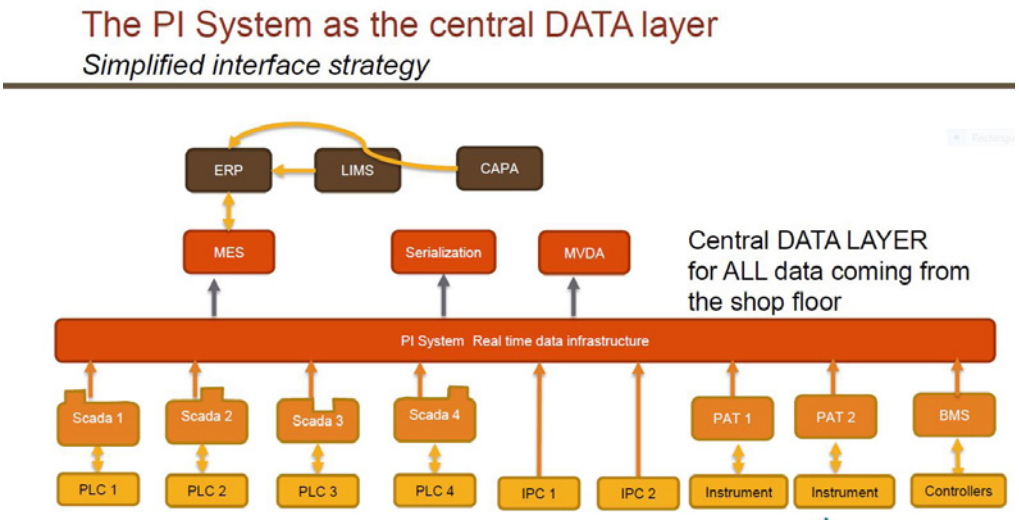
With over eleven thousand associates working in 25 manufacturing sites, Novartis pharmaceuticals produced approximately 2400 tons of medicines, reaching 1.2 billion patients worldwide. To make high quality medicines on time, every time, Novartis visualizes automated Workcenters that create meaningful information from plant data and deliver the right information, to the right user, at the right time. Business drivers include improving product quality, productivity, visibility across the entire supply chain and creating the ability to easily transfer knowledge across their manufacturing sites.

Their challenges included heterogeneity in machine connectivity, data interfaces and associated processes. Novartis implemented a standardization program with an aim to "Design one, build many" for 25 manufacturing plants. The standardization process was based on three pillars: equipment standardization (machines, automation, maintenance, process and KPI visualization), equipment connectivity and interface standardization.

The OSIsoft PI System created a common data infrastructure to connect ALL data coming from the plant floor, including quality, process, process control, environmental, productivity, process analytics data, to MES, ERP, LIMS and other systems requiring data. In some cases, they were able to move from 50 to 1 interface. By eliminating technology islands, the system is easier to maintain and is more cost-effective. **Novartis has already seen 17% savings using this approach.**

As their workcenters evolve, Novartis envision a "lights out" manufacuring environment where plant workers can understand what is going on inside the plant without actually being there, reducing human errors and contamination. Eventually, control charts, alarms and events would regulate production.

Another goal is to create paperless manufacturing when the flow of ALL information would be created and stored digitally. Operators will have the information they need to drive action and to convert data to knowledge that can be shared across ALL Novartis manufacturing sites.



4. Flowserve

Flowserve, a 200-year old “big iron” company, manufactures pumps, valves, and seals for the oil and gas, power, chemical and general industries. Flowserve is undergoing a cultural shift away from being uniquely a “big iron” manufacturer by adopting IoT strategies to offer data-driven services, ultimately to help customers to reduce costs and improve operations.

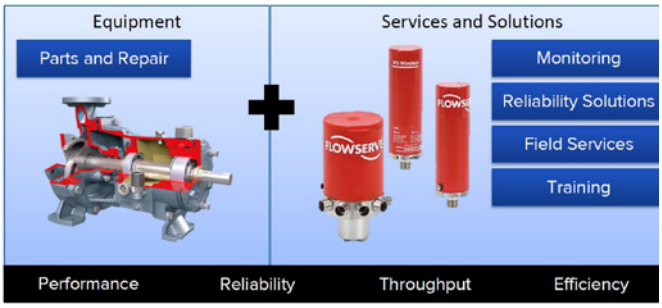
> “Our customers are coming to us and asking what more we can do for them. We keep looking for ways to partner with them beyond supplying them with pieces of metal.”
>
> -Josh Lyon, Flowserve

Flowserve recognized that leading companies are exploring how to use IoT, not only to improve their internal operations but also to improve their services. Flowserve’s Technology Advantage® platform provides aftermarket support for customers who actually own and operate the equipment.

Wireless sensor technology and the PI System empowers Flowserve’s engineers to monitor real-time equipment data, KPIs, and analytics at customer sites. Flowserve engineers can then leverage their expertise to make targeted recommendations to improve reliability for their customers.

Flowserve’s IPS wireless products capture data monitoring pressure, temperature, vibration from customer equipment and then transmit it up to the PI System and Flowserve’s Hosted Platform where they collaborate with customers to solve performance, maintenance and reliability challenges. Together, Flowserve and OSIsoft technology enables Flowserve engineers to apply expertise to real-time data to create actionable information for their customers.

Evolving Business Model / Customer Needs



Flowserve’s services even help customers avoid catastrophic failure. One customer had asked them to instrument their equipment to monitor vibration, temperature and pressure data. When the customer was doing planned maintenance, vibration levels dropped during maintenance, which is completely normal. However, when they brought the equipment back online, the vibration levels actually jumped to abnormally high levels. Flowserve was able to alert the customer and recommend that they inspect that piece of equipment. The customer found that a foreign object had been dropped into the equipment and was stuck in a suction strainer. They removed the object and brought the equipment safely back online. **The customer said that if they had let this go, it could have resulted in a catastrophic failure and 10-14 days of downtime - a significant impact in terms of process shutdown, costing around $650,000.**

What does this all mean for Flowserve? Adopting IoT technology has enabled them to be more responsive, more adaptive, more intelligent when customers were demanding more from them. By leveraging sensor technology and working with OSIsoft, Flowserve has become a better reliability partner for customers, creating a win-win for both Flowserve and our customers.

CONCLUSION

For many enterprises embarking on I4.0, the first step may be in rethinking how to use software they already own. OSIsoft's PI System provides a universal data infrastructure that is capable of collecting, managing and analyzing information from multiple isolated sources across the enterprise and presenting that data in a way that allows management, engineering, operations and staff to share information, solve and even predict problems in time to affect the bottom line.

As industries look for ways to build business value, a PI System infrastructure can serve as the backbone to integrate new sources of IoT data and cyber-physical technologies with core information systems. This strategic approach provides the framework to embrace I4.0 by optimizing enterprise data governance and accessibility as well as ensuring the new technologies can be woven into existing information systems or shared across broader data ecosystems to enable customer-focused business models and collaborative supply chains.

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ABOUT OSISOFT

With the belief that people can improve process efficiency, manage assets and mitigate risk if they have access to the data they need, OSIsoft created the PI System as a common data infrastructure to capture and store real-time data and make it available however and wherever needed. For over 30 years, OSIsoft has delivered the PI System with the singular goal of creating a common data source to connect enterprise data with people making decisions and solving problems.

Today, the PI System is trusted to do just that. Processing over 1.5 billion data streams across 19,000 sites, the PI System is embedded in operations and critical infrastructure in over 125 countries. Our customer base includes Fortune 100 and Fortune 500 companies in power generation, oil and gas, utilities, metals and mining, transportation, critical facilities and other industries.

To see any of the 1100+ customer success stories, product descriptions or global initiatives, please visit **www.osisoft.com**.

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