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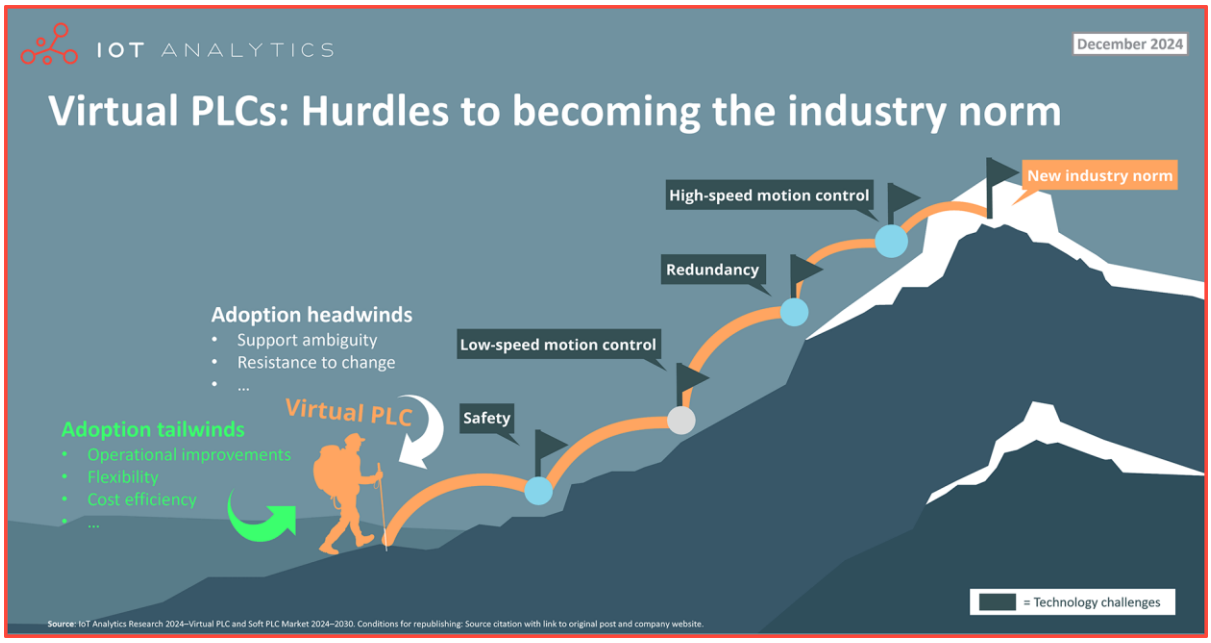
FOR IMMEDIATE RELEASE

Virtual PLCs: Can they become the industry norm by 2030?



[Hamburg, Germany] – [December 11, 2024] – IoT Analytics has released new insights from its Virtual PLC and Soft PLC Market 2024–2030 report, highlighting the key drivers and challenges shaping the adoption of virtual PLCs in industrial automation.

Virtual PLCs represent a paradigm shift for industrial automation by separating control logic software from specific hardware. Audi is at the forefront by replacing numerous decentralized PLCs on its factory floors with centralized, server-based virtual PLCs. The virtual PLC market is very nascent, with vPLCs generally considered at a low maturity level at this point due to limited control task support, no security certifications, no code portability, and no redundancy. While virtual PLCs are expected to gain traction in the coming years, they are not projected to become the industry norm by 2030.

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KEY INSIGHTS

- Virtual PLCs represent a paradigm shift for industrial automation, completely decoupling control logic software from specific hardware.
- Audi is at the forefront of this paradigm shift by moving from many decentralized PLCs on the factory floor to centralized, server-based virtual PLCs.
- The virtual PLC market is very nascent, with vPLCs generally considered at a low maturity level at this point due to limited control task support, no security certifications, no code portability, and no redundancy.
- vPLCs are likely to make significant inroads in the coming years but are unlikely to be an industry norm by 2030.

SELECT QUOTES

Knud Lasse Lueth, CEO at IoT Analytics, comments that "*Virtual PLCs represent a potential seismic shift in industrial automation, and our latest research suggests stronger adoption is on the horizon. While current limitations—such as missing security certifications and high latency—present challenges, pioneering manufacturers like Audi are showcasing their transformative potential. Vendors are increasingly aligning with these innovators. By the end of the decade, we anticipate significant advancements in the vPLC market, though they are unlikely to become the industry norm by 2030*."

Raghav Kadian, Market Analyst at IoT Analytics, adds that "*As manufacturers increasingly demand hardware-independent solutions, virtual PLCs are emerging as a promising yet nascent technology. The market for virtual and soft PLCs is projected to grow significantly, potentially accounting for 25% of new PLC sales by 2030. However, adoption is currently limited due to technology immaturity, with key features like SIL3 certification and redundancy still in development. While vendors face the challenge of transitioning to subscription-based models and navigating the innovator's dilemma, the software-centric nature of virtual PLCs offers opportunities for new revenue streams. The race is now on for vendors to mature the technology and cater to this growing demand, redefining the landscape of industrial control systems*."
[The full research article is attached below]

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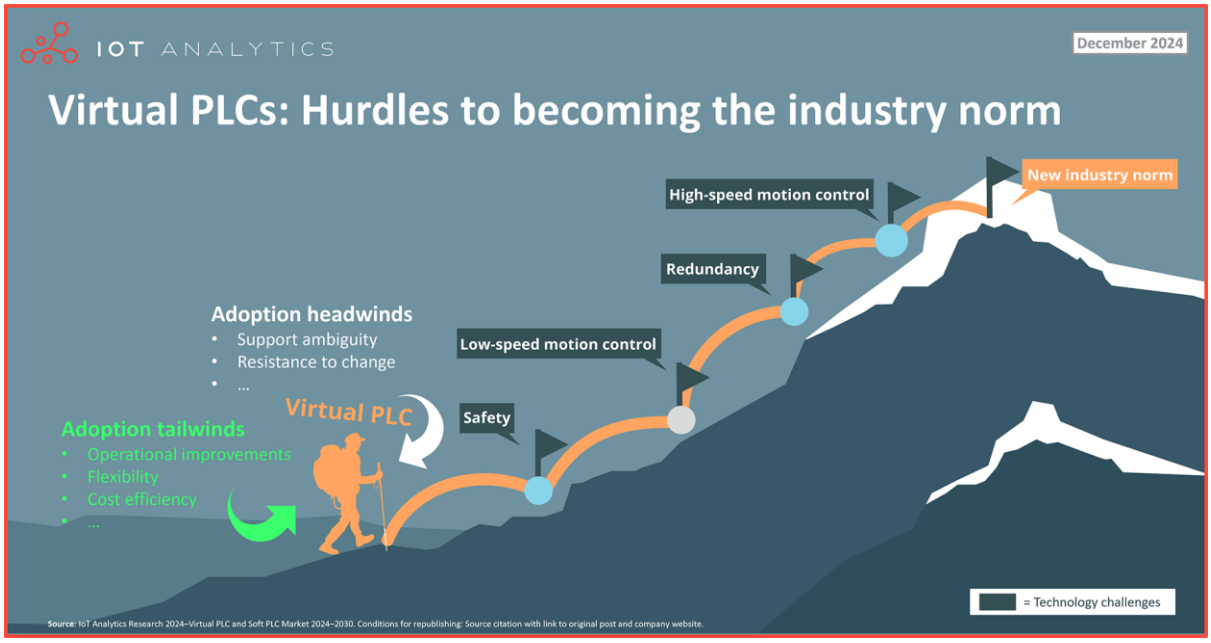
VIRTUAL PLCS: CAN THEY BECOME THE INDUSTRY NORM BY 2030?



Virtual PLC evolution

For decades, PLCs have been a cornerstone of industrial automation. Since the 1960s, these small devices have executed control logic directly on the factory floor, ensuring seamless operation of robots, assembly lines, and other critical systems. To date, their core principles have largely remained unchanged: decentralized hardware spread across the factory floor, with control logic tightly coupled to vendor-specific devices. However, some large manufacturers are starting to challenge this paradigm. One notable example: Automotive OEM **Audi**.

In 2022, Audi launched its Edge Cloud 4 Production (EC4P) initiative, a transformative project that seeks to centralize factory control. Instead of relying on multiple individual PLCs and industrial PCs, Audi's EC4P seeks to consolidate control logic onto *virtual PLCs* (vPLCs) running in data centers miles from the factory floor. This shift from physical to virtualized control is a major departure from the status quo and signals a potential reimagining of industrial automation's future (more on Audi and the EC4P initiative later in this article).

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PLC types defined: The three types of programmable logic controllers

Hard PLC (or hardware-based PLC) **–** A dedicated, standalone computing device designed for industrial automation and control tasks. Hard PLCs are tightly coupled to vendor-specific hardware, designed to operate exclusively with proprietary systems.

Soft PLC – A software-based version of a hard PLC that mimics its functionalities but offers varying degrees of hardware independence. Soft PLCs can be either hardware-specific or hardware-agnostic:

- Hardware-specific soft PLCs operate across a limited range of compatible platforms within the same vendor's ecosystem.
- Hardware-agnostic can run on multiple vendors' hardware.

Virtual PLC (vPLC) **–** A software-based PLC that runs in virtualized environments such as the cloud, edge servers, or industrial PCs. Virtual PLCs utilize containerization and hypervisor technologies, enabling them to deploy control logic independently of underlying hardware.

Virtualization technology a key enabler to software-hardware decoupling for factory control. Virtualization technology has revolutionized IT in the past years (e.g., data centers with servers running multiple virtual machines). IT/OT convergence is now bringing this technology to OT (e.g., virtual machines now coming to OT devices such as Industrial PCs). As manufacturers prepare their future factories to be scalable, automated, and serviceable, PLC and PLC runtime vendors—like Germany-based industrial automation company **Siemens** or automation software provider **CODESYS**, among others—are taking cues from IT and have started offering vPLCs.

Vendors face the innovator's dilemma due to hardware decoupling. Proprietary hardware–based PLCs have been highly profitable and a strong source of revenue for industrial automation vendors (such as **Siemens**, **Rockwell Automation**, **ABB**, **Honeywell**, **Mitsubishi**, or **Schneider Electric**) for years. Decoupling control logic (software) from hardware may shift the revenue model toward software alone, creating what the late Harvard professor and business consultant Clayton Christensen famously termed the "innovator's dilemma": Do vendors adopt the new, possibly profitable innovation at the risk of undermining their well-established and profitable hardware and software model? For years, vendors appeared largely hesitant to support this business models.

Can vPLCs become an industry norm by the decade's end?

Now that major manufacturers like Audi are taking a pioneering lead on adopting vPLCs, the tides seem to be changing. This begs the question: *Can vPLCs become an industry norm by the decade's end?*

To answer this, it is helpful to understand the current state of vPLCs first.

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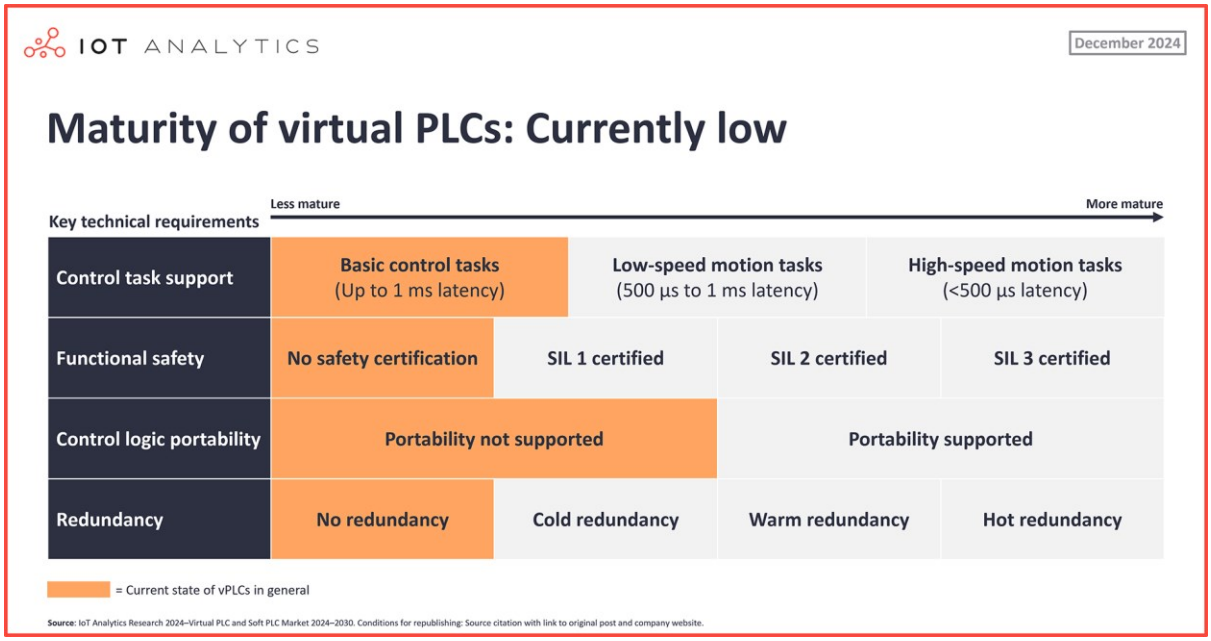
The state of virtual PLCs: Maturity, adoption drivers, and challenges



Maturity of vPLCs based on 4 key technical requirements: As of today, virtual PLCs have low maturity, not supporting all technical requirements that hard PLCs support. (Source: IoT Analytics Research)

vPLCs still in their early development stage. IoT Analytics research identified 4 key technical requirements that vendors must achieve before vPLCs can fully replace hard PLCs and become the industry norm, as shown in the table: control task support, functional safety, control logic portability and redundancy. The more requirements that vendors achieve (and improve upon), the more mature their vPLCs can be considered. Generally (with notable exceptions in the next section), vPLCs are currently capable of basic control tasks, with the following limitations:

- **Control task support:** No vPLC supports control tasks that require execution times faster than 1ms.
- **Functional safety certification:** No vPLC currently publicly supports functional security certifications that are required when operational safety is paramount (IEC 61508 is the foundational standard for functional safety in electrical, electronic, and programmable electronic systems).
- **Control logic portability:** Most vPLCs cannot seamlessly switch between different runtimes (e.g., run on vendor A's runtime as well as vendor B's runtime) without code modifications, keeping them from being truly hardware-independent.

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- **Redundancy:** Most vPLCs lack redundancy, so if multiple vPLCs are installed on a centralized server and the server goes down, so do the vPLC runtimes and the ability to run the control logic.

Automotive leads in early adoption. Thus far, this low maturity has limited broader adoption. Still, according to the research, vPLCs have early adopters in the automotive industry, which comprised nearly a quarter of the very nascent vPLC market in 2023.

8 vPLC adoption drivers. The research identified 8 current vPLC adoption drivers, 3 of which are shared below:

1. **Operational improvement –** vPLCs can be managed from a single, centralized interface, simplifying tasks such as updates and enabling central access to all PLC data.
2. **Flexibility –** Decoupling the runtime from hardware eliminates vendor lock-in, allowing users to customize and deploy applications based on their requirements without relying on vendor-specific tools. Further, PLC runtimes can be deployed on the same hardware to meet evolving operational needs without increasing hardware requirements.
3. **Cost efficiency –** Multiple PLCs can be consolidated onto a single hardware platform, reducing the need to purchase multiple physical PLCs. Further, vPLCs offer lower replacement costs, as any, non-proprietary hardware can be used, and replacing a vPLC largely involves an update.

Case study: Audi's Edge Cloud 4 Production

The EC4P project is Audi's initiative to modernize factory automation by integrating IT and OT systems to create a more efficient, scalable, and secure production environment. The project focuses on consolidating computational workloads and simplifying maintenance by replacing decentralized IPCs with centralized server clusters. As part of EC4P, Audi is integrating virtual PLCs within these centralized servers to migrate control logic from IPCs to the server infrastructure.

Reasons for EC4P include:

- **Significant downtime when updating hardware PLCs –** Manual PLC updates cause significant downtime. Further, physical access to PLCs also creates security risks, as unauthorized changes to the code are possible.
- **High maintenance costs –** Decentralized PLCs require a high level of expensive maintenance.
- **Scalability challenges –** Scaling operations is difficult with decentralized hardware systems. When a new model is introduced, for example, assembly lines must be reconfigured, requiring changes across multiple hardware devices, which increases complexity and time.

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Supporting this effort are **Cisco**, **CODESYS**, **Siemens**, and **VMware**. Cisco provides the network infrastructure connecting the centralized servers to thin clients on the shop floor. VMware's ESXi hypervisor runs on the centralized servers, enabling the creation of multiple virtual machines within which Siemens' SIMATIC S7-1500V vPLC and CODESYS's Virtual Control SL runtimes are deployed.

In July 2023, Audi announced testing for EC4P was successful. The company has since been implementing the project at its Böllinger Höfe facility to support the production of its e-tron GT quattro, RS e-tron GT, and r8 models.

6 challenges to adoption. Amid these drivers, challenges remain. Beyond the maturity level issues mentioned above, the research also identified 6 adoption challenges split between operational/technical challenges and business/strategic challenges. 2 of these challenges are:

1. **Support ambiguity –** As vendors move away from proprietary, vendor-locked solutions and towards hardware-decoupled and -agnostic virtual PLCs, the tech stacks are incorporating components from multiple vendors at various levels. While this enables flexibility, it also introduces challenges, particularly around support and troubleshooting. To address this challenge, vendors can look to developing partnerships to provide unified support across components or integrate diagnostic tools that monitor the entire tech stack to identify and resolve issues quickly.
2. **Resistance to change –** As workloads shift from traditional OT environments to IT infrastructure, employees face significant challenges, particularly those in OT roles. OT personnel, who are historically accustomed to working with legacy systems that have remained largely unchanged, now need to acquire modern IT skills, such as DevOps practices, Agile methodologies, and cloud infrastructure management. Successful commercialization will depend upon how well vendors help their customers overcome the challenge of change management.

Transitional technologies and the advance toward virtual PLC widespread adoption

Vendors offer soft PLCs to address limitations of hard PLCs. While vendors have been working to address the challenges to vPLC adoption and mature their vPLCs, many have taken an intermediate step to address at least some of the limitations of hard PLCs by offering soft PLCs, such as being coupled to specific hardware. Some industrial automation vendors offer soft PLCs compatible with various platforms—but only those within their own ecosystem, making them hardware-specific. Examples include Germany-based **Beckhoff**'s TwinCAT XAR, which runs on its Embedded PC series, and

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Austria-based **B&R Industrial Automation**'s Automation Runtime, which runs on its X20 series of controllers. Meanwhile, other vendors have gone further and made their soft PLCs agnostic to the hardware being used. An example is **CODESYS**'s Runtime, which can be adapted to many platforms with the help of its CODESYS Runtime Toolkit.

Progress toward a virtualized one-to-one replacement to hard PLCs. Though enabling flexibility in the type of hardware the control logic runs in, soft PLCs still tie the control logic to hardware, often near the factory floor. vPLCs promise to reduce the number of hardware systems required and enable centralized management, and some industrial automation vendors are making headway in maturing their offerings and addressing challenges, including:

- **Siemens –** In April 2023, the company launched the SIMATIC S7-1500V, a vPLC that operates in a Docker container and is designed to run on existing or generic hardware. This controller is based on the functions and operation of its SIMATIC S7-1500 (hard) PLC.
- **CODESYS –** In June 2024, it released the CODESYS Virtual Control SL, which allows users to have an ISO 61508 SIL3-certified controller without certified hardware and features dual-channel execution via coded processing, indicating technical maturity.
- **Phoenix Contact –** In November 2024, this Germany-based vendorannounced the release of its Virtual PLCnext Control at SPS 2024. as an Open Container Initiative (OCI) container with the same functions, operating capabilities, and programming options as its hardware-specific PLCnext Control soft PLC.

Note: *IoT Analytics plans to publish an event report for SPS 2024 for its subscribers later in December 2024, soon followed by a blog article detailing the top 10 industrial automation trends as seen at the event. To be notified when the article is published, sign up for IoT Analytics' IoT Research Newsletter by clicking below.*

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Analyst opinion: Can virtual PLCs become the industry norm by 2030?

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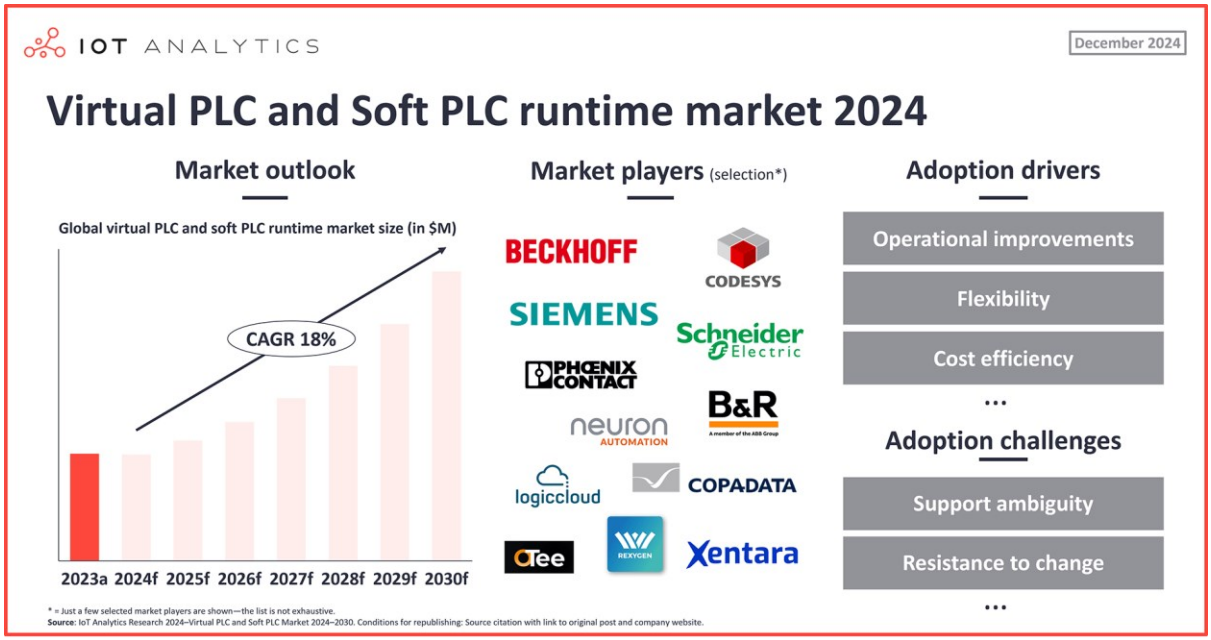

1/4 of new PLC sales in 2030 could be virtual or soft. Though manufacturers like Audi are adopting vPLCs, the vPLC market is in a very nascent stage, currently comprising a very small single-digit percentage share of the overall PLC market. In 2030, IoT Analytics believes that 1/4 of new PLC sales could be either virtual or soft. The rationale: Several vendors are currently pushing the boundaries of virtual PLCs and as such we believe that it is possible that SIL3 certification can be reached by 2030, that low-speed motion can be guaranteed (not high-speed) and that cold and perhaps even warm redundancy may be supported. This will mean that vPLCs will be an attractive option for a large basis of manufacturers. Some manufacturers will require higher maturity in 2030 than what will be achieved by then and therefore will still not be able to use virtual PLCs. At the same time, many manufacturers who could switch to virtual PLCs will likely continue buying hard PLCs because of their reliability and low initial costs.

Our assessment is that vPLCs do not appear poised to be the industry norm by 2030 yet.

As such, our assessment is that vPLCs do not appear poised to be the industry norm by the decade's end (yet) but well on the way to getting there.

Soft PLCs shed light on how long until vPLCs can become a norm. Patience may be a virtue here. To gauge how long until vPLCs could become an industry norm, it is worth considering soft PLCs, which entered the market in the 1990s and have still yet to become a norm. **Beckhoff** was an early purveyor of (hardware-specific) soft PLCs, and it has had the largest share of the overall soft PLC market for years. Though soft PLCs have made it successful, the company only reached $1 billion in total revenue in 2020, giving it approximately a small single-digit share of the overall PLC market. vPLCs could

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see a similar timeline as it matures, though their scalability and cost-effectiveness could give them an edge here, as reflected in their market outlook.

Strong growth prospects present opportunities for vendors. Analysis in the Virtual PLC and Soft PLC Market Report 2024–2030 forecasts strong market growth through 2030, presenting an opportunity for vendors to start capturing market share. Outright, margins on vPLC sales are expected to be diluted compared to hard PLCs due to the exclusion of the hardware element, which is the crux of the innovator's dilemma for current hard PLC vendors, as well as due to the "runtime subscription" nature of the business model. An additional upside may be that vendors have an opportunity to generate additional revenue streams since the software-centric nature of vPLCs allows them to offer new features like centralized data, lower downtime, analytics, and AI applications, just to name a few.

Disclosure

Companies mentioned in this article—along with their products—are used as examples to showcase market developments. No company paid or received preferential treatment in this article, and it is at the discretion of the analyst to select which examples are used. IoT Analytics makes efforts to vary the companies and products mentioned to help shine attention to the numerous IoT and related technology market players.

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