Technical Case Study

# Optimising Data Centre Chiller HVAC Plant with OEM Supervisory Control

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This technical case study explores the benefits of entrusting chiller plant control to the OEM. Evidence presented shows that direct OEM involvement offers tighter logic integration, better use of built-in features, and highly specialised optimisation.

# Abstract


## In data centres, where IT cooling systems account for a significant proportion of operational costs, efficient thermal management is critical.

This paper explores the benefits of assigning complete control of the chiller plant and overall supervisory system directly to the HVAC equipment manufacturer, rather than using a third-party controls provider. Using a case study, we demonstrate how direct manufacturer involvement enables:

- **Tighter integration of hardware and control logic;**
- **Better utilisation of built-in system features; and**
- **Deployment of advanced optimisation algorithms tailored to their equipment.**

All while ensuring system stability, resilience, compliance with customer Service Level Agreements (SLAs), and alignment with key project requirements.

Our results show that as Original Equipment Manufacturer (OEM) controls involvement increases – from equipment-only control to HVAC plant control to supervisory system control – there is an improvement in site-wide energy efficiency ratio and a reduction in total system power consumption. Annual energy savings range from 7% to 30%* of the cooling system's total energy consumption when the OEM is responsible for chiller plant room control, and from 10% to 50%* when the OEM is responsible for supervisory control of the entire HVAC system.

Beyond energy performance, this strategy simplifies system coordination by consolidating responsibility under a single expert – the equipment manufacturer. With one party accountable for operation and optimisation, this reduces fragmentation, streamlines communication and accelerates issue resolution. For data centre operators, this means reduced complexity, fewer vendor conflicts and greater confidence in the reliability and efficiency of their cooling infrastructure, enabling them to focus resources on core operations.


10% to 50%* annual energy savings when the OEM is responsible for supervisory control of the entire HVAC system.

# Current Situation

Data centre development projects typically tender system control and HVAC packages separately. This often results in different companies being contracted to provide the HVAC equipment and the control and supervision systems.

Master system integrators, responsible for installing and commissioning the control systems, execute the operational sequences outlined by the developer. These prioritise reliable, straightforward control algorithms, seek uninterrupted operation of cooling services and aim to minimise IT service downtime.

However, these third-party algorithms rarely, if ever, truly optimise system operation. Integrators can propose enhancements to baseline sequences, but their scope of action is limited due to insufficient information on equipment control logic and restricted access to embedded controllers. Furthermore, any change to the control technical specification must be approved by the developer, who must verify that reliability and operational simplicity are not compromised.

Essentially, even integrators with the highest expertise in HVAC system control have few incentives to introduce innovative sequences, which is why rudimentary algorithms are frequently found in data centres.

Third-party algorithms rarely, if ever, truly optimise system operation.

*** Frankfurt Data Centre Energy Saving with Carrier Management Solution**

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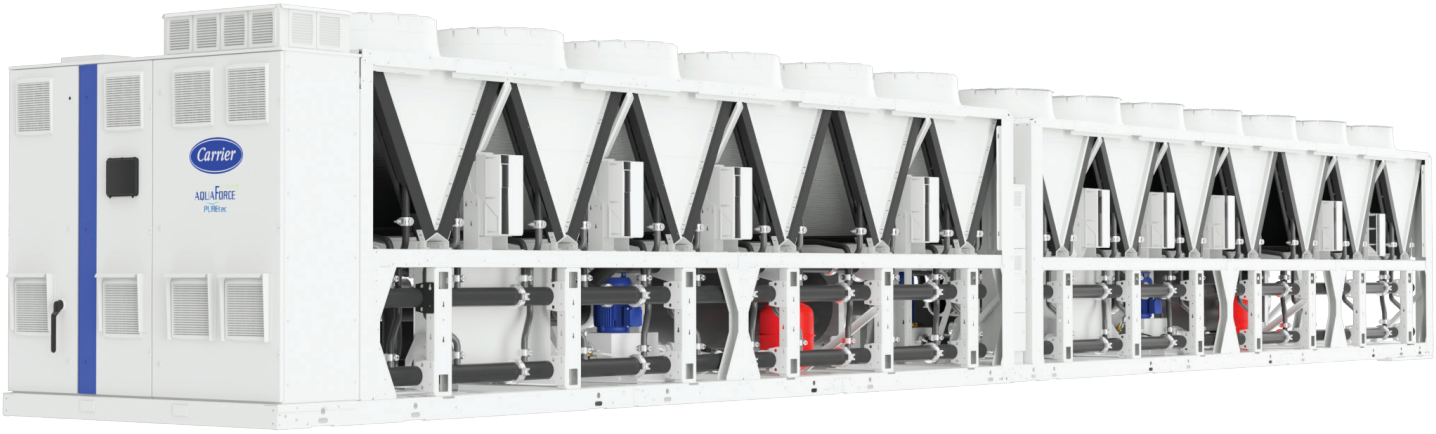

# Proposed Innovation

In our solution, the chiller equipment manufacturer becomes a single-point-of-contact, integrated HVAC solution provider, leveraging deep equipment knowledge and unrestricted access to embedded controllers (unique to the manufacturer) to deploy optimised control algorithms that maximise equipment and system performance. Our innovation is proposed in stages of increasing OEM involvement.

Our baseline is the equipment-only scenario: the OEM supplies chillers with embedded controls, while a third party – such as a master system integrator – handles higher-level control.

At the first level of control enhancement, Carrier's PlantCTRL™ Plant Sequencer is deployed to manage the data centre's chiller plant room. In-built system optimisation algorithms sequentially stage chillers, ensuring the optimum number of chillers and auxiliaries are always running to minimise the plant's energy consumption while satisfying customer specifications.

At the next level, Carrier extends PlantCTRL™ to integrate all relevant HVAC equipment (Chillers, CRAHs, CDUs, etc.) into Automated Logic's WebCTRL™ system-level supervisory control system.*

In addition to fulfilling all the functions of a state-of-the-art building management system, this framework optimises all available operational setpoints that do not violate the customer's hard constraints. In other words, the operation of each piece of equipment is managed comprehensively and collectively to minimise overall energy consumption.

Carrier

PlantCTRL™

WebCTRL®

by AutomatedLogic

Equipment Only

Carrier's PlantCTRL™ Plant Sequencer

Automated Logic's WebCTRL™ System Level Supervisory Control

**Elevating Carrier QuantumLeap™ Offering**

*Automated Logic is a Carrier company.

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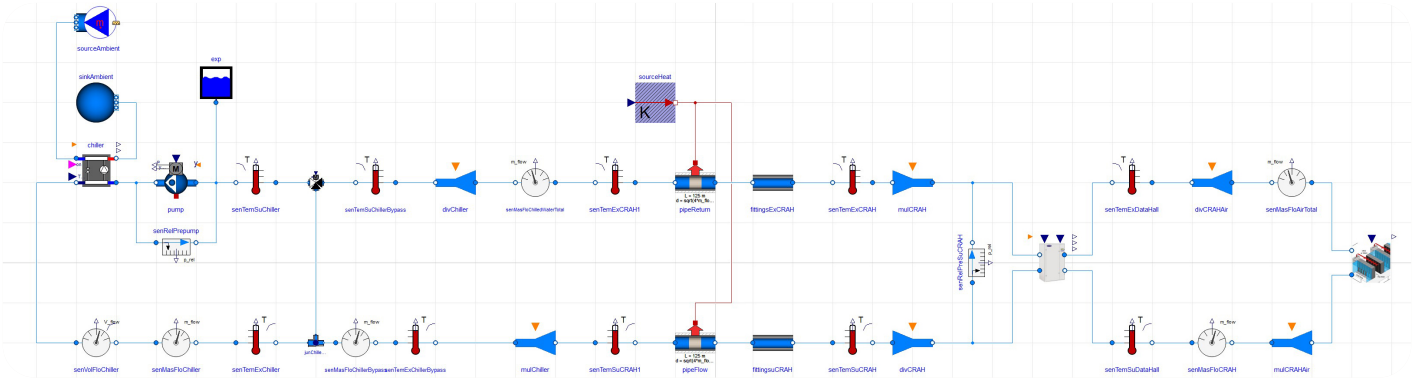
# Case Study & Simulation Results

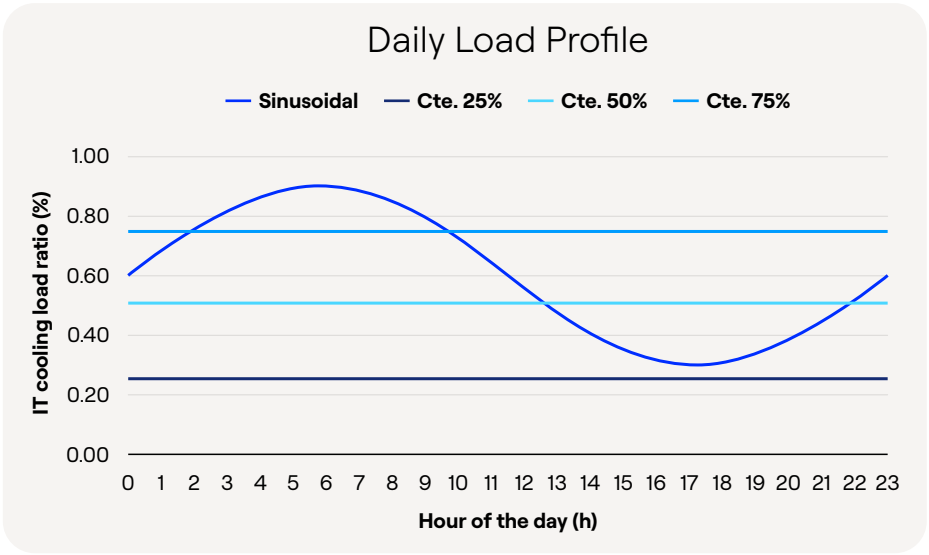
A case study was carried out to quantify the potential energy savings from this approach.

A dynamic simulation model was created to characterise the thermal behaviour of a new-build data centre in central Germany. The HVAC plant comprises Carrier 30XF air-cooled chillers with integrated free cooling, Carrier chiller controls and CRAHs.



As results depend on the IT cooling load, four thermal load profiles were considered:

- **Constant data centre load at 75% of peak;**
- **Constant load at 50% of peak;**
- **Constant load at 25% of peak; and**
- **Sinusoidal load varying from 90% of peak to 30% of peak every 24 hours.**

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## Baseline Scenario:

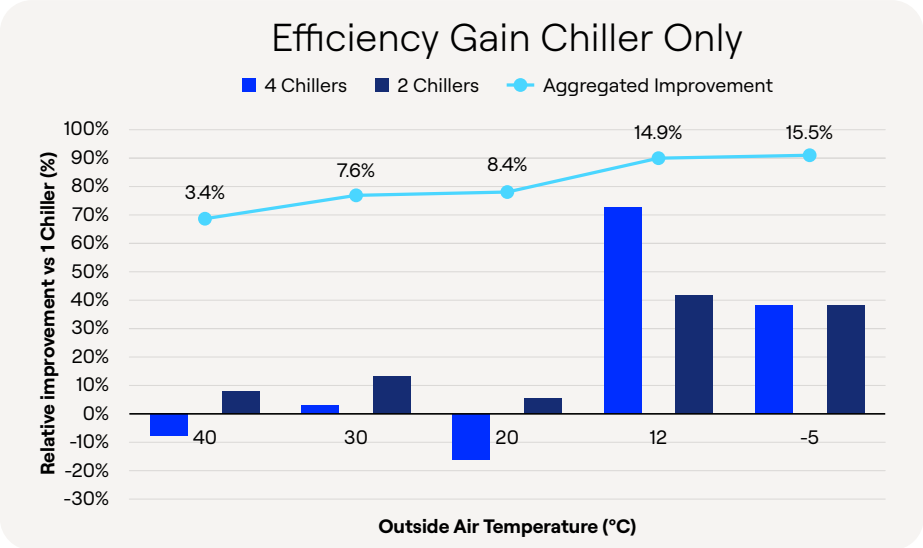
- **Carrier Equipment.**
- **Plant Control by Others.**
- **Supervisory Controls by Others**

## Enhancement 1: Carrier's PlantCTRL™ Plant Sequencer

- **Carrier Equipment.**
- **Carrier PlantCTRL™ Plant Sequencer.**
- **Supervisory Controls by Others.**

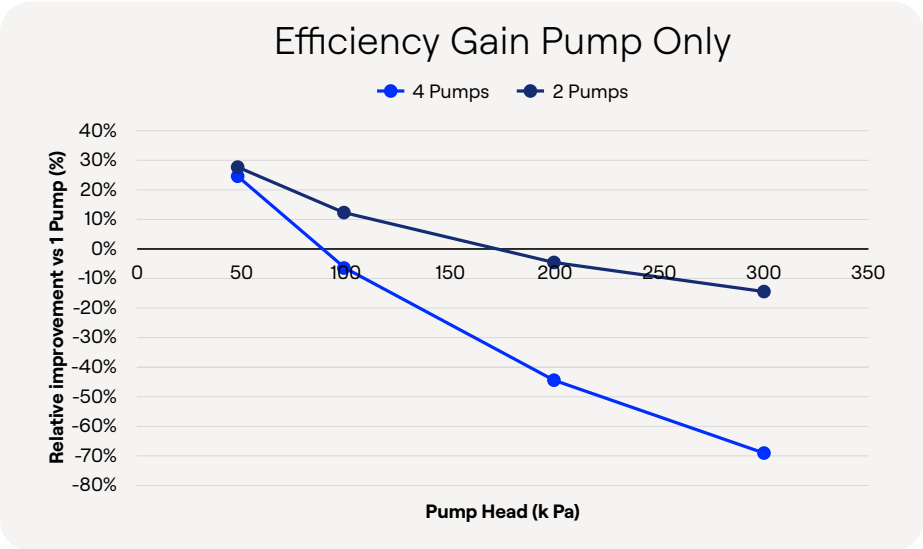
For the data centre modelled, Carrier PlantCTRL™, as plant control manager:

- **Satisfies cooling capacity, chilled water temperature and available chilled water pressure for CRAH units as specified by the customer.**
- **Assesses chiller and water pump efficiency characteristics under current operating conditions (climatic conditions, setpoints, piping characteristics, etc.) and determines which units to enable.**




### Key Point: Chiller Efficiency

As shown in the figure, operating the optimal number of chillers to meet cooling demand can improve chiller efficiency by up to 70% compared to running a single chiller. This enhancement heavily depends on operating conditions, particularly ambient air temperature, and is more significant with free-cooling air-cooled chillers used in data centres. The aggregated improvement (15.5% in this example) depends on the frequency and absolute savings achieved at each operating point.




### Key Point: Pump Efficiency

This figure shows that running more pumps results in higher total energy consumption, except at very low head. Therefore, in addition to the pump's efficiency curve, the pressure drop characteristics of the data centre system's piping must be integrated into any chiller plant optimisation algorithm.

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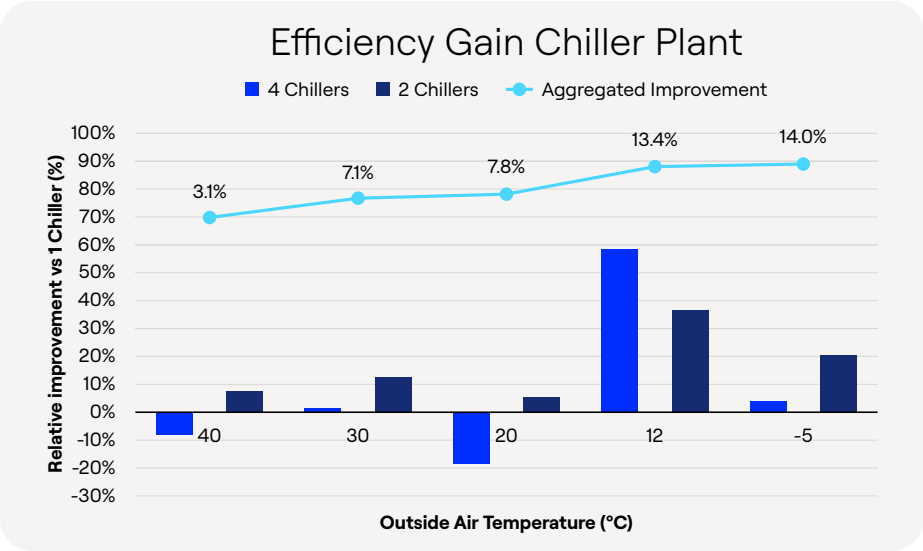


### Key Point: Plant Optimisation

Chiller and pump efficiency often exhibit opposite behaviours when the number of units in operation increases. As shown in the figure, the pumps' influence reduces the overall plant improvement compared to that achieved by the chillers alone. This demonstrates the necessity for a deep understanding of equipment performance under various operating conditions. In other words, generalised optimisation strategies could lead to negative savings in specific scenarios.

Comparing the system's annual consumption using PlantCTRL™ against the baseline shows that even under the least favourable load conditions (i.e. when the data centre is constantly at 75% of its capacity), implementing PlantCTRL™ Plant Sequencer can reduce the HVAC system's overall annual energy consumption by 2.5%. In the best-case load condition (i.e. when data centre load is constantly at 25%), the HVAC energy consumption is reduced by 31.7%. Under the sinusoidally varying load condition (assumed similar to real operation), the energy savings achieved from implementing PlantCTRL™ Plant Sequencer are ~7% of total annual HVAC plant energy consumption.

| Load Conditions | HVAC Energy Savings |
|---|---|
| | PlantCTRL™ |
| Constant load at 75% of max. | 2.5% |
| Constant load at 50% of max. | 11.8% |
| Constant load at 25% of max. | 31.7% |
| Sinusoidal load varying from 90% to 30% of max every 24 hrs. | 7.0% |

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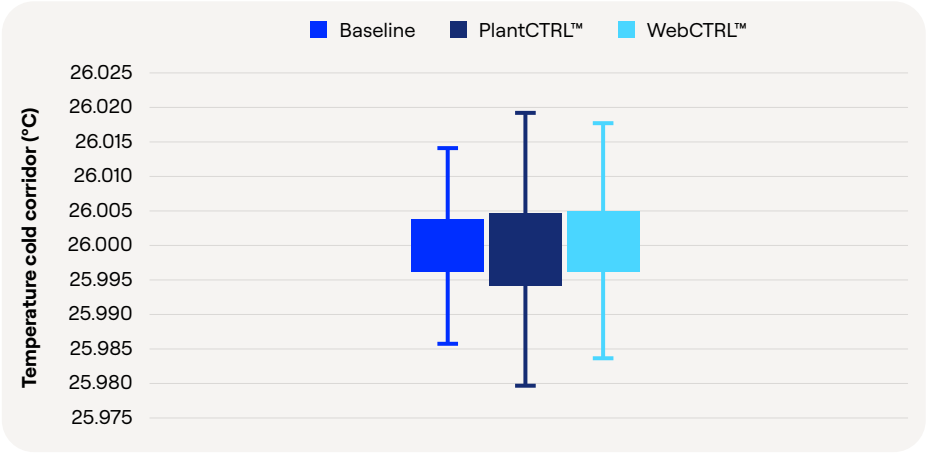
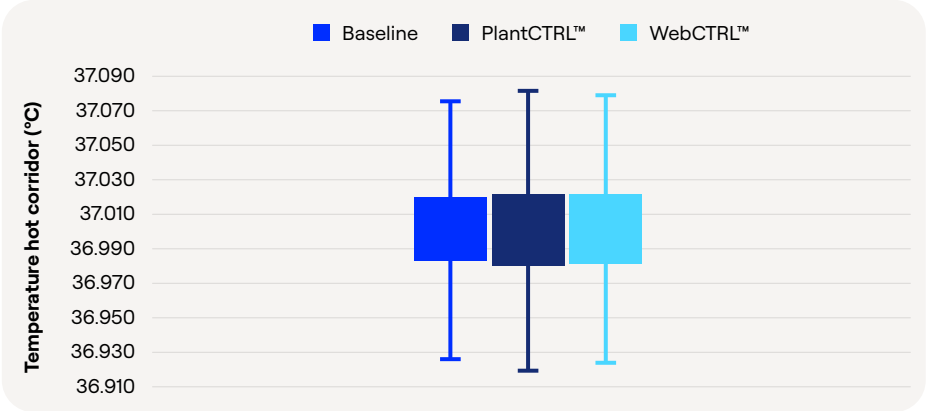
## Enhancement 2: PlantCTRL™ + WebCTRL™ System Level Supervisory Control

- **Carrier Equipment.**
- **Carrier PlantCTRL™ Plant Sequencer.**
- **Automated Logic WebCTRL™ System Level Supervisory Control.**

In the next stage of engagement, the PlantCTRL™ + WebCTRL™ supervisory control system for the data centre under study:

- **Ensures that cooling capacity and supply and return air temperatures in data halls always meet the setpoints specified by the customer.**
- **Monitors the status of all system actuators (CRAH valves, fans, etc.) and resets the chilled water temperature setpoint.**




### Key Point: KPI Compliance

Through dynamic simulations, our HVAC models calculate air-temperature trajectories in the data halls' cold and hot corridors – the two most important KPIs for data centre customers. The statistical analysis of these KPIs reveals that applying energy conservation logic does not compromise compliance with customer requirements. As shown in the figures, neither the median (represented by the line within the box), nor the interquartile range (represented by the box itself), nor the maximum or minimum values (excluding outliers) show any significant deviation due to optimisation sequences.

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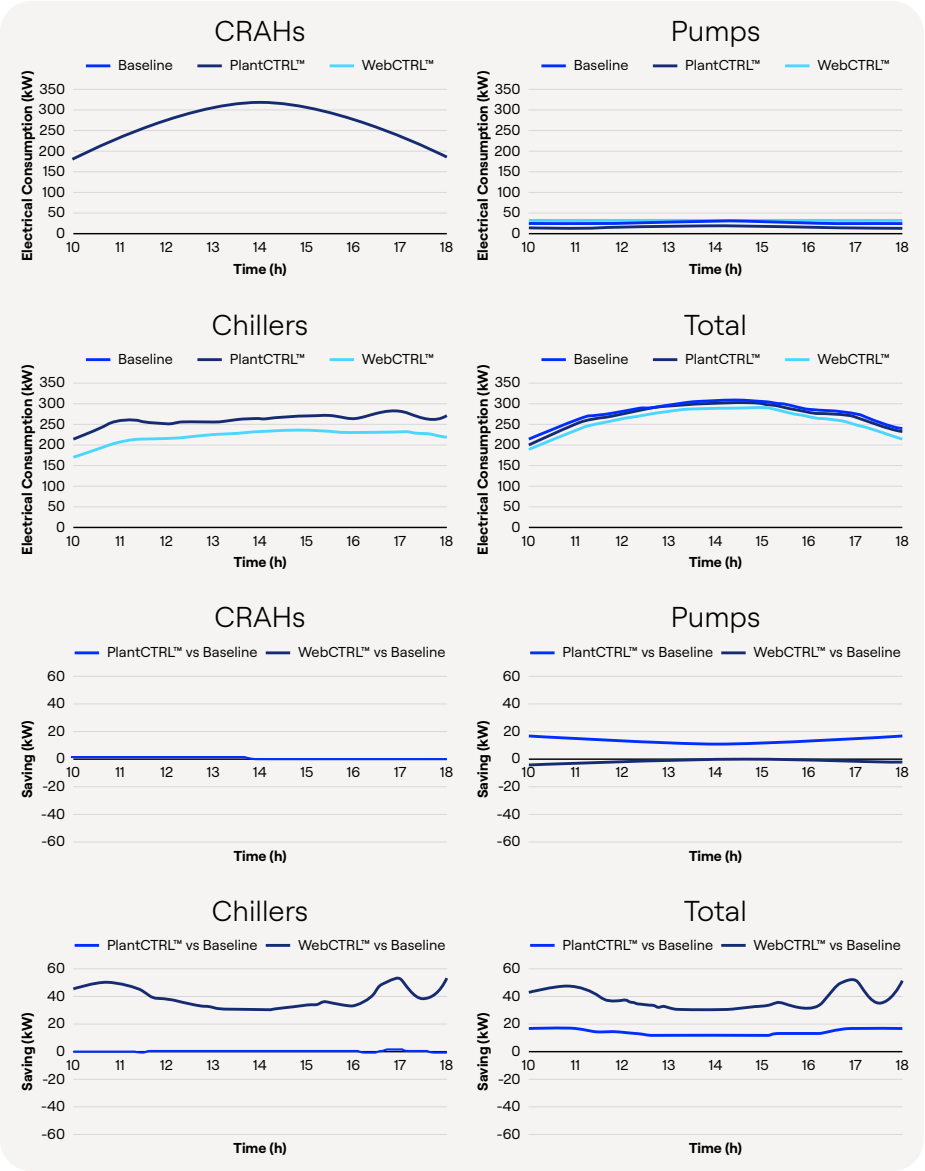


### Key Point: Setpoint Optimisation

Comparing the electrical consumption of the PlantCTRL™ plant sequencer alone with the PlantCTRL™ and WebCTRL™ supervisory system reveals that the floating chilled water temperature setpoint algorithm implemented by WebCTRL™ increases savings. However, a trade-off is necessary to minimise total system electrical consumption. While the floating setpoint reduces chiller consumption, it increases pump consumption. This demonstrates that an inadequate resetting strategy by a supervisory system could result in zero savings and, in some scenarios, could even increase total consumption.

Beyond the enhancements achieved with the PlantCTRL™ plant sequencer, the WebCTRL™ system-level supervisory control reduces the HVAC system's overall annual energy consumption by 5.2% at worst, 50.3% at best, and 10.1% in the sinusoidally varying case.

| Load Conditions | HVAC Energy Savings | HVAC Energy Savings |
|---|---|---|
| | PlantCTRL™ | WebCTRL™ |
| Constant load at 75% of max. | 2.5% | 5.2% |
| Constant load at 50% of max. | 11.8% | 20.9% |
| Constant load at 25% of max. | 31.7% | 50.3% |
| Sinusoidal load varying from 90% to 03% of max every 24 hrs. | 7.0% | 10.1% |

WebCTRL™ system-level supervisory control reduces the HVAC system's overall annual energy consumption by 5.2% at worst, 50.3% at best, and 10.1% in the sinusoidally varying case.

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# Summary & Conclusion

This study demonstrates that employing a chiller OEM (like Carrier) as a single point-of-contact HVAC solution provider yields significant energy reductions in data centre HVAC systems without compromising the customer-specified key performance indicators. This is achieved by applying optimisation control logic which, whilst innovative, is well-understood and robustly proven in this application.

Crucially, it reduces the risk associated with advanced control algorithms, as Carrier becomes the primary point of contact and is wholly accountable for the HVAC system's proper operation.

Finally, customers benefit from high-quality after-sales service, including guaranteed availability of parts and technicians, through reliance on a dependable global brand.

Employing a chiller OEM (like Carrier) as a single point-of-contact HVAC solution provider yields significant energy reductions in data centre HVAC systems

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