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IoT-Based HVAC Services Enabling Sustainability of Buildings

Boosting Building Performance and Climate Goals with Intelligent HVAC

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FOCUS POINTS

1	EVOLUTION AND IMPORTANCE OF BUILDING HVAC MAINTENANCE
2	PREDICTIVE MAINTENANCE IN IoT-BASED HVAC SERVICES
3	AI & IoT-BASED PREDICTIVE MAINTENANCE SYSTEM ARCHITECTURE
4	MARKET METRICS
5	IoT-BASED HVAC SERVICES FOR SUSTAINABILITY OF BUILDINGS
6	GROWTH OPPORTUNITIES
7	CALL TO ACTION FOR IoT-BASED HVAC SERVICES ADVANCEMENT
8	KEY TAKEWAYS

EVOLUTION AND IMPORTANCE OF BUILDING HVAC MAINTENANCE

EVOLUTION OF BUILDING HVAC MAINTENANCE

REACTIVE MAINTENANCE
Fix on Failure

PREVENTIVE MAINTENANCE
Scheduled Servicing

PREDICTIVE MAINTENANCE
Forecast Fault Detection

OUTCOME-BASED MAINTENANCE
Health & Productivity Focussed

IMPORTANCE OF BUILDING HVAC MAINTENANCE

POST-COVID IMPERATIVES

- Protect occupant health & safety
- Enhance ventilation & IAQ
- Improve infection control

AGING POPULATION GROWTH

- Safeguard vulnerable groups

ENERGY, ESG & RESILIENCE

- Reduce energy consumption
- Support sustainability goals
- Ensure uptime & reliability

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Source: Frost & Sullivan

PREDICTIVE MAINTENANCE IN IoT-BASED HVAC SERVICES

Why is Predictive Maintenance Important

Unplanned HVAC downtime can cost $10–25 per sq. ft. annually in commercial buildings due to lost productivity, tenant complaints, and emergency repairs. - *International Facility Management Association*

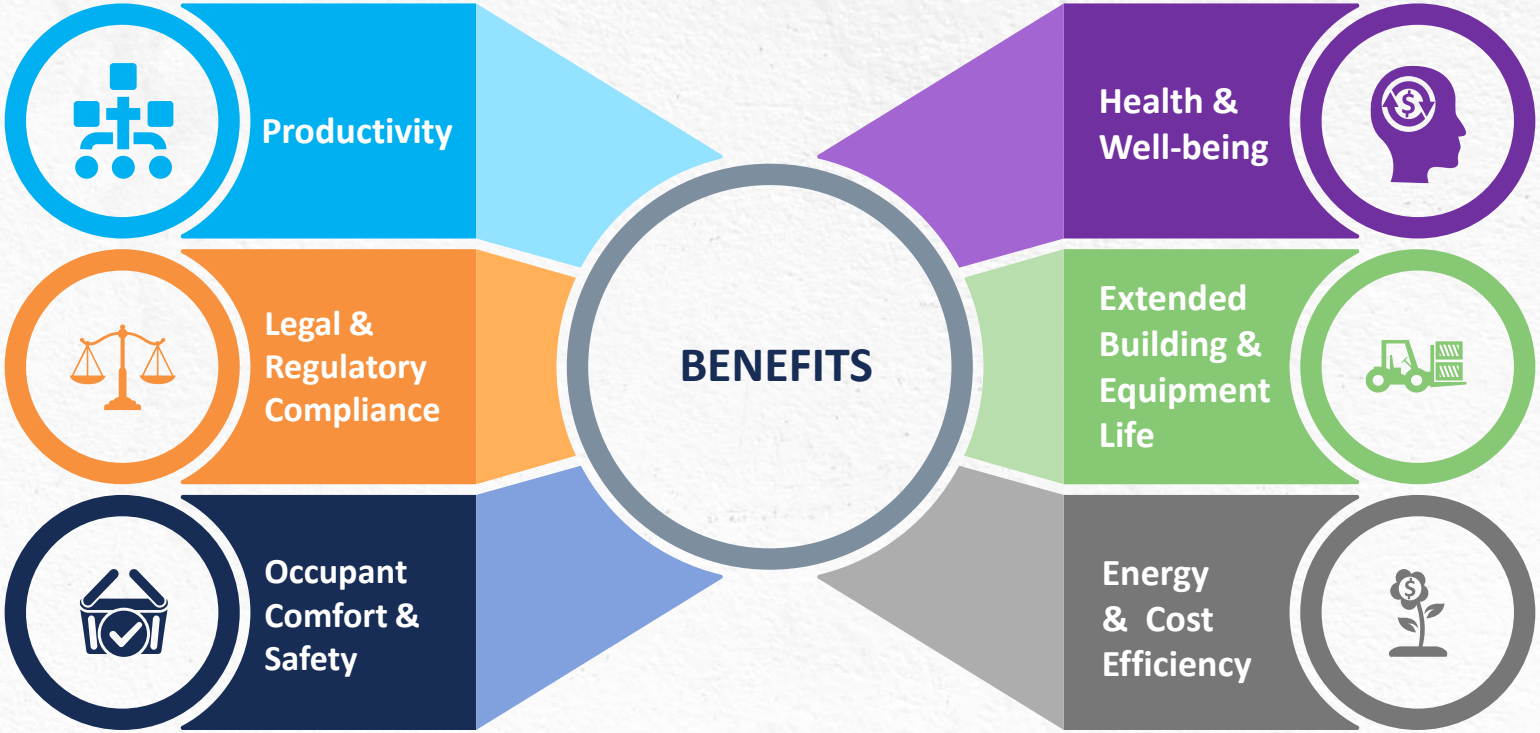
Reactive maintenance is 30-40% more expensive than scheduled or predictive maintenance due to overtime labor, emergency part orders, and extended system downtime. – *U.S. Department of Energy*

Poor HVAC maintenance leads to a **30% higher likelihood of IAQ-related complaints** in commercial properties. - *Building Owners and Managers Association*

Good IAQ management can improve worker productivity by **8–11%** and reduce absenteeism by **up to 35%**. - *Harvard T.H. Chan School of Public Health*

PREDICTIVE MAINTENANCE IN IoT-BASED HVAC SERVICES

Benefits of Predictive Maintenance



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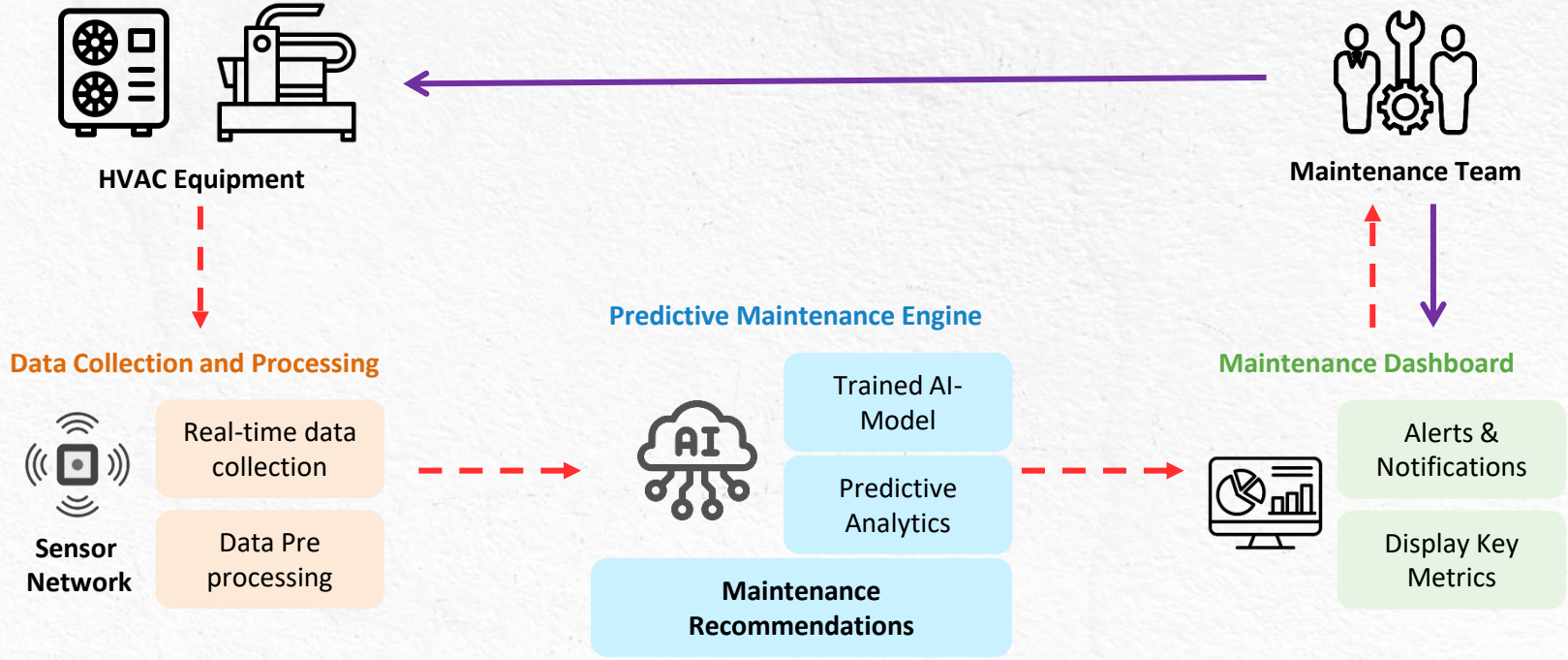
Source: Frost & Sullivan

AI & IoT-BASED PREDICTIVE MAINTENANCE SYSTEM ARCHITECTURE

Overview



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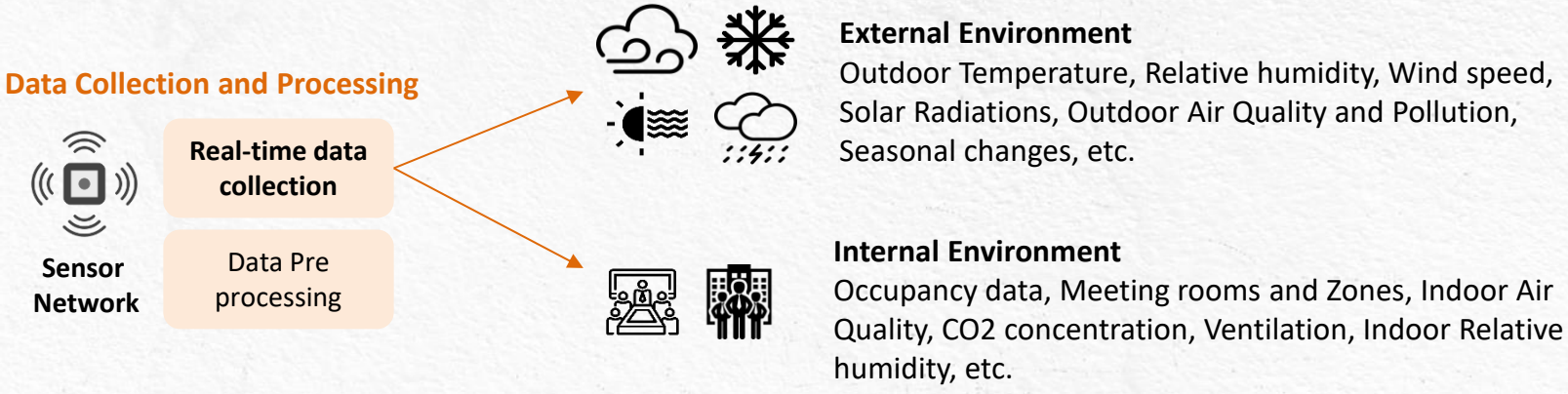
Source: ESP IJACT, 2(3), 6-19, 2024; Frost & Sullivan analysis

AI & IoT-BASED PREDICTIVE MAINTENANCE SYSTEM ARCHITECTURE

Key Parameters for Data Collection and Processing

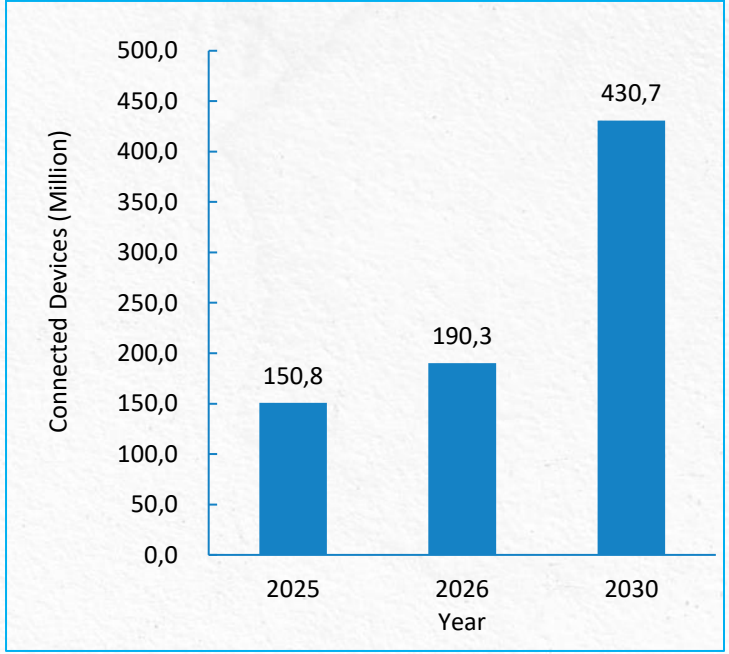


You Can't Manage What You Can't Measure

MARKET METRICS

Installed Base of Connected HVAC Devices

Number of Connected HVAC Devices, Global, 2025, 2026, and 2030



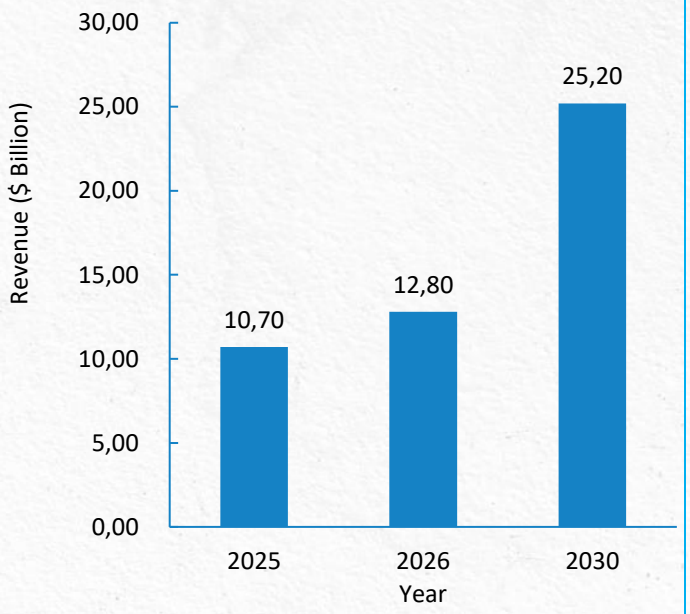
Notable Advancement	
Growth Projections	• +26.2% in 2026 • CAGR of 23.4% from 2025 to 2030
Smarter Operations	• Connected HVAC systems enable early fault detection. • Real-time data helps optimise energy use. • AI and ML automate adjustments based on user habits.
Broader Connectivity	• HVAC is integrating with lighting, security, and other systems. • More connectivity increases cybersecurity risks. • Companies like WebbyLab, Particle, and Aristotle Air offer advanced IoT HVAC solutions.

Source: Frost & Sullivan

MARKET METRICS

Revenue Forecast of IoT-based HVAC Services

IoT-Based HVAC Services: Revenue Forecast, Global, 2025, 2026, and 2030



Notable Advancement

Growth Projections

- +19.7% in 2026
- CAGR of 18.6% from 2025 to 2030

Service Innovations

- Innovation is led by HVAC incumbents and IoT startups.
- Remote diagnostics, predictive maintenance, and energy analytics dominate – differentiation is important.
- Providers are shifting to recurring, outcome-based models like HVACaaS.

Technology and Risks

- Concerns persist around proprietary protocols, AI transparency, and cybersecurity.
- Standardized security frameworks and clearer ESG rules are improving adoption.

Source: Frost & Sullivan

IoT-BASED HVAC SERVICES FOR SUSTAINABILITY OF BUILDINGS

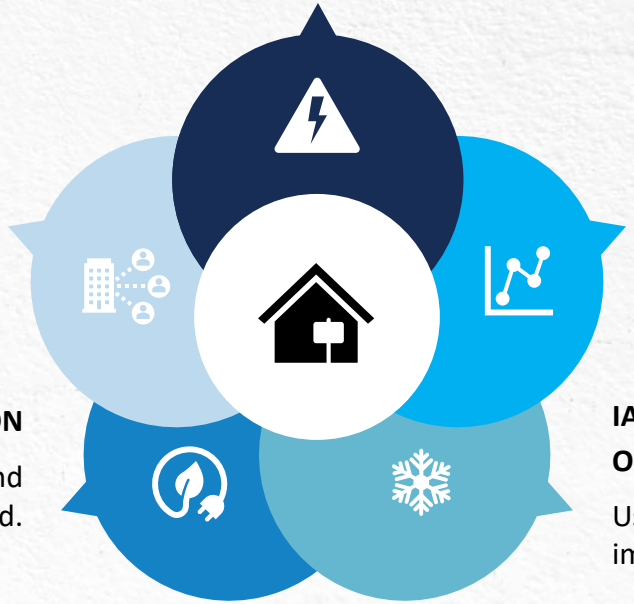
Overview

ENERGY-EFFICIENT HVAC AND LIGHTING RETROFITS

Upgrading systems (VRF, heat pumps, LEDs) to reduce baseline energy use.

AI-POWERED AUTONOMOUS OPERATIONS PLATFORMS

Using IoT data and AI for predictive maintenance, fault detection, and self-optimizing systems.



IoT-BASED ENERGY MANAGEMENT SYSTEMS

Monitoring and optimizing energy use across HVAC, lighting, and plug loads in real time.

ON-SITE RENEWABLE ENERGY INTEGRATION

Integrating solar PV, thermal storage, and load shifting to better manage peak demand.

IAQ MONITORING AND VENTILATION OPTIMIZATION

Using sensors and advanced ventilation to improve air quality and efficiency.

IoT-BASED HVAC SERVICES FOR SUSTAINABILITY OF BUILDINGS

5 Cornerstones

01 Energy-efficient HVAC and Lighting Retrofits

- IoT sensors adjust HVAC and lighting in real time based on occupancy and conditions.
- Predictive maintenance cuts failures and prolongs retrofit system life.
- Integrated controls improve retrofit decisions and automate lighting for higher efficiency.

02 IoT-based Energy Management Systems

- IoT-enabled EMS automates HVAC, lighting, and ventilation to improve energy efficiency.
- Systems optimize consumption by adjusting equipment based on occupancy, schedules, and conditions.
- EMS uses HVAC data for building-wide analytics, reporting, and better energy decisions.

03 IAQ Monitoring and Ventilation Optimization

- IAQ sensors track CO_2, pollutants, humidity, and temperature to support healthier indoor air.
- HVAC adjusts ventilation based on IAQ readings to balance fresh air, comfort, and energy use.
- Real-time IAQ data flags emerging issues and guides proactive ventilation actions.

04 On-site Renewable Energy Integration

- IoT HVAC adjusts heating and cooling to help balance energy supply and demand.
- Systems coordinate with on-site solar to shift HVAC loads during high-generation periods.
- Energy storage and usage data support smarter use of renewable energy across the building.

05 AI-powered Autonomous Operations Platforms

- AI uses HVAC and sensor data to spot issues, learn patterns, and optimize comfort.
- Systems automate HVAC tasks, like pre-cooling and airflow changes, based on occupancy and conditions.
- AI coordinates building systems and improves performance through continuous learning.

GROWTH OPPORTUNITIES

Retrofit for Aging Building Stock

Many old commercial buildings (especially those over 30 years old) are energy inefficient. Smart retrofits using IoT, smart HVAC, and new regulations create strong opportunities to upgrade performance and cut emissions.

Advancing Net Zero

Global momentum for net-zero goals is driving demand for strategies combining efficient HVAC, renewables, IAQ, and energy analytics, with rising investment expected in smart retrofits and electrification through 2030.

Healthy Building Certifications and ESG-Linked Financing

Growing ESG expectations and global certification frameworks are driving demand for healthy buildings. Certifications and ESG-linked financing are increasingly tied to HVAC upgrades, filtration, IAQ improvements, and building performance between now and 2030.

IAQ-as-a-Service and HVAC-as-a-Service

Growing focus on wellness, energy efficiency, and uptime is driving demand for IAQaaS and HVACaaS models, where providers manage systems remotely using cloud tools, sensors, analytics, and predictive diagnostics.

CALL TO ACTION FOR IoT-BASED HVAC SERVICES ADVANCEMENT

Integrated and Scalable Retrofit Offering

Providers should deliver modular, interoperable retrofit solutions and bundled services like monitoring and predictive maintenance, integrating with existing BMS and targeting high-potential sectors such as hospitality and healthcare.

Position as Full-Scope Energy Partners

Providers should position themselves as full net-zero partners by offering auditing, smart retrofits, HVAC upgrades, renewables integration, and digital carbon-tracking tools aligned with growing regulatory and customer requirements.

Partnerships for Certification and Financing

Providers should align solutions with certification requirements, bundle IAQ monitoring and filtration upgrades, partner with REITs and lenders, and demonstrate ROI through improved comfort, retention, and asset value.

Power Next-Gen HVAC Services With Integrated Smart Platforms

Providers should create IAQaaS and HVACaaS bundles with smart equipment, monitoring dashboards, and automated fault detection, while integrating preventive IoT-based maintenance and offering certification-linked service tiers.

KEY TAKEAWAYS

1

HVAC Maintenance Shift:

HVAC is rapidly moving from reactive to predictive, boosting uptime and IAQ.

2

Predictive Maintenance Value:

Predictive maintenance cuts costs, reduces failures, and improves occupant well-being.

3

AI + IoT Enablement:

AI and IoT deliver real-time insights, automated fault detection, and smarter servicing.

4

Connected HVAC Growth:

Connected HVAC devices and IoT-based service models are expanding quickly.

5

Smart & Sustainable Buildings:

IoT retrofits, EMS, IAQ optimisation, and renewables are driving building transformation.