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NEXT Black Sea Basin

STEP2CleanPlan

COOPERATION FOR SUSTAINABLE ENERGY AND CLIMATE ACTIONS PLANNING AND MONITORING IN BSB

STEP2CleanPlan BSB00004

Module 2: Sustainable Urban Mobility and Energy Efficiency

Sub Module 202: Energy Efficiency in Urban Infrastructure

202 D: Smart Building Foundations & BAS Architecture

Trainer:

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Agenda

- What is a Smart Building?
- BAS Architecture and Functions
- Key Components and Protocols
- Integration, SRI and Interoperability
- Smart Renovation and Commissioning
- Data, Optimization, and Policy Links
- Reflection Questions

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What Defines a Smart Building?

- Automated, responsive, connected systems
- Real-time interaction with environment
- Enhanced efficiency and occupant experience

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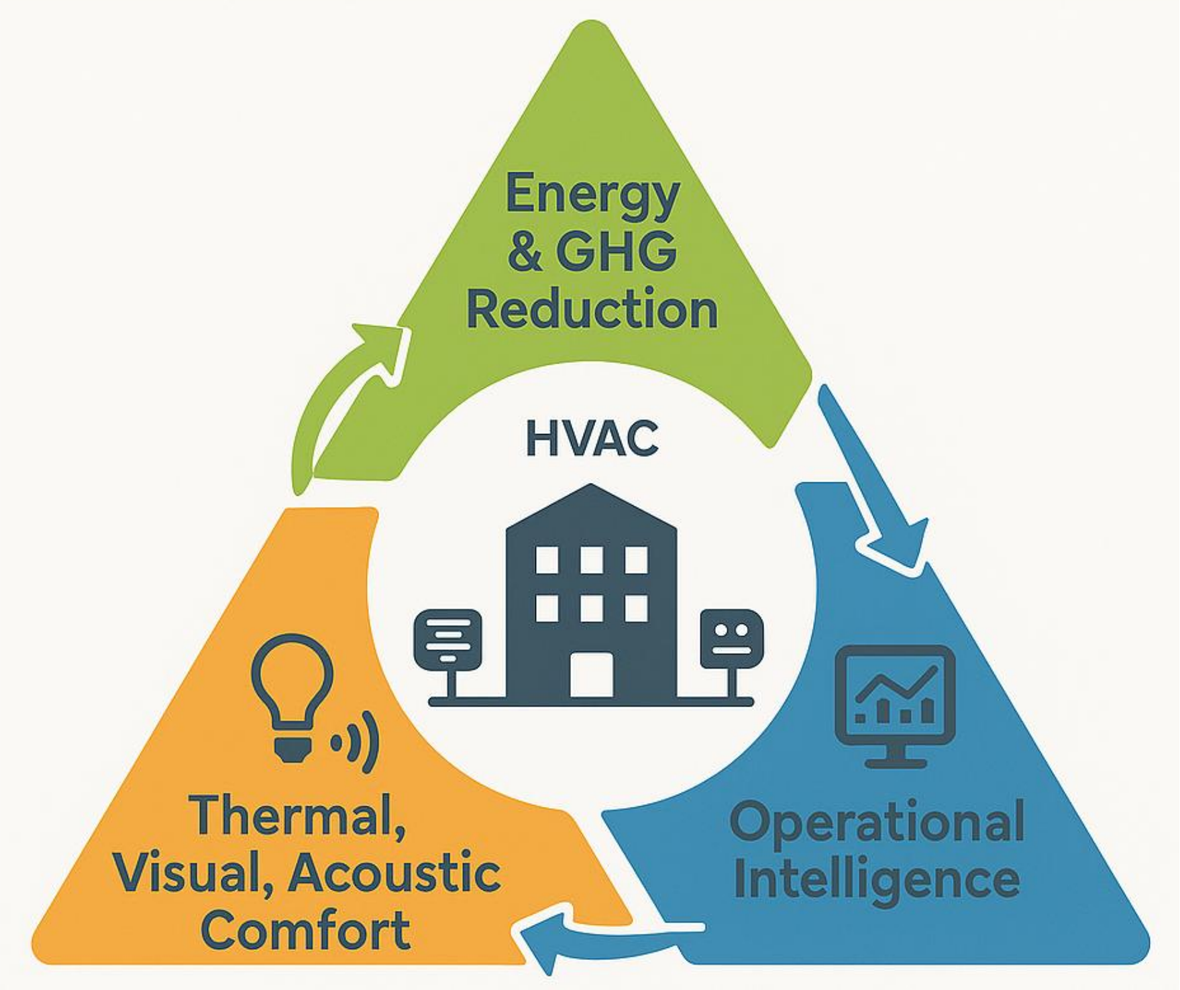
Design Goals of Smart Systems

- Reduce GHG and energy use
- Improve thermal, visual, acoustic comfort
- Enable building intelligence



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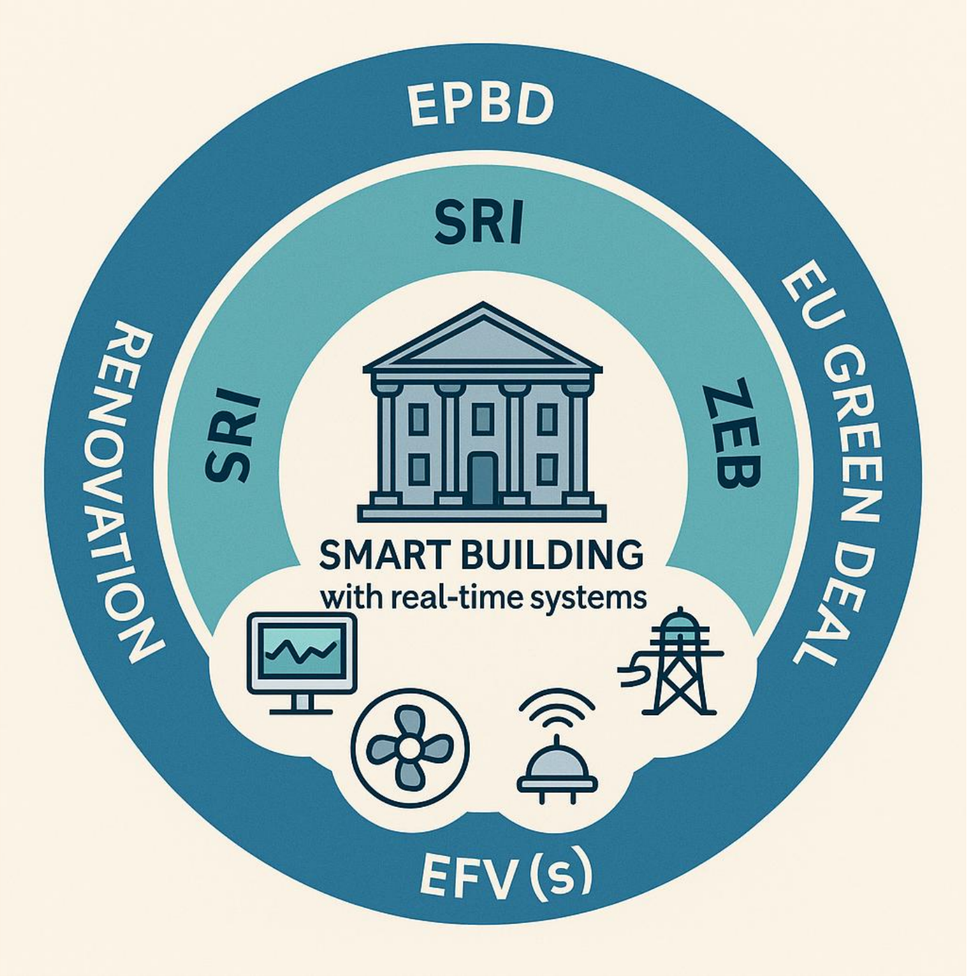
Why Smart Buildings Matter for the EU

- EPBD Recast includes SRI
- Support ZEB, EPC, Level(s)
- Public buildings must lead adoption



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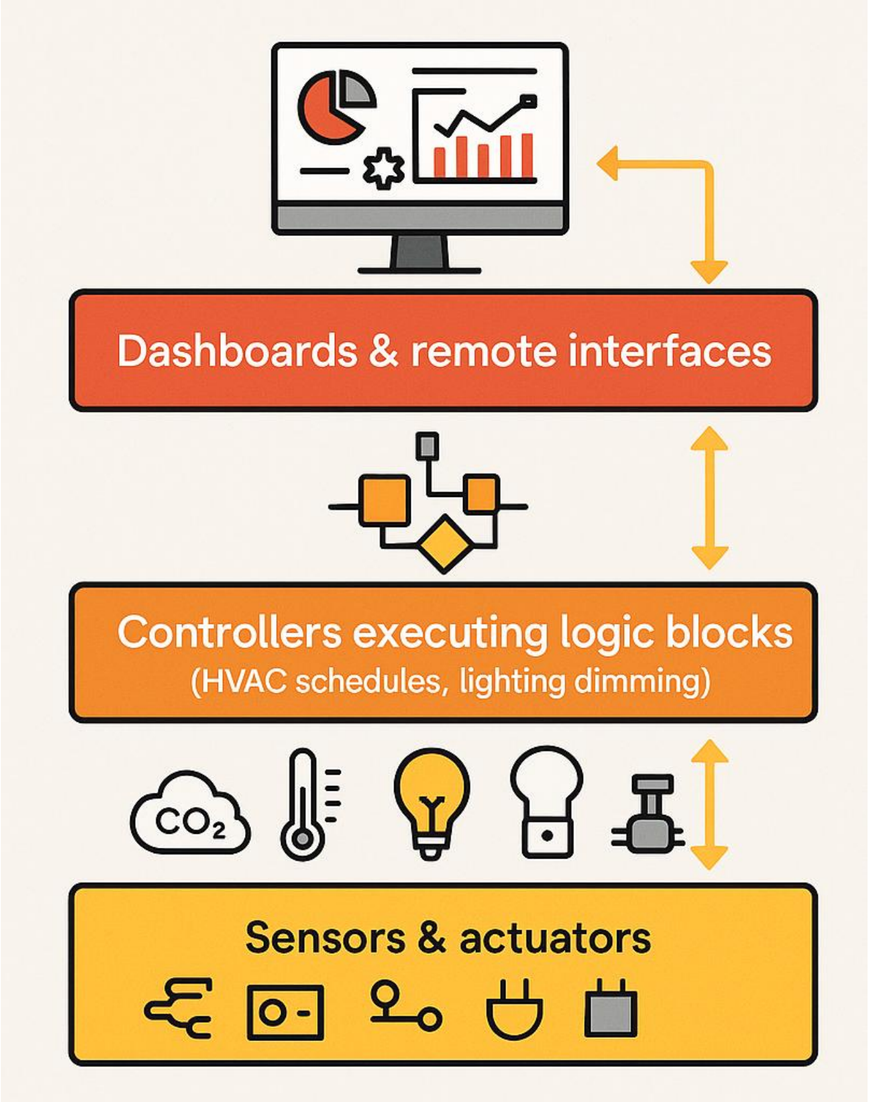
What is a Building Automation System?

- Digital layer for HVAC, lighting, safety, access
- Centralized control of building systems
- Supports automation and optimization



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Core Functions of BAS

- Monitoring and scheduling
- Remote access and control
- Fault detection and diagnostics

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BAS vs BMS vs EMS

System	Key Focus	Components
BAS	Real-time control	HVAC, Lighting, Access, Shading
BMS	Centralized management	Fault detection, Fire Safety, Dashboards
EMS	Energy analytics & strategy	Meters, Carbon Reports, Portfolio Dashboards

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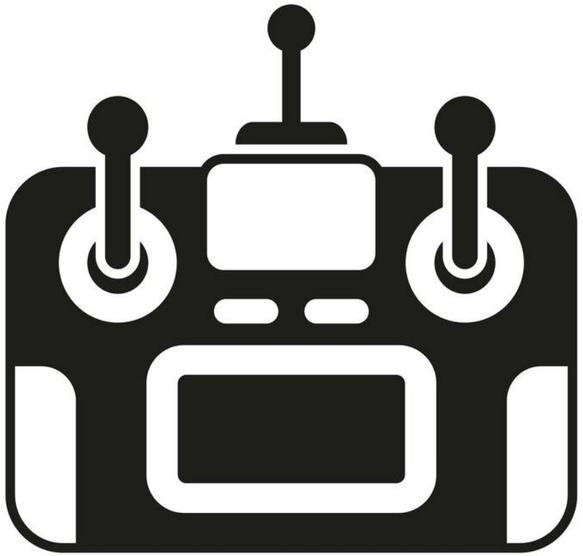
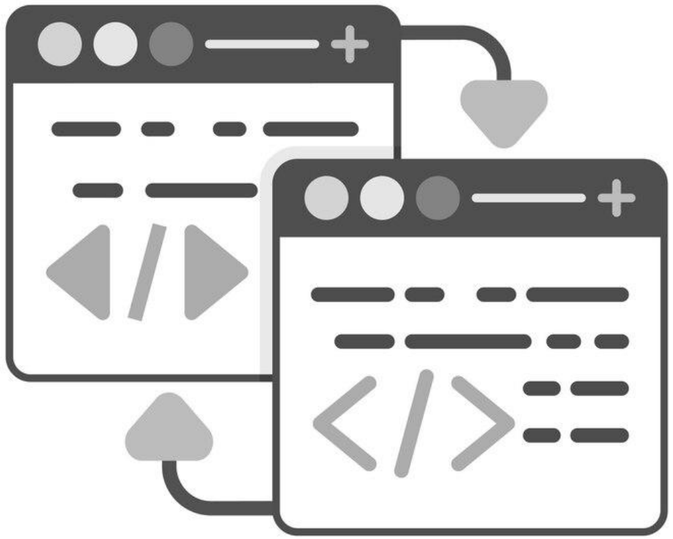
Key Components in BAS

- Sensors (CO_2, temp, presence)
- Controllers and actuators
- User interface and software





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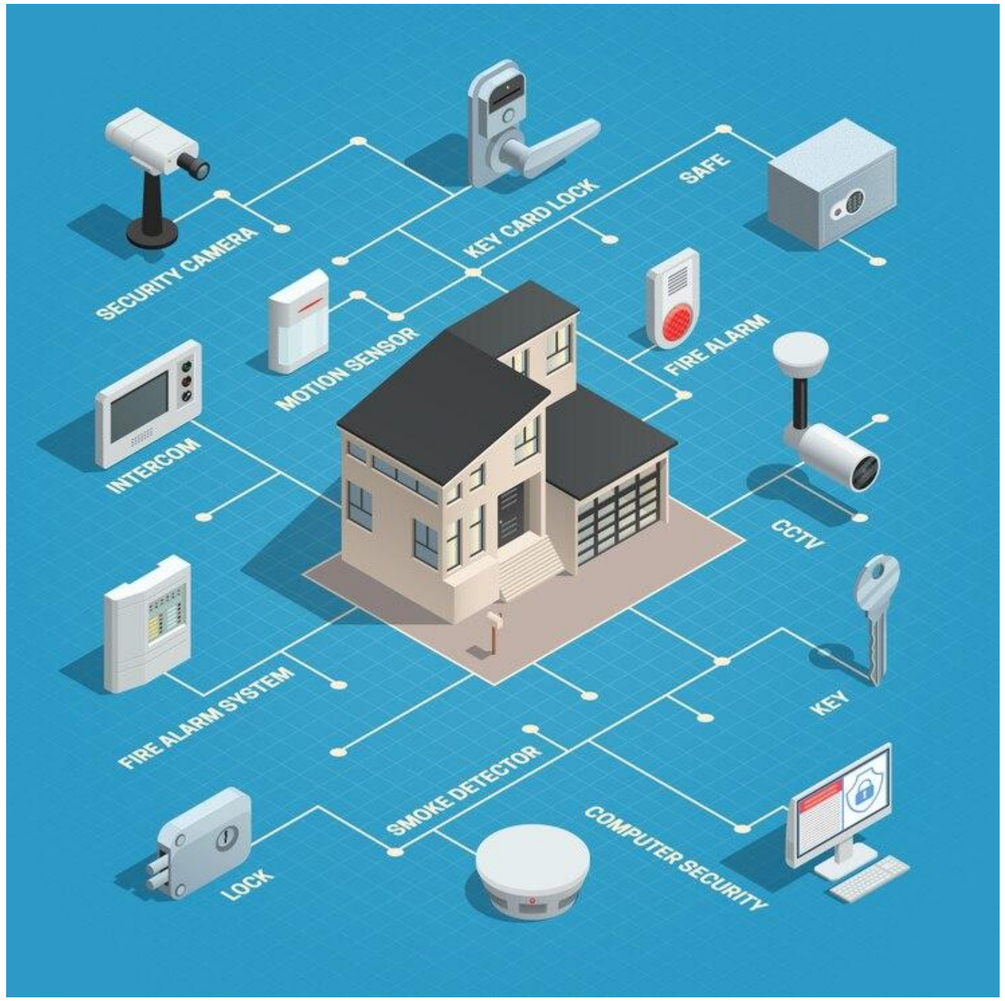
Sensor Use Cases

- Trigger ventilation, lighting, security
- Support comfort and safety
- Critical to smart responsiveness



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Controllers and Logic Programming

- Setpoints, PID loops, safety interlocks
- Logic trees for scenario response
- Local + centralized control layers

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Open vs Proprietary Protocols

Open Protocols

BACnet®

KNX

Modbus

Proprietary Systems

- Vendor-locked
- Limited interoperabilitiy

EU Preference →
Open, Secure, Interoperarable

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Interface Tools: Dashboards

- Real-time visualization of zones
- Mobile and browser-based control
- Role-based access and alerts

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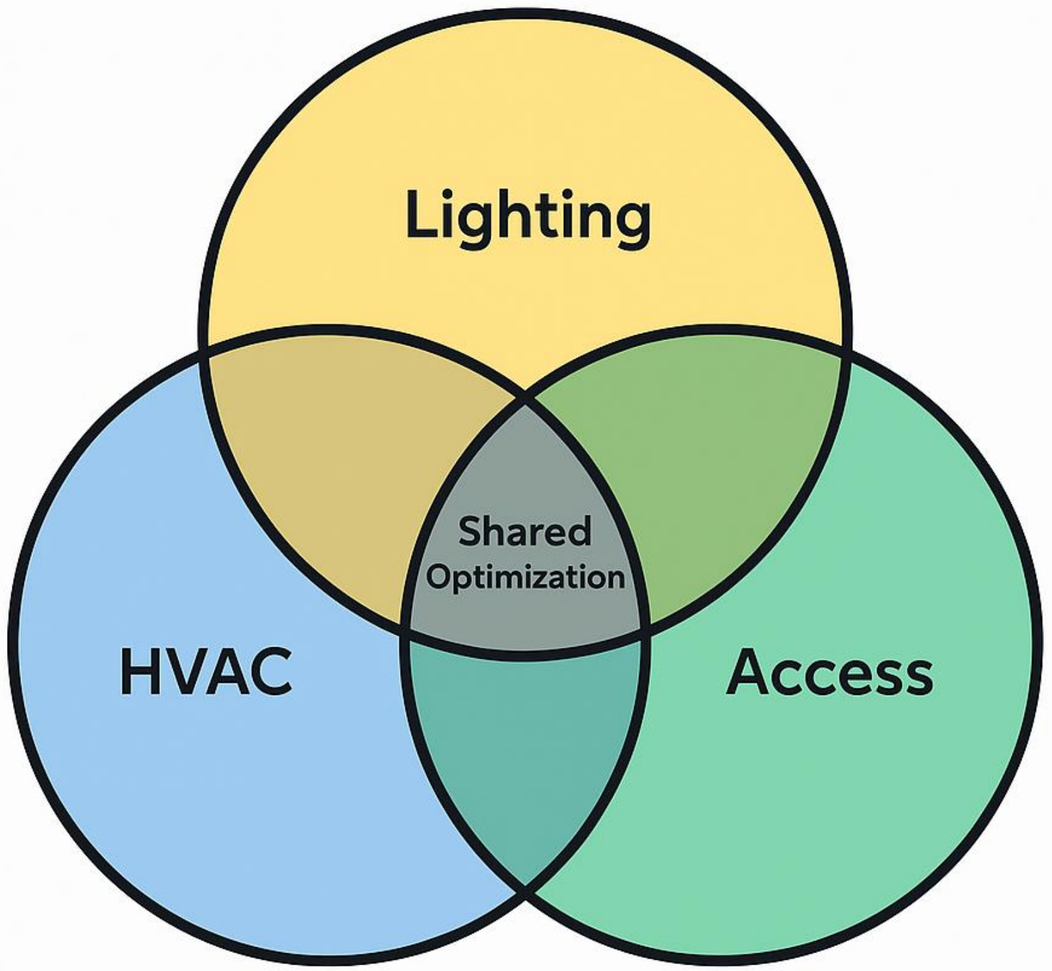
System Integration Benefits

- Avoid silos, improve performance
- Unified control = better coordination
- Scalable logic for future tech



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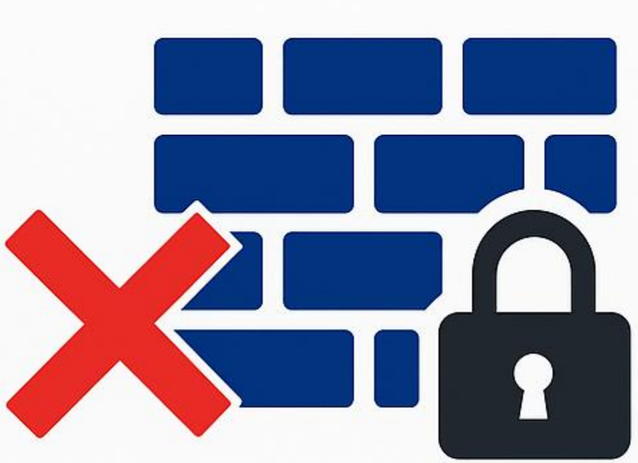
Interoperability Challenges

Legacy systems, protocol clashes



IT/OT firewalls, cyber risk

Lack of skilled integrators

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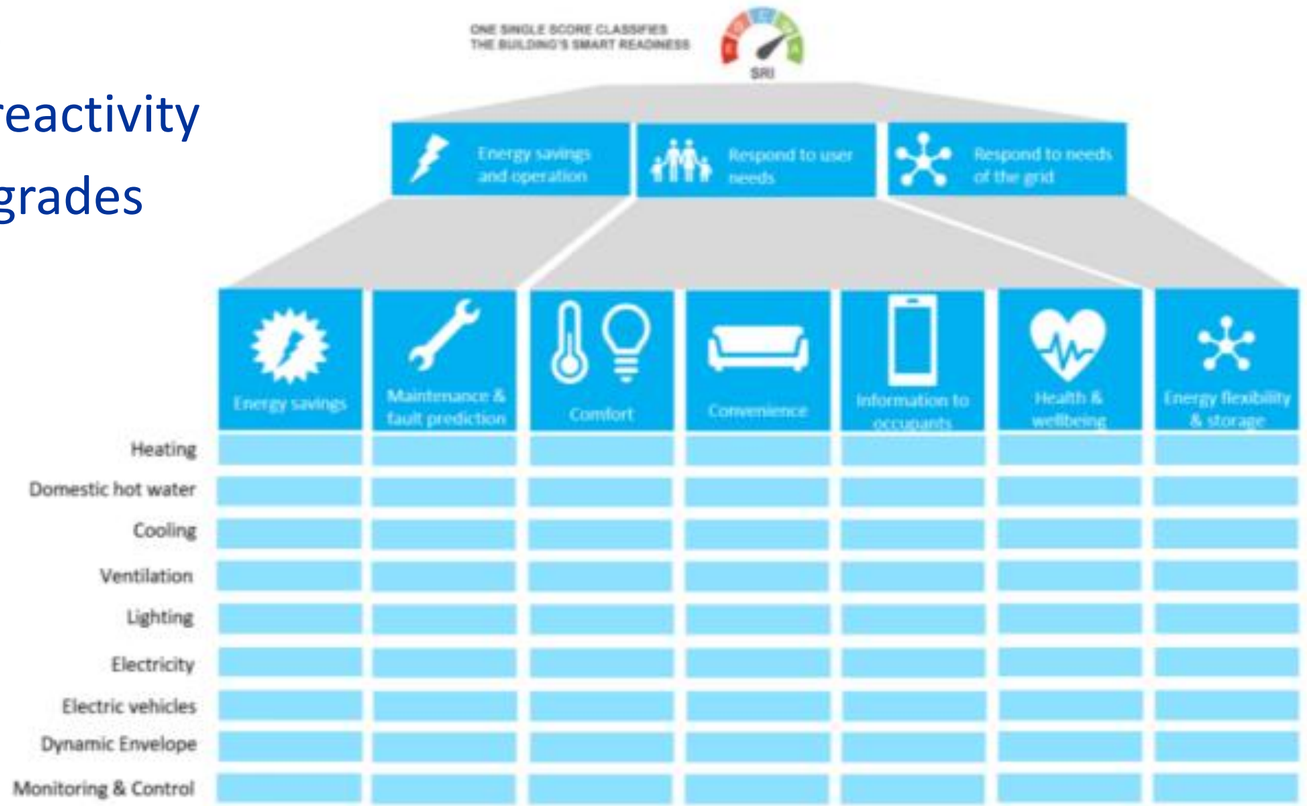
Smart Readiness Indicator (SRI)

- Scores buildings on smart capabilities
- Domains: automation, optimization, reactivity
- Used in passports/logbooks + EPC upgrades



Source: REHVA

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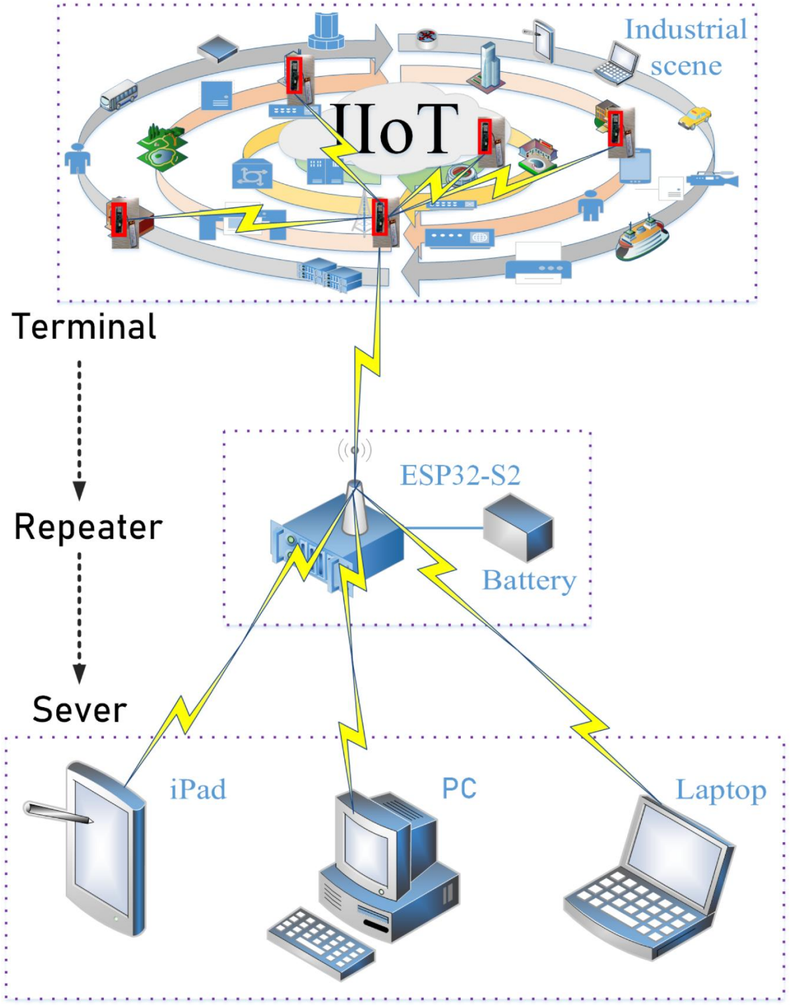
Cloud + Edge BAS Trends

- Cloud = remote insight and updates
- Edge = real-time, local resilience
- EU projects use hybrid approaches



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Smart Retrofitting Approaches

- Wireless or IP-based retrofits
- Step-by-step sensor + controls layering
- Integrate with envelope upgrades

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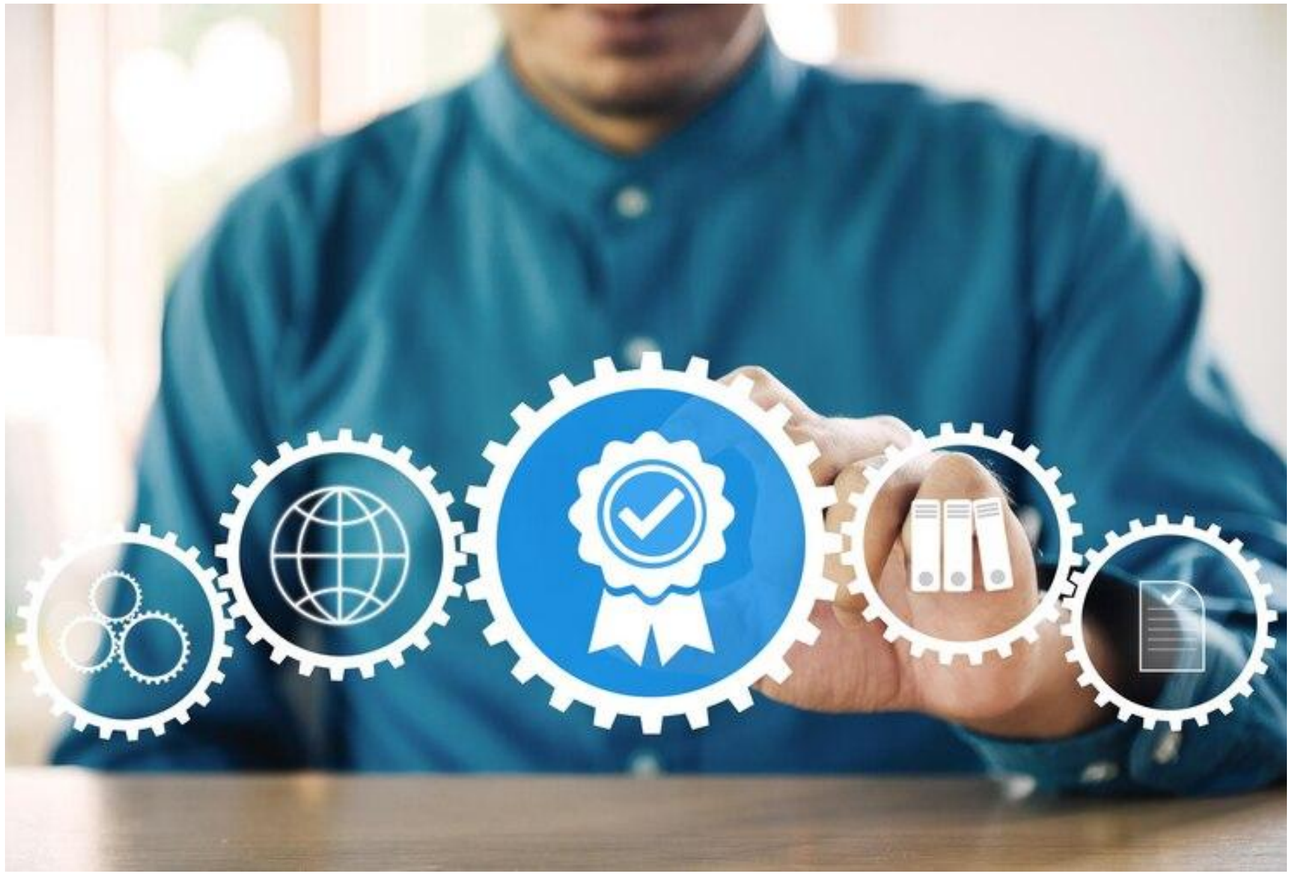
Commissioning and Quality Assurance

- Pre-functional + performance testing
- System calibration and validation
- Handover includes interface checks



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Data Use for Optimization

- Trend analysis + auto-adjustment
- Anomaly detection = proactive O&M
- Input for Level(s), PHPP, EPC upgrades

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How SRI Links to Level(s)

- Both focus on performance + user impact
- Support lifecycle and post-occupancy tracking
- Used in green finance frameworks

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Conclusion & Takeaways

- Smart buildings = EU-ready performance
- BAS is foundational to ZEB operation
- Open + interoperable = futureproof

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Reflection Questions

- Which BAS feature matters most for your role?
- What stands in the way of smart integration?

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Smart Retrofitting: Wireless & IP Protocols

- Wireless: Zigbee, LoRa, BLE enable retrofit zones
- IP-based BAS reduces conduit and cabling needs
- Gateways bridge legacy and smart protocols

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Q & A

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Module 2: Sustainable Urban Mobility and Energy Efficiency

Sub Module 202: Energy Efficiency in Urban Infrastructure

202 H: Cybersecurity and Interoperability for Smart Building Systems

Trainer:

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Agenda

- Cyber Threats in Smart Buildings
- BAS/IoT Vulnerabilities & Attack Vectors
- Protocol Conflicts & Interoperability Gaps
- Cybersecurity Standards & Semantic Governance
- Designing for Security & Lifecycle Monitoring
- Future-Proofing & Risk-Based Modernization
- Conclusion & Reflection

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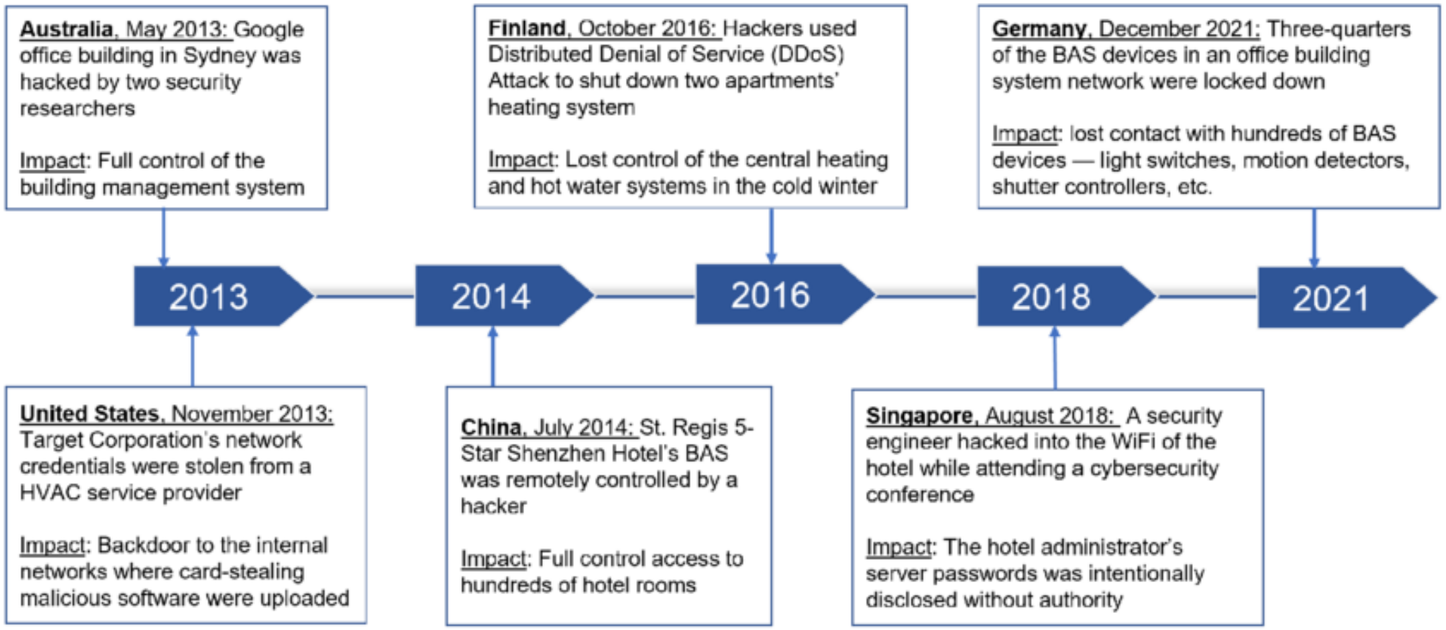
Why Cybersecurity Now?

- IoT adoption → attack surfaces grow
- FM systems now expose operations
- Breaches impact safety, comfort, data



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Vulnerabilities in BAS & IoT Systems

- Flat networks → lateral attacks
- Default credentials & open ports
- Unpatched firmware + outdated protocols

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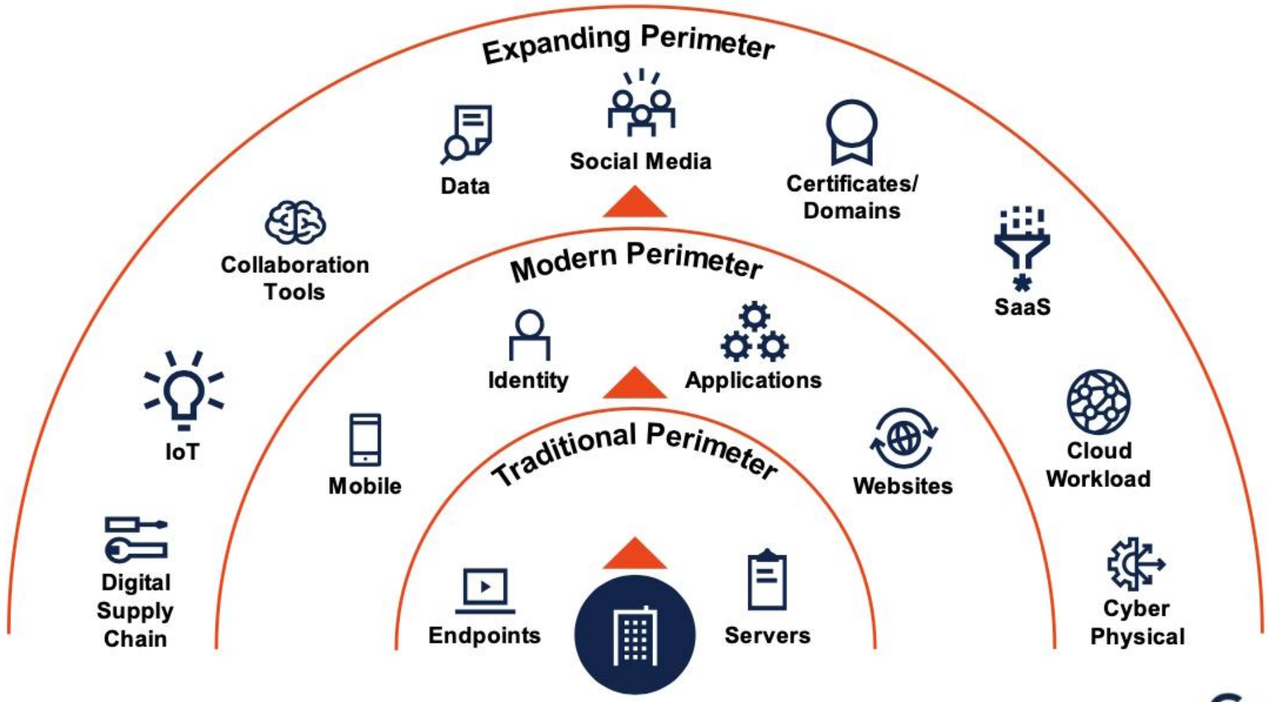
IoT Weaknesses in Smart Buildings

- Cloud dashboards poorly secured
- MQTT replay & fallback disruption
- Edge-to-cloud trust gaps



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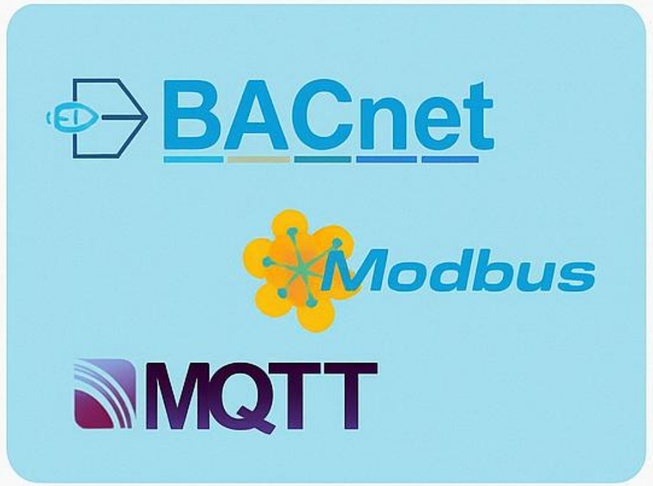
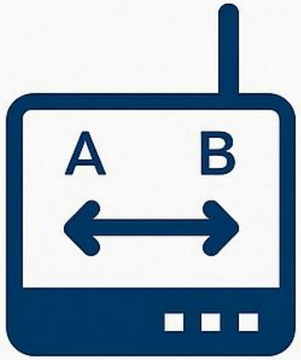
Protocol Misalignment Risks





- no standard handoff

Translation loss & point mismatch

Gateways = single points of confusion

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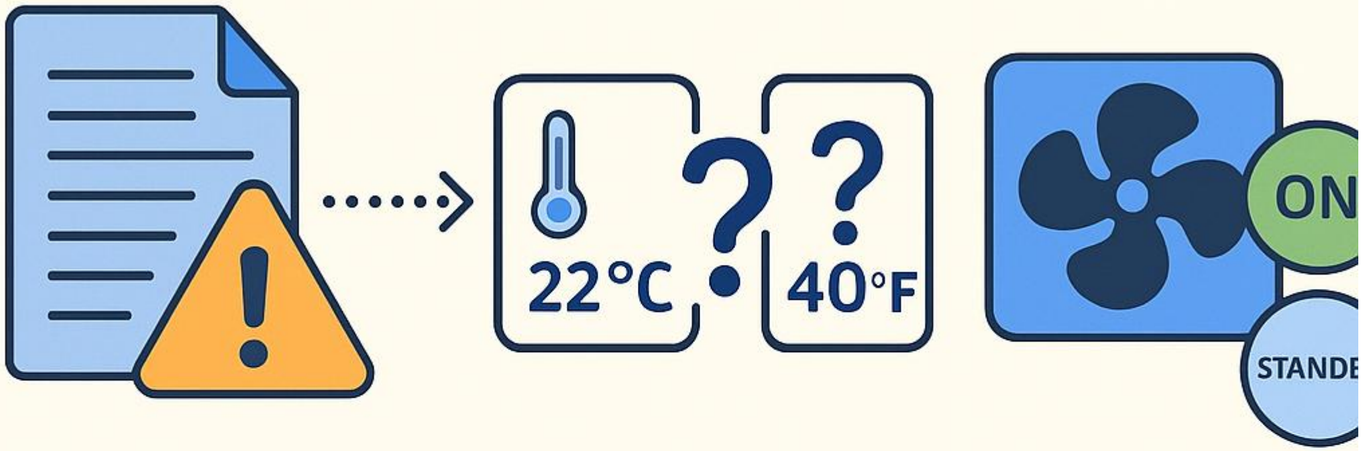
Semantic Conflicts in Integration

- Units, tags, meanings lost in translation
- Room temp vs duct temp confusion
- Fan status: binary vs enum



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Units, tags, meanings lost in translation

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Governance Failures & Blind Spots

- No integration plan → overlapping access
- Inconsistent naming → misfire APIs
- Semantic gaps = unmonitored zones

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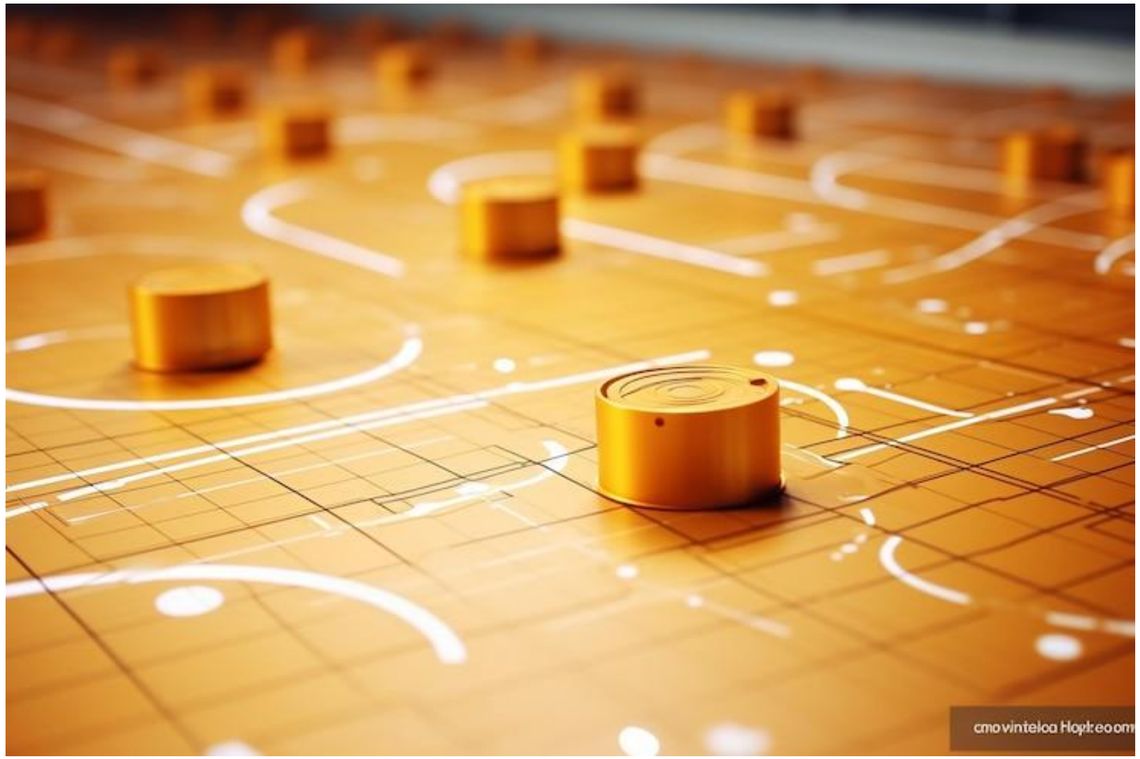
Cybersecurity Standards for Smart Buildings

- IEC 62443: BAS lifecycle approach
- NIST CSF: Identify, Protect, Detect...
- ISO 27001: InfoSec management for FM
- BACnet/SC: Secure encrypted communication



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Semantic Frameworks for Governance

- Brick Schema & Haystack = access + audit
- Support for RBAC + API validation
- Semantic integrity → system accountability

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Designing a Secure BAS Architecture

- Segment with VLANs, firewalls, RBAC
- Patch lifecycle & encrypted logging
- Use protocol filtering at edges

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RBAC & Auditability

- Tech vs Admin → limited permissions
- Audit trails, logs, traceability
- NIST, ISO, IEC support role models

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Real-Time Monitoring & Incident Response

- IDS, SIEM, log analysis in FM context
- Behavior monitoring of edge devices
- Incident playbooks and tabletop drills

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Legacy Systems: Risk & Containment

- Segment, isolate, filter bridges
- Upgrade roadmap + risk heatmap
- Legacy ≠ ignored

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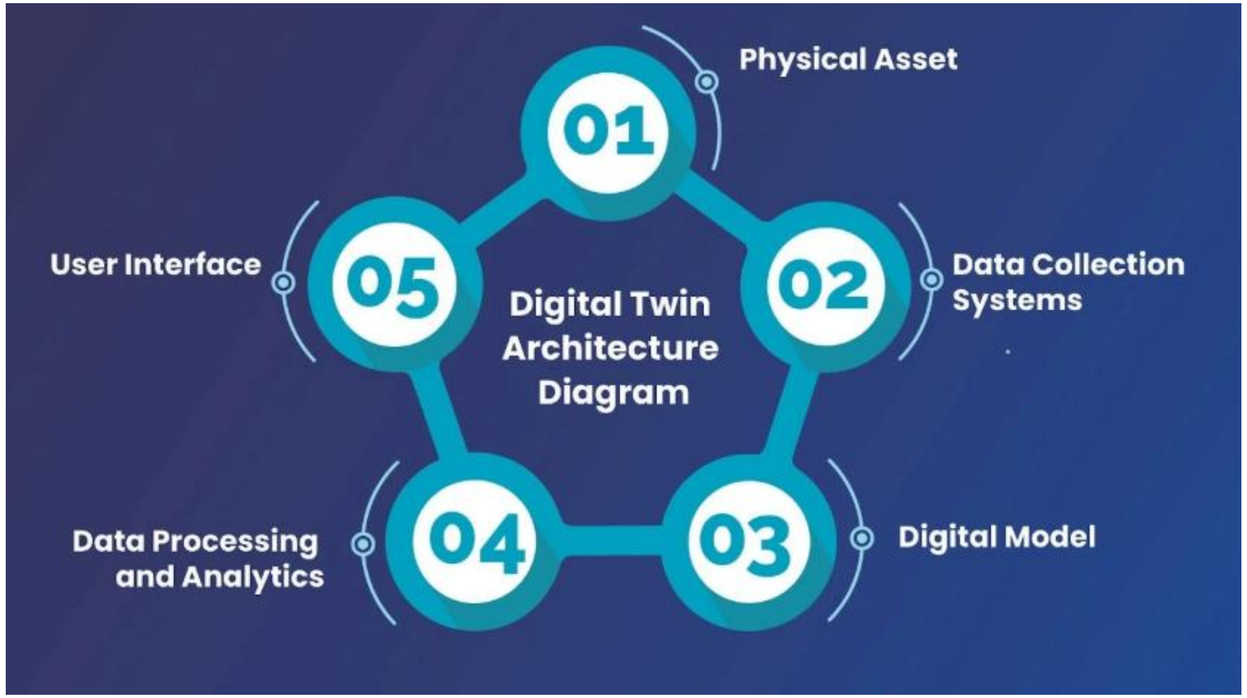
Security by Design & Digital Twins

- Model, test, simulate security workflows
- Embed tag integrity & behavioral baselines
- Train teams with simulation insight



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Ongoing Adaptation & Governance

- Patch, monitor, retrain policies regularly
- Review post-event failures
- Iterate design with new threats

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Conclusion: Design for Resilience

- Security → performance + continuity
- Interoperability → clarity + maintainability
- Govern with foresight, not patchwork

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Reflection Prompts

- What risks exist due to protocol misalignment?
- How can your team support RBAC and segmentation?
- What upgrade priority should be mapped first?

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Modernization Roadmap for Smart Buildings

- Legacy → VLAN segmentation
- Intermediate: protocol filter gateways
- Future: encrypted, semantic twins

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Lifecycle Update Flow

- Scan & detect threats
- Patch & document
- Train & retest teams
- Review policy post-incident

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Q & A

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Module 2: Sustainable Urban Mobility and Energy Efficiency

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202 I: Data Analytics, Fault Detection & GIS Integration

Trainer:

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Agenda

- Data in Smart Building Operations
- KPIs, Dashboards, and Visualization
- Fault Detection & Diagnostics (FDD)
- Predictive Maintenance and Alerts
- GIS Mapping for Urban Efficiency
- Conclusion & Reflection

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Why Data Analytics Matters

- Transforms raw data into insights
- Improves energy, comfort, uptime
- Supports long-term performance planning

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Smart Data Infrastructure

- Logging: local or cloud
- APIs, middleware, storage
- Feeds dashboards and analytics

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What Are KPIs in Smart Buildings?

Energy Performance

- Energy Use Intensity (EUI)
- kWh/m²/year
- Benchmark vs. Design

Comfort Metrics

- Temperature
- CO_2 Levels
- Humidity
- Occupant Satisfaction

Operational Uptime

- System Availability
- Runtime Hours
- Fault Frequency

Occupancy & Usage

- Zone Occupancy
- Occupant Density
- Schedule Alignment

GHG & Sustainability

- GHG Emissions
- Renewable Ratio
- Carbon Intensity

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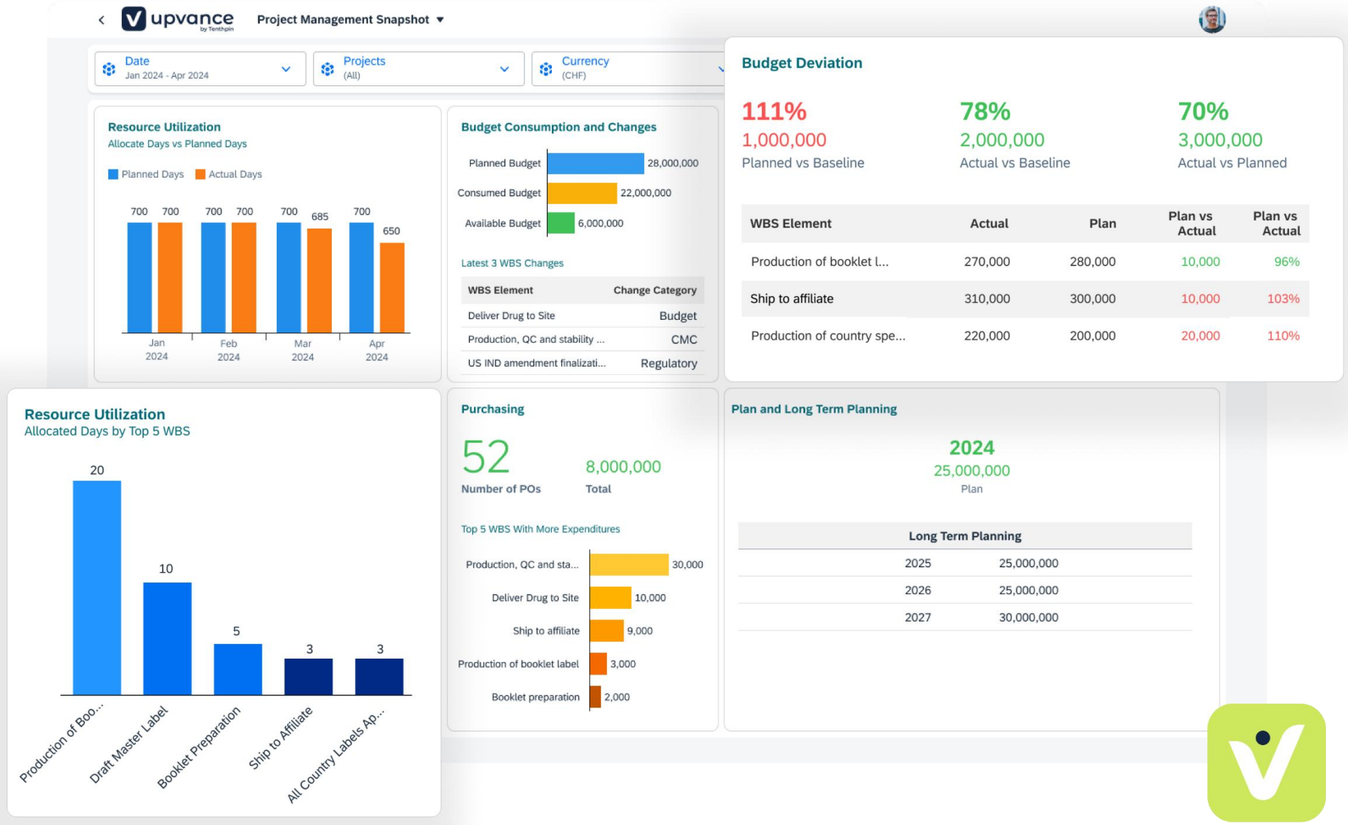
STEP2CleanPLAN

Dashboards and UI Design

- Clarity over complexity
- User segmentation: FM vs admin
- Mobile vs desktop logic



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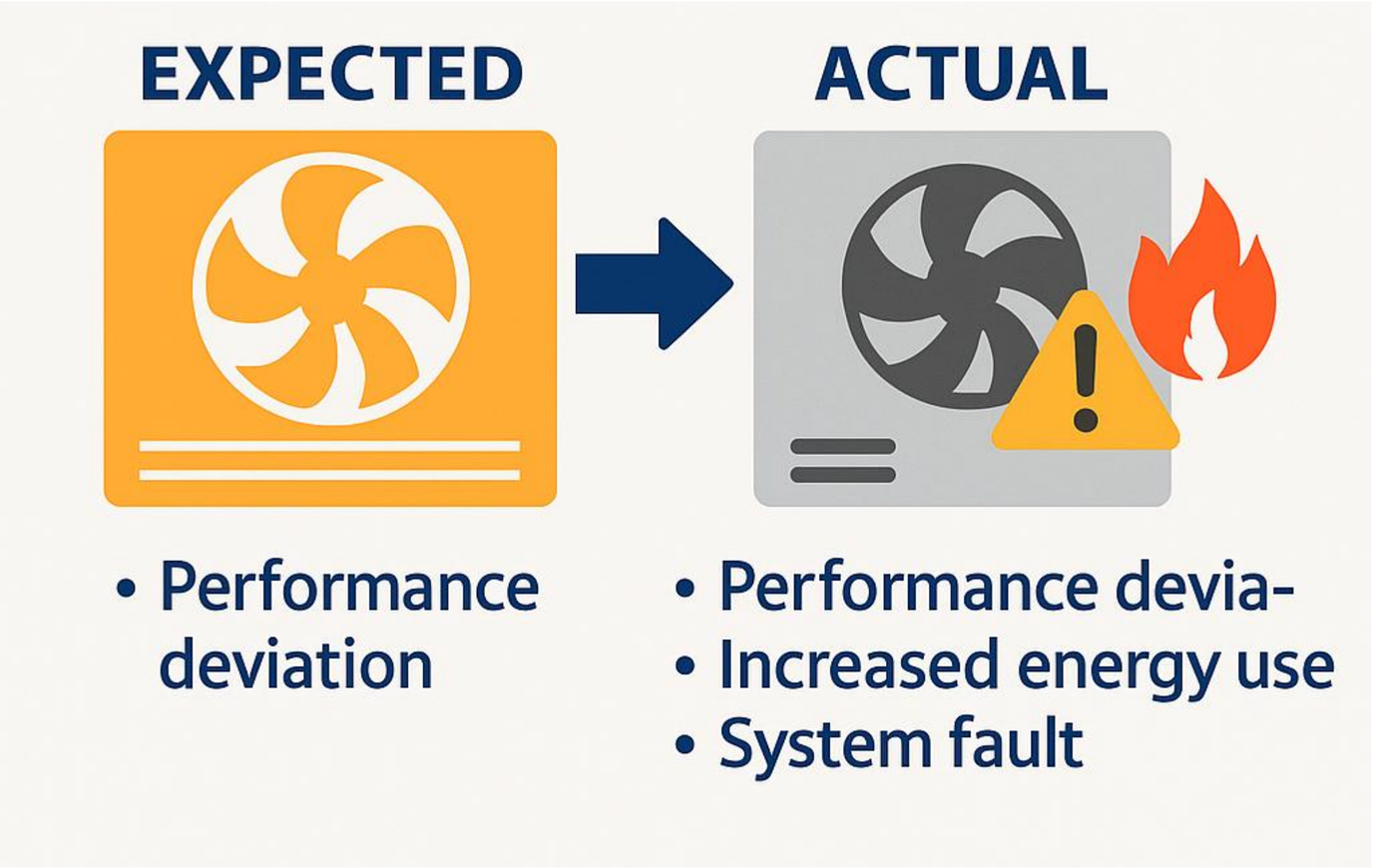
What is FDD?

- Detects performance deviation
- Compares expected vs actual operation
- Flags energy waste or failure



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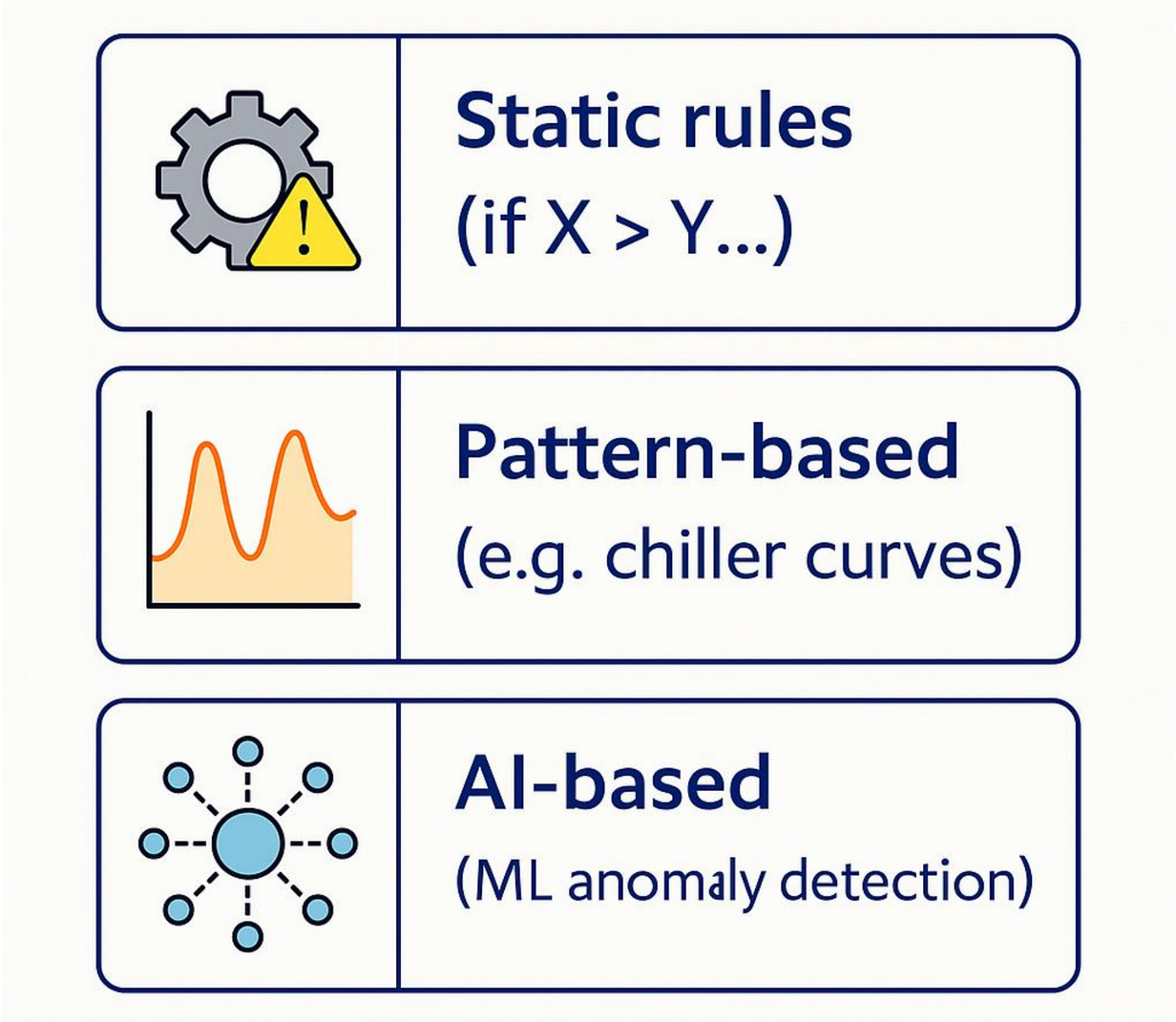
FDD Rule Types



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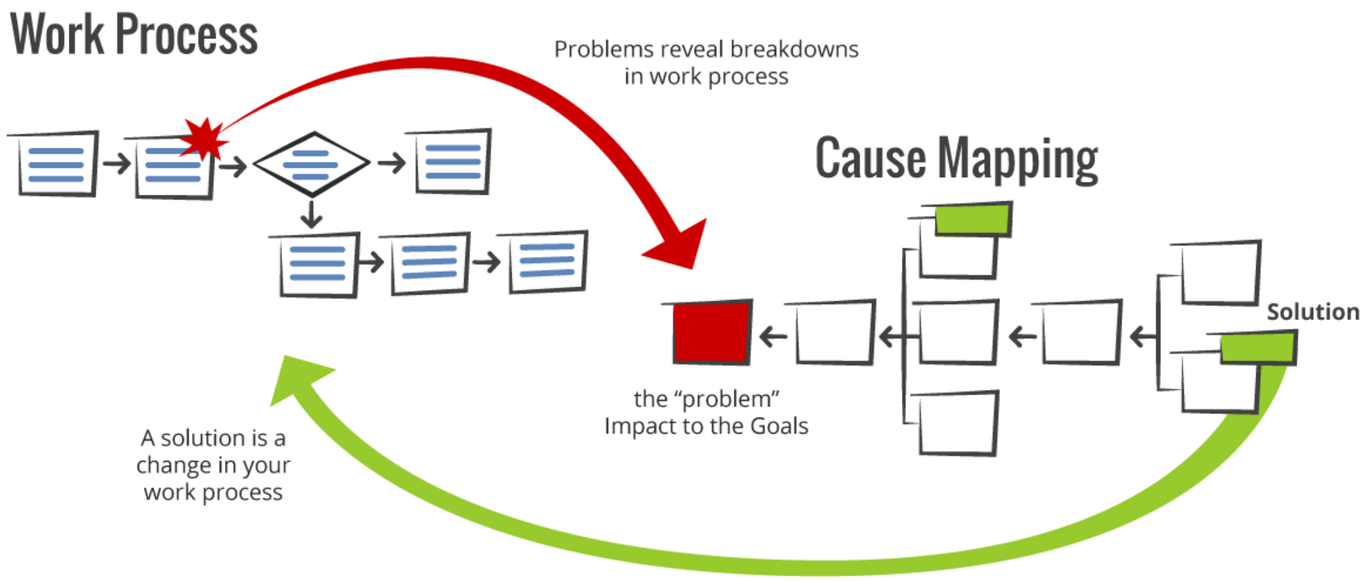
Root Cause Mapping

- Sensor anomaly vs equipment issue
- Control override vs actual fault
- Commissioning logs as reference



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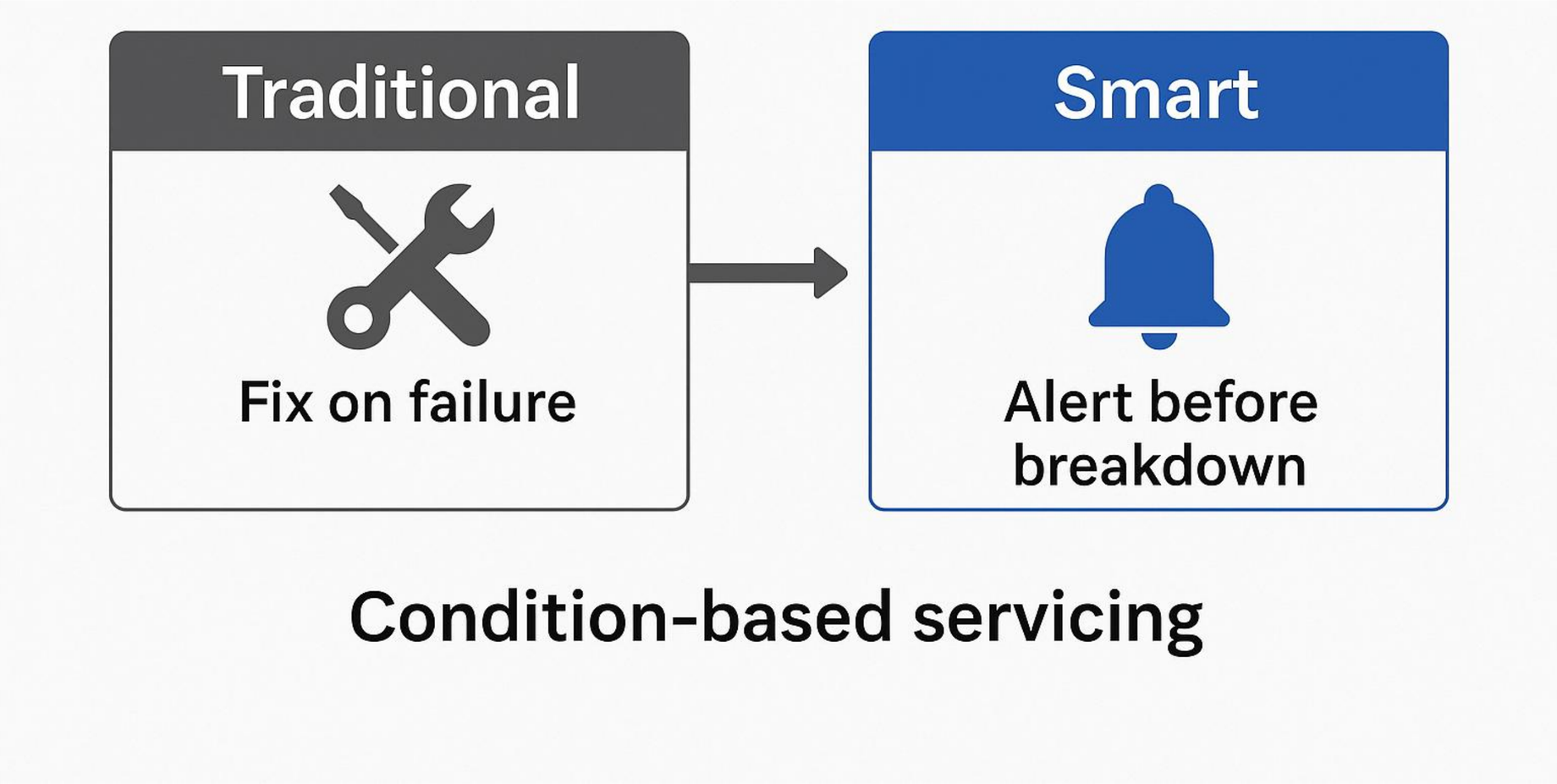
From Reactive to Predictive Maintenance



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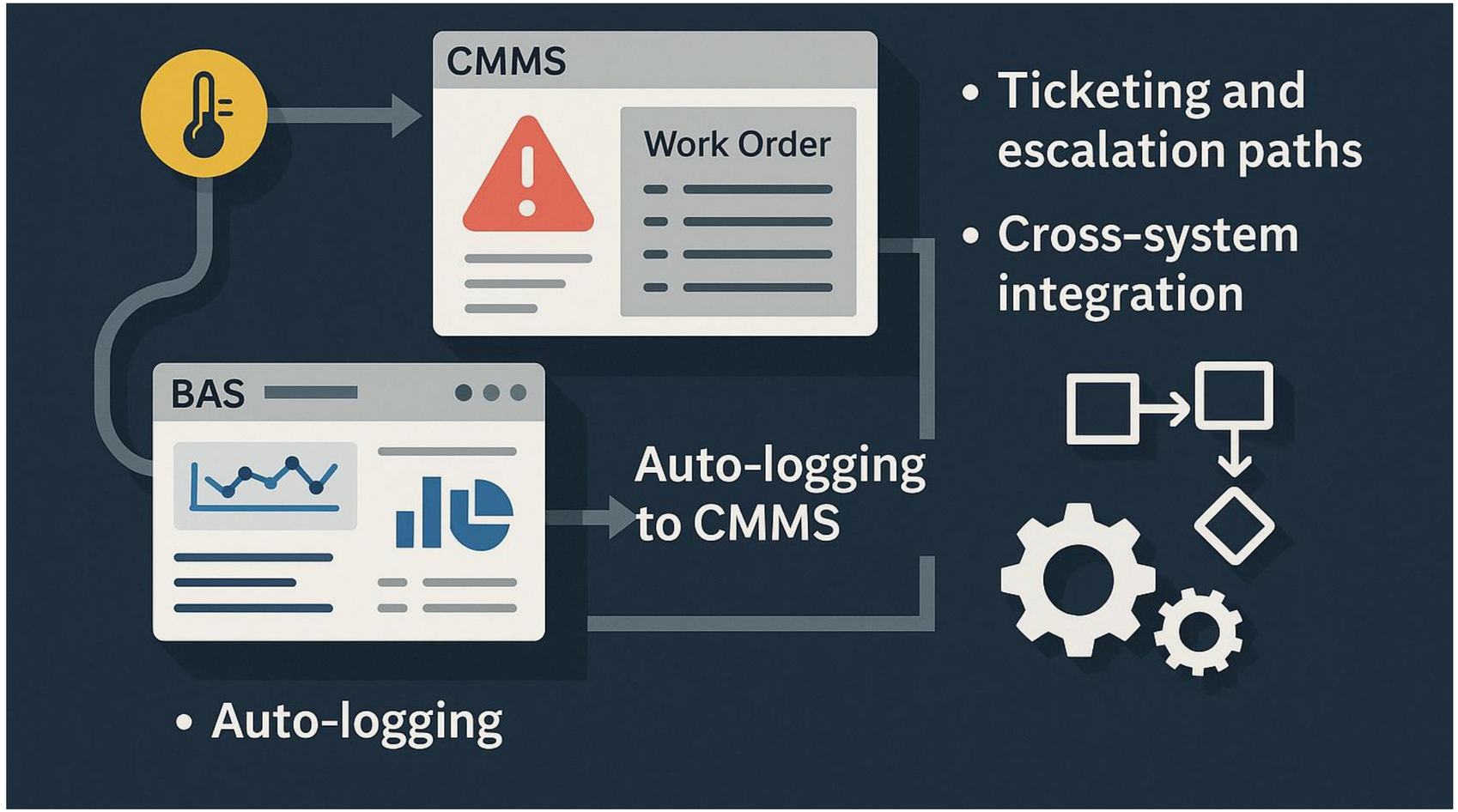
Data-Driven Workflows



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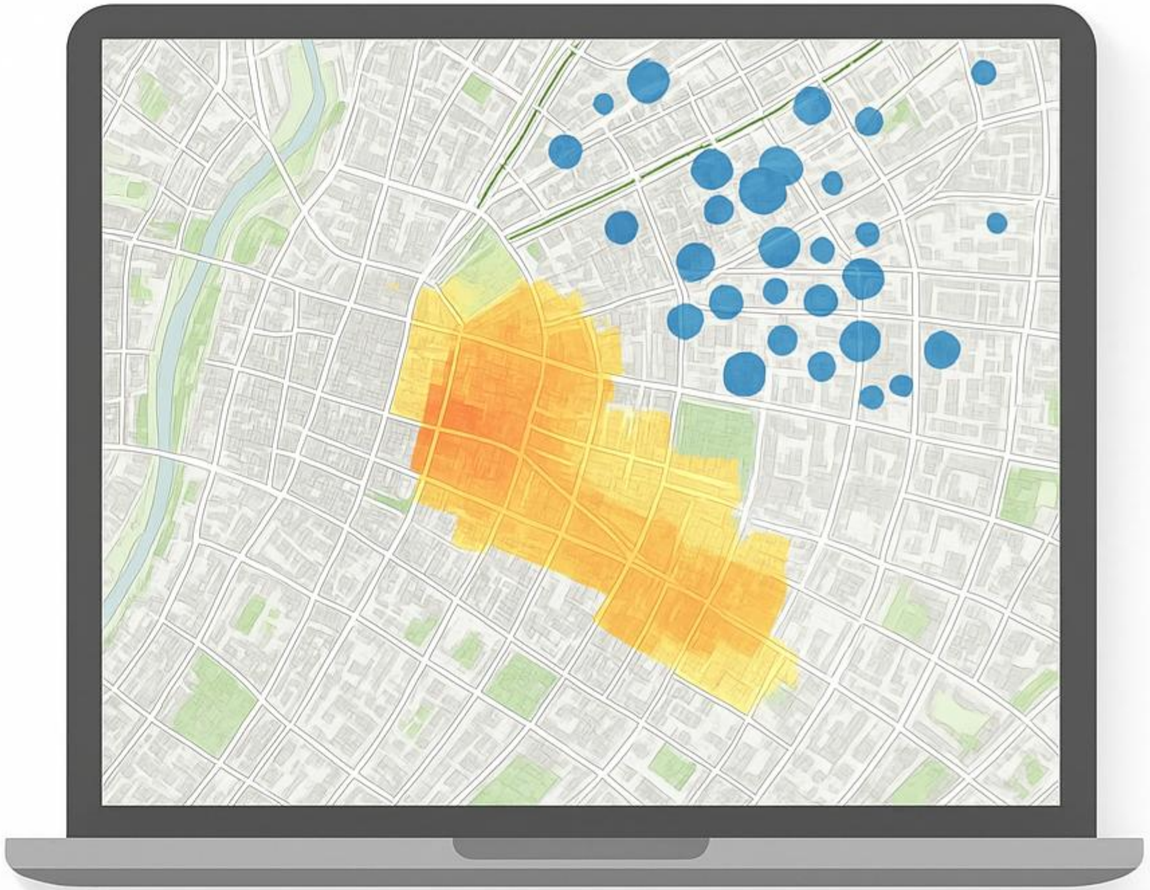
What is GIS in the Built Environment?

Geospatial layering of assets

Environmental + building data fusion

Used in city planning + facility strategy



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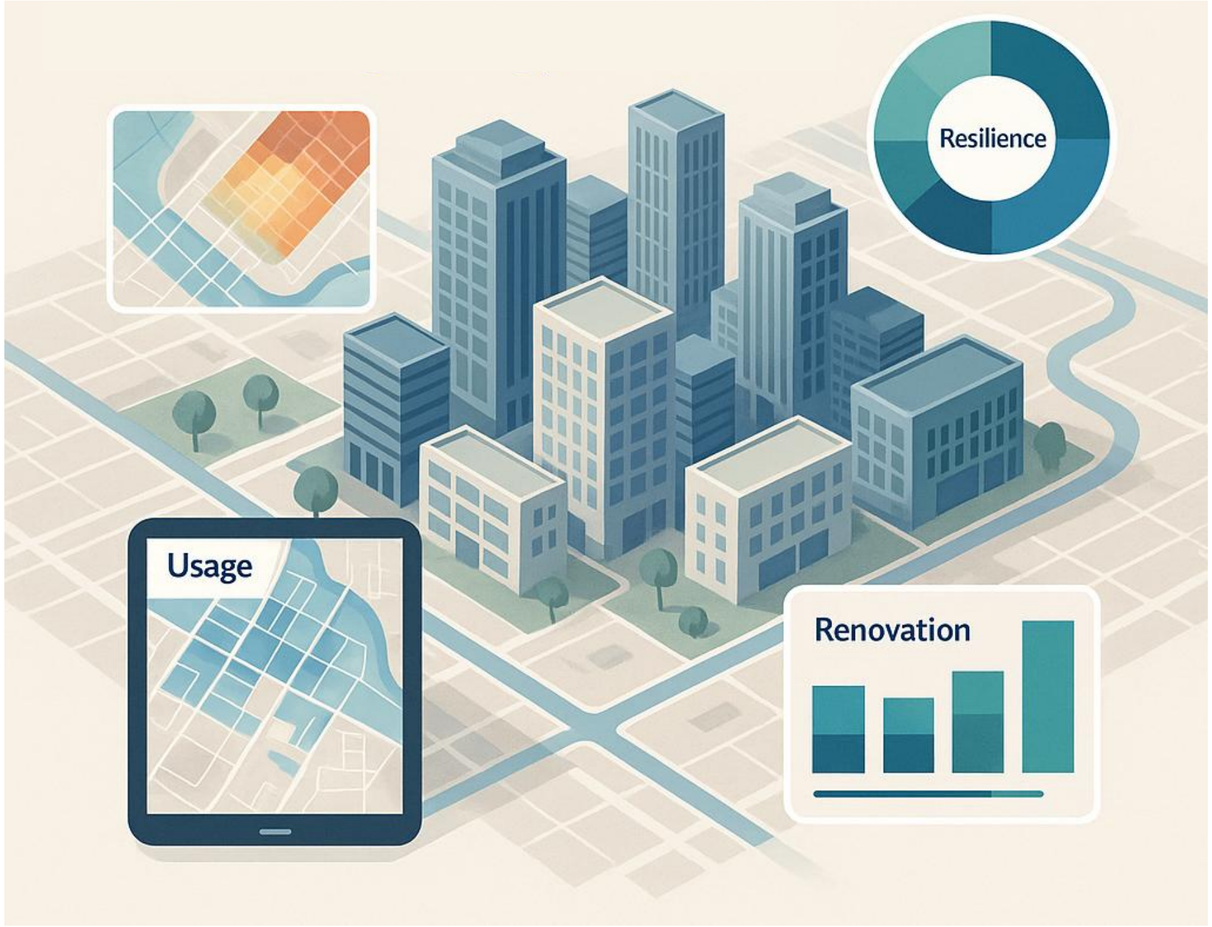
STEP2CleanPLAN

GIS in Smart Building Planning

- Maps usage, solar access, resilience
- Connects micro data to macro scale
- Links zoning, energy, renovation



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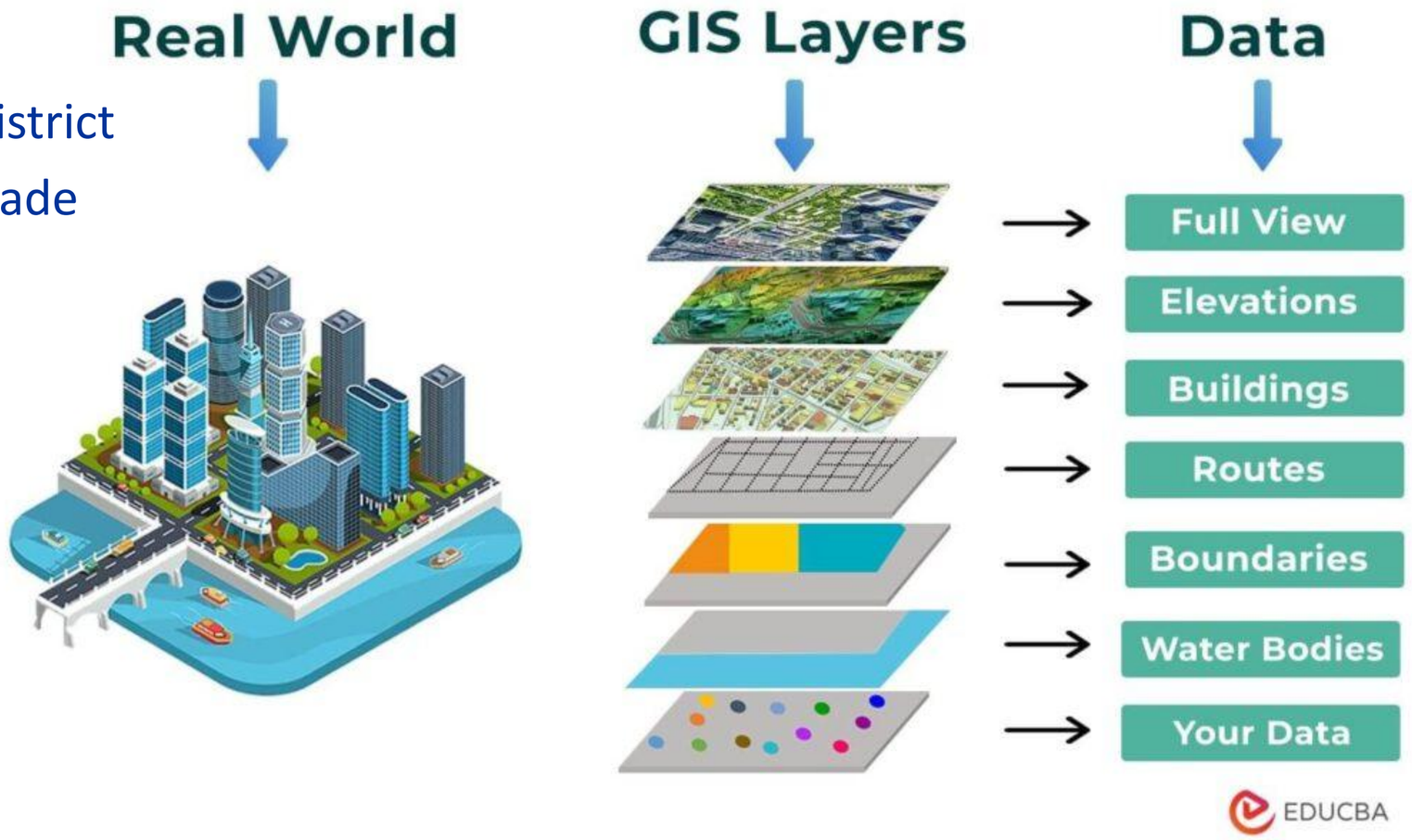
STEP2CleanPLAN

GIS & Equity, Climate Action

- Access to cooling/ventilation by district
- Target underserved areas for upgrade
- Support just transition policies



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Conclusion: Data for Smarter Performance

- Analytics drive ZEB-readiness
- FDD and GIS → smarter investment
- Digital + spatial integration is key

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Reflection Questions

- Which data stream is most useful in your region?
- How is fault detection handled in your context?

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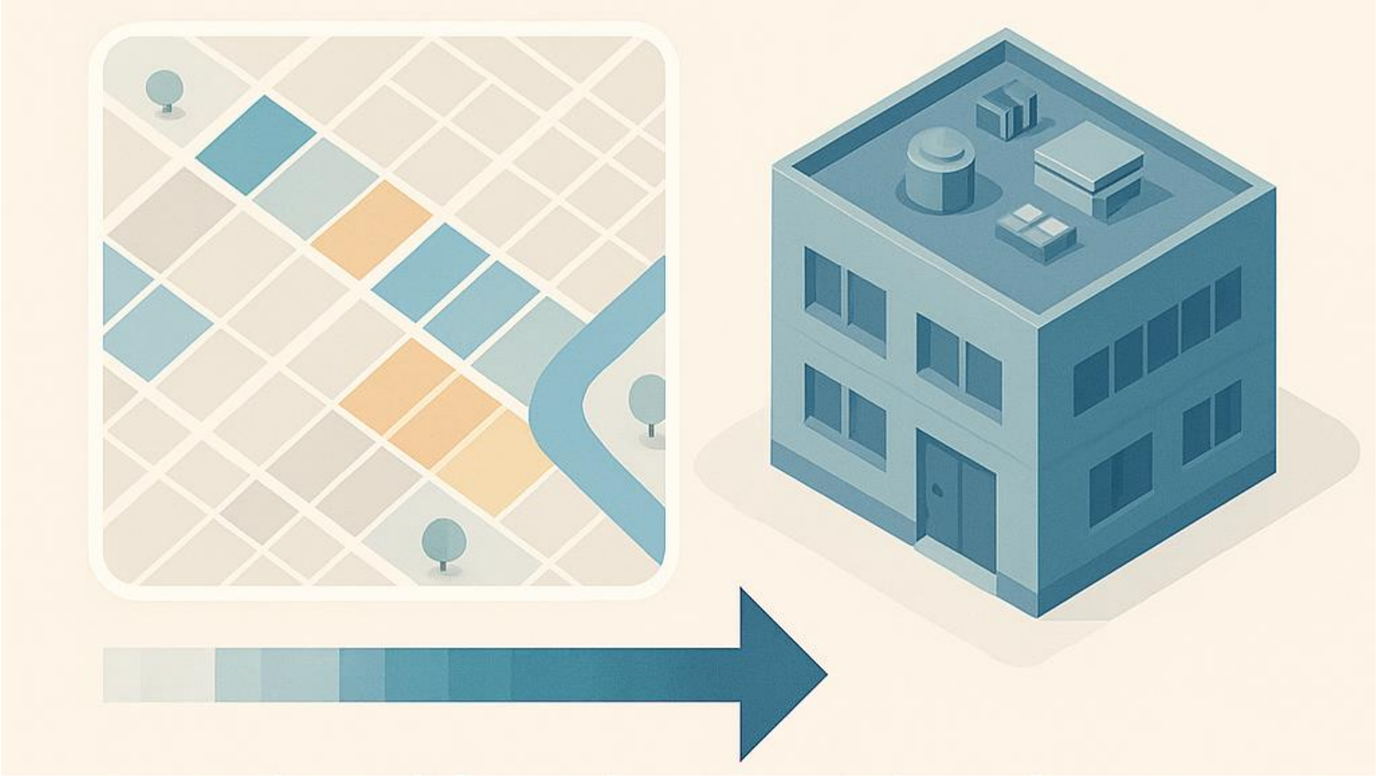
GIS + BIM Integration: Building to District

- GIS: zoning, solar access, utility overlays
- BIM: component-level asset modeling
- Together: lifecycle + spatial performance



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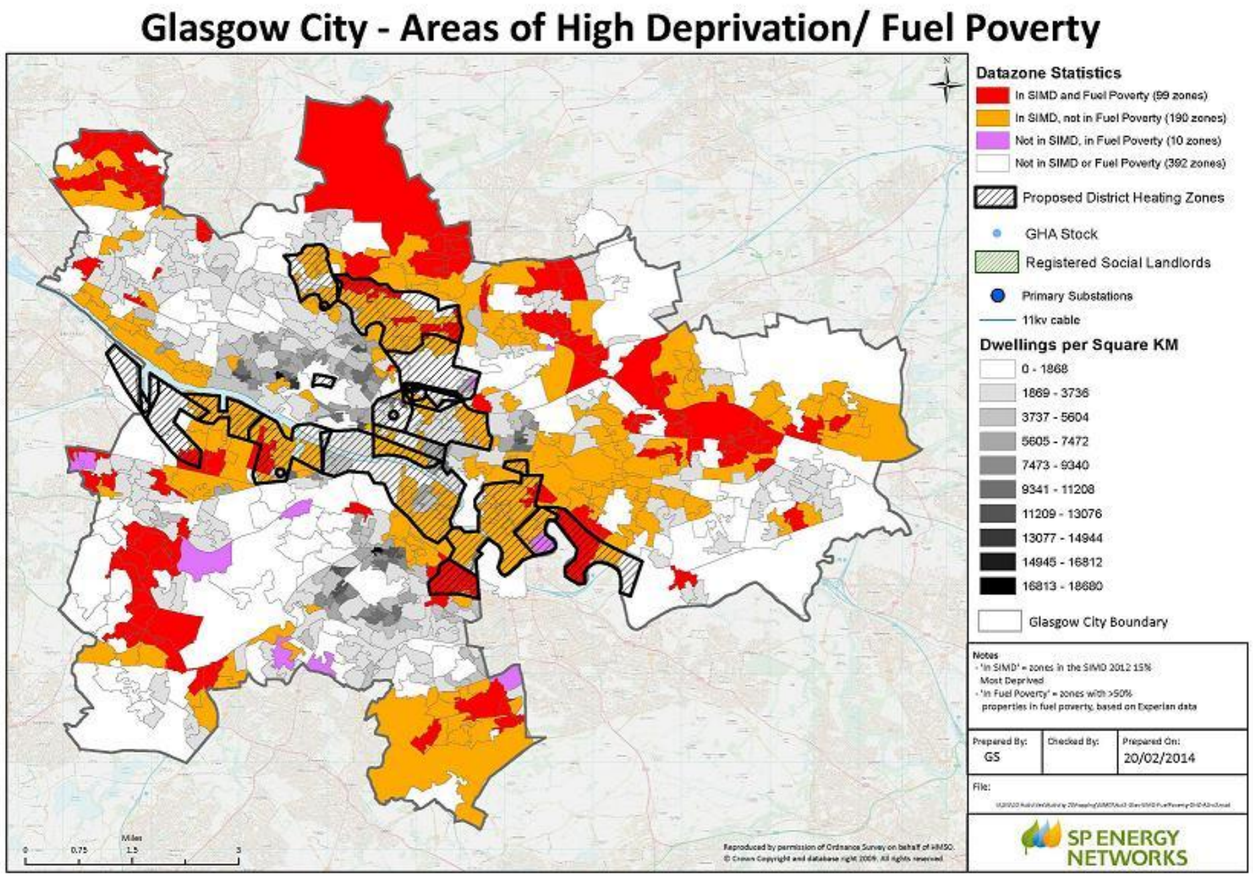
Citywide Energy Use Heatmap

- Darker zones: high energy intensity buildings
- Highlight retrofit priority areas
- Supports equity & climate goals



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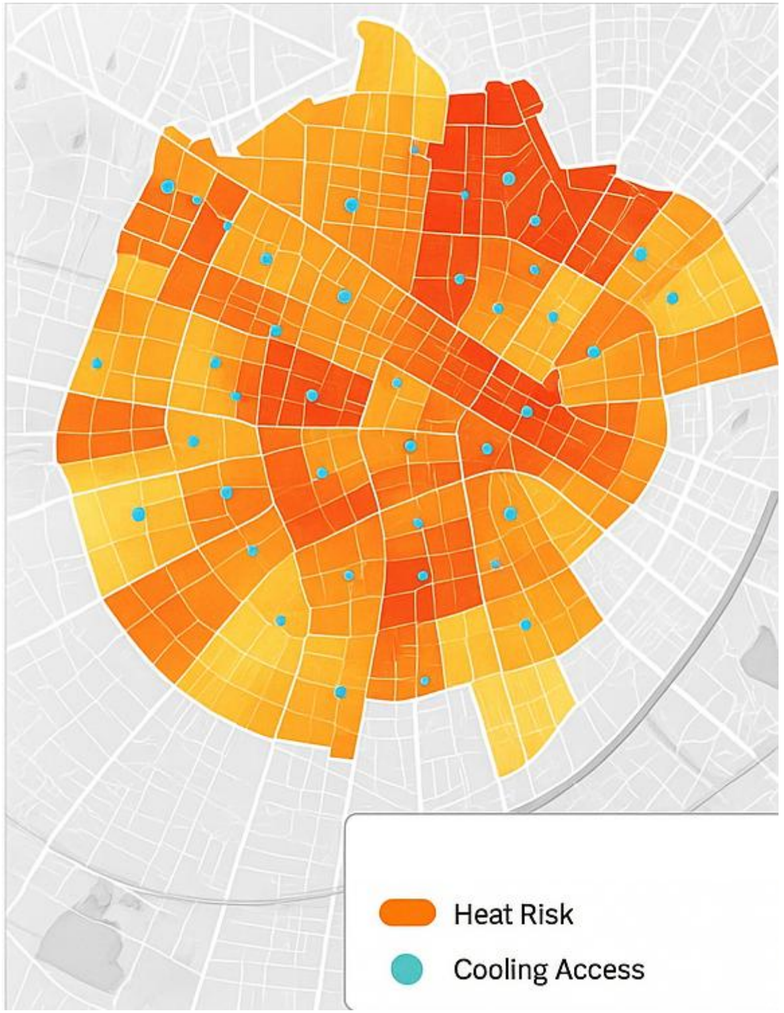
Climate Vulnerability Mapping

- Map cooling access + heat risk by neighborhood
- Target heat islands with retrofit priority



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Emerging Issue: Data Governance in Smart Cities

- Who owns sensor data in public buildings?
- How is it anonymized, stored, reused?
- Policy frameworks lag behind tech capacity

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Q & A

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STEP2CleanPlan

COOPERATION FOR SUSTAINABLE ENERGY AND CLIMATE ACTIONS PLANNING AND MONITORING IN BSB

STEP2CleanPlan BSB00004

Module 2: Sustainable Urban Mobility and Energy Efficiency

Sub Module 202: Energy Efficiency in Urban Infrastructure

202 G: GIS Integration, Portfolio Benchmarking & Spatial Analytics

Trainer:

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Agenda

- GIS in Smart Buildings
- Smart Data Layers & System Integration
- Portfolio Benchmarking with Context
- Case Examples: Greece, Finland, France
- Future Scenarios & Spatial Equity
- Conclusion & Reflection

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GIS as a Strategic Tool

- Visual context for decisions
- Links assets, space, and data
- Acts as bridge across scales

https://www.esri.com/arcgis-blog/products/arcgis-online/announcements/whats-new-arcgis-online-december-2018

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Why GIS Now?

- Policies: EPBD, ZEB mandates
- Data: IoT, CMMS, BMS matured
- Scale: Sites → cities → countries

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Core GIS Data Layers

- Comfort: CO_2, temp, RH, light
- Energy: EUI, peaks, carbon intensity
- Occupancy: sensors, Wi-Fi, schedules
- Asset info: IDs, condition, tickets

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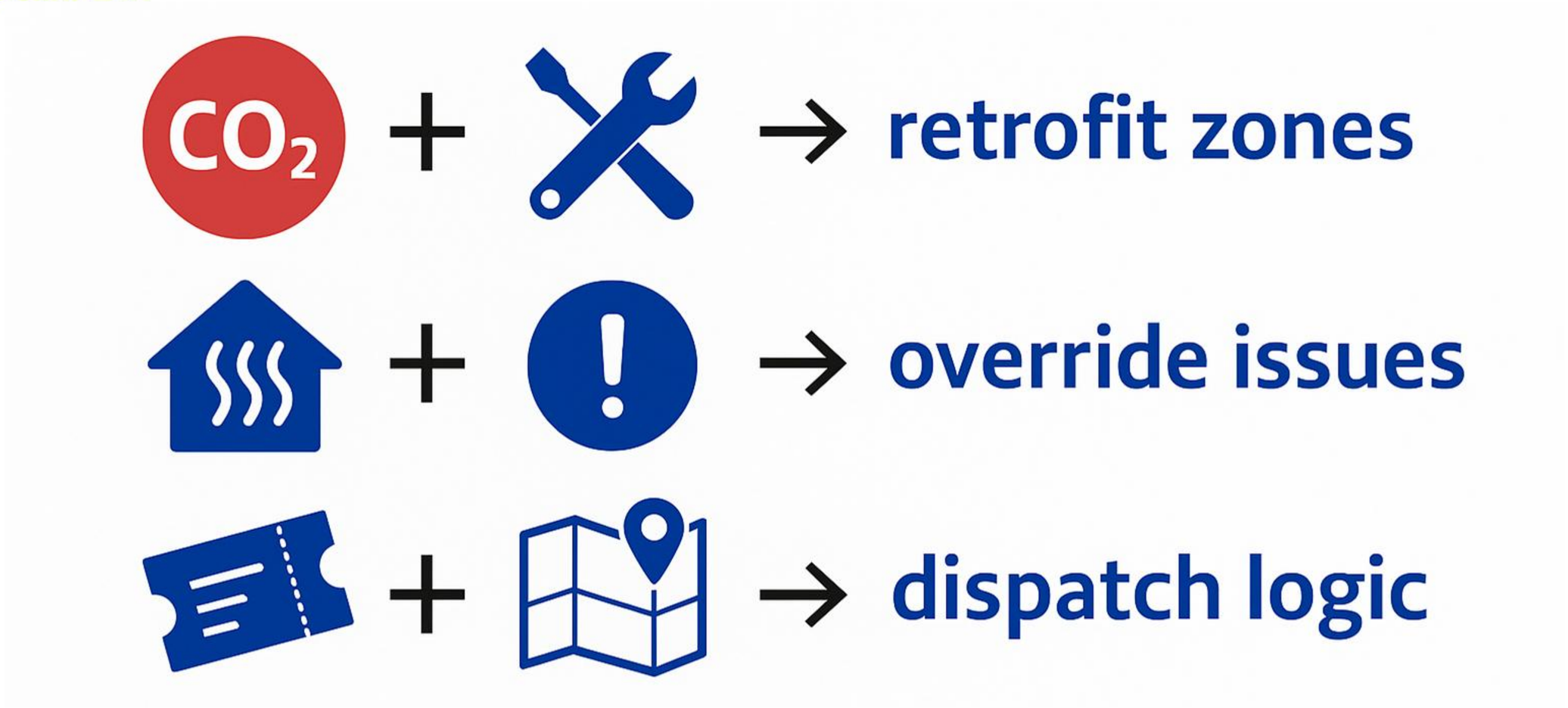
From Layers to Insight



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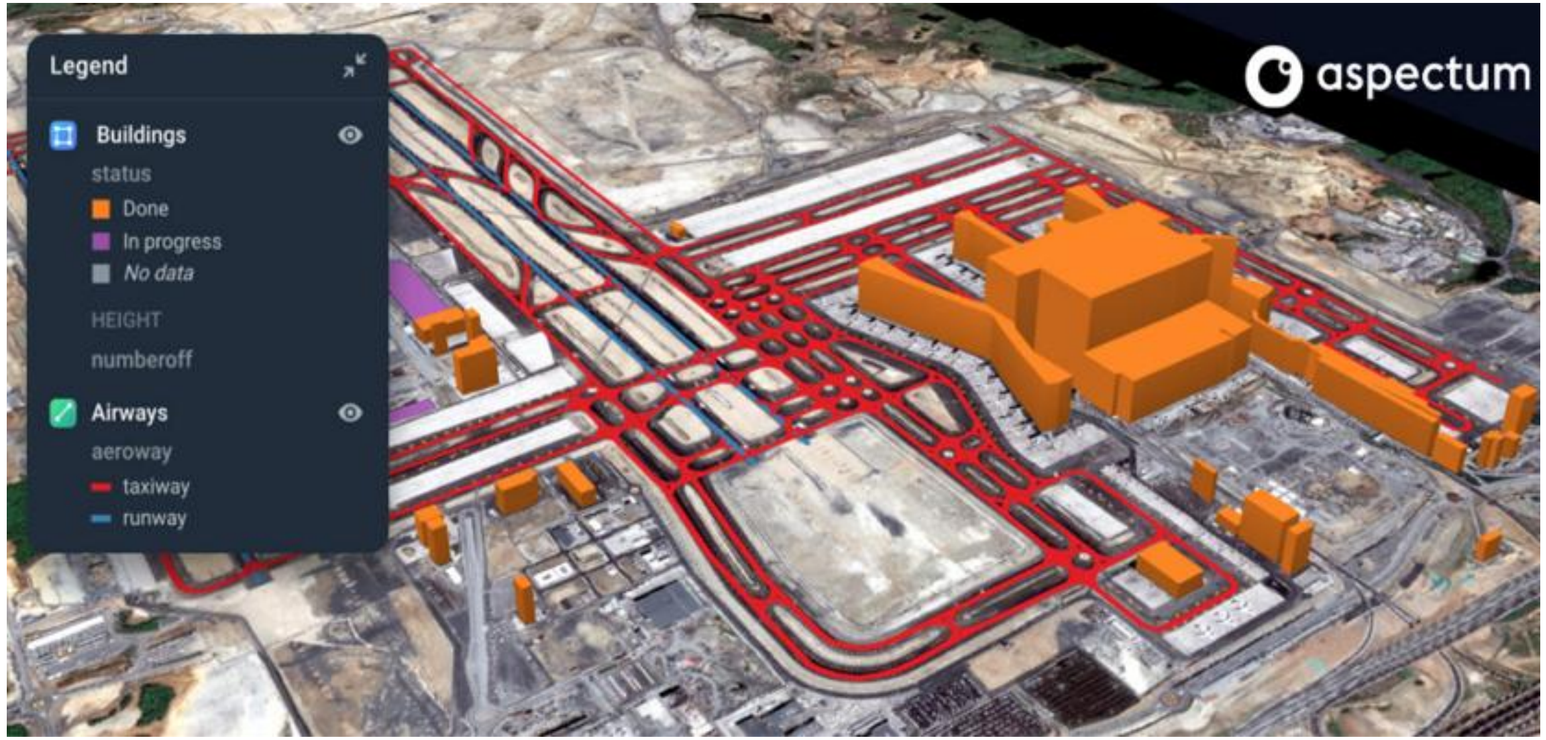
Connecting GIS to Building Systems

- BAS/BMS: overrides, trends, faults
- CMMS: fault tickets & dispatch
- Synchronize IDs & timestamps



https://www.xyht.com/sponsored/gis-implementation-in-construction-techniques-and-benefits/

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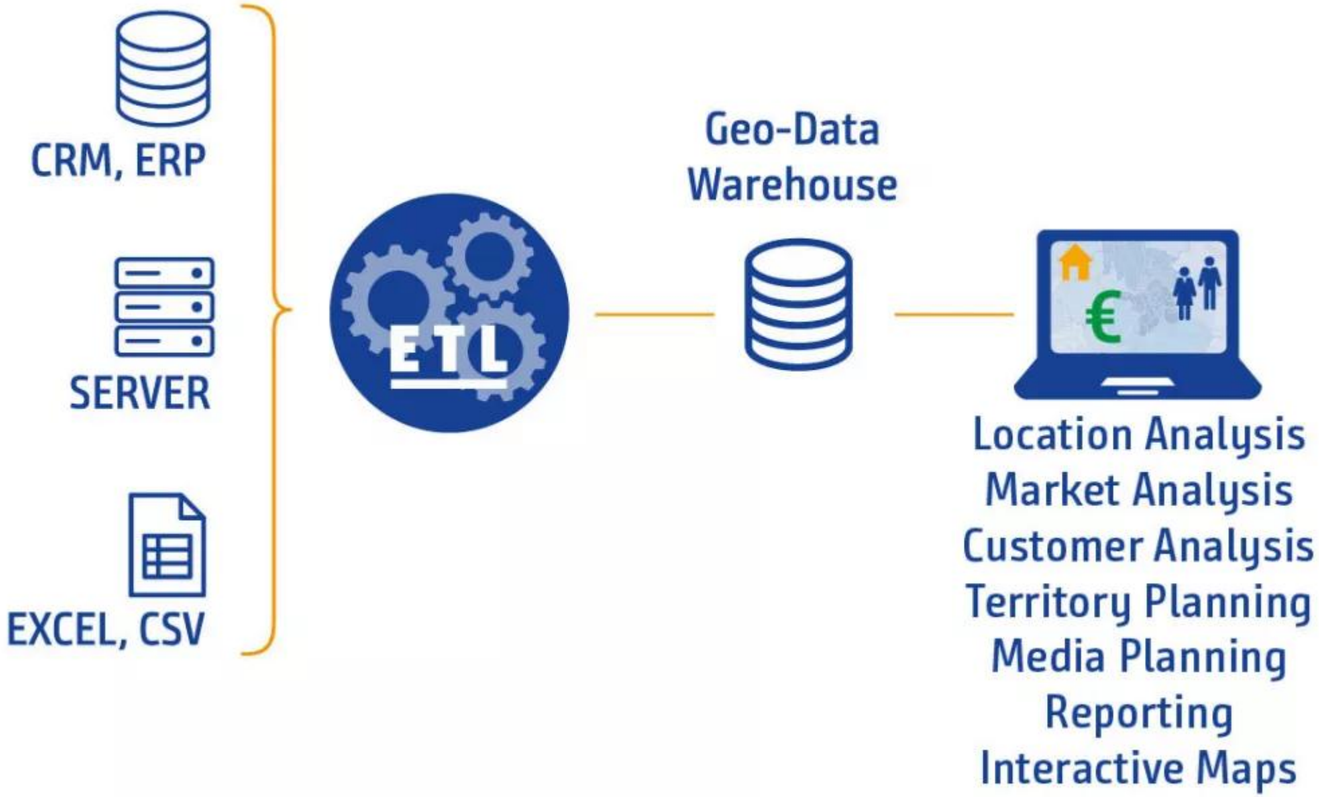
Use Cases from Integration

- Cluster faults by equipment type/age
- Identify override zones during heatwave
- Optimize dispatch by location/SLA



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CMMS Workflow from FDD

- Fault flags via FDD logic
- Auto-ticket in CMMS w/ zone ID
- GIS confirms location, closeout logged

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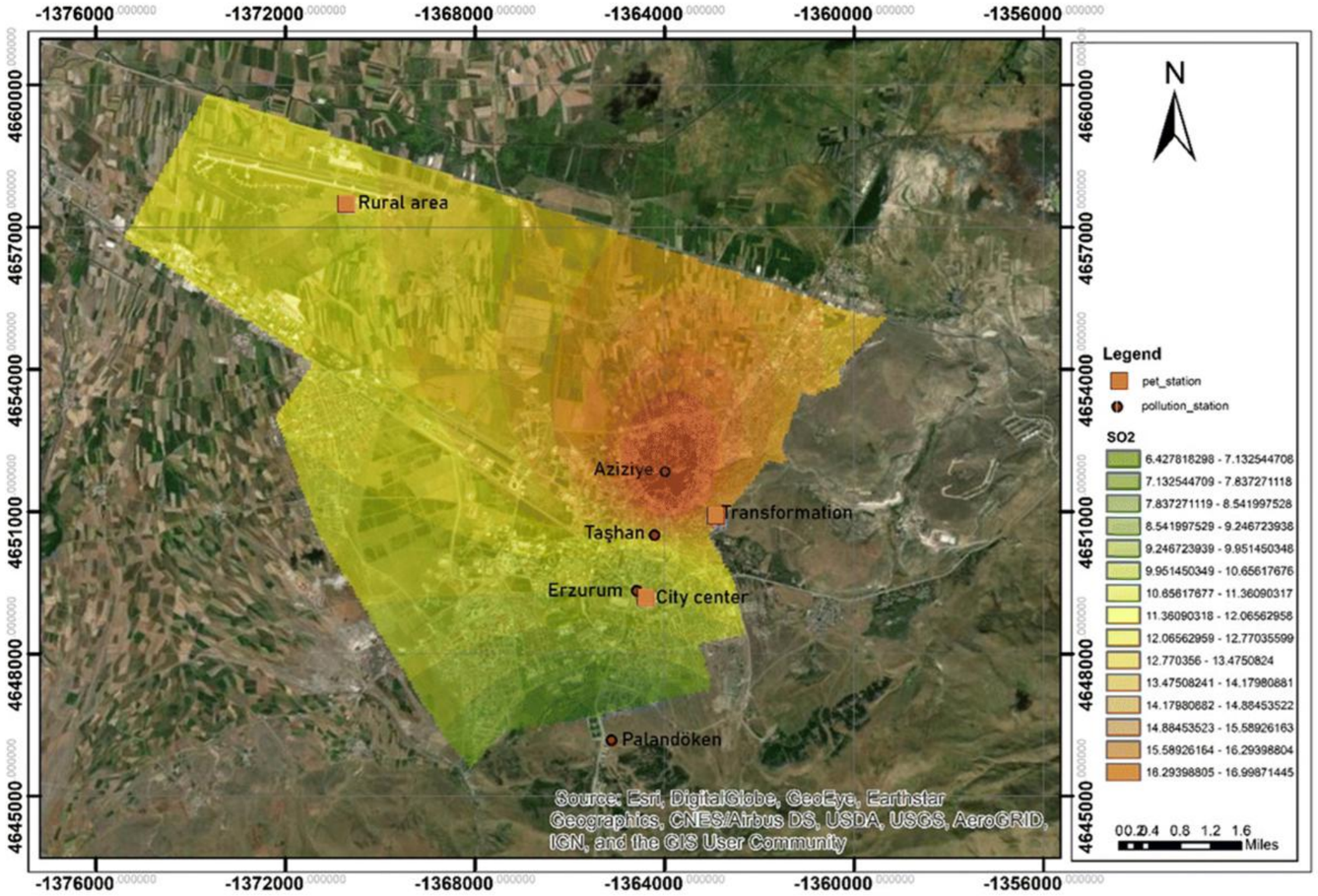
Portfolio Context for Decision-Making

- Normalize 100+ sites with filters
- Overlay zoning + complaints + retrofits
- Identify risk or opportunity clusters



https://link.springer.com/article/10.1007/s11356-021-14082-3

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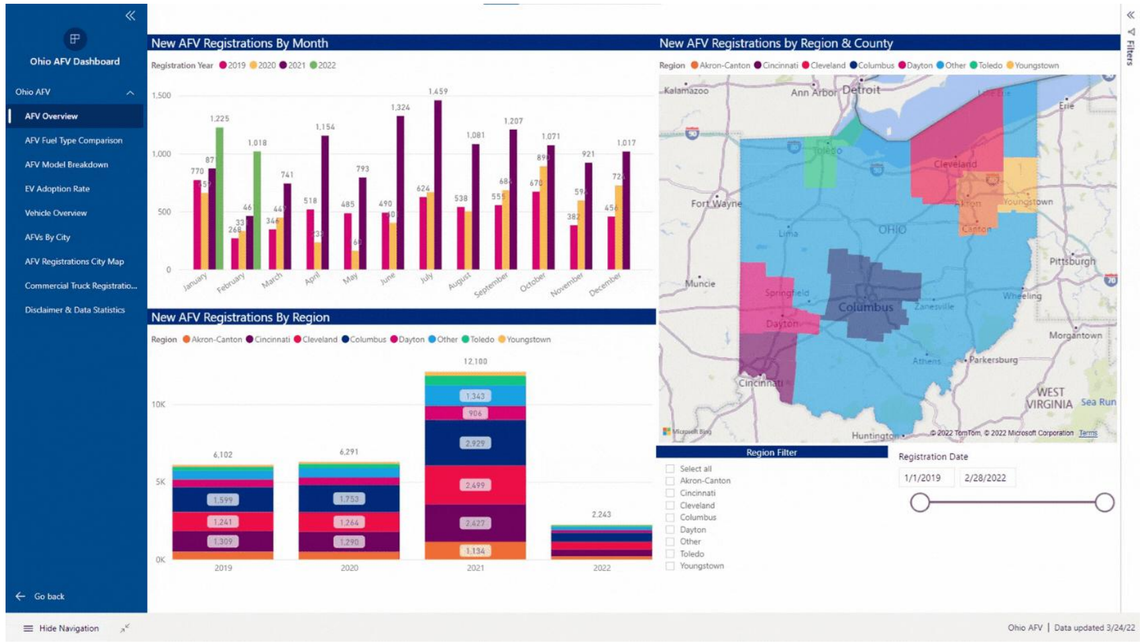
STEP2CleanPLAN

From Benchmark to Retrofit Logic

- Compare retrofit ROI across building types
- Use spatial indicators to set priorities
- Visualize decisions with outcome maps



https://experience.arcgis.com/experience/ba606f0b1a984e48a736f003aefc42c7

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Case: West Attica – Schools Retrofit

- Mapped HVAC comfort violations + CO_2
- Zones near coast prioritized
- Aligned GIS with funding timeline

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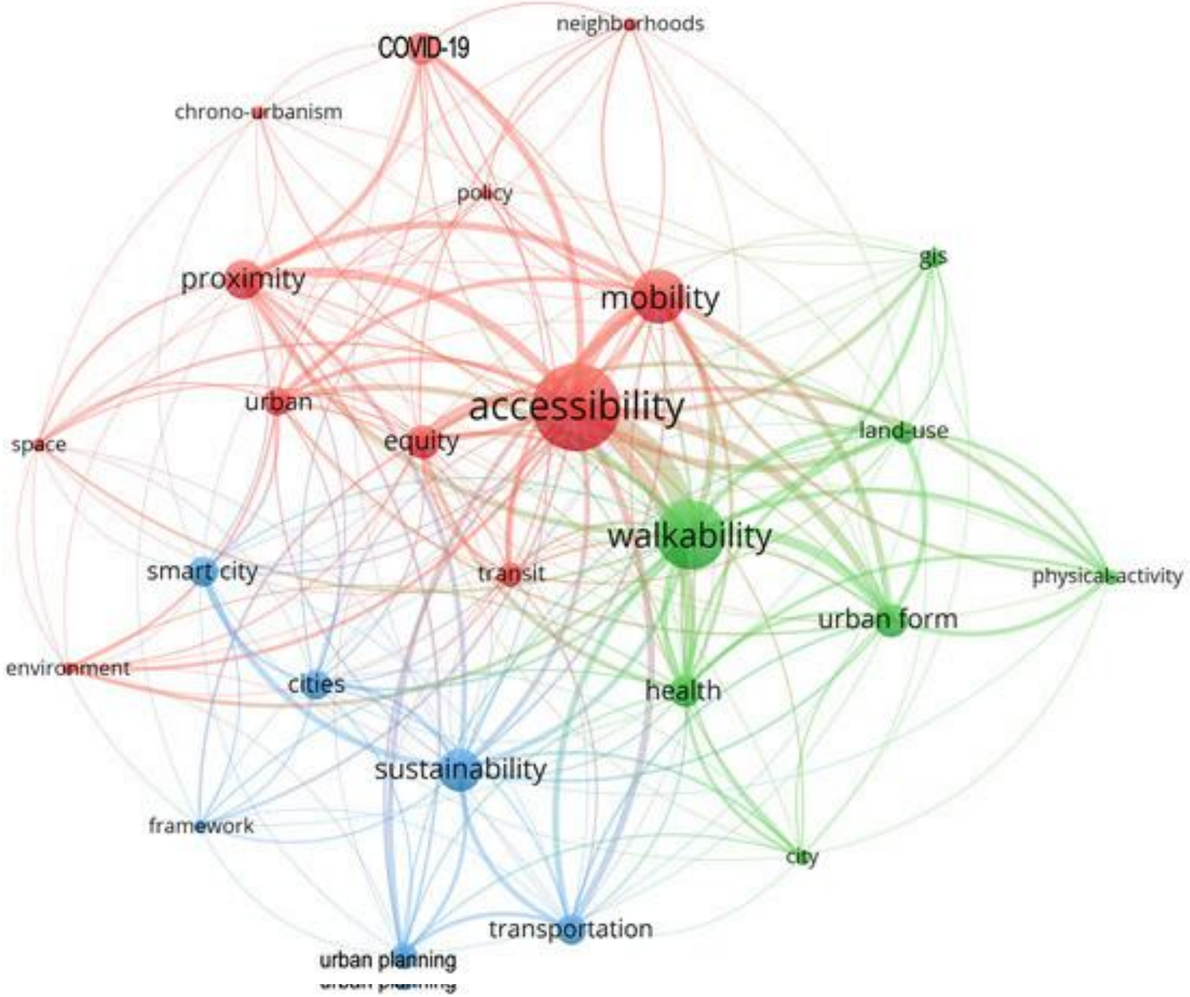
Case: Helsinki Smart Portfolio

- 1,300+ buildings live-tracked
- Equity overlays inform capital budget
- Supports 15-minute city access goals



https://www.mdpi.com/2624-6511/7/4/83

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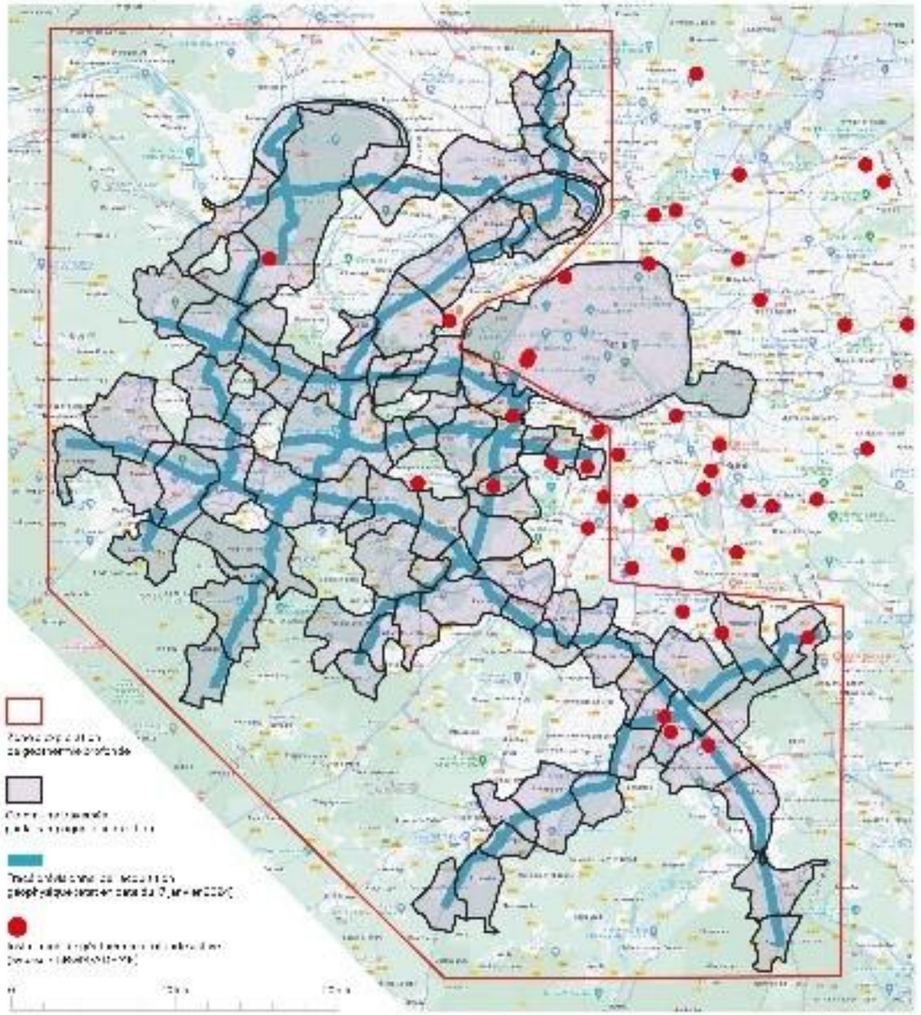
Case: ADEME (France) Retrofit Map

- 230K buildings, mapped EPC + retrofits
- Public + policy users access portal
- Spatial logic for national retrofit waves



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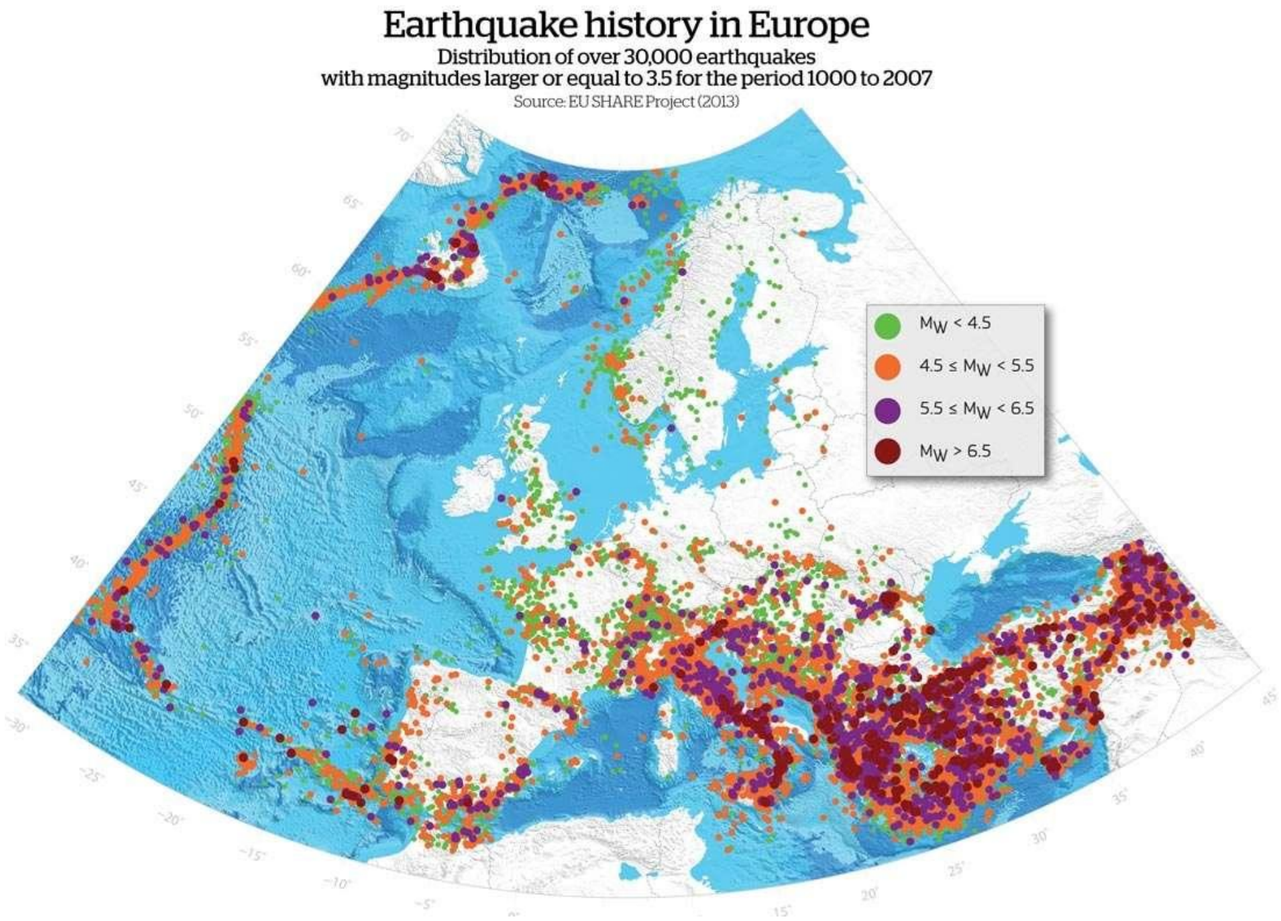
GIS + AI: Predictive Targeting

- Train patterns from fault/CO_2 data
- Predict retrofit payback and risk
- Auto-flag priority zones



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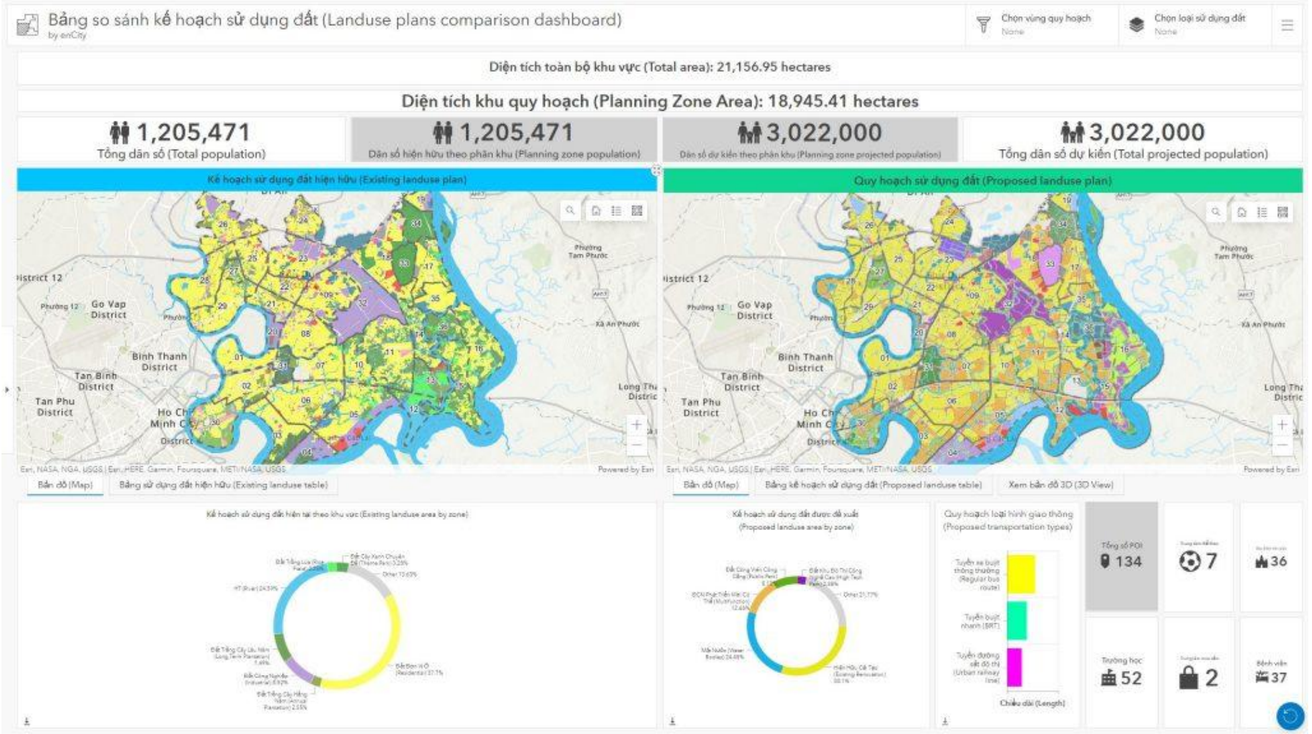
GIS as Urban Operating System

- Integrate zoning, transport, demand data
- EVs, comfort, building carbon in one map
- Core layer of digital twin governance



https://encity.co/online-gis-dashboard-for-planning-management-and-stakeholder-engagement/

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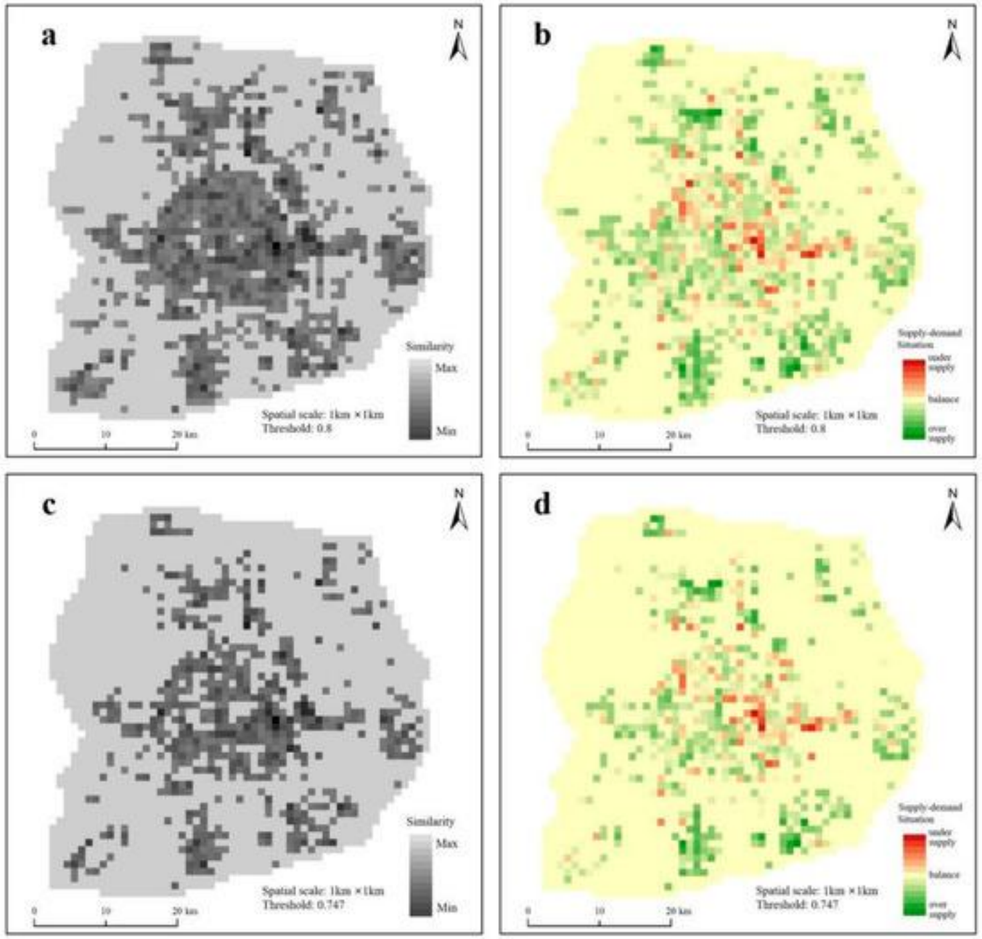
Spatial Equity in Smart Planning

- Map access vs upgrades by income area
- Monitor repair lag by region
- Equity filters for capital spending



https://www.mdpi.com/2220-9964/14/4/157

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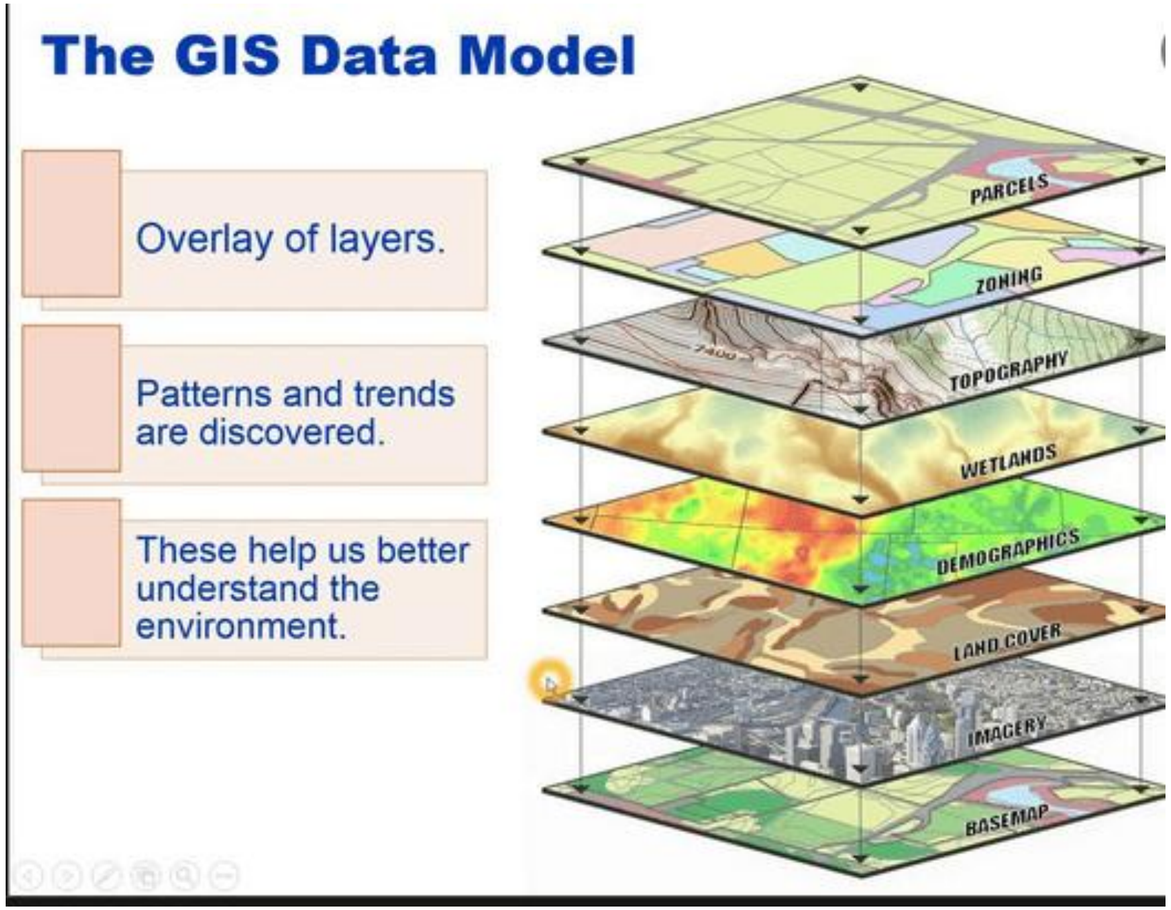
Conclusion: GIS Enables Visual Intelligence

- See patterns, set priorities, build equity
- Combine tech + policy + people via space
- Plan smarter, act sooner



https://ignitarium.com/introduction-to-gis-geographical-information-system-data-its-visualization-and-processing-techniques/

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Reflection Prompts

- Which of your decisions could GIS improve?
- Where could equity be spatially mapped?

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Q & A

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STEP2CleanPlan

COOPERATION FOR SUSTAINABLE ENERGY AND CLIMATE ACTIONS PLANNING AND MONITORING IN BSB

STEP2CleanPlan BSB00004

Module 2: Sustainable Urban Mobility and Energy Efficiency

Sub Module 202: Energy Efficiency in Urban Infrastructure

202 A: Introduction to Zero Emission Buildings, nZEB Goals, and EU Directives

Trainer:

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Agenda

- Why Zero Emission Buildings?
- nZEB, ZEB & Passive House Frameworks
- Policy Landscape (EPBD, Taxonomy, Renovation Wave)
- Metrics & Compliance Tools
- Implementation & National Approaches
- Passive House & Legal Alignment
- Conclusion & Reflection

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Why Zero Emission Buildings?

- 40% of EU energy use
- 36% of EU GHG emissions
- Buildings are central to 2050 neutrality

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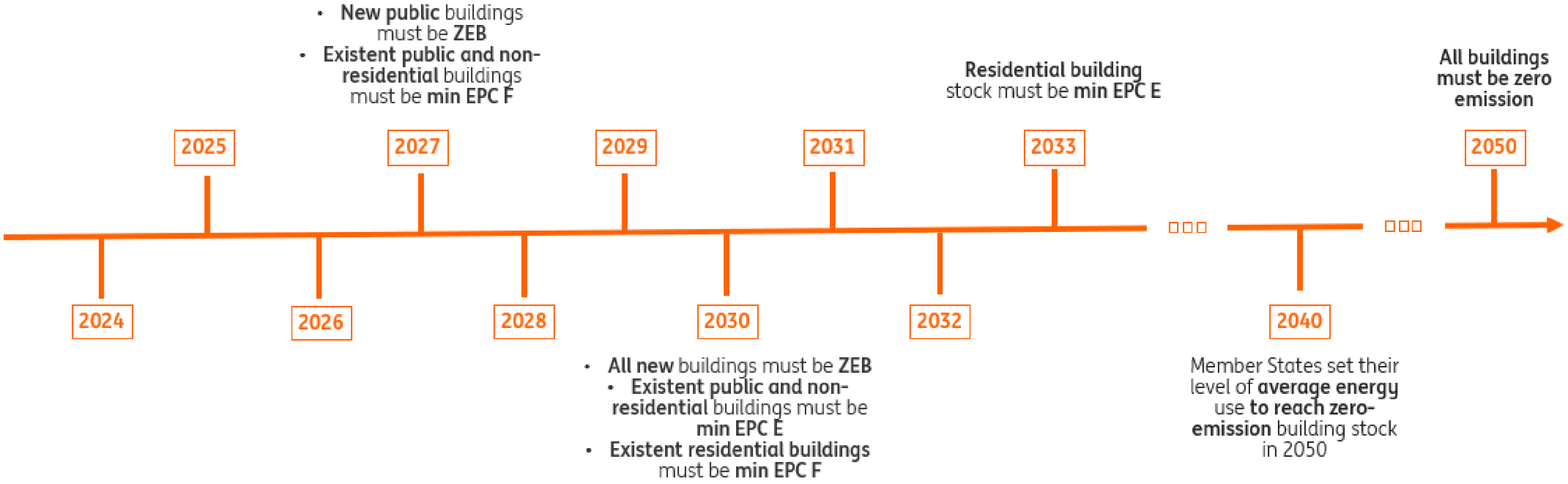
EPBD Recast Milestones



Source: European Commission, ING

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From Efficiency to Emissions

- Old model: focus on demand
- New model: operational GHG
- Legislative and technical evolution

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Performance Tiers Overview

Feature	nZEB	ZEB	Passive House (PH)
Legal Status	National Mandate	EU Directive (EPBD)	Voluntary Certification
Focus	Energy Efficiency	Operational GHG Emissions	Comfort & Demand Reduction
Verification	EPC	GHG Metrics & PED	PHPP + On-Site Testing
Renewables	Partial (varies)	Required (zero-emission)	Optional (usually included)

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nZEB in Practice

- Estonia: 100 kWh/m²/year
- Ireland: 45–60 kWh/m²/year
- Broad national variation

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ZEB by Definition – EPBD Annex III

- Zero operational GHG emissions
- Efficient envelope and systems
- Carbon-free residual energy

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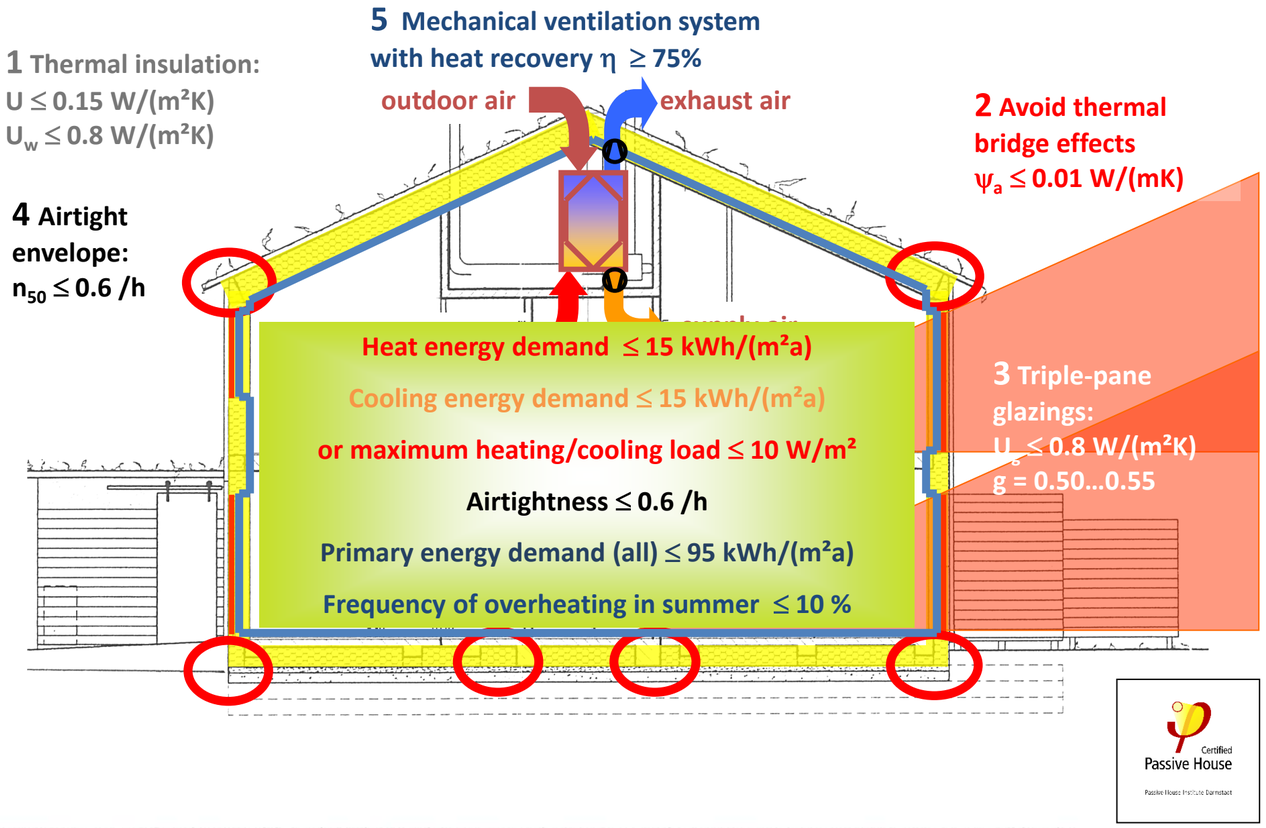
Passive House Criteria

- For cold – temperate region



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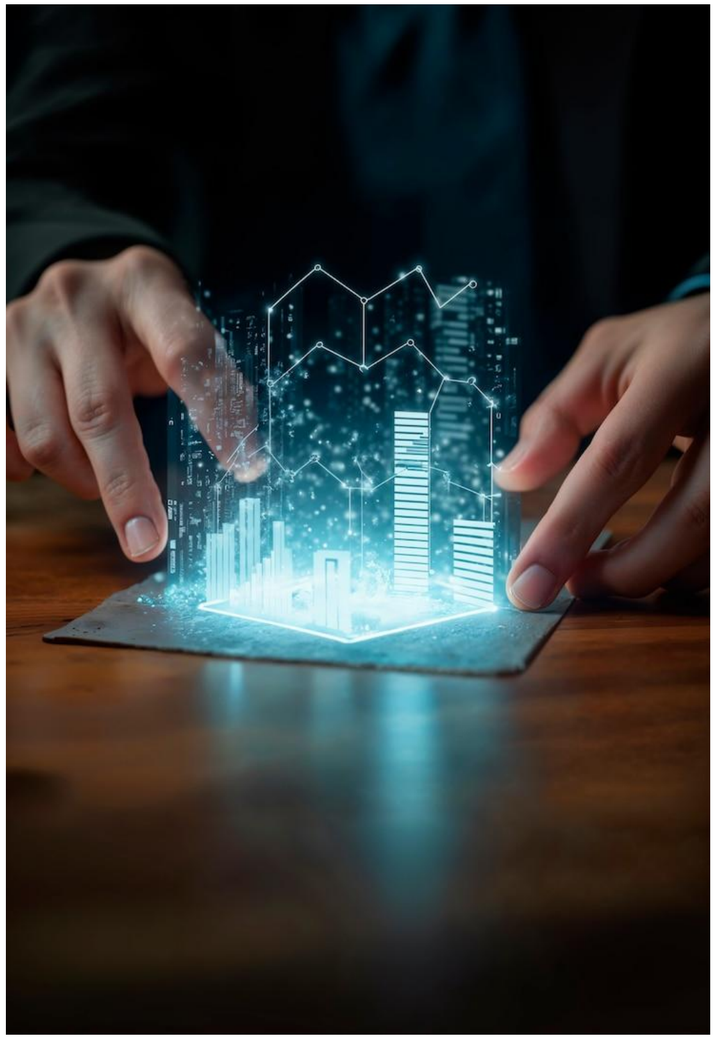
EPBD Recast (2021)

- ZEB as standard → Policy shift
- Operational GHG focus → Central metric: $kgCO_2eq/m^2/year$
- Digital tools introduced → Renovation passports,
  Smart Readiness Indicator, digital logbooks



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EPBD 2024 Update

Pillar	Description
🏛 **MEPS Enforcement**	Minimum Energy Performance Standards enforced for lowest-performing 15–20% of buildings
🏢 **Public Mandates Expanded**	All new public buildings must be ZEB by 2028, renovations mandated
✏ **Design Guidance Strengthened**	Integrated tools: Renovation Passports, Logbooks, SRI, lifecycle thinking

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EU Taxonomy & Green Finance

- PED 10% below nZEB
- Lifecycle emissions required
- Supports climate-proof investments

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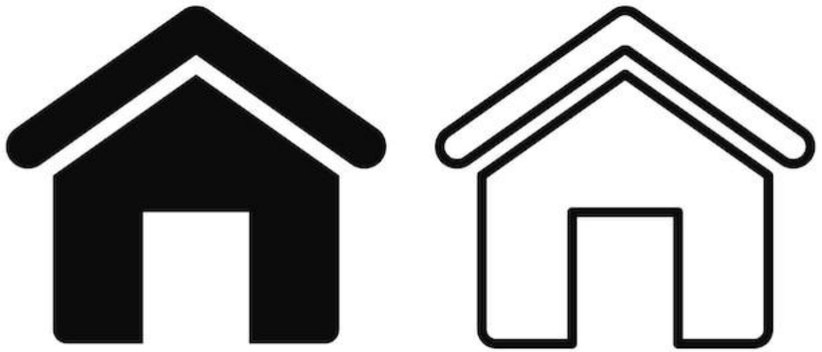
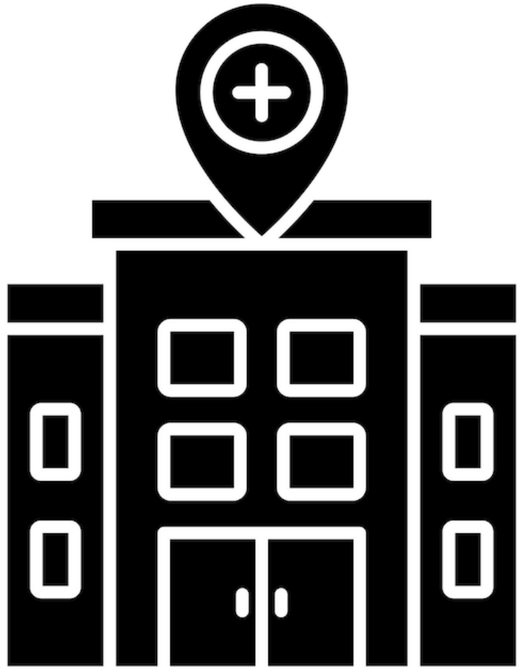
Renovation Wave Strategy

- 35M building renovations by 2030
- Focus: schools, housing, hospitals
- Scale + quality = main aims





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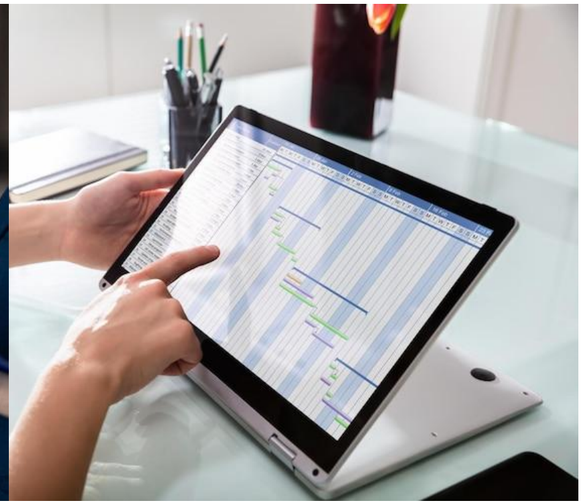
Measuring Real Performance

- Gap between design vs reality
- Smart meters, commissioning needed
- Post-occupancy data emphasized



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Operational GHG as a Metric

- $kgCO_2eq/m^2/year$ = primary metric
- Based on national emission factors
- Defined by building type + zone

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PED & Renewable Share

- PED: primary energy demand
- Renewable ratio: site/nearby preferred
- Combined for ZEB evaluation

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Compliance Tools

Tool Category	Logo/Icon	Description
EPC Tools	SAP	Used for national certification and basic energy modeling (e.g. UK, Ireland)
PHPP	PHPP	Design tool for ultra-low energy and comfort assurance
Dynamic Simulations	EnergyPlus	Used for high-resolution, hourly simulations and public project validation

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Post-Building Validation

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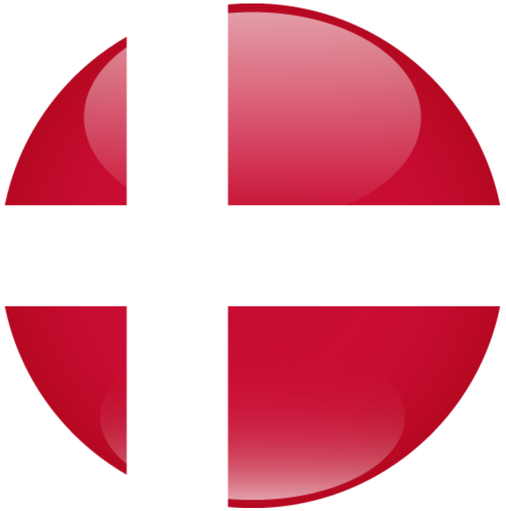
nZEB Variability Across EU

- Denmark: 20–30 kWh/m²/year
- Spain: 60–80 kWh/m²/year
- Estonia: up to 120 kWh/m²/year



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ZEB Early Movers

- Austria: GHG-linked subsidies
- Netherlands: BENG method
- France: RE2020 carbon budgets

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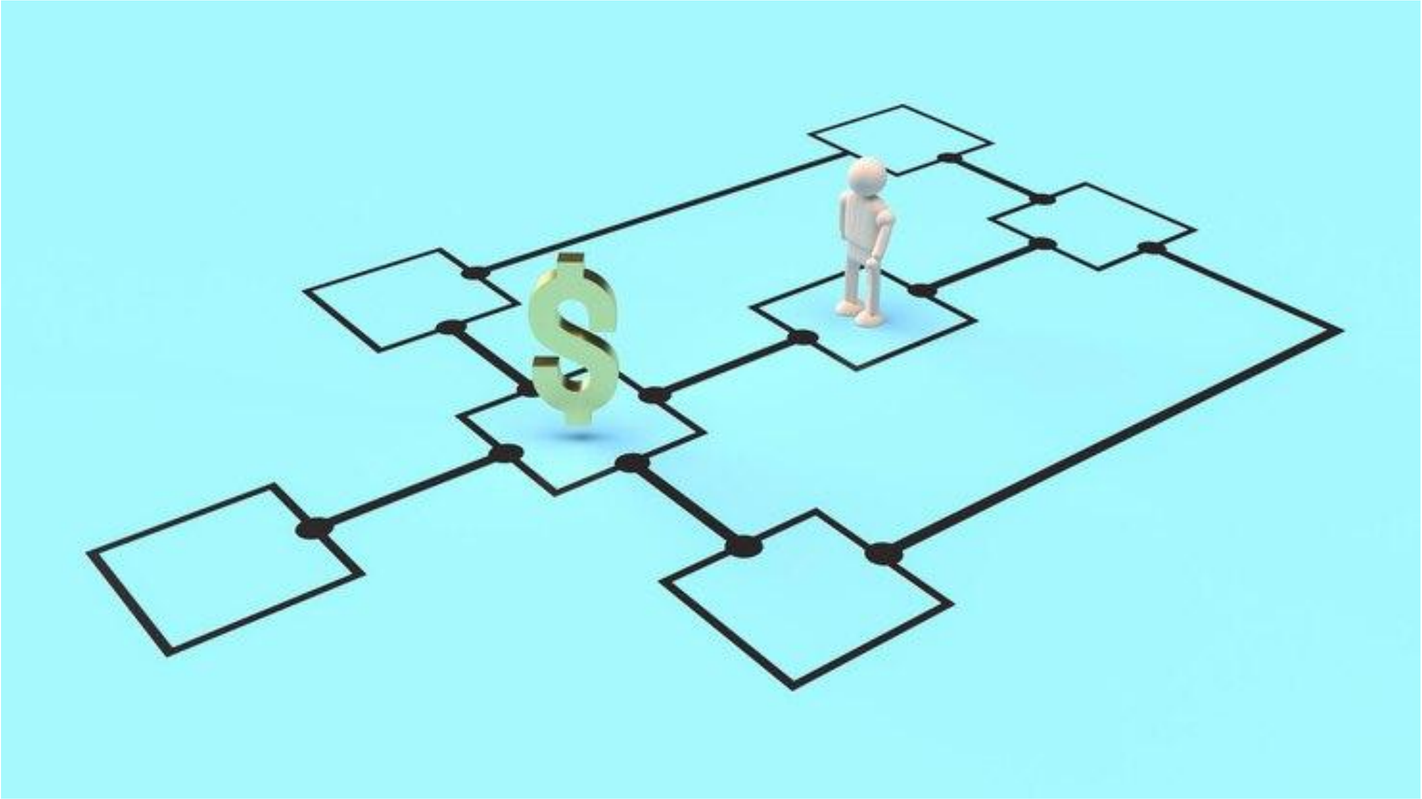
Implementation Barriers

- Labor shortage, enforcement gaps
- Lack of verification infrastructure
- Unclear financial ROI



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Best Practices Emerging

- One-stop shops (FR, LT)
- Digital EPC + BIM (FI)
- Public procurement drivers (DE)

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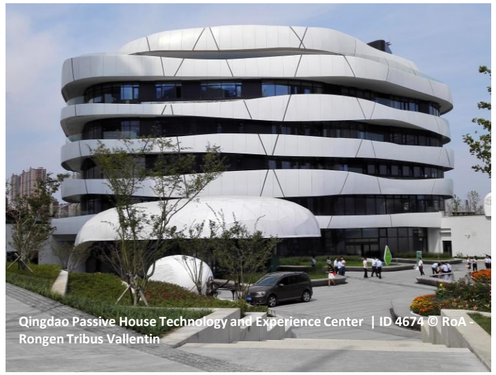
Passive House: Voluntary Model

- Envelope-first, demand-led
- Proven tools + QA
- No legal mandate

Norwich Goldsmith Steet | ID 6045 © Tim Crocker


Qingdao Passive House Technology and Experience Center | ID 4674 © RoA Rongen Tribus Vallentin

V. Senger School, Frankfurt, Germany | ID 1955 © Mara Monetti Fotografie

House at Cornell Tech, New York, ABD © C. Sifferlen

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Policy vs Design Frameworks

ZEB (Policy Framework)	Passive House (Design Framework)
GHG compliance goal	Comfort + demand reduction goal
EPC / emissions thresholds	PHPP (design simulation)
Regulated (EPBD)	Voluntary (PHI)
Focus on operational carbon	Focus on demand, comfort, quality
Compliance = documentation	Compliance = modeling + testing

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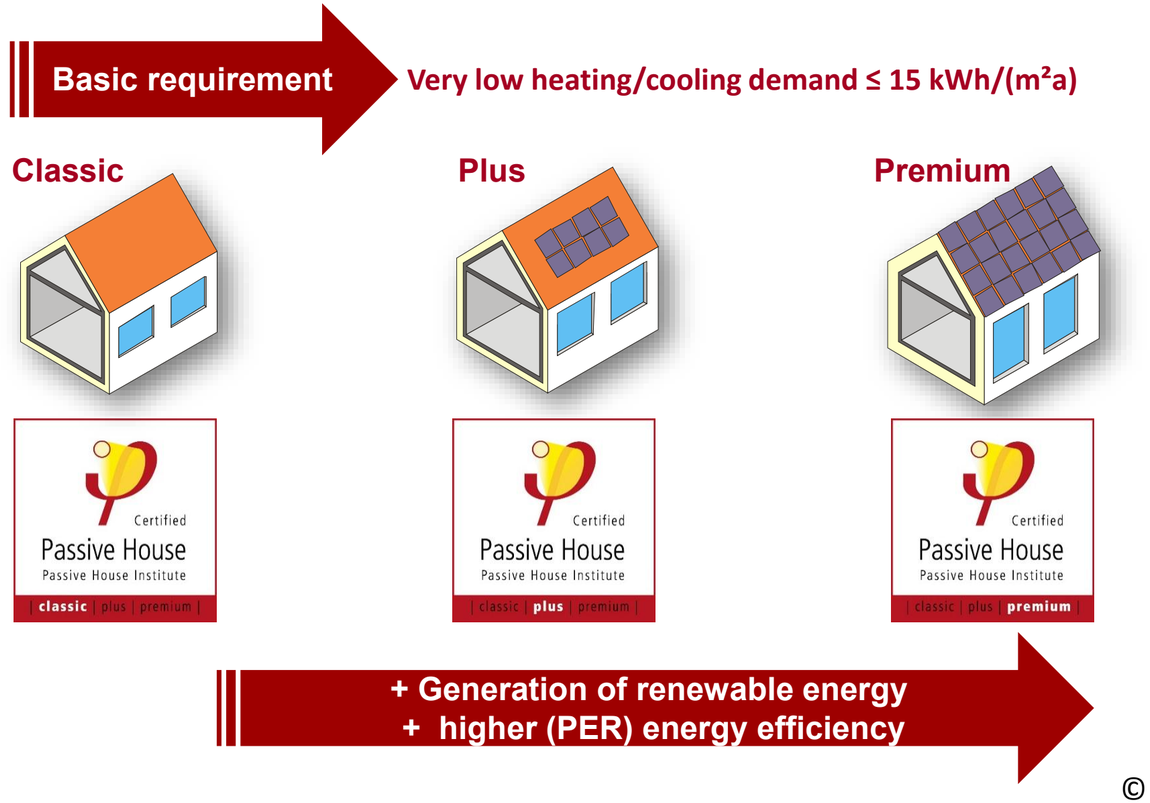
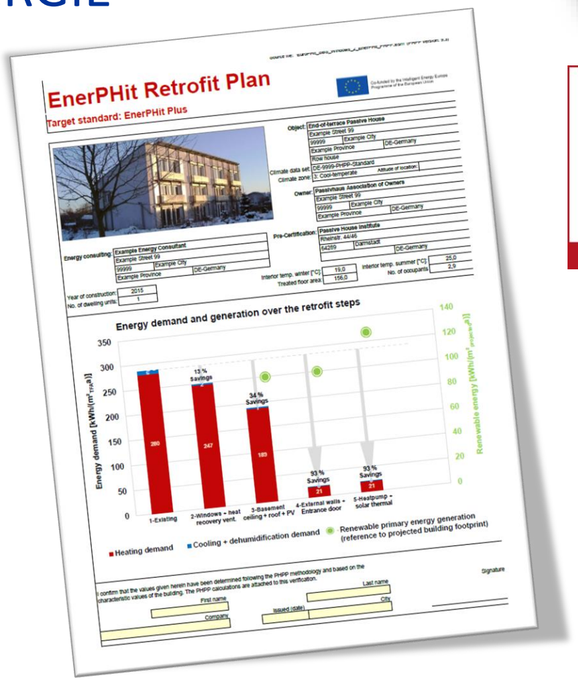
Beyond Passive: Advanced Voluntary Standards

- PH Plus, PH Premium
- EnerPHit for retrofits
- Active House, MINERGIE





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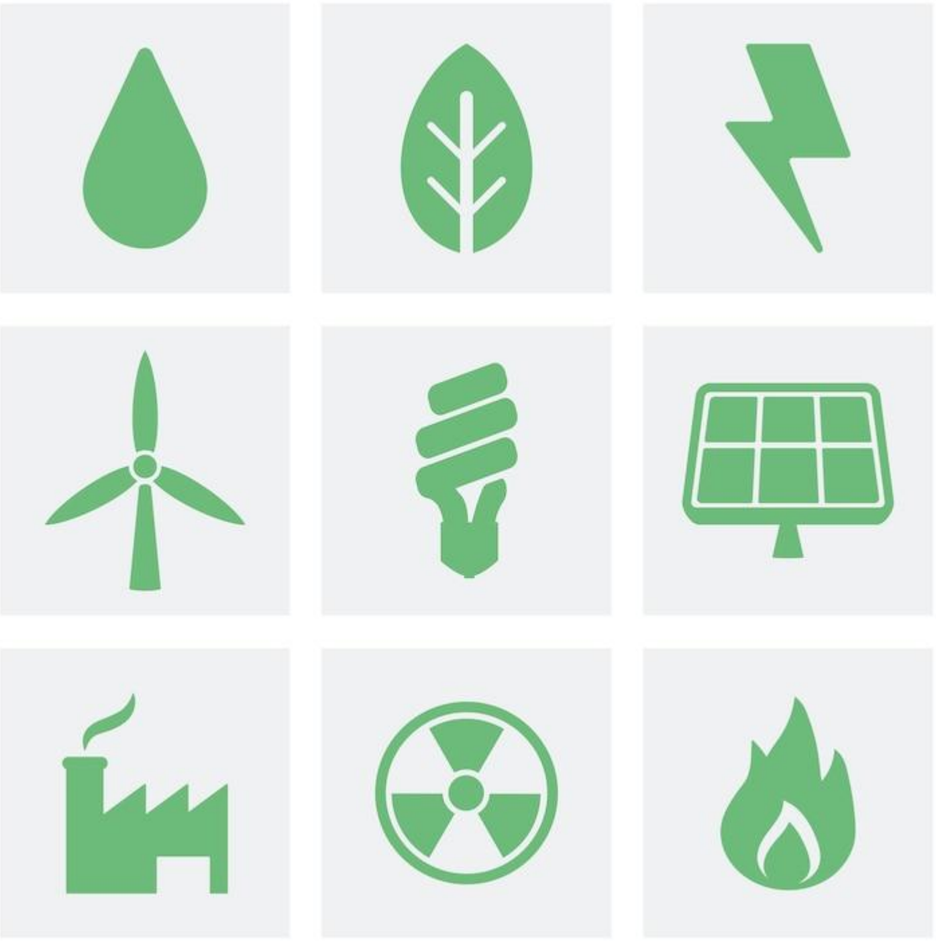
Conclusion & Reflection

- ZEB: regulatory shift
- National variety persists
- Which metric drives change: energy, GHG, or comfort?



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ZEB Early Movers – Country Examples

- France – RE2020 includes carbon budgets for all new buildings
- Netherlands – BENG: primary energy, airtightness, and daylight factors
- Austria – Ties subsidies to operational GHG performance

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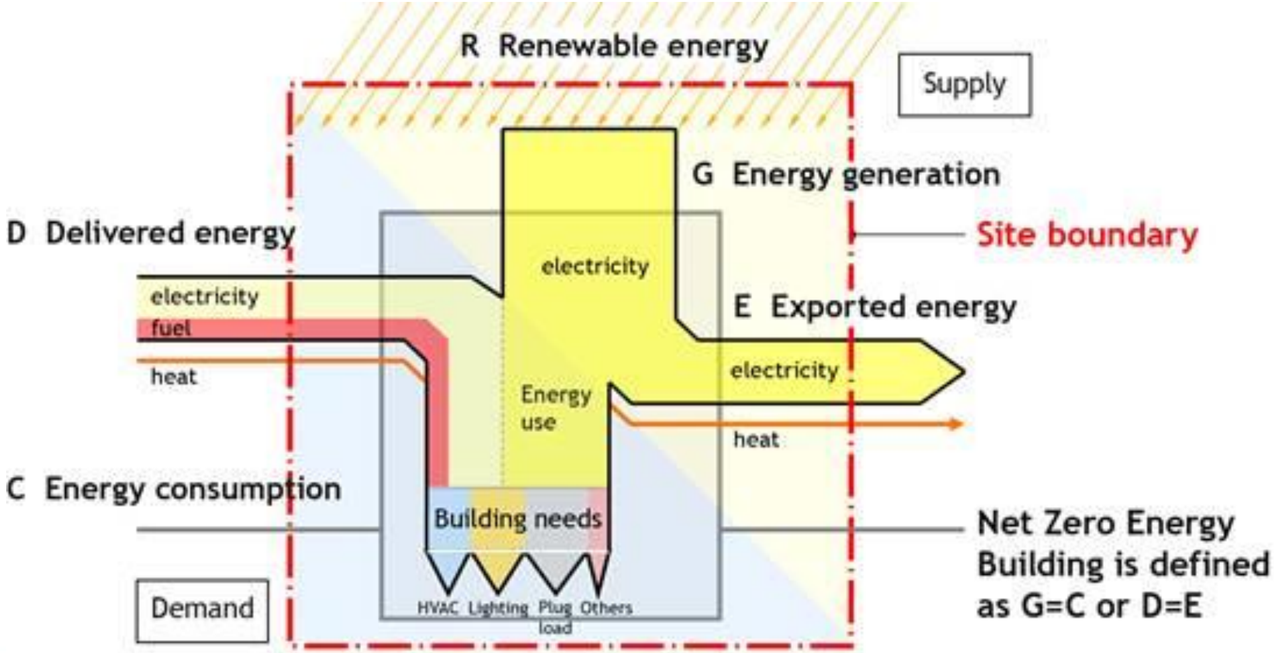
Understanding GHG & PED Thresholds

- GHG: $kgCO_2eq/m^2/year$ – set by building type and climate zone
- PED: Primary Energy Demand – max site+source energy
- Combined to define ZEB performance boundaries



Source: https://www.rehva.eu/rehva-journal/chapter/current-situation-and-actions-for-zeb-in-japan

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Thank you!

Q & A

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STEP2CleanPlan

COOPERATION FOR SUSTAINABLE ENERGY AND CLIMATE ACTIONS PLANNING AND MONITORING IN BSB

STEP2CleanPlan BSB00004

Module 2: Sustainable Urban Mobility and Energy Efficiency

Sub Module 202: Energy Efficiency in Urban Infrastructure

202 B: Passive House Design Principles

Trainer:

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Agenda

- Why Passive House Matters
- Core Performance Metrics
- PHPP Tool Overview
- Case Study Applications
- EU Compliance Interactions
- Conclusion & Reflection

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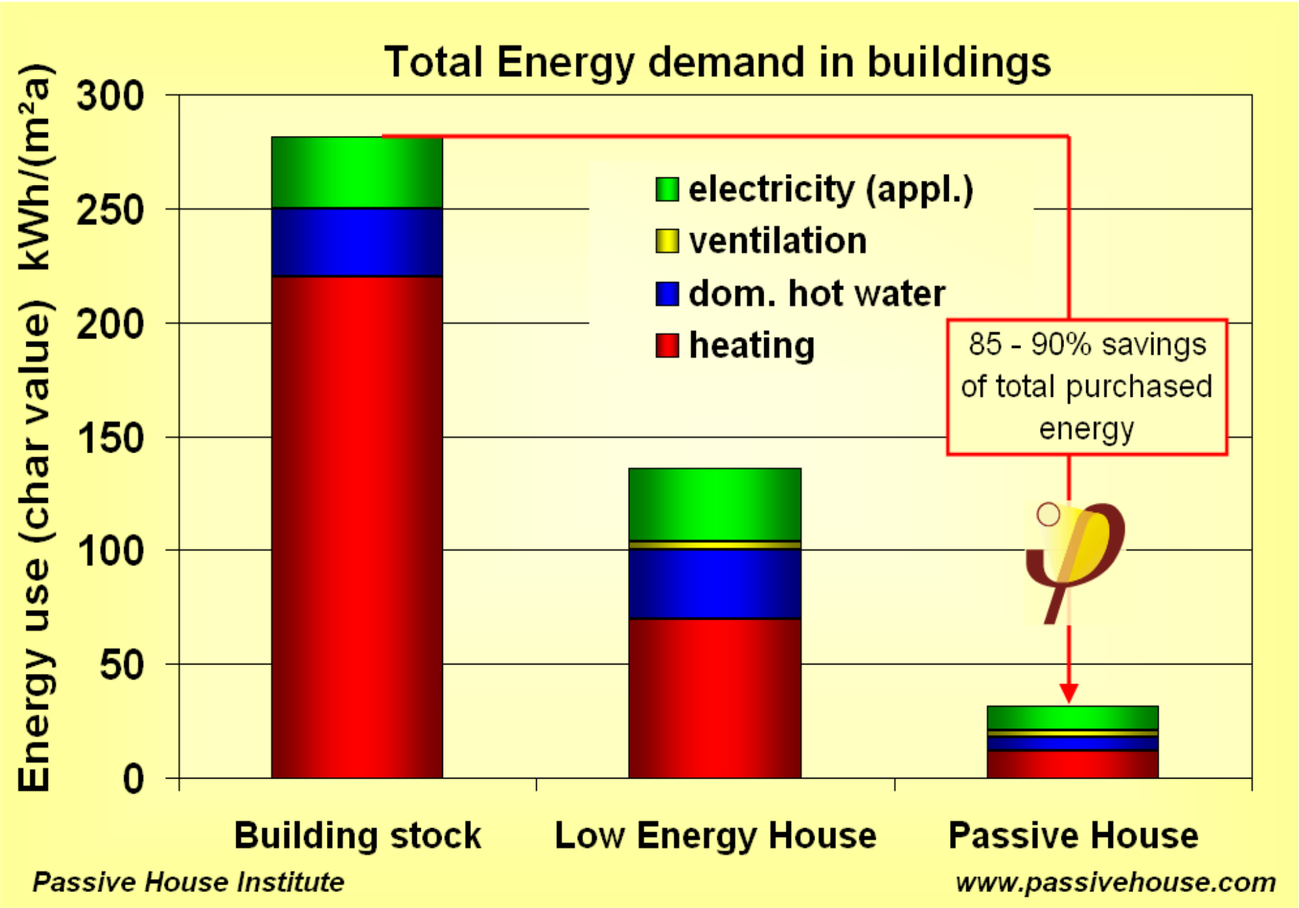
Why Passive House Matters?

- Voluntary, high-performance design
- Reduces demand before renewables
- Aligns with EU ZEB goals



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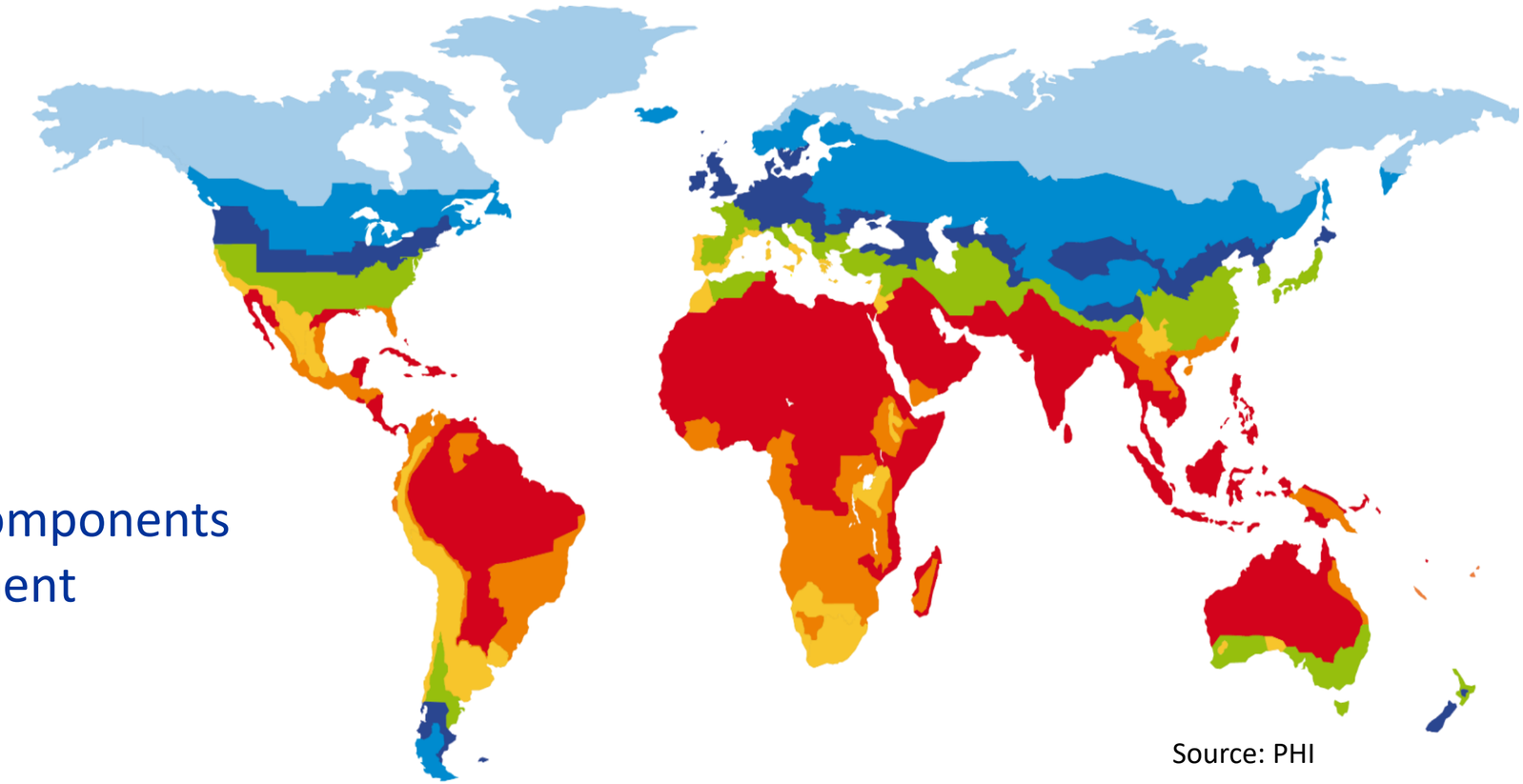
Passive House Criteria

cool, temperate climate

CERTIFIED COMPONENT

Passive House Institute

- The values of all certified components are available in the component database and in PHPP



Source: PHI

	Arctic	Cold	Cool-temperate	Warm-temperate	Warm	Hot	Very hot
Walls (opaque)	**0.09**	**0.12**	**0.15**	**0.3**	**0.5**	**0.5**	**0.3**
Glazing type recommended	Vacuum / 4-glazed low-e	3- or 4-glazed low-e	3-glazed low-e	3-glazed low-e	2-glazed low-e	2-glazed anti-sun	3-glazed anti-sun
Uw, installed MAX (vertical)	**0.45**	**0.65**	**0.85**	**1.05**	**1.25**	**1.25**	**1.05**

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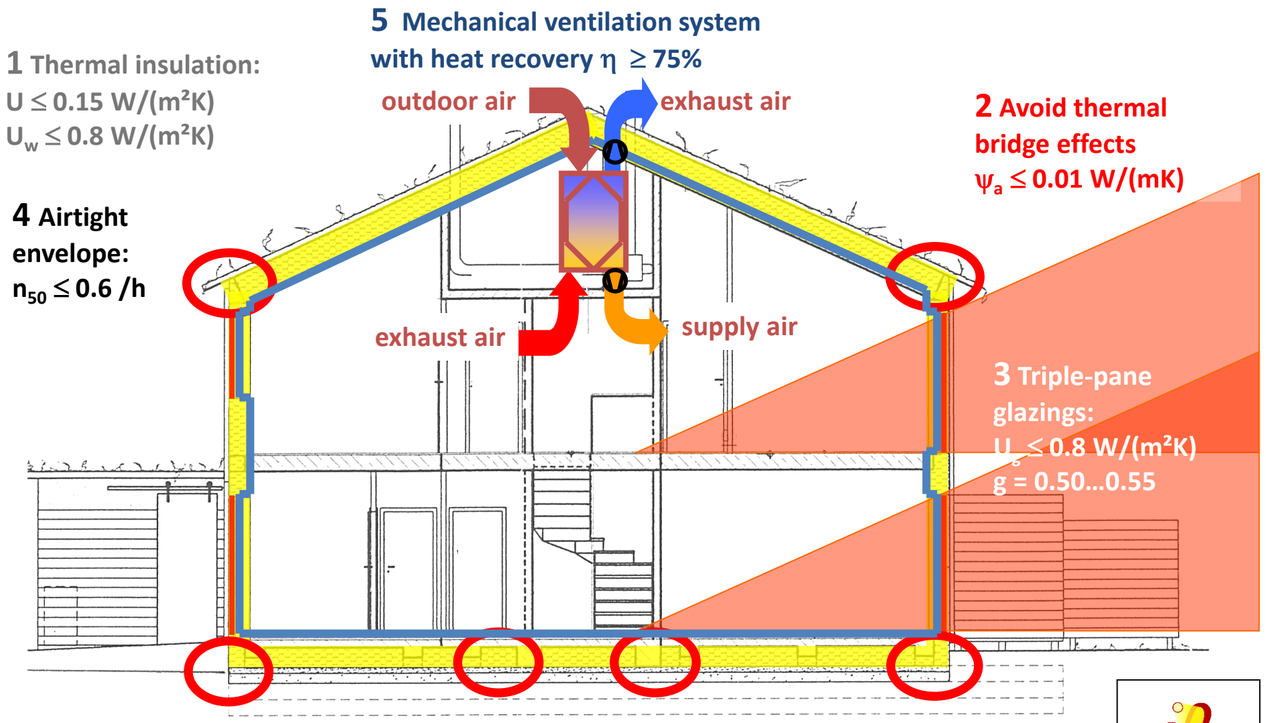
Passive House Criteria

- For cold – temperate region

- ≤15 kWh/m²/year heating & cooling
- ≤0.6 ACH @ 50 Pa
- PER ≤60 kWh/m²/year or
  PE ≤95 kWh/m²/year



Certified Passive House

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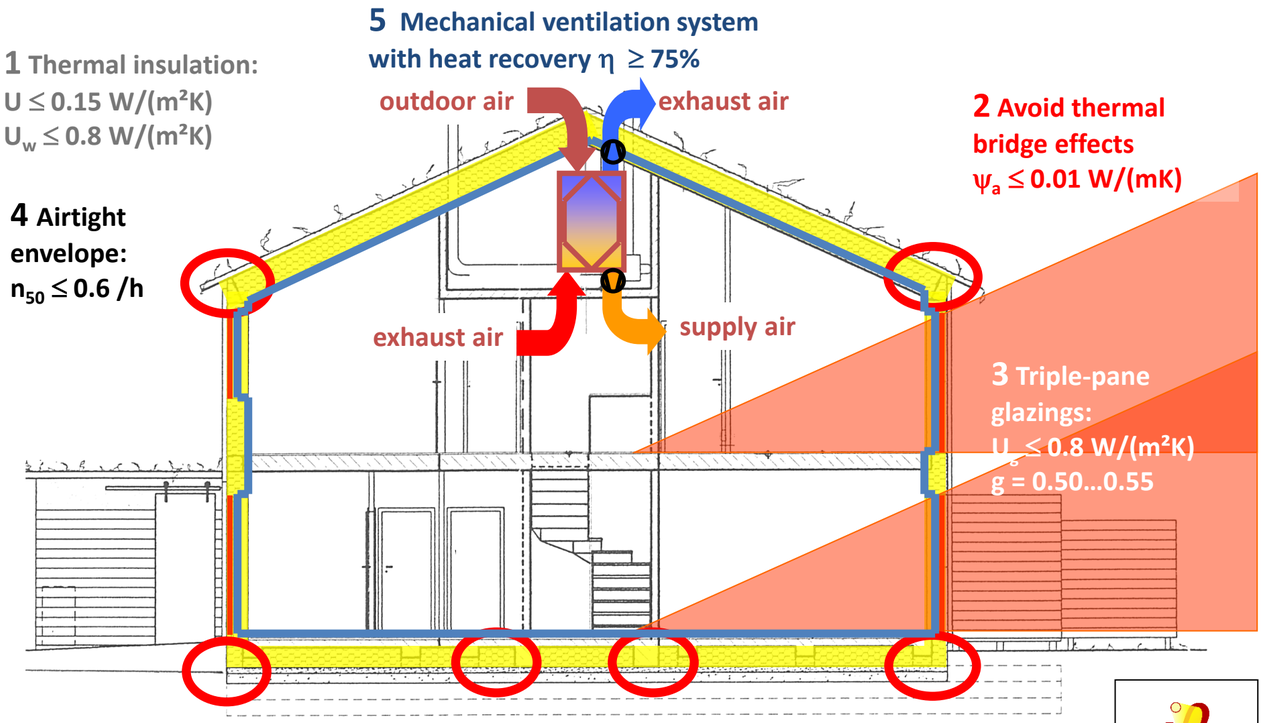
Thermal Comfort & MVHR

- Stable indoor temps 20–25°C
- ≤10% hours >25°C
- Balanced MVHR with 75%+ recovery



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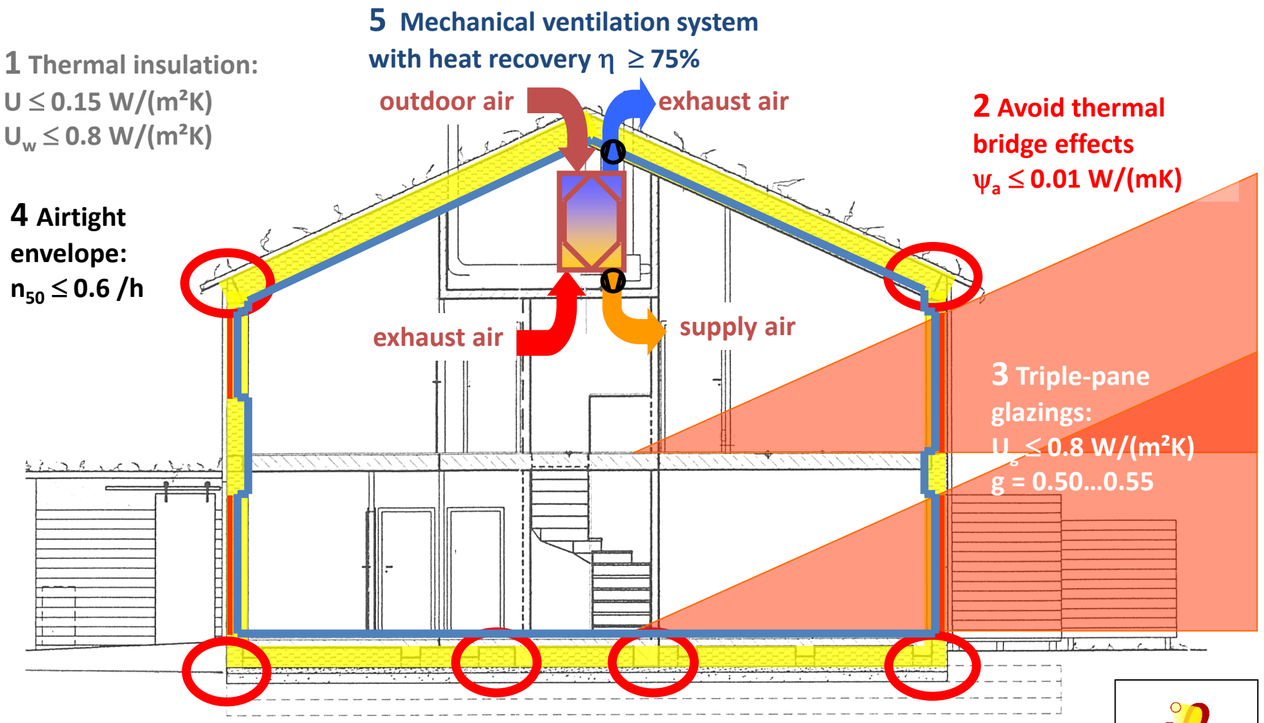
Thermal Bridge-Free Detailing

- Psi-values ≤ 0.01 W/mK
- All junctions modeled
- Avoids mold, improves comfort



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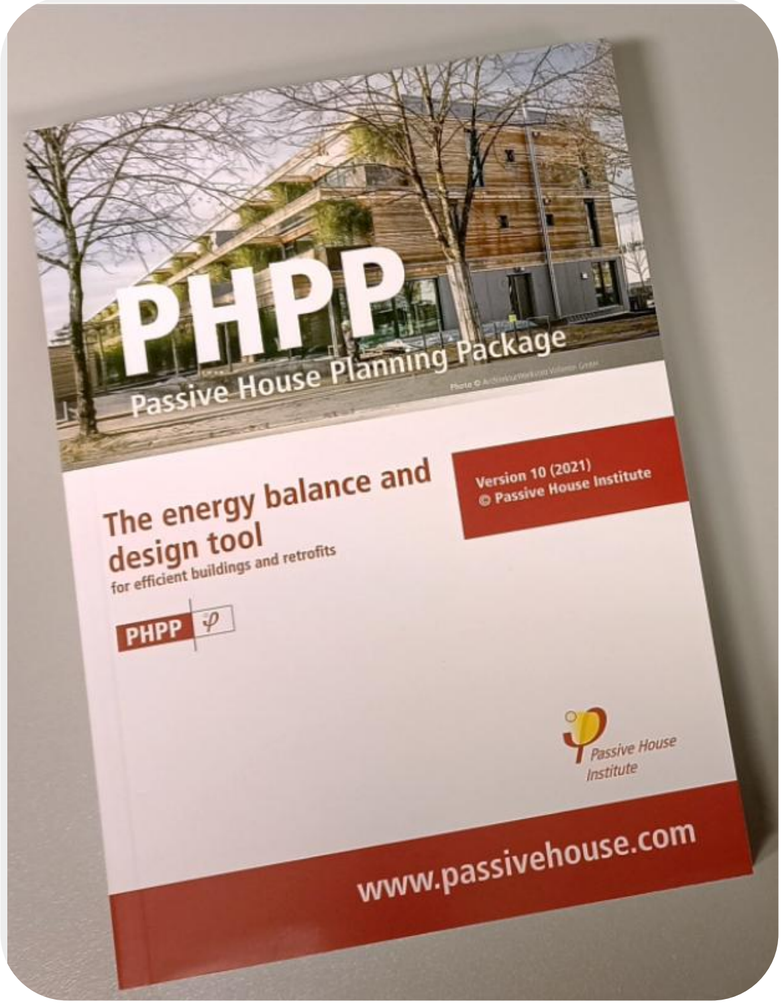
What is PHPP?

- Excel-based, monthly balance tool
- Detailed input, traceable results
- Preferred for Passive House

Specific building characteristics with reference to the treated floor area

					Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area	m²	175.5				
Space heating	Heating demand	kWh/(m²a)	**11**	≤	15	-	**Yes**
	Heating load	W/m²	**10**	≤	-	10	
Space cooling	Cooling & dehum. demand	kWh/(m²a)	**-**	≤	-		**-**
	Frequency of overheating (> 25 °C)	%	**1**	≤	10		**Yes**
	Frequency of excessively high humidity (> 12 g/kg)	%	**0**	≤	20		**Yes**
Airtightness	Pressurisation test result n_{50}	1/h	**0.6**	≤	0.6		**Yes**
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	**58**	≤	-		**-**
Primary Energy Renewable (PER)	PER demand	kWh/(m²a)	**58**	≤	60	60	**Yes**
	Renew. energy generation (in rel. to projected building footprint area)	kWh/(m²a)	**13**	≥	-	-	



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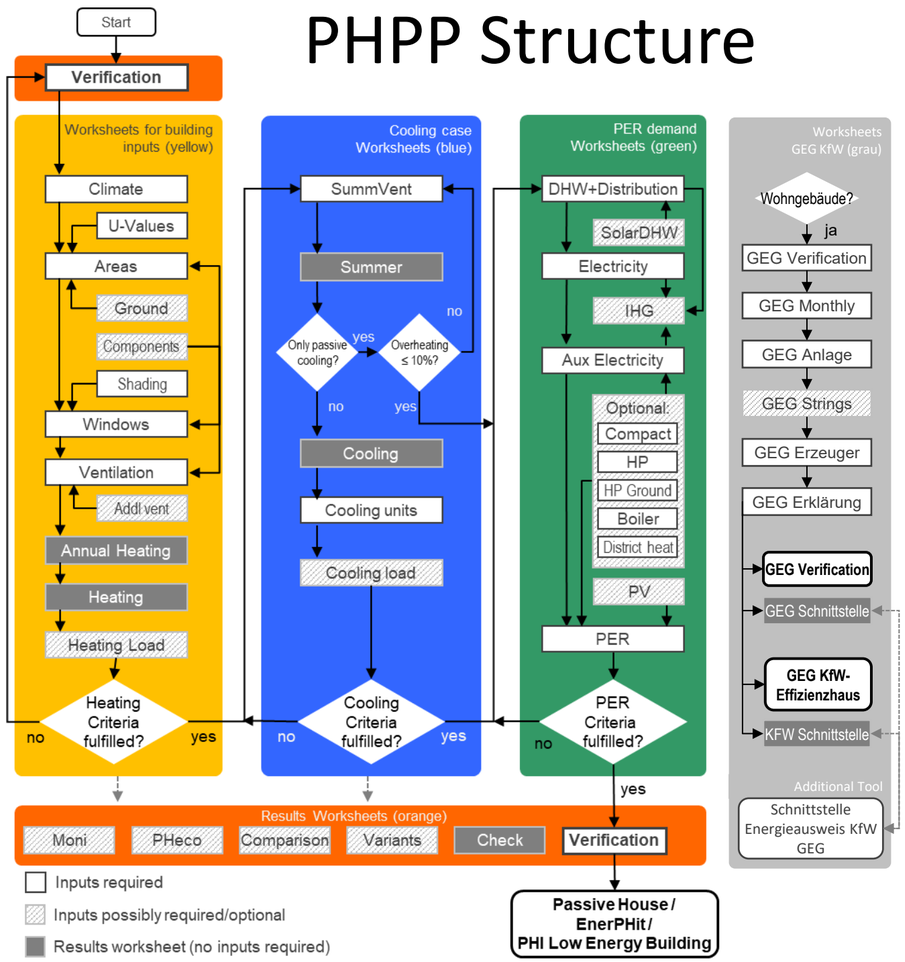
PHPP Inputs

- U-values, window specs, MVHR, shading
- Climate file and occupancy
- Ventilation and airtightness data

PHPP Structure



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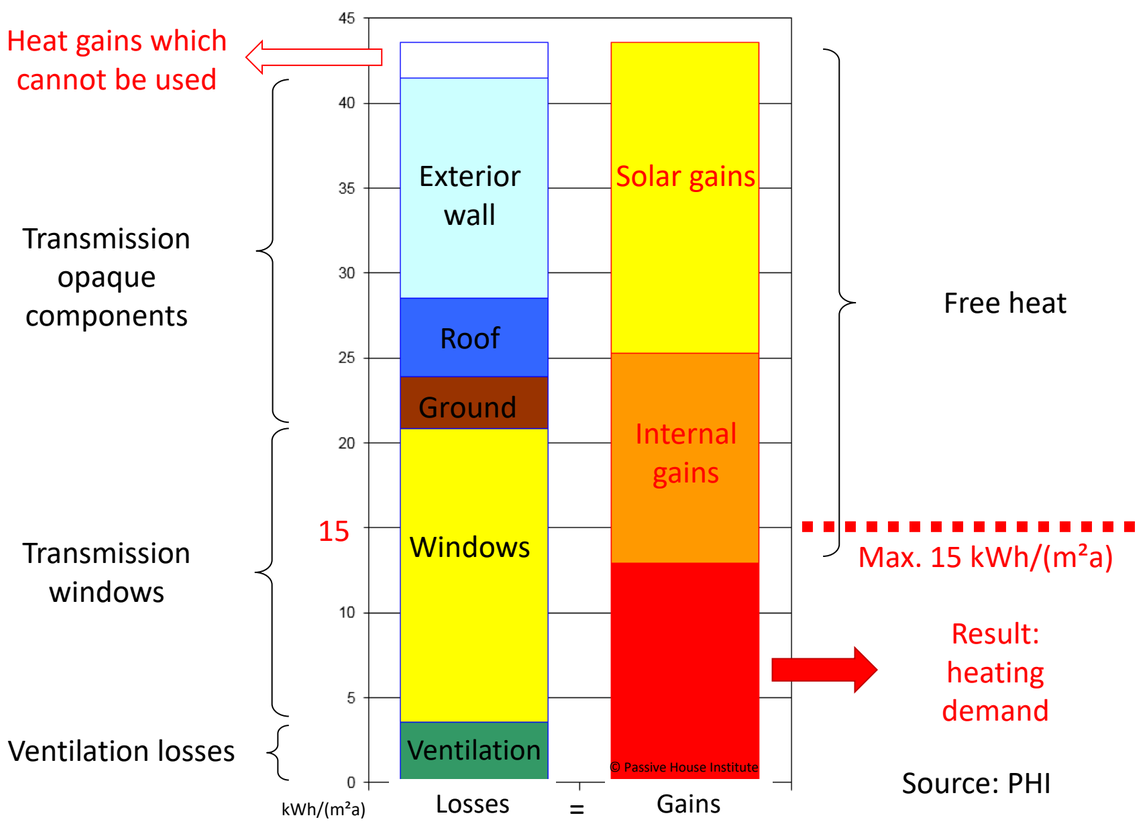
PHPP Outputs

- Heating/cooling demand
- Overheating % and PER
- Ventilation efficiency



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PHPP and Iterative Design

- Envelope tuning (WWR, shading)
- Optimizing MVHR and systems
- EnerPHit upgrade modeling

active Variants

Variants 1, 2, 3 …

Variant calculation

End-of-terrace Passive House / Climate: PHPP-Standard / TFA: 156 m² / Heating: 149.8 kWh/(m²a) / Cooling: 0.7 kWh/(m²a) / PER: 479.4 kWh/(m²a)

6 Number of the last variant --> data table is configured accordingly

© PHI

	Select the active variant here >>>>>>>	Active			
		3-Basement ceiling + Roof	Existing building	Windows + Ventilation	Basement ceiling + Roof
Results	**Units**	3	1	2	3
Heating demand	kWh/(m²a)	**149.8**	313.1	232.8	149.8
Heating load	W/m²	**65.5**	138.6	95.1	65.5
Cooling & dehum. demand	kWh/(m²a)	**0.7**	8.5	2.5	0.7
Frequency of overheating (> 25 °C)	%				
PER demand	kWh/(m²a)	**479.4**	890.0	689.9	479.4
EnerPHit (Component method) Premium?	yes / no	**No**	No	No	No
Error messages	Quantity	**1**	1	1	1
Final energy		-	-	-	-
User-defined results		-	-	-	-
		Last row for data table calculation	Last row for data table calculation	Last row for data table calculation	Last row for data table calculation

Activ		**Input variables**	**Units**	**Value**	**1**	**2**	**3**
X		**Building assembly layers**	U-value				
X	c	Insulation layer roof	W/(mK)	0.04			0.04
			mm	300			300
X	d	Insulation layer of basement ceiling	W/(mK)	0.025			0.025
			mm	100			100

Source: PHI

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UZUNKÖPRÜ 1868 BELEDİYESİ

Lodenareal – Innsbruck (PH Classic)

- Build type: apartment house
- 361 units
- Air tightness: n_{50} = 0.18/h test result
- Annual heating demand:
  14 kWh /(m^2a) calculated according to PHPP
- Heating load: 9 W/m^2
- PE demand: 117 kWh /(m^2a) calculated according to PHPP
  on heating installation, domestic hot water, household electricity and auxiliary electricity calculated
- Building structure costs (gross)1600 €/m^2 Treated Floor Area according to PHPP

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Zaragoza – Spain (PH Classic)

- ClimateWarm, temperate
- Air tightness n_{50} = 0.3/h
- Annual heating demand: 12 kWh /(m^2a) calculated according to PHPP
- Heating load: 10 W/m^2
- PE demand (non-renewable Primary Energy): 87 kWh /(m^2a) on heating installation, domestic hot water, household electricity and auxiliary electricity calculated according to PHPP
- PER demand (renewable Primary Energy): 53 kWh /(m^2a) on heating installation, domestic hot water, household electricity and auxiliary electricity calculated according to PHPP
- Generation of renewable energy: 0 kWh /(m^2a) based on the projected area
- Cooling load7 W/m^2
- Cooling and dehumidification demand: 10 kWh /(m^2a) calculated according to PHPP

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Şile, İstanbul – Türkiye (PH Plus)

Heating: 9 kWh/m²a
Cooling: 9 kWh/m²a
RE Generation: 53 kWh/m²a
External Wall U-Value: 0.102 W/m²K
Ground Floor U-Value: 0.110 W/m²K
Roof U-Value: 0.113 W/m²K
Window U-Value: 0.8 W/m²K
Heat Recovery Efficiency: 86%
Air tightness n_{50} = 0.6/h

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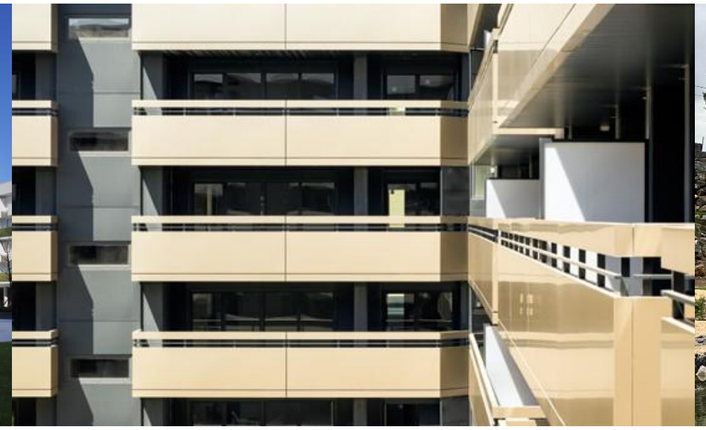
Lessons Across Projects

- Early integration: success
- PHPP supports reliability
- Construction execution matters



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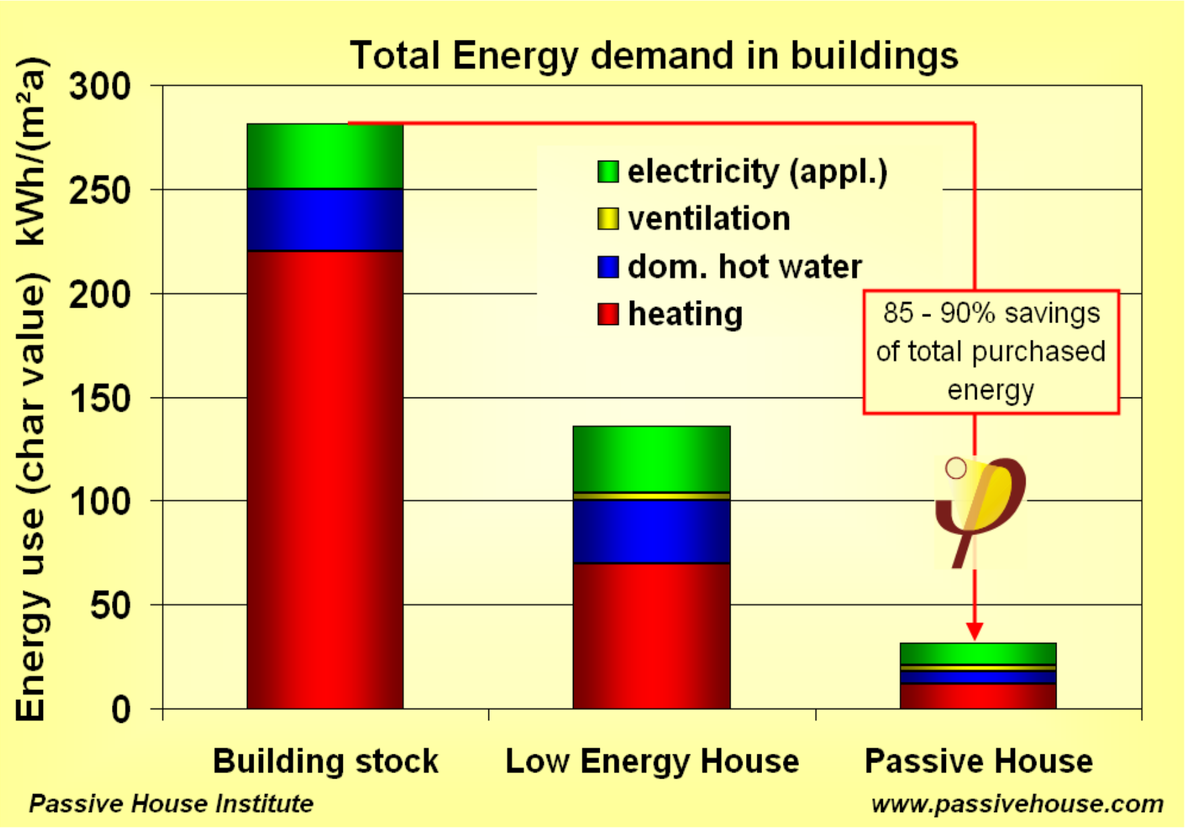
How PH Aligns with EPBD

- Ultra-low demand meets ZEB targets
- PHPP transparency supports QA
- Measured performance → reliable output



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Where PH Falls Short

- No native GHG reporting
- Not accepted as EPC substitute
- No embodied carbon coverage

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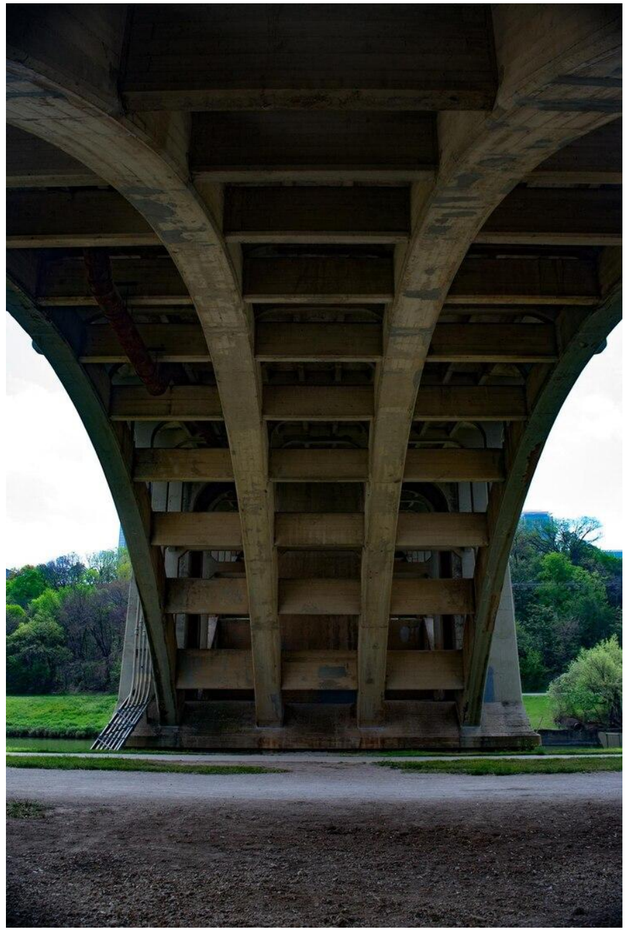
Bridging the Gap

- Add emissions calcs to PHPP
- Dual tracking with EPC tools
- Use Level(s) for whole-life indicators



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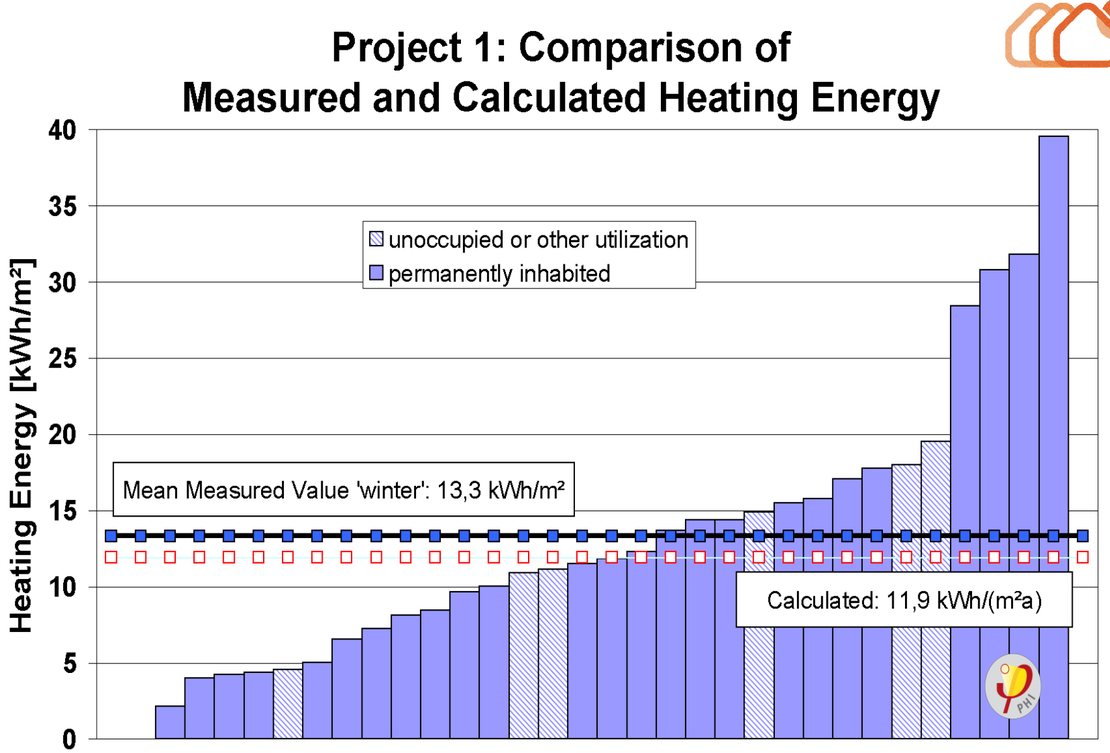
PHPP vs Real Energy Use Example

- PHPP modeled: 11,9 kWh/m²a
- Measured: 13,3 kWh/m²a
- Small deviation shows reliable forecasting



Source: PHI

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Passive House vs Local Norm Conflicts

- PH requires low demand, but may conflict with:

- Local SHGC limits (cooling zones)
- EPC modeling software assumptions
- Building form or site restrictions

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Passive House Classes: Classic, Plus and Premium

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Conclusion & Reflection

- PH: consistent high performance
- Not a law, but a method
- What would boost PH adoption in your region?

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Thank you!

Q & A

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NEXT Black Sea Basin

STEP2CleanPlan

COOPERATION FOR SUSTAINABLE ENERGY AND CLIMATE ACTIONS PLANNING AND MONITORING IN BSB

STEP2CleanPlan BSB00004

Module 2: Sustainable Urban Mobility and Energy Efficiency

Sub Module 202: Energy Efficiency in Urban Infrastructure

202 C: Retrofitting and Construction for Zero Emission Performance

Trainer:

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Agenda

- Why Retrofit for Zero Emission Goals?
- Envelope First: Insulation & Airtightness
- Ventilation, Windows, and HVAC Integration
- Retrofit Workflow & Coordination
- EnerPHit and Staged Sequencing
- Case Strategies for Real-World Success
- Conclusion & Reflection

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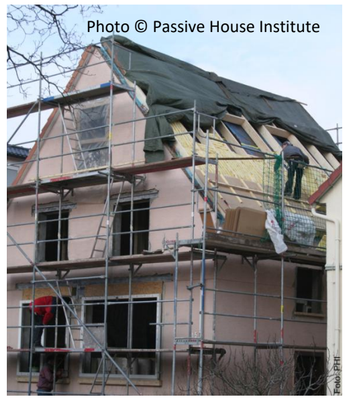
NEXT Black Sea Basin

STEP2CleanPLAN

The Retrofit Imperative

- 85% of buildings pre-modern codes
- Still in use by 2050
- Renovation: climate strategy



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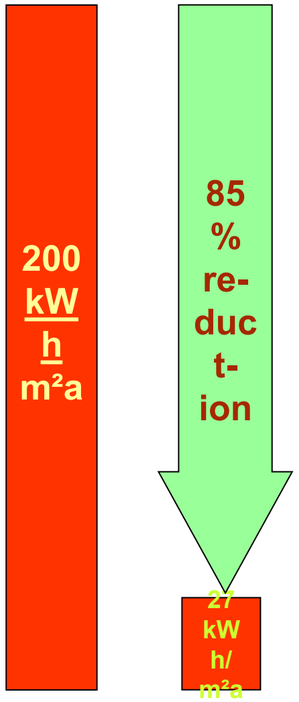
Deep Retrofit Benefits

- Up to 80% GHG reduction / 85% energy consumption reduction
- Improved comfort, durability
- Supports energy poverty relief

before



after retrofit

- basement insulated
- walls insulated
- Passive House windows
- ventilation with highly efficient heat recovery

Photos and diagram: © Schulze-Darup

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Why Shallow Renovations Fail

- Boiler/window swaps ≠ performance
- Miss airtightness, ventilation
- Lack of systems integration

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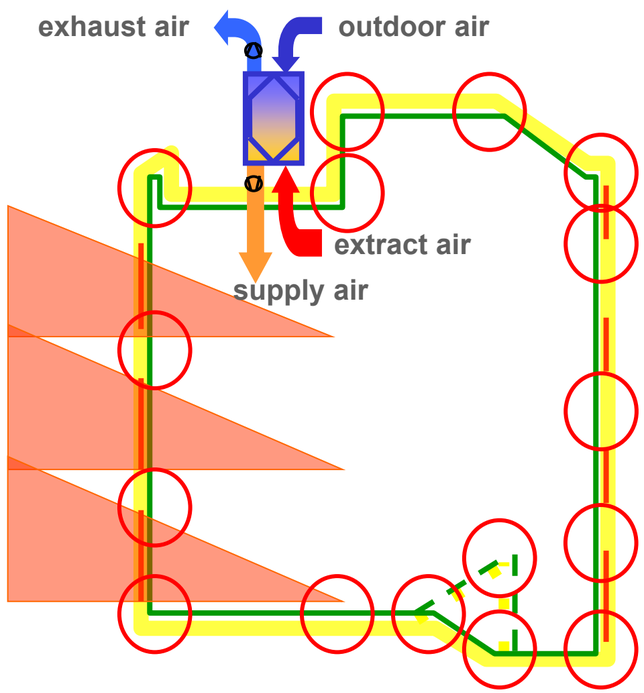
Envelope as Retrofit Foundation

- Thermal enclosure comes first
- Insulation, airtightness, bridge-free
- Enables other systems to perform



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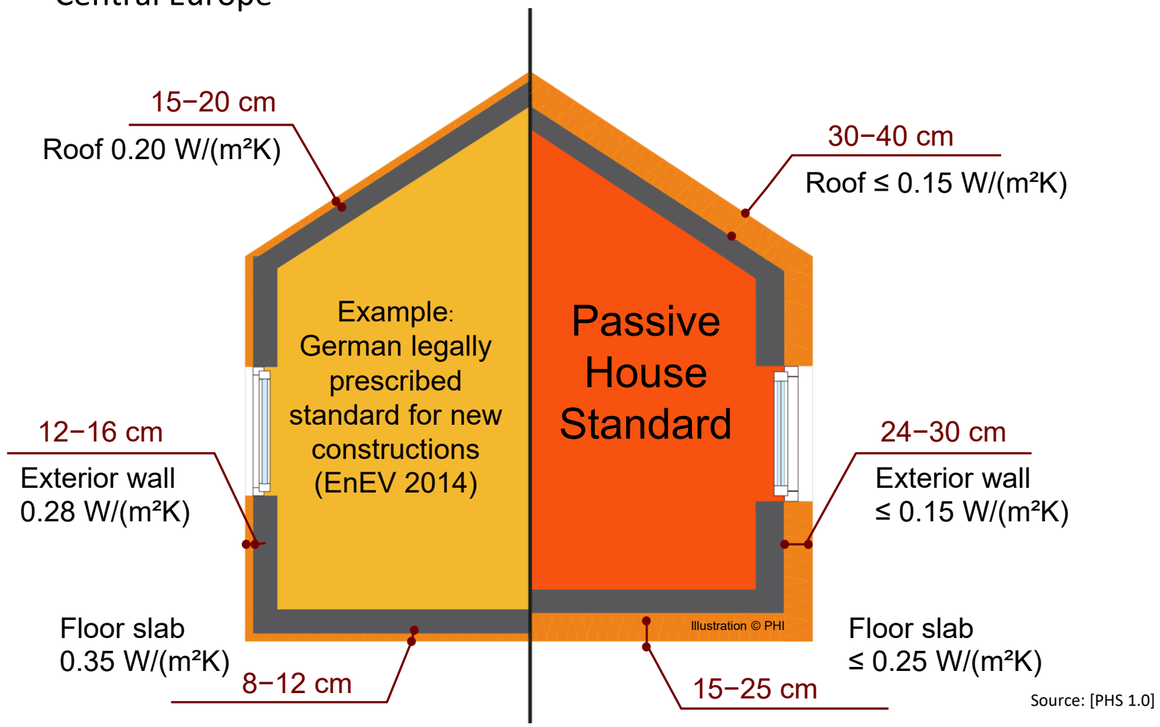
Insulation Best Practices

- Continuity > thickness
- External preferred (e.g., ETICS)
- U-values: wall 0.10–0.15, roof 0.08–0.12

Typical U-values and insulation thickness for a Passive House building in Central Europe



Source: [PHS 1.0]

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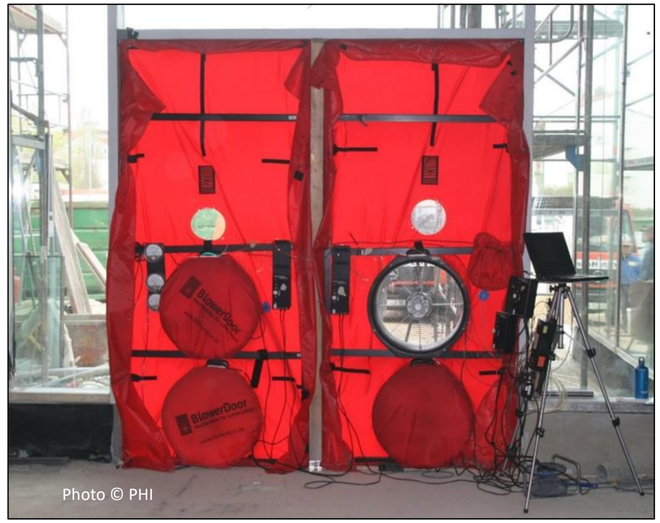
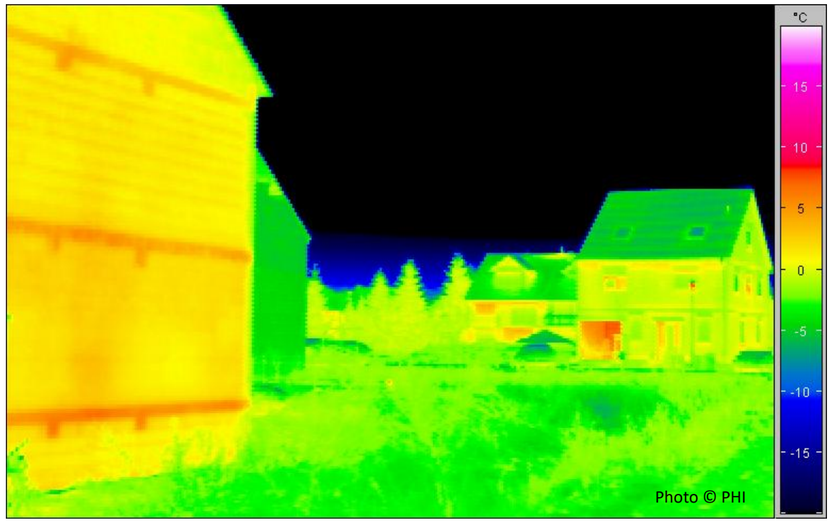
Airtightness Detailing

- EnerPHit: ≤1.0 ACH @ 50 Pa
- Defined layer, taped transitions
- Pre/post blower door tests





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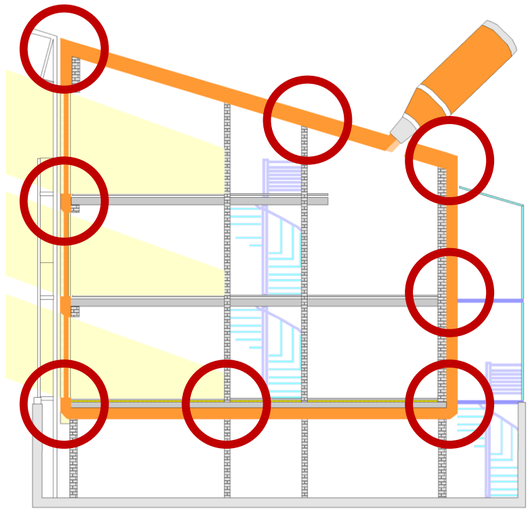
Thermal Bridge Elimination

- Ψ-values < 0.01 W/mK
- Sill/jamb/foundation wraps
- Modeled with THERM or Flixo



The insulating envelope encloses the entire heated volume.

Thermal bridge-free design:
$\Psi_e \leq 0.01$ W/(mK)

Avoidance Rule:
The insulating envelope should not be interrupted if this can be avoided.

Penetration Rule:
If penetration of the insulating layer is unavoidable, the thermal conductivity of the penetrating material should be as low as possible.
Use porous concrete or even better wood, or PUR or foam glass elements.

Connection Rule :
Insulation layers at building component connections merge into each other over the entire surface without interruption.

© PHI

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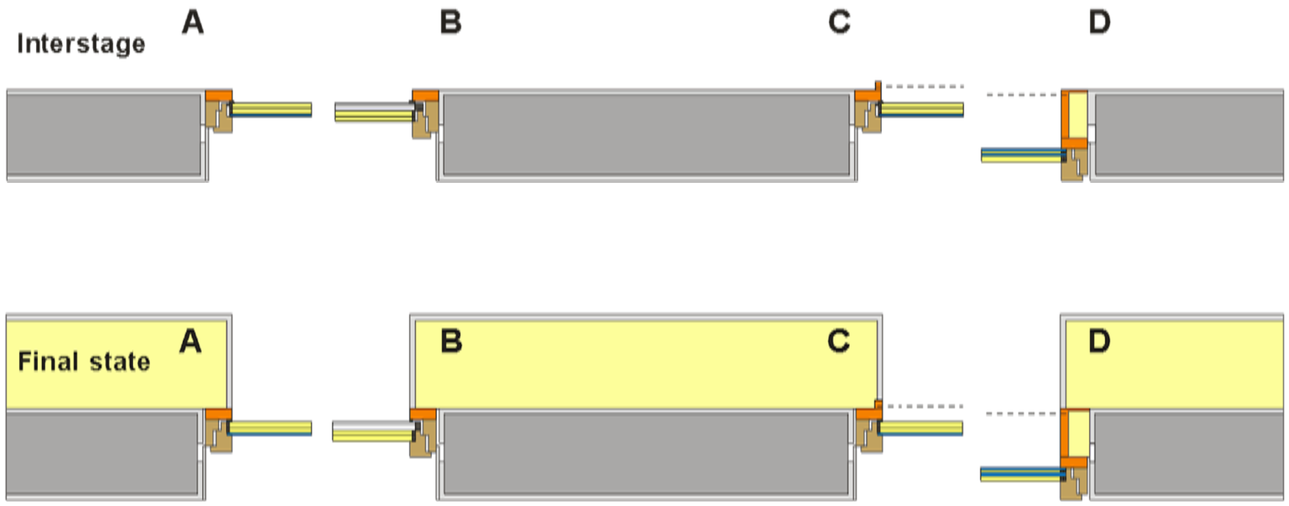
Sequencing Envelope Work

- Windows before insulation
- Air barrier before finishes
- Insulation after prep/testing



Figures © Passivhaus Institut

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Planning & Verification Tools

- Airtightness plans, thermal modeling
- Blower door, infrared camera
- U-value calculations

Plan → Test → Confirm

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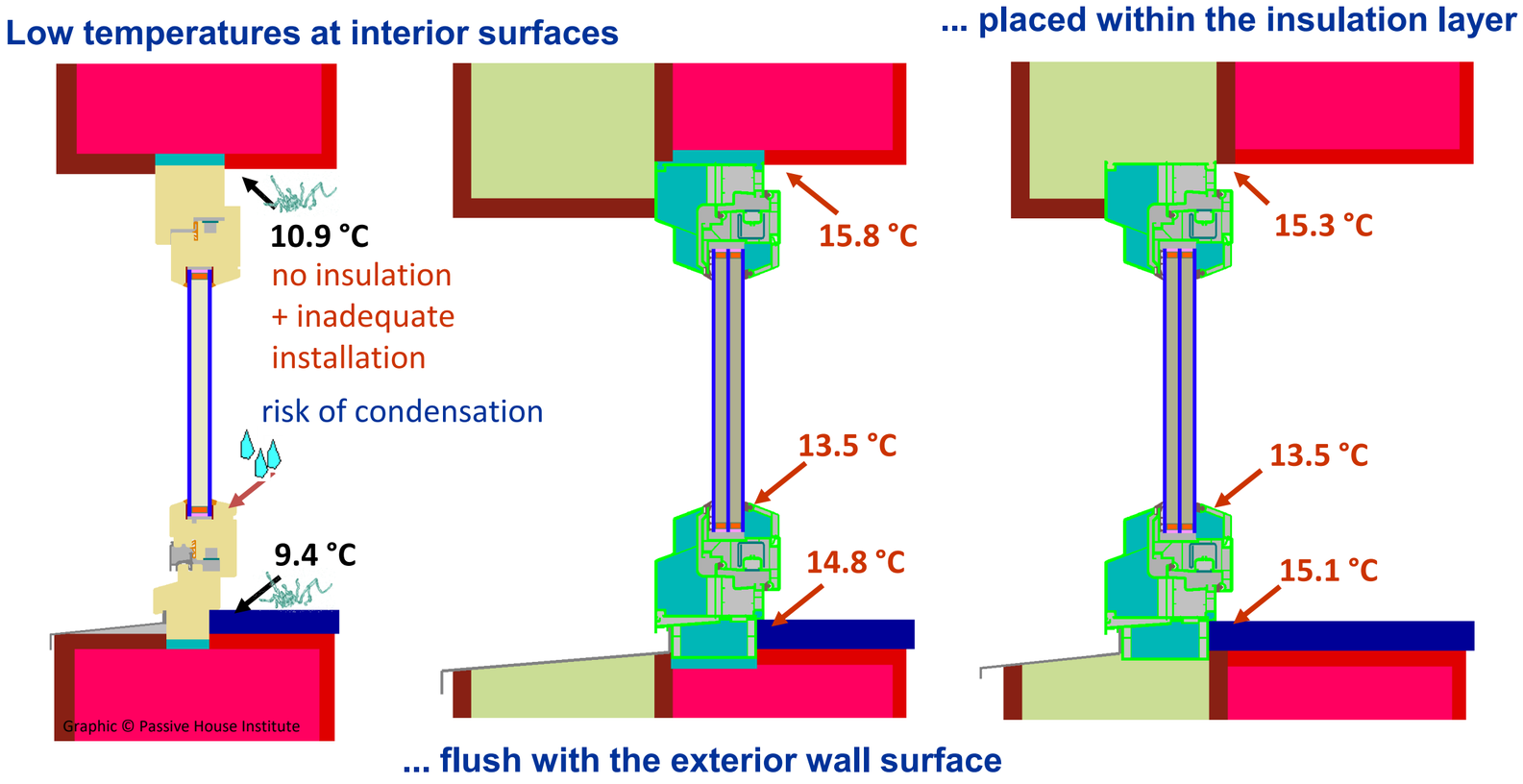
High-Performance Windows

- U ≤ 0.85–1.0 W/m²K, triple-glazed
- Orientation: SHGC strategy varies
- Air/thermal continuity at frame



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HVAC for Passive Loads

- Small systems for small loads
- Prefer heat pumps, low-temp delivery
- Smart zoning, defrost readiness

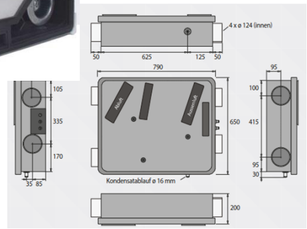
© Nilan Comfort CT150

HRV unit for installation in a **wardrobe**...

© Vallox Heinemann

...or in a kitchen wall **cupboard**

© Ventilair Fox Comfort



...or in a **plumbing wall** (HRV unit only 20 cm deep)

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Whole-System Synergy

Envelope enables ventilation

Ventilation stabilizes air quality

Systems right-sized by PHPP

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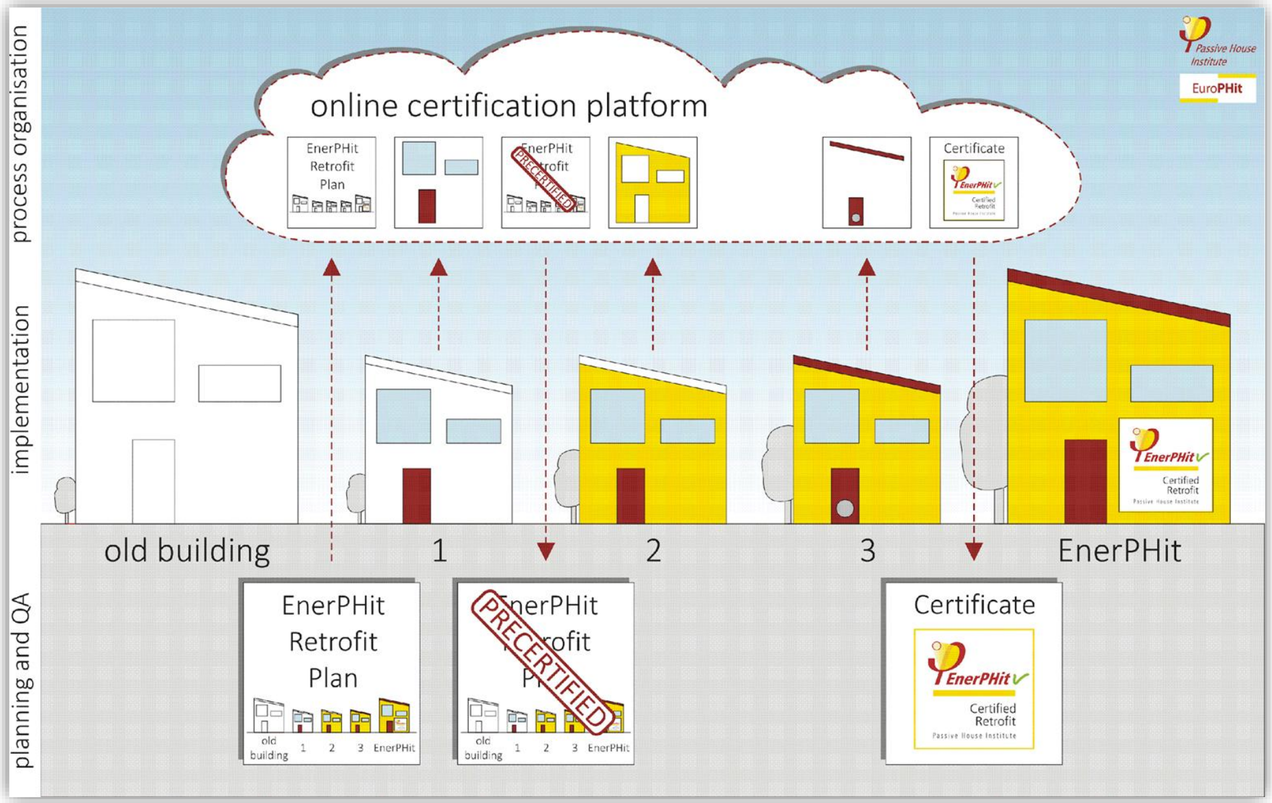
Retrofit Workflow Logic

- Diagnostics → Design → Envelope → MVHR → QA
- Air test before finishes
- PHPP modeling aligns each step



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Contractor Risk Mitigation

- Pre-start workshops/mockups
- Annotated site drawings
- Passive House trained crews

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Budget & Time Pressures

- Upfront cost + time = higher
- But lifecycle + ROI = strong
- Use energy + comfort gains to sell

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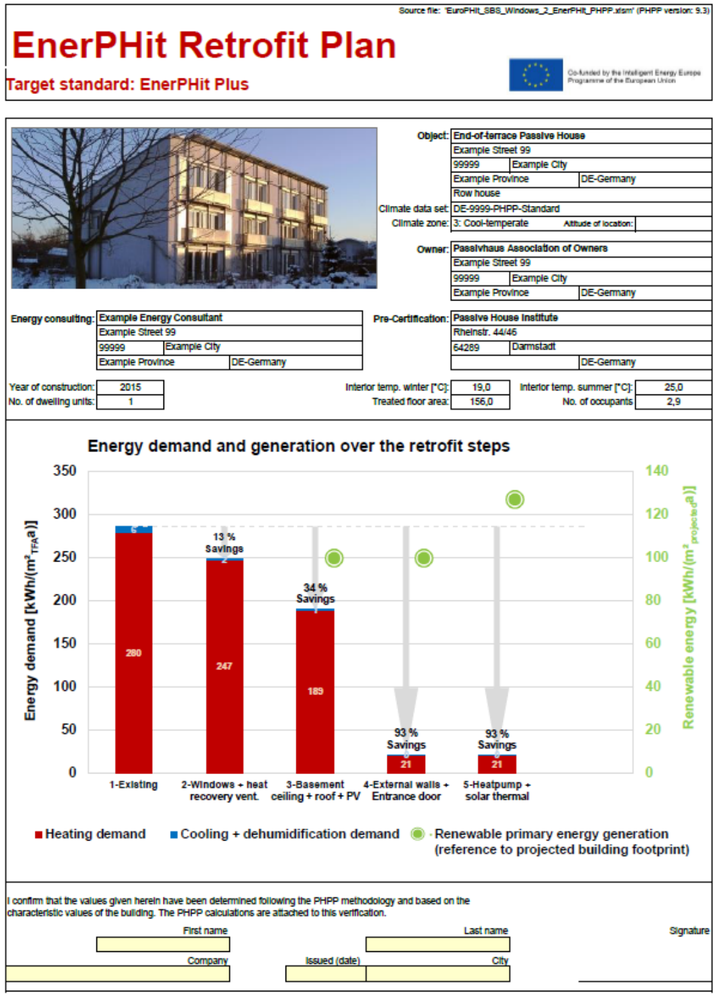
NEXT Black Sea Basin

STEP2CleanPLAN

EnerPHit Principles

- Flexible: phased or full
- 25 kWh/m²/year heating target
- Allows component upgrades



Source file: 'EuroPHit_SBS_Windows_2_EnerPHit_PHPP.xlsm' (PHPP version: 9.3)

EnerPHit Retrofit Plan

Target standard: EnerPHit Plus

Co-funded by the Intelligent Energy Europe Programme of the European Union

Object:	End-of-terrace Passive House
	Example Street 99
	99999 Example City
	Example Province DE-Germany
	Row house
Climate data set:	DE-9999-PHPP-Standard
Climate zone:	3: Cool-temperate Altitude of location:
Owner:	Passivhaus Association of Owners
	Example Street 99
	99999 Example City
	Example Province DE-Germany

Energy consulting:	Example Energy Consultant
	Example Street 99
	99999 Example City
	Example Province DE-Germany
Pre-Certification:	Passive House Institute
	Rheinstr. 44/46
	64289 Darmstadt
	DE-Germany

Year of construction:	2015	Interior temp. winter [°C]:	19,0	Interior temp. summer [°C]:	25,0
No. of dwelling units:	1	Treated floor area:	156,0	No. of occupants	2,9

Energy demand and generation over the retrofit steps

I confirm that the values given herein have been determined following the PHPP methodology and based on the characteristic values of the building. The PHPP calculations are attached to this verification.

First name | Last name | Signature

Company | Issued (date) | City

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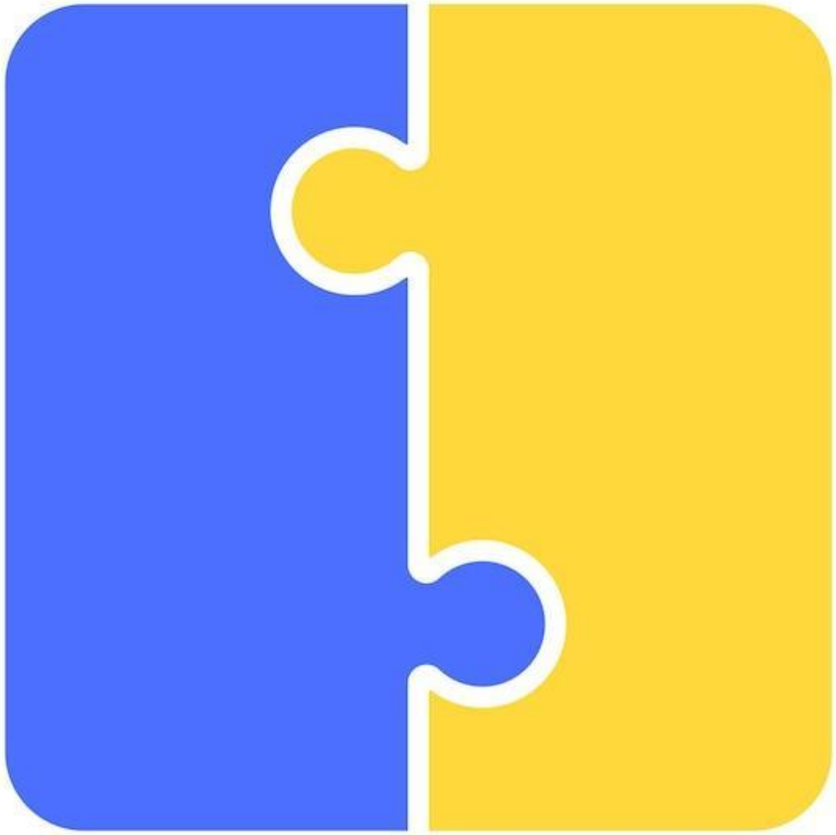
UZUNKÖPRÜ 1868 BELEDİYESİ

Phased vs Whole-Building Approach

- Staged = budget/practicality
- PHPP supports step-by-step
- Requires airtightness foresight



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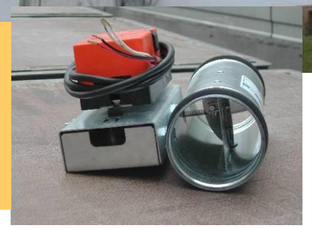
NEXT Black Sea Basin

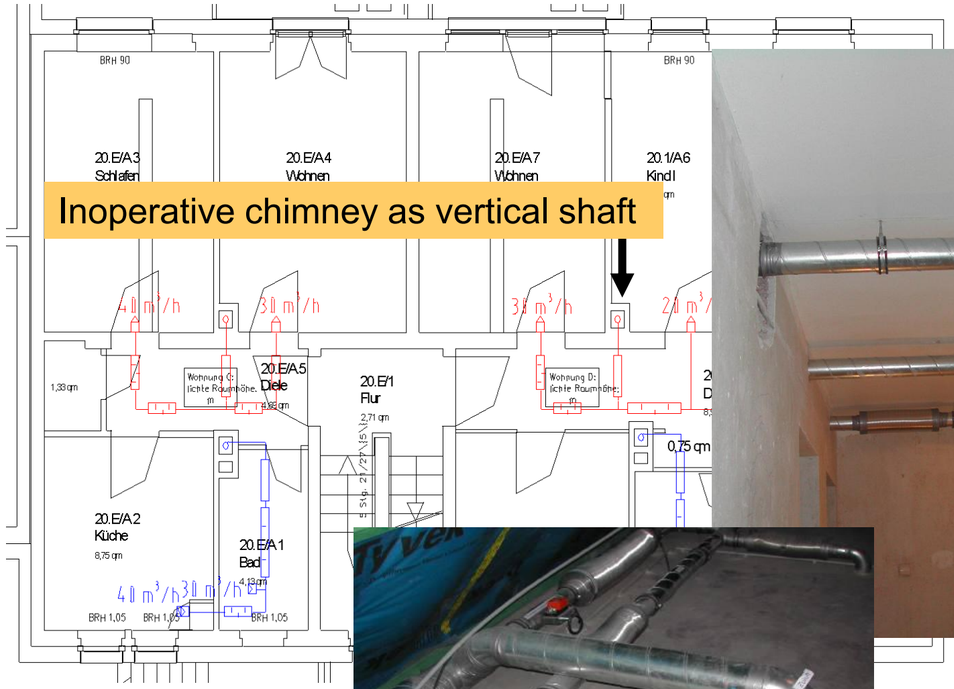
STEP2CleanPLAN

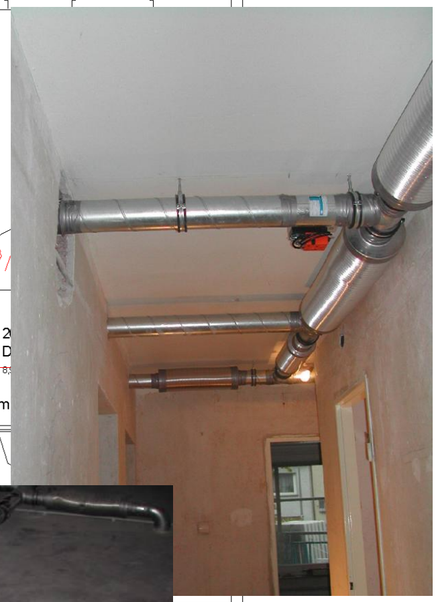
Apartment Building Hofheim, Taunus

Photos © Planungsgruppe DREI



constant volume flow regulator





supply air

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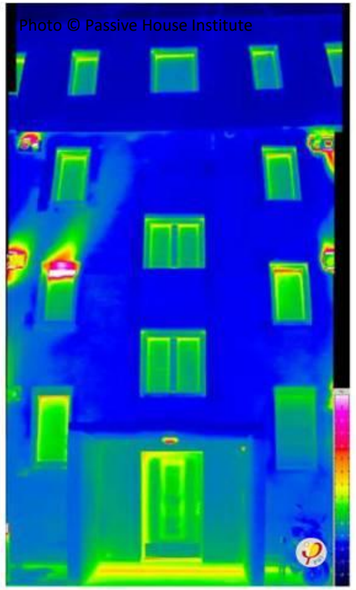
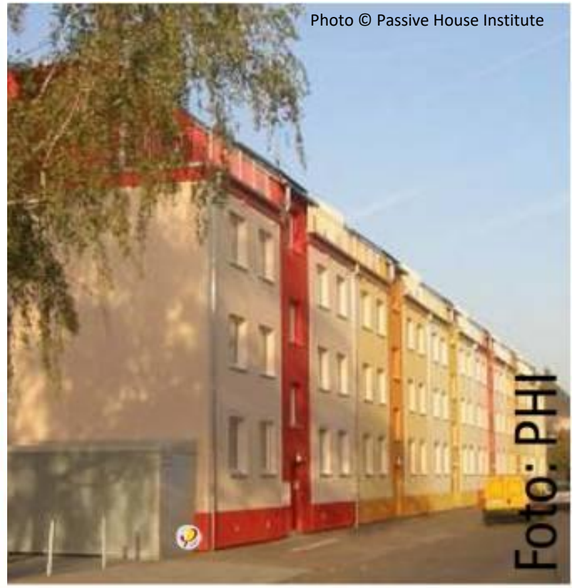
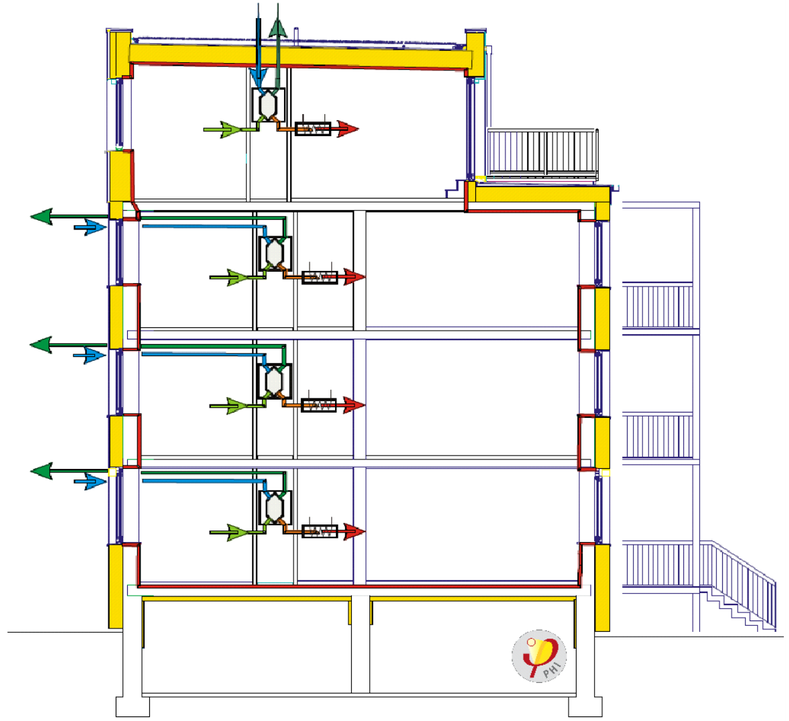
UZUNKÖPRÜ 1868 BELEDİYESİ

Retrofit Project, Tevesstrasse, Frankfurt, Germany

Retrofit Project, Tevesstrasse, Frankfurt







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Reflection Prompt

- Where do YOU hold leverage?
- Detailing? QA? Coordination? Client framing?

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Contractor Training & Construction Mockups

- Passive House–aligned training improves quality
- Mockups for complex joints (e.g. floor-wall-air barrier)
- Toolbox talks: align sequences, reduce clashes

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Thank you!

Q & A

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NEXT Black Sea Basin

STEP2CleanPlan

COOPERATION FOR SUSTAINABLE ENERGY AND CLIMATE ACTIONS PLANNING AND MONITORING IN BSB

STEP2CleanPlan BSB00004

Module 2: Sustainable Urban Mobility and Energy Efficiency

Sub Module 202: Energy Efficiency in Urban Infrastructure

202 E: Sensors, IoT Devices & Control Strategies

Trainer:

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Agenda

- Sensor Fundamentals
- Types and Applications
- IoT Devices & Network Logic
- Control Strategies & QA
- Override Failures & Fusion Logic
- Security, Calibration & Reflection
- Conclusion & Reflection

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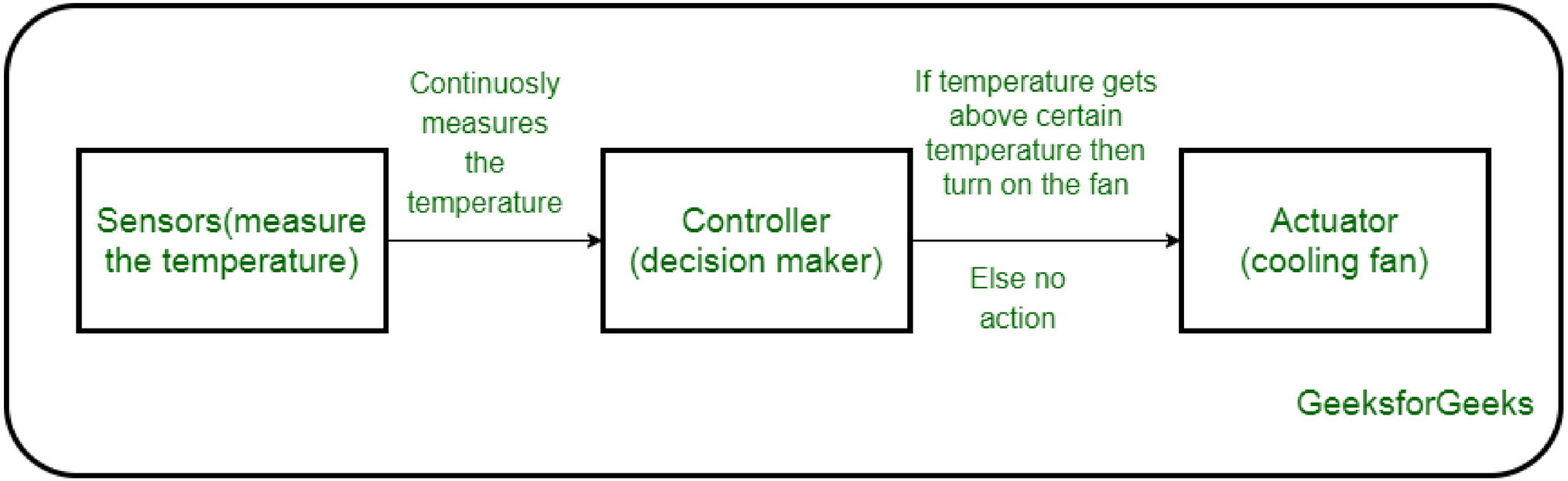
Why Sensors Are Foundational

- Enable automation and efficiency
- Connect user comfort to system logic
- Basis for BAS and smart operation



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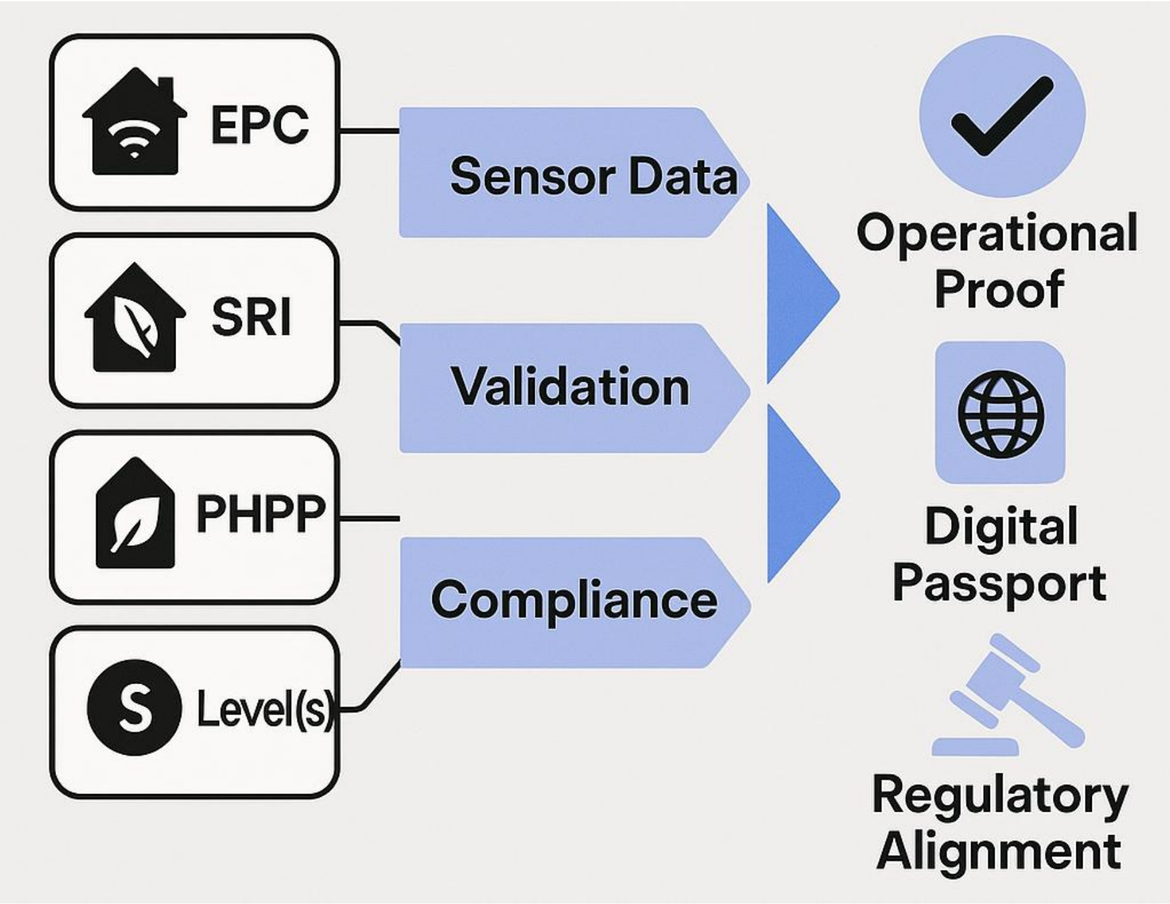
Sensors in EU Policy Frameworks



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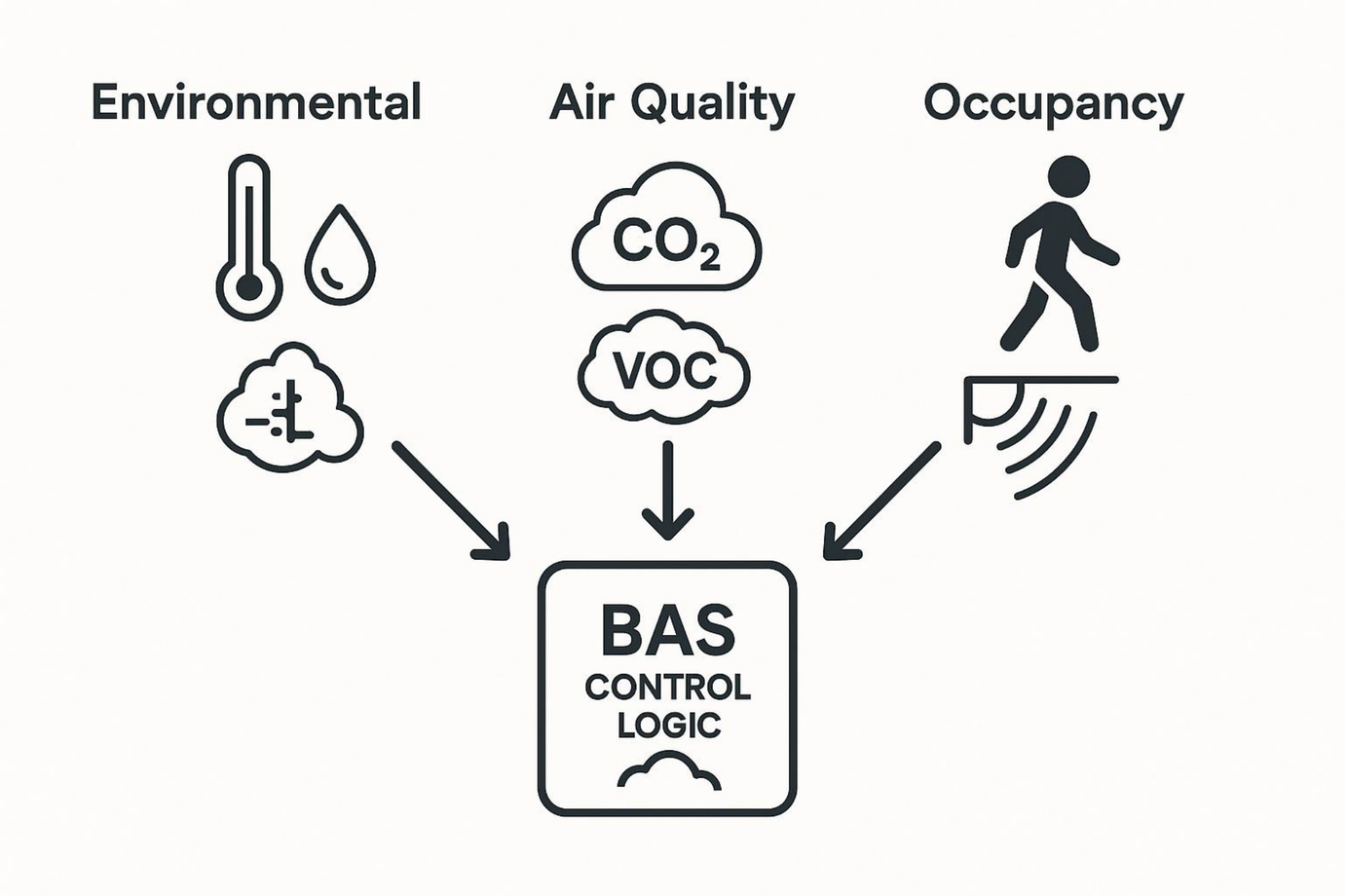
Common Sensor Types in Smart Buildings

- Temperature / Humidity
- CO_2 / VOC / IAQ
- Occupancy / Motion / Presence



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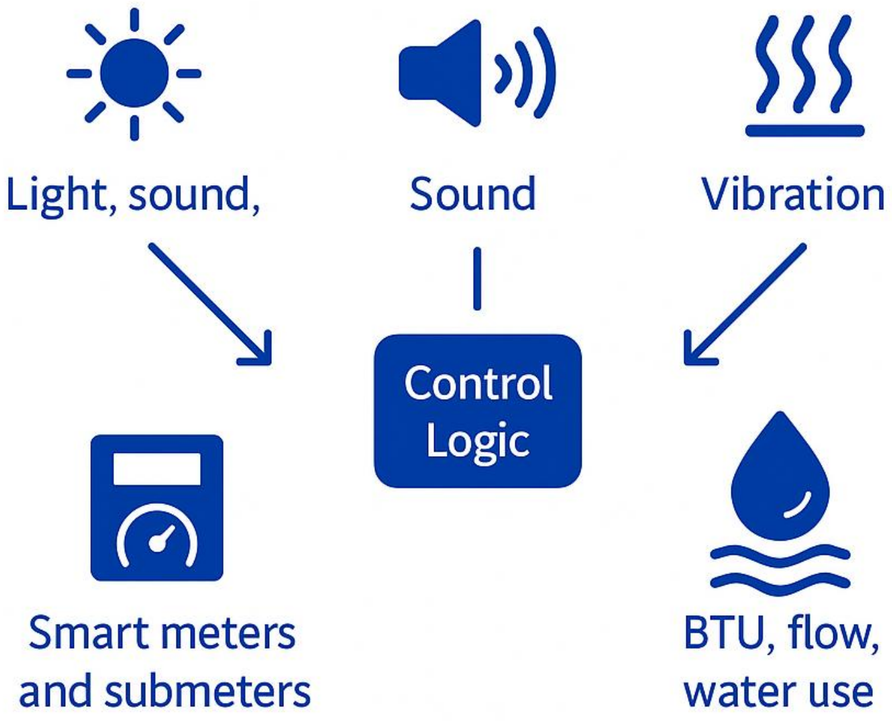
Specialized & Energy Sensors

- Light, sound, vibration
- Smart meters and submeters
- BTU, flow, water use



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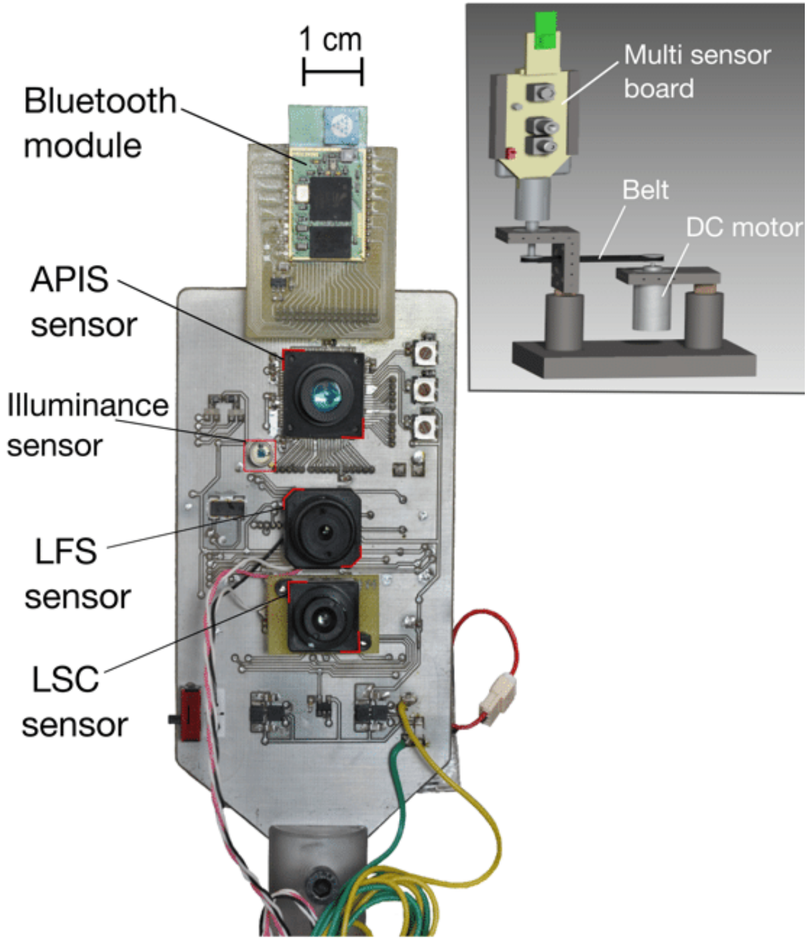
Multi-Sensor Devices

- Combined: CO_2, temp, motion
- Enable predictive logic
- Reduce installation points



https://www.researchgate.net/figure/The-multi-sensor-PCB-board-includes-three-OF-sensors-an-illuminance-sensor-based-on-a_fig4_232656243

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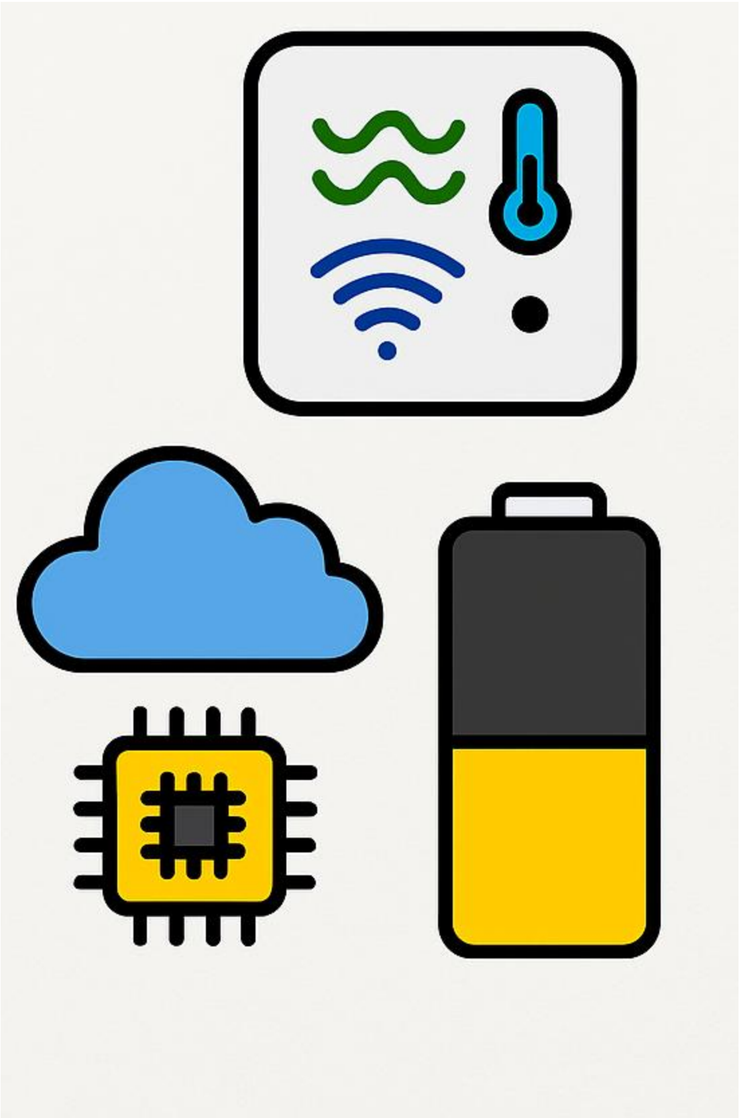
What Makes a Device 'IoT' in Smart Buildings?

- Sensing + communication
- Cloud-ready, edge-aware
- Often wire-free and self-powered



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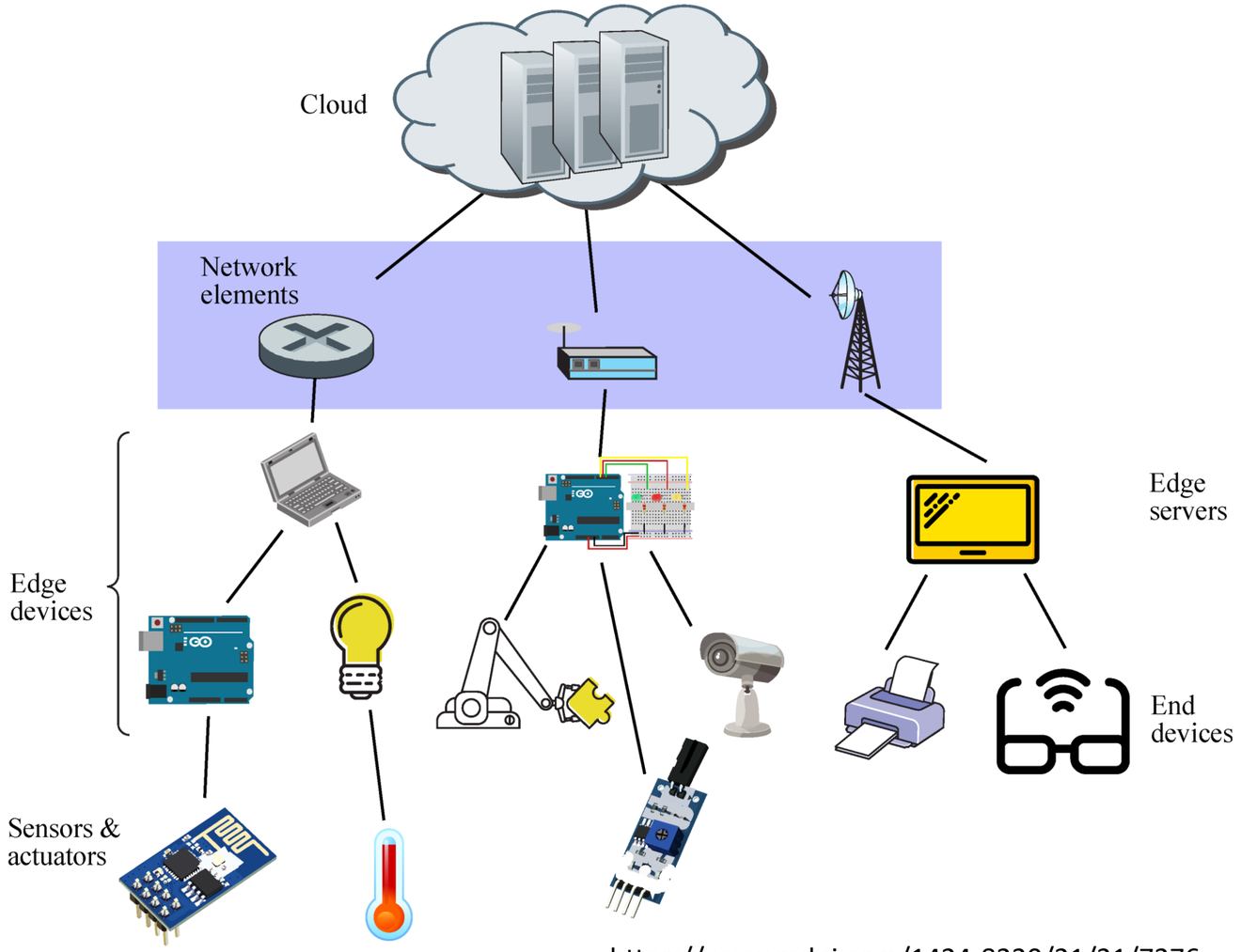
Smart Building IoT Topologies

- Edge > Gateway > Server
- Distributed data and control
- Supports zoning and local override



https://www.mdpi.com/1424-8220/21/21/7276

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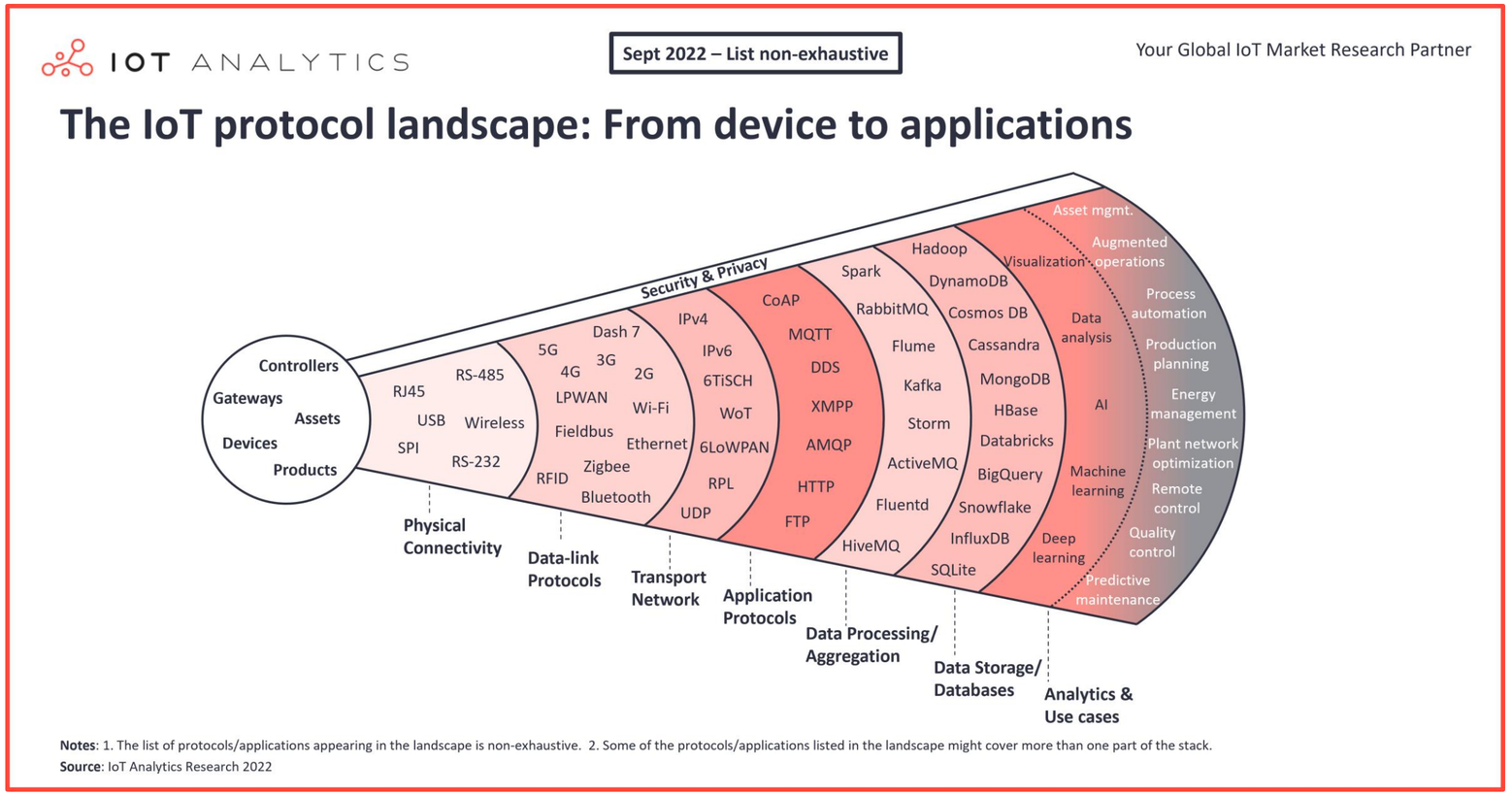
IoT Protocol Comparison

- Zigbee: short-range, mesh
- LoRaWAN: long-range, slow data
- BLE / WiFi / Thread trade-offs



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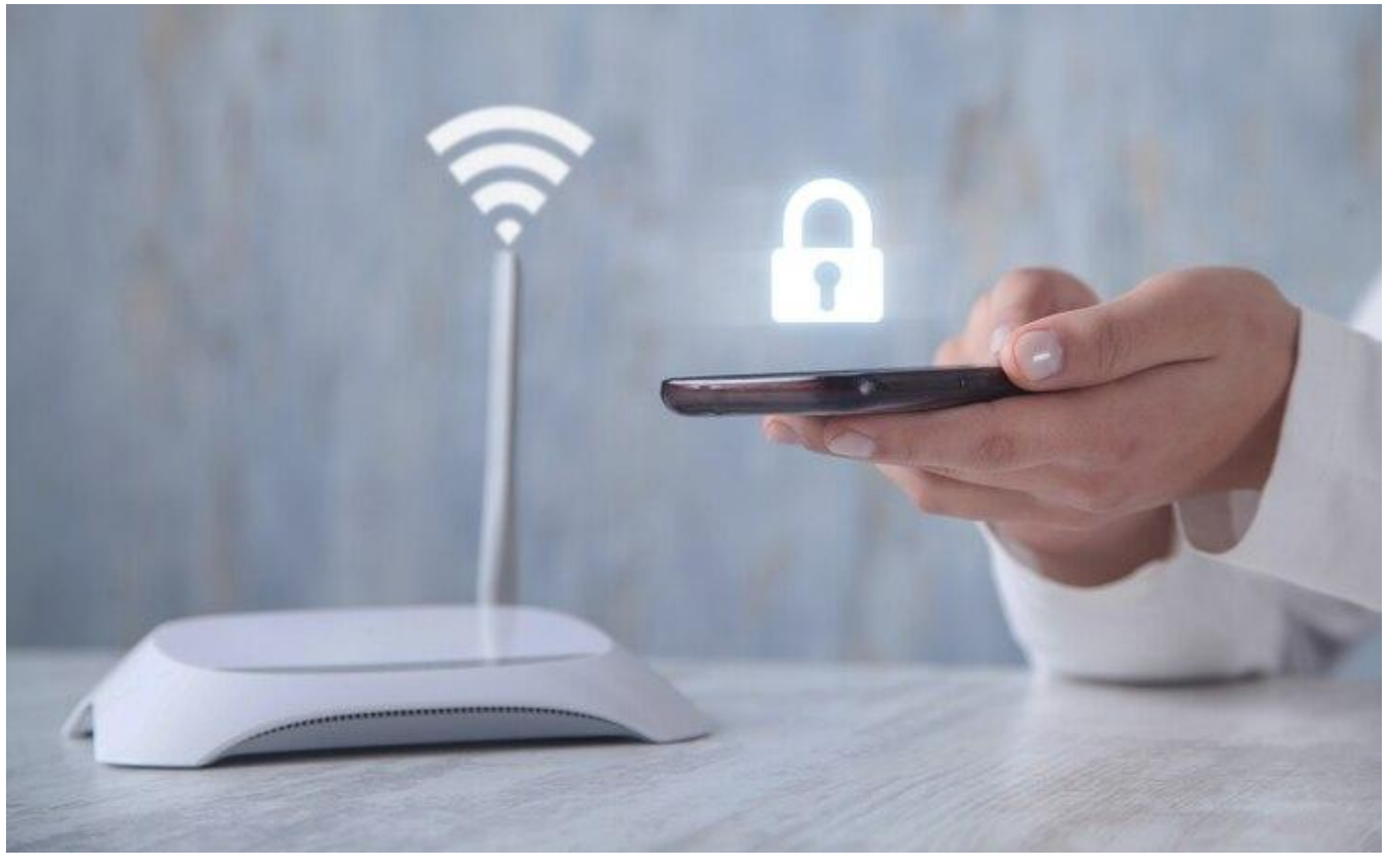
Security in IoT Devices

- Authentication, encryption
- Firmware update cycles
- Risk from default credentials



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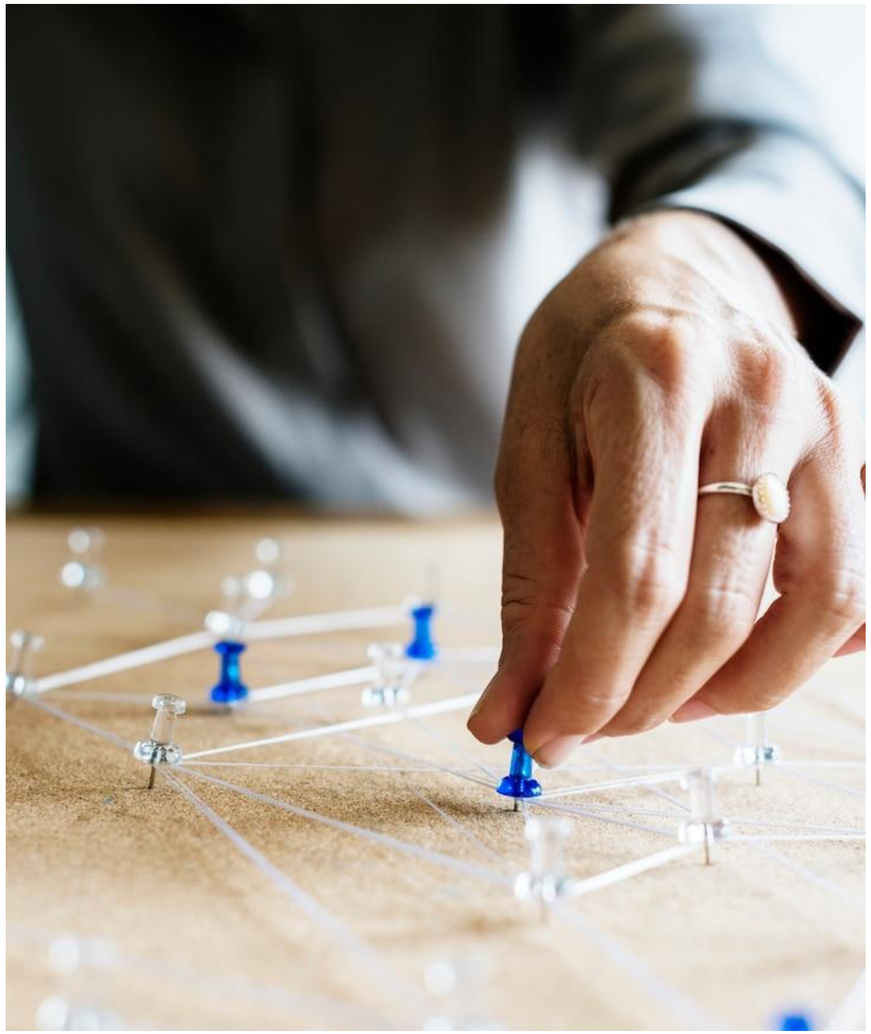
What is a Control Strategy?

- Rule or logic-based response
- Sensors feed decisions
- Key to ZEB-ready operation



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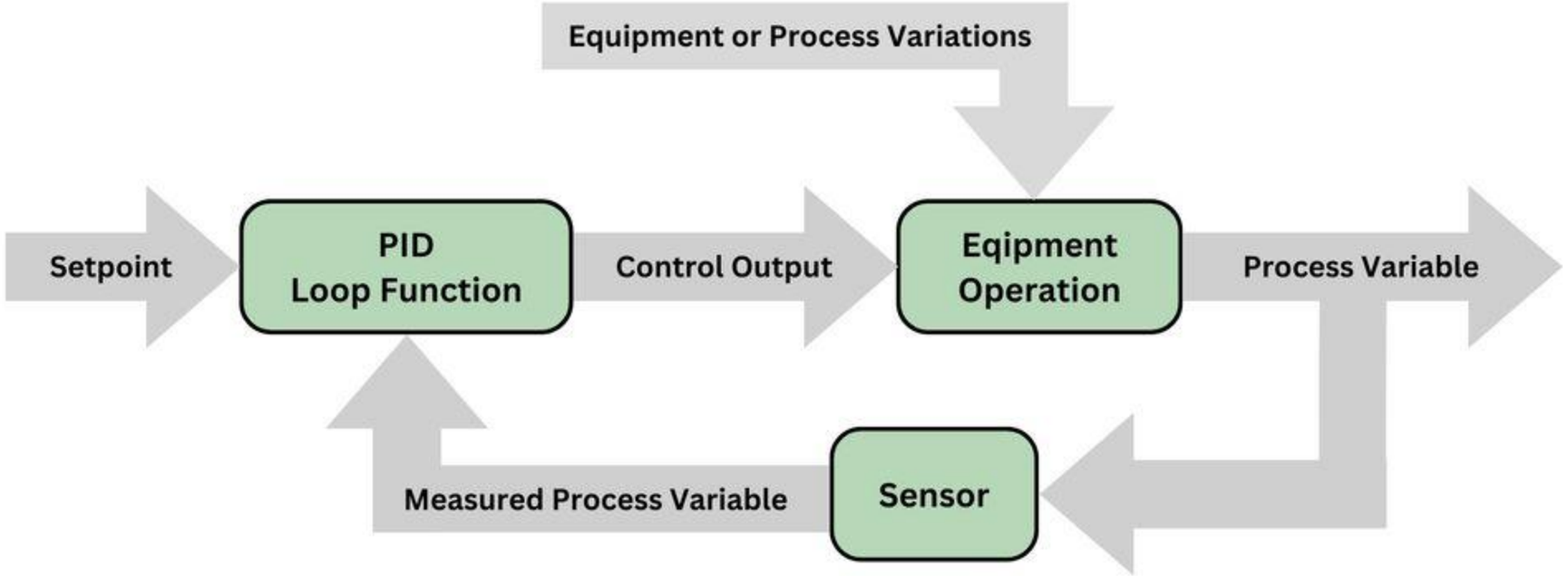
Types of Control Logic

- On/Off (bang-bang)
- Schedule / Occupancy
- PID loop tuning



https://www.wevolver.com/article/pid-loops-a-comprehensive-guide-to-understanding-and-implementation

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Tuning and Commissioning

- Each sensor/control link calibrated
- QA pre-checks, field override testing
- Logging and data integration

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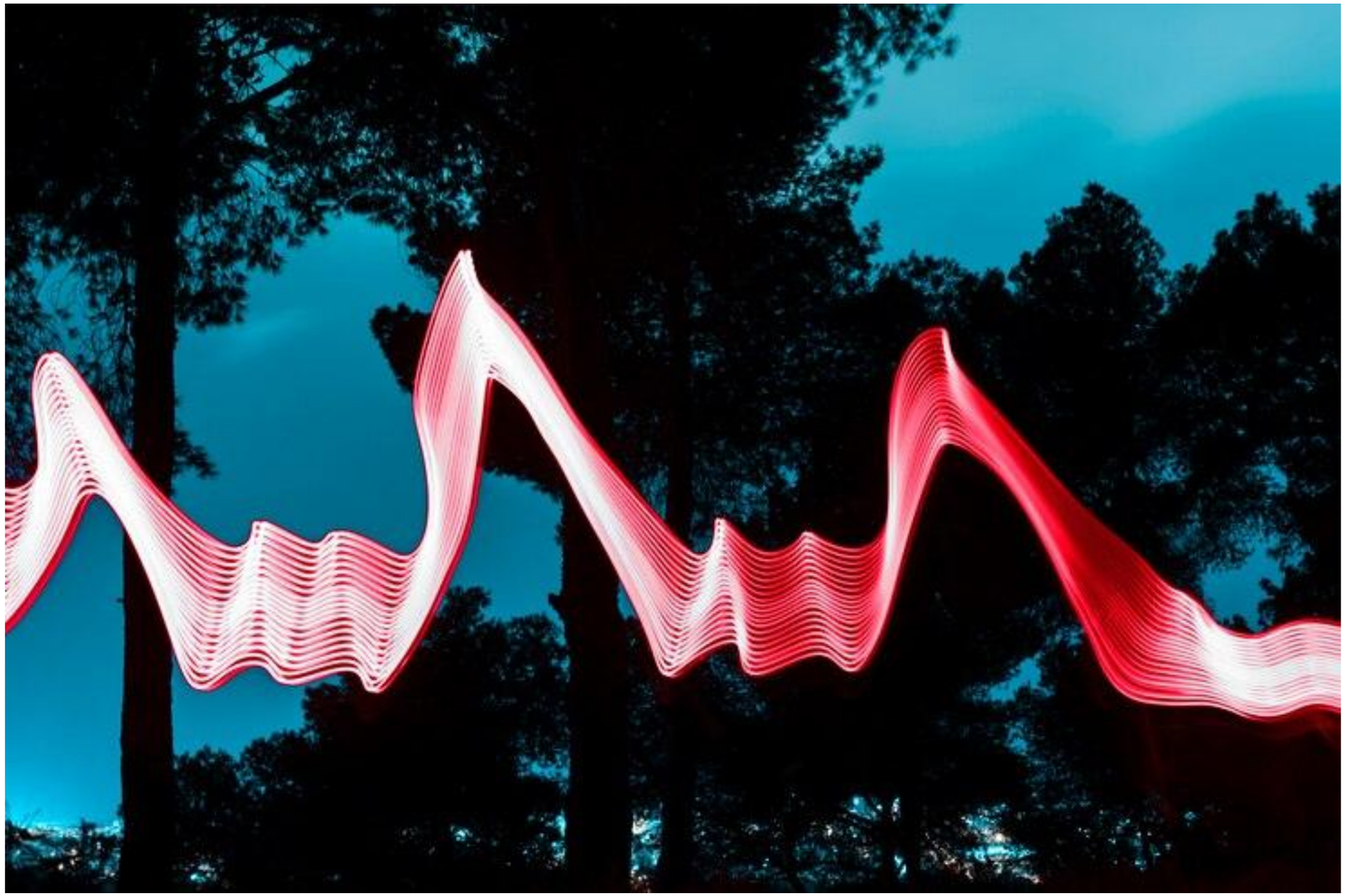
Override & Drift Scenarios

- Manual setpoint changes
- Occupant override loops
- Disconnected logic → inefficiency



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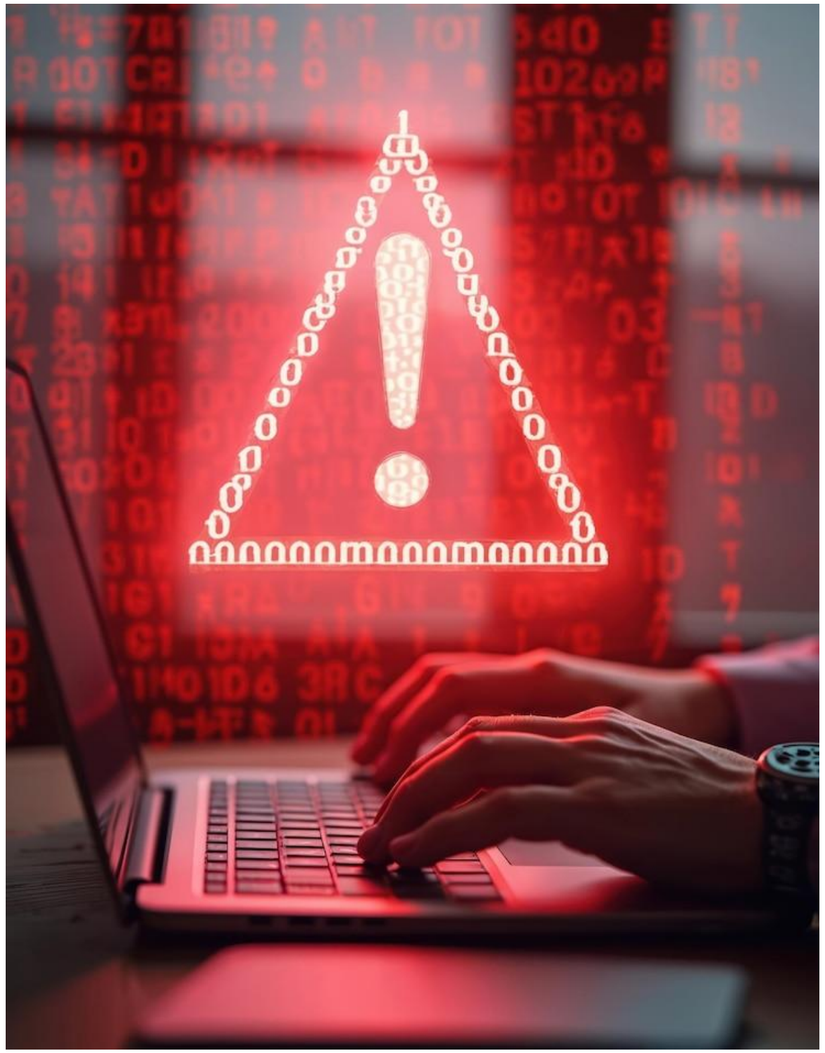
System Failure Risks

- Sensor drift / misplacement
- Network dropout / stale data
- Firmware bug in actuator response



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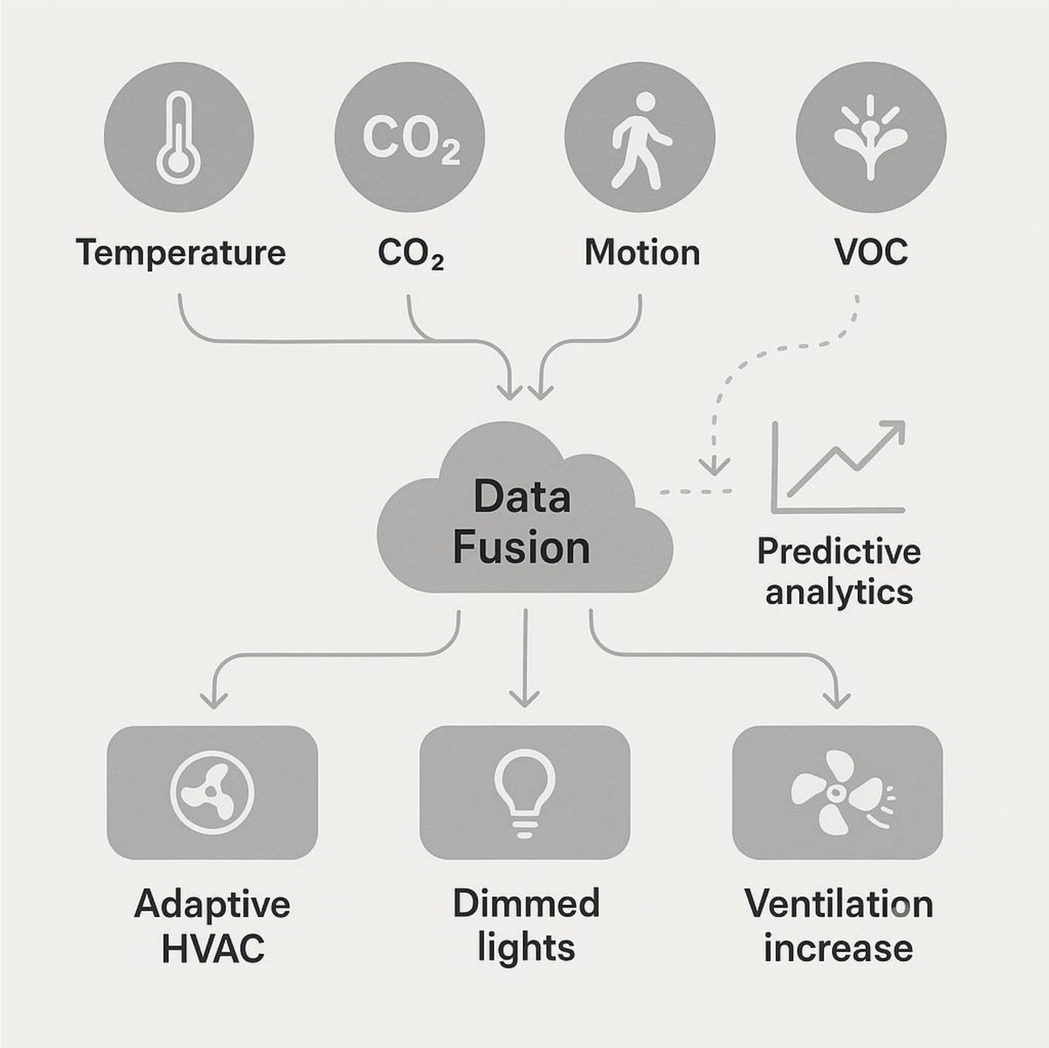
Sensor Fusion → Multivariable Logic

- Combines temp + CO_2 + motion
- Used for adaptive HVAC, lighting
- Basis for predictive analytics



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Examples of Fusion in Control

- CO_2 + occupancy → ventilation trigger
- Lux + motion → lighting dimming
- IAQ + thermal → window opening

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Conclusion: Reliable Sensing → Reliable Buildings

- Sensors → performance gatekeepers
- Control → balancing comfort + policy
- QA, tuning, security → success

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STEP2CleanPLAN

Reflection Prompts

- Where is your biggest sensor risk?
- Which controls fail silently in your region?
- Where can IoT or fusion logic add value?

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UZUNKÖPRÜ 1868 BELEDİYESİ

Long-Term Sensor Drift

- CO_2 sensor baseline rises after 18–24 months
- Humidity sensors drift due to particulate buildup
- Requires scheduled recalibration (1–2 years typical)

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Example: Manual Override Causing Energy Waste

- Office user overrides setpoint to 23°C all summer
- BAS fails to revert logic due to access settings
- Energy spike + discomfort in adjacent zones

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Sensor Commissioning QA Checklist

- Checklist: location, label, response time, paired device
- Cross-reference with control input and visual tag
- Trend chart shows baseline test data

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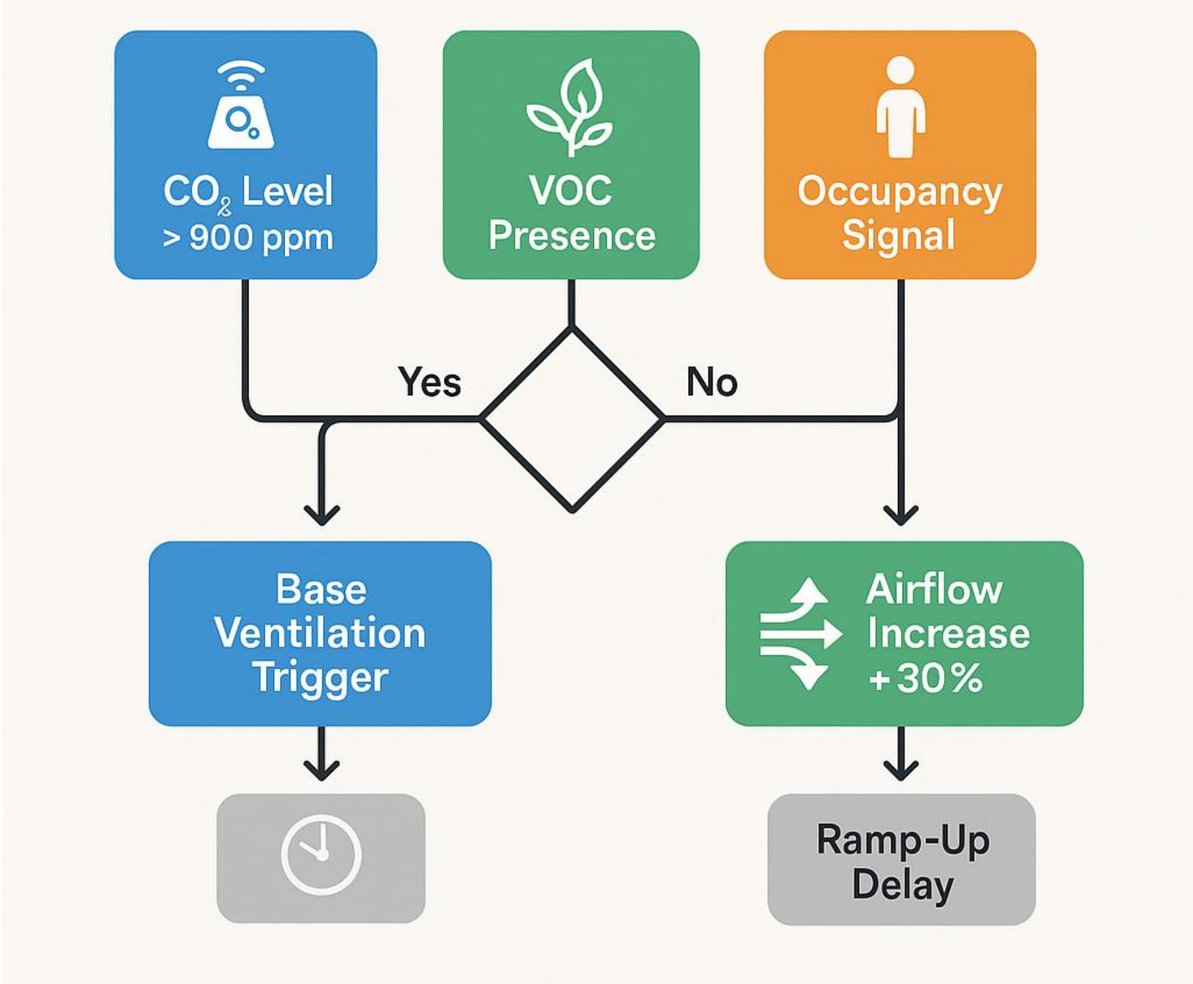
Multivariable Fusion: Adaptive Ventilation Logic

- CO_2 > 900 ppm → base ventilation trigger
- VOC detected → add 30% airflow
- Occupancy signal absent → delay ramp-up



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Q & A

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