TETRA TECH
High Performance Buildings Group

# Building intelligence

## Enabling better outcomes for people and planet

**Andrew Bullmore**
Director of Innovation
Hoare Lea

# Part of Something Bigger

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Cosentini
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GLUMAC
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HOARE LEA
A TETRA TECH COMPANY

Norman Disney & Young
A TETRA TECH COMPANY

# Agenda

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1. Introductions – **Steve Straus**
2. The imperative – **Andrew Bullmore**
3. Existing buildings – **Eimear Moloney**
4. New buildings – **Cameron Sandell**
5. The future – **Tom Collins**

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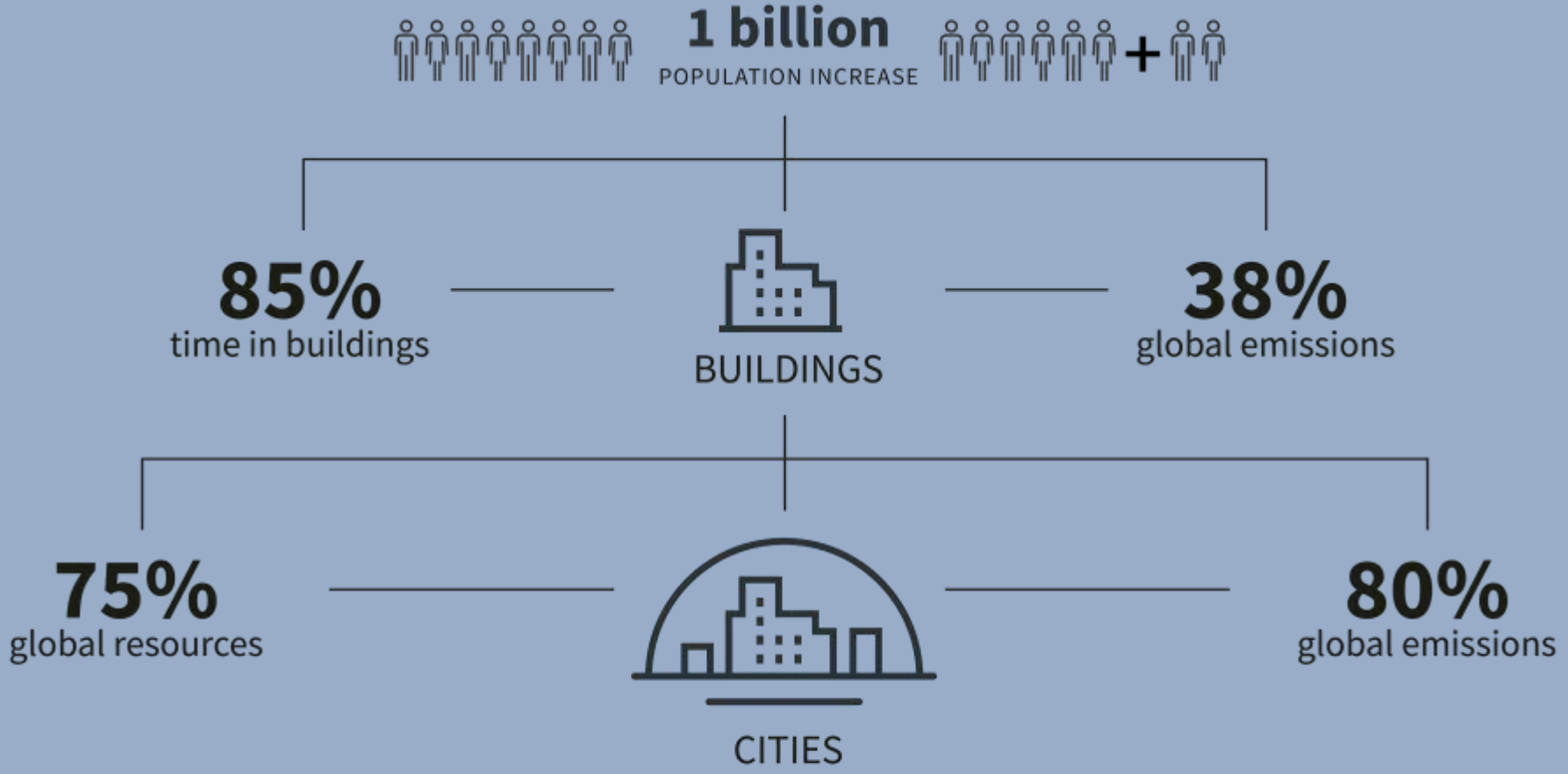
High Performance Buildings
can be simply defined as:

‘Buildings which deliver sustainable outcomes for both people and planet in the face of today’s demands, and are resilient to future changes in demand.’

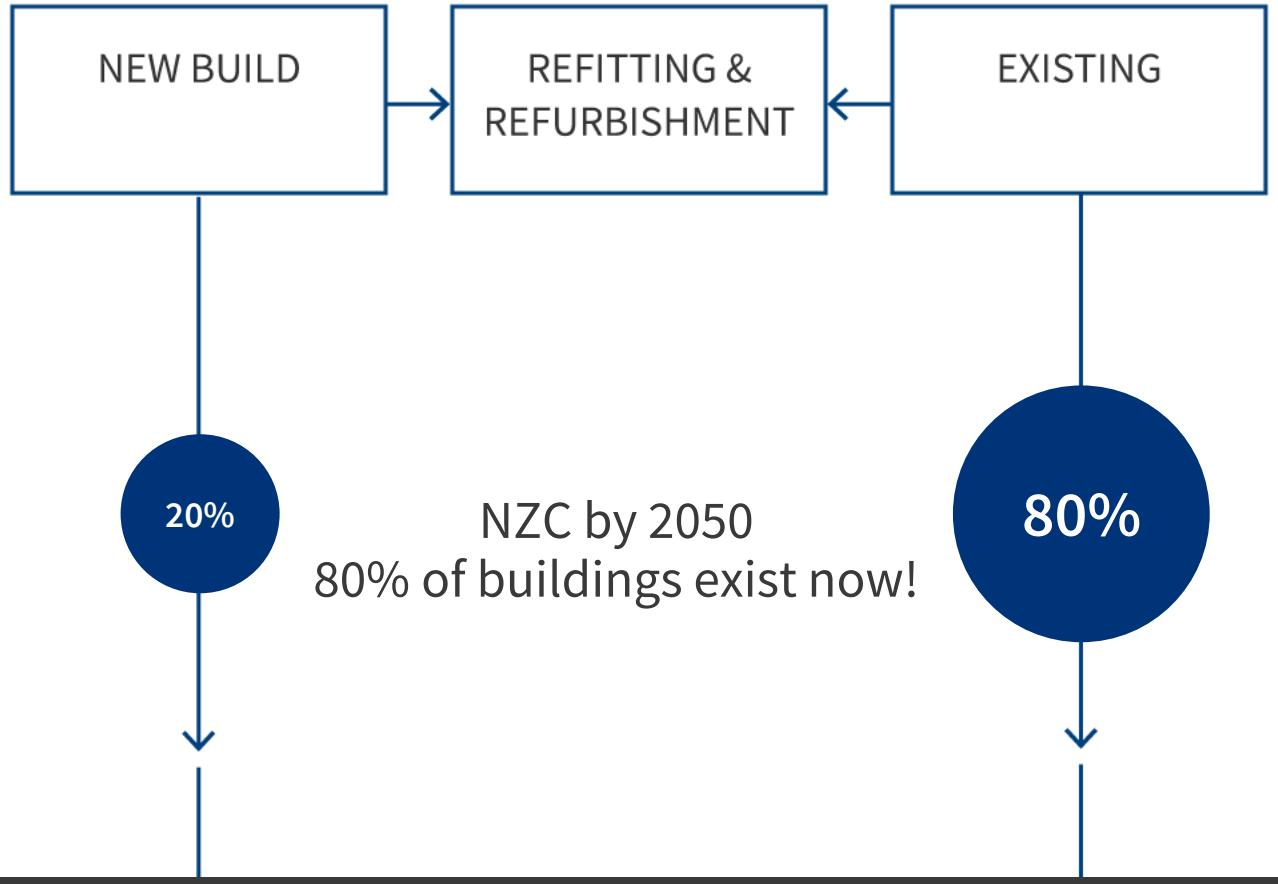
# Talk 2
# Building intelligence – the imperative

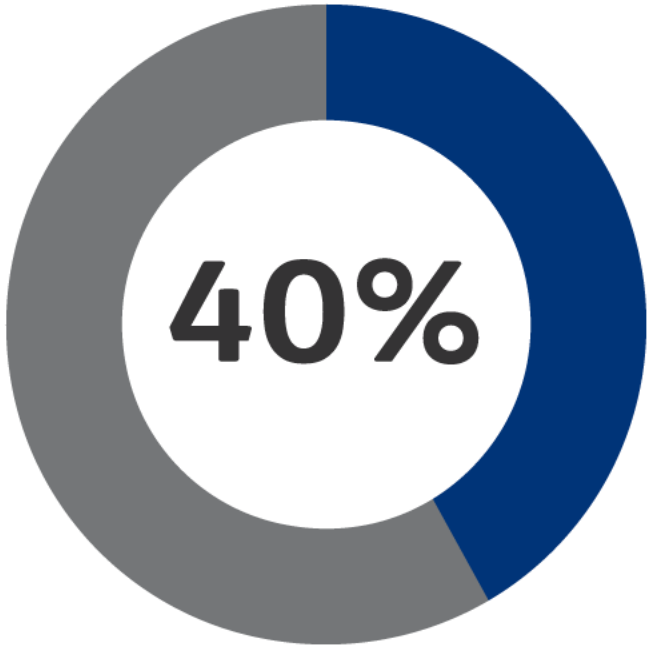
1. The **climate crisis** has shone a spotlight on **building energy performance**
2. The current **global energy crisis** has further focussed this spotlight
3. The shift from a carbon-based to a **low-carbon economy** means that energy use really counts, no longer just in terms of operational costs but also in the **retained financial capital value** of buildings as assets
4. **Covid19** has increased awareness of occupant health & wellbeing meaning that **Indoor Environmental Quality** (IEQ) counts now more than ever before
5. Investors and owners are increasingly seeking hard evidence of building performance in all regards (energy & 'productivity') for the purposes of both **investment/property portfolio management** and Environmental, Social & Governance (ESG) reporting
6. **ESG** is increasingly driving the need to deliver **holistically sustainable outcomes** across all five capitals of human, social, natural, physical and economic performance.



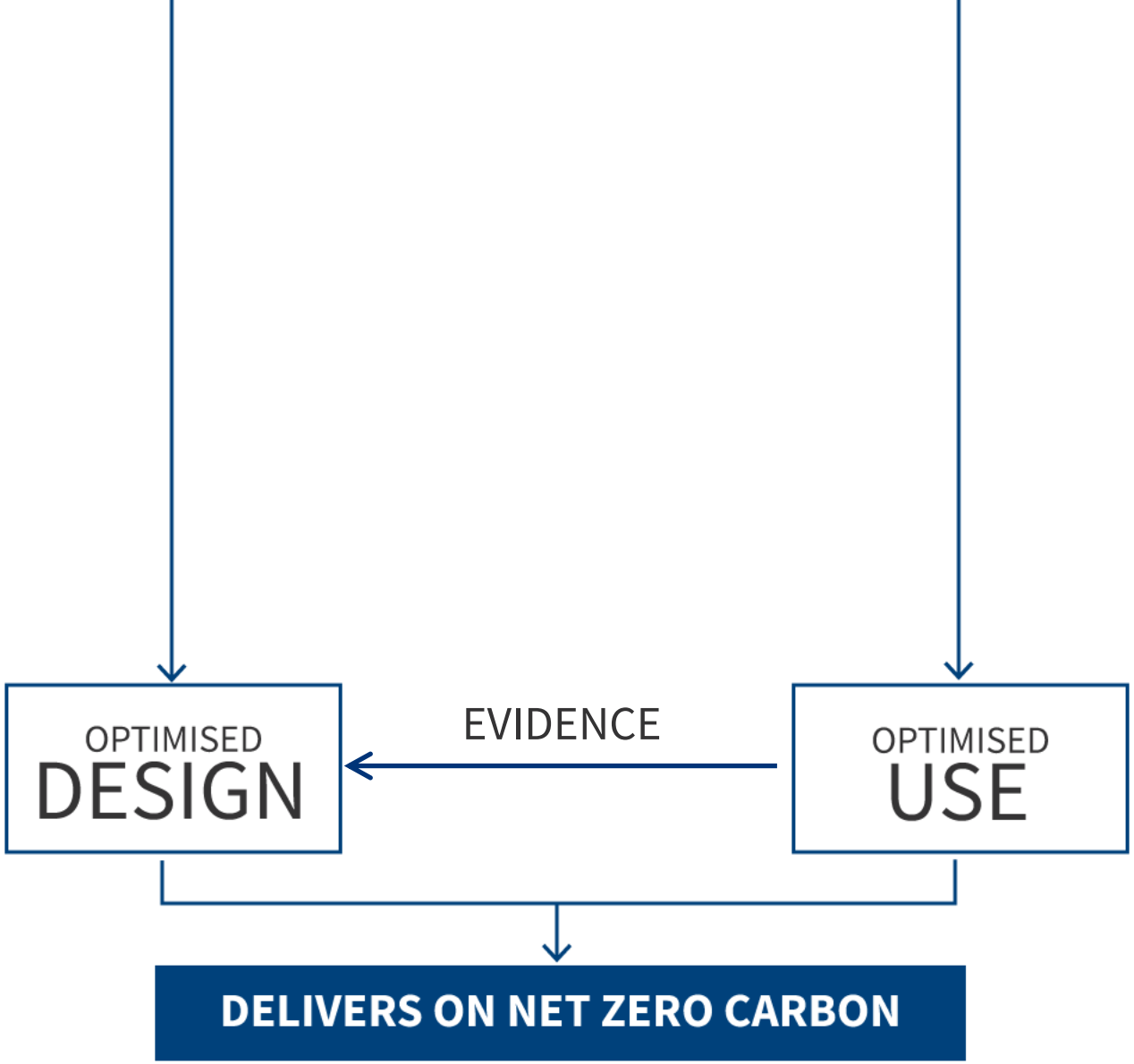

# The climate crisis
# Buildings matter

# It’s all about energy reduction
## Embedded in design & operation




Grid decarbonisation can only deliver so much.

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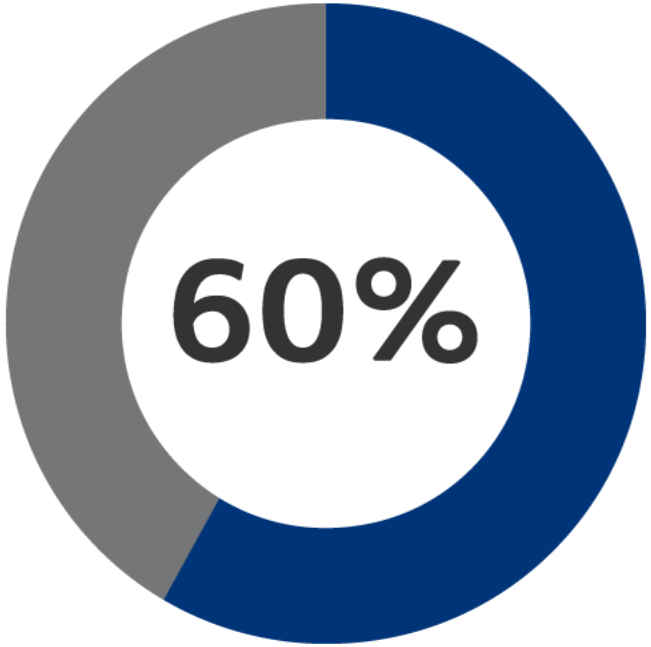
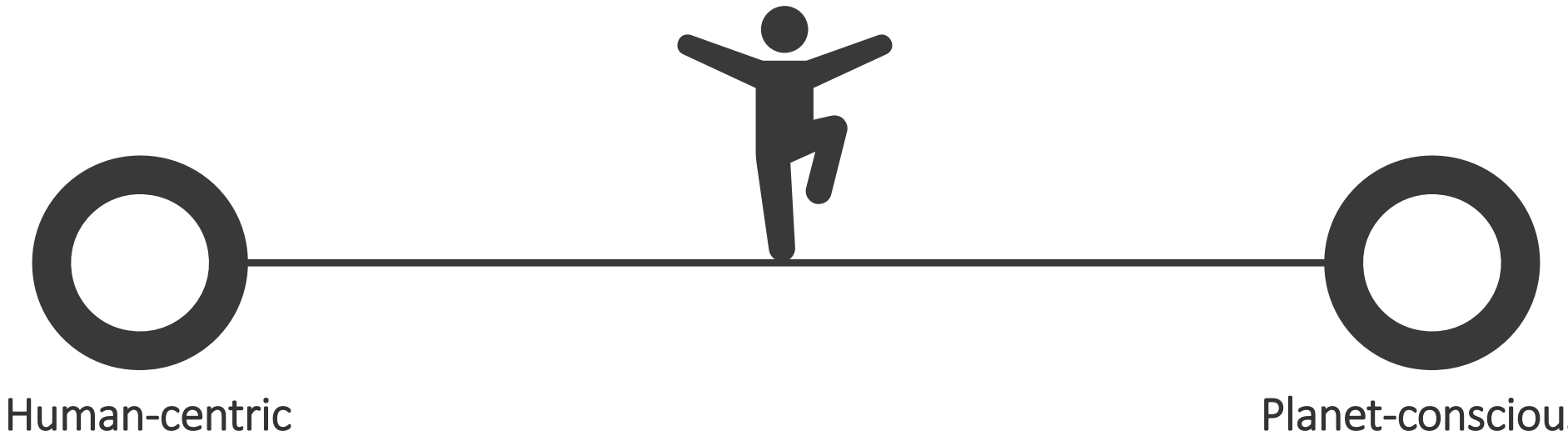
Huge reductions in building energy use are needed.



‘Zero carbon leadership begins with experience but is maintained with evidence-driven insight.’

# Balancing the building
## Human-centric and planet-conscious



# Evidence is everything
## Assess, reduce, improve

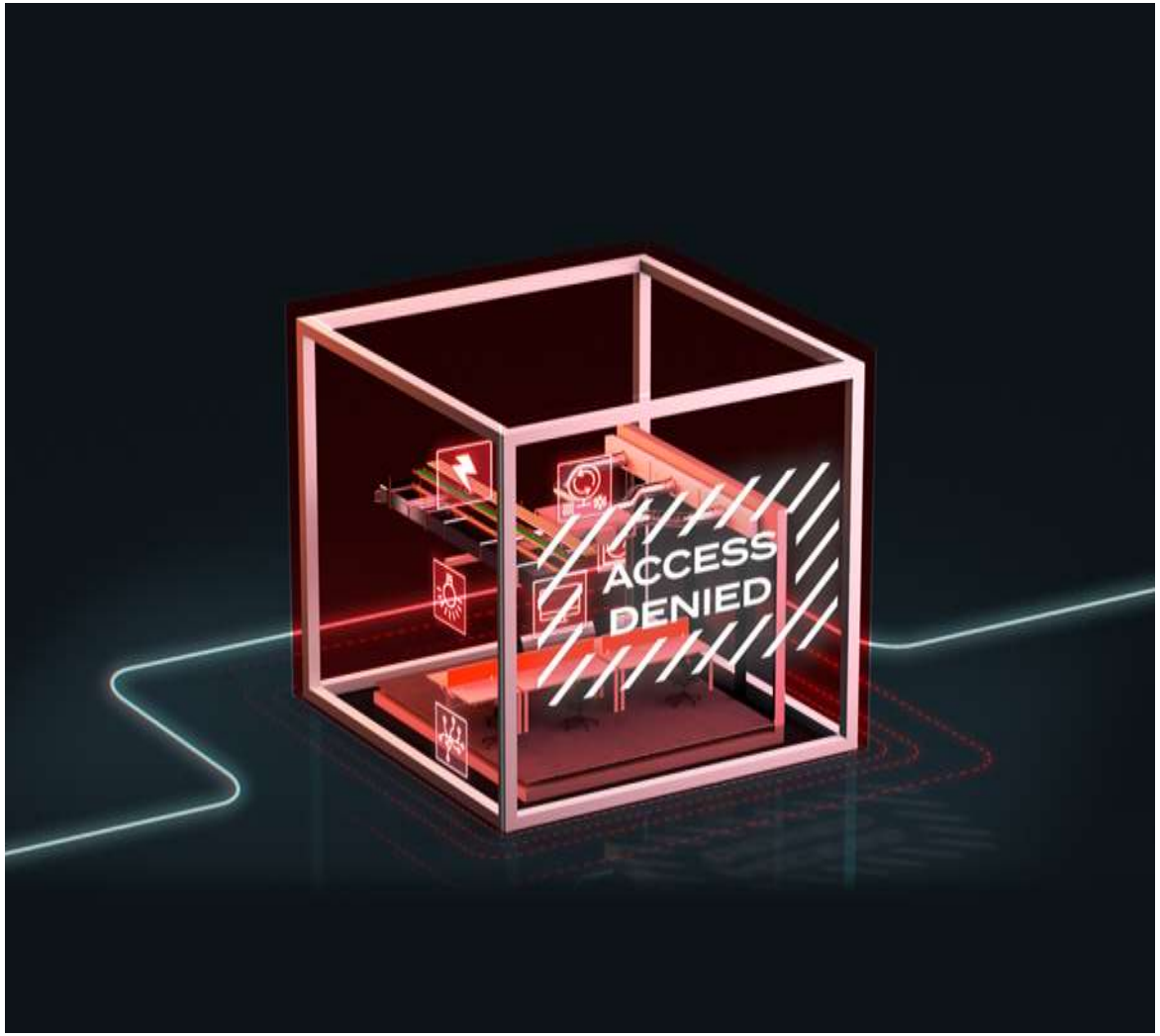
Monitoring means stakeholders can assess:

- how a building is meeting its NZC ambitions.
- how a building is delivering on a human level.

Insight based on robust evidence enables:

- actions to be targeted towards outcomes.
- the effectiveness of actions to be established.

Robust evidence relies on fit-for-purpose data.



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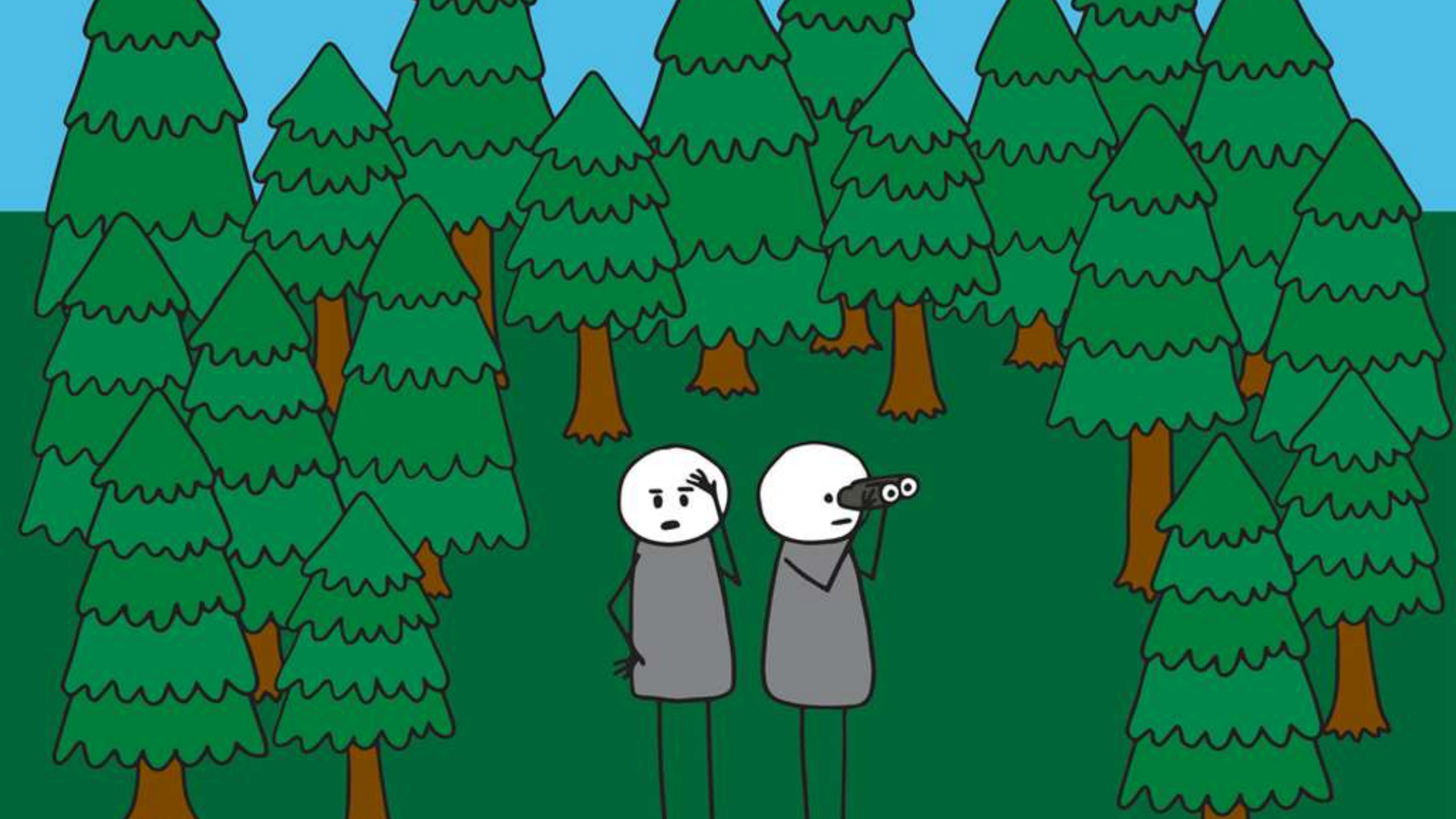
Successful measurement leads to successful buildings.

**Do we know what we are measuring?**



# Modern buildings are flush with data. From multiple sources.

- Meter readings
- Temperature sensors
- Pump and fan speeds
- $CO_2$ sensors
- Occupancy levels
- Fire and security details

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Another question:

# Why are we not using this data?

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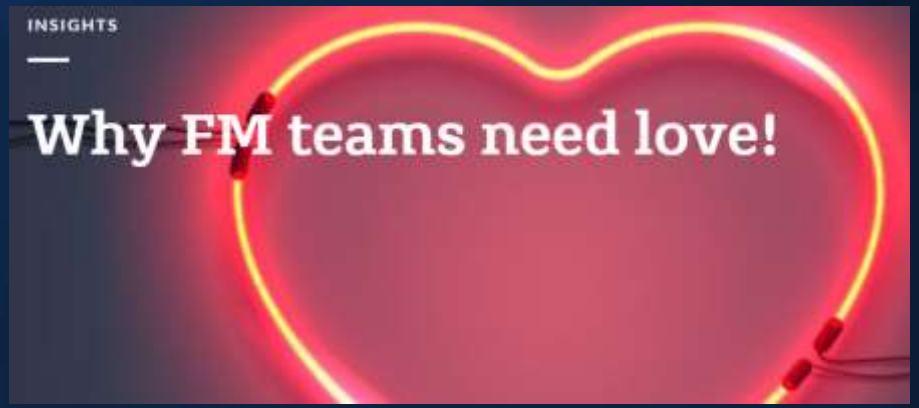
Focus on the facilities team.

# Building managers are the key to unlocking the potential in your existing assets.



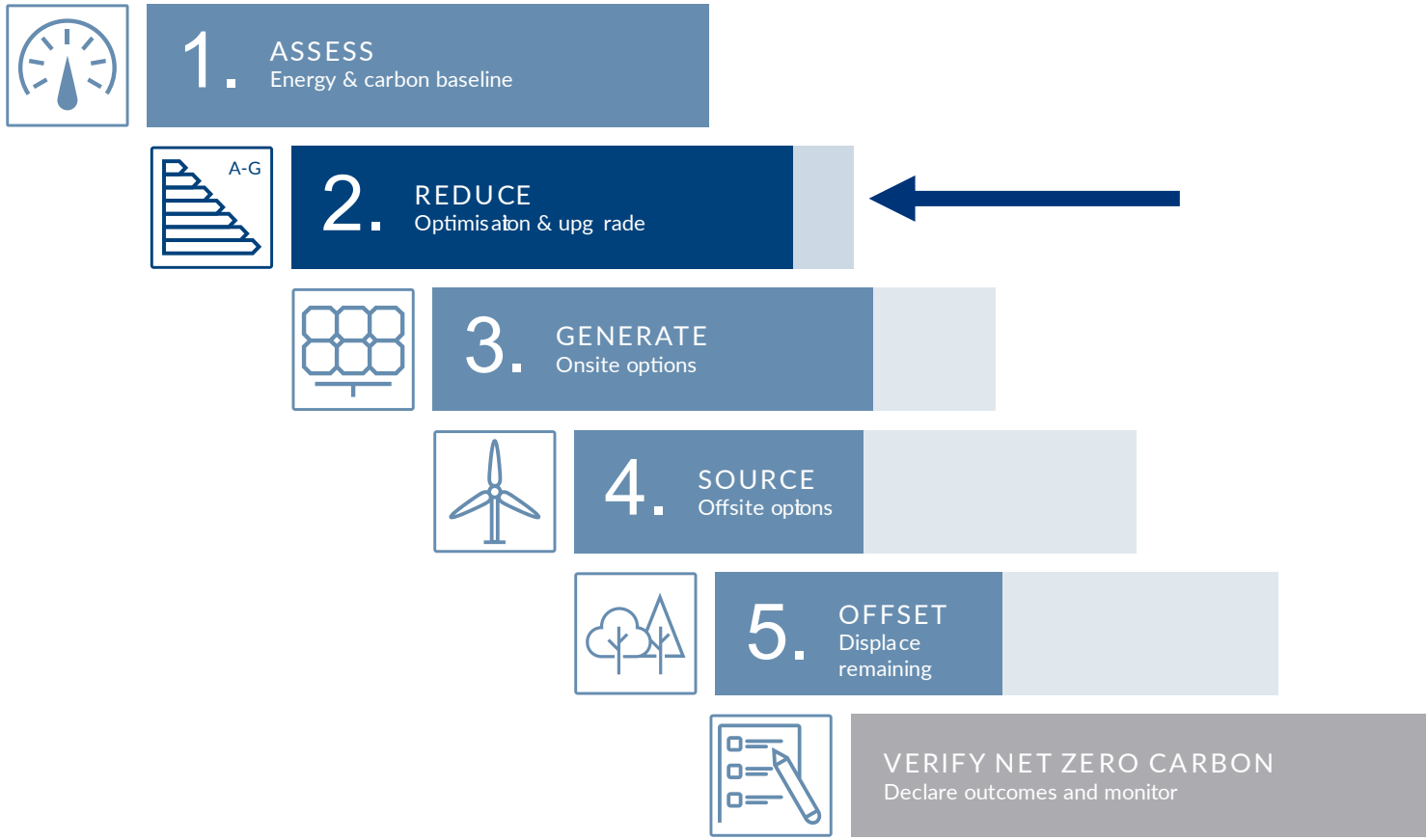
# Prioritise FM.
# Use their skills.

- Invest in their **training**
- **Listen** to their ideas
- Provide them with **resource**.

In essence, place them front and centre in buildings.

# Why this matters now more than ever.

Decarbonizing existing buildings is a technical challenge above all else.



# California State University Los Angeles

Project Scenario Analysis

Building Portfolio | EEM Database | Project Analysis

| Campus Nat. Gas Rate | Campus Electricity Rate |
|---|---|
| $0.65 | $0.163 |

## Building Name

- [ ] Select all
- [ ] Biological Sciences
- [ ] Engineering & Technology
- [ ] JFK Memorial Library
- [ ] Physical Education
- [ ] Science Complex - Rosser Hall
- [ ] Theater

## Energy Efficiency Measure

- [ ] Select all
- [ ] BS: AHU 3 RCX
- [ ] BS: Building RCx
- [ ] BS: Demand Control Ventilation (DCV)
- [ ] BS: Dual Duct AHU Conversion - VAV
- [ ] BS: Dual Duct AHU Conversion - VAV with ...
- [ ] BS: Dual Duct Dual Fan Retrofit
- [ ] BS: Fan Wall Array Retrofit
- [ ] BS: LED Retrofit with Controls Upgrade
- [ ] E&T: AHU 3-6 Economizer
- [ ] E&T: AHU-1 & 2 Economizer Retrofit
- [ ] E&T: AHU-1 and AHU-2 Scheduling
- [ ] E&T: AHU-1 CAV to VAV
- [ ] E&T: AHU-3 Occupancy Based Controls
- [ ] E&T: AHU-4 Occupancy Based Controls
- [ ] E&T: AHU-5 Occupancy Based Controls
- [ ] E&T: AHU-6 Occupancy Based Controls
- [ ] E&T: AHU-6 System Conversion - VAV
- [ ] E&T: Building RCx
- [ ] E&T: Decarbonize HHW with ASHP
- [ ] E&T: Dual Duct Dual Fan Retrofit
- [ ] E&T: Fan Wall Array Retrofit
- [ ] E&T: LED Retrofit
- [ ] E&T: LED Retrofit with Controls Upgrade
- [ ] JFK: Adjust AHU Operating Schedule
- [ ] JFK: CHW and HHW Distribution Repairs
- [ ] JFK: Clean AHU Filters

## Electricity Escalation Rate

0.00%

## Natural Gas Escalation Rate

0.00%

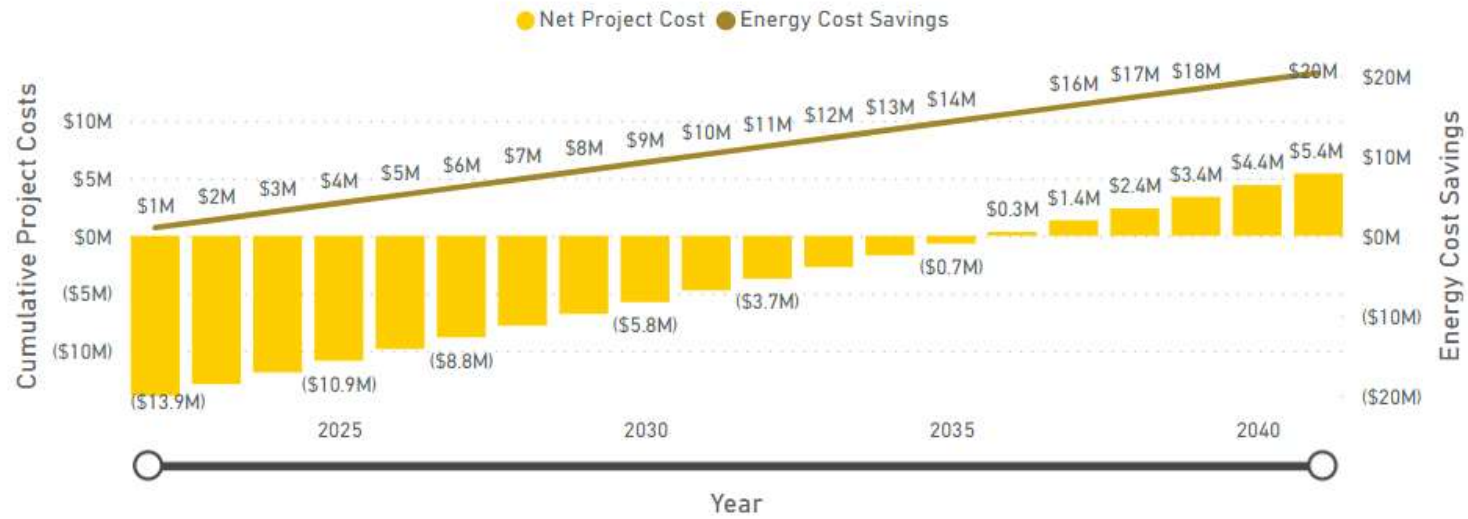
## Key Metrics: Post-Project Implementation

Annual Carbon Emissions


Annual Energy Cost


| Total Emissions Reduction | Reduction Effectiveness |
|---|---|
| 3,093 [MT CO2e] | $4,827 [$/MT CO2e] |

| Total Investment Required | Year 1 Energy Cost Savings | Simple Payback |
|---|---|---|
| $14,928,528 | $1,045,745 | 14.28 |



# Data.
# Why this matters.

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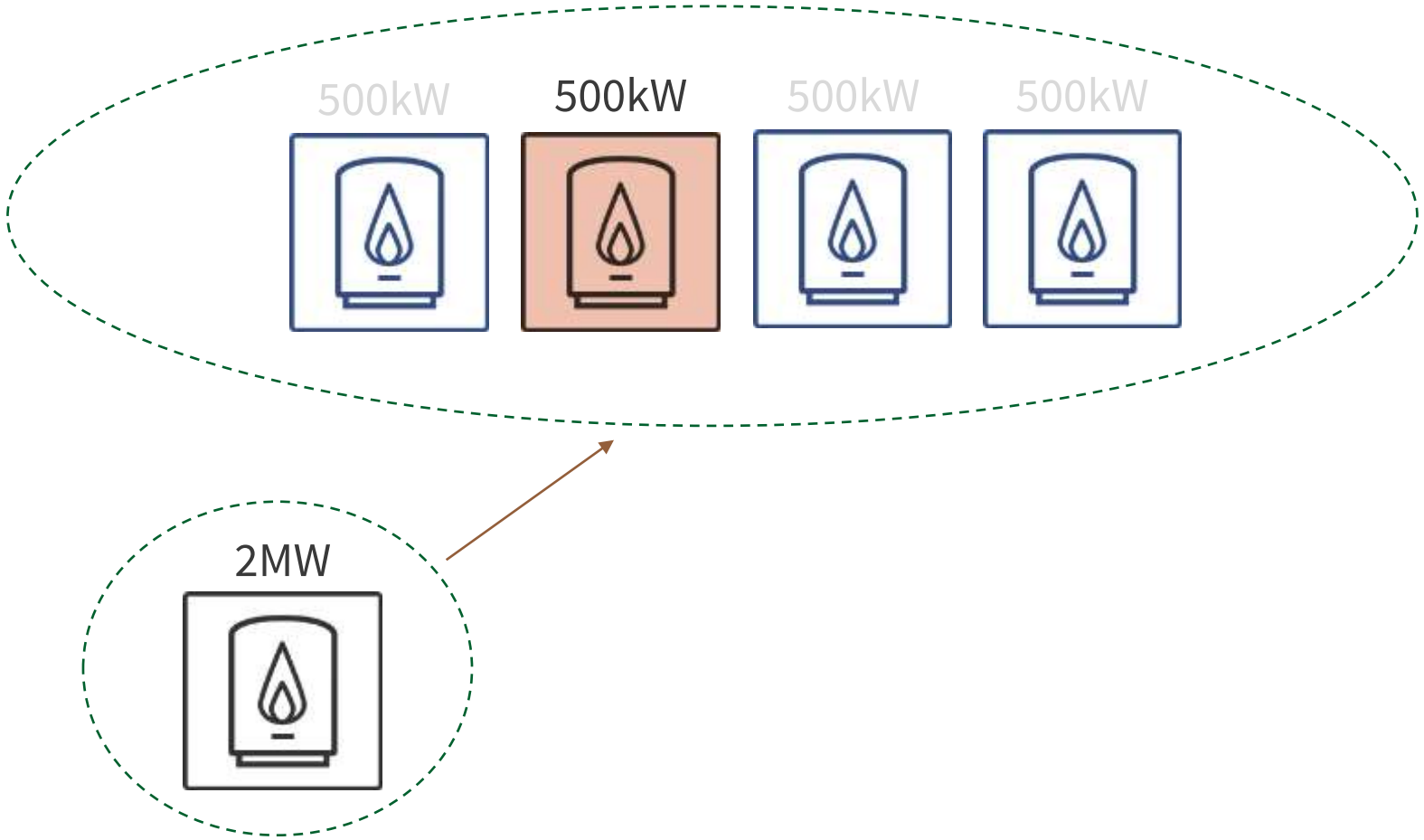

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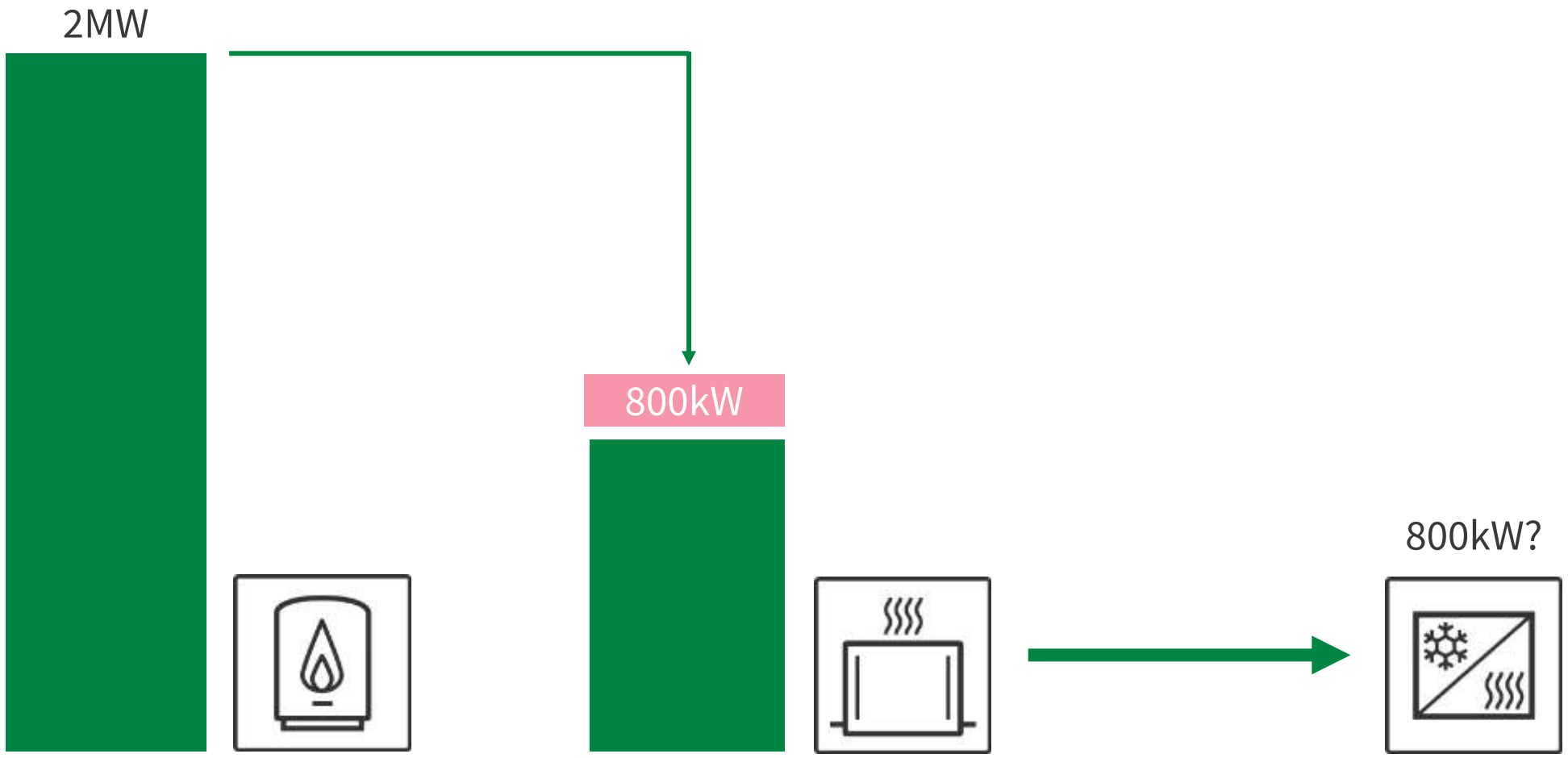

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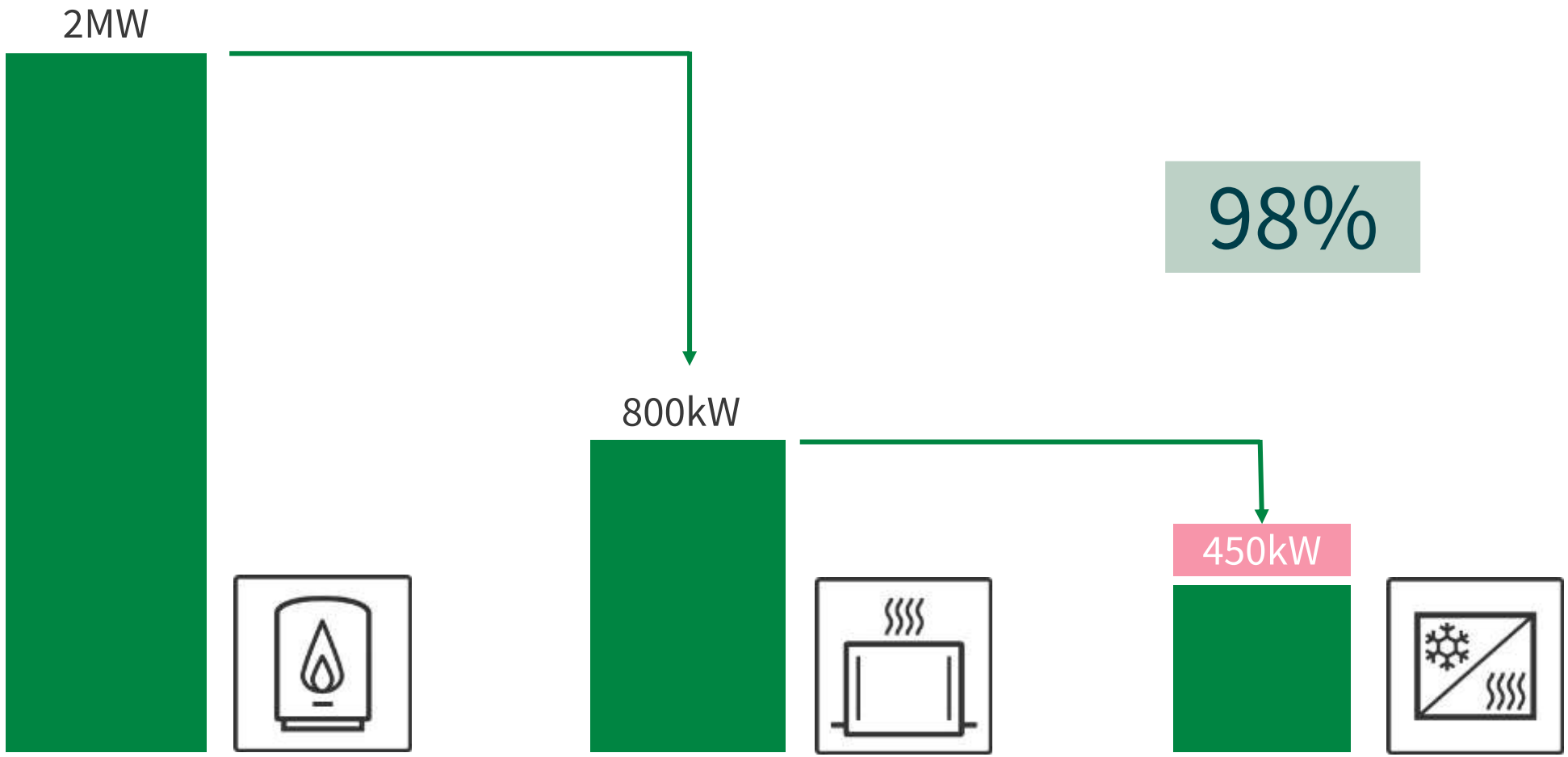

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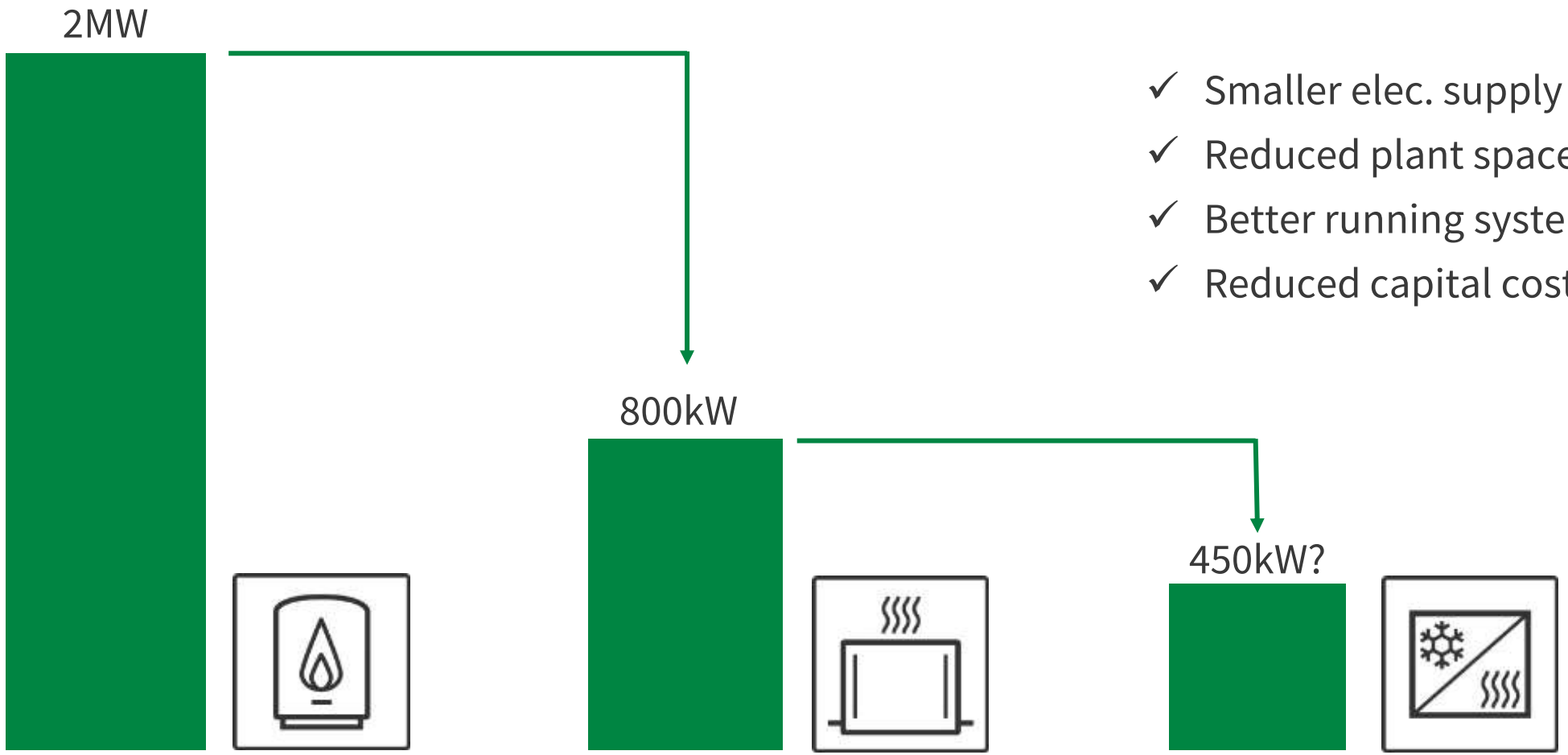
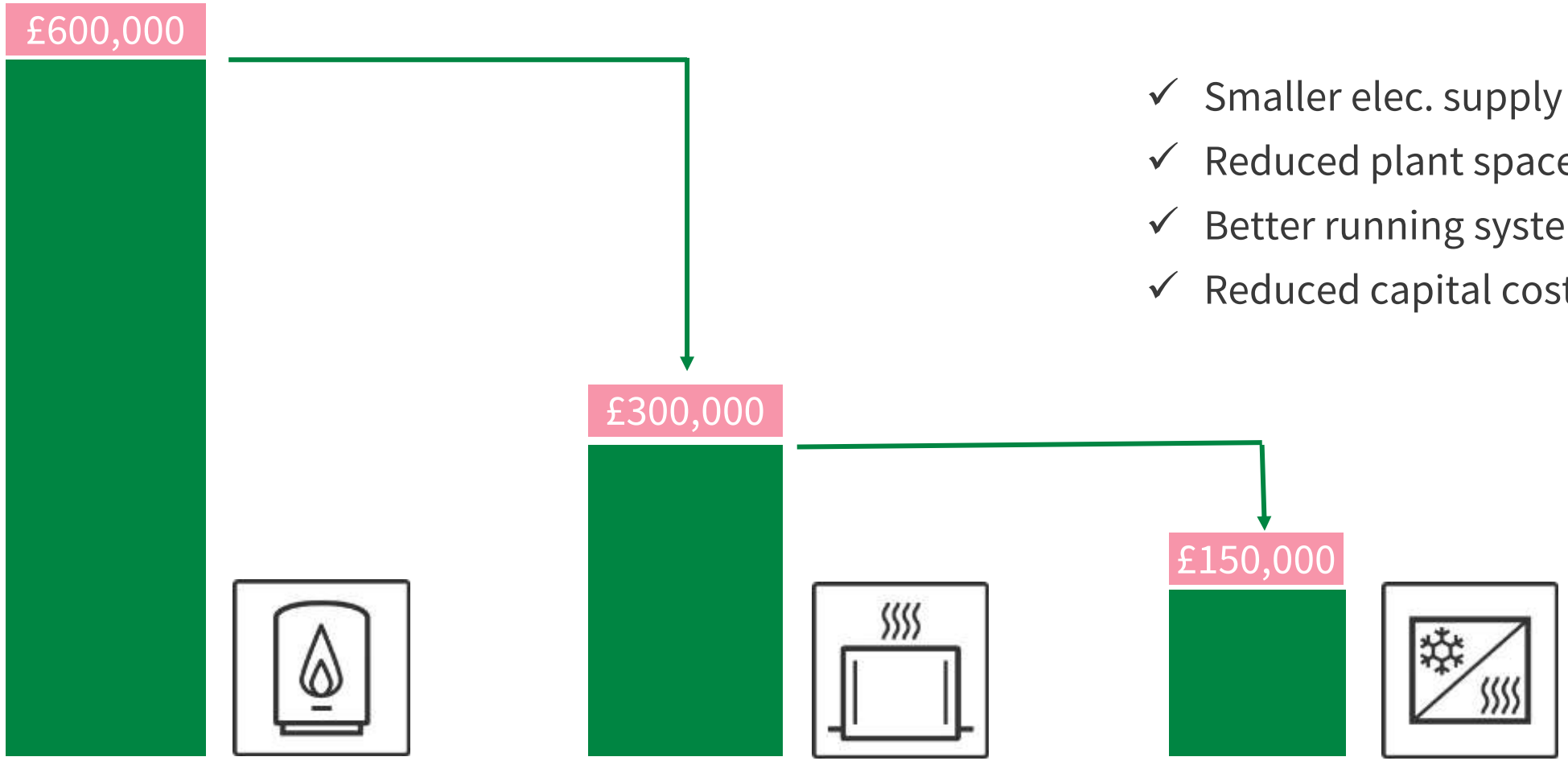



- ✓ Smaller elec. supply
- ✓ Reduced plant space
- ✓ Better running system
- ✓ Reduced capital cost

# Data.
# Why this matters.




- ✓ Smaller elec. supply
- ✓ Reduced plant space
- ✓ Better running system
- ✓ Reduced capital cost

# Legal & General.

# University of Oxford BMS Optimisation.

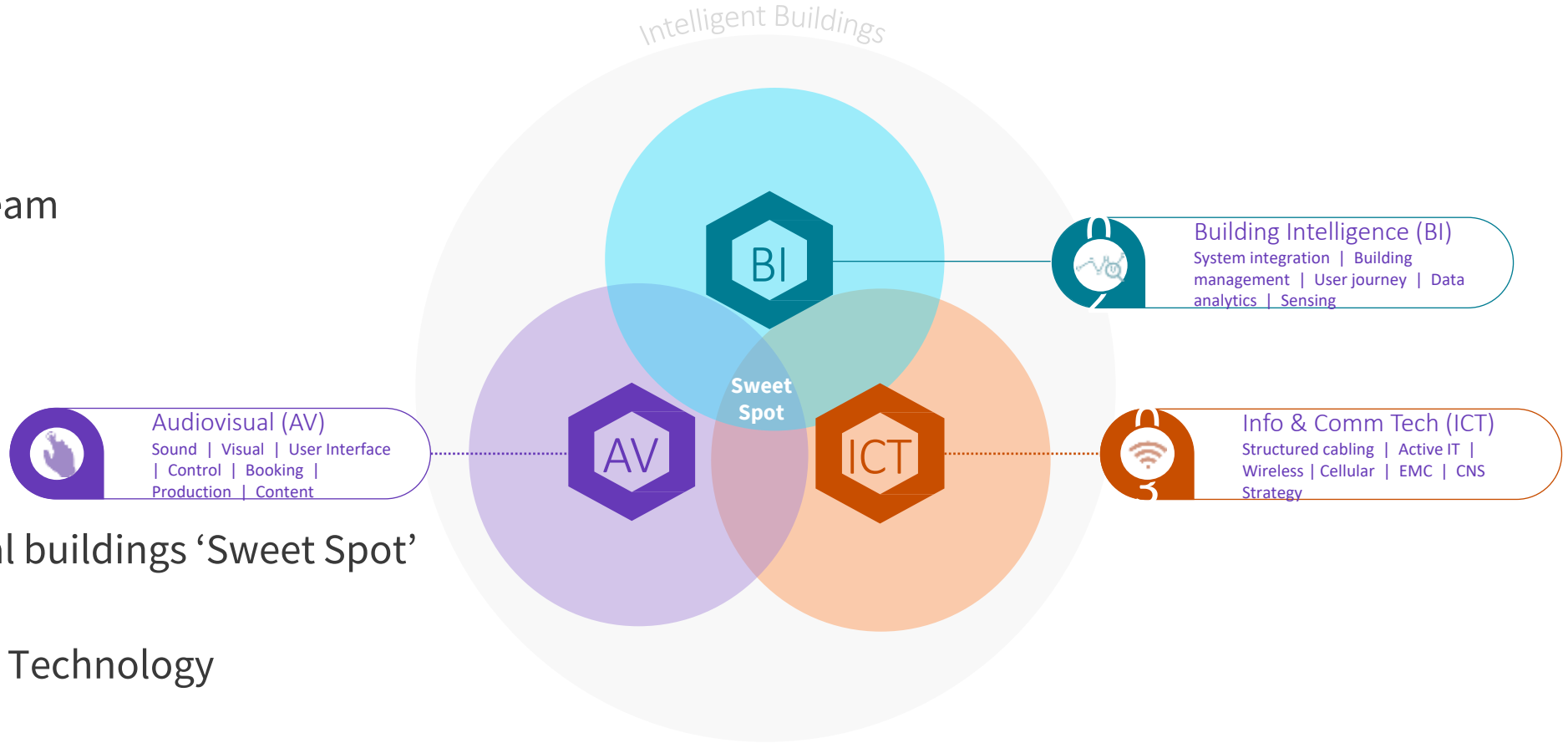
>2tCO2 / yr

1.5 yr payback

No disruption to building users

# High Performance Buildings Group
## Global Smart/Intelligent Buildings Team

- Globally distributed team
- Regular collaboration
- High Profile Projects
- Operating in the digital buildings ‘Sweet Spot’
- Driving Net Zero using Technology

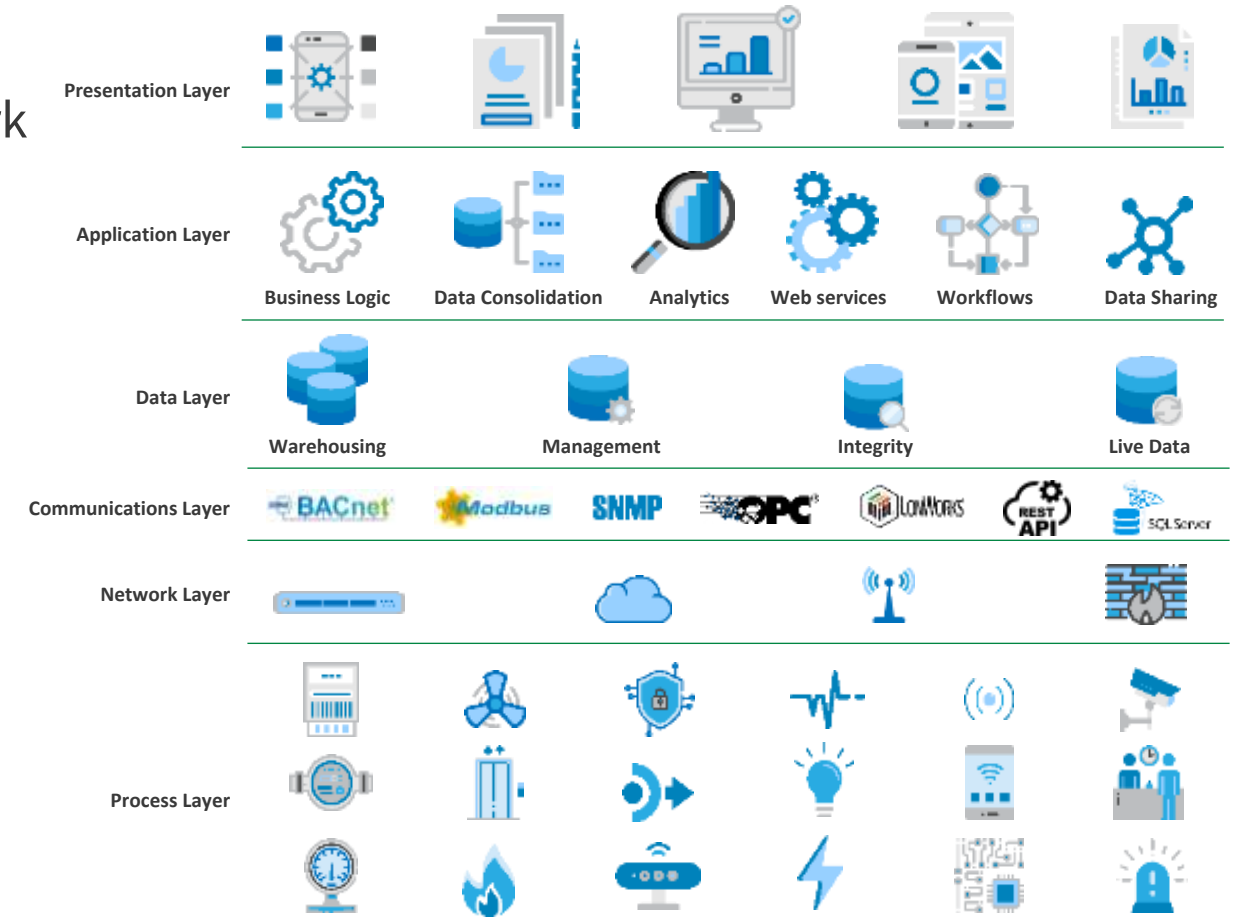


# What is Smart?
# Demystify the Buzzwords

- Single Pane of Glass (SPoG)
- Analytics & Machine Learning
- User Journeys
- Smartphone Applications
- Open Protocols
- Naming Conventions
- Data Normalisation
- Digital Twins

# How is it Delivered?
# Connecting the dots.

- Cybersecure Converged Building Network
- Data Capture and Management
- Normalisation and Blending
- Measurement and Reporting
- Analysis and Diagnostic
- Feedback and Change
- Presentation



# Understanding the aspiration, why Smart?
# Benefit and Value.

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An intelligent building can deliver benefit and value multiple needs. each requiring different outcomes as a result of their varied **interactions** and **relationship** with the building.

### Human Centric.

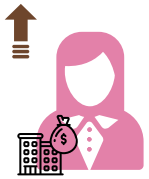
End users of the building who will gain benefit through greater building digital experiences.

### Operational Focus.

Operations users of the building whose efficiency and productivity increases through enhanced workflows.

### Management Enterprise.

Access to rich data for enhanced performance and operational analysis while also for wider digital data exchanges.



### Owner Investors.

Increase asset value, enable additional revenue streams, attract tenants and deliver to ESG

- Cost uplift in Digital Enablement
- Some of cost is offset vs Traditional Siloed Building
- Technology can generate revenue
- Data can validate sustainability goals

SmartScore CERTIFIED

RESET

WELL

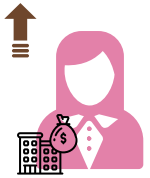
# Understanding the opportunities.

## Technology enables outcomes

**Human Centric.**

**Operational Focus.**

**Management Enterprise.**



**Owner Investors.**

| Abstract | Wellbeing | Efficiency | Information | Commerce |
|---|---|---|---|---|
| Benefit | Enable users to focus on the day ahead, their tasks and getting on with their agenda in a positive environment. | Enable energy reduction opportunities and operational efficiencies. | Enable a structured design feedback and benchmarking Enable wider business system interaction | Structured visibility of investments and ROI. |
| Function example | Bike-rack space booking, Wayfinding, Automation, Environmental conditions for peace of mind | Occupancy density and environmental monitoring, dynamic maintenance and supply change automation | Automated benchmark reporting, Building usage detail. | Documented functions and benefits.<br>Additional revenue streams |
| Value | Attract employees<br>Frictionless property | Reduce energy consumption<br>Reduce operation and maintenance costs. | Informed business decisions, improved design feedback, | Increased asset value<br>Market attractiveness<br>Delivering to ESG |

# Smart and Secure
# Single point of entry to the Network

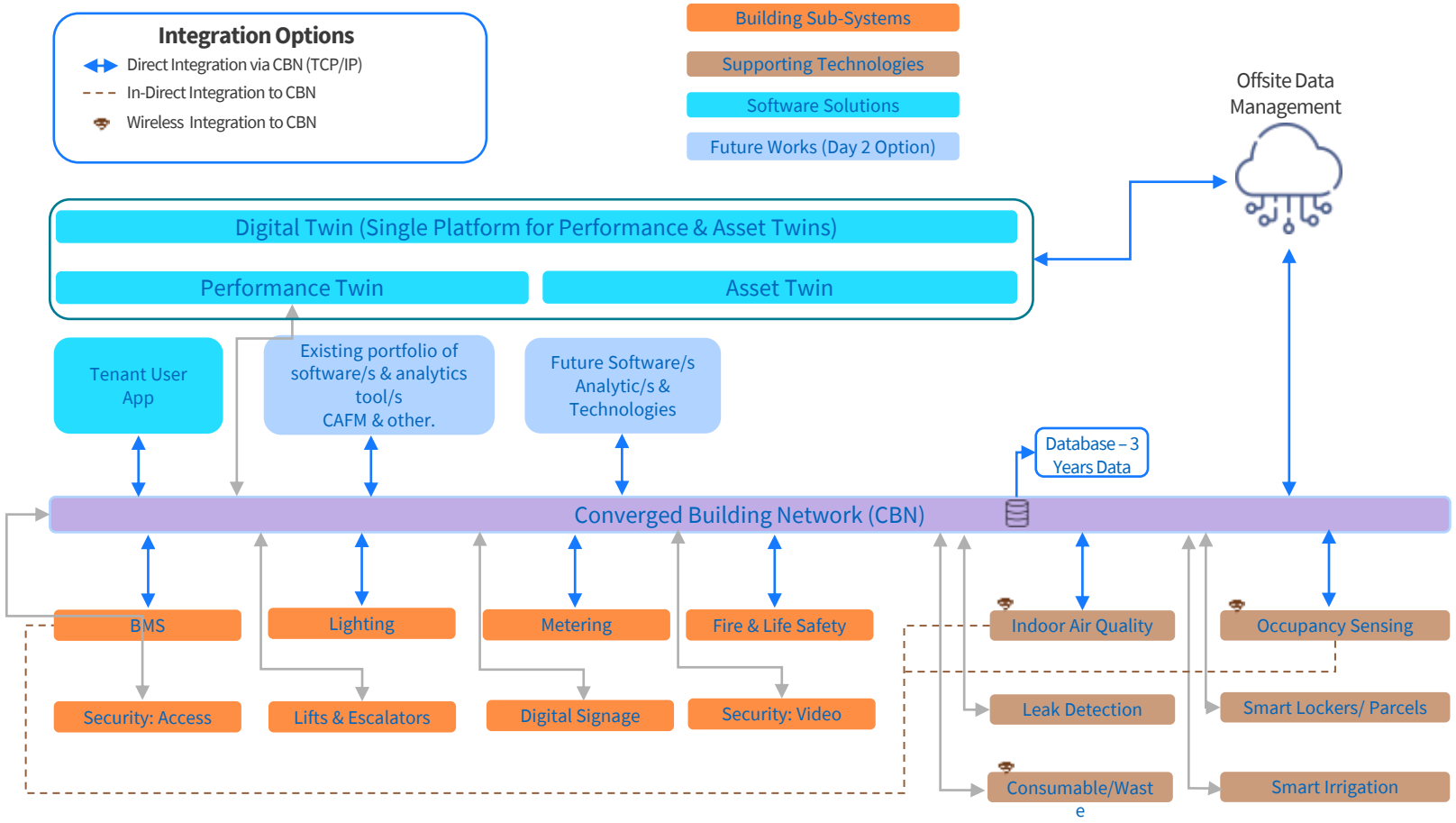
TOTAL RESULTS

19,992

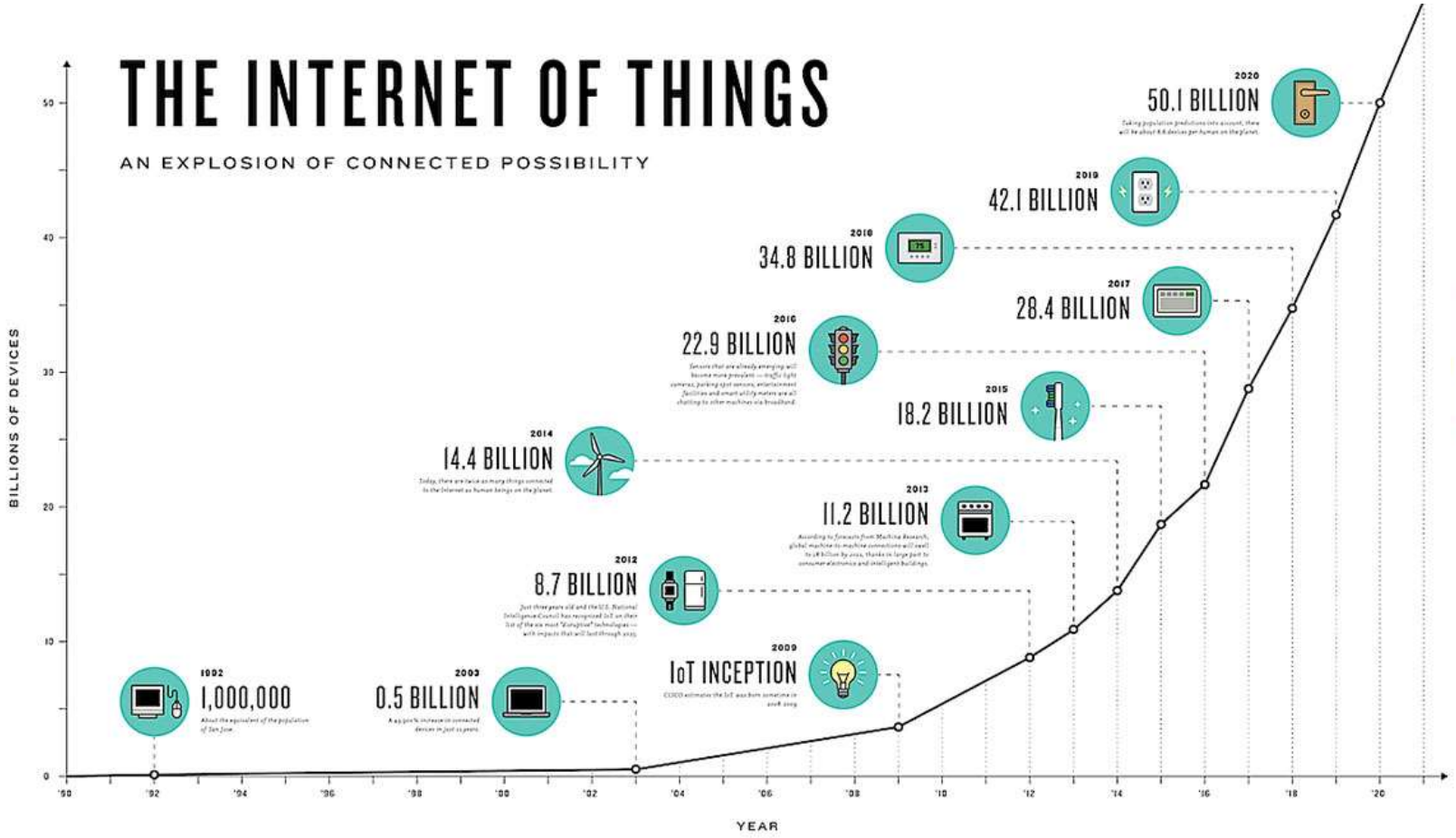
TOP COUNTRIES

| | |
|---|---|
| United States | 13,814 |
| Canada | 1,708 |
| Japan | 575 |
| Germany | 334 |
| France | 320 |
| More... | |

Number of BMS controllers connected directly to the internet



# Where we are headed?
# Yesterdays future is today.




LoRaWAN

API { REST }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We create about 1.7Mb per person per second. This equates to about 100,000 floppy discs of information per day!

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**“Technology has never moved as fast as it does today and will never move this slowly ever again”**

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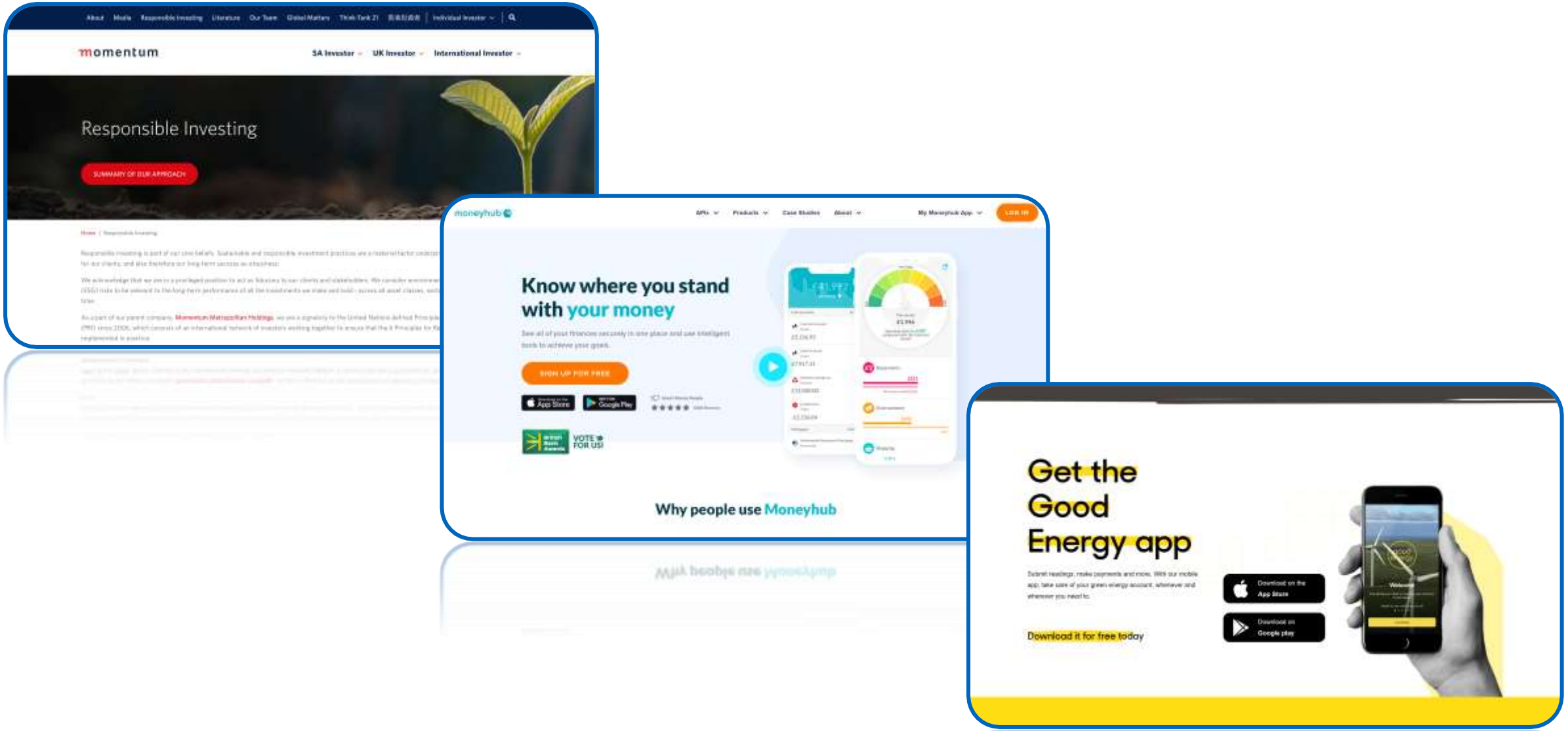
# Why am I talking to you?


momentum
Responsible Investing
Know where you stand with your money
Why people use Moneyhub
Get the Good Energy app
Download it for free today

**convergence of data**

**+ user experience**

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**better outcomes**

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# What we must be.

## Designers and engineers who demonstrate outcomes based on evidence.

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# What we must do.

We must converge **design & operational** consultancy so that buildings meet their required performance.

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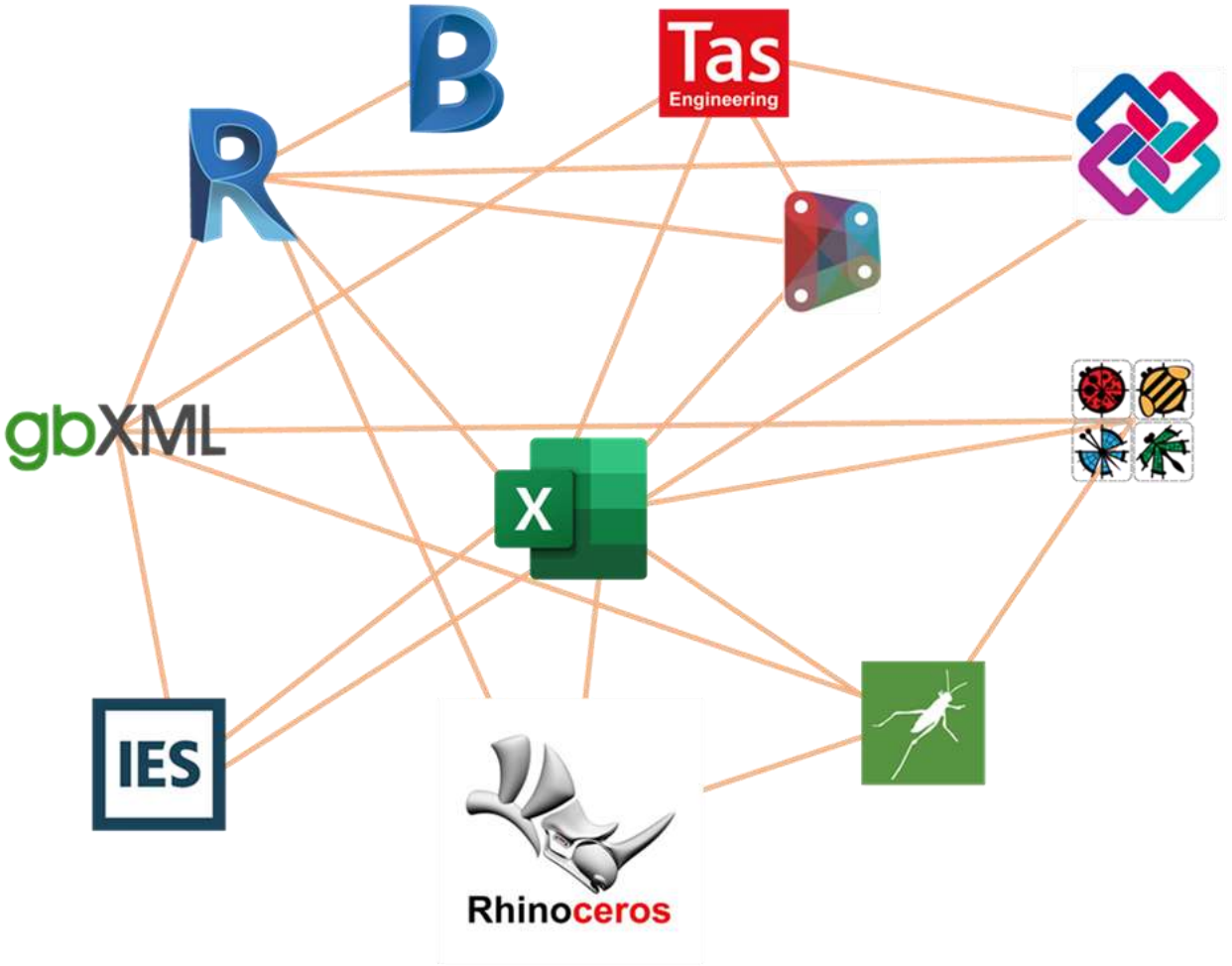
# Where we must focus.

Delivering complex outcomes

Driven by data & evidence

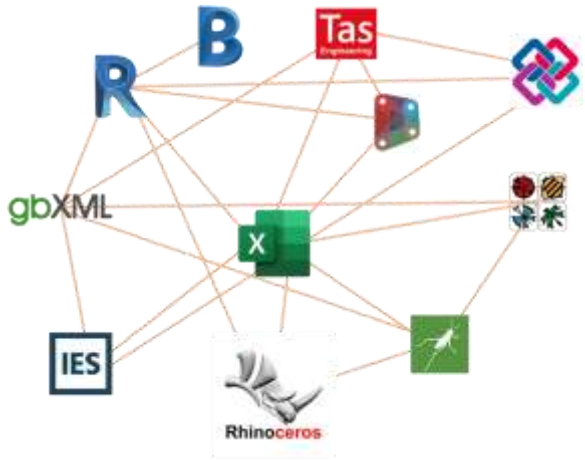
From ‘copy-paste culture’ to **systems thinking**

# When building data = files



# When building data = files

Not just once, but every time data is exchanged …




IMPORT | FIXING THINGS! | ACTUAL DESIGN | EXPORT

… losing time, and possibly information!

# Why don’t we turn those files over…

**… and let objects coalesce into the simplest form we call them:**

- project, site, building
- levels / stories
- spaces / rooms
- walls, floors, ceilings, doors, windows
- ducts, pipes, containment
- equipment, furniture, fittings
- calculations, simulations, assumptions
- external and environmental data sources

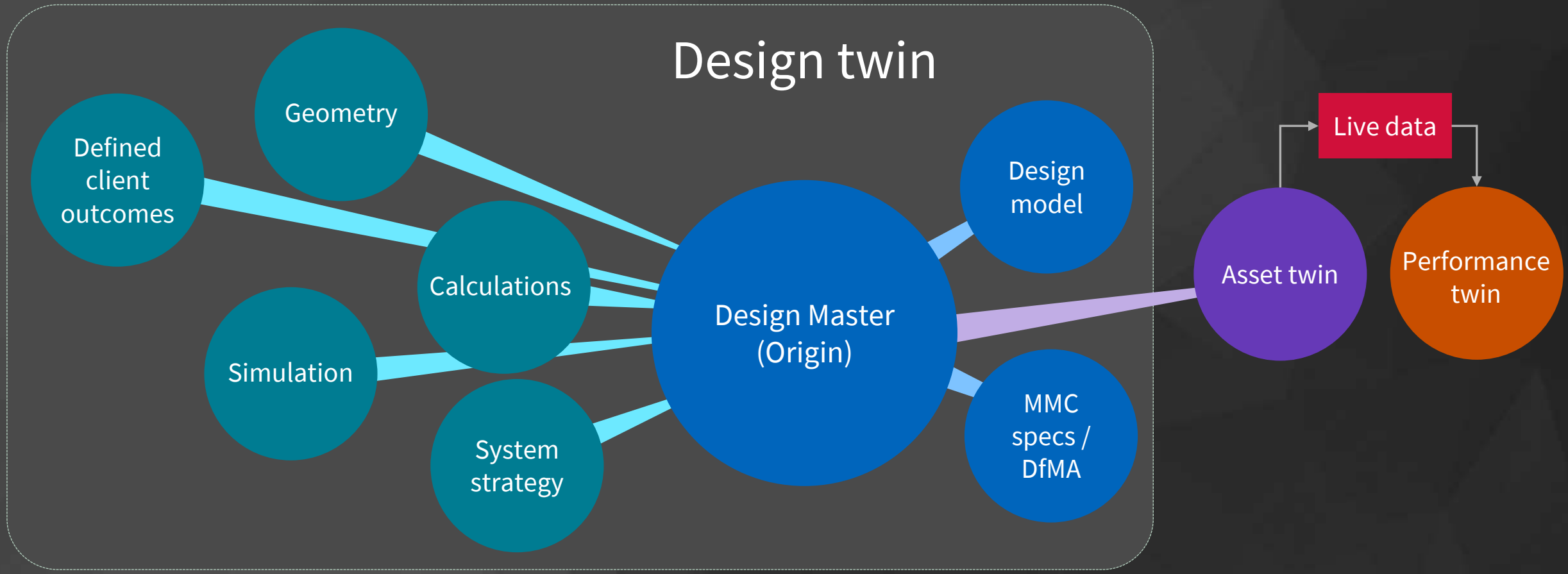

# A single source of information…

… so engineers can see the ‘whole’ and focus on what they do best.


RAPID INSIGHT → ACTUAL DESIGN → RAPID INSIGHT → ACTUAL DESIGN

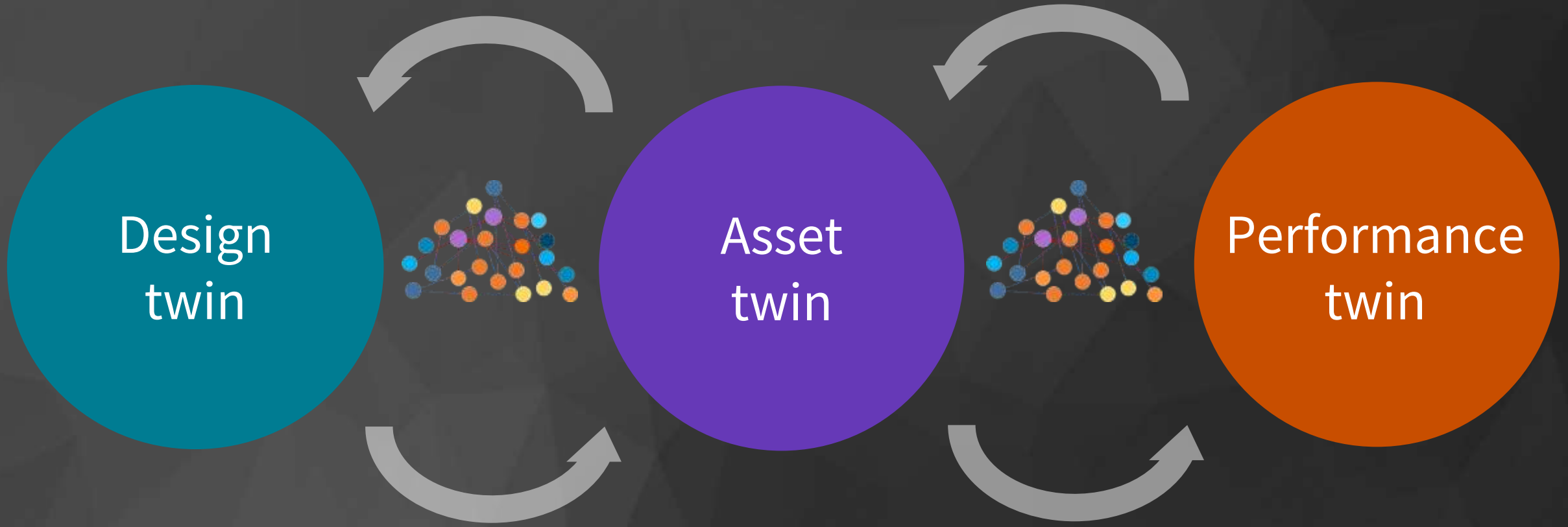
\+ AUTOMATION

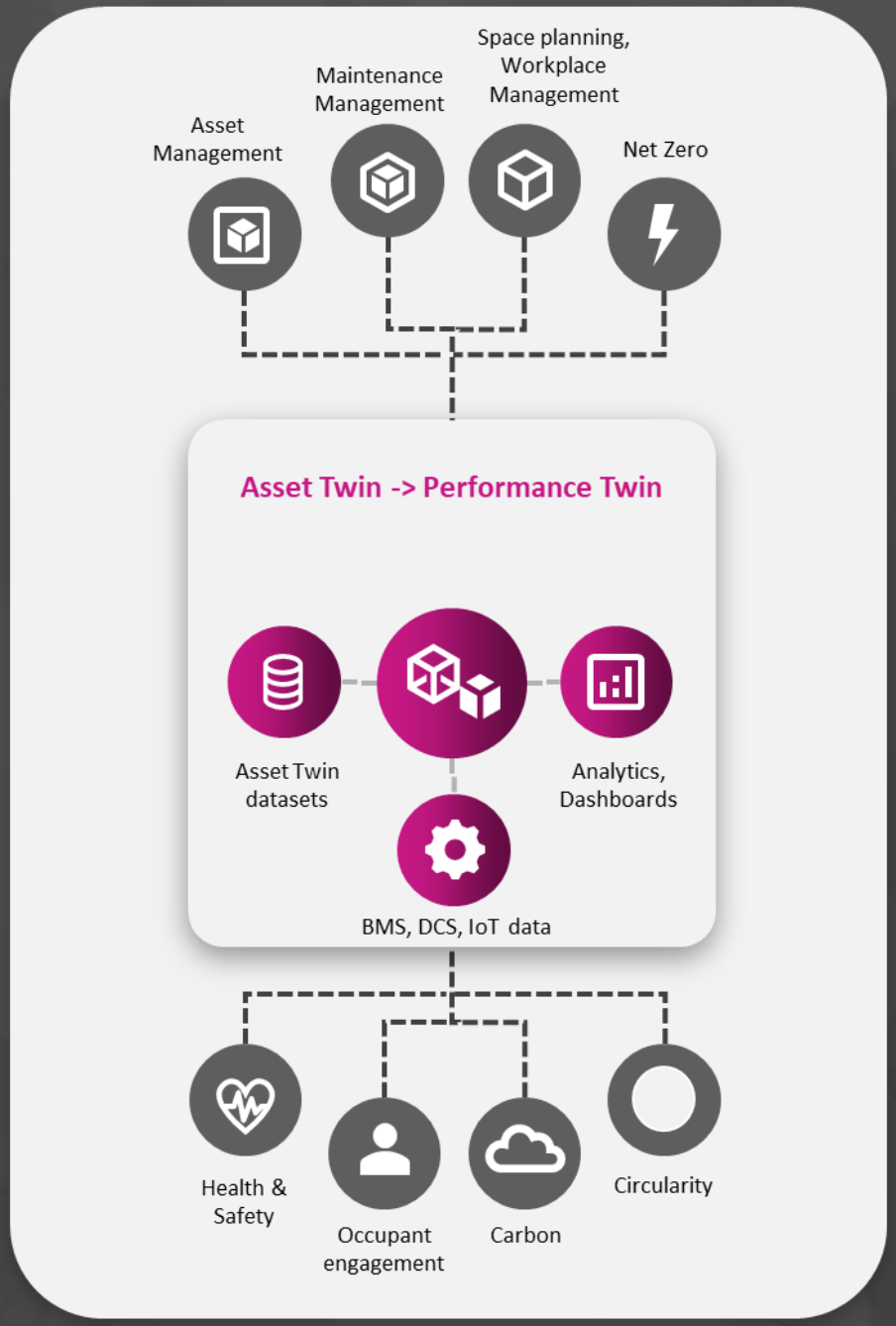
# **Convergence to a design twin.**
Design as a knowledge graph.



# Building digital twins

## From design to operation



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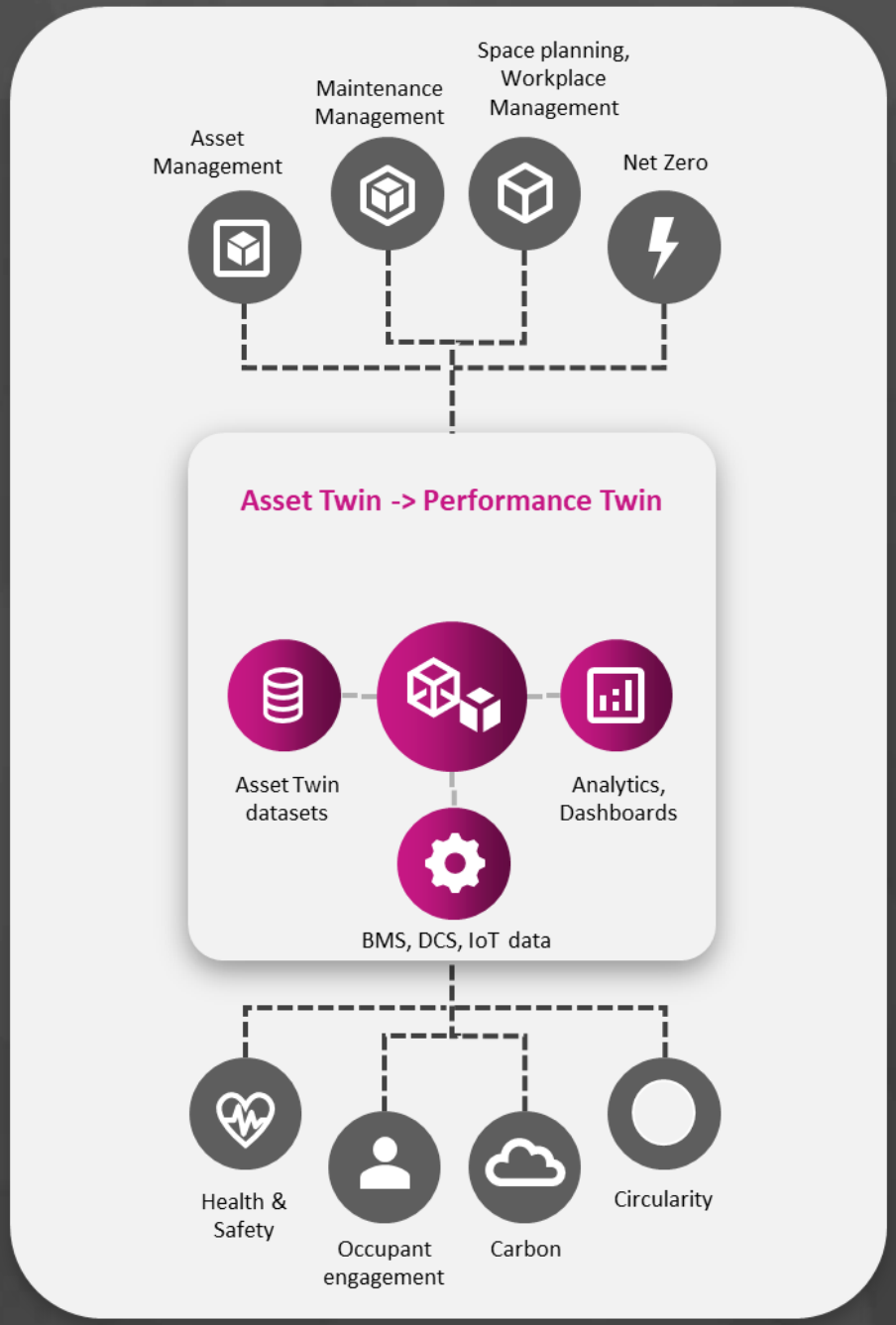
# Building digital twins
## A composable platform solution




# Building digital twins

## A composable platform solution

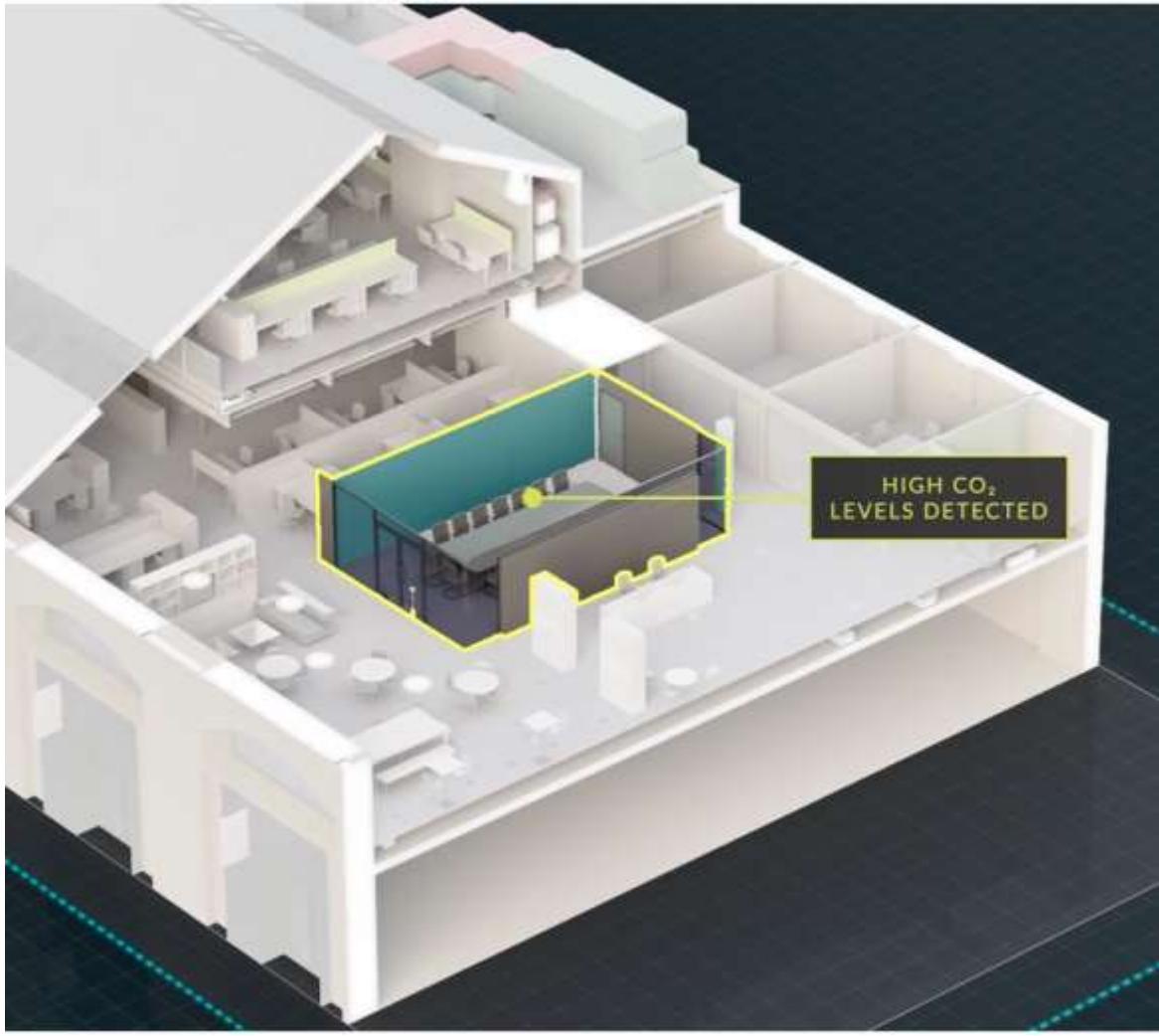
"Every building is unique and has unique demands. The ability to rapidly compose bespoke solutions is key."

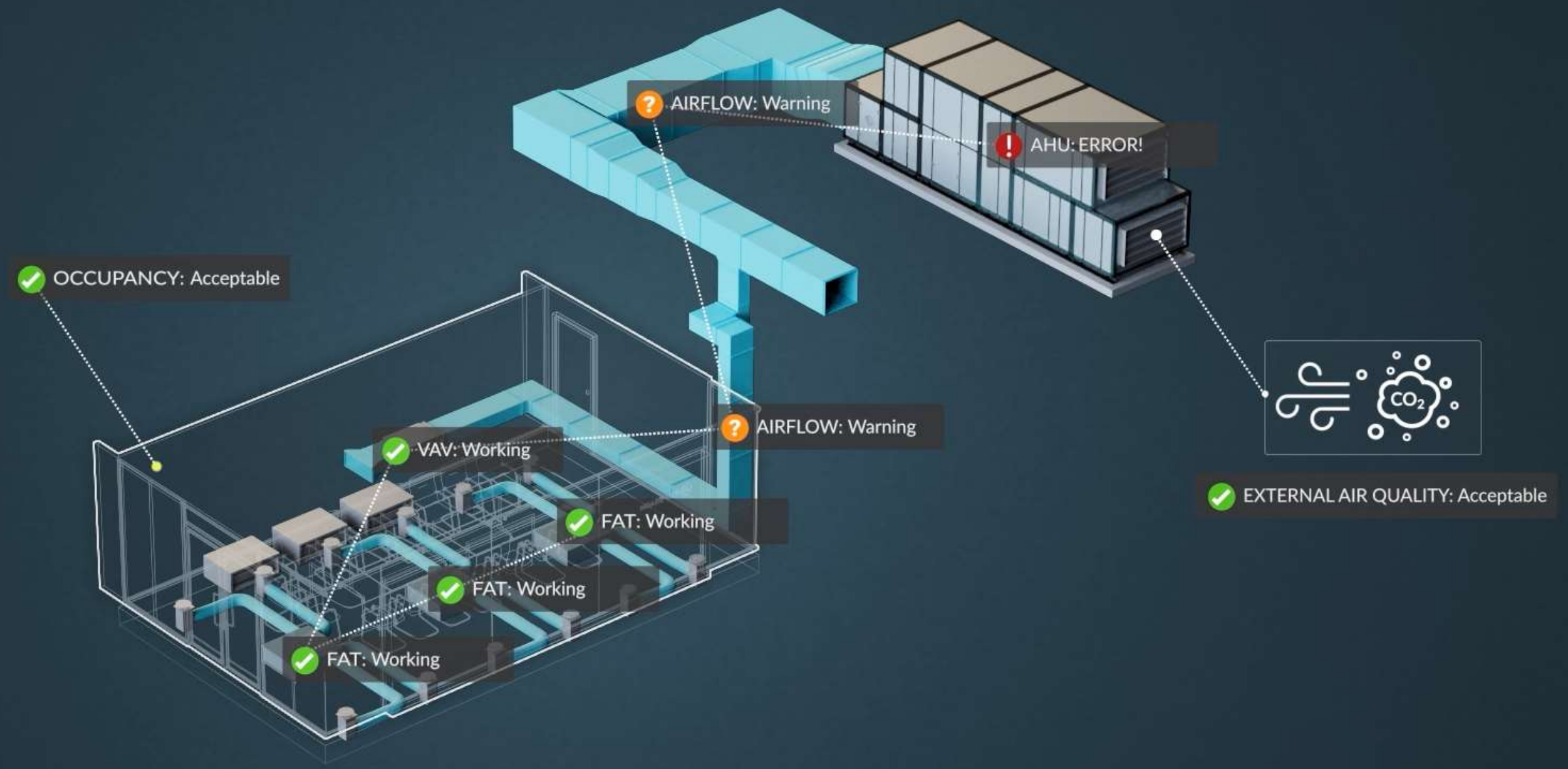
Anand Mecheri (CEO & co-founder, Invicara)

Image courtesy www.Invicara.com


HOARE LEA
Western Transit Shed
Systems
AHU 03 Supply Air for MCR
Found 2 alerts.
Elements
Sync with Viewer
Air Handling Unit | AHU-03 | 257...
MCR Supply Duct Run
Variable Air Volume | 92 | 26020...
Ducting
Fan Assisted Terminal | 66 | ...
Fan Assisted Terminal | 65 | ...
Fan Assisted Terminal | 67 | ...
SP_01-08_Main Conferen...
RESET VIEW
PROJECTION
VIEW
SHADING
NAVIGATION
MEASUREMEN
CUTTING PLAN
2D VIEWER
FOCUS MODE
SETTINGS
SHOW ALL
TOP
FRONT
RIGHT
SEARCH
SYSTEMS
Air Handling Unit | AHU-03 | 2579811

# Digital twin use cases
## Indoor air quality




AIRFLOW: Warning
AHU: ERROR!
OCCUPANCY: Acceptable
AIRFLOW: Warning
VAV: Working
FAT: Working
FAT: Working
FAT: Working
$CO_2$
EXTERNAL AIR QUALITY: Acceptable

# Western Transit Shed

The Western Transit Shed forms part of the Goods Yard complex designed by Lewis Cubitt in 1852. It is located along Stable Street and fronts the retail and foodie hotspot destination the Coal Drops and Lewis Cubitt Square which is notable for it's water jet arches.

The building is laid out over three floors. The upper two floors house 55,000 sq ft of office space with floor plates of c. 27,500 sq ft. A mix of cafés, bars, restaurants and shops are at street level in the Victorian brick arches.

## System Alerts

Filter By:

| Alert | Source | Urgency | Keywords |
|---|---|---|---|
| Main Conference Room CO2 High | Main Conference Room | High | CO2 IAQ MCR |
| AHU-03 Temporary Fault | AHU-03 | High | AHU HVAC POWER |

HOARE LEA

Western Transit Shed

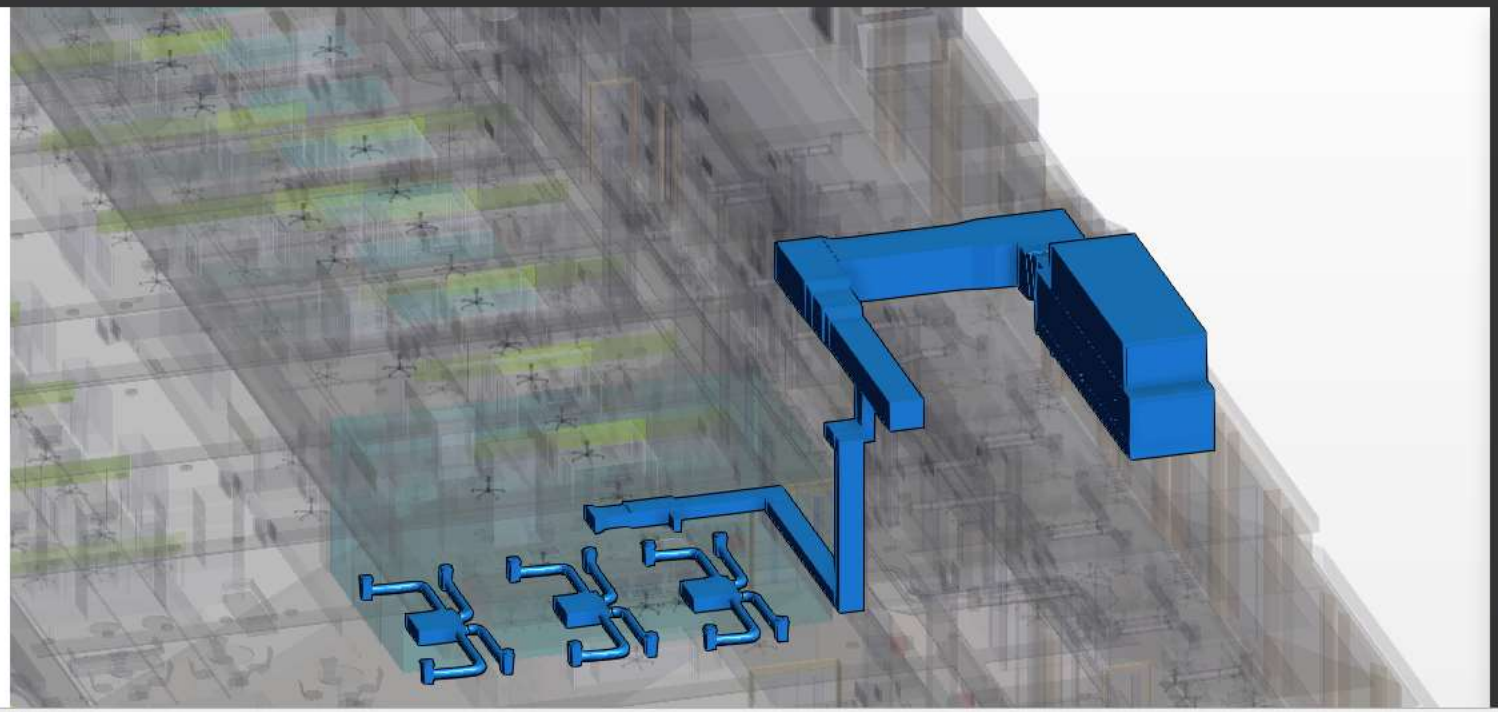
Systems

AHU 03 Supply Air for MCR

Found 2 alerts.

Elements  Sync with Viewer

- Air Handling Unit | AHU-03 | 257...
  - MCR Supply Duct Run
    - Variable Air Volume | 92 | 26020...
      - Ducting
        - Fan Assisted Terminal | 66 | ...



RESET VIEW

PROJECTION

VIEW

SHADING

NAVIGATION

SEARCH  SYSTEMS  SP_01-08_Main Conference Room

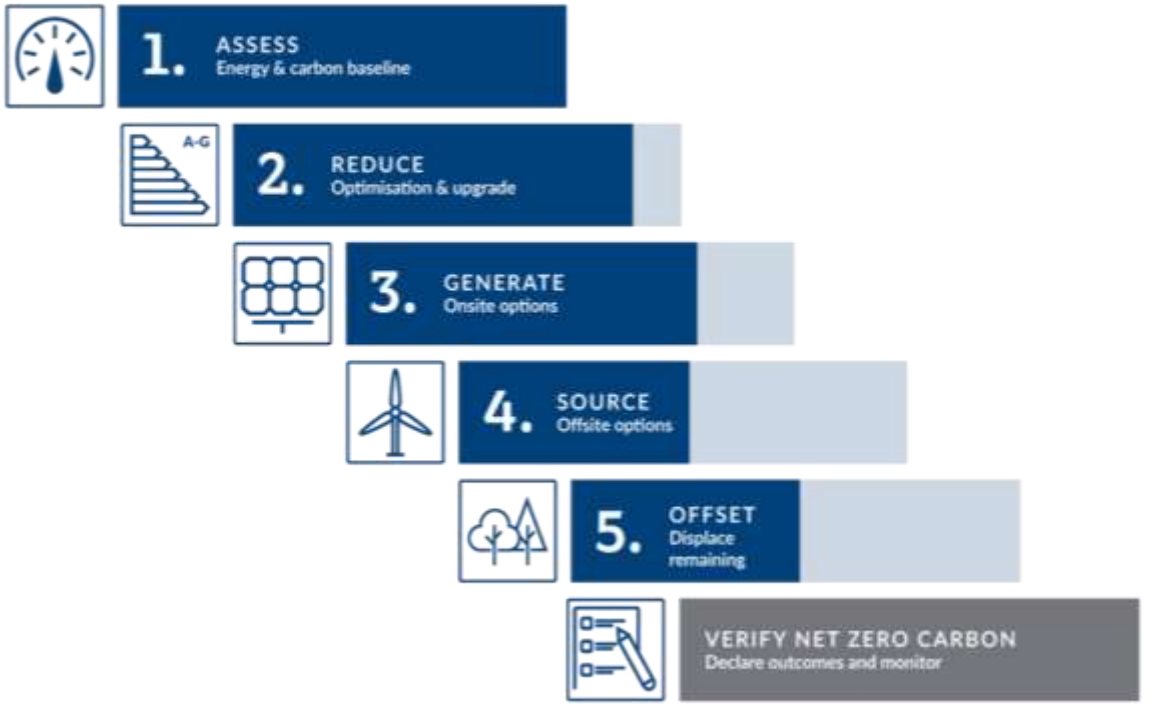
Space Properties

Real Time IAQ

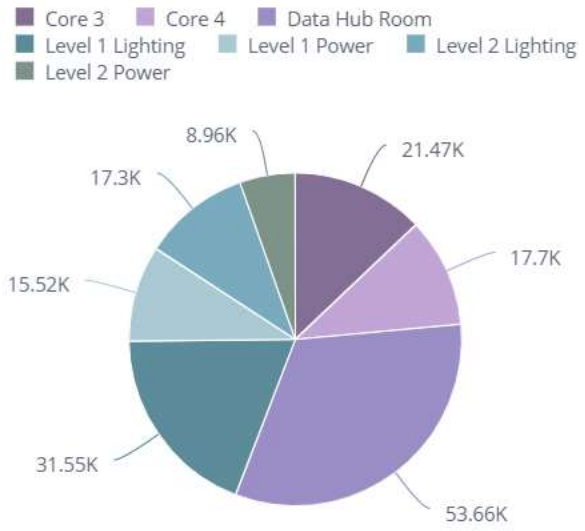
Occupancy vs CO2

| Metric | Value |
|---|---|
| *co2* | 476.38 |
| *humid* | 39.33 |
| *lux* | 0 |
| *pm10_est* | 1.21 |
| *pm25* | 0 |
| *score* | 94 |
| *spl_a* | 46.31 |
| *temp* | 24.03 |
| *voc* | 463.92 |

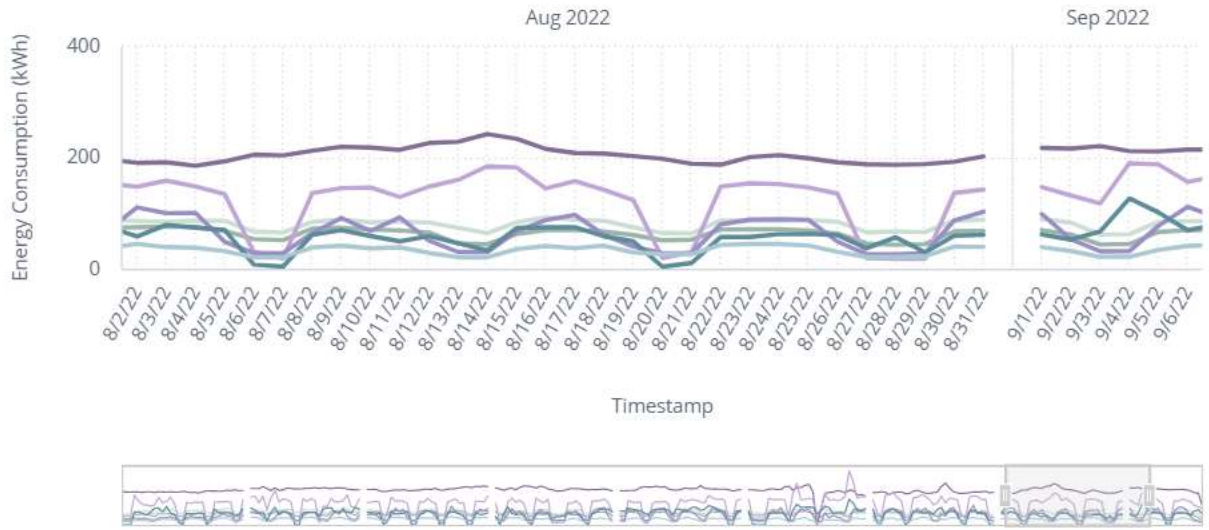
# Digital twin use cases
## Energy and Net Zero Carbon



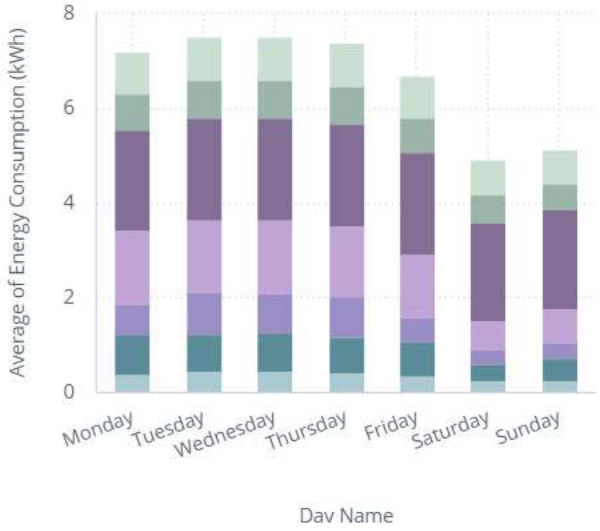
### Energy Consumption (kWh) by Usage



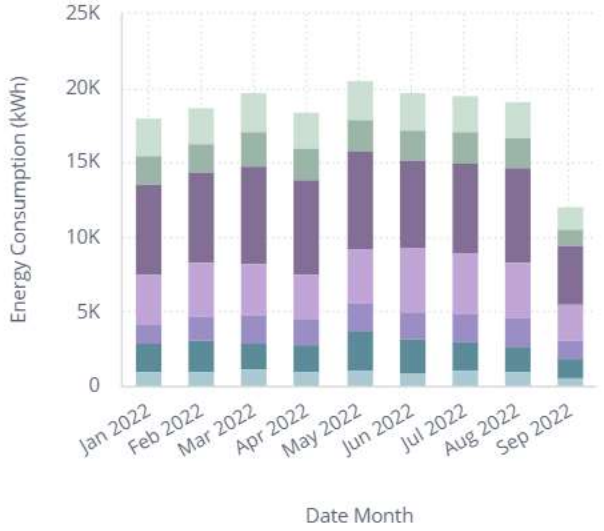

### Energy Consumption (kWh) by Timestamp and Usage



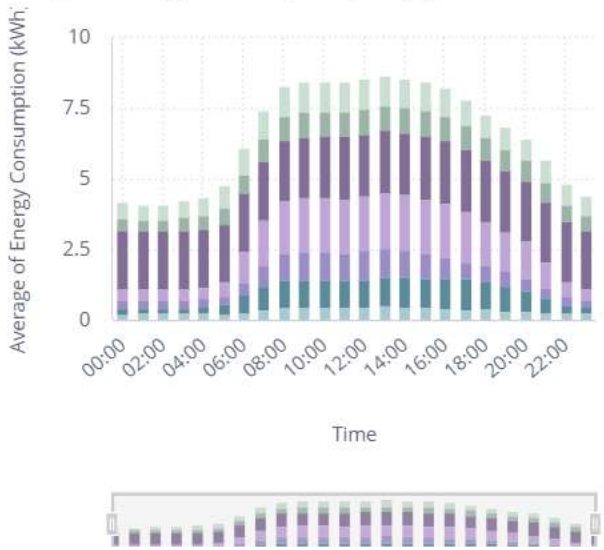

### Average of Energy Consumption (kWh) by Day Nai




### Energy Consumption (kWh) by Year, Month and Us




### Average of Energy Consumption (kWh) by Time an




### Filters

- Meter — Include all
- Months in timestamp — Include all
- Hours in timestamp — Include all
- weekday — Include all

HOARE LEA

# NZC Road Map

## Western Transit Shed
Hoare Lea London Office

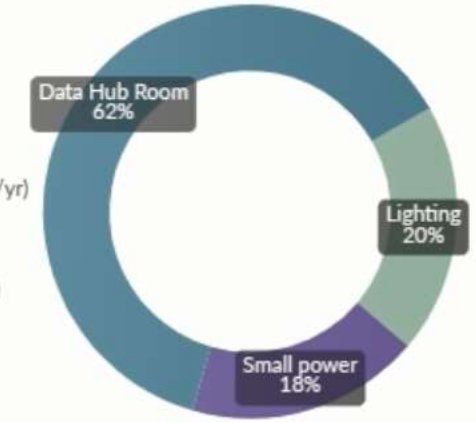
Click on the icons below to navigate through the various sections.

ELECTRICITY | INFRASTRUCTURE | FINANCIAL | CARBON | DESIGN | NZC ROADMAP

### Select measures

- [x] Replace lights with LED
- [x] Daylight Dimming
- [x] Scheduling of Lighting
- [x] Zoning Lighting
- [x] Demand-led Ventilation
- [x] Move IT Servers

## Energy Breakdown & Baseline Usage



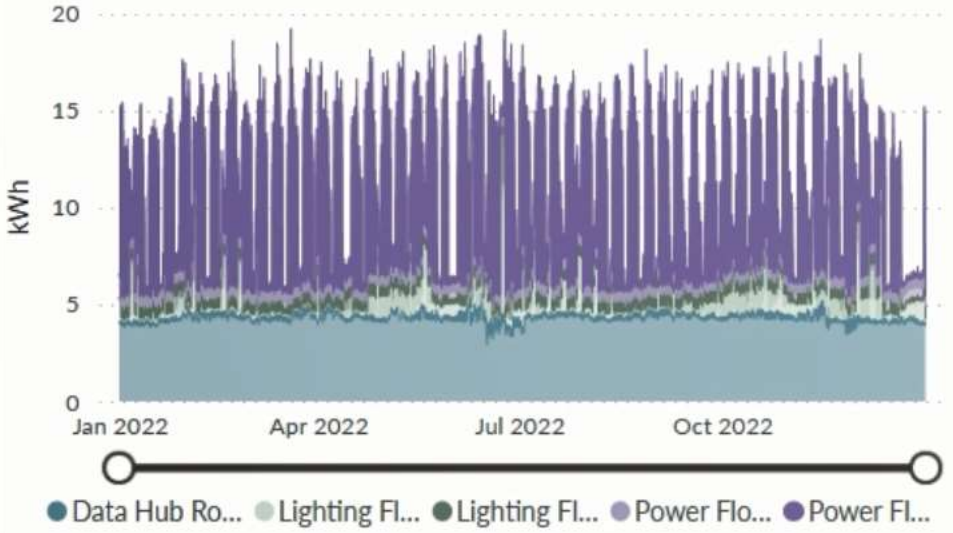

26,836
Baseline CO2 (kgCO2/yr)

£54,830
Baseline cost (£/yr)

176,845
Baseline usage (kWh)

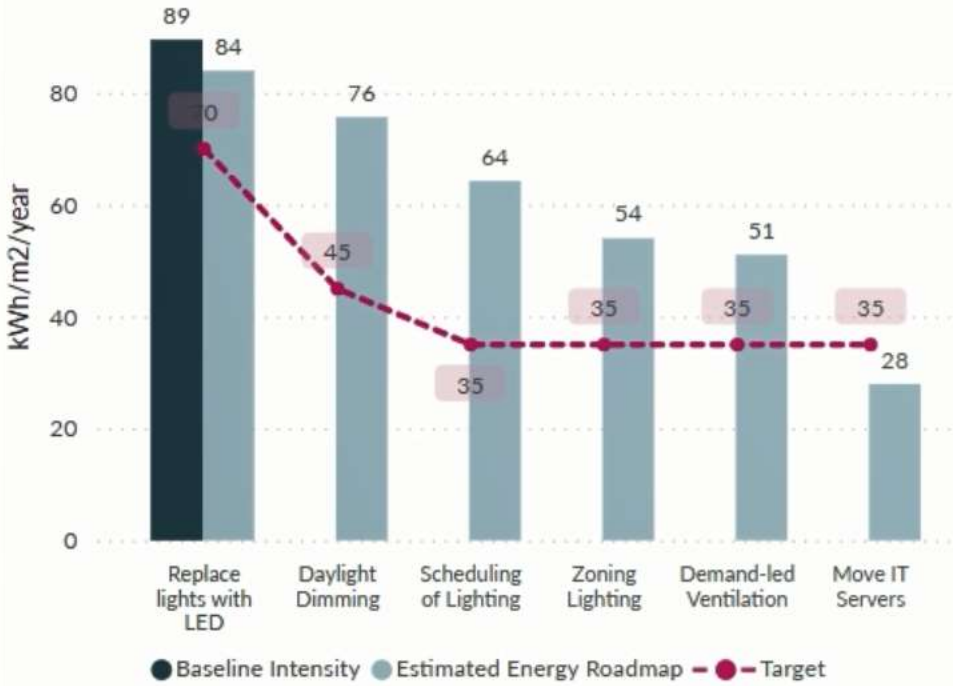
89
kWh/m2 - Baseline

## Baseline Energy Profile




| Measure | % of annual energy usage | Energy reduction kWh/yr | Energy intensity reduction kWh/m2/yr | Reduction kgCO2/yr | Cost reduction £/yr |
|---|---|---|---|---|---|
| Replace lights with LED | 38% | 10,902 | 6 | 1,654 | £3,380 |
| Daylight Dimming | 38% | 16,373 | 8 | 2,215 | £5,616 |
| Scheduling of Lighting | 38% | 22,567 | 11 | 3,384 | £6,410 |
| Zoning Lighting | 38% | 20,243 | 10 | 3,072 | £6,276 |
| Demand-led Ventilation | 6% | 5,836 | 3 | 886 | £1,809 |
| Move IT Servers | 43% | 45,645 | 23 | 6,927 | £14,152 |
| **Total** | **202%** | **121,566** | **62** | **18,137** | **£37,644** |

## Energy intensity road map




## Impact of selected measures

55,279
Estimated new energy usage (kWh/yr)

27
Estimated new energy intensity (kWh/m2/yr)

8,699
Estimated new CO2 (kgCO2/yr)

£17,186
Estimated new electricity costs (£/yr)

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# Energy scenarios

## Western Transit Shed

Hoare Lea London Office

Click on the icons below to navigate through the various sections.

ELECTRICITY | INFRASTRUCTURE | FINANCIAL

CARBON | DESIGN | NZC ROADMAP

Use the toggle buttons underneath to switch options for the energy scenario.

**Lighting**

- No lighting optimisation
- Automated scheduling
- Daylight dimming

**Photovoltaic solar array**

- No PV array
- 150 m2 of PV array
- 500 m2 of PV array

**Battery storage**

- No battery
- 10 kWh battery (0.5 C-rate)
- 70 kWh battery (0.5 C-rate)

Baseline carbon impact ($kgCO_2$)

26,836

Scenario carbon impact ($kgCO_2$)

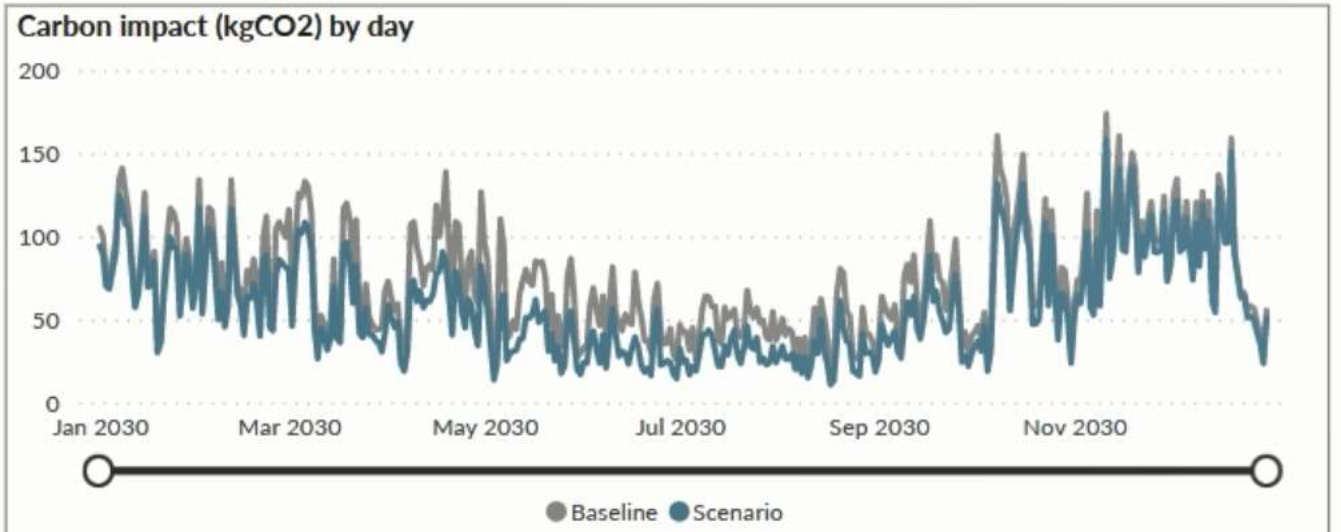
21,159

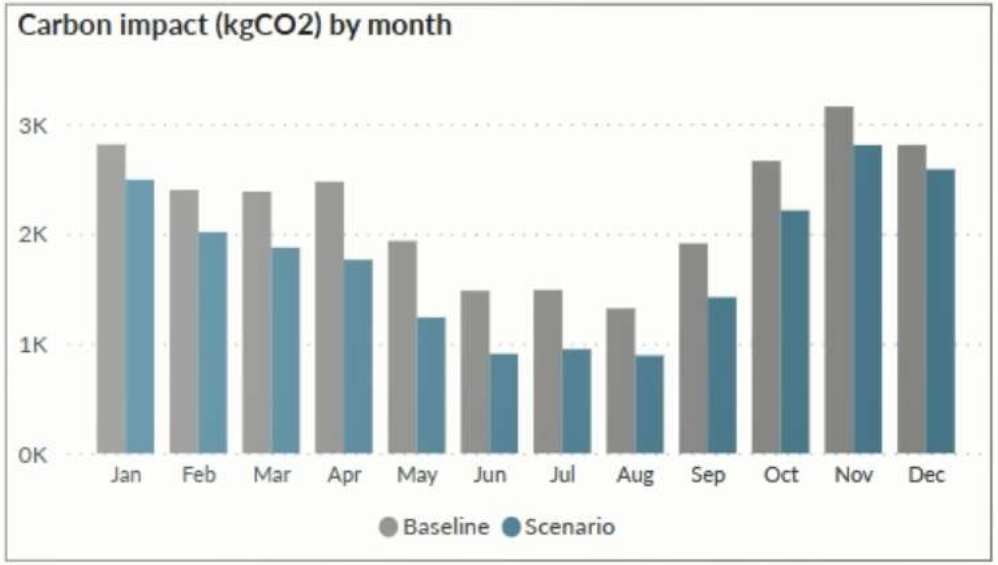
-21.2%

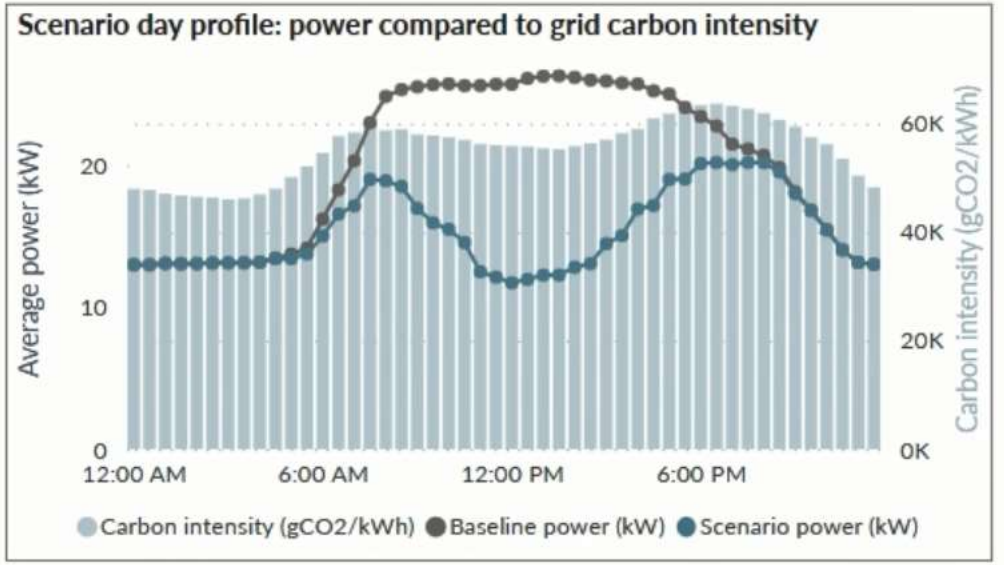
Select elements or legends on the charts below to filter information.

**Carbon impact ($kgCO_2$)**
based on real-time regional electricity generation data for London

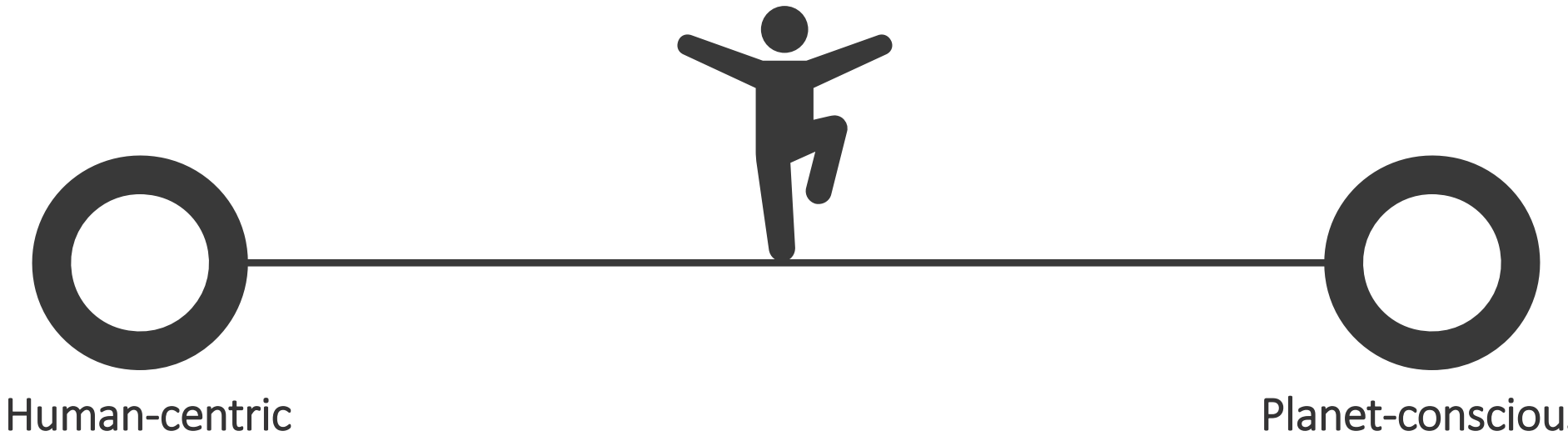

**Carbon impact ($kgCO_2$)**
based on government official GHG conversion factor (national annual average)



# Balancing the building
## Human-centric and planet-conscious



# Data for different users

TETRA TECH
High Performance Buildings Group

Enterprise management

Occupant

Owner investor

Facilities management

Building management

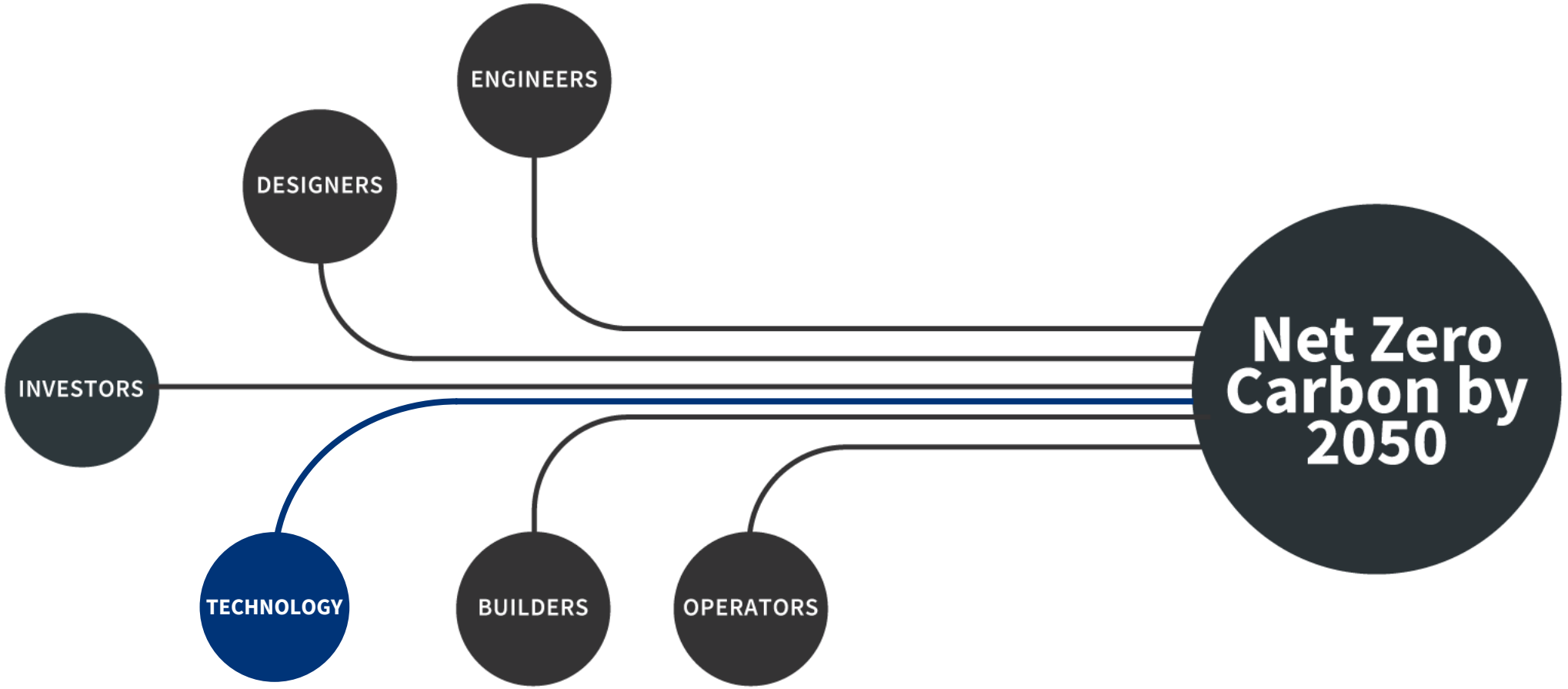
Composable platforms enables one to present the right info in the right way to the right people, to take the right actions.

# Our vision.

TETRA TECH
High Performance Buildings Group

**A platform composed by experts for every building.**
**A conductor who can balance and optimise each instrument within.**
**A foundation to enable better outcomes for people & planet.**

# Delivering Net Zero Carbon
## From investment to operations



# Delivering Net Zero Carbon
## Approach & Considerations

- Policies & Regulations
- Technologies
- Infrastructure
- Implementation
- Funding
- Financing
- Return on Investment

TETRA TECH
High Performance Buildings Group

# Indoor Air Quality

## Webinar in February 2023

TETRA TECH

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