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Egis Insights | Thought Leadership

Digital Twins

From Static Audits to Virtual Replicas

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1 A New Era of Energy Management

Educational campuses are big energy users, and most still manage energy the old way: a detailed audit, a set of recommendations, and fixed operating schedules.

Audits are valuable, but they are a snapshot in time.

They cannot react to a hot afternoon, an exam week or a cloud passing over the solar panels.

Thisis where a Digital Twin comes in: alive virtual replica of the building, fed by sensors, that can simulate changes and decide when energy should be used. The research behind this article tests the idea on the Administrative Block of Punjab Engineering College (PEC), Chandigarh.



Administrative Block, Punjab Engineering College (PEC), Chandigarh

The Case Study in Numbers

365,480
kWh used per year in the baseline audit

66%
of the loadcomes from airconditioning

213,153
kWh/year of rooftop solar potential

0.78 yr
modeled paybackof thedigital dispatch layer

Why static audits fall short

The audit counted 516 appliances with a total connected load of about 130 kW. Air conditioning dominates, so demand swings with the academic calendar and the weather: from 78,295 kWh in the busiest billing period (Aug–Sep) down to 46,380 kWh in the quietest (Feb–Mar). A single yearly average hides all of that, and it hides the mismatch between when cooling is needed and when solar power is available.

516
appliances

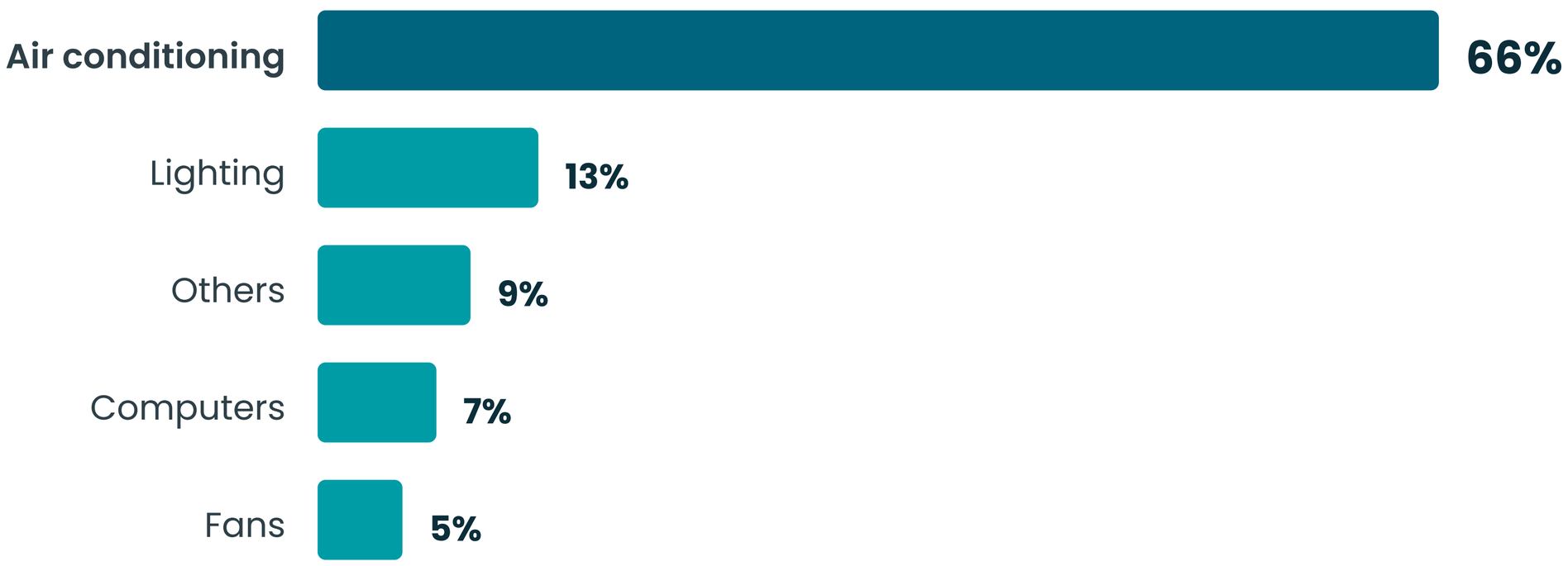
~130 kW
total connected load

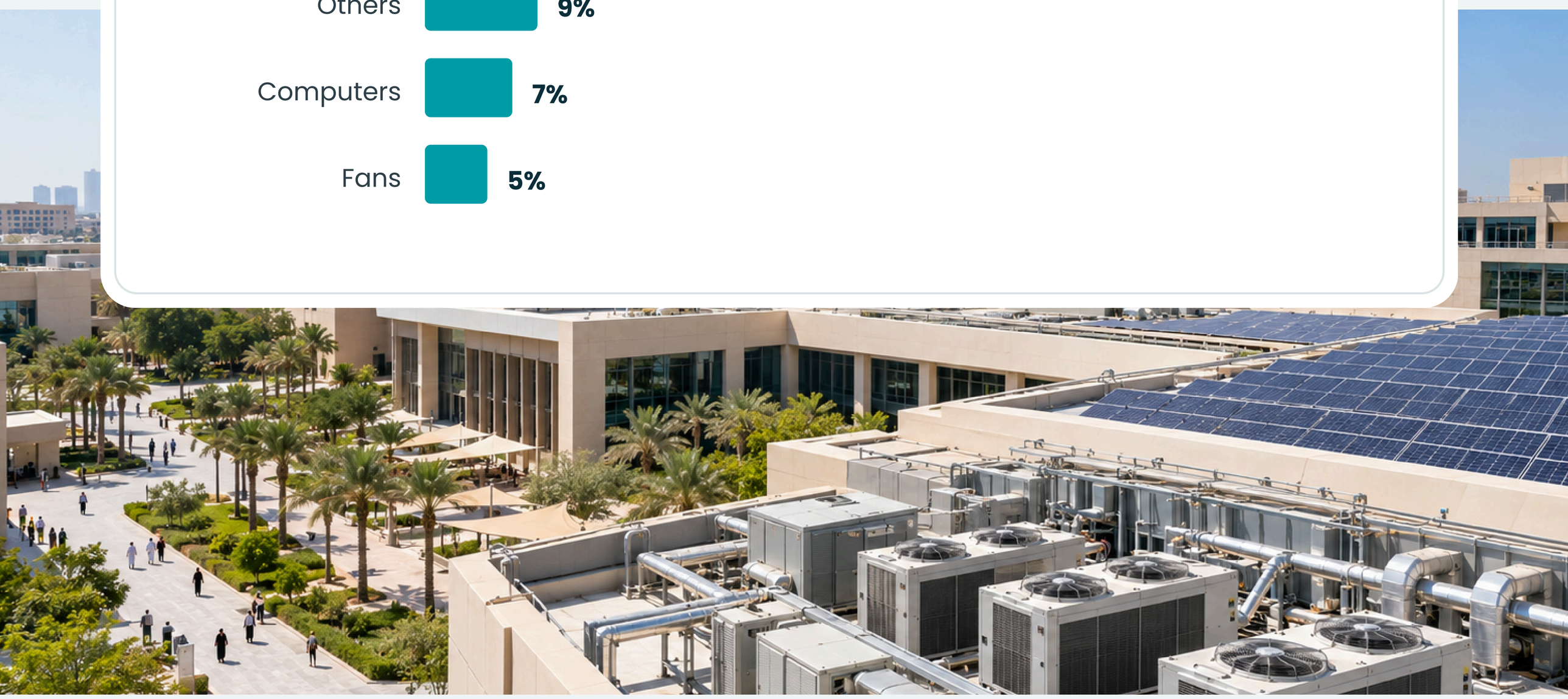
Busiest billing period · Aug–Sep
78,295kWh

→

Quietest billing period · Feb–Mar
46,380kWh

Where the energy goes (share of connected load)





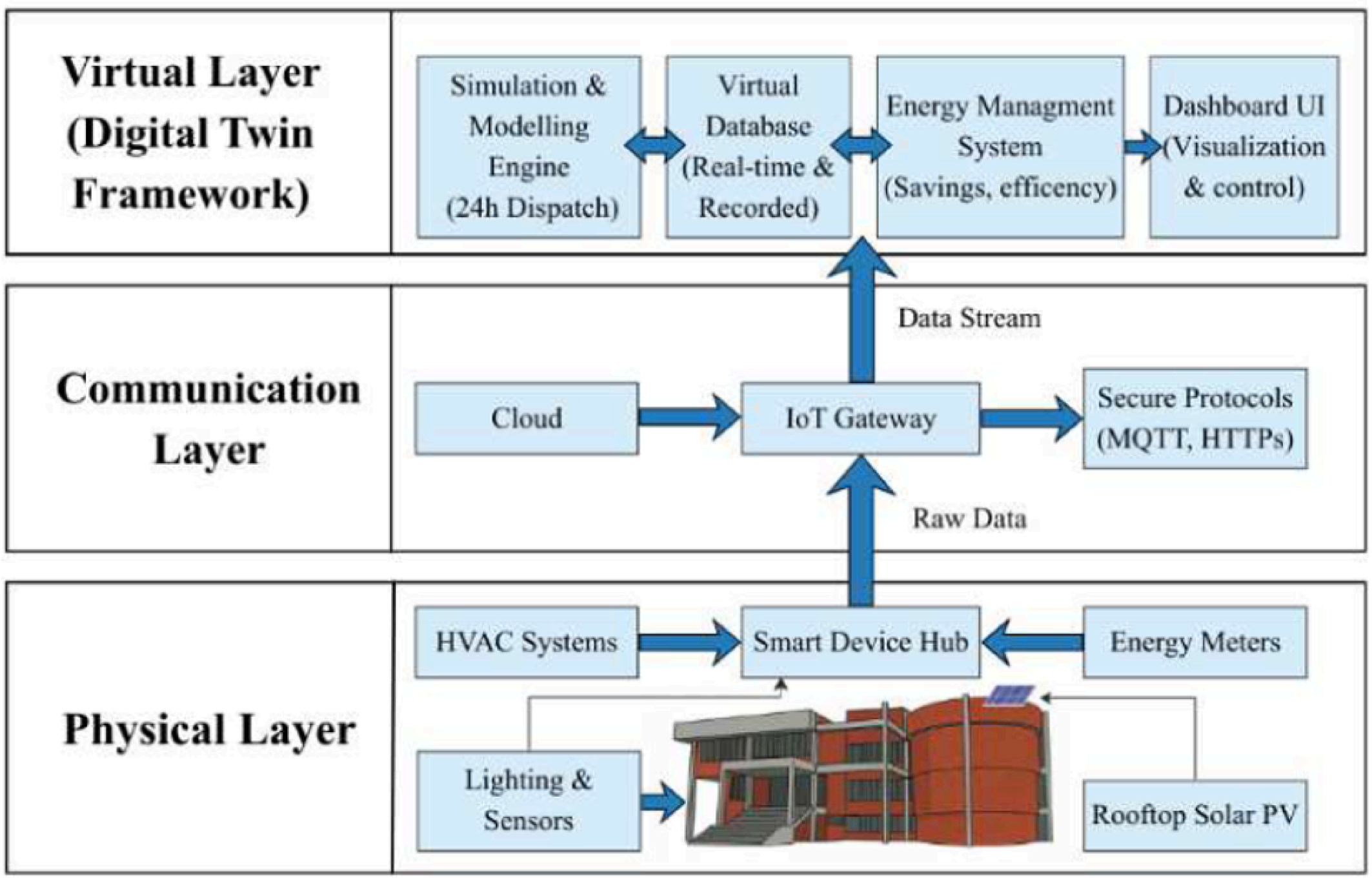
2 Inside the Framework

The key lesson: the twin is only as good as its connection to the real building.
The framework is built from three layers that work together.

Virtual Layer — Simulation engine · Real-time database · Energy management · Dashboard

Communication Layer — IoT gateway · Cloud · Secure protocols (MQTT, HTTPS)

Physical Layer — HVAC systems · Lighting & sensors · Energy meters · Rooftop solar PV



What the twin shifts: a managed HVAC reduction of 92,460 kWh/year (about 253 kWh/day) is aligned with solar generation of about 584 kWh/day. In the simulation this suppresses the late-afternoon grid import peak.

~253
kWh/day managed HVAC reduction

~584
kWh/day solar generation

92,460
kWh/year managed HVAC reduction

Meet RAHDA: the brain of the twin

The Renewable-Aligned HVAC Dispatch Algorithm (RAHDA) is deliberately simple. Rather than heavy predictive control, it uses a transparent, rule-based method:

1. **Rank the Hours:** each hour of the day is ranked by how much solar surplus it has, after the fixed load (lighting, computers) is covered.

2. **Place flexible cooling:** the flexible air-conditioning energy is assigned first to the sunniest hours, then the next best, until the daily target is met.

3. **Respect the audit targets:** RAHDA works within the daily energy requirement taken from the audit, so the algorithm changes when energy is used, following the sun.

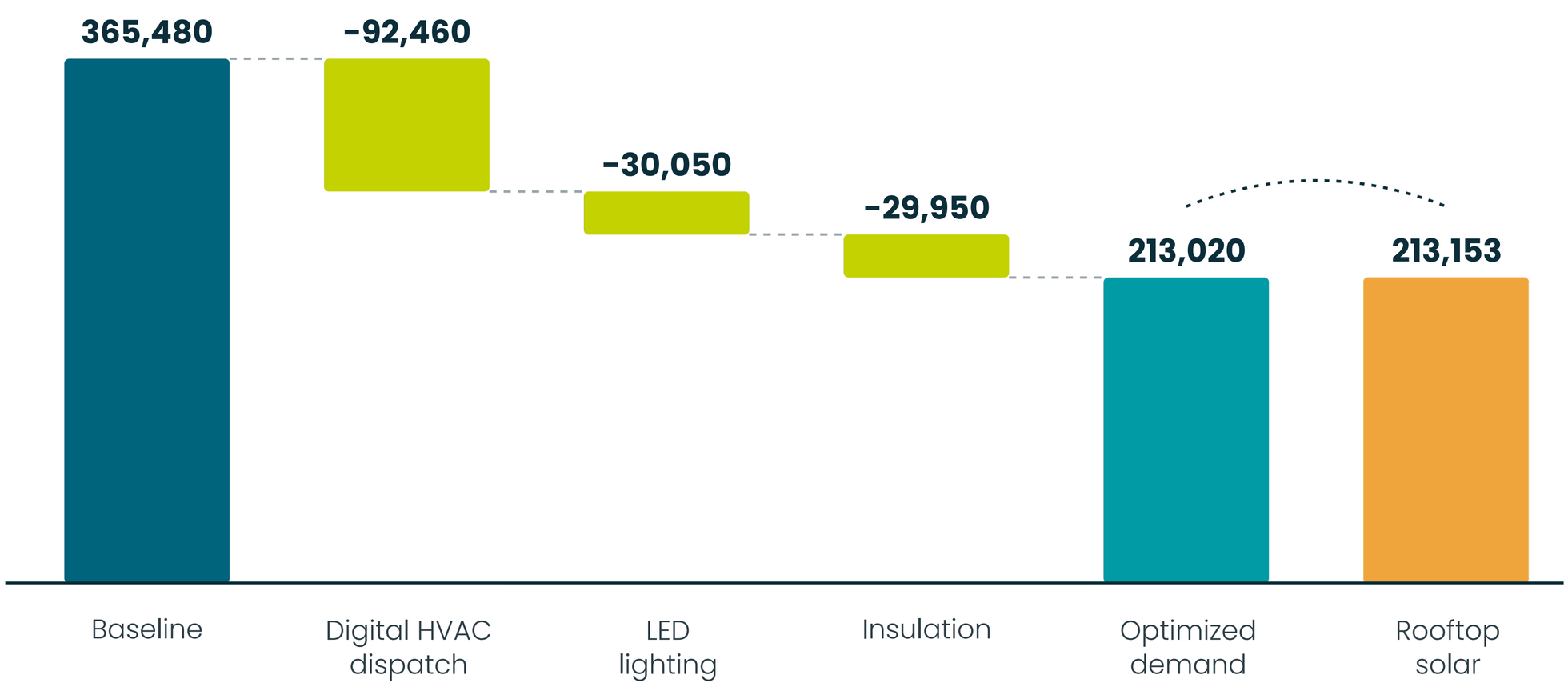


3 Results & Sustainability Impact

Digital dispatch is only one piece. Combined with two physical upgrades, the modeled campus energy demand falls from 365,480 to 213,020 kWh/year, almost exactly matching the 213,153 kWh/year that rooftop solar can produce: a near net-zero balance with a modeled surplus of about 133 kWh.

Path to near net-zero (kWh per year)

Near net-zero · modeled surplus of about 133 kWh



Does it pay back?

Measure	Savings (kWh/yr)	Cost savings (INR/yr)	Investment (INR)	Payback (years)
Digital twin HVAC dispatch	92,460	739,680	500,000	**0.78**
High-efficiency LED lighting	30,050	240,400	300,000	**1.25**
Insulation & facades	29,950	239,600	200,000	**0.83**
Solar PV installation	100,000*	800,000	1,200,000	**1.50**

* Direct offset portion used for the payback calculation. Based on an estimated tariff of INR 8/kWh and maintenance costs of 20% of capital for the digital layer.

Sustainability

Smarter, Cleaner, Responsible

Shifting flexible cooling into the solar window means more of the building's power comes from on-site renewables and less from the grid at peak times. It supports India's net-zero 2070 and 500 GW non-fossil capacity goals, and costs far less than a structural rebuild.

Outlook

An honest note on limits

These results are a first-order simulation built from bi-monthly billing data, not live telemetry. They do not yet model weather randomness, thermal dynamics or closed-loop control. The next step is real-time validation with high-resolution sensor data.

2070 India's net-zero goal

500 GW non-fossil capacity goal





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