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Integrated Urban Energy Systems: Smart Grids, Microgrids, and District-Level Energy Optimisation

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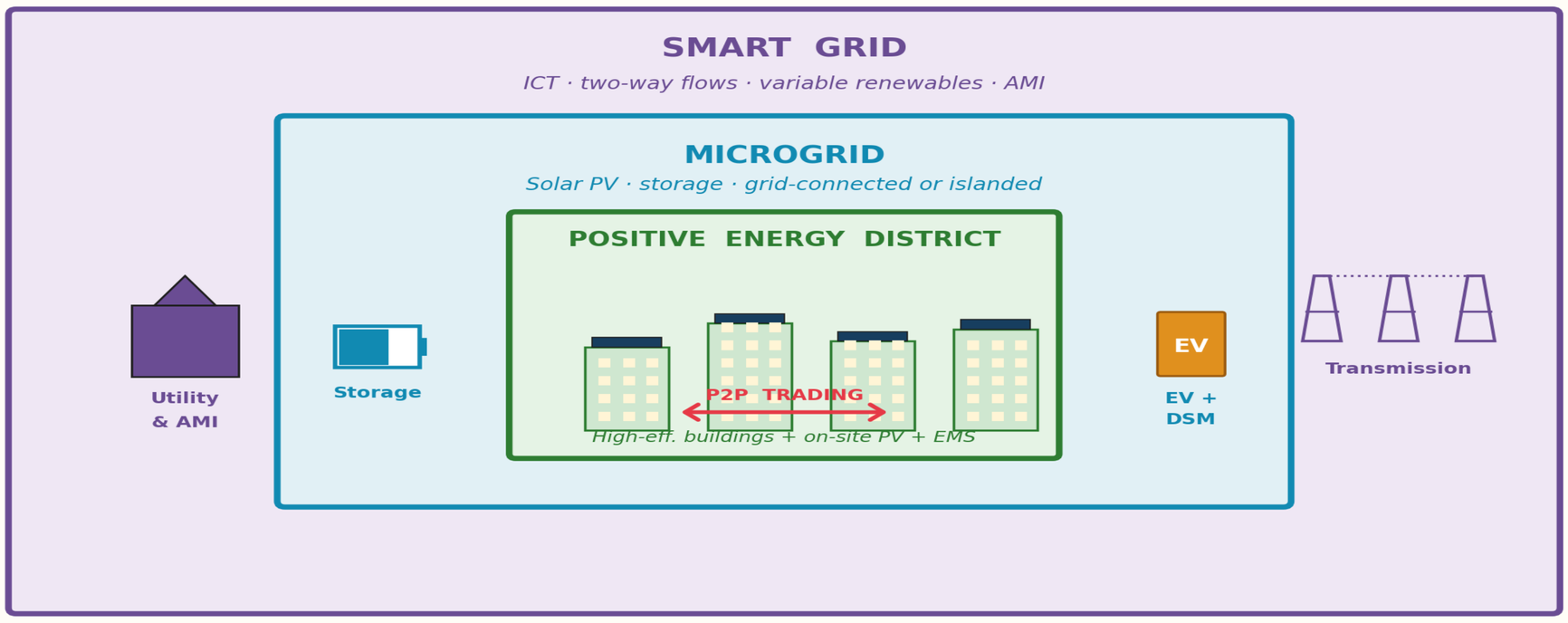
80%
of GHG emissions from cities

PEDs
Net-zero districts are feasible

Three Nested Layers of Integrated Urban Energy

Smart Grid > Microgrid > District / Positive Energy District



From utility-scale grid to neighbourhood: nested control for efficiency, flexibility, resilience

Demand-side management · DERs · blockchain-enabled local markets

1 · INTRODUCTION & AIM

> Cities = **50% pop · 75% energy · 80% GHG**

> Centralised grids: one-way flows, struggling to integrate variable renewables

> Smart grid → ICT-enabled, two-way flows; microgrid → islandable, DER-rich; **PED → net-zero neighbourhood**

> Need: efficiency · flexibility · resilience · equity

AIM How can smart grids, microgrids and district-level optimisation be integrated to deliver efficient, flexible and resilient urban energy?

2 · METHOD

1. Bibliometric review
Peer-reviewed articles 2018–2025 on smart grids, microgrids, urban-energy optimisation

2. Content analysis
Mapped tech & implementation across 5 thematic areas (grid · DER · DSM · P2P · PED)

3. Case-study analysis
Brooklyn Microgrid · Amsterdam Smart Grid · European Positive Energy Districts

4. Mixed-methods assessment
Quant: efficiency, peak-shaving, CO2; Qual: policy, stakeholders, regulation

3 · KEY RESULTS

> Smart meters / AMI → **real-time grid visibility** + better RE integration

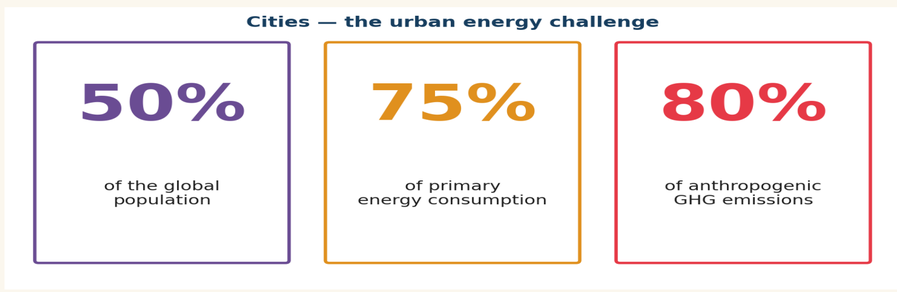
> Microgrids: **higher resilience** + greater on-site renewable self-consumption

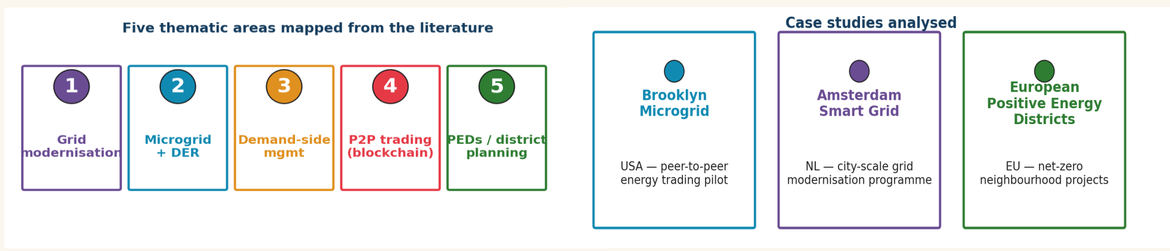
> P2P trading via **blockchain smart contracts** balances prosumer flows

> DSM (real-time pricing, incentives) → **flatter load curves**

> PEDs feasible: **efficient buildings + on-site RE + advanced EMS**

> Barriers: **regulation · interoperability · cybersecurity · social equity**





4 · CONCLUSION & TAKE-HOME MESSAGE

Take-home **Nest smart grid + microgrid + district optimisation to deliver climate-neutral urban energy at scale.**

1. Scale pilot microgrids to district level 2. Standardise interoperability protocols 3. Embed AI/ML for predictive energy management 4. Modernise regulation for decentralised systems & P2P trading 5. Inclusive governance — equitable benefits across populations

5 · DISCUSS · SCAN · CONNECT

Talk to us → *which barrier blocks scale-up the most?*

[1] Regulatory misalignment with decentralised systems
[2] Interoperability across devices / vendors
[3] Cybersecurity of smart-grid endpoints
[4] Social equity / inclusive access
[5] Capital cost & financing of pilots

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6 · REFERENCES

Selected references

[1] IEA. Renewables 2024 / World Energy Outlook (2024).
[2] IRENA. Innovation Outlook: Smart Charging & Microgrids (2023).
[3] Brooklyn Microgrid (LO3 Energy) project documentation.
[4] City of Amsterdam. Smart Grid programme reports.
[5] EU JPI Urban Europe — Positive Energy Districts.