National Institute of Urban Affairs

WORLD ECONOMIC FORUM

In collaboration
with Accenture

Urban Electrification and Energy Efficiency: 10 Global Best Practices

COMMUNITY PAPER

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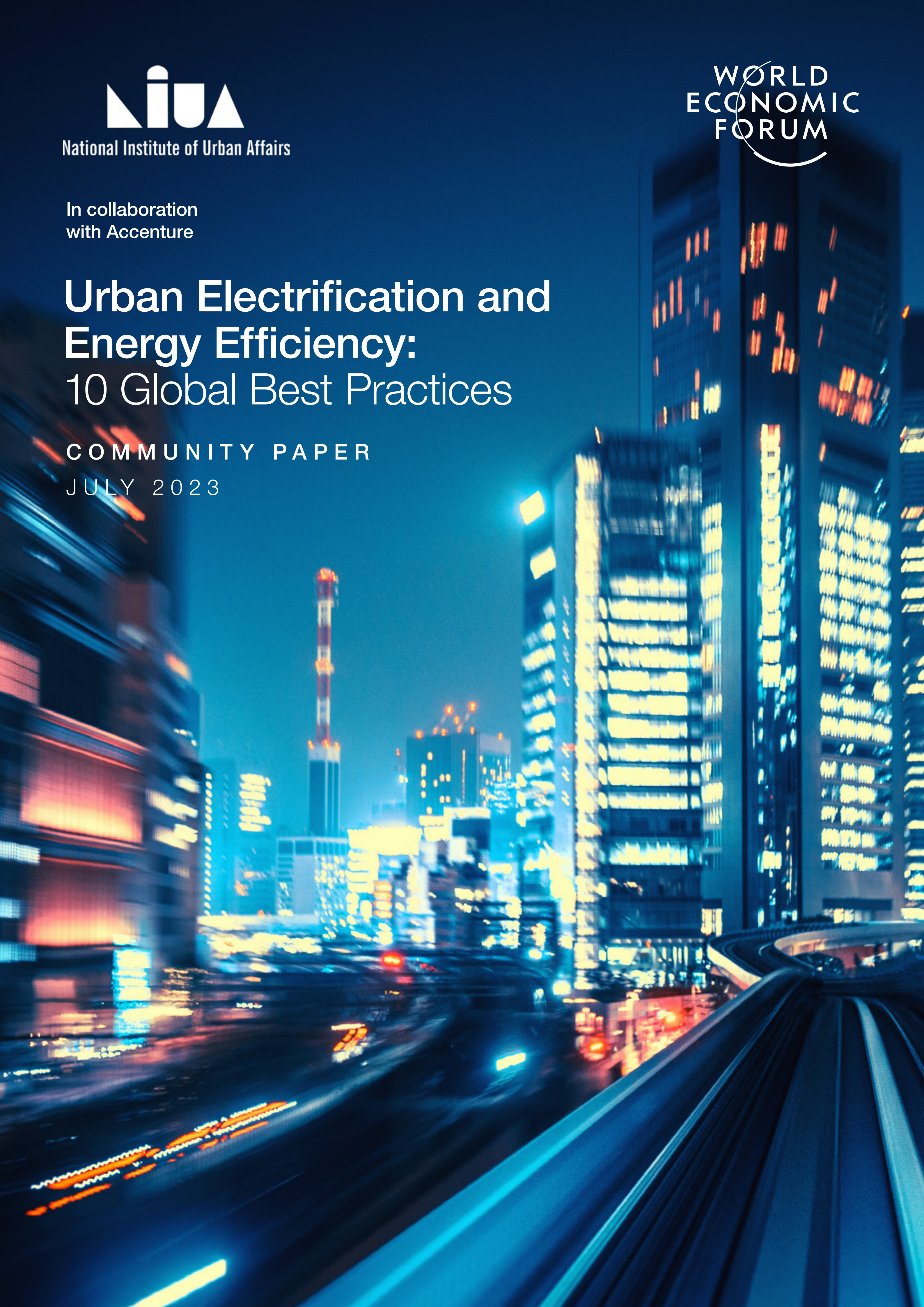

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Foreword

Collaboration between government and business leaders is imperative to effectively reshape energy consumption in cities.

Kristen Panerali,
Head, Clean Power and Electrification,
World Economic Forum

Hitesh Vaidya,
Director, National Institute of Urban Affairs

If the world is to keep pace with limiting the global temperature rise to below 1.5°C compared to pre-industrial levels, a transition to a clean electrified world is necessary. More than half of the global population live in cities, and while cities cover only 3% of the Earth's land surface, they are responsible for more than 70% of all carbon emissions, mainly from buildings, energy and transport.[1]

For the urban energy transformation to help us attain our climate-related goals, it must be guided by the need for a just, affordable and resilient transition – while also providing reliable access to supply. Government and business leaders have a vital role to play in reshaping energy consumption in cities. In particular, shifting energy usage in the transportation and built environment sectors from fossil fuels to electricity leads to improved energy efficiency. Electrification holds great potential to reduce final energy demand as electric technologies are generally much more efficient than fossil fuel-based alternatives.

This paper highlights 10 innovative solutions seeking to transform energy consumption in cities, that will result in a range of benefits, including emissions reductions, job creation, resilience and a more just system. These approaches are intended to inspire business and government leaders and contain elements that can be replicated in different geographies. The World Economic Forum's Toolbox of Solutions,[2] supported by knowledge partner Accenture, is the result of a collaboration between multiple partners. It hosts additional solutions, such as those featured in this report, and includes approximately 300 best practices and case studies across the energy, built environment, mobility, and water and waste management domains.

The World Economic Forum engages government, business and civil society leaders on topics including the clean energy transition and urban transformation. Several programmes focus on enabling clean electrification. The Net Zero Carbon Cities programme,[3] for example, aims to create an enabling environment for clean electrification and circularity, resulting in urban decarbonization and resilience. The initiative aims to do this by fostering public-private collaboration to bridge the gap across the energy, built environment and transport sectors. Meanwhile, the Clean Power and Electrification Program[4] is mobilizing global and regional alliances of business and government leaders to take action today in order to meet the 2030 goals for clean energy transition. Together, stakeholders can address the policy and business model frameworks needed for the large-scale deployment of clean electricity supply, transmission and electrification. One major focus is on the actions needed to rapidly scale electrification and improve energy efficiency across industry, buildings and transport to achieve net-zero goals.

The National Institute of Urban Affairs is committed to promoting the cross-sector collaboration critical to urban sustainability transitions. This includes the sharing of best decarbonization practices, policy ideas, technologies and business models to support cities with the implementation of climate-related measures.

Executive summary

The urban transition towards electrification and improved energy efficiency plays a crucial role in limiting the increase in global temperatures.

Cities consume more than 78% of the world's primary energy and generate 70% of total carbon emissions.[5] By 2050, more than two-thirds of the world's population is set to live in cities, and demand for energy is expected to increase, with associated environmental impacts.

Emerging markets and developing economies are critical to global climate efforts: in the past decade they accounted for more than 95% of the increase in greenhouse gas (GHG) emissions,[6] and this decade are expected to account for 98% of global population growth, further driving energy demand.[7]

Improved energy efficiency and electrification backed by clean power sources are the priority measures needed to accelerate the energy transition. Government and business leaders have roles to play in electrifying urban energy consumption and making it more efficient, and deploying new technologies, business models and digitalization.

Electrification in the urban domain refers to the adoption of electric power as the primary source of energy in various sectors, including the built environment and transportation. More efficient use of energy and resources, combined with behavioural change, will help offset increases in energy demand as the world economy grows and access to energy is extended to all.

City-wide approaches

– The City of Ithaca, USA, pledging to become a carbon-neutral city by 2030, is addressing these challenges by adopting its own Green New Deal, a programme focused on maximizing energy efficiency, decarbonizing transport and buildings and transitioning to a renewable electricity supply. This innovative business model includes securing private-sector funding, transforming low-income housing and sharing the benefits across the city.

– Bologna, Italy, in partnership with Enel X, has installed adaptive street-lighting technologies in 33,000 of its streetlights, which use cameras to adjust the lighting levels based on traffic intensity and weather conditions. This reduces the related energy consumption by 35%, as well as improving city safety by automatically increasing brightness in case of accidents or particularly high traffic flows.

– To improve the financial feasibility of its environmentally sustainable projects, Indore Smart City, India, initiated a carbon credit project cycle for waste management and renewable energy, generating revenue by selling carbon credits on the international market. The city registered three projects – a 600-tonnes-a-day compost plant, a bio-methanation plant and a solar plant under the Verified Carbon Standard (VCS) programme.[8]

Buildings

Buildings are currently responsible for 39% of global energy-related carbon emissions: 28% from operational emissions (energy used to heat, cool and power them) and 11% from materials and construction.[9]

Digital solutions are key to the rapid decarbonization of buildings, and could bring significant benefits, often underestimated by conventional research. In a smart building, real-time data is reported and used to inform decisions and control building operations.

– Siemens' corporate campus in Vienna, Austria, was redeveloped with a microgrid (a self-contained electrical network) of comprehensive smart systems to optimize the management of energy and heating.

– Elsewhere, Schneider Electric helped Landsec create its flagship net-zero building in London, United Kingdom, containing optimized building-management systems and the ability to monitor real-time energy usage.

– The Energy and Resources Institute (TERI) in Bengaluru, India, employs advanced sustainability features to fulfil its power needs, incorporating integrated daylight streaming, rainwater harvesting and a 5kW solar photovoltaic system.

Transportation

Transportation accounts for nearly a quarter of global energy-related carbon emissions, with the majority attributed to road transport.[10] To minimize emissions arising from the road transport sector, electrification and energy efficiency can be achieved through the adoption of fuel-efficient and electric vehicles (EVs), the rollout of related charging infrastructure, and the provision of alternative public transport modes and smart transport systems.

- The Metro de Madrid, Spain, has implemented a self-learning AI-based ventilation system, developed by Accenture, that minimizes carbon emissions while ensuring high air quality and commuter comfort. Taking inspiration from the behaviour pattern of a bee colony, the system has enabled Madrid Metro to reduce its ventilation energy costs by 25% and cut CO_2 emissions by 1,800 tonnes annually.

- Guangzhou, China, has converted its entire bus fleet to run solely on electricity, making it one of China's foremost cities for sustainable urban mobility. The $2.1 billion project also included the installation of a network of 4,000 charging stations and adjustment to the city grid.

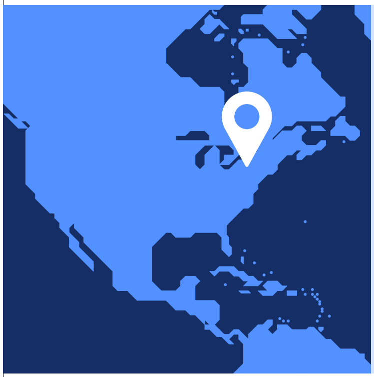
- Rockville, USA, offers an energy-as-a-service bus fleet business model that deploys an integrated microgrid and electric bus charging infrastructure system, containing integrated solar generation, battery energy storage and on-site energy generators to achieve 100% resilience to severe weather and grid outages. The generated solar energy can directly power the buses or be stored in battery energy storage systems for later use during periods of high demand or when the grid is unavailable. The project delivers 62% carbon emissions reduction from buses charged by the microgrid and a lifetime GHG benefit of almost 160,000 tonnes.

- E-rickshaws were introduced in Delhi, India, as an eco-friendly alternative to fossil fuel-powered rickshaws. E-rickshaws are also an affordable mode of transport for short distances, as electric power is more cost-effective than fossil fuel-powered rickshaws and taxis. This also provides cost savings for operators through energy efficiency.

1 10 global best practices

Redefining energy consumption in cities through innovation and digitalization.

1.1 Equitable city-wide electrification



City

Ithaca, United States

Emissions driver

Built environment; power and energy infrastructure

Toolbox of Solutions link

Equitable city-wide electrification

What is the solution?

– The City of Ithaca is the first city in the US to begin the 100% decarbonization of buildings. Its goal is to achieve community-wide carbon neutrality by 2030[11]

– Ithaca aims to achieve this by carrying out an energy efficiency retrofit and the electrification of all buildings, as well as electrifying transport backed by clean power sources

– The strategy is based on three pillars: energy efficiency and electrification; decarbonization of the electric grid; and carbon-negative technologies/low-carbon fuels

Who should use this?

– Cities wishing to achieve city-wide decarbonization through building retrofit and electrification

Implementation considerations

Enablers

– Workforce development: skilled labour capable of executing the projects

– Infrastructure: assessing the state of the city's distribution grid will be necessary

– Partnerships among the private sector, public sector, academia and civil society

Owners of change

– City administration: willingness of city council to implement the programme and support with funding

– Public citizens: community engagement to allow for an absolute reduction in energy demand

– Technology providers/engineers: support with the retrofit and electrification of buildings

Funding

– Supply-side efficiencies and bulk purchasing to reduce the cost of retrofitting and electrification

– Combination of public and private capital innovative funding model, national funding and government subsidies

– Energy demand aggregation and creation of a diverse residential and commercial building portfolio

Case study

– A pilot project was designed in 2021, using 1,000 residential buildings and 600 commercial/industrial buildings. The objective was to assess the financial and technical viability and effectiveness of the model

– The City of Ithaca's Sustainability Office estimates that a 50% reduction in energy intensity, combined with a 90% reduction in carbon intensity, may lead to an ~80% reduction in the city's overall emissions[12]

1.2 Adaptive public lighting

City

Bologna, Italy

Emissions driver

Built environment; power and energy infrastructure

Toolbox of Solutions link

Adaptive public lighting

What is the solution?

- Adaptive lighting solutions that use advanced camera systems capable of adjusting brightness automatically, based on traffic intensity
- Local sensors perform automatic analysis and communicate information using a wireless connection to a remote server. Data is then processed, stored and displayed in a control interface
- Brightness can also increase automatically in case of an accident or particularly high traffic flows

Who should use this?

- Cities with high levels of car dependency and significant lighting requirements (e.g. low sunlight, night-time economy); this solution is especially beneficial for cities with large urban sprawl

Implementation considerations

Enablers

- Data analysis capabilities and digital infrastructure
- Pre-established video-monitoring capabilities in areas where the solution will be implemented

Owners of change

- Government: implements and manages the remote monitoring system
- Private sector: collaborates with government to implement, install and manage the technology

Funding

- Upfront investment recouped through operating cost savings

Case study

- Enel X overhauled the city lighting, managing and maintaining 45,555 light points and 5,100 traffic lights, including a lighting control station
- This reduced electricity consumption by 10 million kWh (kilowatt hours) per year and CO_2 emissions by 8 million tonnes per year, while improving safety, quality of service and lighting

1.3 Municipal green bonds

City

Indore, India

Emissions driver

Power and energy infrastructure

Toolbox of Solutions link

Municipal green bonds

What is the solution?

- A carbon credit is usually equivalent to 1 tonne of CO_2e, which can be used to offset a carbon footprint by investing in an activity that has reduced or sequestered GHGs at another site
- Indore Smart City initiated the carbon credit project cycle for its waste management projects and a solar project
- The revenue was used to finance green projects and solutions, which can be difficult to implement otherwise due to limitations in terms of available government subsidies and foreign investment

Who should use this?

- Metropolitan cities with high carbon-emission generation, requiring huge investments with a long gestation period

Implementation considerations

Enablers

- Strong bureaucracy and leadership, informed decision-making, transparency, and community awareness and engagement

Owners of change

- City government: implements and manages the sale of carbon credits

Funding

- The credits earned through the listing of the projects can be monetized by selling them on the international carbon market

Case study

- Indore Smart City generated revenue by selling carbon credits on the international market. The city generated a revenue of INR 5 million (around $60,000) by selling credits against 0.3 million tonnes of CO_2
- The city registered three projects – a 600-tonnes-a-day compost plant, a bio-methanation plant and a solar plant – under the Verified Carbon Standard (VCS) programme

1.4 Campus microgrid

City
Vienna, Austria

Emissions driver
Built environment; power and energy infrastructure; transport and urban form

Toolbox of Solutions link

Campus microgrid

What is the solution?

- Installation of a microgrid, a smart system to optimize energy management and heating requirements on the company premises
- A smart microgrid controller centrally orchestrates connected assets and the heating supply, and optimizes the power supply to take account of peak loads and grid capacity
- The measured data is gathered in an internet of things (IoT) platform and provides a valuable resource for optimizing consumption management using data analytics solutions

Who should use this?

- Cities with increasing penetration of connected photovoltaic (PV) panels, storage, electric vehicles and connected heating at distribution grid level

Implementation considerations

Enablers

- Collaboration with public and private sectors to scale rollout of microgrid technologies
- Enabling financial incentives and understanding of the benefits of microgrids

Owners of change

- Industrial and manufacturing organizations: provide more connected and smart energy systems and devices
- Government: supports the optimization of microgrids and building management systems

Funding

- Co-investment in connected energy across the public and private sectors
- Provide incentives for private-sector investment in new developments in connected energy

Case study

- Siemens' corporate campus in Vienna was redeveloped with a microgrid of comprehensive smart systems to optimize the management of energy and heating
- The project is unique due to its connection to the existing infrastructure and the combination of PVs, battery storage, microgrid controller, load control and optimized charging solutions for electric vehicles

1.5 Future-ready net-zero buildings

City

London, UK

Emissions driver

Built environment; power and energy infrastructure

Toolbox of Solutions link

Future-ready net-zero buildings

What is the solution?

- The Forge is the UK's first commercial building designed in line with the UK Green Building Council's net-zero carbon framework in both construction and operations
- Through an IoT smart building and energy management platform, The Forge optimizes operational energy consumption to provide full life-cycle energy efficiency and sustainable operations

Who should use this?

- Large cities and areas with a significant need for new builds, building repairs/retrofits and deferred maintenance backlogs

Implementation considerations

Enablers

- Requires expertise in efficient building management systems and energy conservation measures
- Also requires equipment upgrades, advanced lighting technology sensors and controls
- An offsite construction process that pre-packages units for building management system controls

Owners of change

- Real estate and technology companies: integrate technology and redesign building standards
- Government: identifies opportunities, creates legislation and financial incentives
- Developers: adhere to and comply with standards

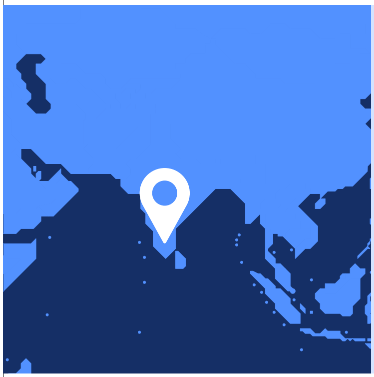
Funding

- Performance contracting can provide a funding mechanism for facility repairs and renovations

Case study

- The solution was applied to new construction using optimized building management systems to maximize operational efficiency, provide data for actionable insights and monitor real-time energy usage and infrastructure
- The Forge showed a 25% reduction in embodied carbon from the initial design stage and was selected as a demonstrator project for the Transforming Construction Challenge initiative[13]

1.6 Solar passive architecture



City

Bangalore, India

Emissions driver

Built environment; power and energy infrastructure

Toolbox of Solutions link

Solar passive architecture

What is the solution?

- Passive architecture in office buildings can be used to maintain indoor temperature through the right mix of fresh air and recirculation, daylight and artificial lighting
- The energy from the sun is used to heat and cool living spaces. The system relies on natural heat transfer processes to collect, store and redistribute energy

Who should use this?

- Cities in hot climates, to mitigate heat and humidity, improve natural ventilation and minimize the reliance on mechanical cooling systems

Implementation considerations

Enablers

- Adherence to building guidelines
- Partnership with developers
- Pre-existing building standards and policies that can be built upon and scaled

Owners of change

- Government: enacts passive architecture building standards and investment in development
- Private entities and citizens: participation in upgrades

Funding

- Provide incentives for private-sector investment in new developments

Case study

- Energy and Resources Institute (TERI) office building in Bengaluru uses integrated daylight streaming through skylights that shine into the heart of the building
- Additionally, an efficient rainwater harvesting system and a 5kW solar photovoltaic system meet a good part of its power requirement

1.7 AI metro ventilation system

City
Madrid, Spain

Emissions driver
Power and energy infrastructure; transport and urban form

Toolbox of Solutions link

Artificial intelligence (AI) metro ventilation system

What is the solution?

- The ventilation system uses AI to leverage data on air temperature, station architecture, train frequency, passenger load and electricity price to determine optimal levels
- This reduces energy costs and emissions, as well as improving the air quality within stations
- The ventilation system also features a simulation engine and a maintenance module. It detects fan operation failures and allows Madrid Metro to carry out equipment maintenance

Who should use this?

- Large cities with an underground transport network

Implementation considerations

Enablers

- Existing public underground or metro network with available data
- An implementable public transport management system with integrated AI solution

Owners of change

- Technology providers: engineers/designers/ developers to integrate the system
- City administration: willingness to implement system from public-sector transport department and the required funding to do so

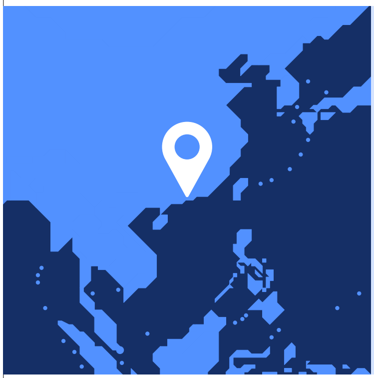
Funding

- Government funding or incentives to support energy efficiency projects
- Private-sector investment in AI solutions and energy management

Case study

- The Accenture Applied Intelligence team helped Madrid Metro ventilation experts devise and implement a system that uses an algorithm to identify the optimal balance of ventilation at each station
- The improved ventilation system has enabled the Madrid Metro to reduce its energy costs for ventilation by 25% and cut CO_2 emissions by 1,800 tonnes annually

1.8 Public transport fleet electrification



City

Guangzhou, China

Emissions driver

Power and energy infrastructure; transport and urban form

Toolbox of Solutions link

Public transport fleet electrification

What is the solution?

– Electrification of a public transport system requires the careful selection and purchase of an electric bus fleet or battery-powered electric buses (BEBs) and installation of large-scale charging infrastructure

– This solution is complemented well by a bus rapid transit (BRT) system, carbon-free last mile transportation modes and supporting carbon-free public transport

– It resulted after 6 million citizens demanded it as the air and noise pollution of the previous fossil fuel-powered buses had become a major irritant

Who should use this?

– Best fit for cities with larger public transport programmes that contribute heavily to the city's carbon footprint

Implementation considerations

Enablers

– Existing network of electric vehicle (EV) charging infrastructure that the public transport fleet can use

– Partnerships with EV players in the private sector

– Other modes of public transport in the city to support integrated transport offerings

Owners of change

– Government: funds and manages BEB programmes with existing transport authority

– Utility/renewables provider: engages municipality throughout the electrification process

– Private entities and citizens: use electrified public transport and support municipal debt issuance

Funding

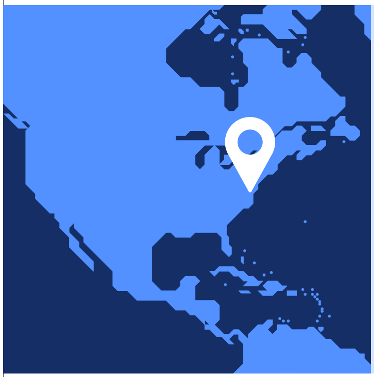
– Government funding or incentives to support EV charging infrastructure expansion

Case study

– In 2018, Guangzhou converted its entire fleet of 11,220 buses to run on electricity; this was supported by 4,000 municipal charging stations with a programme cost of $2.1 billion (each bus cost around $266,000)

– A carbon emissions reduction of 300,000 tonnes annually has been realized by the city, which is now in the process of electrifying its taxi fleet

1.9 Energy-as-a-service bus fleet electrification



City

Rockville, Montgomery County, United States

Emissions driver

Power and energy infrastructure; transport and urban form

Toolbox of Solutions link

Energy-as-a-service bus fleet electrification

What is the solution?

- Technologies can support the transition from fossil fuel-powered buses to electric buses with customized energy and infrastructure solutions, ensuring uninterrupted services during power outages or disruptions
- Energy-as-a-service business models and enabling technologies avoid utility demand charges, while time-of-use tariffs provide fleet operations with ultimate dispatch flexibility
- Energy-as-a-service approaches eliminate upfront costs including microgrid and charging infrastructure, and provide long-term cost predictability for energy supply, alongside local job creation

Who should use this?

- Best fit for cities with larger public transport programmes that contribute heavily to the city's carbon footprint

Implementation considerations

Enablers

- Partnerships with EV players in the private sector
- Integrated public transport and mobility offering

Owners of change

- Government: funds and manages programmes with existing transport authority
- Utilities: support electrification and grid upgrades
- Citizens: opt to use electrified public transport

Funding

- Government funding or incentives to support expansion of EV charging infrastructure

Case study

- Montgomery County's energy-as-a-service fleet electrification infrastructure project integrates solar PV canopies, on-site generation, battery energy storage, microgrid controls and electric bus chargers
- This ensures the fleet's continuous operation regardless of utility outages, with sustainable and resilient energy and charging infrastructure supporting at least 44 electric buses at the Brookville, Montgomery County, Smart Energy Bus Depot

1.10 Electric vehicle subsidies for two- and three-wheelers

City
Delhi, India

Emissions driver
Power and energy infrastructure; transport and urban form

Toolbox of Solutions link

Electric vehicle subsidies for two- and three-wheelers

What is the solution?

- E-rickshaws run on electric power and provide last-mile connectivity, particularly in congested areas and narrow lanes that larger vehicles cannot easily navigate
- E-rickshaws are also more energy-efficient, providing cost savings for operators, and significantly reducing air and noise pollution compared to their petrol or diesel counterparts
- Cities that attract a large number of tourists can benefit from e-mobility solutions to enhance their transport systems and reduce the environmental impact of tourism

Who should use this?

- Metropolitan areas, consisting of a central city and surrounding suburbs, to address transport challenges across a larger geographic area

Implementation considerations

Enablers

- Existing network of EV charging infrastructure that the public transport fleet can use
- Partnership with EV players in the private sector

Owners of change

- Government: funds and manages programme with existing transport authority
- Utility/renewables provider: engages municipality throughout the electrification process
- Citizens: use subsidies and transition towards electric vehicles and micro mobility

Funding

- Government funding or incentives to support EV charging infrastructure expansion
- Financial incentives such as taxes and congestion charges create revenue to reinvest in net zero options

Case study

- Delhi's government offers subsidies to retrofit and register e-rickshaws, alongside dedicated parking facilities
- The solution offers an affordable mode of transport for short distances. The fare charged to passengers is generally lower than that of auto-rickshaws or taxis

Contributors

Lead Authors

Martin Cruickshank
Project Fellow, Clean Power and Electrification, World Economic Forum

Jotham Prabhu
Program Officer Energy – CITIIS, The National Institute of Urban Affairs

World Economic Forum

Prerana Pakhrin Misrahi
Lead, Clean Power and Electrification – Centre for Energy and Materials

Kristen Panerali
Head, Clean Power and Electrification – Centre for Energy and Materials

The National Institute of Urban Affairs

Uttra Dasgupta
Knowledge Officer – CITIIS

Naim Keruwala
Program Director – CITIIS

Bibek Sandhu
Program Manager – CITIIS

Accenture

Hollie Adams
Management Consulting Analyst

Sanda Tuzlic
Global Connected Energy and E-mobility Lead

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Global best practice contributors:

Best Practice 1.1
Luis Aguirre-Torres
Director, Financial Planning and Analysis, and Financing Solutions, New York State Energy Research and Development Authority

Best Practice 1.2
ENEL X

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CapaCITIES

Production

Laurence Denmark
Creative Director, Studio Miko

Ali Moore
Editor, Astra Content

Endnotes

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WORLD ECONOMIC FORUM

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World Economic Forum
91–93 route de la Capite
CH-1223 Cologny/Geneva
Switzerland

Tel.: +41 (0) 22 869 1212
Fax: +41 (0) 22 786 2744
contact@weforum.org
www.weforum.org