ENERGISE 2025
BOOK OF ABSTRACTS

	Technical Session Theme 1: Resilient and adaptive built environments Sub-Themes:

Paper ID: 1278

De-centralized Dry and Garden Waste to Pellets – A Sustainable Waste-to-Energy Solution (URJWALA)

Ashish Vaishnav[1]
Gangotree Energy Projects Private Limited, Pune, India

Abstract

Municipal Solid Waste (MSW) management in India's urban areas—spanning residential societies, townships, banquet halls, hotels, and institutional campuses—continues to face a massive and growing challenge due to the prevailing centralized waste handling approach. A significant portion of urban waste comprises non-recyclable dry waste and garden waste, which is typically mixed with other streams, making it unsuitable for material recovery and leading to either landfilling or open burning.

To address this, the URJWALA model offers a decentralized, at-source waste-to-energy solution designed specifically for India's waste and energy landscape. The model deploys mobile and stationary shredding and pelletizing units, ranging from 500 kg/day to 2 TPD capacity, to process non-recyclable dry and garden waste into high-calorific solid fuel pellets. These pellets are clean-burning, energy-dense, and suitable for co-firing in existing industrial boilers. Long-term combustion trials with Thermax Ltd. have demonstrated the technical viability and emission compliance of these pellets, with successful 15–20% substitution alongside biomass fuels in steam generation systems.

The model delivers multiple co-benefits: it reduces landfill dependency, cuts down on transportation emissions, promotes segregation at source, and creates livelihood opportunities by engaging informal waste workers as trained operators, known as 'UrjaDaatas'.

This paper presents the complete methodology, results from on-ground pilot implementations in Pune (at BEG and KCB), and the operational integration of pellet supply with industrial users showcasing the viability of this approach. The URJWALA solution not only addresses urban waste processing but also aligns with India's thermal energy demand, climate mitigation goals, and circular economy principles—offering a scalable, economically viable alternative to conventional RDF and WTE models.

Paper ID: 1259

The Cooling Impact of Street Trees along with built morphology on Urban Heat Island Mitigation

Suman Maurya[1a], Aaditya Pratap Sanyal[1b] Gauri Sukare[2]
[1]IIT(BHU) Varanasi, India
[2]Institute of Environment & Sustainable Development-BHU, Varanasi, India

Abstract

The urban heat island (UHI) effect is a pressing challenge in urban planning, as cities tend to experience higher temperatures than their rural surroundings. This phenomenon is exacerbated by the increasing prevalence of extreme temperatures globally. As urban areas struggle with rising temperatures and the Urban Heat Island (UHI) effect, strategic shading becomes an essential passive cooling technique. This review synthesizes findings from various studies examining how trees and built morphology work together to regulate urban

microclimates, highlighting the importance of integrating 3D modeling in urban heat studies. The research shows that appropriate tree and building placement can greatly lower land surface temperatures (LST), improve thermal comfort, and reduce solar heat gain by examining how building and vegetation spatial arrangements affect shade dynamics. This study contributes to the expanding body of knowledge on sustainable development by giving actual information about the effectiveness of urban forests and street trees in alleviating UHI. High-resolution, integrated 3D modeling that takes into consideration the temporal and spatial interactions between natural and constructed elements is what this study promotes. It emphasizes how crucial elements like evapotranspiration, building orientation, material albedo, and tree canopy structure are in determining urban thermal performance. With a focus on evidence-based planning that makes use of interconnected green and built infrastructures, the findings help shape climate-resilient urban design strategies. The study suggests that incorporating urban woods and street trees is a viable and cost-effective way to reduce UHI effects. The study emphasizes the significance of species selection, tree density, and positioning in optimizing thermal benefits. Future study may incorporate predictive models for optimal tree dispersal and assessing long-term climate resilience effects.

Paper ID: 1254

Relevance of Solar Passive Architecture in design of Air conditioned buildings.

Ar. Samyukta Raman[1], Ar. Harshita Vangara[2]
[1]JNAFAU, Hyderabad, India
[2]JNAFAU, Hyderabad, India

Abstract

Architecture for climate comfort considers building envelope, natural ventilation, and landscape design for achieving climate comfort. In current times, with the advent of commercial buildings, sealing of the building envelope has become mandatory to increase efficiency of the HVAC system thereby making natural ventilation techniques irrelevant.

The Authors aim to test passive design maxims for envelope design and natural ventilation to check their relevance against building performance criteria used today.

Objectives of the research are-

1. Relevance of passive solar design techniques- window distribution, shading techniques, thermal lag achieved through wall systems for reducing EPI of air-conditioned buildings.
2. Relevance of the above-mentioned techniques in achieving thermal comfort in naturally ventilated buildings.

Specific effectiveness of passive design techniques in warm humid climates where traditional passive design also considers cooling through air movement.

Paper ID: 1185

Holistic Sustainability: Reducing Carbon Footprint from Material Selection to Building Operation

Pramod A[1]
[1]buildAhome , Bengaluru , India

Abstract

The construction industry plays a major role in global carbon emissions, contributing around 38% of total CO2 emissions. This includes emissions generated from building materials, construction activities, and the energy required for building operations. The production of

materials like cement, steel, and aluminium is a significant source of these emissions. Carbon emissions are closely linked to climate change, which leads to rising temperatures, extreme weather conditions, sea level rise, altered precipitation patterns, and adverse effects on ecosystems and human health. These environmental shifts impact water availability, food production, wildlife habitats, and overall human well-being.

This study explores the concept of green homes, modern building materials, and sustainable construction techniques aimed at minimizing carbon emissions. It emphasizes the use of low-carbon materials, energy-efficient construction methods, and strategies to reduce waste and transportation impacts. Materials such as porotherm blocks, clay tiles, Athangudi tiles, and ceramic tiles contribute to lowering emissions. Additionally, adopting filler slabs made from clay pots, glass bottles, and other recycled materials enhances thermal insulation. Techniques like rainwater harvesting, gray water recycling, and sewage treatment plants (STPs) help achieve net-zero water usage. The integration of solar panels, geothermal cooling, thermal insulation, and cross-ventilation methods significantly reduces energy consumption and electricity usage.

Between 2017 and 2024, the transition to green homes has led to considerable improvements in power, energy, and water conservation. Carbon emissions have dropped from 15,075 tonnes to 3,600 tonnes for 75 houses of 6,000 sqft, demonstrating the success of sustainable construction practices. A major factor in this reduction is the decreased use of steel and concrete. For every 6,000 square-foot building, these methods help cut carbon emissions by 153 tonnes.

Paper ID: 1298

Building Stock Intelligence: Leveraging Geospatial Analytics for Urban Landscape Assessment in India

Rohit Jindal[1], Jorley Johnson[2]
[1]Alliance for an Energy Efficient Economy, New Delhi, India

Abstract

With the rapid growth of open geospatial data, researchers have powerful tools to better understand India's built and natural environments. This paper presents a comparative analysis of widely used open-source datasets for buildings—Google Open Buildings, Microsoft Building Footprints, and OpenStreetMap—alongside MODIS and Landsat datasets for Land Surface Temperature (LST). These datasets are assessed on key parameters such as spatial and temporal resolution, accuracy, and suitability for large-scale analysis in India. The study goes beyond comparison to demonstrate how integrating building and LST data with open land use, energy consumption, and socioeconomic indicators can offer richer insights for building stock analysis. We present a clear workflow for this integration and discuss practical data mining methods, including building density calculations and spatial joins. The findings highlight that while no single dataset is perfect, thoughtful integration can compensate for individual limitations, unlocking the potential of open geospatial data to inform disaster response, urban resilience, and energy management—key priorities as Indian cities continue to grow and face increasing climate risks.

Paper ID: 1342

The difficulties in quantifying indoor thermal comfort

Ojo Patrick Duke[1,2,3], Anupama Kowli[1], Jenny Zhou[2]
[1]Department of Electrical Engineering, Indian Institute of Technology Bombay, Mumbai, India

[2]Department of Civil and Environmental Engineering, Monash University, Clayton, 3800, VIC, Australia
[3]IITB-Monash Research Academy, IIT Bombay, Mumbai, 400076, Maharashtra, India

Abstract

Quantifying indoor thermal comfort remains a significant challenge due to the interplay between environmental variables, physiological states, and subjective human perception. This study evaluates the performance of widely used thermal comfort indices—PMV, PET, SET, and empirical indices like the Discomfort Index (DI) and Heat Index (HI)—against occupant-reported thermal sensation and thermal comfort using data from the Indian subset of the ASHRAE Global Thermal Comfort Database II. Employing both correlation analysis and confusion matrix-based evaluation (accuracy, precision, recall, and F1-score), we find that while computed indices such as PMV and the two-node model exhibit strong internal agreement (r=0.83), they align poorly with actual occupant feedback (F1-scores < 0.33). In contrast, DI shows the best overall performance across multiple scenarios, especially under air-conditioned conditions, where it achieves an accuracy of 0.77. The analysis also reveals that building cooling strategy strongly impacts model performance, with air-conditioned spaces yielding higher classification accuracies than naturally ventilated or mixed-mode environments. A detailed investigation into behavioural and seasonal variables (Clothing insulation (Clo), Metabolic rate (MET), Season, and thermal preference (TP)) further highlights why model–occupant misalignment persists, underscoring the need for adaptive, context-aware comfort models. These findings suggest that simplified empirical models may outperform complex indices under certain indoor conditions and that future comfort assessment tools must better integrate human adaptability and environmental dynamics.

Paper ID: 1335

Why Insulation Falls Short in India's Residential Buildings A Life Cycle Cost Analysis Comparing Insulation and Air-Conditioning Systems

Gaurav Vakil [1,3], Yashima Jain[2,4], Prasad Vaidya[2,3]
[1]eCube Consultancy, Aurangabad, India
[2]Indian Institute for Human Settlements, Bengaluru, India
[3]Alliance for an Energy Efficient Economy, New Delhi, India
[4]Lawrence Berkeley National Laboratory, Berkeley, USA

Abstract

This paper evaluates the financial viability of investing in either wall insulation or energy-efficient air conditioning systems in Indian residential buildings. India’s rapid urbanization is expected to create demand for approximately 230 million new housing units by 2047, and rising living standards combined with increasing temperature and humidity are anticipated to drive an increase in air-conditioner demand. The study aimed to determine which option, insulated wall assemblies or efficient air-conditioning, offers better long-term cost-effectiveness and adaptability for Indian residential buildings.

The Government of India introduced the Eco-Niwas Samhita (ENS) in 2018 that includes minimum Residential Envelope Transmittance Value (RETV), which minimizes envelope heat gain. However, prevalent construction practices in India, such as Mivan (monolithic concrete) technology and fired brick walls do not comply with the ENS requirements. Achieving compliance typically requires assemblies using aerated autoclaved concrete (AAC) blocks or additional insulation layers, both of which pose workmanship challenges, slow down construction, and, in the case of AAC, present their own material issues. Despite the promotion

of ENS standards through financing programmes, insulated wall construction has not seen any momentum in residential construction.

Notably, a majority of Indian homes continue to use natural or mixed-mode ventilation strategies rather than full-house and year-round air conditioning. Our previous research indicates that, in mixed-mode buildings, wall insulation can reduce thermal comfort when the building operates in natural ventilation mode in several climate zones of India. Building on these findings, this study conducts a 50-year life-cycle cost (LCC) analysis using a calibrated simulation model for four climate zones in India, comparing the cost-effectiveness of insulated walls and efficient air-conditioning systems under two operational scenarios: fully air-conditioned mode (AC-Mode) and mixed-mode (MM-Mode).

The results reveal that in both AC-Mode and MM-Mode, efficient air-conditioning provides a marginal economic advantage of 0–3% Life-Cycle Cost reduction across four Indian climate zones compared to insulation. Moreover, efficient air-conditioning offers greater flexibility, as occupants can upgrade to more advanced models every decade, and provides better cash-flow opportunities due to its lower initial capital cost. In contrast, insulation is a one-time installation with no scope for future performance improvement, is susceptible to degradation from poor workmanship, moisture ingress, or structural changes, and rarely ensures thermal comfort on its own. In residential development, developers also face the challenge of recovering insulation costs through home-sale prices, which impacts affordability. These findings highlight that, particularly in AC-Mode operation, efficient cooling technologies represent a more practical and adaptable long-term strategy for Indian residential buildings.

Paper ID: 1323

Performance assessment of BIPV cladding: Integration approaches for summer and winter

Priyanka Rai[1], Amartya Chowdhury[1]

[1]Centre for Energy and Environment, Jaipur, India

Abstract

The ventilated Building-Integrated Photovoltaic (BIPV) façade is one of the most widely adopted and innovative solutions, offering significant energy-saving benefits by integrating photovoltaic (PV) modules into the building envelope. However, due to its complex thermal and electrical interactions, accurately predicting its real-world performance through numerical analysis remains challenging. This study presents the findings of an extensive monitoring conducted on a BIPV test chamber with different PV integration strategies to compare their thermal and electrical performance in a composite climate. Specifically, the research focuses on evaluating the transient thermal response of the building envelope for two configurations: (i) PV cladding installed directly on the front surface and (ii) PV cladding combined with a front glass layer. The monitoring campaign was conducted during both summer and winter seasons, ensuring consistent conditions by using walls with equivalent thermal transmittance (U-value-0.49 W/m²K). The experimental investigation aimed to assess how these configurations impact heat transfer mechanisms, convective airflow, and electrical efficiency. The results indicate that integrating PV with a front glass layer increases convective heat flow within the air cavity by 4.4 - 4.9 W/m², leading to enhanced “solar chimney effect” but causing a reduction in electrical efficiency due to higher module temperatures. Conversely, when PV panels are positioned in front of the envelope with an air gap of 10 cm, the electrical efficiency by 7-8% due to better cooling effects and enhanced airflow. These findings highlight the trade-offs between thermal and electrical performance in different BIPV configurations and provide

valuable insights for optimizing PV integration strategies in buildings. The study contributes to the advancement of BIPV systems, aiding in the development of more efficient and sustainable building envelopes.

Paper ID: 1314

Scaling Cool Roofs for Heat Resilience: Field Evidence from Chennai's low-income housing

Akanksha Agrawal[1], Akhil Singhal[1]
[1]RMI India Foundation, Delhi, India

Abstract

Chennai, one of India's rapidly urbanising cities, experienced a 70% increase in built-up area between 1991 and 2016, largely at the cost of vegetative cover. This amplified the urban heat island effect, with urban zones recording temperatures 3 to 5°C higher than nearby rural areas. Widespread use of heat-absorbing materials like concrete and asphalt, combined with consistently high relative humidity levels between 60% and 65%, these conditions exacerbates thermal discomfort. Roofs comprise 20% to 25% of the urban surface and play a critical role in this heat build-up, particularly for low-income residents in top-floor units of poorly insulated public housing. To address this, a cool roof pilot was implemented in a slum rehabilitation housing cluster on the outskirts of Chennai. A total of 7,200 square feet of roof area was coated with an acrylic-based, flexible, microfibre-reinforced cool roof coating. The material demonstrated SRI 102 (Solar Reflectance – 0.81, Thermal Emissivity – 0.90). These properties enable it to reflect a significant portion of solar radiation and emit absorbed heat effectively, reducing rooftop heat gain and enhancing indoor thermal comfort. A comparative monitoring setup assessed surface temperature reduction, indoor thermal performance, and comfort outcomes. Results indicate a reduction of 9°C to 12°C in peak roof surface temperatures and 0.5°C to 1.5°C lower indoor temperatures in treated homes. Comfort hours, based on the Indian Model for Adaptive Comfort, improved from 65% to 85%. With the cost of reflective coating application being 60₹ per square foot, this intervention is both cost-effective and scalable. The findings provide a replicable model for improving heat resilience in affordable housing and support the integration of cool roofs into housing programs and heat action plans across Indian cities.

Paper ID: 1290

Surviving the Choppy Waters: A Case of Floods and Resilience in Kolhapur

Meenal Surawar[1], Apurva Upadhye[1], Soham Dange[1], Ashwathi Sharathkumar[1], Sai Raghavendra Kompella[1]
[1]Visvesvaraya National Institute of Technology, Nagpur, India

Abstract

India ranks second globally in flood-related fatalities, with climate change and rapid urbanization intensifying the crisis. Kolhapur, Maharashtra—a city repeatedly devastated by floods in 1989, 2005, 2019, and 2021—faces increasing vulnerability due to its riverine geography, rapid urban expansion, and changing rainfall patterns. Addressing the urgent need for adaptive infrastructure, this study proposes a flood-resilient, energy-efficient temporary shelter model tailored to disaster-prone regions like Kolhapur. The research combines community engagement with climate-responsive design and sustainable construction practices to develop scalable and inclusive solutions. The proposed shelter integrates passive cooling strategies, renewable energy systems, and flood-resistant materials to ensure safety,

comfort, and self-sufficiency during emergencies. A prototype housing module for 250 people demonstrates the feasibility of this approach. Preliminary analysis reveals a 53.5% reduction in energy consumption achieved through thermal optimization, natural ventilation, and the use of high thermal mass materials. Locally sourced bamboo, selected for its strength and rapid renewability, reduces embodied carbon by 61% while enhancing structural resilience. Prefabrication techniques further lower environmental impact and support swift deployment during disasters. Beyond physical resilience, the shelter design prioritizes energy, water, and food sufficiency, alongside affordability and ease of construction. This holistic approach fosters long-term adaptability and empowers communities with infrastructure that supports both immediate disaster relief and sustainable recovery. By offering a replicable and context-sensitive model, the study contributes a timely and vital solution to disaster-resilient housing, addressing the growing challenges faced by vulnerable regions amid escalating climate threats.

Paper ID: 1284

XAI for Democratization of Deep Learning led Chiller Plant Performance Optimization for Commercial Buildings

Vamanie Perumal[1,2,*], Sibibalan Balasubramaniam[2], Jayesh Jain[2], Satyanarayan Seshadri[1,2]

[1]Indian Institute of Technology Madras, Chennai, India

[2]EnergyEta Solutions Pvt. Ltd., Bangalore, India

Abstract

With the rapid urbanization, there has been a substantial increase in the demand for highly efficient cooling systems. Chiller plants are critical components of building HVAC systems and represent a significant portion of overall energy consumption and operational costs. The imperative for energy efficiency in buildings has driven significant interest in optimizing chiller plant operations. Furthermore, increasingly stringent energy efficiency regulations worldwide are setting demands for significant improvements in the operational performance of these energy-intensive systems. Advanced modeling techniques, particularly deep learning, offer substantial potential for energy savings. However, the inherent complexity and lack of transparency in these "black-box" models present a significant barrier to their widespread adoption by building operators, who often lack specialized data science expertise. This research directly addresses this challenge by demonstrating the utility of an Explainable AI (XAI) framework that synergistically combines the predictive power of deep learning with the interpretability afforded by domain knowledge integration. The XAI framework was rigorously validated using real-world operational data collected from three different commercial buildings with diverse chiller plant configurations and operational profiles. The results demonstrate that the integration of explainability significantly strengthens the optimization capabilities of the underlying deep learning models while concurrently enhancing user trust and the likelihood of adoption. Furthermore, the explainable component enables building operators to understand the causality behind model decisions, facilitating quicker and more accurate fault identification and enabling more informed operational adjustments beyond the initial recommendations. Overall, this improves accessibility and instills confidence in the model-driven insights for achieving sustainable and energy-efficient building operations, ultimately leading to substantial reductions in energy costs and environmental impact.

Paper ID: 1279

Sustainable Design of a Commercial Building in Delhi through High-Performance Analysis and Life Cycle Assessment

Ankur Kulkarni[1], Swati Sawant[1], Ambar Mittal[1]
[1]Kaizen Design Solutions Pvt Ltd, Mumbai, India,

Abstract

This study presents a comprehensive assessment of the environmental performance of a commercial building through the application of Life Cycle Assessment (LCA) combined with energy modeling, aimed at supporting climate-resilient design in the Indian context. The objective was to quantify both embodied and operational carbon emissions and evaluate the effectiveness of integrated sustainability strategies throughout the building's life cycle. A real-world case study from New Delhi was used to ensure practical relevance and to validate the application of LCA in actual project conditions. The methodology involved detailed material inventory, energy simulation, and life cycle impact assessment across all stages of the building's lifespan. By optimizing material selection, the study achieved a 18% reduction in embodied carbon, primarily through the substitution of high-impact construction materials with lower-carbon alternatives. Additionally, a more than 50% reduction in operational carbon was demonstrated through the adoption of passive design measures and high-efficiency building systems. To further support decision-making, sensitivity analysis was conducted to explore the environmental trade-offs of various design scenarios and to identify the most impactful areas for improvement. The findings highlight the importance of using both LCA and energy modeling in tandem to inform early-stage design decisions and achieve measurable reductions in carbon emissions. This approach not only enhances the environmental performance of the building but also aligns with broader goals of climate resilience and sustainable development. The study contributes valuable insights for architects, engineers, and policymakers seeking to implement data-driven, lifecycle-based strategies in building design and planning.

Paper ID: 1269

Climate-Responsive Architecture in Arid Regions: A Correlative Study of India and KSA

Ruman Madambi[1], Shamri. NP[2]
[1]Eranad Knowledge City College Of Architecture, Manjeri, Malappuram, India

Abstract

This research explores the integration of traditional passive design strategies into contemporary architecture within arid regions, focusing on India and Saudi Arabia. The objective is to evaluate how vernacular techniques—such as solar shading, natural ventilation, and heat control—can be adapted and enhanced through suitable materials and spatial configurations to improve thermal comfort and reduce energy consumption. A comparative analysis of key case studies, including Patwon Ki Haveli, Bhunga House, Nassif House, and Salwa Palace, was conducted to assess the effectiveness of architectural elements like courtyards, windcatchers, and high thermal mass. The study also explores innovative combinations such as coral stone with ECO Pact concrete and bamboo with compressed stabilized earth blocks, demonstrating their potential to enhance passive cooling and structural resilience. Findings reveal that traditional materials—such as sandstone, lime plaster, and terracotta in India, and coral stone, adobe, and mudbrick in Saudi Arabia—significantly improve building performance by reducing reliance on mechanical HVAC systems. Micro-level analysis highlights the influence of building orientation, envelope design, and thermal mass in optimizing energy efficiency and

indoor comfort. The research concludes that blending traditional wisdom with sustainable practices offers a viable path toward climate-resilient architecture. This integrated approach not only preserves cultural and material heritage but also provides scalable solutions adaptable to future climate extremes. In doing so, the study contributes to the global discourse on sustainable building practices in hot desert climates and supports the development of energy-efficient, resilient design strategies aligned with both environmental and cultural contexts.

Paper ID: 1263

One Watt per Square Foot: Redefining Building Energy Standards

Sneha Murthy[1], Venkatesh S[1], Zameer Ahmed[1], Eunice Miraclyn[1]

[1]McD BERL, India

Abstract

One-watt building challenge presents an audacious yet achievable target in the realm of energy-efficient building design that aims to reduce the demand load and energy consumption in commercial buildings to a mere one watt per square foot. The purpose of this research is to assess the feasibility and implementation strategies to achieve One-Watt per square foot building design.

One-watt building challenge is rooted in the theory of "Ideal World" by Amory Lovins, which proposes the concept of creating an Ideal World Scenario wherein all environmental parameters 'slow down' after contact with the building envelope. Lovin's philosophy emphasizes that buildings can drastically reduce their energy consumption without sacrificing comfort, functionality, or aesthetic appeal. This challenge underscores the urgent need for the building sector to adapt to the evolving demands of climate change.

The building sector emits approx. 37% of the global CO2 and is considered as the largest energy-consuming sector globally. The need for innovative design strategies, efficient envelope designs, and ultra-efficient mechanical systems is crucial. This research compares two commercial offices in Bengaluru India, both same in the form and function but distinct in energy efficiency. The base case represents a super-efficient case designed to minimize energy use, while the proposed One-Watt case is designed to push boundaries through ultra-efficient technology and design strategies. The challenge in the research was not just to optimize energy usage but also to maintain indoor thermal comfort under variable climatic conditions. The super-efficient base case represents a typical energy-efficient commercial building that operates within a range of 2.5 to 3 watts per square foot which is a significant improvement over conventional commercial buildings which consumes between 4.5 to 6 watts per square foot. The one-watt case outperforms other cases and strives to transcend these improvements by cutting energy consumption to more than half, challenging the limits of what's possible in energy-efficient design and operation.

This research adopts an exploratory approach conducting energy simulations on two different buildings of the same typology and design. Comprehensive design, technological, and operational solutions are addressed to meet the aspirational goal of One-Watt Building, fostering an unimaginable shift in sustainability and energy efficiency. This challenge offers practical pathways to redefine sustainable building design and set new benchmarks for energy efficiency in the built environment. One watt-building concept, if widely used, may completely change the way buildings are designed and built.

One-watt challenge calls on engineers, architects, designers, and developers to adopt cutting-edge technologies that put energy efficiency without sacrificing usability or comfort. Government and policymakers can use these findings to establish building codes and energy efficiency regulations aligning with global carbon reduction targets.

Paper ID: 1260

Enhancing Urban Flood Resilience with Nature-based Solutions: A Comparative Review of Global Case Studies

Devesh Tripathi[1], Aaditya Pratap Sanyal[2]
[1,2] Indian Institute of Technology (BHU), Varanasi, India

Abstract

Urban flooding is a rapidly escalating challenge worldwide, exacerbated by climate change, unplanned urbanization, and ecosystem degradation. Traditional grey infrastructure alone has proven insufficient to sustainably mitigate flood risks. Nature-based Solutions (NbS) offer a transformative approach by integrating natural processes into urban flood management.This study conducts a comparative review of six case studies — Rotterdam, Singapore, New York City, Copenhagen, Wuhan, and Bhubaneswar — where NbS have been employed to enhance urban flood resilience. It systematically analyzes their design, implementation, effectiveness, and community integration, while identifying success factors and trade-offs.The unique contribution of this review lies in its development of a comparative typology of NbS approaches, integrating global best practices with Indian realities to inform urban planning. Results show that NbS reduce flood risks while providing co-benefits such as biodiversity, urban cooling, and community well-being. However, governance, funding, and land tenure challenges persist, underscoring the need for integrated policy support.

Paper ID: 1258

Systematic Literature Review of GIS and AI applications to Construction & Demolition Waste Management to promote Circular Economy.

Parvinder Kaur Marwah[1], Prof. (Dr.) Neeraja Lugani Sethi[2]
[1]Guru Gobind Singh Indraprastha University, University School of Architecture and Planning, New Delhi, India,

Abstract

Construction & Demolition waste management has become an socio-economical and environmental concern across the world due to Rapid urbanization. Traditional waste management methods struggle with the volume and heterogeneity of the waste segments. Minimizing the human factor is an important issue in terms of time, labour, and performance. Data-driven approaches with faster performance rates should be tried and tested to find a real-time solution towards sustainable development. This research conducts a comprehensive literature examination of scientific research advancement of Geographic Information System and AI applications specific to management of Construction and Demolition waste and analyse how they automate the process to promote circular economy. A systematic review was done by applying the PRISMA® methodology to the academic literature published in peer reviewed databases like Science Direct and Google Scholar with a time frame limit from January 2018 till April 2025. Current trends, gaps, potential future directions and challenges were investigated by performing methodological data analysis. All the strategies which are critical for Artificial Intelligence and Geographic Information System based techniques are reviewed and analysed to identify their benefits.

Paper ID: 1247

Assessing Thermal Comfort and Retrofit Performance through Simulation in a High-Rise Aluminium Formwork Apartment under Composite

Climate

Rahul Ukey[1], Himanshu Saini[2], Krishan Sharma[3], Brijesh Pandey[1], Raj Kumar Verma[1]
[1]Alliance for an Energy Efficient Economy, New Delhi, India

Abstract

India's rapid urbanization has led to widespread adoption of monolithic RCC buildings using aluminum formwork for low-cost housing. While these systems offer speed and economy, they raise concerns about indoor thermal comfort and energy efficiency. This study evaluates the thermal performance of a high-rise apartment constructed using aluminum formwork under composite climatic conditions through in-situ monitoring and calibrated energy simulations. Measurements over five months showed the room was thermally acceptable only 32% of the year, with 39% of hours unacceptably hot and 29% unacceptably cold. Using the ASHRAE 55 adaptive thermal comfort model, we analyzed the baseline performance and explored four passive retrofit strategies: external shading for glass doors, double glazing, cool wall coatings, and wall insulation. External shading was found to be the most effective, increasing comfort hours by 14 percentage points, followed by double glazing (12 points), cool wall (9 points), and wall insulation (6 points). These retrofits offer practical, low-energy solutions to improve thermal comfort in fast-track housing, minimizing the need for mechanical cooling. The findings underscore the critical need for incorporating passive design principles into India's mass housing stock and provide a roadmap for energy-efficient retrofitting of thermally suboptimal building envelopes.

Paper ID: 1246

Optimizing HVAC Energy Efficiency with Digital Twin-Enhanced Micro-Zonal Occupant-Centric Control (MZOCC)

Jeslu Celine Jacob[1], Debapratim Pandit[2], Joy Sen[2]
[1]Stanford University, California, USA
[2]Indian Institute of Technology, Kharagpur, India

Abstract

The present paper aims to optimize air-conditioning in existing office spaces using the Micro-Zonal Occupant-Centric Control (MZOCC) strategy, which creates micro-comfort zones around occupants through smart control of conventional HVAC systems and non-intrusive occupant sensing. While earlier research introduced bi-level protocols for MZOCC, where Level 1 optimizes static elements like zone size and diffuser layout, and Level 2 guides airflow strategies based on dynamic occupant usage patterns, its application in real-world offices remains underexplored.

To address this research gap, the paper presents a case-study from a working office in Cochin, South India. A digital twin was developed using CFD simulations informed by field experiments to design and evaluate MZOCC strategies tailored to the case-study office. The study assesses energy savings, thermal comfort improvements, implementation costs, and return on investment. Results show that implementing MZOCC requires approximately 30% additional investment over the current system but achieves a 64% reduction in HVAC energy consumption and a 40% improvement in thermal comfort. The investment can be recovered within 2.6 years and demonstrates the cost-effectiveness of MZOCC.

One of the key limitations of the present paper is that the results are specific to the case study office and may not be directly generalizable to other contexts. Future research will consider a broader range of geographic locations, climate zones, and building types to enhance the generalizability of results. Long-term evaluation of MZOCC's performance, including maintenance needs and occupant satisfaction, will be conducted. In addition, protocols for

integrating MZOCC with redesign of interior layouts will be explored to further optimize energy savings and occupant comfort.

Despite these limitations, the study confirms that MZOCC offers a scalable, occupant-centric HVAC solution. The digital twin-based approach presents a replicable, data-driven framework for architects, engineers, and facility managers to enhance energy efficiency and thermal comfort in existing office buildings.

Paper ID: 1234

Impact of passive parameters on the thermal performance of shelter in a cold climate and high altitude.

Ajeet Kumar[1], Dibakar Rakshit,[1,2], B. Premachandran[1]
[1]Indian Institute of Technology Delhi, New Delhi, India
[2]Indian Institute of Technology Delhi, Abu Dhabi, UAE

Abstract

This study evaluates the impact of passive parameters on the thermal performance of pre-fabricated shelters in cold climates and high-altitude regions. These shelters face extreme temperature variations and limited energy access, making passive design strategies crucial for energy efficiency and occupant comfort. The study employs a simulation-based approach using DesignBuilder software to analyse how building envelope variations, such as orientation, window glazing, insulation thickness for walls and ceilings, and window-to-wall ratio (WWR), affect indoor thermal comfort. The base model of the shelter, with overall dimensions of 18.45 m by 7.62 m, is situated in Leh, Ladakh, and is used for the study. Polyurethane foam (PUF) was used in wall and ceiling insulation, and polycarbonate sheets for window glazing in the existing shelter. The results show that north-facing (0º) and south-facing (180º) orientations provided the highest indoor temperatures compared to other directions; however, north-facing has slightly higher average indoor temperatures. Increasing wall and ceiling insulation thickness improved thermal performance, with ceiling insulation showing a greater impact. A diminishing return was observed beyond 120 mm (walls) and 100 mm (ceiling). Single-layer PC glazing achieved the highest indoor temperature, but double glazing has superior insulation, maximising daytime heat gain and minimising nighttime heat loss. An increase in WWR on the south side significantly enhances winter comfort. Increasing the WWR to 40% WWR raised indoor temperatures by over 8°C, while a decrease on the north side had a negligible impact. These findings underscore the need for climate-optimised. shelter design with particular attention to orientation, insulation thickness, and window design for energy-efficient buildings and prefabricated shelters in cold climates and high-altitude regions.

Paper ID: 1207

Assessment of Solar-Air Temperature Dynamics using Real-Time Climatic Data via a Revamped Radiant Time Series Approach

Shyamvishal Dangi[1], R. R. Bhavsar[1], Shashi Kumar Jain[2]
[1]Space Applications Centre, Ahmedabad, India
[2]Technocrats Institute of Technology, Bhopal, India

Abstract

Heating, ventilation, and air conditioning systems constitute a critical component of modern building infrastructure, accounting for approximately 30 – 40% of the total energy consumption in commercial buildings. The energy demand of ventilation and air conditioning

systems has been further intensified by increased ventilation requirements due to infiltration, fresh air intake, and mandatory health protocols introduced during the COVID-19 pandemic. In the pursuit of energy efficiency, accurate estimation of the peak cooling load is essential for optimal air conditioning design. This study presents a revamped Radiant Time Series (RTS) methodology as an enhancement of the original RTS procedure, aimed at improving the estimation of solar-air temperature and maximum cooling load. The proposed approach integrates in-situ measurements of dynamic climatic parameters – including beam and diffuse solar irradiance, ambient dry-bulb temperature, and relative humidity – alongside specific building envelope characteristics. By capturing the complete physics of heat transfer phenomena, revamped method enables a more precise evaluation of thermal loads. To demonstrate the effectiveness of this approach, surface temperature and maximal cooling load values are computed and compared for original, revamped, and actual measured under peak summer conditions. The results affirm that the revamped methodology yields a more accurate and physically grounded estimation, contributing to the development of energy efficient heating, ventilation, and air conditioning designs. This enhanced approach has been validated through in-situ measurements, which serve to establish the reliability and authenticity of the newly developed method. The close alignment between predicted and measured data underscores the practical viability of the methodology in real-world scenarios.

Paper ID: 1183

Assessing the Potential Impact of Kinetic Facades on Building Energy Efficiency

Ginka Rajeshwar Rao[1]

[1]School of Architecture and Planning, Woxsen University, Hyderabad, Telangana, India,

Abstract

To comprehensively evaluate the energy-saving potential and design optimization strategies of kinetic facades compared to traditional static building envelopes, synthesize data from various research studies and case studies across different climatic contexts and building types. Kinetic facades are elements that are embedded into the building envelope and can move to turn, change position, retract, and so on. Options such as the design of kinetic facades advanced as dynamic architectural shells attracted attention due to the ability for such surfaces to adaptively respond to environmental conditions to ensure the optimal performance of the building envelope in a sustainable manner. Energy-saving potential and design optimization attempt to synthesize data from various research studies and kinetic façade case studies to compare the energy-saving potential of kinetic façades to that offered by traditional, static building envelopes. This paper covers a range of kinetic facade technologies, including moveable shading devices and dynamic glazing systems, as well as responsive building skins. Apart from those baseline assumptions, gathering centered analysis of energy metrics for heating, cooling, and lighting across varying climate contexts and building types. The use of kinetic facades is compared with static facades, showing the improved daylighting, natural ventilation, and overall indoor environmental quality for the user. This paper also discusses the complications of kinetic facades concerning initial costs, maintenance, and the energy demand of the kinetic systems themselves. These results indicate a significant advantage for kinetic facades in the fields of sustainable architecture, as building energy performance and occupant comfort are major challenges of modern society. This paper adds to the increasing knowledge surrounding adaptive building technologies and will serve to facilitate the adoption of kinetic facades in sustainable building design by providing insights for designers, engineers, and policymakers considering their implementation.

Paper ID: 1179

Post-occupancy Unobtrusive Adjustments for Enhancing Daylight Access: A Study of Multi-Occupant Office Spaces in Ahmedabad

Parvathy Rajan[1], Minu Agarwal[1]
[1]CEPT University, Ahmedabad, India

Abstract

Occupant satisfaction plays a crucial role in workplace, as employees spend significant amount of time exposed to indoor environment conditions. This study evaluates two multi-occupant office spaces situated in Ahmedabad, one side-lit and the other a double -height office spaces, to assess daylight penetration and access to views. Daylight availability directly impacts occupant productivity, satisfaction, and well-being. The objective of this study is to assess the efficacy of existing design of the office space and propose minimal interventions improve the daylight access and occupant comfort. Using a combination of field measurements and occupant surveys, vertical illuminance levels were monitored for a week in each space and compared against recommended standards. Despite generous daylight penetration ranging from 51 to 342 lux in the side-lit space and 164 to 182 lux in the double-height space; frequent blind usage was observed, with 66–83% and 39–49% window coverage respectively. This was attributed to excessive illuminance levels (over 2000 lux) and high daylight factors (up to 6% and 45%), causing glare and heat discomfort, particularly for occupants seated near windows. The study found that high window-to-wall ratios, while enhancing daylight, led to increased artificial light usage due to visual discomfort. Simulations based on insights from the onsite field study demonstrated that strategic interventions, such as using low-permeability blinds and optimizing blind heights, could significantly improve visual comfort. In the side-lit office, Annual Sunlight Exposure (ASE) reduced by 47.6%, daylight glare (sDG) by 58.2%, and excessive illuminance by 55.5%. In the double-height space, ASE was reduced by 26.5%, glare by 68.7%, and high illuminance areas by 42%. Workstation repositioning further minimized glare exposure for the double-height office space. non-intrusive design strategies highlight the importance of post-occupancy evaluations in improving daylight utilization, visual comfort, and energy efficiency in office environments.

Paper ID: 1178

Post occupancy assessment of urban cooling strategies for heat island mitigation

Deepa Parekh[1], Sakshi Agrawal[1], Shatakshi Suman[2], Aun Abdullah[2], Atul Patil[2], Akhil Singhal[3,] Mrinal Shrivastava[3]
[1]Kapadia Associates, Mumbai, India
[2]Lodha Group, Mumbai, India
[3]RMI India Foundation, Mumbai, India

Abstract

Urban Heat Island Effect (UHIE) poses a significant environmental challenge in rapidly urbanizing Indian cities, where conventional development practices often intensify heat retention in built environments. This study investigates the effectiveness of urban cooling strategies at a city scale by examining the case of Palava City, a planned urban development located 40 kilometres from Mumbai. Covering 18 square kilometres and developed in phases, Palava City offers a unique opportunity to evaluate how urban design decisions influence thermal comfort. The research focuses on key design interventions such as the orientation of city blocks, street layout, built-to-open space ratios, landscape integration, and material

choices. To assess temperature trends, land surface temperature (LST) data was analysed using satellite imagery and validated with on-site measurements from three monitoring stations. Comparative analysis of Palava's two phases: Phase I and II with the surrounding rural and urban areas was conducted to understand spatial variations in temperature. Findings indicate that Palava Phase-1 has experienced a reduction of approximately 7°C in LST from 2008 to 2023. In addition, its maximum LST remains 2°C cooler than central Mumbai and 3°C cooler than the adjacent Kalyan-Dombivli region. Within Palava Phase-2, developed zones were found to be consistently 1.5–2°C cooler than the neighbouring control settlement of Khoni, even under similar climatic conditions. These results highlight the potential of thoughtful urban planning to mitigate UHIE through passive design strategies. The study underscores the importance of integrating climate-responsive principles into city-scale developments to enhance thermal comfort, reduce heat stress, and contribute to sustainable urban growth.

Paper ID: 1175

Identifying synergies between circular economy and resilience through shelter design in impacted communities

Mehak Gupta[1]; Swarnahiya Ganguly[1]; Asad Sahir [2,*]
[1]Consulting Architect, Alumnus - MBS School of Planning and Architecture, New Delhi
[2]Indian Institute of Technology Ropar, India

Abstract
Golaghat, Assam, is a region highly vulnerable to recurrent flooding and seismic activity, placing its communities at constant risk of displacement and infrastructural collapse. The lack of long-term, adaptable shelters in such disaster-prone zones highlights the urgent need for a sustainable solution that can provide both immediate refuge and long-term community support. *Vanshah Sahaya* is a sustainable Community Resilience Shelter (CRS) developed in response to these critical challenges. In partnership with SEEDS India, the project adopts a multidisciplinary, net-zero approach, integrating renewable energy, water conservation, and locally sourced materials. Designed to serve as an emergency refuge during disasters and a fully functional community center during normal times, it addresses the social and environmental needs of vulnerable populations. The shelter employs Passivated Emitter and Rear Cell (PERC) solar panels, a FLOW battery system, and Maximum Power Point Tracking (MPPT) algorithms to optimize energy generation, achieving a potential output of 3902.5 kWh/year.

Paper ID: 1167

Bridging Climate Goals and Local Action, A Planning Support System for Urban Resilience

Saket Sarraf*[1], Shivang Vyas[2], Archana Mittal[2]
[1]ps Collective, Ahmedabad, India
[2]Independent consultant, Ahmedabad, India

Abstract
Local Area Plans (LAPs) and Town Planning Schemes (TPS) are critical instruments for translating national climate goals into spatially grounded action at the neighbourhood scale in India. Yet, these processes often lack integrated sustainability metrics, scenario-based evaluation, and structured stakeholder engagement, partly due to data limitations, institutional silos, and constrained technical capacity.

This paper addresses these issues through the development of a modular, scalable, and open-source Planning Support System (PSS) designed to enable early-stage, data-informed, and

participatory scenario planning for LAPs and TPS. Built as a lightweight plugin within QGIS, the tool embeds climate-relevant metrics—energy use, carbon emissions, water demand, and mobility impacts—into routine planning workflows. Guided by principles of transparency, usability, and adaptability, the tool supports planners in visualizing alternative futures, comparing trade-offs, and embedding sustainability into the formative stages of plan-making.

The paper makes three contributions: (1) establishes a conceptual and methodological foundation for climate-responsive PSS in the Indian context; (2) demonstrates a prototype tested through academic and simulated statutory pilots; and (3) outlines a roadmap for thematic expansion, algorithmic refinement, and institutional integration. Achieved features include a modular architecture, transparent and editable assumptions, and participatory-friendly outputs; pending work includes additional thematic modules, higher-resolution data integration, a web-based platform, and operational pilots with urban local bodies.

By embedding climate metrics into early statutory planning workflows, the PSS shifts sustainability from a peripheral concern to a core design principle. While this version focuses on LAP/TPS, the architecture is adaptable for future application to Development Plans, Master Plans, and city-scale Climate Action Plans, offering a pathway toward more climate-aligned and inclusive urban planning. This work contributes a practice-ready model for scalable, context-sensitive, and climate-responsive urban planning.

Paper ID: 1141

"It's cool and breezy in here!": Case study of an earth-tube cooled building in Ahmedabad

Niyati S. Naik[1], Dnyanada Joshi[2]

[1] Assistant Professor, Faculty of Architecture, CEPT University, Ahmedabad, India,

Abstract

Non-refrigerant based low-energy cooling techniques are pervasive in India's building sector. In the past three-four decades architects have experimented with integrating them within building design. On the one hand while research efforts are directed towards their design optimization it is also important on the other hand to investigate their architectural integration and thermal environmental performance in existing cases. Our goal through this work was to examine the applicability of earth-tube cooling systems in composite climates by conducting a case-study of an 18-year-old earth-tube cooled auditorium at Gujarat Vidyapeeth in Ahmedabad, India. The objectives were to document the architectural integration and operation of the cooling system, and to investigate its impact on the indoor thermal environment and predicted thermal comfort. The open-loop hybrid system under consideration was designed to combine earth-tube cooling with evaporative cooling, fan-forced and stack ventilation strategies. We used methods like archival research, interviews with the stakeholders, and on-site observations followed by indoor environmental assessment during summer months with and without the system under operation. We identified factors that contributed to funding such important building projects and the barriers that prevent their efficient operation and maintenance. With the earth tube cooling system in operation, it could significantly dampen the summer-time diurnal swings in the indoor temperature and successfully keep the environment within the thermal comfort zone as predicted by the PMV-PPD model. The cooling system lowered the day-time indoor air temperatures by 8-9 °C and increased the relative humidity by 20-30% compared to outdoors. With the adequately design ventilation, indoor air speeds remained in the range of 0.6-0.7 m/s. These aspects made the indoor conditions comfortable during hot-dry summers. Through this case study, we highlight how an integrated design approach leads to a thoughtful building design.

Paper ID: 1126

Million square feet of super-efficient office space: A case study

Pooja Suresh Hollannavar[1], Prasad Vaidya[1], Manoj Hegde[1], Guruprakash Sastry[2]
[1]Indian Institute for Human Settlements, Bangalore, India
[2]Infosys, Bangalore, India

Abstract

This case study explores the Infosys Crescent Building in Bengaluru, India, as a benchmark for High-Performance Building design. Constructed in 2019 and recognised among the "100 Iconic Sustainable Buildings" by the G20 Indian Presidency in 2023, the Crescent Building exemplifies how integrated design and technology can deliver environmental performance without additional construction cost.

The study combines analysis of architectural and construction documentation, performance data, and interviews with design, construction, and operations teams. It evaluates key strategies such as precast construction with integrated insulation, high-performance glazing, solar shading, radiant cooling systems with Dedicated Outdoor Air Systems (DOAS), and on-site renewable energy generation. The building's envelope, lighting systems, and HVAC strategies are optimised for energy and water efficiency while maintaining occupant comfort.

The Crescent Building achieves an Energy Performance Index (EPI) i.e. annual energy consumption in kilowatt-hours, of 75 kWh/m²/year - 50% below the Bureau of Energy Efficiency (BEE) benchmark, yielding over 5.4 million kWh in annual energy savings and INR 57 million in cost reductions. Water conservation strategies, including rainwater harvesting and wastewater recycling, meet 100% of non-potable demand, significantly lowering municipal water dependency.

Quantified outcomes include a reduction of 4,718 tons of CO_2 emissions annually and 341,640 kWh generated from rooftop solar panels. The building's LEED v4.1 Platinum certification and superior indoor environmental quality further underscore its sustainability performance.

This study provides actionable insights for architects, engineers, and policymakers, highlighting how economic viability and environmental responsibility can be simultaneously achieved. It positions the Infosys Crescent Building as a model for resilient, high-performance architecture, promoting broader adoption of integrated sustainable design strategies.

Paper ID: 1117

Integrated Architecture Framework for Indoor Environment and Energy Optimization

Arsh Arora[1], Ronak Sutaria[1], Kevin Joshi[1], Gaurav Rajan[1]
[1]Respirer Living Sciences, Pune, India

Abstract

This paper proposes an AI-driven building management framework to bridge critical gaps in managing indoor environmental quality (IEQ), including insufficient data, contextual adaptability, and scalability. The system integrates a network of IoT-based sensors to monitor real-time air quality and thermal comfort. Algorithms based on building physics and artificial intelligence analyze this data to optimize HVAC settings, implement passive ventilation strategies, and provide actionable recommendations. A dynamic feedback loop ensures effective communication between systems, facility managers, and occupants, enhancing decision-making and automation. Field implementation in an IGBC Platinum-rated corporate office yielded remarkable outcomes: 47% improvement in IAQ compliance and 18.5% energy savings via demand-controlled ventilation and passive cooling. This study highlights the transformative potential of AI-driven solutions for healthier, energy-efficient buildings and offers a roadmap to overcome existing automation challenges.

Paper ID: 1111

Analysis of Life-Cycle Carbon Emissions from Urban Residential Buildings Located at Bengaluru

Saswati Chetia[1], Nivit Mital[1], Sonija Kapooria Phogat[1], Prashant Bhanware[1], Mohit Jain[1], Sameer Maithel[2]
[1]Greentech Knowledge Solutions (P) Ltd., New Delhi, India
[2]Independent Practitioner, Bengaluru, India

Abstract

This study quantifies and explores strategies to reduce both upfront embodied carbon (A1-A5) and operational carbon (B6) in residential buildings in Bengaluru. Three residential building projects were analysed: a high-rise built with monolithic concrete construction, and two low- and mid-rise developments using RCC frame with masonry. Upfront embodied carbon was estimated using bills of quantities, supplier data, and construction-related energy consumption, while operational carbon was assessed over a 50-year period through building energy simulations incorporating projected climate scenarios. The results, normalized per built-up area, indicate upfront embodied carbon values ranging from 338 to 419 $kgCO_2e/m^2$ and operational carbon emissions between 550 and 777 $kgCO_2e/m^2$ over 50 years. The analysis highlights that construction technology, material selection, and sub-structure design significantly influence embodied carbon outcomes. This study estimates that the upfront embodied carbon in most new urban residential buildings in India ranges between 300 and 500 $kgCO_2e/m^2$. This variation reflects differences in construction methods, material use, and regional practices, while also indicating significant potential for further reductions. Key strategies to lower embodied carbon include optimizing structural design to reduce the use of high-impact materials like concrete and steel, incorporating industrial by-products such as fly ash and slag in cementitious mixes, and adopting low-carbon masonry solutions. Integrating passive cooling techniques along with renewable energy systems can further contribute to reducing operational carbon. These findings highlight the importance of holistic, low-carbon approaches to support national climate targets in the residential building sector.

Paper ID: 245

Evaluating the influence of trees evapotranspiration on building cooling demand: A study in hot and dry climate

Neha Salat[1], Subham Das[2], Tej Chawda[2]
[1]CEPT University, Ahmedabad, India
[2]CARBSE, CEPT University, Ahmedabad, India

Abstract

The Urban Heat Island Effect (UHIE) in rapidly urbanizing cities has intensified cooling energy demands and overall energy consumption. Trees mitigate localized temperature rise through shading and evapotranspiration, which alters the microclimate by increasing ambient humidity. While shading directly reduces surface temperatures, the effect of evapotranspiration on buildings' latent cooling load remains underexplored. This study quantifies the influence of tree evapotranspiration on cooling energy demand across different urban morphologies in Ahmedabad.

Representative locations with distinct land-use characteristics within a 1 sq.km. area were identified using remote sensing and microclimate analysis. Tree-specific parameters, including seasonal Leaf Area Index (LAI) and canopy density, were collected through field surveys and literature review. Evapotranspiration rates were estimated using meteorological data and the Penman-Monteith equation, while microclimatic variables such as air

temperature and relative humidity were analyzed through ENVI-met simulations. The findings provide insights into the role of trees in influencing cooling energy consumption and HVAC performance.

This study presents a quantitative framework to evaluate the impact of tree evapotranspiration on building cooling demand—an aspect often overlooked in urban microclimate research. A key contribution is the integration of field data, evapotranspiration estimation using the Penman-Monteith equation, and ENVI-met simulations, forming a comprehensive method to assess the relationship between building energy performance and microclimate. Results show that tree evapotranspiration lowers microclimate air temperature but increases relative humidity, thereby elevating latent cooling loads. This impact varies with urban form, seasonal shifts, and time of day. Simulations under four representative climatic conditions revealed a maximum latent load increase of around 2%, particularly under peak dry-bulb temperature and nighttime scenarios. These findings emphasize the importance of context-specific analysis in integrating urban greenery into energy models.

	Technical Session Theme 2: Reimagine-Redesign-Renew: Policy, Governance, and Market Transformation

Paper ID: 1338

Developing Seasonal Energy Efficiency Ratio (SEER): A Climate-Specific Approach for India

Raj Gupta[1]*, Rana Veer Pratap[2], Jyotirmay Mathur[1], Vishal Garg[3]
[1]Centre for Energy and Environment, Jaipur, India
[2]Alliance for Energy Efficient Economy, New Delhi, India
[3]Plaksha University, Mohali, India
*Corresponding Author

Abstract

The Indian Seasonal Energy Efficiency Ratio (ISEER) serves as a benchmark for evaluating air-conditioning system performance based on part-load efficiency across a standardized temperature profile. However, India's diverse climatic zones result in substantial regional variations in cooling load patterns, which are not adequately captured by the nationally averaged ISEER weighting. This study proposes a climate-specific Seasonal Energy Efficiency Ratio (SEER) by deriving climate specific part-load weights using building energy simulations and the load bin method.

A reference commercial office building was simulated using ISHRAE weather files representing major climatic zones. Cooling loads were analysed at two indoor setpoint temperatures (24°C and 26°C), and operation hours were distributed across four part-load bins. The resulting bin-hour percentages were used as weights to calculate SEER values tailored to specific climate zones.

The findings reveal notable differences between regional weights and current ISEER values. For instance, composite zones closely align with ISEER at 75% load, while warm-humid and hot-dry regions experience significantly more full-load operation. In contrast, temperate climates show fewer full-load hours, highlighting a mismatch with ISEER assumptions. These discrepancies underscore the need for regionally adaptive SEER metrics to avoid misrepresenting system performance.

The proposed framework enables users, manufacturers, and policymakers to evaluate and compare cooling systems based on actual climate-specific performance. This approach supports more accurate energy labelling, informed technology selection, and refined policy design. By integrating climatic data into SEER calculation, this study enhances the accuracy and relevance of cooling efficiency assessment in India, contributing to more sustainable and context-appropriate energy use in buildings.

Paper ID: 1283

Bridging the gaps: A Critical Evaluation of Building Byelaws and Strategies for Integrating Sustainability

Harshada Akolkar[1], Shweta Kulkarni[2]
Prayas Energy Group, Pune, India

Abstract

The residential buildings in India are rapidly transforming. Significant number of buildings and residential units are being added every year. The design and materials used for this

construction are geared towards quick completion of projects with little or no consideration to providing thermal comfort to occupants thereby increasing environmental impact in construction as well as operational phase. Building developments are regulated by the local governments through byelaws. These byelaws and mandatory clearances applicable at the local level are influenced by Central and State level policies and guidelines. However, most byelaws suggest that sustainability in and of buildings is desirable but not mandatory. At the National-level recommendations/guidelines for improving sustainability have been introduced as part of the National Building Code of India (NBC, 2016) , Energy Conservation Sustainable Building Code - Residential Buildings (ECSBC-R, 2024) and Model Building Byelaws (MBBL, 2016) . And at the state level, there are unified development control regulations, local building byelaws and rules for policy implementation as notified by the state government. In this study we present a comprehensive assessment of sustainability parameters from the Unified Development Control and Promotion Regulations (UDCPR, 2020) of Maharashtra and building byelaws of ten states across India and also include parameters as suggested by NBC 2016 Part 11, MBBL 2016 and ECSBC-R 2024. We aim to identify gaps/shortcomings in the existing UDCPR and improve inclusion of sustainability features in buildings based on this comprehensive assessment.

Paper ID: 1281

Studying energy transition governance in the buildings sector: Insights from the Energy Transition Preparedness Initiative (ETPI)

Rushabh Soni[1], Sumedha Malaviya[2], Deepak Tewari[3]
[1]WRI India, Mumbai, India

Abstract

Energy Transition Preparedness Initiative (ETPI) is a collaboration between WRI India, Prayas (Energy Group) and Sustainable Futures Collaborative. The initiative is a multi-sectoral, multi-state endeavour to understand state-level plans, actions, and governance processes in India towards an energy transition. At the core of our approach is the 24-indicator ETPI framework that covers key governance themes in electricity, buildings, transport and cross-cutting sectors. For buildings, there are five thematic indicators that broadly review state intent, processes and outcomes on the implementation of building energy codes and the integration of energy efficiency and renewable energy in buildings. The ten states studied were Bihar, Delhi, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Rajasthan, Tamil Nadu, and Uttar Pradesh. We completed the study for two time periods - FY20-21 and FY23-24 and relied on publicly available data to study the states on 25 attributes. In this paper we share the building sector indicator framework and summarize the findings and insights from the two study periods. It was found that (1) in states that have notified building energy codes, compliance on ground, continues to be a gap (2) solarisation of residential buildings has received strong push through national programs but only Uttar Pradesh and Delhi provide additional incentives (3) All Discoms have promoted energy efficient LEDs, with a few notable exceptions from Delhi, Maharashtra and Karnataka where energy efficient fans and ACs have also been promoted (4) solarising public buildings has been a low hanging fruit but few state interventions focused on energy efficient public buildings and (5) Except Tamil Nadu, no state has affordable housing policies that consider thermal comfort, energy efficiency and clean energy requirements. We share conclusions on the state of play derived from our discussions with stakeholders and experts to provide preliminary recommendations on strengthening the building sector’s contribution to state energy transition efforts.

Paper ID: 1261

Financing Sustainable Development in Urban India

Winamra Negi[1]
[1]AEEE, New Delhi, India

Abstract

India's cities generate over 60% of GDP yet face persistent infrastructure deficits, climate risks, and fiscal constraints. This paper assesses the urban infrastructure investment ecosystem in India and explores how sustainable urban financing can be structured by leveraging climate finance from domestic and international sources to meet city-level infrastructure needs. Urban infrastructure investment refers to capital and operating expenditure on urban assets; sustainable urban financing denotes durable fiscal and financing arrangements that preserve municipal solvency while expanding service delivery; and climate finance comprises mitigation and adaptation-oriented flows and instruments accessible to cities and states

Using data from the Reserve Bank of India, Comptroller and Auditor General audits, ASICS 2023, SEBI disclosures, and national programme guidelines, the study maps current financing flows and bottlenecks. Findings show investment at about 0.6% of GDP—below the ~1.18% requirement—alongside concentrated municipal bond issuance, incomplete adoption of accrual accounting, uneven planning mandates, and weak integration of climate budgeting. A sustainable financing pathway is proposed, anchored in Green Public Financial Management, pooled and credit-enhanced borrowing, MDB-supported PMUs for climate budgeting and planning, and performance-linked transfers tied to technical capacity and proposal quality. This approach aligns infrastructure needs with climate-responsive funding and governance reforms to strengthen ULB readiness.

Paper ID: 1249

Scaling DRE-based Micro Cold Rooms in Maharashtra Through Policy and Financing Solutions

Shubham Mankar[1], Khushboo Gupta[1]
[1]Alliance for an Energy Efficient Economy, India

Abstract

This study investigates the potential of Distributed Renewable Energy (DRE)-based micro cold rooms as a scalable solution for reducing post-harvest losses in Maharashtra's agricultural sector. Despite being the second-largest producer of fruits and vegetables, India faces significant wastage due to inadequate cold chain infrastructure, disproportionately affecting smallholder farmers. Through a mixed-methods approach, this research combines policy analysis, stakeholder consultations, and pilot interventions to explore systemic barriers to adoption, namely financial inaccessibility, complex application procedures, and limited capacity at the grassroots level. Key findings highlight that while multiple government schemes exist, their uptake is hindered by documentation burdens, poor coordination among departments, and a lack of awareness. The paper introduces Standard Operating Procedures (SOPs), capacity-building, and alternative business models such as leasing and pay-per-use to facilitate deployment. Early pilot results across Maharashtra reveal improved FPO engagement, enhanced application success rates, and increasing confidence in adopting micro cold stores. The study concludes with policy and financial recommendations, including front-loaded subsidies, convergence platforms, and blended finance approaches. These integrated interventions are essential for unlocking inclusive, decentralized cold chain solutions, advancing both food security and rural income resilience

Paper ID: 1242

A Feminist Approach to Empowering Women in Rural India through Solar Energy

Shreya Borah*, Priyani Pranab
Department of Policy and Management Studies,
TERI School of Advanced Studies, New Delhi

Abstract

Within renewable energy sources, solar power plays a critical role in India's transition towards a sustainable and resilient energy nation, offering significant potential to address its growing energy demands while reducing greenhouse gas emissions. Despite this potential, there are growing concerns about inequitable participation between women and men in decision-making and availing benefits from large-scale solar energy projects. Studies indicate that women are more likely to have limited access to emerging technologies, suggesting the potential inequalities in the transition to renewable energy. Additionally, women are significantly underrepresented in sectors like construction, renewable energy, manufacturing, and public transportation, which are critical to a green economy. The paper studies the scope and impact of existing solar energy policies in India on women, particularly in rural and underserved areas. Through a feminist perspective, it identifies challenges that restrict the widespread deployment of solar technologies to women there. This study utilises data from the Multiple Indicator Survey (MIS) of the National Sample Survey 78th round (2020-21) conducted by the National Sample Survey Office (NSSO) of India. The paper takes into account that climate change affects women disproportionately, who face additional vulnerabilities such as water scarcity and lack of clean energy access. The paper highlights the transformative impact that solar energy can have on women in rural areas, who are disproportionately affected by fossil fuel usage. There is a need for targeted efforts to address social and institutional barriers preventing women from entering the solar energy sector in India. Gender-sensitive approaches must be adopted when designing solar energy projects in the country; considering women's specific needs, challenges, and opportunities throughout the project cycle. By integrating women into the solar value chain, from governance to project design and implementation, solar power can serve as a tool for social empowerment. The paper argues for a people-centric, rather than technology-centric, approach to solar energy, advocating for policies that involve communities in decision-making processes and foster just transition.

Paper ID: 1191

Analyzing the Policy Landscape for Supporting the Clean Energy Transition in Small and Medium Enterprises in India

Gowthami T S
World Resources Institute, India

Abstract

This paper delves into policies, schemes, and programs geared toward bolstering energy efficiency, fostering the adoption of clean energy sources, and mitigating SMEs' carbon footprint, whether through direct implementation or indirect facilitation. The existing body of work on the energy transition in SMEs focuses largely on financial and technological impediments, whereas this paper explores the impact of clean energy policy uptake and the resulting benefits for SMEs. This paper undertakes a comprehensive review of the policies

announced by the central government and state governments for SMEs over the period 2010–20 and analyzes them by developing a quantitative and qualitative assessment framework. The paper also examines previous policies to learn from ministry officials and state nodal agencies about initiatives in selected states (Haryana, Rajasthan, Gujarat, Tamil Nadu, and Himachal Pradesh) that have helped steer the energy transition in SMEs. This paper contributes to the current understanding of policy dynamics and the energy transition within SMEs. It aims to provide valuable insights for decision-makers striving to achieve a successful energy transition within the SME sector. It does so by assessing the policies introduced to support the energy transition in SMEs, focusing on emission reductions and other benefits such as reduced energy costs and improved energy accessibility. The paper aims to serve as a useful primer to guide policymaking in the future.

Paper ID: 1172

Clean cooking transitions for urban poor in Odisha: Bringing together the demand and supply sides

Neha Malhotra Singh[1], Katie Pyle[2], Anand Iyer[3]
[1]Janaagraha Centre for Citizenship and Democracy, Bengaluru, India

Abstract

This study identifies feasible clean cooking pathways for the urban poor in Odisha within a just transitions framework. The research uses a robust mixed-methods approach, including a survey of 5,368 urban poor households, focused group discussions, co-creation exercises, expert interviews, and secondary research. A life cycle assessment – cradle to grave lens - evaluates clean cooking alternatives across four impact categories: human health, ecosystem, climate change, and resources, ensuring that the transition is 'just' for both the people and the country. Biogas from dung, biomass pellets, Solar Nutan, renewable electricity, PNG, and LPG emerge as the relatively cleaner cooking alternatives, with LPG being less clean among the cleaner options. The study captures demand-side perspectives on clean cooking adoption, including openness to transition, willingness to pay/travel, health/environment priorities, and Indian cooking needs and choice behaviors. The research reveals a strong community desire to adopt cleaner technologies, with community biogas and Solar Nutan being the most preferred, followed by LPG. These preferences are strongly contingent on contours of cost, travel, and convenience. The aspirations of the urban poor are not centered around cooking more but improving the quality of the cooking experience – 'a value story'. Further, the study introduces a two-axis framework that maps fuel cleanliness against transition effort, incorporating ecosystem readiness, knowledge, and adoption feasibility. The framework reveals an inverse relationship between fuel cleanliness and ecosystem readiness, highlighting significant gaps on the supply side. Bringing the demand and supply sides together, the research outlines pathways for each clean cooking technology, identifying bottlenecks in bringing these pathways to life. The study calls for a multi-stakeholder approach, defining roles for technology providers, supply chain, governments, and CSOs/funders, and emphasizes integrating community realities and local action into development and implementation of clean energy technologies, policies and initiatives.

Paper ID: 1148

Climate Smart Innovation: Driving Market Transformation for Built-Environment Startups

Suyashi Srivastava[1], Ritabrata Sen[1], Prasad Vaidya[1], Geetha Krishnan[2]
[1] Alliance for an Energy Efficient Economy (AEEE), Delhi, India
[2] Indian Institute for Human Settlements (IIHS), Bangalore, India

Abstract

This paper examines the Climate Smart Innovation (CSI) initiative as a strategic platform designed to accelerate the deployment of low-carbon and adaptation-focused solutions in India's building sector. CSI aims to bridge the critical gap between sustainability-focused startups and key stakeholders, such as accelerators, investors, developers, and industry leaders, through a structured process involving open calls, evaluations, mentorship, and public exhibitions. The initiative supports innovations targeting energy efficiency, sustainable materials, and smart resource management within the built environment.

This paper presents a comparative analysis of five startup support programs: Social Alpha, Brigade REAP, Climate Collective, CSI, and HCL ClimaForce Fund to assess the strategic depth of each initiative in areas such as focus, sectoral coverage, certification support, pilot facilitation, and investment readiness. Findings reveal that while CSI is uniquely positioned due to its sector-specific focus and stakeholder integration, systemic challenges persist across all programs, particularly in areas of certification, pilot funding, and mainstream market adoption. However, persistent challenges are noted across all platforms, including limited support for certification, post-pilot scaling, and broad-based market adoption.

The analysis reveals a systemic gap in coordinated support for the middle-market segment, characterised by cost sensitivity and risk aversion, where innovation adoption is crucial but under-supported. While CSI has demonstrated early success in enhancing startup visibility and engagement, significant barriers remain in third-party validation, manufacturing scale-up, and commercialisation financing.

This paper argues that accelerating sustainable innovation in India’s building sector requires ecosystem-level strategies that prioritise scale, product certification, and affordability. It concludes with actionable recommendations to strengthen platforms like CSI and build coordinated, sector-specific innovation ecosystems aligned with national climate goals.

Paper ID: 1128

Cold Chains and Carbon Gains: Tapping India’s Frozen Potential

Vivek Singh[1]

[1]Alliance for an Energy Efficient Economy, New-Delhi, India

Abstract

India suffers significant post-harvest food losses in its horticulture sector, leading not only to economic setbacks for farmers but also to substantial greenhouse gas emissions, particularly from methane produced during organic waste decomposition. This study explores the dual challenge and opportunity of addressing food loss and climate change through renewable-powered cold chain infrastructure.

I have analyzed the potential emission reductions from improved cold storage and integrating it with RE powered solutions and quantify the environmental impact of current food losses using standardized emission factors. My research indicates that the modernization of existing cold storages, deployment of decentralized cold storage systems, powered by renewable energy, can reduce food loss by up to 27% directly and avoid up to 20 million tonnes of CO_2-equivalent emissions annually.

The integration of renewable cold chains with carbon financing mechanisms has the potential to build resilient agricultural value chains while contributing to India's climate targets under the Paris Agreement.

	Technical Session Theme 3: Shaping Tomorrow: Emerging Technologies for Sustainable Future

Paper ID: 1310

Feasibility study for a small-scale vertical axis wind turbine unit

Amruthraj Nagaraja, Prasad Vaidya
Indian Institute for Human Settlements (IIHS), Bengaluru, India

Abstract

The purpose of this study was to investigate the feasibility of installing a small-scale vertical axis wind turbine on the site of the upcoming IIHS campus near Kengeri, Bengaluru.

The IIHS Kengeri Campus is planned as a Net-Zero energy campus, consisting of a micro-grid for sustainability. Solar panels on multiple buildings generate energy during the day, and with energy storage being expensive, wind renewable energy was explored to generate energy at night. At the IIHS Kengeri campus, an installation of small-scale vertical axis wind turbines was planned on top of an existing structure, to further the goal of being a Net Zero energy campus. To this end, the SolarMill from Windstream was chosen as the product due to its compact size, and operations at low wind speeds of 2.5 m/s.

Wind data from four different meteorological stations on the campus were analysed, and the total energy potential in the wind pattern was calculated. The power curve of the SolarMill wind turbine provided us the energy generated by the turbine at different wind speeds over its operating wind speed range. The equation of the power curve was extracted, and wind power generated for different wind speeds at the Kengeri campus, and the total power generated over one year was calculated.

Considering the product, installation and maintenance cost, the payback period for the product was calculated to be more than 25 years, and at this time, it was not found to be financially viable to go ahead with the installation.

Paper ID: 1190

Empowering Farmers: Building Sustainable Cold Chain Access through a Finance and Technology Aggregator Model

Anil Kumar Choudhary[1], Sumedha Awasthy[2] , Pran Saurabh[3]
[1]Energy Efficiency Services Limited (EESL), New Delhi, India
[2]CLASP, New Delhi, India & [3]Energy Efficiency Services Limited (EESL)

Abstract

Financing is a critical gap in scaling cold storage in agriculture, essential for reducing post-harvest losses, increasing farmer incomes, and strengthening supply chains. This paper presents an ESCO-led finance model combining leasing, energy-efficient cooling, and technology solutions to accelerate deployment. Piloted by Energy Efficiency Services Limited (EESL) in India with funding from the Asian Development Bank (ADB), the model employs a lease-to-own approach through sub-aggregators, ensuring cost recovery and accessibility for smallholder farmers. CLASP provided technical assistance to develop, pilot, and raise investments for scaling the initiative. Addressing India's The magnitude of the problem is staggering. According to a study by NABARD Consultancy Services (NABCONS) conducted between 2020 and 2022, India suffers a food loss of about 17703.33 million dollars annually due to post-harvest losses of crops and allied produce. This loss accounts for approximately 22% of the country's foodgrain output, translating to around 74 million tonnes of food wasted each year. The initiative also aligns with national policy

frameworks such as the India Cooling Action Plan and doubling farmers income, ensuring environmental sustainability. The model has the potential to show a reduction in post-harvest loss from 30% to under 10% and increase farmer incomes by 20%–35%. Now investment-ready, the model presents a scalable and replicable approach to transforming India's agricultural cold chain. The paper concludes with recommendations to support nationwide replication and enable sustainable, climate-resilient agriculture.

Paper ID: 1302

Mathematical modelling and sizing of solar photovoltaic-powered decentralised cold room with hybrid storage system

Sreelekha Arun[1*], Anindita Roy [1*], Stefano Landini [2], Akshay Pahade[3]
[1]Symbiosis Institute of Technology, Pune, India
[2]University of East Anglia, Norwich, UK
[3]Gratitude Synergy, Pune, India

Abstract

Cold-chain management plays a crucial role in the agriculture sector. However, traditional centralized cold storage facilities often fail to meet the needs of rural and remote areas due to high logistics costs, inadequate infrastructure, and power supply challenges. Hence, decentralized cold rooms are essential for enhancing food security, reducing post-harvest losses, and supporting small-scale farmers and businesses. Standalone cold storage systems preserve harvest at farm-gates, especially in rural areas with disrupted electric supply. This study proposes to develop a mathematical model for cold storage, working on vapour compression refrigeration system, using solar power with battery and thermal (hybrid) energy storage, making it a grid-independent, stand-alone unit. The developed model is simulated over a given time horizon for a specified set of weather conditions, to obtain a set of feasible options for the system parameters. A design space, which is a collection of all such feasible options, is generated on the plot of solar photovoltaic rating vs battery capacity for varying compressor power for a minimum of 6 hours of thermal backup. System optimisation is undertaken by minimising the Cost of Energy (CoE) to arrive at the optimum solution from these feasible options. For illustration, a 3.4m3 cold room operation on a typical day in April was simulated. The optimum combination comprised of 0.9 kW compressor power, 13.3 kW of solar PV rating and 4.54 kWh of battery capacity, for which CoE was evaluated as 8.57 Rs/kWh. Experimental results highlighted a reduction of 38% in the energy consumption with PCM integration in a decentralised cold room.This methodology is generic and can be flexibly adopted for cold room of varying storage capacity, proving to be advantageous for future scalability.

Paper ID: 1285

Dynamic Display of Power in Room Air Conditioner- via Urja Sanchay

Paras Bhattarai[1], Sumedh Agarwal[2]
[1] Alliance for an Energy Efficient Economy (AEEE), New Delhi

Abstract

Climate change and rising temperatures in India have amplified the demand for cooling, with room air conditioners (RACs) becoming a dominant contributor to residential electricity consumption. Despite energy efficiency initiatives like the Bureau of Energy Efficiency's (BEE) 24-Degree Campaign, over 60% of Indian households prefer air conditioners setpoints below 24°C. This study investigates RAC usage patterns and evaluates the effectiveness of behavioural nudges—specifically, dynamic power consumption displays (via smart plug and temperature and humidity sensor installed at RAC unit) and feedback notifications—in promoting nudging households to increase the setpoint temperature of RAC usage, and

optimise their RACs electricity consumption. A survey, along with a Randomised Control Trial (RCT) was conducted among 100 households across Rajasthan, Haryana, and Delhi. The households were divided into two groups, with treatment groups receiving real-time consumption data and tailored nudges, while control groups had no intervention. The findings revealed that comfort and economic factors significantly influence setpoint preferences, with quick cooling misconceptions acting as a barrier. During intervention period, treatment households exhibited a 3.4% reduction in electricity consumption compared to the control group, with average room temperatures rising by 0.5°C. The implementation challenges included device compatibility, privacy concerns, and weather variability, underscoring the need for robust engagement strategies. The study demonstrates that behavioural interventions can modestly curb RAC energy demand, offering policymakers insights into scalable, non-financial strategies for sustainable cooling.

Paper ID: 1237

On-Board Propane Refrigeration for Post-Harvest Fish Preservation in Small Fishing Boats: A Energetic and Environmental Assessment

Prosenjit Singha[1]*, Mani Sankar Dasgupta[1]
[1]Department of Mechanical Engineering, BITS Pilani, 333031, India

Abstract

The Indian seafood cold chain, particularly at the supply end, faces significant challenges in preserving fish quality and minimizing post-harvest losses, primarily due to the lack of adequate onboard cooling infrastructure in small motorized fishing vessels. This study investigates a natural refrigerant-based onboard refrigeration system using propane (R290), powered by surplus energy from the boat engine, to generate ice or slurry ice on demand from seawater. To mitigate the flammability risks associated with R290 and reduce refrigerant charge, a secondary loop configuration using a thermic fluid and a plate heat exchanger (PHE) is also explored. System performance is assessed using real compressor models under marine operating conditions and compared against both a conventional R290 setup and on-shore R404A and R407A systems. While the lower evaporation temperature in the secondary loop leads to a 6.1% increase in compressor work compared to the baseline R290 system, it remains 5% and 4% lower than that of R404A and R407A systems, respectively. The coefficient of performance (COP) of the conventional R290 system (≈1.85) is 12.1% and 10.7% higher than R404A and R407A, while the secondary loop configuration retains a COP advantage of 5.4% and 4.2%, respectively. Combined COP (CCOP) for baseline R290 is 2.57, which is 3.7%, and 5.5% higher than R404A and R407A, while the secondary loop system shows 1.5% and 3.2% gains over R404A and R407A systems. The secondary loop system also offers an 18.7% reduction in refrigerant charge, enhancing safety. Environmental analysis indicates that the R290 baseline and secondary loop configurations are capable of reducing equivalent CO_2 emissions by 67.7% and 65.7% compared to R404A, and 65.7% and 46.6% compared to R407A. The proposed R290-based system presents a promising low-global warming potential solution for sustainable post-harvest preservation of fish quality in small fishing vessels.

Paper ID: 1232

Evidence-based analysis of cold storage inefficiencies in Uttar Pradesh

Akansha Ujala Dean[1], Santosh Kumar Saini[1], Khushboo Gupta[1]
[1]Alliance for an Energy Efficient Economy (AEEE), New Delhi, India

Abstract

India’s total cold storage capacity stands at 40 million metric tonnes, with Uttar Pradesh accounting for 15.1 million metric tonnes of this capacity. About 66% of units are more than

two decades old, with high energy use, outdated insulation, and inefficient refrigeration systems contributing to post-harvest losses and rising operational costs. This condition of cold storage demands urgent modernisation to enhance efficiency and reduce post-harvest losses. This study aims to generate scientific evidence and analysis to highlight system inefficiencies in cold storage infrastructure and support informed decision-making for improvements. During this study, field surveys were conducted across a large sample of cold storage facilities, and detailed energy audits were carried out at four representative sites. The surveys indicated a strong inclination among owners toward adopting energy-efficient technologies, while the audits highlighted prevalent inefficiencies such as inadequate insulation, aging equipment, inconsistent temperature control, and limited automation. The analysis shows that adopting recommended measures can save 50,000–219,000 kWh/year per facility, reduce emissions by up to 160 tCO_2/year, and offer 2–7 years payback periods, depending on the adopted measure. These findings underscore not just the urgency, but the immense opportunity to transform cold storage facilities into efficient, climate-resilient infrastructure powering a future that ensures food security, energy savings, and sustainable development.

Paper ID: 1231

Improving Radiant Cooling Ceiling Panels: A product development experience

Manoj Hegde[1], Amanda Thounaojam[1], Prasad Vaidya[1], Guruprakash Sastry[2], Punit H Desai[2]
[1]Indian Institute for Human Settlements, Bangalore, India
[2]Infosys Limited, Bangalore, India

Abstract

Space cooling accounts for nearly 31% of energy use in Indian commercial buildings, driven largely by inefficient air-based HVAC systems that require low-temperature chilled water and high airflow rates. While radiant cooling offers a more energy-efficient alternative, existing solutions face major limitations. Embedded slab systems are difficult to control and nearly impossible to retrofit, while imported radiant panels are expensive, complex to install, and often acoustically incompatible with commercial interiors.

To overcome these challenges, the infrastructure team at Infosys developed Radiflux-a modular, extruded aluminium radiant ceiling panel designed for the Indian context. Unlike conventional systems, Radiflux integrates the fluid channel, heat transfer fin, and radiant surface into a single aluminium profile, eliminating thermal interfaces and significantly reducing thermal resistance. The system is designed for local manufacturing, easy installation, and integration with acoustic ceilings or ceiling fans-making it equally viable for retrofits and new construction.

Radiflux operates with 16–20°C chilled water, improving chiller efficiency while delivering up to 140 W/m² at 150 mm spacing of the baffles, and up to 190 W/m² at 100 mm spacing under optimal conditions. This outperformed the leading commercial panels by upto 50% following the European standard EN 14240 [10] for performance testing of chilled ceilings. The development process included iterative prototyping, CFD simulations, and full-scale testing, with third-party validation under EN 14240 standards. Installation is simplified through pre-assembled panel clusters and PEX shrink-fit fittings, eliminating the need for manifolds or specialized labor.

Today, Radiflux is deployed across over 5 million square feet of Infosys buildings, reducing fan energy by 70%, cutting overall cooling energy by up to 35%, and supporting higher temperature setpoints without compromising comfort. Its cost-one-third that of imported systems makes it uniquely scalable.

Radiflux demonstrates that high-performance radiant cooling can be locally designed, manufactured, and deployed at scale, offering a practical path toward net-zero and climate-resilient buildings in India and other hot, developing regions.

Paper ID: 1228

Concept of EV-Centric Inter-State Bus Terminals (ISBTs) as Catalysts for Accelerating EV Adoption in Hilly Regions: A Case Study of Meghalaya

Anmol Jain[1], Md Saddam Hussain[1], Sumedh Agarwal[1], Vikas Nimesh[2]
[1]Alliance for an Energy Efficient Economy, Delhi, India
[2]Indian Institute of Technology Delhi, Delhi, India

Abstract

The rapid evolution of electric vehicles (EVs) as a sustainable alternative to conventional fossil fuel-based transportation has highlighted the critical need for robust supporting infrastructure, particularly in challenging terrains such as hilly regions. Establishing charging infrastructure in these areas is particularly challenging due to geographical and logistical constraints, a significant factor contributing to the slower adoption of EVs in such regions. This study introduces the concept of an EV-Centric Inter-State Bus Terminal (ISBT) designed to support not only buses but creating a comprehensive EV ecosystem. The 'EV ecosystem' encompasses buses, IPT (two-, three-, and four-wheelers), charging infrastructure, renewable energy integration, and associated maintenance and service facilities. Focusing on Meghalaya, a state in northeastern India known for its hilly terrain and environmental challenges, the study explores the feasibility and benefits of such a facility. By electrifying public transportation and integrating Intermediate Public Transport (IPT) and other modes, the proposed ISBT aims to overcome key barriers to EV adoption, reduce carbon emissions, promote renewable energy use, and enhance the efficiency of the regional transport network.

A detailed analysis of technical, financial, and environmental aspects highlights the transformative potential of the EV-Centric ISBT as a benchmark for similar regions and neighboring states. Critical success factors such as stakeholder engagement, community participation, and alignment with policy frameworks are emphasized. The findings underscore the project's pivotal role in fostering sustainable mobility, advancing Meghalaya’s EV policy objectives, and creating a replicable model for EV infrastructure development in hilly geographies.

Paper ID: 1214

Smart Cooling Strategies for Cold Storage: R290-Based Subcooling and Solar Integration

Mani Sankar Dasgupta[1]
[1]Birla Institute of Technology and Science, Pilani, India[2]Indian Institute of Technology Delhi, Delhi, India

Abstract

India’s rapidly expanding cold storage sector is vital to ensuring food security and reducing post-harvest losses. However, the majority of existing facilities operate on energy-inefficient vapor compression refrigeration (VCR) systems, particularly under peak summer conditions when ambient temperatures exceed 40°C. This study investigates the retrofitting of a Dedicated Mechanical Subcooling (DMS) system using propane (R290), a natural refrigerant, to improve cooling performance in large commercial cold rooms. A thermodynamic modeling and simulation framework is employed to assess the impact of R290-based subcooling on system efficiency, cooling capacity, and compressor performance. To enhance sustainability, the study

also evaluates solar photovoltaic (PV) integration to power the subcooling unit, aligning peak solar availability with refrigeration demand. Simulation results show that the R290-DMS retrofit can deliver approximately 10°C of subcooling at 40°C ambient, yielding a coefficient of performance (COP) of ~3.2—substantially higher than conventional refrigerants like R404A and R134a. The retrofit not only improves COP but also reduces compressor discharge temperature, thereby enhancing reliability and extending equipment life. Economic feasibility of solar-assisted subcooling is also demonstrated, offering energy resilience and reduced dependency on grid electricity. Preliminary consideration is given to absorption cooling as an alternative subcooling approach. These smart cooling strategies—centered on natural refrigerants, energy-efficient retrofits, and renewable integration—support India's transition to sustainable cold chains. The findings are particularly relevant to scalable applications such as farmer cooperatives and align with emerging Cooling as a Service (CaaS) business models. Future work will focus on experimental validation and techno-economic feasibility for broader adoption.

Paper ID: 1202

Energy Audits for Circular Economy: Advancing Sustainable Manufacturing in Nepal's Pulp and Paper Industry

Amrit Abhamani Dhakal[*1,2,3], Yaju Shrestha[1,3], Hemanta Bhandari[1,2,3], Ayush Adhikari[1,2,3], Muna Bhattarai[1,3], Sampurna Ghimire[1]

[1]Rastriya Urja Dakshata Kendra Pvt. Ltd., Kathmandu, Nepal

[2]Institute for Energy Efficiency and Climate Studies, Kathmandu, Nepal

[3]Association of Energy Engineers- Nepal Chapter, Kathmandu, Nepal

Abstract

The circular economy prioritizes resource efficiency, waste (energy/material) minimization, and sustainable energy use as key considerations for energy-intensive manufacturing industries . Energy-intensive industries in developing nations struggle to adopt circular economy (CE) principles due to limited sector-specific energy efficiency research and implementation frameworks. This gap is particularly evident in Nepal, where industrial sector accounts for 22.17% of national energy consumption yet lacks comprehensive energy benchmarking studies. The study bridges this gap by demonstrating how Investment Grade Energy Audits (IGEA) can promote CE transitions in resource-constrained industries. An IGEA was conducted in a selected pulp and paper industry of Nepal: Shree Maruti Papers and Chemical Industry Limited, with the methodology following Water and Energy Commission Secretariat guideline . The methodology combined primary and secondary data analysis to analyse four performance parameters: energy consumption profile, specific energy consumption, significant energy usage, and emission quantification, and also identify energy efficiency optimization opportunities. Initial findings indicated significant energy efficiency potential of the industry, with an annual energy consumption of 293,019 GJ (90%- thermal energy, 10%- electrical energy). The specific energy consumption was 259.59 kWh/ton (electrical) and 8.64 GJ/ton (thermal), with annual greenhouse gas emissions of 807.72 tCO_2-eq. A parallel literature review of CE concepts was performed to prepare tailored CE principles to establish direct correlations between audit findings and CE implementation. These results demonstrate that standardized energy audits provide more than efficiency diagnostics, they offer a methodological bridge to CE adoption by quantifying resource-energy parameters and prioritizing circular interventions. The developed framework proves particularly valuable for industries with untapped waste (energy/material) recovery potential, positioning energy optimization as a practical first step toward circularity. This research offers an evidence-based

model for aligning energy audit practices with circular economy goals, particularly in developing economies where CE infrastructure is still evolving.

Paper ID: 1197

Waterway Transportation: A solution to transit in Tier 2 and Tier 3 cities

Anish Perumal[1], Rohan Chaturvedi[1]
[1]R V College of Architecture, Bengaluru, India

Abstract

When talking of public transport planning and development in India, the Tier 2 and Tier 3 cities often get overlooked. These urban centres with lower population cannot create enough demand to justify large scale investment in conventional rapid transit mediums like metro or suburban railways. As a result, transit in these cities remain confined to buses or BRTs. But it is also a fact that, India is a country rich in rivers and waterways, which may provide an alternative solution to transit. The paper analyses this aspect for all cities classified under the 'Y' tier as per the House Rent Allowance (HRA) slabs. It sources data mainly from secondary sources in form of studies and reports by Inland Waterways Authority of India (IWAI) and other institutions, as well as primary sources like GIS (Geographical Information System) data. The data collected is analysed to study aspects like the relationship of the waterway to the city's major travel corridor, physical characteristics, navigability of the waterway, its seasonality, and so on. This data is then used to score and analyse the feasibility of using waterway transport in these cities. The analysis shows that out of the 47 cities analysed, in 23 cities waterways are feasible for urban transit, in an additional 18 cities they are feasible in conjunction with other networks, and in only 6 they are not feasible. The paper further discusses case studies, governance, and other challenges, and proposals for the implementation of urban waterway transport.

Paper ID: 1188

Techno-Economic Assessment of Heat Pumps for Decarbonizing Dairy Processing Industry

Nishant Modi[1], Aswin Raghunathan[1, 2], and Satyanarayanan Seshadri[1, 2*]
[1]Energy & Emissions Research Group (EnERG), Department of Applied Mechanics and Biomedical Engineering, Indian Institute of Technology Madras, Chennai, India.
[2]Trigen Decarbonisation Private Limited, Chennai, India.
[*]*Corresponding Author*

Abstract

Dairy plants often discharge substantial amounts of waste heat into the environment while simultaneously depending on fossil fuel-fired boilers to meet their heating demands. To address this inefficiency, this study proposes integrating a Vapour Compression Heat Pump (VCHP) to recover and upgrade the waste heat for reuse in the plant's heating processes, thereby replacing the boiler. A case study was conducted at a major dairy plant in Chennai, where approximately 20.24 GJ/day of waste heat is currently rejected, while 23.48 GJ/day of heating demand is met using a wood-fired boiler. Comprehensive thermodynamic, economic, and environmental models were developed to assess the techno-economic feasibility and decarbonization potential of the VCHP system. Thermodynamic analysis revealed that a single-stage, water-source VCHP, using R245fa as the refrigerant and a heating capacity of 347 kW, can meet the plant's thermal demand with a coefficient of performance of 2.53. Economic evaluation showed a Simple Payback Period (SPP) of 3.53 years (~ 43 months). While the VCHP's capital expenditure was approximately 28.19% higher than that of a boiler, this was

offset by an 18.98% reduction in operating expenditure. The Net Present Value (NPV) over a 15-year life span was estimated at 86.63 lakh INR. Additionally, the levelized cost of heat was reduced by 17.22%, resulting in daily savings of 6573 INR. Environmental analysis projected an annual greenhouse gas emission reduction of approximately 348.20 tons. Further sensitivity analysis based on regional energy costs showed that states with lower electricity costs, such as Gujarat, could reduce the SPP by up to 57.50% and increase NPV by 260.60% compared to higher-tariff regions like Tamil Nadu. These findings highlight the energy, economic, and environmental benefits of VCHP integration and its potential for scalable adoption in India's industrial decarbonization efforts.

Paper ID: 1182

Advancing Performance Evaluation and Policy Implementation for More Sustainable Air Conditioners and Heat Pumps

Miquel Pitarch Mocholi[1], Won Young Park[2], Yash Shukla[3], Ankit Kalanki[4], Brian Holuj[1], Nihar Shah[2], Patrick Blake[1], Saikiran Kasamsetty[1]
[1]United Nations Environment Programme; [2]Lawrence Berkeley National Laboratory; [3]CEPT Research and Development Foundation, CEPT University; [4]RMI

Abstract
In response to the rapidly increasing global demand for cooling, primarily driven by air conditioner usage, this study explores how clear policy guidance accompanied by concrete implementation examples in target markets accelerates the transition to energy-efficient air conditioning with lower global warming potential (GWP) refrigerants. This study examines the United Nations Environment Programme (UNEP) United for Efficiency (U4E) initiative's Model Regulation Guidelines for air conditioners, which aim to harmonize energy efficiency standards, reduce compliance burdens, and drive economies of scale to underpin market transformation toward sustainable cooling. Focusing on Southeast Asia and Africa, two major climate-vulnerable regions, this study highlights the Guidelines' role in shaping regional and national minimum energy performance standards inclusive of refrigerant GWP considerations, in keeping with the aims of the Kigali Amendment to the Montreal Protocol and Paris Climate Agreement. Policy impacts for these regions-primarily in terms of annual/cumulative electricity savings and carbon mitigation-are estimated using a model that integrates macroeconomic indicators with sector-specific factors. In parallel, the Global Cooling Efficiency Accelerator (GCEA) is working to inform future performance testing procedures that better reflect real-world conditions and reward products that are optimized for performance under such conditions, particularly where dehumidification is critical. The revision to the U4E Guidelines which will be finalized by end of 2025 include leveraging GCEA's work toward higher efficiency thresholds that can be used in sustainable procurement, as well as information about new product types and requirements reflecting technology improvements and market changes since the Guidelines were first published in 2019. By employing a mixed-methods approach—combining quantitative analysis of energy savings with qualitative assessments of policy uptake—this study demonstrates how U4E and GCEA's efforts foster greater market alignment, support consumer awareness, and encourage manufacturers to innovate. The findings underscore the importance of harmonized, real-world-relevant standards in enabling emerging economies to leapfrog to high-efficiency, climate-friendly cooling technologies.

Paper ID: 1177

Solar Irradiance Forecasting: From Machine Learning Models to Poor Man's Ensemble

Mathew George[1], Ankit Varma[1], Prasad Vaidya[1]
[1]Indian Institute for Human Settlements (IIHS), Bangalore, India – 560024

Abstract
Adoption of solar energy management in micro-grid application requires reliable forecast. The study focuses on testing various machine learning models for real time deployment of solar irradiance forecast. To determine the best machine learning model for solar irradiance forecasting, we experimented with different dataset selection, feature selection and performance metrics from the literature. Out of 18 models, three models – Random Forest, Extra Tree, and Gradient Boosting- were the best depending on how we chose the dataset, feature or the performance metrics. Additionally, we developed a combination of machine learning model using Poor Man's ensemble method to get three values – lower bound, mean, and upper bound. We calculated reliability of all the forecasts based on overprediction or unmet hours/days. The best model was Poor Man's ensemble with 3.5 % of unmet hours for lower bound values and the best single machine learning model at 31.3 % for the initial 9-day analysis. Further testing of 83 days were conducted with clear, overcast and rainy days. The percentage unmet daily and hourly for lower bound energy were 24.1 % and 21.8 % respectively. This is considerably better than a single machine learning model. In conclusion, a single machine learning model lacks the reliability for energy management in micro-grid control operation. We recommend using Poor Man's ensemble model for solar energy management in micro-grid. Future objectives will involve reducing the solar curtailment, unmet energy deficit and unmet hours.

Paper ID: 1173

Insights on Decarbonization Strategies for Ethylene Production through Planning and Thermodynamic Models

Bhawna Chauhan[1], Asad H. Sahir[1,*]
[1]Indian Institute of Technology Ropar, Rupnagar, India
*Corresponding Author,

Abstract
Ethylene is an important building block in the petrochemical industry, widely used in the production of plastics, rubber, and various chemical derivatives essential to sectors such as packaging, automotive, construction, and textiles. In India, the demand for ethylene is increasing due to the growing consumption of polymer-based products. This study aims to enhance the performance of the Indian ethylene production system by optimizing energy use and reducing carbon emissions.

To achieve this, a Linear Programming (LP) model is developed to determine the most efficient feedstocks and production routes, considering factors such as energy consumption, production cost, and capacity constraints. The model leads to a framework which potentially addresses on how ethylene may be produced economically and its eventual implications on environment.

The results of the modelling exercise elucidates the role of ethylene as a high-value product and its synergy with natural gas prices under various demand and growth scenarios. For instance, at a natural gas price of USD 3/MMBTU and a 10% compound annual growth rate (CAGR), ethylene production reaches 10.6 million tons/year, contributing USD 29.3 billion to overall industry revenue. Even as natural gas prices rise to USD 5/MMBTU, ethylene retains a strong share in the product mix, underlining its economic importance. Along with the LP model, thermodynamic energy calculations are conducted to estimate the minimum energy requirements for steam cracking, the primary method of ethylene production. Additionally,

Python-based simulations are used to quantify CO_2 emissions from various petrochemical processes.

The research outcomes highlight the need for decarbonization strategies, including energy optimization in ethylene plants and the need of developing low-carbon alternatives such as bio-ethylene and electrified cracking technologies.

Paper ID: 1164

Electric Vehicle Adoption Patterns and Energy Infrastructure Analysis in Hyderabad, India- A Socio-Technical Perspective

Charan Vijayan[1]
, Anoushka Mukherjee[2]
[1] IIHS, Bengaluru, India
[2]AECOM, New Delhi, India

Abstract
This study investigates the interrelationship between electric vehicle (EV) adoption patterns, charging infrastructure development, and urban spatial dynamics in Hyderabad, India. It aims to identify location-specific opportunities and challenges in advancing a sustainable EV ecosystem. By integrating , current EV trends and policies the research evaluates how land use configurations and charging station distribution influence EV adoption. A mixed-methods approach is employed to examine the spatial and infrastructural dimensions of EV adoption, with a focus on the Greater Hyderabad Municipal Corporation (GHMC) region. Quantitatively, the study analyzes EV charging consumption data and utility records in conjunction with the proposed land use from the HMDA Master Plan 2031, tracing the temporal evolution of infrastructure development and energy demand. Complementing this, qualitative data is gathered through stakeholder surveys to capture user perspectives on accessibility, cost, and convenience. The findings reveal variations in adoption trends, with high-growth corridors and emerging residential zones exhibiting increased demand and infrastructure stress. The study underscores the critical role of urban planning in aligning charging infrastructure ensuring equitable access, and safeguarding grid capabilities. Key outcomes include data-driven recommendations for optimizing distribution, enhancing capacity in high-demand areas, and establishing EV infrastructure within broader urban development strategies. This research contributes to the ongoing discourse on sustainable mobility by emphasizing on energy systems and urban growth trajectories with insights relevant for rapidly expanding cities.

Paper ID: 1153

EVCI Planner Tool: A systematic approach to siting charging infrastructure in Indian cities and along freight corridors

Shaurya Anand[1], Prajkta Adhikari[1,] Ira Athale Prem[2]
MP Ensystems, Mumbai, India[1],
[2]MP Ensystems, Goa, India[2]

Abstract
The widespread adoption of electric vehicles depends significantly on the availability of reliable and accessible charging infrastructure. In India, the current approach to locating spaces for the installation of public charging infrastructure has largely been ad-hoc, leading to underutilisation and gaps in optimal coverage, thereby undermining its techno-commercial viability. This, in turn, contributes to range anxiety among electric vehicle users across the board (both commercial freight and personal use). To address this challenge, MP Ensystems

has developed a geospatial planning tool designed to optimize the siting of electric vehicle charging stations for 4-wheelers. The tool has two versions: EVCI City Planner Tool for private passenger vehicles in cities and EVCI Freight Planner Tool for commercial freight vehicles across major expressways and national highways. Both versions of the tool incorporate parameters such as integration with existing grid infrastructure, revenue potential, utilisation rate, and deployment cost, enabling informed decision-making for policymakers, urban planners, and investors. A central focus of the tool is data-driven co-location of charging infrastructure with existing utilities and demand hotspots to ensure maximum impact and efficiency. The model uses grid data, parking data, site data, and substation data to co-locate charging sites with existing substations and transformers, supporting planning for diverse vehicle types, including fleets and privately owned vehicles. The tool has been deployed across multiple Indian cities and transport corridors. The results demonstrate the tool's potential to improve charger utilisation, reduce network planning costs, and align deployment with real demand clusters. However, drawbacks include the need for expanded real-time data integration, more granular consumer behaviour modelling, and dynamic tariff consideration. Additional features that could be incorporated include predictive modelling for future EV adoption, integration with renewable energy generation forecasts, and automated scenario-based deployment planning to adapt to changing technology, policy, and market conditions. EVCI chargers can be co-located with bus depots nationwide, in collaboration with depot owners, to coordinate with the grid and enable demand response and flexibility, thereby creating a new revenue stream. By adopting a systematic, science-driven approach that factors in the above-mentioned parameters, such as proximity to the grid—minimising installation costs and ensuring a stable power supply—while also addressing impact, user convenience, and optimisation of CPO revenues, India can accelerate transport sector decarbonisation, supporting the national goal of achieving carbon neutrality by 2070.

Paper ID: 1151

SCADA-Integrated Residential BTU Metering: Enhancing Energy Efficiency and Smart Monitoring.

Kartik Kumar Prajapati[1], Jaydeep Chakravorty[2]
[1]Indus University, Ahmedabad, India

Abstract

The integration of residential British Thermal Unit (BTU) meters into Supervisory Control and Data Acquisition (SCADA) systems represents a transformative approach to energy monitoring and management in residential settings. Traditionally utilized in industrial applications, SCADA systems are now being adapted for residential energy monitoring, enabling real-time tracking and control of energy consumption. This research explores the feasibility, benefits, and challenges of integrating BTU meters with SCADA systems, leveraging advanced communication protocols, Internet of Things (IoT) devices, and data analytics to optimize energy usage. Preliminary results from pilot implementations demonstrate significant improvements in energy efficiency, with homeowners achieving a 10% reduction in energy expenditure over twelve months. This paper presents a novel framework for SCADA integration in residential energy systems, highlighting its potential for scalability, adaptability, and widespread adoption in smart urban infrastructure with some challenges.

Integrating Residential BTU meters into a SCADA system for residential energy monitoring involves leveraging advanced technologies to enhance energy efficiency and management. SCADA systems, traditionally used in industrial settings, are now being adapted for residential use to provide real-time monitoring and control of energy consumption. This integration can

lead to significant economic and environmental benefits by optimizing energy usage and reducing waste energy.

Paper ID: 1145

Presentation type: Oral

Charge Ahead: Harnessing Electric Vehicles for Utility Growth and a Greener Tomorrow

Anmol Jain[1], Md Saddam Hussain[1], Sumedh Agarwal[1], Vikas Nimesh[2]
[1]Alliance for an Energy Efficient Economy, Delhi, India
[2]Indian Institute of Technology Delhi, Delhi, India

Abstract

The global transition towards Electric Vehicles (EVs) presents a transformative opportunity for utilities to play a pivotal role in supporting sustainable transportation and decarbonization efforts. India's strategic initiative to enhance EV market penetration by 2030 targets 30% for private cars, 70% for commercial vehicles, 40% for buses, and 80% for two- and three-wheelers. This policy-driven shift promotes sustainable transportation and supports the national agenda for decarbonization. The expansion of EV infrastructure must accommodate household and high-power fast charging needs for an expanding EV fleet. However, the concentrated high charging capacities of EVs might induce substantial fluctuations in power demand, posing challenges to grid stability due to local distribution constraints.

This study aims to understand the impact of EVs on power distribution companies, key economic opportunities, infrastructure needs, and innovative business models for utilities to effectively integrate EVs into the utility ecosystem. The research employs a mixed-methods approach, combining qualitative and quantitative analysis to provide a holistic view of the EV transition landscape in India. Data collection includes global case studies from leading utility providers, policy documents, and industry reports, analysed using frameworks to assess economic viability, infrastructure readiness, and policy alignment. The analytical framework includes evaluating grid impact, revenue potential, and consumer engagement strategies, ensuring a robust exploration of the evolving role of utilities in the EV transition.