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Grid-Interactive Net Zero Energy Buildings

An Indian Perspective

MAITREE
Market Integration and Transformation Program for Energy Efficiency

eds
environmental design solutions

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Foreword

Over the past decade significant progress has been made towards enhancing energy efficiency in buildings, increasing the share of renewable energy in the electricity mix, and modernizing the grid. Concurrently, rapid strides have been made in the areas of communications technology, artificial intelligence, and machine learning. All of this implies that it is now increasingly possible, and expedient, for the grid to maintain a two-way communication with buildings, distributed energy resources, and consumers. The conversations surrounding buildings and the grid need no longer be disparate; issues at the intersection of the two can (and must) be addressed through an integrated framework.

India is poised to witness the fastest growth in its buildings sector energy consumption through 2040 - at more than twice the global average. Already, this sector accounts for nearly 33% of the total electricity consumption in the country. The large projected growth in building stock is, in fact, a distinctive opportunity to ensure that demand flexibility offered by buildings is harnessed towards a decarbonized and resilient grid. Buildings must be equipped to reduce, shed, shift, and modulate their load in tandem with the variable supply of electricity from renewable resources, to maximize the use of carbon-free power and to relieve grid stress.

The ZerO-In Dialogues were launched with the objective of creating a momentum for a transformative push towards Grid-Interactive Net Zero Energy Buildings (G-NZEB) that demonstrate high-performance, have low environmental impact, and offer load flexibility. This white paper is the culmination of the efforts of the USAID MAITREE program to nudge the conversation on NZEBs towards concerns that lie at the intersection of buildings and the grid.

I would like to thank Shri Arun Kumar Mishra, CEO, EESL, for his encouragement and support for taking the G-NZEB initiative forward. I am grateful to Shri Atul Bali, Chief General Manager, National Smart Grid Mission, who not only enriched each session of the series by his insightful presence but has also been generous in sharing his technical expertise. Experts from across the spectrum participated in the ZerO-In Dialogues, engaging the audience with their experience and technical knowledge.

The conversation around G-NZEBs, integral components of the decarbonized, digitized, and decentralized grid of the future, has now been commenced.

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https://unsplash.com/@tunagraphy

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Chief General Manager

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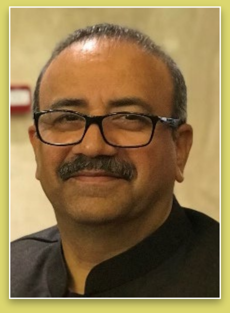

Government of India (GoI) has embarked on the journey in bringing flexibility and resilience in power distribution domain through Reforms-based and Results-linked, Revamped Distribution Sector Scheme (RDSS). There is special emphasis on Improvement of quality, reliability, and affordability of power supply to consumers and financially sustainable and operationally efficient Distribution entities which encompasses large scale deployment of smart prepaid meters (~250 million) including promotion of advanced technologies like Artificial Intelligence etc.

National Smart Grid Mission (NSGM) established by GoI is spearheading the Smart Grid Deployment and has facilitated several-firsts with initiatives like Smart Meter Standardisation, Model Smart Grid regulations, Functional requirements of Advanced Metering Infrastructure (AMI), National Smart Metering Monitoring Dashboards etc. NSGM has also partnered with United States Agency for International Development (USAID) on several pioneering smart grid initiatives, including innovative pilots, tools, model regulations and a global centre of excellence on smart grids.

NSGM in partnership with USAID MAITREE program brought the innovative element, of building and smart grid integration in the form of "Grid-Interactive Net Zero Energy Buildings (NZEB)" as a catalyst to move towards decarbonization.

NSGM partnership with USAID MAITREE program has resulted in successful ZerO-In Dialogues that have created a momentum towards Grid-Interactive Net Zero Energy Buildings. The whitepaper on "Grid-Interactive Net Zero Energy Buildings – An Indian Perspective", will contribute significantly by moving the dialogue to next phase in this regard and integrate with development of future Smart Grid Roadmap.

I take this opportunity to acknowledge and express gratitude towards our partners and experts, who have contributed towards the conceptualization and development of this initiative.

Atul Bali

https://unsplash.com/@toddquackenbush

John Smith-Sreen

Director, Indo-Pacific Office

USAID

Buildings are the critical last mile of the smart grid of the future. Understanding the demand flexibility offered by buildings, appliances, and integrated renewable energy generation and storage is important for the utilities in planning future developments. USAID has undertaken pioneering initiatives in promoting building energy efficiency and smart grid implementation.

USAID partnership with the National Smart Grid Mission (NSGM) under the US-India bi-lateral MAITREE program has built a new narrative that integrates buildings as a part of the smart grid. A series of ZerO-In Dialogues on enabling policies, integrated design, emerging and innovative technology and consumer engagement for Grid-Interactive Net Zero Energy Buildings (G-NZEBs) were organized. The dialogues have been catalytic in expanding the discussion from a singular net zero building to high performing, smart, connected, and flexible communities and cities moving towards net zero emissions.

The whitepaper on Grid-Interactive Net Zero Energy Buildings, developed on the foundation of ZerO-In Dialogues, establishes the role of buildings in grid decarbonization and outlines the next steps towards a building-grid integrated net zero emission future.

I am proud of our partnership with NSGM, who have been instrumental in development of the ZerO-In program. I also thank the program implementing partner, Environmental Design Solutions [EDS] for their commendable work in putting this program together, creating a momentum for a transformative push towards Grid-Interactive Net Zero Energy Buildings.

John Smith-Sreen

John Smith-Sreen

Acronyms & Abbreviations

BEE	-	Bureau of Energy Efficiency
BIS	-	Bureau of Indian Standards
CFCs	-	Chlorofluorocarbons
EER	-	Energy Efficiency Ratio
EMS	-	Energy Management System
GeM	-	Government e-Marketplace
GHG	-	Greenhouse gas
GWP	-	Global Warming Potential
HCFCs	-	Hydrochlorofluorocarbons
HFCs	-	Hydrofluorocarbons
ISHRAE	-	Indian Society of Heating, Refrigerating & Air-conditioning Engineer
ISO	-	International Organization for Standardization
ISEER	-	Indian Seasonal Energy Efficiency Ratio
LCA	-	Life Cycle Assessment
LCC	-	Life Cycle Cost
LCCA	-	Life Cycle Cost Analysis
LCCP	-	Life Cycle Climate Performance
MTPA	-	Million tons per annum
ODP	-	Ozone Depletion Potential
RAC	-	Room Air Conditioners
RE	-	Resource Efficiency
SCP	-	Sustainable Consumption and Production
SDG	-	Sustainable Development Goals
SME	-	Small and Medium Enterprises
SPP	-	Sustainable Public Procurement

TCO	-	Total Cost of Ownership
TEWI	-	Total Equivalent Warming Impact
TR	-	Tonnage
UNEP	-	United Nations Environment Programme
USAID	-	United States Agency for International Development

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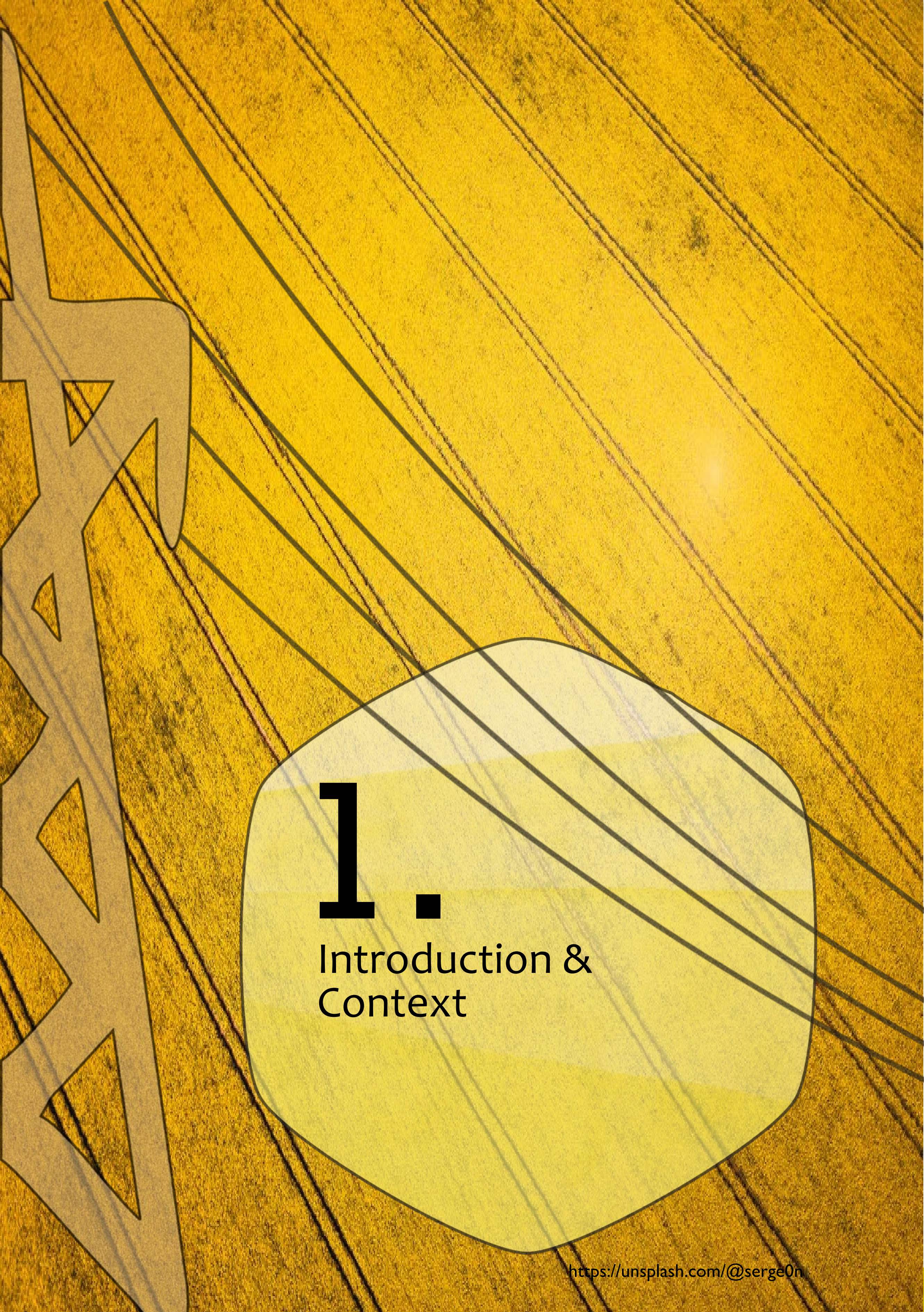

1. Introduction & Context

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1 Introduction & Context

Buildings are an important last mile connection to the grid of the future, and demand flexibility offered by buildings and equipment is an opportunity untapped. The USAID Market Integration and Transformation for Energy Efficiency (MAITREE) program is supporting efforts towards super-efficient, high performing, and net zero energy buildings in India: to address the energy challenges of the country.

Grid-Interactive Net Zero Energy Buildings (G-NZEB) can be described as 'highly energy-efficient, grid-connected buildings that meet their energy needs through renewable means, while maintaining a two-way communication with the grid'. Grid-interactive and highly energy efficient buildings can serve the needs of consumers and distribution utilities alike while reducing overall energy consumption. Consumers, utilities, and the grid form symbiotic entities of such a G-NZEB web. The USAID MAITREE ZerO-In program is aimed at creating a momentum for a transformative push towards G-NZEBs that not only demonstrate high-performance and low environmental impact, but also offer demand flexibility.

Context

Buildings account for nearly 33 percent of the total electricity consumption in India[1]. It has been estimated that more than 50 percent (~700-900 million sqm of urban space annually) of the buildings stock required for 2030 is yet to be built[2]. The U.S. Energy Information Administration's International Energy Outlook 2017 (IEA 2017) projects that amongst all regions in the world, India will witness the fastest growth in building sector energy consumption through 2040 (at more than twice the global average)[3].

Rapid economic growth, rising standard of living, growing population, and urbanization are the contributing factors for the growth of India's buildings energy consumption, resulting in increasing dependence on imported fuel, contributing to higher greenhouse gas (GHG) emissions, and further straining the country's fossil fuel dependent infrastructure. Countries across the globe are working on two fronts:

Embracing net-zero or near-zero goals as they seek to diminish the energy footprint and carbon emissions of their building stock. Zero strategies typically emphasize taking a systems approach to reduce the overall impact of the resource use cycle for water, energy, material, transport, and waste footprint. Since intensive energy use is seen as a primary driver for climate change today, net-zero energy or carbon targets are being prioritized. (Examples – Cape Town, Copenhagen, Durban, Heidelberg, Johannesburg, London, Los Angeles,

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[1] Impact of Energy Efficiency Measures for the Year 2018-19, report published by BEE, https://beeindia.gov.in/sites/default/files/BEE%20Final%20Report_1.pdf

[2] beeindia.gov.in/content/ecbc-commercial, January 2022

[3] https://www.eia.gov/todayinenergy/detail.php?id=33252, December 2021

Medellin, Melbourne, Montreal, New York City, Newburyport, Oslo, Paris, Portland, San Francisco, San Jose, Santa Monica, Seattle, Stockholm, Sydney, Tokyo, Toronto, Tshwane, Vancouver, and Washington, D.C.[4]

Transitioning to a decarbonized, decentralized, and digitized grid of the future. This includes revising of renewable energy targets to shift the country's energy mix. A renewable energy prioritized energy mix affords flexibility to the grid. Several countries are now developing and testing unique business models that harness the flexibility offered by utilities and DISCOMs; including those offered by buildings. (Examples – Connected Neighborhoods Project at Birmingham, Alabama; forward looking initiatives in California, Hawaii, Minnesota, Nevada, and New York, such as Minnesota's Integrated Distribution Planning requirements and Hawaii's Integrated Grid Planning process).

So far, building energy demand and grid services have been distinct discussions, with the only overlapping interface being that of renewable energy. Globally, countries are now realizing that buildings are an important last mile connect to the smart grid of the future, and demand flexibility offered by buildings and equipment is a vast opportunity. USAID MAITREE's ZerO-In program is that platform which seeks to expand the discussion from a singular 'net zero' building to 'high performing, smart, connected, and flexible' developments that have lower environmental impact.

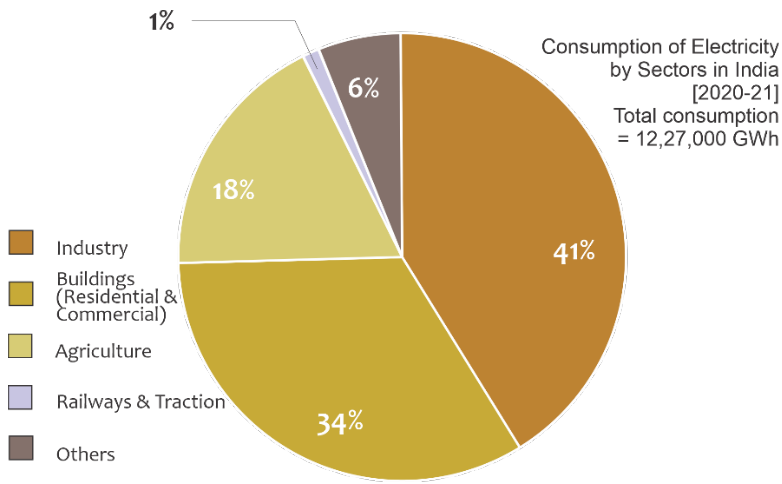


Figure 1 – Buildings account for nearly 34% of electricity consumption in India. Source: Energy Statistics India-2022, National Statistical Office

[4] C40 Cities; Net Zero Carbon Buildings Declaration, planned actions to deliver commitments.

Zero Energy Buildings in India – the Journey so Far

In India, it is essential that net-zero goals must be accompanied by robust energy efficiency measures that include a sound climate-responsive approach to passive solar design, low-energy comfort systems, daylighting and lighting controls, efficient equipment and systems, adaptive thermal comfort standards, and, most importantly, strategies that bolster user acceptance and behavior modification towards a sufficiency-based lifestyle. While implementing energy performance standards for buildings will contribute towards checking the increasing energy demand, net-zero goals are imperative for ensuring energy security. Achieving net-zero goals requires an enabling ecosystem that includes performance benchmarks, supportive renewable energy policies, demand response ready equipment, and a comprehensive smart grid program.

The first Net Zero Energy Buildings (NZEB) International Seminar in India, organized in 2013, witnessed international experts from USA, EU, and Asia, as well as national experts, converging to assess barriers to large scale adoption of NZEBs in the country. The experts discussed their experiences related to design, technology, policy, and metrics. Tested solutions that could be replicated in India with contextual modifications were presented as case studies. A NZEB Knowledge Portal was also launched (with support from BEE) and a NZEB Alliance was formed with active participation from industry experts. Most importantly, NZEB performance indicators were integrated in the updated Energy Conservation Building Code 2017. This was a crucial achievement as it firmly anchored NZEBs in the foremost building energy efficiency performance standard in India. BEE is tirelessly working towards promoting NZEBs. As a part of India's Nationally Determined Contribution (NDC), the National Mission for Enhanced Energy Efficiency (NMEEE) aims to strengthen the market for energy efficiency by creating a conducive regulatory and policy regime. It seeks to upscale the efforts to unlock the market for energy efficiency and net zero.

Smart Grid Development in India

The Ministry of Power released the 'Smart Grid Vision and Road Map for India' on September 10, 2013. The Roadmap was drafted by the India Smart Grid Task Force with the assistance of India Smart Grid Forum, and is spread over the 12th, 13th and 14th five-year plan periods from 2012 to 2027. The vision behind the Roadmap is to transform the Indian power system into a secure, adaptive, sustainable, and digitally enabled eco-system that, with active participation of stakeholders, provides reliable and quality energy for all.

The Government of India established National Smart Grid Mission (NSGM) in 2015 to plan and monitor implementation of policies and programs related to Smart Grid activities in India. The Smart Grid activities aim to make Indian power infrastructure cost effective, responsive, reliable and self-healing. The NSGM's vision, in line with the vision of Smart Grid, is to 'transform the Indian power sector into a secure, adaptive, sustainable, and digitally enabled ecosystem that provides reliable and quality energy for all'.

NSGM has been very successful in demonstrating various smart grid functionalities in several pilots across the country and in the development of Advanced Metering Infrastructure (AMI) ecosystem in the country. Apart from facilitating technology selection guidelines and relevant policy interventions, NSGM has been playing a key role in training and capacity building of utility professionals. Some salient achievements of NSGM include development of Smart Meter Standard (IS 16444), Model Smart Grid Regulations, and Model Standard Bidding Documents for AMI Service provider (AMISP) on Design Build Finance Own Operate Transfer (DBFOOT) basis.

Smart Grid activities in India are also laying great emphasis on development of smart cities, increasing the installation of roof top solar generation capacity, enhanced renewable energy integration, increasing electrical vehicle penetration, smart meter roll-out, and choice to consumer on selection of electricity supplier. The year 2020 has also seen the emergence of real time energy markets, new tariff policies, and draft rights of electricity consumer. A definition of a 'prosumer' has now been included in power policies; thereby enabling an environment for demand flexibility.

Role of Buildings in Grid Modernization

Electricity requirements of India have grown tremendously with demand running ahead of supply for decades, with the per capita electricity consumption nearly doubling from 592 kWh during 2003-04 to 1181 kWh during 2018-19[5]. This demand-supply gap has steadily narrowed after the enactment of Electricity Act, 2003. During the 11th and 12th Plan periods, delicensing of generation significantly boosted capacity addition.

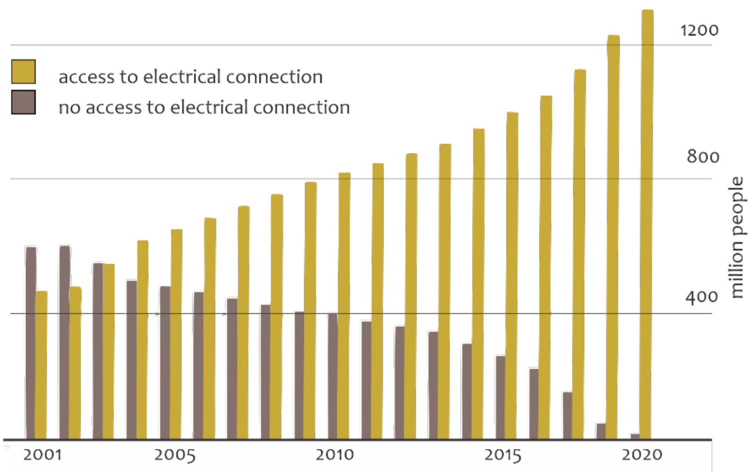


Figure 2 – Nearly 500 million citizens gained access to an electrical connection in the last decade, in India. Source: The India Energy Outlook 2021, International Energy Agency

[5] https://cea.nic.in/old/reports/others/planning/irp/Optimal_mix_report_2029-30_FINAL.pdf

The country's plan to provide reliable and affordable power supply to all by rapid electrification has largely been implemented successfully. The India Energy Outlook 2021 by the International Energy Agency says that 'near universal household access to electricity was achieved in 2019' – this means that over 900 million people gained an electrical connection in the last two decades[6]. Although all aspects of electricity – generation, transmission, and distribution – have undergone tremendous enhancement in capacity and reliability, most of this augmentation has been in coal-based generation. Keeping carbon emissions within control, therefore, continues to pose tremendous challenges for the Indian power industry. To meet these challenges through clean energy resources, India accelerated its efforts and commitment to promote renewable substitutes - particularly solar and wind. Simultaneously, the imperative to modernize the existing grid is being acknowledged through smart grid initiatives. This will contribute towards not only reducing technical and commercial losses, but also carbon footprint.

The initial cost involved in making the grid smarter is very high - priorities based on relative importance of various aspects of a smart grid should, therefore, be identified at the outset. Installation of smart meters and promotion of demand side management are clear choices for immediate reduction in energy losses and peak demand. According to the Central Electricity Authority, India's peak energy demand has increased by 35% over the past decade. With increased cooling demand and use of air-conditioners, some cities are now observing a second peak in the early evening. Further, utilities are facing challenges to upgrade network infrastructure to cater to peak demands, especially in densely populated cities, and are now deploying storage as an intermediary solution. Meanwhile, the installed capacity of renewable energy sources continues to increase - as of September 2020, it constitutes approximately 36% of the energy mix. With increased penetration of renewable energy resources, electrical vehicles, and battery storage, the grid of the future will be subject to more variability of demand and supply. Growing peak electricity demand, multiple peaks, new electricity demand from electrical vehicles, infrastructure constraints, and a growing share of variable renewable electricity generation will increasingly pose a challenge for the Indian electrical grid. Also, nearly 64% of India's energy mix today continues to be thermal – this makes it more difficult to respond at speed to variable demand.

As the electric grid becomes increasingly complex, flexibility in demand plays an important role in maintaining grid reliability, improving energy affordability, and integrating a variety of generation sources. Services that support the generation, transmission, and distribution of electricity and enhance grid optimization through avoided electricity system costs, are collectively termed 'grid services'. Buildings can provide grid services across energy, capacity, and ancillary systems – by offering load flexibility to utilities and DISCOMs, reducing energy waste, and balancing energy use during times of peak demand. Grid-interactive, energy efficient buildings can enable demand forecasting and address the load balancing challenge of the utilities. Although buildings are the key driver of electricity demand, they can also be a

[6]https://iea.blob.core.windows.net/assets/1de6d91e-e23f-4e02-b1fb-51fdd6283b22/India_Energy_Outlook_2021.pdf

part of the solution to problems related to soaring peak demand. Demand response may present a cost attractive alternative to avoid or defer network equipment upgrades (transformers, for instance). Dispatchable control can limit demand, especially for areas where the demand is increasing faster than network upgrades can be delivered, thereby avoiding burnouts or load shedding.

Electrical load in many buildings is already flexible and through advanced controls can be managed to operate at specific times and at different output levels. Advanced controls and communications would enable buildings to adjust electricity consumption to meet grid needs through controls applied to existing equipment - such as lighting and heating, ventilating, and air conditioning (HVAC) - along with on-site renewable energy, electric vehicles charging, and electrical storage. These control strategies can change the way a building schedules energy use to avoid high peak load costs and make building operations more resilient. Demand response strategies may include reducing energy consumption, load shifting to another time, modulating the energy use, or even increasing energy consumption to store for later use. The technical potential offered by dispatchable loads is yet to be explored for different contexts in India.

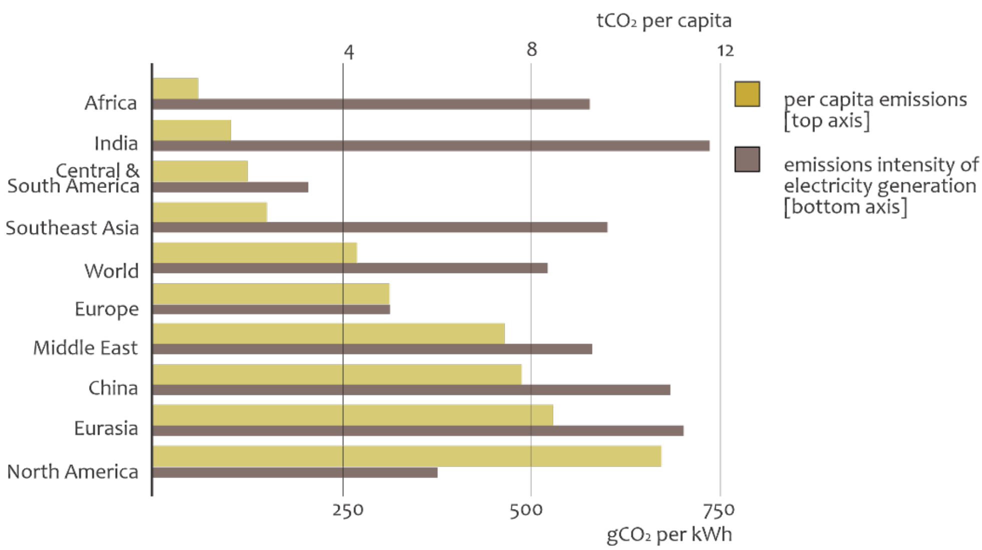


Figure 3 – India has low per capita emissions but one of the highest emissions intensities of electricity generation. Source: The India Energy Outlook 2021, International Energy Agency

900 million
number of people who gained access to electrical connection over the last 20 years

Installed capacity of renewable energy sources
36%

Electricity consumption by the buildings sector
34%

45%
Indian population that will live in urban areas by 2040

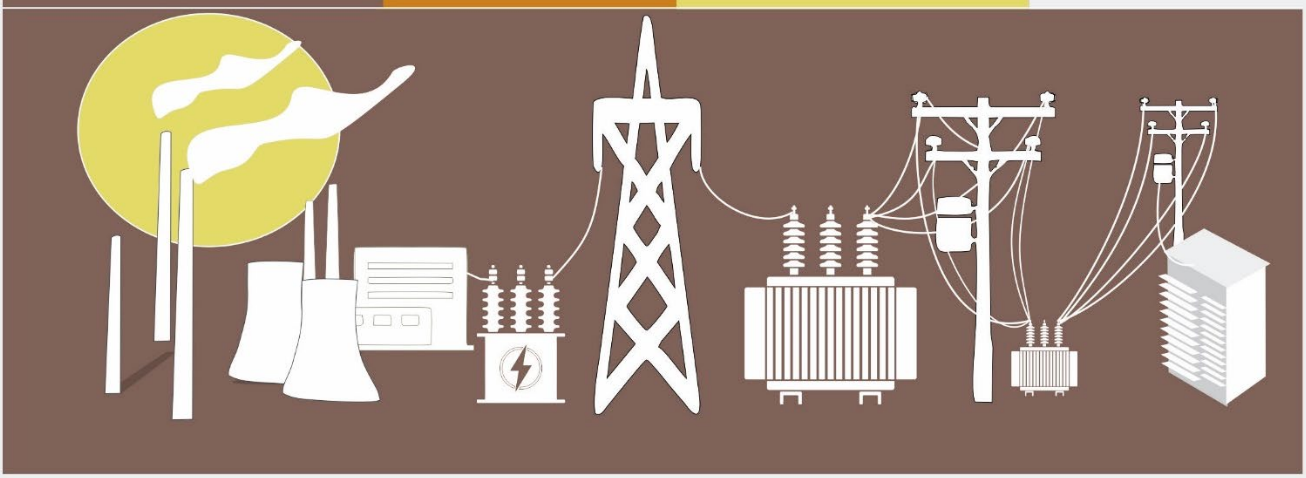
Increase in peak demand over the last 10 years
35%

45%
India's per capita emissions

725 gCO_2
Carbon intensity of India's power sector per kWh

National Smart Grid Mission launched in the year
2015

Generation | **Transmission** | **Distribution** | **Consumption**



2.
What are Grid-Interactive NZEBs?

2 What are Grid-Interactive Net Zero Energy Buildings?

Grid-Interactive Net Zero Energy Buildings (G-NZEBs) are highly energy-efficient, grid-connected buildings that meet their energy needs through renewable means, while maintaining a two-way communication with the grid to balance demand with electricity supply. These high-performing building uses smart technologies, on-site renewable energy sources, and load balancing of equipment to provide demand flexibility while optimizing for energy cost, utility services, and occupant needs and preferences, in a continuous and integrated way.

The following graph (Figure 4) shows the varying daily load profiles of a prototypical office building when different interventions are applied. Energy efficiency improves the load curve through lowering energy consumption and attempts to flatten it. Solar offsets often coincide with utility peak loads. Energy efficient buildings with solar PV though also reduce energy demand on utilities; but can also cause steep ramping of loads which is an issue for utilities. A grid integrated building optimizes energy consumption while supporting utilities through demand response capability - thus offering stability and resilience.

Grid-interactive net zero energy buildings can deliver several forms of demand flexibility:

1	Energy Efficiency	Lowering energy use and energy demand through energy efficiency
2	Load Shedding	Curtailing one or more energy uses through load shedding
3	Load Shifting	Flattening the building's demand curve by moving energy consumption from peak periods to other times to reduce both costs and grid stress through load shifting
4	Modulating	Modulating electricity use and even supply of power to the network to provide important voltage and frequency regulation to assure power quality

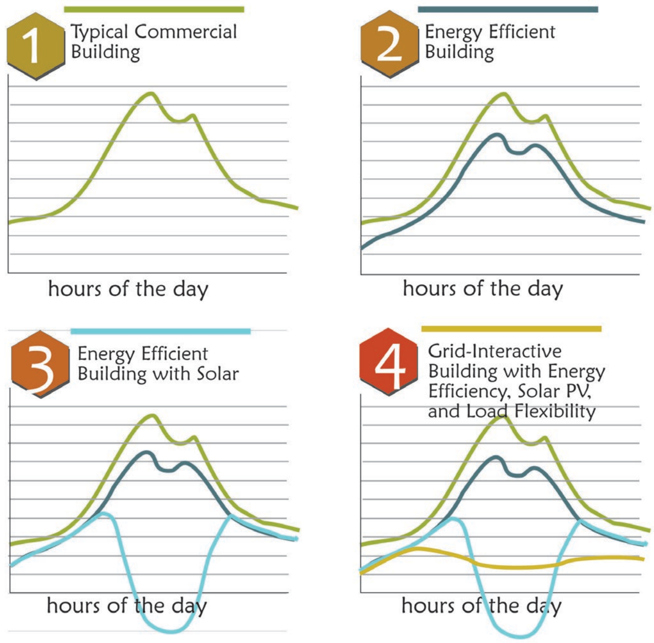


Figure 4 – Demand curves of typical commercial buildings, and G-NZEBs. Source: Rocky Mountain Institute, Value Potential for Grid-Interactive Efficient Buildings in the GSA Portfolio: A Cost-Benefit Analysis

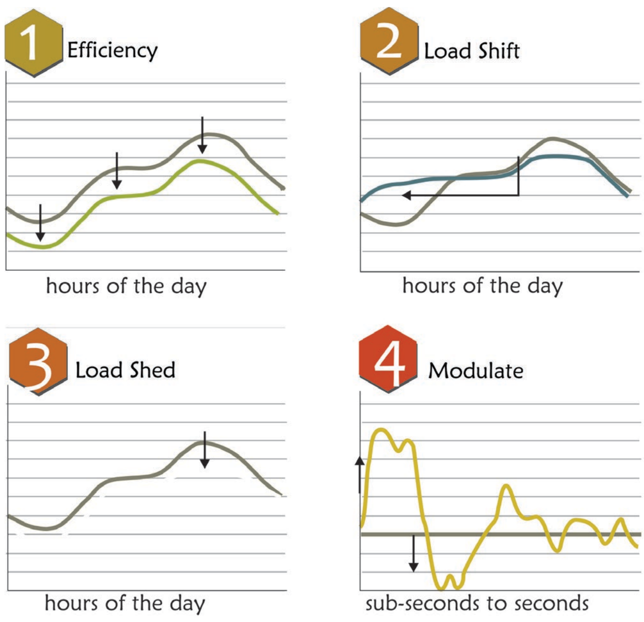


Figure 5 – Load flexibility of buildings. Source: Rocky Mountain Institute, Value Potential for Grid-Interactive Efficient Buildings in the GSA Portfolio: A Cost-Benefit Analysis

Efficient, Smart, Connected, and Flexible

G-NZEBs are energy efficient; with optimized building design, thermally appropriate walls and windows, high-performance appliances, and equipment to reduce both net energy consumption and peak demand. Secondly, they are connected, that is, they respond to the time dependent needs of the grid. Thirdly, these buildings are smart; enabling data analytics to optimally manage loads, occupant preferences and grid requirements. And lastly, they are flexible; where the building energy loads can be dynamically adjusted and optimized.

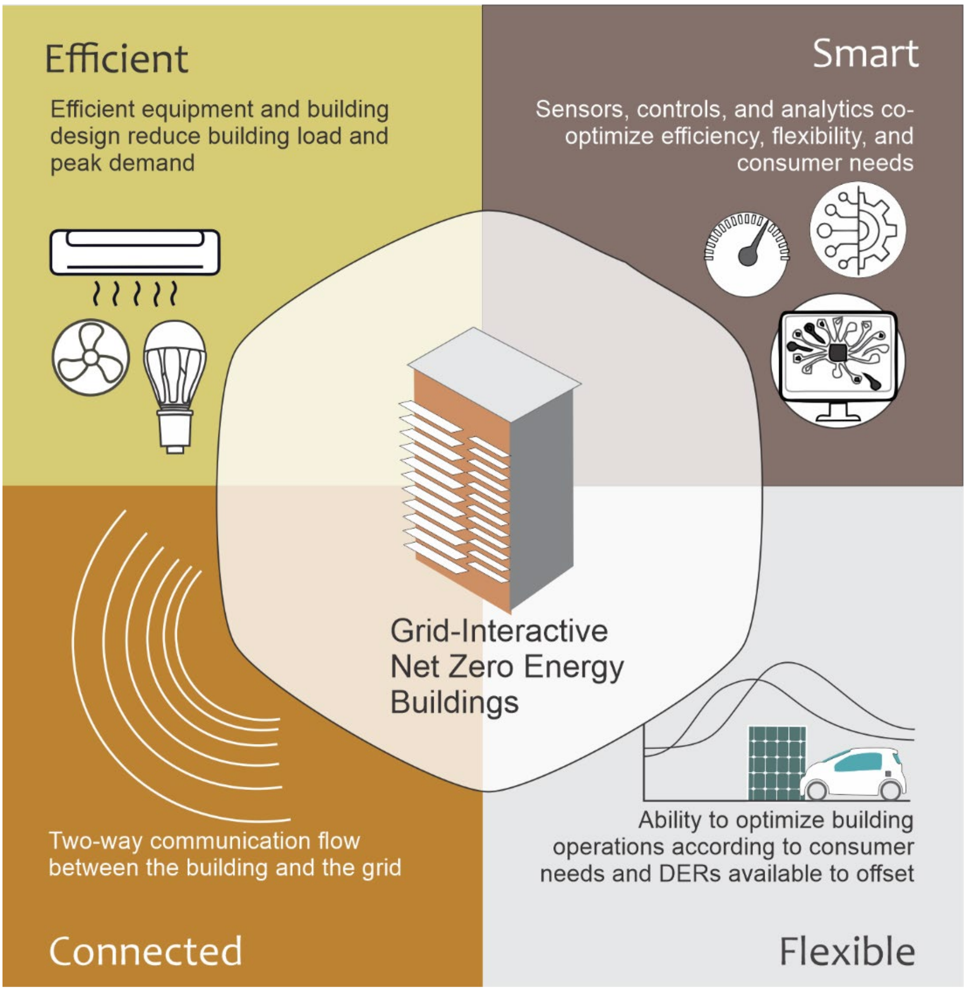
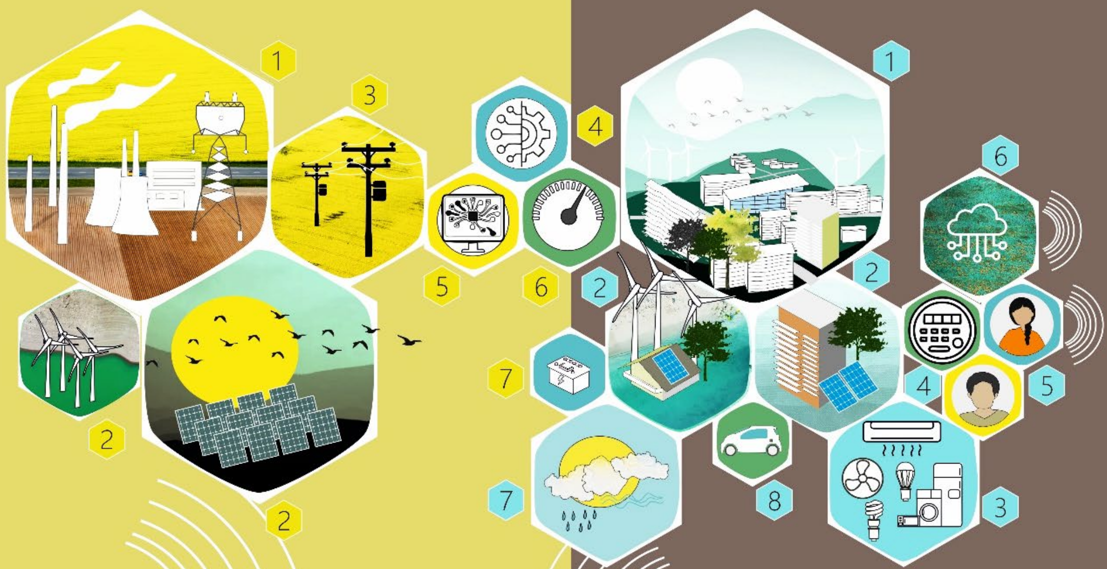


Figure 6 – G-NZEBs are efficient, smart, connected, and flexible.

Components of Grid-Interactive Net Zero Energy Buildings



GRID

1 Thermal Power Plant

2 Renewable Energy (Solar & Wind)

3 Distribution & Transmission

4 Controls

5 Artificial Intelligence Algorithms

6 Measurement & Sensors

7 Battery & Storage

BUILDINGS

1 Development

2 Distributed Solar & Wind

3 Efficient Appliances

4 Smart Meters

5 Occupants

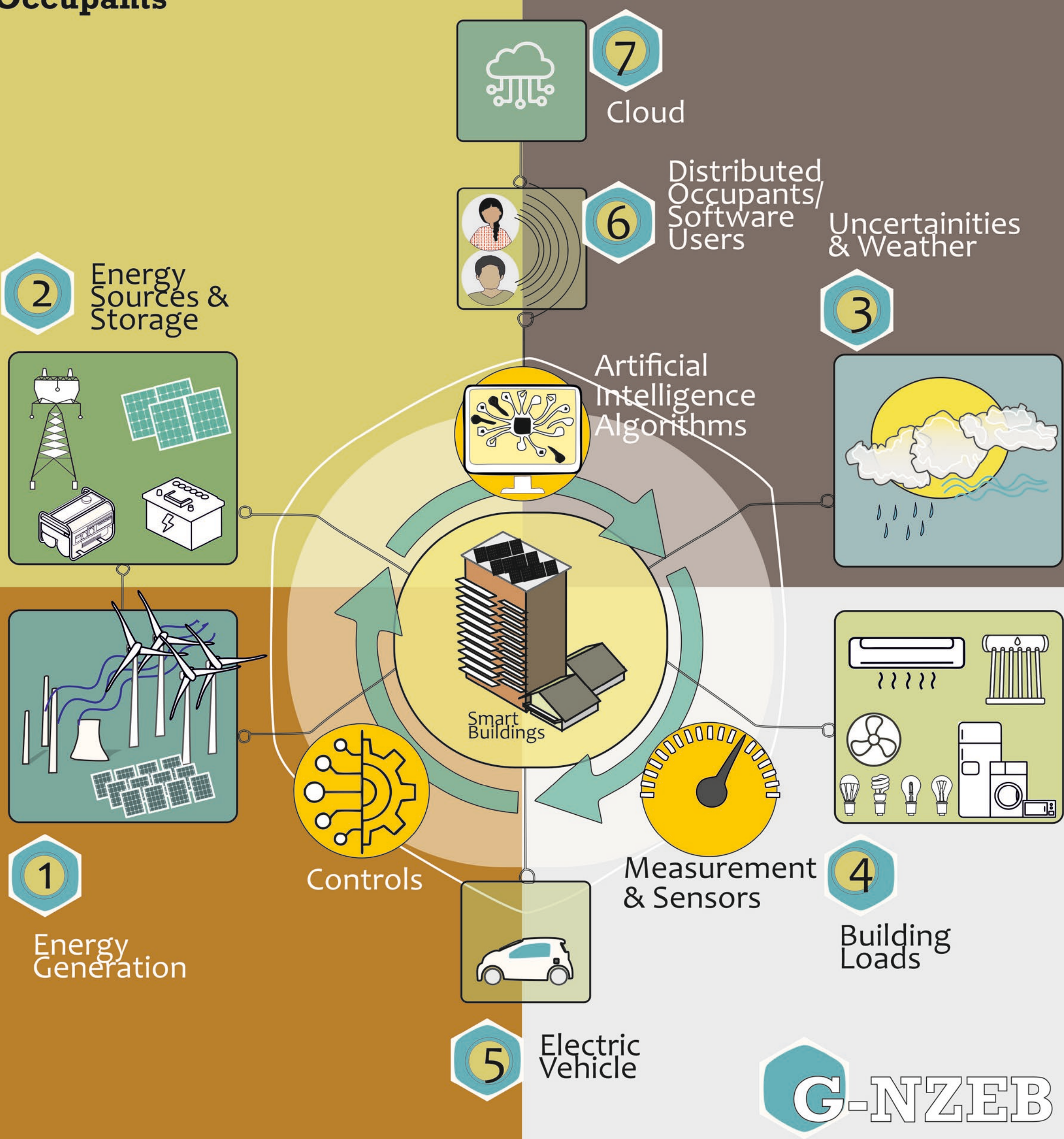
6 Cloud

7 Weather Uncertainties

8 Electric Vehicles

G-NZEB

Grid-Interactive Buildings Communicate with the Grid, DERs, Appliances, and Occupants



3. Benefits & Opportunities

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3 G-NZEB – Benefits & Opportunities

It is expected that by 2050, approximately 50% of the global demand for power will be met through renewable energy[7]. This will result in a more dynamic grid that will balance supply and demand with an increasingly complicated set of inputs that include power generation by distributed energy resources (DERs). On the surface this scenario may appear complex and unpredictable. However, for the grid of the future, the increased connectivity and communication offers unique opportunities for decentralizing and decarbonizing energy supply.

The DER Challenge

The deployment of DERs had a modest beginning that went unnoticed for years. These were simple behind-the-meter devices (like rooftop solar and diesel generators) that could largely be ignored by the centralized grid. As the number and capacity of distributed resources gained significance, the utilities noticed the increased unpredictability of demand on the grid due to bi-directional power flows as well as increased variability introduced by thousands of discrete power generators. The demand curve - that utilities aspire to flatten - started witnessing more peaks and troughs than ever before. Although DERs still constitute a small fraction of the generation capacity (more so in India), they have mobilized a transformational response from the utilities that may well turn them into the largest allies and assets of the grid of the future.

The Opportunity

The formidable deployment of DERs has been accompanied by a host of attendant technologies - like electric vehicle chargers, energy storage, and microgrids – that connect to the grid at the distribution level. Acknowledging and communicating with these technologies not only increases the resilience of the grid but also its reliability. Additionally, it is a largely untapped opportunity for mega-scale decarbonization (as DERs include many clean sources of power). A step at a time, the cumbersome and unidirectional legacy grid is paving the way for a more agile and modern system.

Benefits of the Building-Grid Nexus

General

Increases grid and building resilience

- Reduces use of fossil fuels
- Reduces greenhouse gas (GHG) emissions
- Reduces energy cost

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[7] "Flexible energy systems will power the future". Eaton, 22 December 2021, https://www.eaton.com/in/en-us/company/news-insights/energy-transition.html?source=post:1460900591906088027

Utilities

- Peak load can be better managed thereby avoiding burnouts or load shedding. There is less stress on equipment due to immediate ramp up and down requirements.
- Improved resilience for peak demand periods, or when natural calamities, equipment failures, accidents damage key generation, transmission, and even distribution assets.
- Demand response can help defer or avoid replacement and upgrades to equipment capacity. It also allows for deferral or avoidance of traditional transmission and distribution (T&D) system upgrades such as lines and transformers.
- Demand response driven load shifting, shedding, and onsite supply also reduce transmission losses and physical stresses to equipment, thus lowering costs.

Improved accuracy of demand forecasting to address load balancing challenges.

- Mitigates grid management challenges of the future with the prospect of additional load due to EVs and increased RE in the network.

A study by Brattle Group stated that the U.S. national load flexibility portfolio could deliver over USD 16 billion of annual savings in 2030, mostly from avoided generation capacity, followed by energy cost savings, avoided transmission and distribution capacity, and frequency regulation.8

For Consumers

- Cost savings through reduction in peak loads (and lower demand charges), taking advantage of utility time-of-use rates.
- Enhanced building performance and occupant comfort.
- Better power quality.

A study by the Rocky Mountain Institute (RMI) and the U.S. General Services Administration (GSA) estimated that implementation of grid interactive efficient buildings encompassing HVAC, lighting, plug-load, renewable energy, and storage measures across the GSA-owned office portfolio could yield 165 megawatts (MW) of peak reduction and 180 gigawatt-hours (GWh) per year of energy savings, reducing energy bills by USD 50 million annually or about 20 percent of GSA's annual energy spending.[9]

Harnessing Demand Flexibility

With a significant increase in the percentage of power supplied by intermittent power generators (like solar and wind), the grid is faced with the enormous challenge of real time balancing of supply and demand. As the range of technologies that enable the grid to talk to distributed resources grows, demand flexibility offered by building can be harnessed to the benefit of both – utilities and consumers. Advancements in technologies are opening doors

[8] R. Hledik, A. Faruqui, T. Lee, and J. Higham, 2019, "The National Potential for Load Flexibility: Value and Market Potential Trough 2030," The Brattle Group.

[9] C. Carmichael, M. Jungclaus, P. Keuhn, K. Porst Hydras, 2019, "Value Potential for Grid-Interactive Efficient Buildings in the GSA Portfolio: A Cost-Benefit Analysis," Rocky Mountain Institute and U.S. General Services Administration.

to optimizing the demand flexibility offered by buildings – at stand-alone, community, and building sector levels. Studies conducted on residential demand side management by Building Technology and Urban Systems Division, Lawrence Berkeley National Laboratory, characterized and quantified energy flexibility. It showed that the dominant flexibility type is load shifting, constituting 60% of the applications (followed by shedding (19%), generation (16%), and modulating (6%)[10].

Table 1 – Benefits of G-NZEBS for the smart grid of the future. Adapted for India from: https://sftool.gov/learn/about/638/grid-interactive-efficient-buildings, Sustainable Facilities Tool, U.S. General Services Administration

Characteristic	Present	Future
1. Interoperability and communication from building to grid	Demand response (DR) programs are increasingly being recognized as a priority by utilities. Some DR pilots have been launched Advanced Metering Infrastructure is being deployed	Ability to receive and respond to utility price signals Ability to send load flex potential
2. Integration and interoperability across building systems	Building management systems (BMS) control all major loads (HVAC and lighting) in large commercial buildings Individual system controls are increasingly being utilized by several commercial buildings (cooling, lighting, storage)	AIML to monitor and control all loads, including plug loads and storage Ability to optimize for cost, carbon, and reliability
3. Load flexibility and demand optimization	Thermal energy storage Battery storage Utilities moving towards Time of Use tariffs	Dynamic pricing Intelligence to track and map demand Ability to shift or shed load rapidly based on inputs such as price, weather, carbon, events, etc.

Engaging the Consumer

In the future, smart buildings will rely heavily on advanced technologies to communicate with the grid. Equally, the attainment of an optimized smart grid ecosystem will depend upon how successfully building occupants are engaged in the process. Buildings and their occupants form an integral part of two significant approaches to grid optimization – energy

[10] https://www.sciencedirect.com/science/article/pii/S2666792421000469

efficiency and demand response. While energy efficiency focuses on reducing the year-round energy use, demand response addresses peak demand. By reducing electricity use during peak hours, occupants benefit by avoiding peak charges or receiving monetary incentives. The grid benefits from increased reliability and lowered costs. It is also able to avoid the costs of upgrade and expansion.

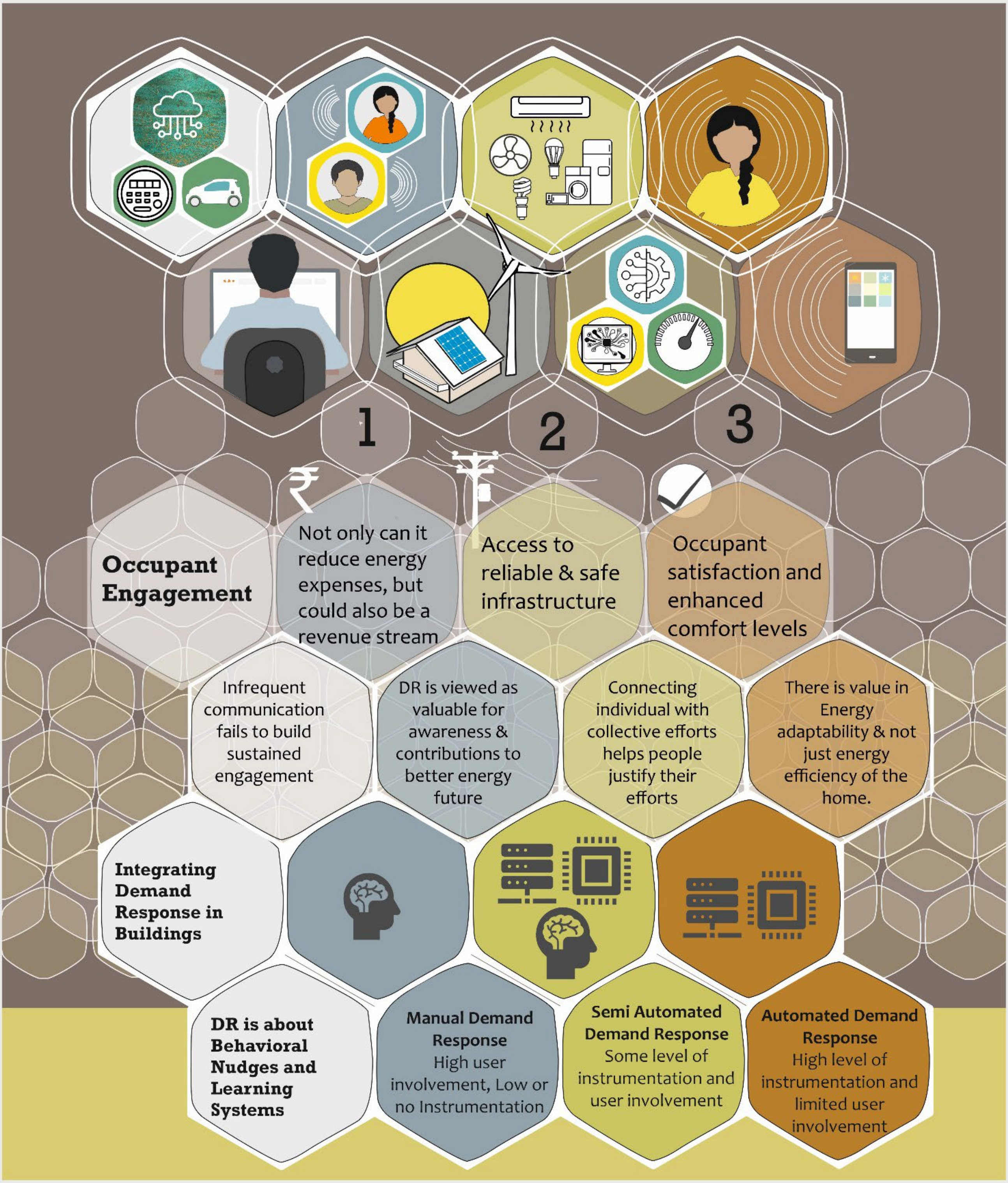
The simplest form of a DR program is one where buildings must reduce their loads on receiving a signal. Demand response can be classified into broad categories - dispatchable and non-dispatchable. Communication systems that activate a direct response to a signal from the grid are part of dispatchable demand response. Non-dispatchable demand response requires the active participation of a building manager in response to a signal.

Designing and integrating a Demand Response (DR) Program in buildings is a key aspect of a G-NZEB. The demand response in a building can be integrated in three ways - manual, automated and semi-automated. This depends on the extent of user engagement, level of instrumentation and investment in integrating learning analytics. Further, behavioral nudges like responding to peak grid period, add to this whole process. Some examples of engaging the consumers in the DR program are - using smart mobile app meters and installing smart thermostats.

Participation of consumers in this process provides opportunities for not only reduced energy expenses but also a revenue stream leading to monetary benefits for them. It provides access to a reliable and stable grid, thereby enhancing the power quality and security for appliances and infrastructure. The flattening of the demand curve ensures consumer satisfaction and improved comfort levels.

Complex technologies, opaque front-of-the-meter operations, risk averseness, and active engagement required for demand response (DR) programs can easily overwhelm occupants into reluctance to participate. At times, monetary benefits may not appear persuasive enough. Other program benefits (to the environment, for instance) may not be obvious to the consumer. Open communication, outreach efforts, education, and incentives are imperative for implementing a successful DR program.

A study by the Australian Renewable Energy Agency demonstrates that infrequent communication failed to build a sustained engagement. Consumer awareness and their contributions increases the value of demand response and in turn contributes to a vision for a better energy future. Connecting individual's efforts with collective efforts help people justify their involvement and keeps them engaged. And finally, there is also a realization that it is not just energy efficiency but also energy adaptability that people are looking at. Depending on the adaptability and engagement of consumers, the design of DR program therefore becomes critical.


1
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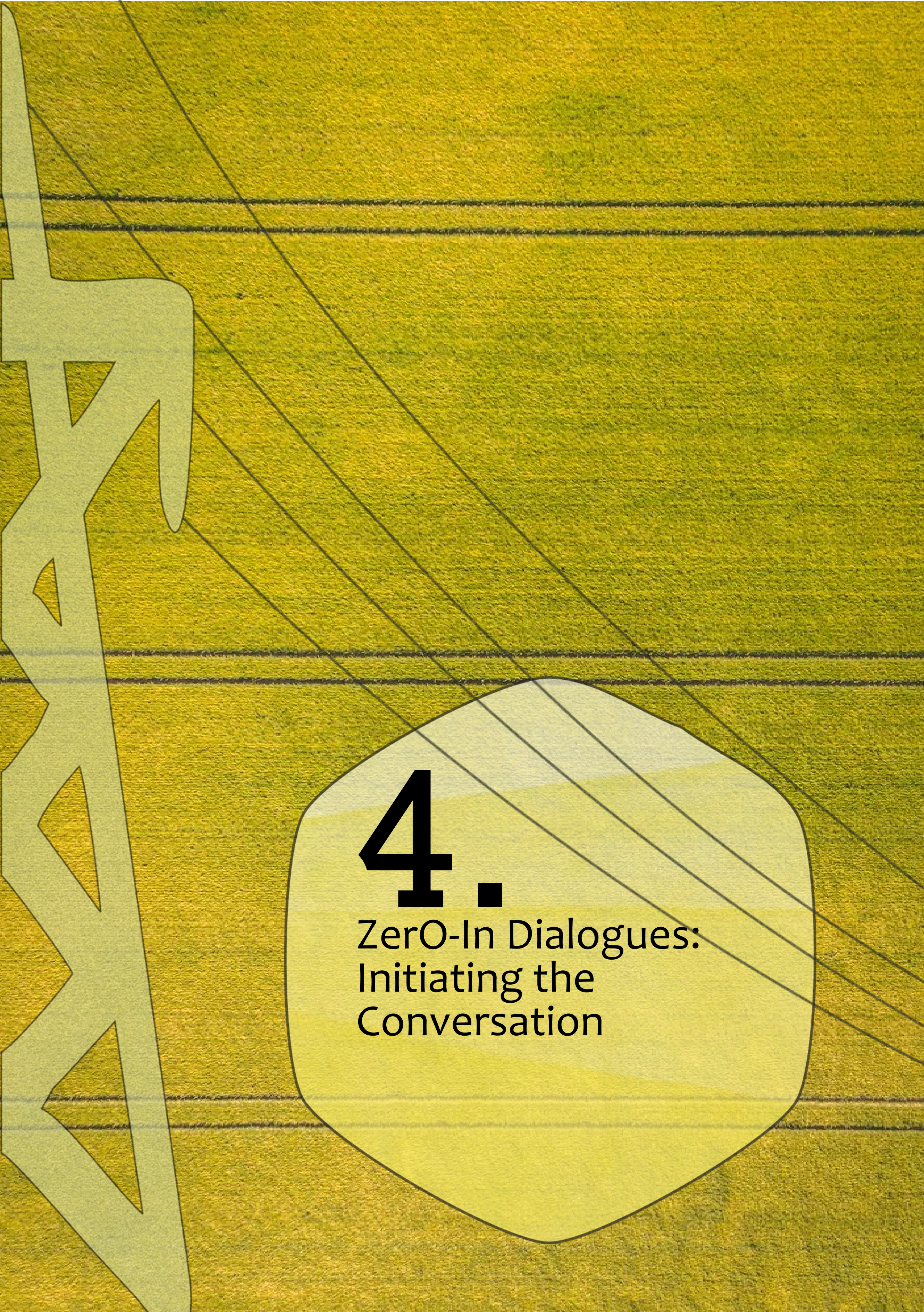
Occupant Engagement
Not only can it reduce energy expenses, but could also be a revenue stream
Access to reliable & safe infrastructure
Occupant satisfaction and enhanced comfort levels
Infrequent communication fails to build sustained engagement
DR is viewed as valuable for awareness & contributions to better energy future
Connecting individual with collective efforts helps people justify their efforts
There is value in Energy adaptability & not just energy efficiency of the home.
Integrating Demand Response in Buildings
DR is about Behavioral Nudges and Learning Systems
Manual Demand Response
High user involvement, Low or no Instrumentation
Semi Automated Demand Response
Some level of instrumentation and user involvement
Automated Demand Response
High level of instrumentation and limited user involvement



4.

ZerO-In Dialogues: Initiating the Conversation

4

ZerO-In Dialogues: Initiating the Conversation

The ZerO-In program is aimed to create a momentum for a transformative push towards G-NZEBs that demonstrate high-performance, have low environmental impact, and offer flexibility services. This will be possible through:

- An enabling policy environment.
- Availability, accessibility, affordability and awareness of design tools.
- Integration of innovative and advance technologies.
- Engaging the consumer.

The ZerO-In Dialogues were envisioned around the four themes mentioned above. The audience for the Dialogues comprised of more than 500 policy makers, experts from building and construction sector, utilities, engineers, architects, technology providers, equipment manufacturers, service providers, IoT companies, public and private sector developers – several with the potential to steer the market towards an increased uptake of G-NZEBs. The thematic areas are elaborated below.

Enabling Policy

There have been many national and state level efforts on building energy codes, standards, byelaws, and renewable energy policies. Simultaneously, efforts towards decarbonizing, decentralizing, and digitizing the grid of the future are underway. Recently, we have witnessed developments such as the emergence of real time energy markets, new tariff policies, and draft rights of electricity consumers. The ZerO-In program will work towards defining the vision, alignment, and convergence of different policies, regulations, and codes for enabling grid-interactive net zero energy buildings. The program will bring in a global perspective through learnings from international policies and their application in the Indian context.

Integrated Design

Net zero energy building designs are adaptive, comfortable, and less dependent on air-conditioning without compromising on air quality. Grid-interactive buildings use smart technologies, on-site renewable energy sources, and load balancing of equipment to provide demand flexibility while co-optimizing for energy cost, grid services, and occupant needs & prefere nces in a continuous and integrated way. The ZerO-In program will work towards integrating design process as an essential component of architecture and planning practice.

Emerging Technology

In India, energy use is steadily increasing as standards of living improve. Growing electricity demand, emergence of multiple peaks, distributed power, electric vehicles, infrastructure constraints, and an increasing share of variable renewable electricity generation are a challenge for the electrical grid. As the grid becomes increasingly complex, flexibility in demand will play a vital role in ensuring its efficiency and stability. Buildings can provide flexibility by reducing energy waste and balancing energy use during times of peak demand through appliance efficiency, interactive technology, and renewable solutions. ZerO-In program will focus bringing forth successful models of integrated low energy cooling systems and design for integration of technologies to offer flexibility and load balancing. It will also work towards creating awareness on smart renewable energy integration with buildings (including response to RE variability, storage, and grid integration).

Consumer Engagement

Grid interactive buildings are smart - enabling data analytics to optimally manage loads, occupant preferences, and grid requirements. However, there is growing recognition that technology alone cannot achieve energy efficiency goals. Consumer behavior and preferences must align with energy conservation and demand response objectives. ZerO-In program will work towards creating awareness on role of data analytics towards influencing consumer behavior. International experiences demonstrating how data analytics can successfully nudge occupant preferences to align with grid requirements, will be brought forth for key decision makers.

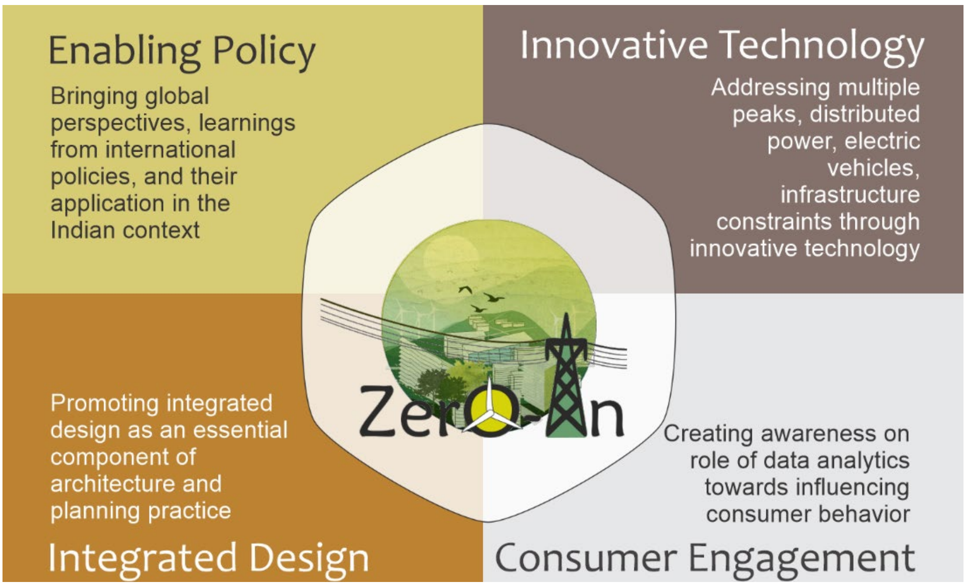
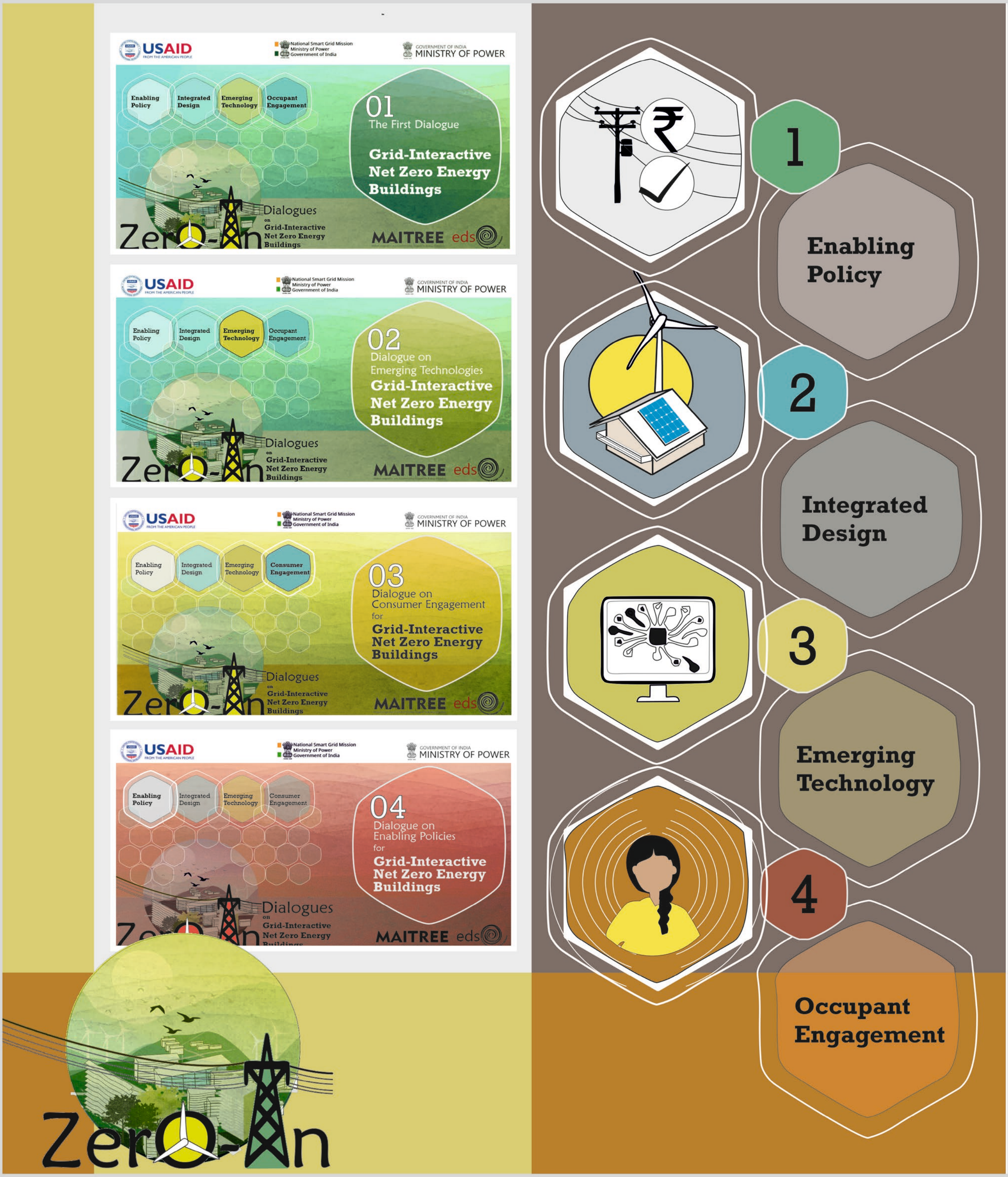


Figure 7 – The ZerO-In Dialogues addressed issues at the cusp of energy efficient buildings and smart grids through four tracks – enabling policy, integrated design, innovative technology, and consumer engagement.


USAID
National Smart Grid Mission
Ministry of Power
Government of India
MINISTRY OF POWER
Enabling Policy
Integrated Design
Emerging Technology
Occupant Engagement
01
The First Dialogue
Grid-Interactive Net Zero Energy Buildings
Dialogues on Grid-Interactive Net Zero Energy Buildings
MAITREE
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02
Dialogue on Emerging Technologies
Grid-Interactive Net Zero Energy Buildings
Consumer Engagement
03
Dialogue on Consumer Engagement for
Grid-Interactive Net Zero Energy Buildings
04
Dialogue on Enabling Policies for
Grid-Interactive Net Zero Energy Buildings
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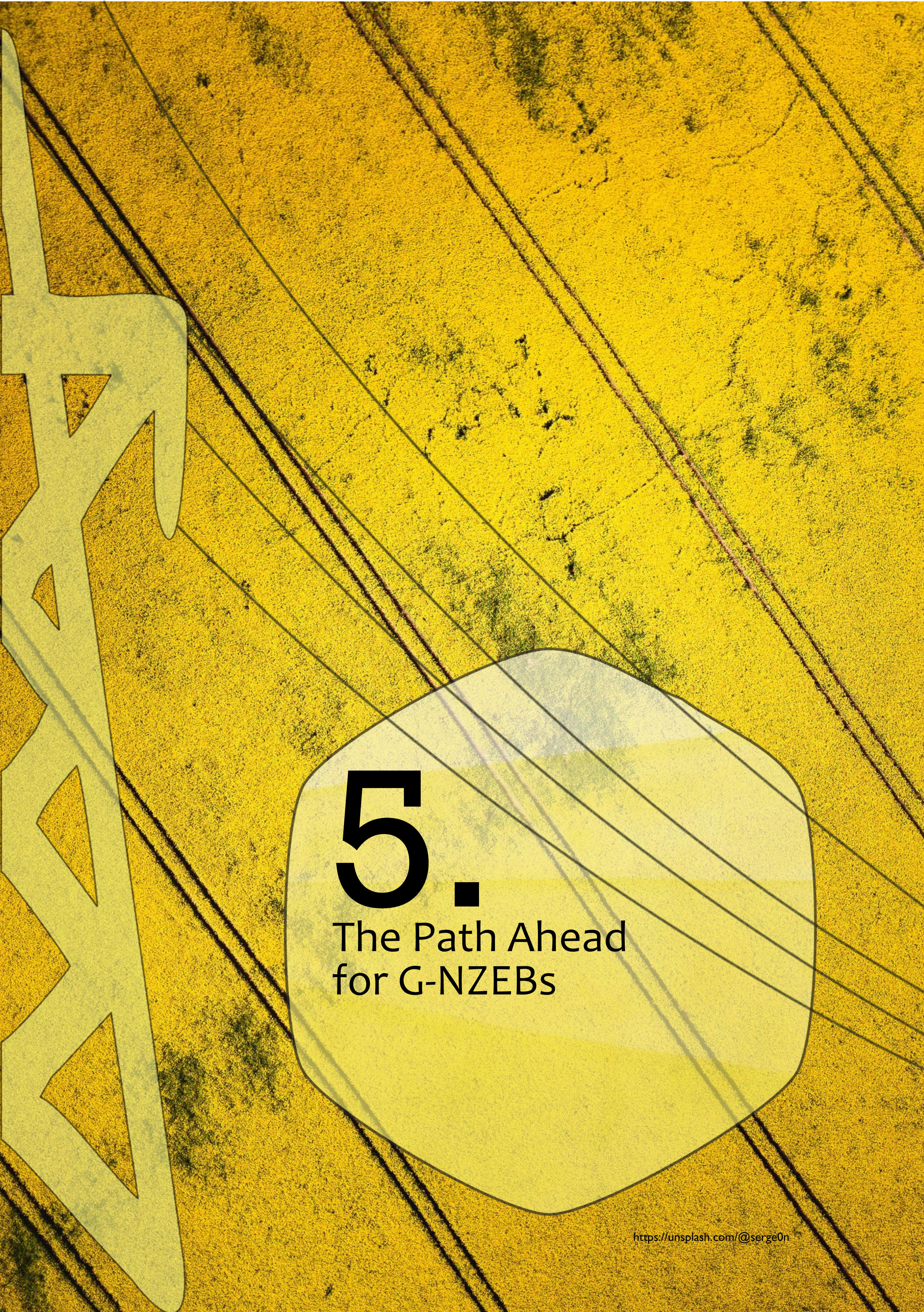
Enabling Policy
2
Integrated Design
3
Emerging Technology
4
Occupant Engagement



5.
The Path Ahead for G-NZEBs

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5 The Path Ahead for G-NZEBs

In the year 2019, the Intergovernmental Panel on Climate Change (IPCC) made the following grave announcement - "Global net human-caused carbon dioxide emissions would need to fall by around 45 percent from 2010 levels by 2030, reaching 'net zero' around 2050" to keep global warming to 1.5°C, the Paris Agreement's objective. Further, it stated that total greenhouse gas emissions must be zero between 2063 and 2068. Under the Paris Agreement, 192 countries have committed to address global warming. Spurred by the UN Race to Zero campaign, several cities, corporations, and communities have pledged to time-bound net zero goals. Despite concerted efforts, the climate crisis continues to brew, partly due to missed targets and attenuated accountability.

The Brewing Climate Crisis

Decarbonization will be a defining imperative of the decades to come. Carbon dioxide is one of the most significant contributors to global warming – lingering in the atmosphere for a long time. Reducing greenhouse gas emissions through curtailing (or eliminating) the burning of fossil fuels for our energy needs is imperative for achieving the Paris goals. Decarbonizing the grid and switching to renewable sources of energy to keep buildings comfortable, safe, and healthy is a promising path to embark upon for meeting the targets set by the Paris Agreement.

India - Climate Commitments and Decarbonization Goals

At the 26th Conference of Parties (CoP26), India announced a five-fold strategy to achieving India's commitment to net zero emissions by 2070. The strategy declares that:

- India will get its non-fossil energy capacity to 500 GW by 2030
- India will meet 50 percent of its energy requirements from renewable energy by 2030
- India will reduce the total projected carbon emissions by one billion tonnes by 2030
- By 2030, India will reduce the carbon intensity of its economy by less than 45 per cent
- And, by the year 2070, India will achieve its net zero target

India's 2019 emissions amount to 2.88 CO_2 gigatons. At present, India relies heavily on oil and coal to meet its energy needs. Accounting for approximately 35% of total energy consumption, the building-grid nexus is poised to forge a significant partnership to enable a transition to clean sources of energy.

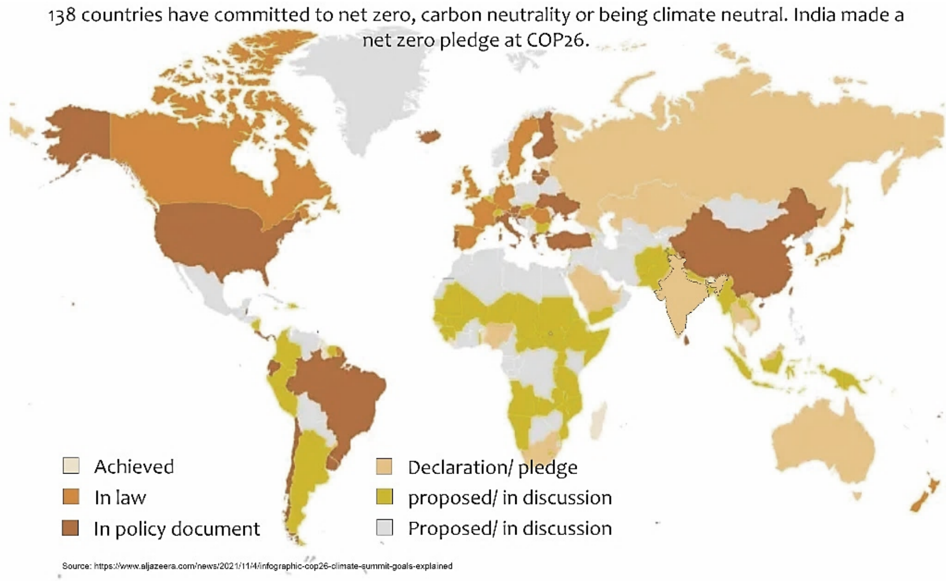


Figure 8 – Map of net zero commitments made by countries. Source: Al Jazeera and News Agencies (data from Energy and Climate Intelligence Unit, updated November2, 2021)

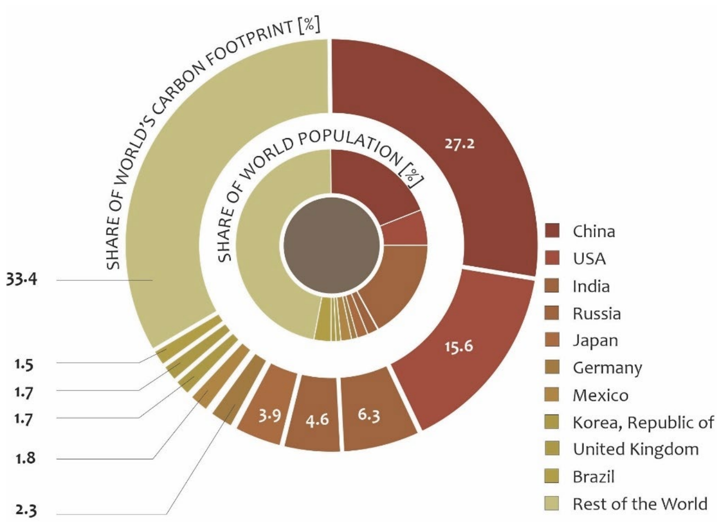


Figure 9 – Global carbon dioxide emissions by countries. Source: Al Jazeera and News Agencies (data from Energy and Climate Intelligence Unit, updated November2, 2021)

Evolving Codes & Policy Landscape

The G-NZEB policy landscape is evolving rapidly and propitiously, bolstered by supportive policies and codes, globally. On May 17, 2021, the US Department of Energy released a comprehensive pathway for enhancing Grid-Interactive Energy Efficient Buildings – 'A National Roadmap for Grid-Interactive Efficient Buildings'. The Roadmap lists 'Supporting GEB deployment through federal, state, and local enabling programs and policies' as the fourth and final pillar of measures for enhancing the G-NZEB concept. It encourages governments to 'lead by example' by demonstrating the feasibility, resilience, and cost-effectiveness of G-NZEBs by successfully integrating the concept in their own facilities. In this context, the TSREDCO and TSSPDCL Office Building in Telangana - India's First SuperECBC & G-NZEB Building – is a step in the right direction.

Building codes and steadily moving towards addressing the components of distributed energy resources that promote load flexibility and responsiveness. California's 2019 Building Energy Efficiency Standards (Title 24) has already incorporated a section on 'Mandatory requirements for Demand Management'. Further, it defines Demand Flexibility Measure as 'a measure that reduces TDV (time dependent value) energy consumption using communication and control technology to shift electricity use across hours of the day to decrease energy use on-peak or increase energy use offpeak, including but not limited to battery storage, or HVAC or water heating load shifting'.

The U.S. Environmental Protection Agency's ENERGY STAR Connected Products has included a 'connected' criteria for several products. A connected product offers several benefits that include energy reporting and connections to other devices or systems (both behind and in front of the meter). These criteria can be met through a host of products like smart thermostats, room air conditioners, refrigerators, freezers, light fixtures, ceiling fans, and electric vehicle equipment.

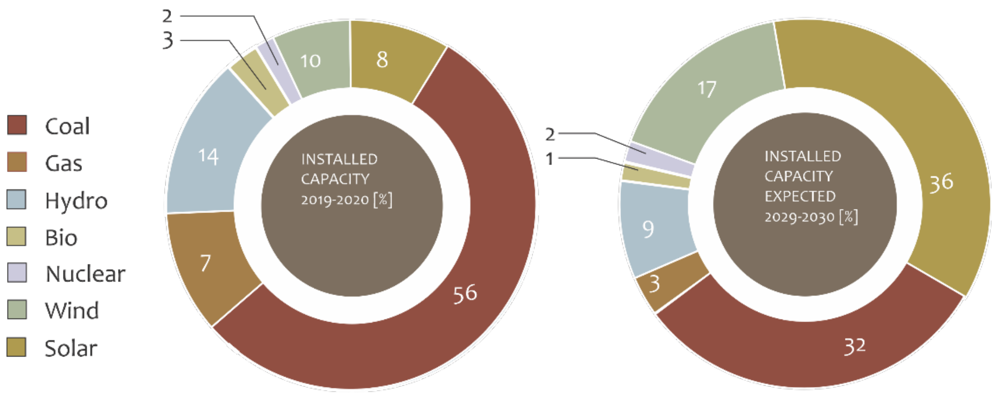
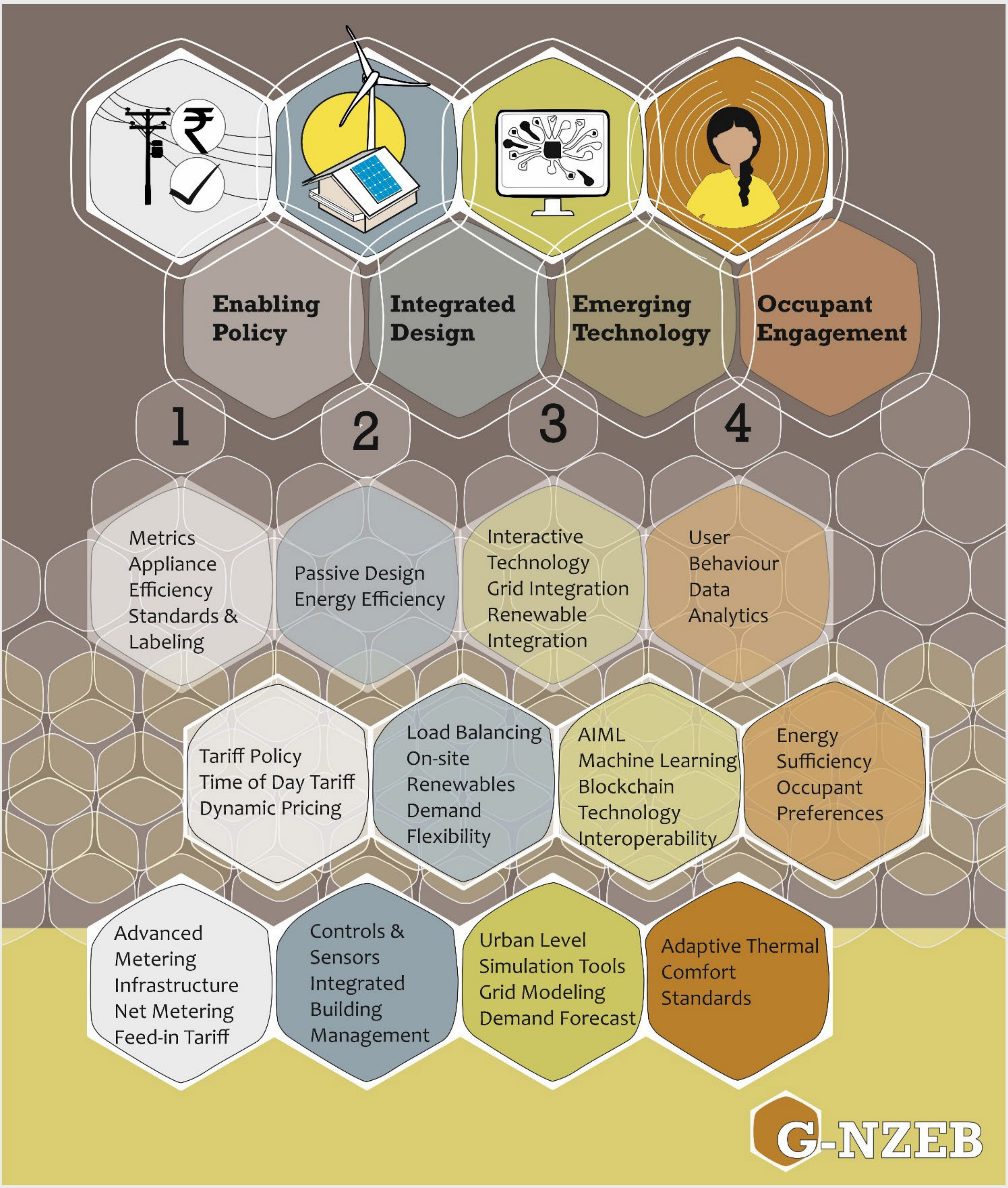


Figure 10 – Global carbon dioxide emissions by countries. Source: ET Energyworld.com


Enabling Policy
Integrated Design
Emerging Technology
Occupant Engagement
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Metrics Appliance Efficiency Standards & Labeling
Passive Design Energy Efficiency
Interactive Technology Grid Integration Renewable Integration
User Behaviour Data Analytics
Tariff Policy Time of Day Tariff Dynamic Pricing
Load Balancing On-site Renewables Demand Flexibility
AIML Machine Learning Blockchain Technology Interoperability
Energy Sufficiency Occupant Preferences
Advanced Metering Infrastructure Net Metering Feed-in Tariff
Controls & Sensors Integrated Building Management
Urban Level Simulation Tools Grid Modeling Demand Forecast
Adaptive Thermal Comfort Standards
G-NZEB

G-NZEB

Policy | Roadmap
Grid-Interactive Efficient Buildings Initiative
US Department of Energy

Metrics | Policy | Guides | Tools
GridOptimal Buildings Initiative, NBI

Roadmap | Guides | Paper
Blueprint for Integrating Grid-Interactive Efficient Building Technologies into U.S. General Services Administration Performance Contracts, NREL
Smart Grid Application Guide, ASHRAE

Papers
Building Our New Energy Future, ASHRAE
The economics of Grid-Interactive Efficient Buildings, RMI

Standards
Facility Smart Grid Information Model (ASHRAE 201- 2016) → ISO 17800

Paper
Presenting the value of flexible buildings
SmartEN Europe

Program | Policy
Energy Flexible Buildings, Annex 67
Energy Flexible Buildings Towards Resilient Low Carbon Energy Systems, Annex 82
IEA Energy in Buildings & Community (EBC) Program

Standards
AS/NZS 4755 framework - DR capability requirement
Smarter Homes Technical Standards and Requirements.
Demand Response modes
Greenhouse and Energy Minimum Standard (GEMS) Determination

United States

Utility Programs | Automated Demand Response
Duke Energy's EnergyWise Business program (C&I)
Austin Energy's Load Co-op pilot (C&I)
BPA Smart Water Heater Pilot (R)

Utility Programs | Automated Demand Response + EE
PG&E's ADR program (C&I)
Dominion's Smart Thermostat program (R,C)

Utility Programs | DER aggregation pilots
Southern Company's Smart Neighborhood pilot (R)
MECO's Jumpsmart Maui pilot (R)
SMUD's 2500 R Street pilot (R)
PG&E's Smart Grid Test Bed pilot (R)

India

Pilot
Telangana State Renewable Development Corporation (C)
USAID MAITREE

Pilot
Dispatchable Air Conditioning Program (R)
UK Innovate Grant – HWU, AVC, SCENE, FIRE, & EDS

Way Forward & Conclusion

India has set an interim milestone to reduce the carbon intensity of its economy by 45 percent, by the year 2030. To put it in perspective, by that year, it is estimated that the United States will have nearly 200 gigawatts (GW) of cost-effective load flexibility potential, equal to 20 percent of estimated U.S. peak load. That is three times the existing demand response capability, with savings for consumers from avoiding utility system costs estimated at $15 billion annually. India must tap into the potential offered by building load flexibility to cross the milestones on the way to a decentralized, decarbonized, and digitalized energy ecosystem. Some immediate and other long-term measures in the following areas must be propelled into action to accelerate this process:

1	Develop a comprehensive roadmap for Grid-Interactive Net Zero Energy Buildings
2	Assess building energy and peak demand growth trajectories and alternate scenarios for distribution utilities and the grid
3	Evaluate and quantify grid integration potential for buildings
4	Develop metrics for DER and demand flexibility for grid-optimized buildings
5	Set codes and standards for grid-optimized buildings
6	Develop business models and consumer engagement strategies for utilities
7	Disseminate information to and build capacity of utilities
8	Increase awareness and build capacity of building sector stakeholders
9	Engage the consumer
10	Launch pilot projects

Apart from the high-level strategies mentioned above, the G-NZEB ecosystem can be strengthened through long-term planning that addresses research, innovation, and technology. Here are some specific long-term strategies that are essential for the uptake of G-NZEBS:

- Promoting Energy Efficiency in Utilities
- Empowering Facility Managers, Building Owners, and G-NZEB Operators
- Incentivizing the Consumers
- Deploying G-NZEB Technologies

Building End-use and Envelope Systems

Sensors, Controls & Machine Learning

Adopting Building Codes to Address Grid-Interaction

Reach codes for Grid-Integration Provision

Codes for 'Connected' Appliances

Developing Metrics & Standards

Benchmarks for Grid-Interactive Buildings

Rating Systems

Supporting Emerging Technologies for Building-Grid Communication

G-NZEB Platforms

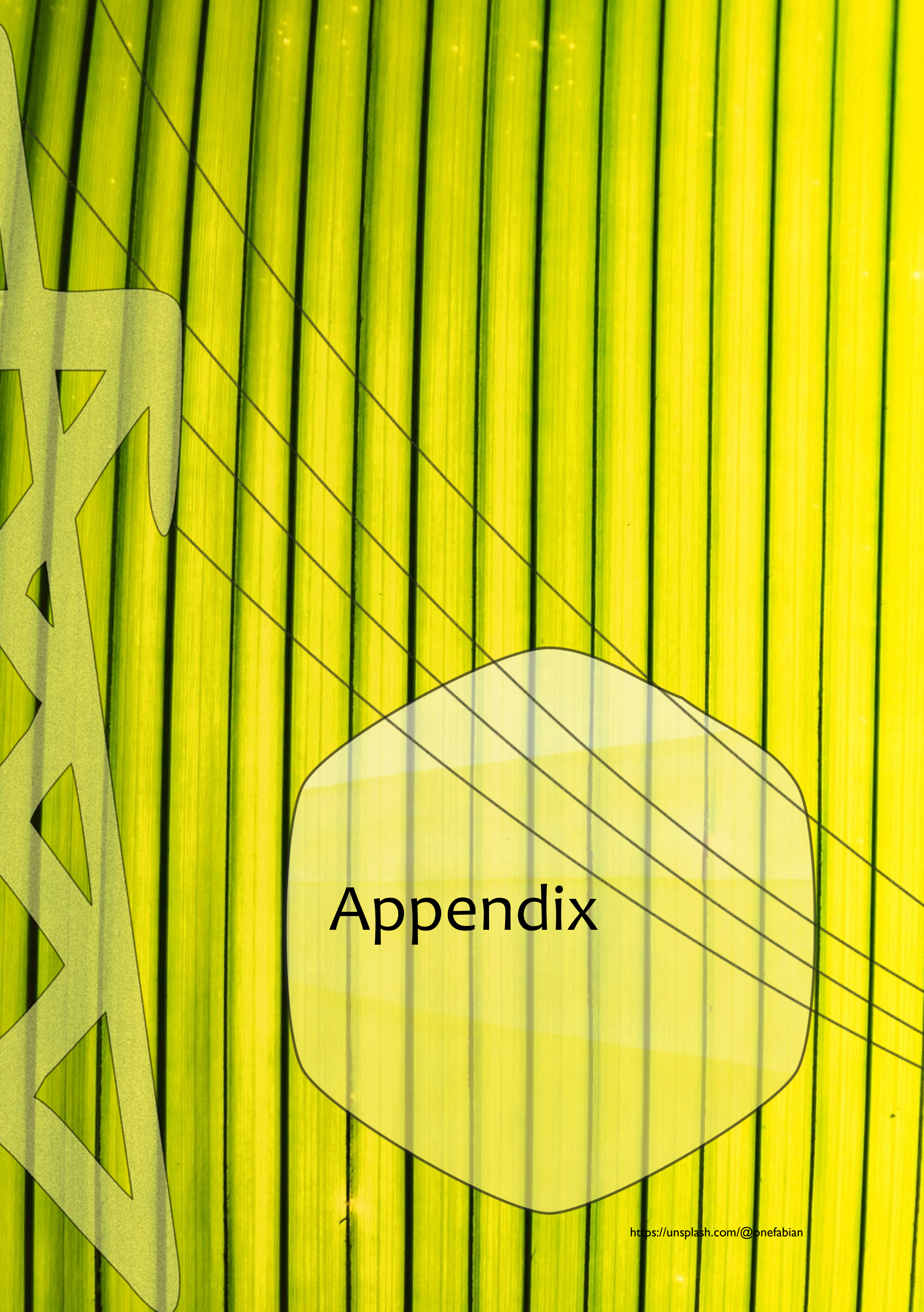
Research and Innovation

Real-time Information Convergence and Integration

Interoperability

The transition to a decarbonized and decentralized grid is in harmony with India's resolve to meet its emissions reduction declarations. The country's energy mix too, is shifting towards renewable resources. Buildings have the potential to contribute significantly to this process of decarbonization by harnessing load flexibility. Buildings and cities can now evolve from passive consumers of electricity to active participants in a two-way communication with the grid.

Appendix



https://unsplash.com/@onefabian

Appendix A

ZerO-In dialogue series

Buildings are a crucial last mile element of the smart grid of the future. Demand flexibility offered by buildings and appliances is an untapped opportunity for the distribution utilities. Grid-Interactive Net Zero Energy Buildings (G-NZEBs) are highly energy-efficient, grid-connected buildings that meet their energy needs through renewable means, while maintaining a two-way communication with the grid to balance demand with electricity supply. The ZerO-In dialogue series expanded the discussion from a singular net zero building to high performing, smart, connected, and flexible communities and cities moving towards net zero emissions.

ZerO-In Dialogue #01

Inaugural Session
December 10, 2021

The first dialogue of the ZerO-In dialogue series introduced the concept of Grid-Interactive Net Zero Energy Buildings, as strategic integrated approach; based on the foundation that buildings can be energy positive; have the potential to be major producers of renewable energy and can offer the demand flexibility; thereby playing a key role in a low emission smart grid of the future. This dialogue covered the role, importance, and benefits offered by buildings-grid integrated networks.

Role of buildings for equitable decarbonization of economies

The global climate crisis is inevitable, unprecedented, and irreversible; with climate change impacting all species on the planet. The focus is towards not increasing the global temperature beyond 1.5 degrees. Carbon emissions continue to rise unabated (417 ppm on September 2021, source: NOAA) which is a great concern. Additionally, issues such as air quality which disproportionately impact people from low-income strata, are also a concern. Diversity, equity, inclusion, and economic disparity need to be integrated such that the 'energy burden' on disadvantaged communities is reduced. In the U.S., buildings use approximately 75% of all power transmitted and distributed of the grid. Buildings are not seen as climate solutions and need to be brought to the forefront of the climate discussions. New Buildings Institute (NBI) with focus on Zero Energy and Carbon Neutral buildings has been tracking the growth of such buildings since over a decade. NBI has also worked recently on the development of the Carbon Neutral Buildings Roadmap. Road mapping exercises are very important to demonstrate how an ambitious goal like the decarbonizing economy or the building sector can be achieved.

New Buildings Institute has laid down five foundations for building decarbonization:

Energy Efficiency – It is very important to continue to drive down energy use in buildings, while moving towards decarbonization of buildings. Reducing energy in buildings by 50%-75% is a key strategy to getting to zero.

Renewable Energy Integration – Focus on prioritizing onsite renewables as a first strategy for renewable energy integration – roof top solar PV or building integrated photovoltaics. In dense urban areas where there are no on-site opportunities, focus can then shift to off-site renewables through variety of contractual arrangements such as direct ownership, power purchase agreements, community solar and utility delivered renewables.

Building Electrification – In the US, building electrification has come to the fore, and it's estimated that approximately a billion appliances would need to be replaced for transformation of the building sector. Globally, the greenhouse gas impact of building electrification is approximately six percent. However, when considering direct combustion of fossil fuels, thirty three percent of the emissions can be attributed to buildings and the implications are worse, as its not only the energy cost burden but also air pollution- both inside buildings and in surrounding communities. The effort towards building electrification and decarbonization is to get that the air pollution to zero as well.

U.S. Electrified buildings database – www.electrifiedbuildings.com

Building Electrification Technology Roadmap developed with California Public Utilities, describes the product end-uses that need to be electrified and state of technology advancement of different end-uses.

Making buildings electrification ready, is important as buildings are the nexus point between electric vehicle infrastructure and the grid. Buildings can offer resilience, where with the advent of two-way charging, buildings will not be relying on battery / storage systems but electric vehicles as batteries / storage systems.

Life-cycle Impacts –

Low-GWP refrigerants - Most refrigerants have high global warming potential that is up to thousands of times more polluting than carbon di oxide. Attention is now also being paid to the greenhouse gas emissions from these refrigerants. While there is focus on advancing energy efficient heating and cooling systems, there is also a need to focus on refrigerants with low-GWP.

Low Embodied carbon materials – Construction materials alone are responsible for about 11% of all global carbon emissions. Focusing on reducing the use of high-embodied materials such as steel, aluminium, and concrete, as well as building reuse, materials reuse are ways to reduce embodied carbon and contribution towards global carbon emissions.

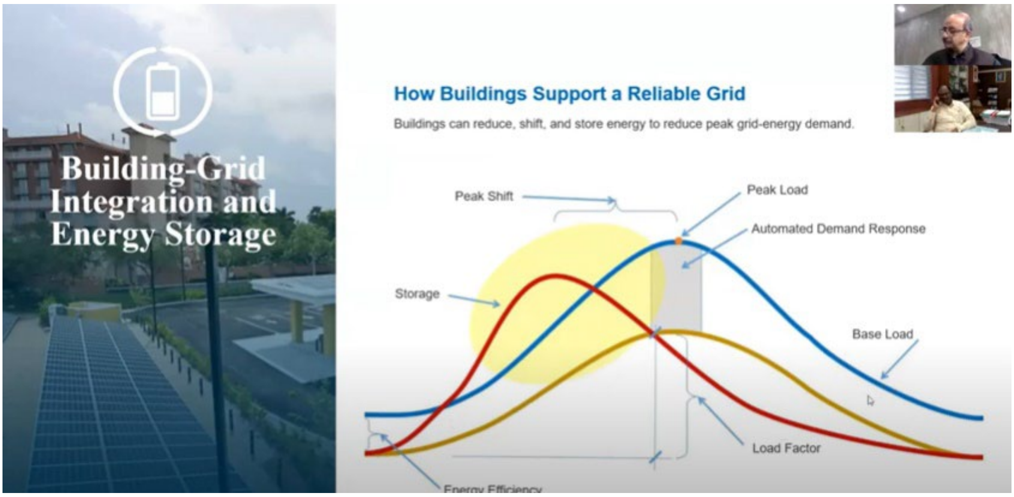
Grid-Integration + Storage + Electric Vehicle Infrastructure – US Department of Energy in partnership with National Renewable Energy Lab (NREL) has put together "A National Roadmap for Grid-Interactive Efficient Buildings." A focus on Grid-Interactive and high performing buildings can reduce the cost of grid modernization and investments on grid infrastructure. This roadmap is focused on four pillars:

1. Advancing Grid-Interactive Efficient Buildings through research, development, and data
2. Enhancing the value of Grid-Interactive Efficient Buildings to consumers and utilities.
3. Empowering Grid-Interactive Efficient Buildings users, installers, and operators
4. Supporting Grid-Interactive Efficient Buildings deployment through federal, state, and local enabling programs and policies.

This roadmap can be adapted for the Indian context for nation-wide roll-out.

Building-grid integration for grid decarbonization

GHG intensity of the grid varies widely from hour to hour, day to day, season to season and geographic location; and this variability will continue to grow as more renewables get integrated into the grid. In the US, and in India, varied renewable sources power the grid in different parts of the country and hence buildings need to be designed to respond to these varied renewable sources and time variable dependent intensity. Building-grid integration allows buildings and the grid to coordinate energy supply and demand to optimize energy consumption, reduce peak demand, offer clean energy and provide a reliable electricity supply.



GridOptimal Buildings Initiative seeks to transform the one-way grid into a two-way interactive grid with distributed energy resources. This initiative was created to analyze and characterize a grid- friendly building. Grid-Friendly Building Strategies:

- Permanent Efficiency – Efficient building envelope and systems
- Peak Shifting and Flexible Loads – smart controls, thermal mass, energy storage / batteries
- Dispatchable Energy Storage – Intelligent, grid-integrated communications; smart systems and devices for different energy end-uses.

Under the GridOptimal Buildings Initiative, a set of eight unique metrics were developed to define the new normal for the building-grid interaction by providing guidance on how to measure and quantify building features and operating characteristics to support more effective and cleaner grid operation.

Table1: GridOptimal Metrics

GridOptimal Metric	What it Measures
Grid Peak Contribution	Degree to which building demand contributes to load on the grid during system peak hours
Onsite Renewable Utilization Efficiency	Building's consumption of renewable energy generated onsite (not exporting to grid) over a year
Grid Carbon Alignment	Degree to which the building demand contributes to upstream (grid) carbon emissions over a year
Energy Efficiency vs. Baseline	Percent better than code (annual total energy use)
Short-Term Demand Flexibility	Building's ability to reduce demand (shed) for 1 hour
Long-Term Demand Flexibility	Building's ability to reduce demand (shed) for 4 hours
Dispatchable Flexibility	Building's ability to automatically reduce demand (shed) for 15 minutes, controlled by utility/ third party
Resiliency	Building ability to island from grid and/or provide energy for critical loads for 4-24 hours; motor soft start capability to help grid restart after outage

Smart Grid in India

India's power system is enormous, with nearly 400 GW of supplier installed capacity, 200 GW peak demand (June 2021). Power consumption is growing at nine percent and all demand cannot be met with increasing capacity alone. In the last three years, over thirty million people have been given access to electricity and creating a huge latent demand in the electricity sector. Distribution is key to address the energy challenge wherein dynamic and time of use tariff will play an important role.

A smart meter is a key cornerstone of the smart grid, that connects the consumer, the building, and the utility. Nearly three million meters have already been installed and over 250 million meters are yet to be installed. Grid-Interactive Net Zero Energy Building considers the building and consumer as the last mile of this smart grid, with smart meter as the interface.

Sixty percent of the electricity mix is fossil fuel based. Increasing penetration of both electric vehicles and renewable energy in the electricity mix require integration of demand forecasting, demand response and flexibility in the grid.

Retrofitting Buildings for Energy Efficiency and Demand Response

Buildings play a crucial role in contributing to the energy demand of the country. Energy Efficiency Services Limited (EESL) has been focused on unlocking the potential of energy efficiency, which is now recognized as the first mover for addressing global warming. EESL through its "Ujala" program embarked on the journey of energy efficiency with a goal to manage peak demand. This resulted in reducing the peak demand by nine-gigawatt and transformed the lighting market in India. EESL has since then expanded the programs to include more energy efficient consumer products such as super-efficient air conditioning, fans, etc.

Renewables will be a substantial share of grid supplied electricity, requiring flexibility to be integrated and backed by policies and successful pilot programs. While on the supply side, there are many initiatives in the country such as real-time and day-ahead markets, demand side initiatives are yet to manifest. Considering that the element of dynamic monitoring is crucial for flexibility and is missing in the country, EESL is now working towards unlocking the smart meter market in India. EESL with NSGM is prodding utilities towards incentivizing consumption not only based on fixed time of the day but based on need. Expanded platform of energy efficient products that are demand-response ready, coupled with extensive smart-meter roll out will enable dynamic adjustments, in-turn enabling the supply and distribution companies to tap on to flexibility offered by the buildings.

Constructing a super-efficient and grid-interactive net zero energy building

Asia's first Super ECBC compliant and G-NZEB of approximately 5000 square meters is being constructed in Hyderabad under the leadership of Telangana State Renewable Energy Development Corporation. Environmental Design Solutions under the USAID MAITREE program is providing hand holding support for its design and implementation. The building aims to be net positive with an estimated Energy Performance Index at 45 kWh/sqm/year. The energy generated on-site would be more than that consumed by the buildings. Key features include - radiant cooling technology strategy for air-conditioning, occupancy sensor integrated lighting system, on-site renewables such as rooftop solar photovoltaics, building integrated photovoltaics on facades, micro wind turbines, off grid systems, solar air-conditioning. Electric charging points, real time energy display, building and environmental management system have also been integrated to enable the building to be smart-grid ready.

Expert Speakers
Ralph DiNola, CEO, New Buildings Institute (NBI)
Arun K Mishra, CEO, Energy Efficiency Services Limited (EESL)
Neelam Janaiah, Vice Chairman and Managing Director, Telangana State Renewable Energy Development Corporation (TSREDCO)
National Smart Grid Mission
Atul Bali, Chief General Manager, National Smart Grid Mission (NSGM)
USAID MAITREE
John Smith-Sreen, Director, Indo-Pacific Office, USAID/India
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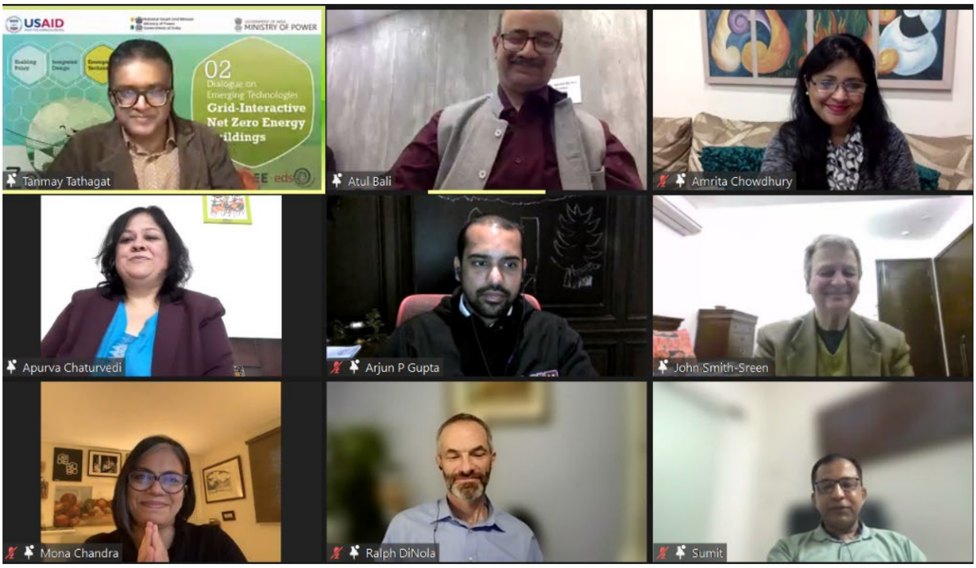
ZerO-In Dialogue #02

Emerging Technologies
December 22, 2021



ZerO-In Dialogue, December 22, 2021

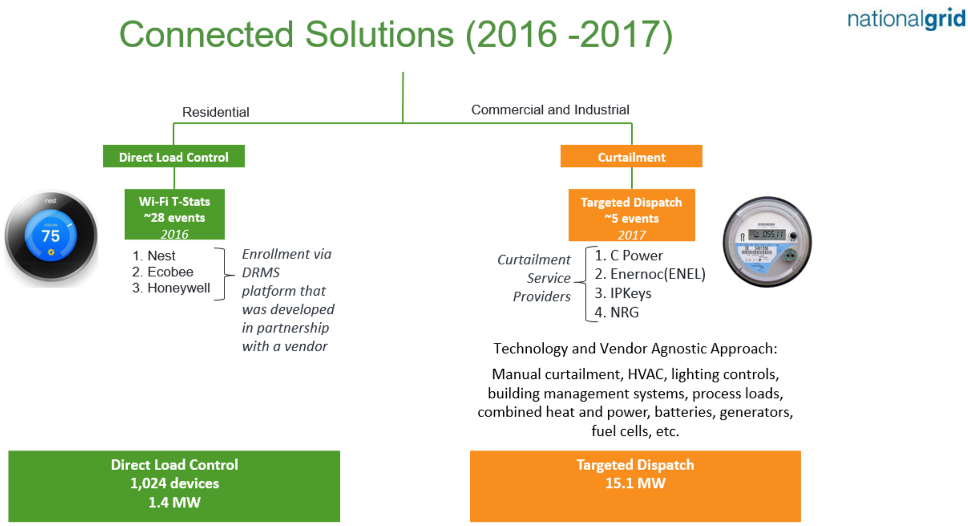
Growing electricity demand, emergence of multiple peaks, distributed power, electric vehicles, infrastructure constraints, and an increasing share of renewables in the network are a challenge for the utilities in India and South Asia. As the electricity grid becomes increasingly complex, flexibility in demand plays a vital role in ensuring its efficiency and stability. Grid-Interactive Net Zero Energy Buildings provide flexibility by reducing energy waste and balancing energy use during times of peak demand through climate responsive design, appliance and equipment efficiency, interactive technology, and integrated renewable solutions. This dialogue focused on emerging and innovative technologies that enable tapping on to the demand flexibility offered by buildings and appliances, in turn empowering utilities with improved demand management.

Demand Management and Distributed Energy Resources – A utility perspective

The National Grid, Waltham is an investor-owned, regulated utility in the North-East of the United States serving more than twenty million customers. They own and operate electricity and gas networks in New York, Massachusetts, and Rhode Island. National Grid is a transmission and distribution utility, working at the heart of one of the greatest challenges the society is facing— transforming electricity and natural gas networks with smarter, cleaner, and more resilient energy solutions to meet the goal of reducing greenhouse gas emissions.

In Massachusetts, National Grid serves approximately over two million residential customers and three percent of that are commercial customers. The "Green Communities Act" is the umbrella law under with utilities and program administrators implement energy efficiency and demand response programmes. In Massachusetts, the smart meter penetration is very limited and there is no time of use rates for residential customers. Even though the fuel mix is predominantly natural gas, renewables and nuclear, they do tend to use fossil fuel and oil to manage the summer peak loads.

National Grid launched a demand response program – Connected Solutions in 2016 to curtail the peak load on the system in both residential and commercial sectors. The program provided customers with an incentive for enrolling and ongoing incentives every year for performance during peak events.



On the residential side, it was a was a direct load control program launched in partnership with three Wi-Fi manufacturers Nest, Ecobee and Honeywell. As the market transformed, more thermostats and other enabled devices were enrolled in the program as an opportunity to reduce the peak load. A demand management software platform was also created to enrol and engage customers. The key factors being tested were:

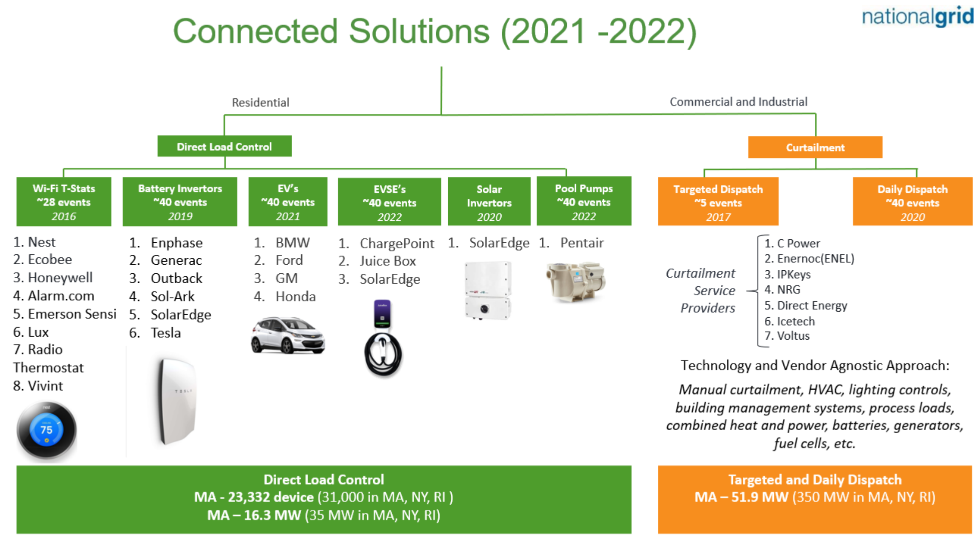
Amount of load reduction by the customer.

Drivers / Motivation for customer participation.

Program messaging

Within a year, 1.4 MW of reduction was recorded with almost 1000 enrolled devices. By 2021, manufacturing companies for Wi-Fi thermostats, battery inverters, EV's, EVSE's, solar invertor and pool pumps were enrolled. The key learning was on how to motivate customers to change their behavior, develop partnerships at the onset to launch such programs.

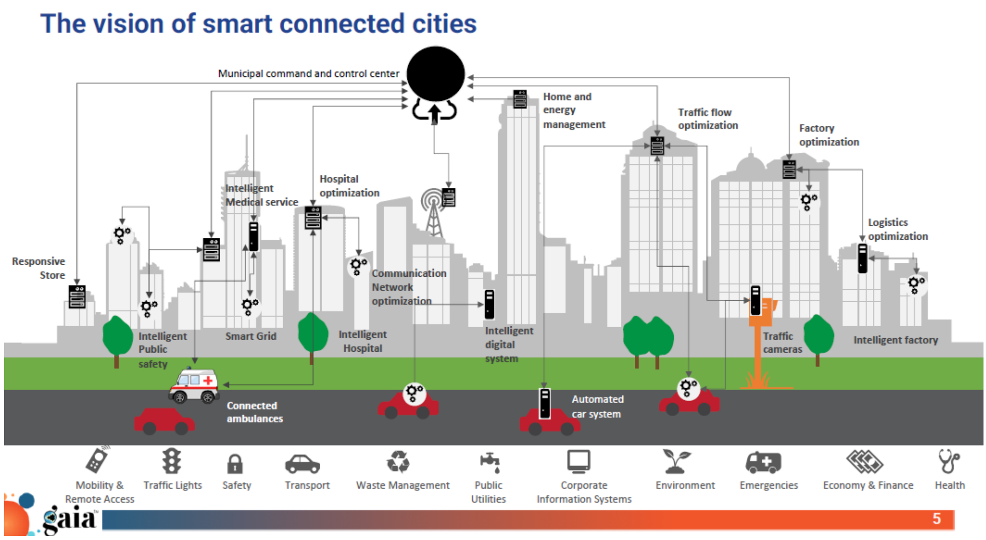
The commercial and industrial program is a targeted dispatch, technology-agnostic program and focused on curtailment for large commercial and industrial customers. Curtailment service providers were engaged to reach out to customers for load reduction. Within a year, 15.1-megawatt peak reduction was observed.



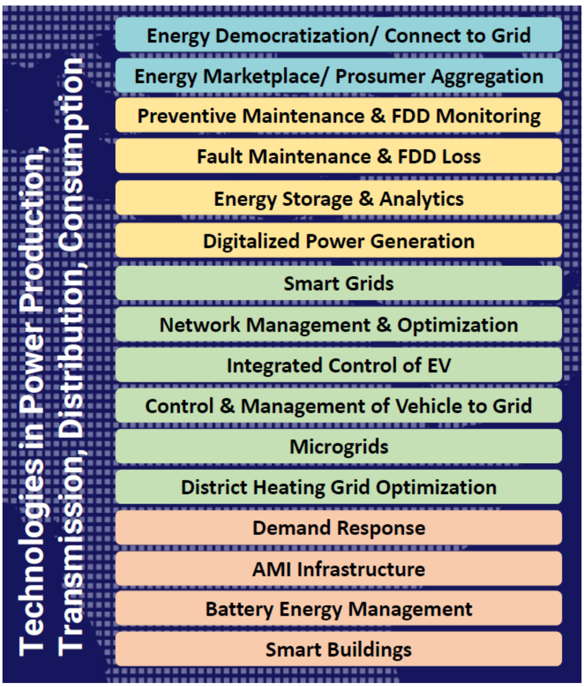
National Grid is currently looking at Gas Demand Response Program, dealing with localized distribution, and geo-targeting constrained areas where electric and gas DR can play a role.

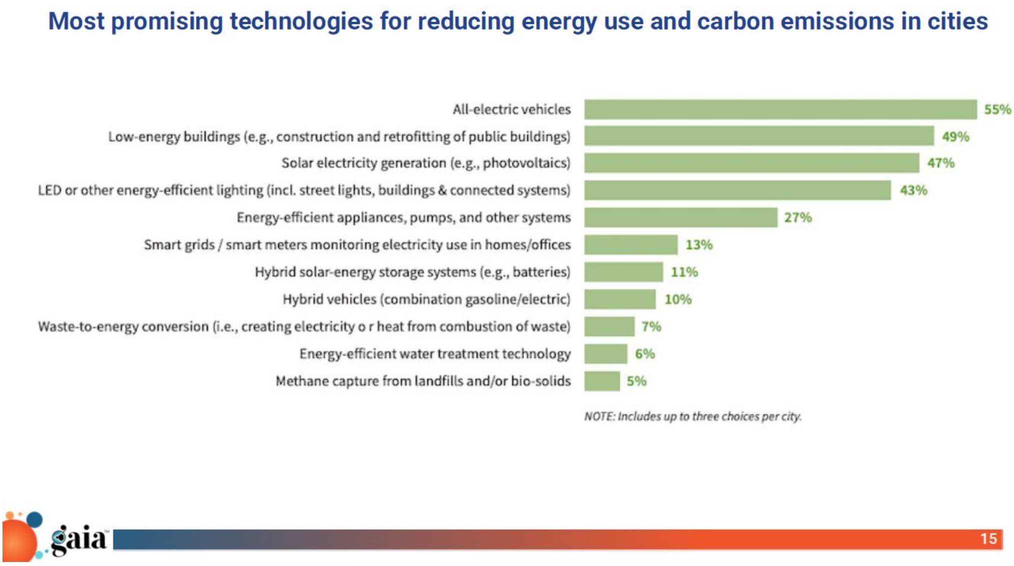
IoT for Interconnected Intelligence in Grid-Interactive Buildings and Smart Cities

The major drivers impacting the demand side of electricity include population growth, electrification, urbanization, industrialization, agriculture automation and overall rise in consumption. Decreasing the local consumption through efficiency, increasing the local generation (like solar rooftops, PV, NRE, Bio waste plants, Waste to Energy) and then moving towards shifting and shedding of load profiles to take advantage of the dynamic pricing from the tariff's perspective are the imperatives for both Grid Interactive Buildings and Smart Cities. This can be established by maintaining a two-way connection to help in understanding the building's status and maintain the peak demand.



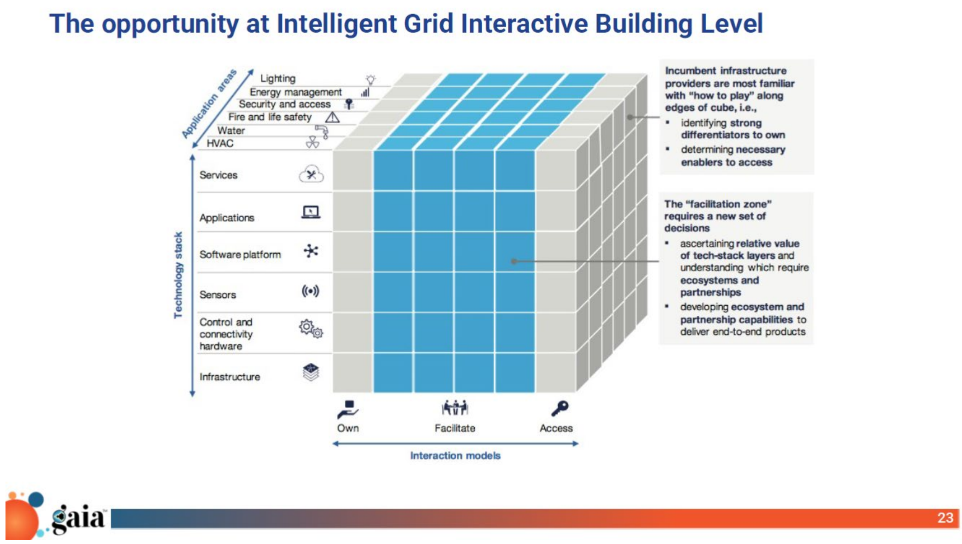
A systematic management is required to control the peaks at an individual, district, city or country level. There has been a lot of focus on utilities and basic provision of infrastructure with the addition of technology to measure and monitor this peak demand. There are many technologies across the grid network - power generation, transmission, distribution, consumption.





There are many ways in which cities can contribute both from the building and at the city distribution level to connect back into the grid. Modelling and forecasting of net increase in electricity demand is important during the planning of cities, to bring energy efficiency and energy lens into the city's system. There are many new energy focused city programs such as municipality energy efficiency programs dealing with water utilities, public lighting, and clean energy; Swachh Bharat Programs such as programs related to waste to energy plants, bio methanation plants, wastewater treatment plants and circular economy.

Customers are still looking at return of investment but monitoring and optimization of operations at various scales (building –campus- grid – city) can enable behavior change. There are many opportunities for this. While lighting and energy management, the water systems, HVAC systems are all net consumers of electricity in a building, there are ways to optimize these systems to reduce energy consumption. These are opportunities for startups and others on various fronts - building management, sensor & controls, data analytics, connectivity management.

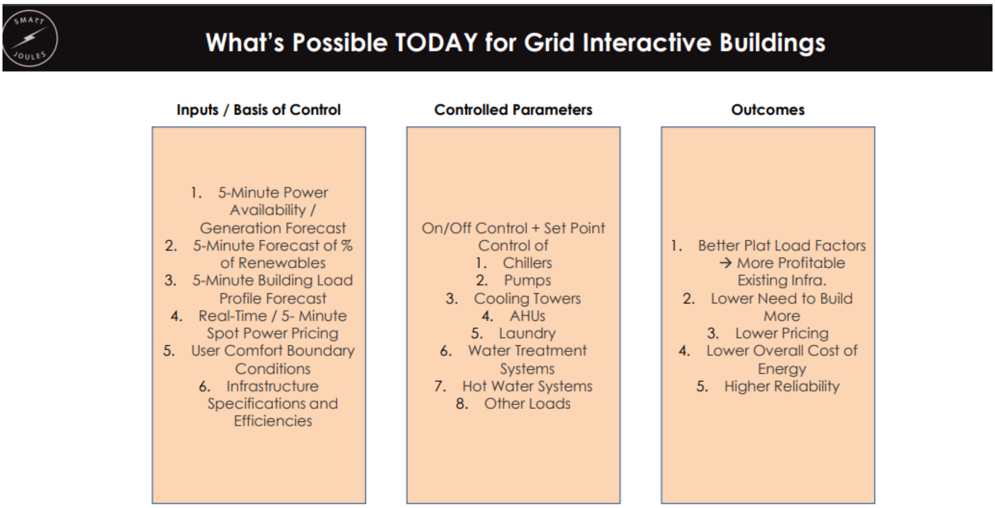


A case for innovations in technology for continuous energy optimization in buildings

D-Joule is an IoT Platform, developed by Smart Joules which streams minute-by minute system level energy consumption data on to cloud enabling development of insights for demand-side energy management. This information can be used in multiple ways and create a two-way communication to optimize energy consumption in a building. Building load patterns on the platform can enable utilities to identify potential for demand response at a building level.

"Joule Recipe," is a generic web-based tool that can trigger any alert or take any action automatically to any equipment that is connected to an IoT system → when any set of specified conditions become true. These conditions can be adjusted for any period of time and can be based on any parameter and/or combination of parameters and can be real time and/or based on historical data or any other source of data. This allows for ultimate flexibility to control any equipment, based on any logic or combination of logics or parameters, and allows for both speed and flexibility for the grid. Such a platform enables building-grid interaction.

Some of the cooling equipment level examples delivered through this tool include the dynamic chilled water - flow modulation (pumps) and set point modulation; dynamic cooling tower fan speed modulation and tonnage injection- taking demand off the grid for certain periods of time. This enables reducing and controlling cooling load of building contributing towards reduced energy demand and stress on building additional power plants to manage peaks, lower cost of energy and high levels of reliability.



Expert Speakers
Mona Chandra, Distributed Energy Resources, National Grid, Waltham MA
Amrita Chowdhury, Co-founder, Gaia Smart Cities
Arjun Gupta, Founder and CEO, Smart Joules

National Smart Grid Mission
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ZerO-In Dialogue #03
Consumer Engagement
January 12, 2022

ZerO-In Dialogue, January 12, 2022

Grid interactive buildings are smart – enabling data analytics to optimally manage loads, occupant preferences, and grid requirements. However, there is growing recognition that technology alone cannot achieve energy efficiency goals. Occupant behaviour and preferences must align with energy conservation and demand response objectives.

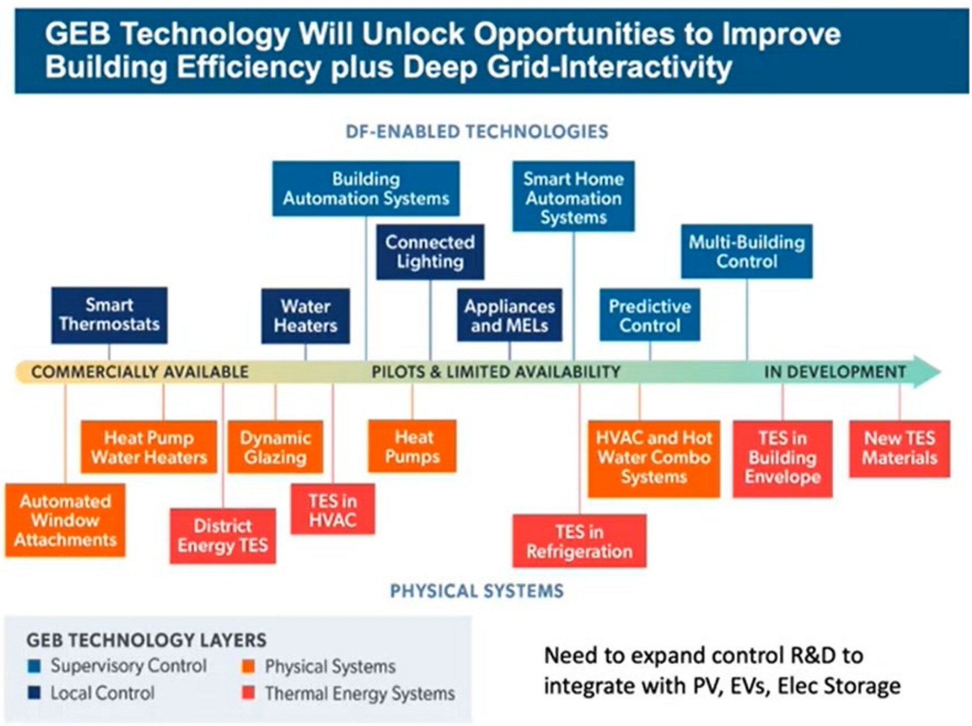
Designing and integrating a Demand Response (DR) program in a building is a key aspect of a G-NZEB. The demand response in a building can be integrated in three ways: Manual, Automated and Semi-Automated. Depending on the extent of user engagement, level of instrumentation and investment in integrating learning analytics; consumers behavioural nudges such responding to peak load events can be built in. Active consumer participation provides opportunities for not only reduced energy expenses but also an additional revenue stream. A study by the Australian Renewable Energy Agency highlighted that consumer awareness increases the value of demand response. There was also a realization in addition to energy efficiency, energy adaptability also plays an important role in demand response programs.

The third dialogue of the series on the Grid-Interactive Net Zero Buildings (GNZEBs) brought in the consumer engagement perspective in context of grid-interactive buildings and demand response.

Background: Grid-Interactive Efficient Buildings by US Department of Energy

A National Roadmap for Grid-Interactive Efficient Buildings was developed by the U.S. Department of Energy (US DoE) to characterize Grid-Interactive Efficient Buildings and their need:

- Integration of the growing share of variable renewable energy.
- Reducing costs in upgradation of electricity system infrastructure and improving system reliability.
- Assisting decarbonization goals through reduced fossil fuel generation and increasing electrification.
- Optimization of energy use based on customer preferences.
- Some of the technologies prioritized by US DoE to improve building efficiency and enable grid-interactivity are shown in the figure below:



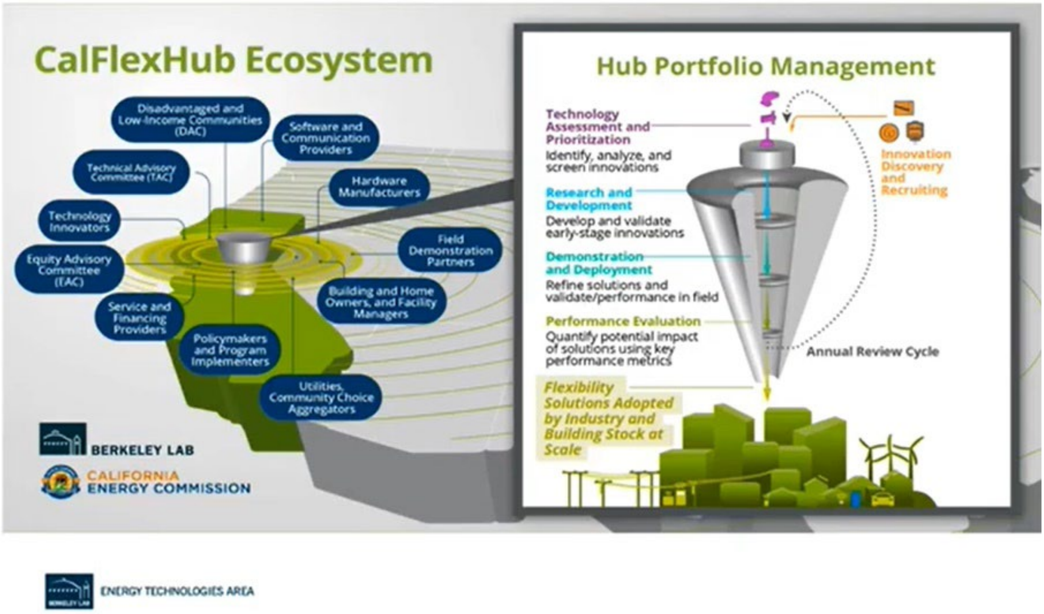
The US Department of Energy recently launched the Connected Communities program, and the Berkeley lab is the national coordinator for this program. The feasibility and potential of scaling these technologies is being experimented in these ten connected community projects across the United States.

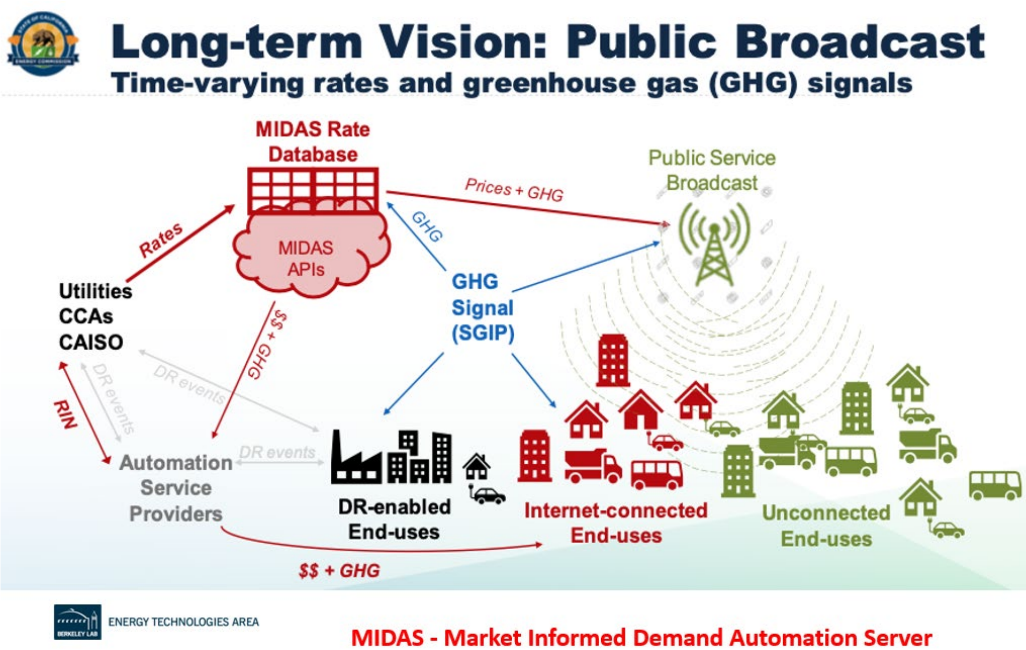
CalFlexHub – A Platform for Advancing Dynamic Energy Management

The California Load Flexibility Research and Development Hub (CalFlexHub) brings together a multidisciplinary team of experts from numerous sectors—including industry, utilities, academia, manufacturers, and non-profits to identify ways to improve usability of technology solutions to increase consumer benefits. CalFlexHub seeks to advance the capability of buildings to provide a flexible electricity load for the State of California. CalFlexHub works on research projects that help:

- Identify, evaluate, develop, and demonstrate pre-commercial, load-flexible pre-commercial technologies
- Standardize the signals used to communicate dynamic price and GHG information to these technologies
- Load shaping demand response and supply-side demand response capabilities.

"Prices to Devices" concept developed by CalFlexHub looks at local control levels such as smart thermostats, water heaters, connected lighting, appliances as well as the entire home controls levels such as building automation systems, smart home automation systems, predictive control, and multi-building control. This concept allows buildings to automatically receive continuous price information and automatically adjust the electricity consumption for maximum affordability and/or reduced carbon emissions. CalFlexHub seeks to benefit all Californians, including those from disadvantaged communities by using technologies that are affordable, practical, and reliable.





Load flexibility is a key element to decarbonization. If investments are not made on communication technologies, the utilities are going to face challenges with the new added electric loads and not being able to interact and enable loads to be more flexible and integrated with the grid. The California Energy Commission is proposing that in the future all electric utilities will need to provide the electricity rates in a machine-readable format. Utilities in California have over a hundred different tariffs. These tariffs once available in a machine-readable format, can be static day-set or be made real-time data feed. The database is then a stream of real-time prices that the internet-connected devices can respond to.

At the consumer / building level, CalFlexHb is working on projects to evaluate technologies for improved building load flexibility, price response capability, impact on the load shape and the consumer bill, cost-benefit opportunities, the non-energy (maintenance, comfort) benefit and user acceptance associated with these technologies. At the power-system level, CalFlexHub is also looking at opportunities for technology diffusion, system load shape impacts, system load flexibility potential, avoided system costs, avoided GHG and pollutants and grid cost-benefits.

CalFlexHub Projects	Funded Partners	Other Partners	Location/Sites
Residential Smart Fan with Integrated Thermostat	UCB	Big Ass Fans	UCB, Stockton Senior Center
Dynamic Heat Pump for Residential Space Heat and DHW	UCD	Ecobee, Rheem, Carrier	UCD, Future Multi-Family Site
Dynamic Space Heat for Small Commercial HVAC	LBNL	Melrok	LBNL FlexLab, EPIC HP-Flex Sites
Integrated Heat Pump and Cold Storage for Small Commercial HVAC	LBNL	Sunamp, Aermec, UCD Facilities	UCD
Model Predictive Control for Dynamic Large Commercial and District Energy Systems	LBNL, UCSD	UC Merced Facilities	LBNL, UCSD, UC Merced
Home Energy Management System to Maximize Electrical Panels with Electric Storage	LBNL	Orison, Heila, Span.io	LBNL

Integrated Small Commercial Energy Management with DERs	UCD, Extensible Energy	Gridpoint	UCD
Integrated Heat Pump with Storage for DHW and Space Conditioning	UCD	Villara	Nor Cal Homes
Residential HVAC and Hot Water Using Integrated Storage	LBNL, Harvest Thermal		East Bay Homes
Household Flexible EV Charging	UCB	BMW	California Homes
Bi-Directional EV Charging	UCD	Honda	UCD and UCSD
Control and Coordination of Distributed Flexible Loads	Olivine, SkyCentrics	Ecobee, Pentair, Sonoma Clean Power, Belmont Redwood Shores Schools, Richmond MSH Properties, City of Pittsburg Unified Schools, UCB Richmond Field Station	Belmont, Richmond, Pittsburg, Sonoma, LA County, and others

Working on demand response potential studies to explore the size and value of Grid-Interactive Efficient Buildings; four grid services terms have been coined:

Shape : persistent daily load modifications

Shed : acts like virtual **generation** capacity

Shift : acts like a virtual **storage** resource

Shimmy: acts like a virtual regulation / ancillary services response.

Key question guiding these studies is – **How large** is the Shed and Shift resource, **where** are the resources and **when** is it available, and at **what cost?**

Key takeaway – Shift can play an important role in California renewable grid, but it will need to grow. The next steps would be to explore ways to lower costs and drive consumer participation.

While technologies play a role in reducing energy demand and managing loads, there is also an equally important role of controls and communication systems for a successful building-grid integrated ecosystem. There is a need to move from static energy efficiency towards dynamic energy management. A building with integrated connectivity and intelligence marks an emergence from static to dynamic energy management.

Expert Speaker
Mary Ann Piette, Director, Building Technology and Urban Systems Division; Director, Demand Response Research Center, Lawrence Berkeley National Laboratory (LBNL)

National Smart Grid Mission
Atul Bali, Chief General Manager, National Smart Grid Mission

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ZerO-In Dialogue #04

Enabling Policies
January 19, 2022

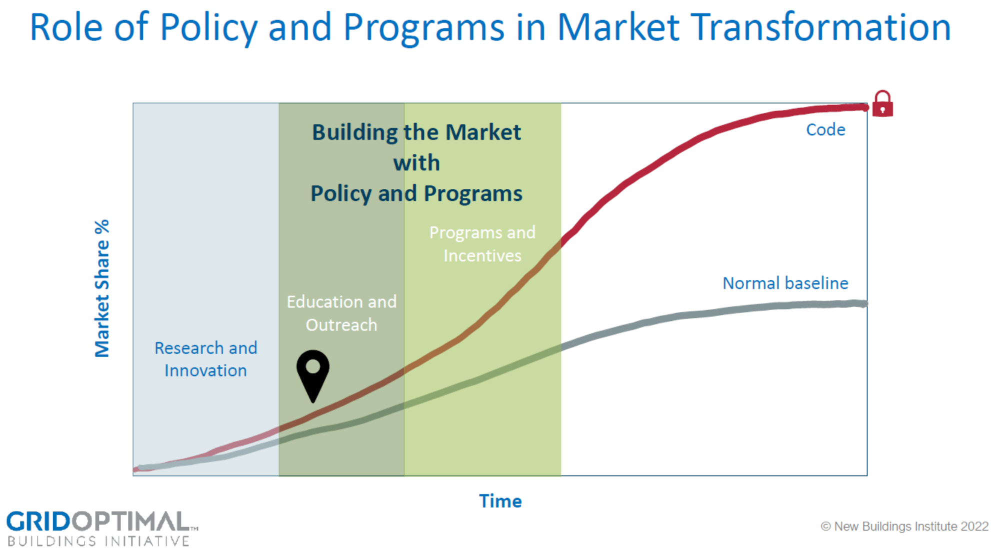
ZerO-In Dialogue, January 19, 2022

Growing electricity demand, emergence of multiple peaks, distributed power, electric vehicles, infrastructure constraints, and an increasing share of renewables in the network are a challenge for the utilities in India and South Asia. As the electricity grid becomes increasingly complex, flexibility in demand plays a vital role in ensuring its efficiency and stability. Dealing with increased distributed energy resources on the grid, is a challenge for the utilities today. These challenges can be addressed by mapping the demand and supply-side equation on the grid through the lens of grid-interactive buildings. Pro-active programs, incentives, policies, education, associated outreach will lay the foundation for drafting of integrated building-grid policies and codes.

The ZerO-In Dialogue on Enabling Policies for Grid-Interactive Net Zero Energy Buildings brought a global perspective on cutting-edge strategies, utility program approaches, and opportunities in the fast-developing building-grid integration space. Leading experts recognized the importance of building codes and policies to cut carbon emissions and save energy to align with our climate related targets.

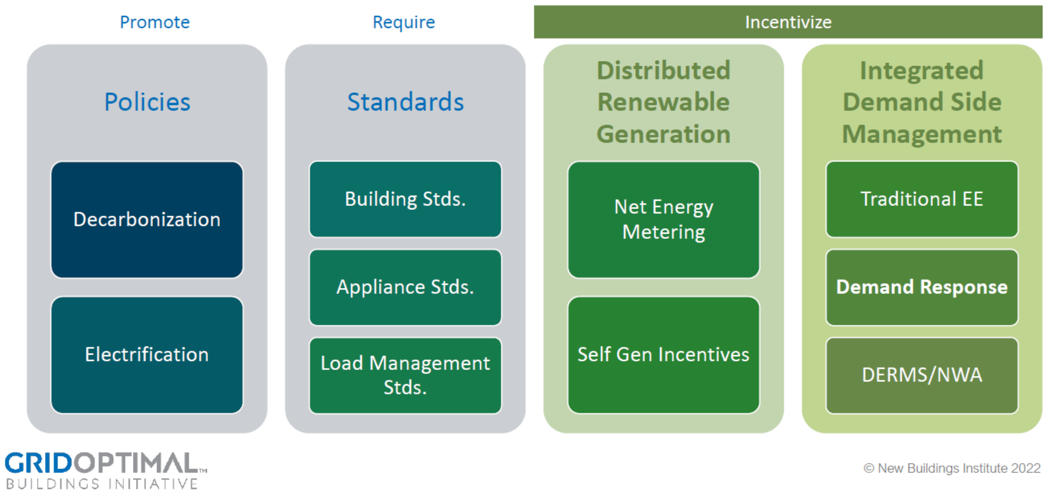
Programs and policies for building grid interaction

The utility and building energy management challenges are opportunities for market transformation. Policies and programs can help accelerate the adoption for grid-interactive net zero energy buildings and can create the market for building grid interaction. The right programs and policies can incentivize smart grid modernization related controls, communications protocols, connected devices, IoT, advanced metering infrastructure to be deployed in the market at scale and thereby create awareness and bring down the costs of technology and assist adoption. Eventually, when the entire market share is building grid integrated, this can then be locked into a code. The codes then in-turn will enforce developments that are grid-integrated.



Advanced Meter Infrastructure (AMI) is one of the key enabling technologies that can help guide policies. It is however dependent on the granularity of information captured. With AMI, both the utilities and the consumers are enabled to have information that is actionable and usable. In the US, the AMI penetration rate is at 65% and that is one of the key enablers for demand response resources. AMI, coupled with connected devices, communication protocols, all contribute towards a network of connection, not just in terms of electricity flow but also data flows for grid-interactivity.

Programs and policies have been categorized at four levels. Macro policies are around decarbonization of economy and a step towards that is electrification of the building energy end-uses. These policies promote buildings that have devices and connected DERs that become enablers. The next level is requirements that are in the form of building standards (example requirement of connected devices), performance metrics that include carbon emission metrics (example, ASHRAE 189.1); load management standards that require all utilities to transmit their price signals that are reflective of the grid condition.



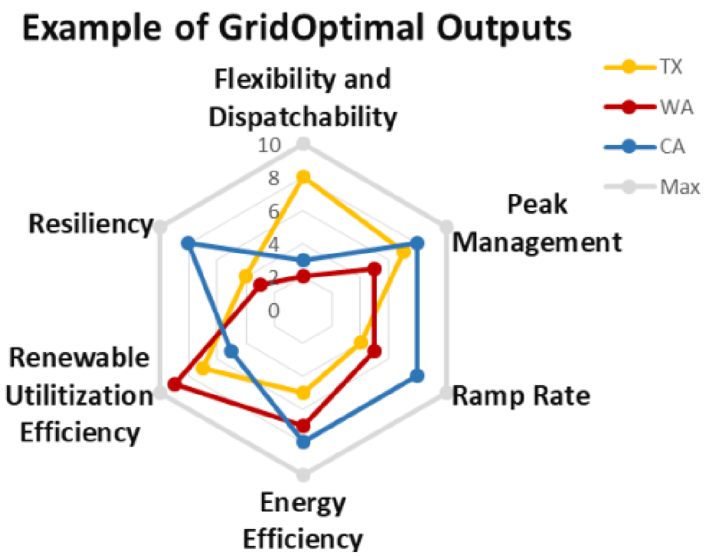
The next set of policies and programs are focused on incentivizing – such as policies on distributed renewable generation through a tariff mechanism that allows for net energy metering and self-generating incentives. Integrated demand side management policies include the traditional energy efficiency, demand response, and allow the flexing of the different DERs. Demand response (DR) programs are under the category of time-varying pricing and dependent on value of energy during certain time. DR programs can be implemented through different mechanisms such as peak time rebates, real time pricing, critical peak pricing (event driven), time of use pricing. Traditional demand response programs are incentive based such as direct load control (automated), interruptible load programs (commercial and industrial), demand bidding and ancillary services (third part aggregation services).

GridOptimal Buildings Initiative

National building Institute (NBI), in partnership with the U.S. Green Building council (USGBC) developed GridOptimal Buildings Initiative focusing on key barriers for improving building grid integration with the goal of making buildings enablers of the broader decarbonization of the energy ecosystem. At the core of this initiative was the development of metrics to measure and quantify building features and operating characteristics that support effective grid operations.

NBI is focused on driving implementation of the GridOptimal metrics through rating systems, utility programs, code, and policy avenues. In addition, the market-facing resources developed including building design guidelines and factsheets, would facilitate uptake and delivery of enhanced grid interactivity outcomes. This initiative will reinforce the integration of distributed energy resources (DER) and utility-scale renewable energy to support least-cost decarbonization of the grid. These metrics and guidance will facilitate the operation of buildings with grid-friendly load shapes and flexible demand, reduced stress on the grid, maintain occupant comfort and transform the market towards grid-interactive buildings.

Metrics and Framework: Both building-side and grid side categories are considered for development of the GridOptimal metrics and framework. The figure below shows an example of normalized GridOptimal output metrics for three buildings in different locations (Texas, Washington, and California).



These metrics are at the core of the new GridOptimal Buildings LEED pilot credit. These metrics assess the building-grid integration readiness parameters such as:

The building's ability to minimize its peak power demand during grid critical peak hours.

The degree to which the building's ramp rate mitigates alignment with grid ramp rates.

The building's renewable utilization efficiency (ability to maximize consumption of onsite renewable generation).

The degree to which the building's load profile aligns with the regional renewable profile.

The presence of flexible loads and capabilities in the building.

The dispatchability of flexible loads and capabilities.

Energy efficiency in the building.

Resiliency capabilities such as phased start up or islanding.

Design and Operations Guidance Material: NBI has released easy-to-understand fact sheets that provide key context and recommend selected high-impact building design and operations strategies for a variety of building types and U.S. region that can be thereby adapted in the Indian context.

GridOptimal Building LEED Pilot Credit (Alternative Compliance Path): NBI has developed a grid harmonized pilot credit language and structure based on the GridOptimal metrics. The pilot credit language has been incorporated into the LEED rating system as an alternative compliance pathway for the Grid Harmonization Pilot Credit. Similarly, efforts are underway to facilitate this in the Austin Energy Green Building Rating System.

Expert Speakers
Smita Gupta, Director for Building Innovation, New Buildings Institute
Alexi Miller, Associate Technical Director, New Buildings Institute

National Smart Grid Mission
Atul Bali, Chief General Manager, National Smart Grid Mission

USAID MAITREE
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Tanmay Tathagat, Director, Environmental Design Solutions Pvt. Ltd.
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Lakshmi Kamath, Project Manager, Environmental Design Solutions Pvt. Ltd.
Deepanjali Wadkar, Senior Policy Analyst, Environmental Design Solutions Pvt. Ltd.
Shradha Shaji Paul, Communications Specialist, Environmental Design Solutions Pvt. Ltd.

Glossary

A glossary of definitions and terminologies commonly used in the context of grid-interactive net zero energy buildings has been provided. They may be defined differently in other contexts.

Building Demand Flexibility – Building demand flexibility is the capability provided by on-site DERs to reduce, shed, shift, modulate or generate electricity. Building demand flexibility can be used, typically in response to price changes or direct signals, to provide benefits to buildings' owners, occupants, and to the grid.

Distributed Energy Resource – Distributed Energy Resources (DER) are small scale power generating stations (3 kW to 50 MW) or energy storage facility/equipment located usually in proximity of the end users. DERs are less expensive alternatives to large power plants offering better power quality, reliability, energy efficiency and energy independence. DER has been in existence in our buildings since many years in the form of back-up generators or Diesel generators. Renewable DERs such as the solar power plant, wind power plant, hydro-power plant are environmentally friendly and help in carbon emissions offset.

Demand Response – The strategy of reducing/ shifting of energy consumption during peak load period with respect to certain financial incentive is the demand response.

Demand-side Management – With the help of flexibility in energy demand, prioritization of critical loads, distributed energy resources (DER) and smart control systems, the load profile of a building can be altered to lower the peak demand, consume energy when the tariff is low and add inductive/capacitive load depending upon the power factor for the stability and lowering cost of operations of the grid and the process of managing loads is called demand side management.

Demand Variability – The variations in the demand of power from the grid within a stipulated period of time is the demand variability. The predictable variation in power demand is different from the uncertainties which occur due to equipment failure or power outages due to natural calamities.

Energy Efficiency – Reduction in the consumption of energy without lowering the requirements and usage is known as energy efficiency. Energy efficiency is achieved by the intervention of technology and best operating practices and the term "energy efficiency" covers a wide ranging topics related to energy efficiency, energy savings, energy consumption, energy sufficiency, and energy transition in all sectors across the globe.

Energy Storage Systems – An equipment with its peripherals which store energy in any form so that it could be utilised whenever needed. Example Batteries storing energy in the form of chemical energy which can be converted into electrical energy. Energy storage systems also help to smoothen the power output, compensating for the spikes and sags of the generation side.

Feed-in Tariff – Feed-in tariffs (FiT) distinguish between on-site electricity generation and electricity consumption from the grid, through differential pricing. This arrangement requires two separate power meters – one to measure the amount of electricity drawn from the grid and the other to measure the outflow of electricity from the site to the grid. FiT is based on time-bound contractual agreement between the consumer and the utility, wherein the utility agrees to purchase renewable power from the consumer at a price that is typically higher than the prevailing retail price. A predefined tariff degression plan reduces the tariff over time.

Feed-in tariff schemes are typically based on a 15-20 year long contract where prices are pre-defined above retail with a tariff degression, which effectively reduces your earnings over time. For every kWh you generate you get paid. Unlike net metering, feed-in tariffs do require prior arrangement and notification. Only six states across the U.S. currently have some form of feed-in tariff scheme as of today: California, Florida, Vermont, Oregon, Maine and Hawaii.

Grid Services – In addition to supplying power, a grid provides a wide range of services optimizing productivity, performance, budget and safety, thereby reducing service disruptions for instance net metering, feed-in tariff mechanism, smart metering and intelligent end devices, distributed energy resources, demand flexibility etc.

Load Forecasting – The prognostication of power demand to meet the short term (few hours), medium term (few weeks upto a year) and long term (more than a year) demands is termed as load forecasting. The load forecast aids to schedule generation reserve required, demand side management and dispatch.

Load Profile – The graph of variation of power consumption with respect to time is the load profile. It represents the pattern of electricity usage of a customer and the information can be used for billing.

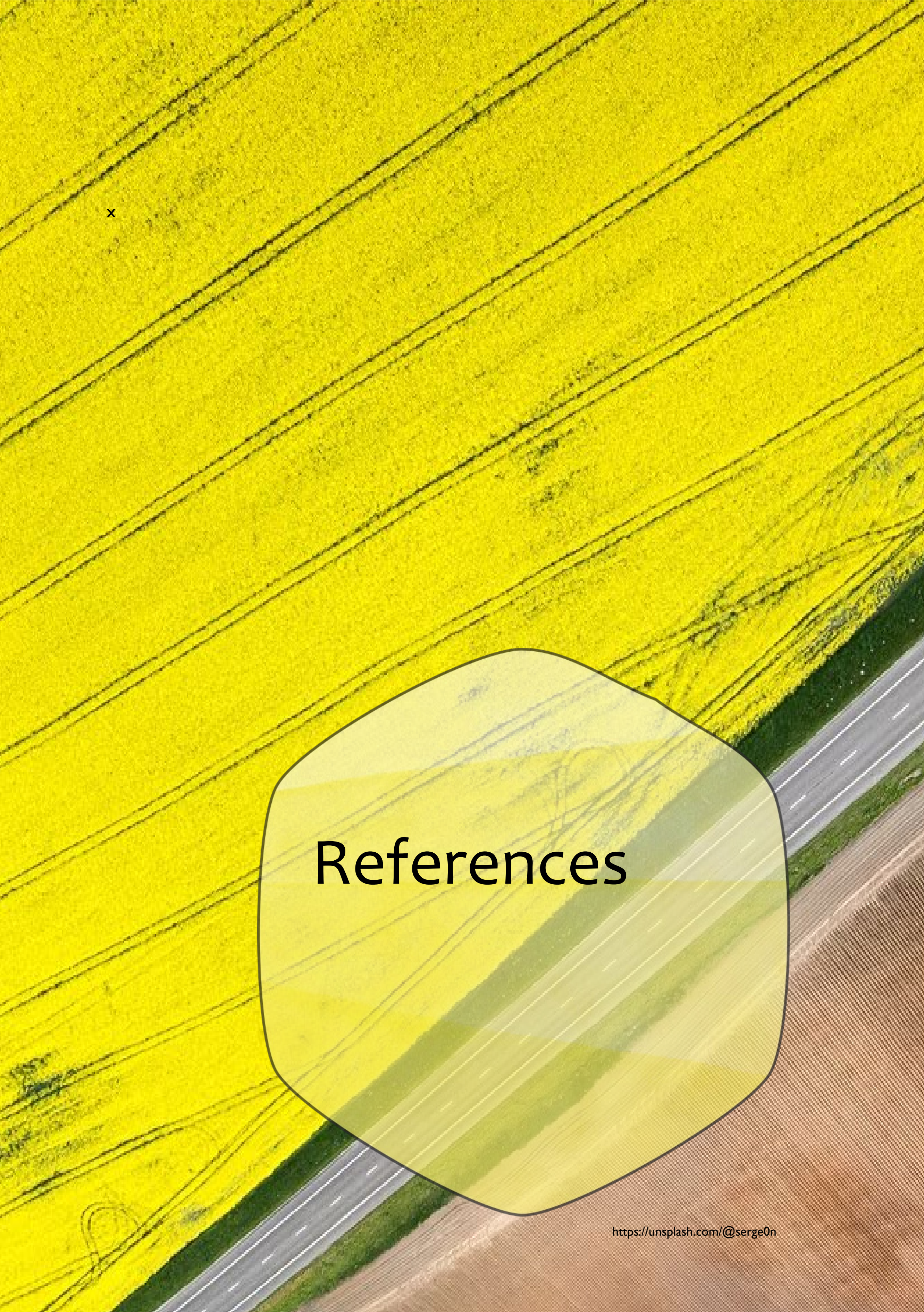
Negative Prices – Negative power prices occur when there is a low demand and there is a large power input from an inflexible generating plant to the grid. Inflexible conventional power stations and cheap renewable power are responsible for prices dropping below zero.

Net Metering – Net metering allows consumers to bank excess electricity produced by their solar panels and trade it for electricity drawn from the grid. Net metering requires a bi-directional meter that can measure current flowing in two directions – from the site to the grid and from the grid to the site. Under this arrangement, the consumer sells and purchases power at the prevailing retail value. Net metering is ideal for residential and small commercial buildings.

Peak Demand – Peak Demand refers to the maximum power usage during a certain interval of time and is measured in kiloWatts (kW). In general, daily peak demand on a grid is during the evening when people switch-on the lights and other household appliances.

Ramp Rates – The increase or decrease in output power per minute of a generating unit is called the ramp rate. Ramp rates of flexible power generating plants help to stabilize the grid in case the power input to the grid from other plants alter.

Smart Technologies for Energy Management – Some of the technologies for energy management are building energy management system, home energy management system, Automatic demand response, community ergy management system, smart appliances, smart switches, SCADA.



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https://unsplash.com/@serge0n

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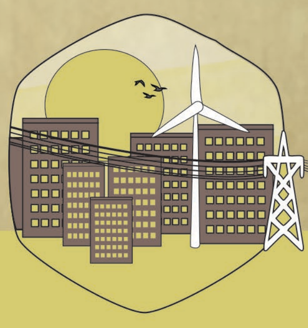

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USAID MAITREE

United States Agency for International Development (USAID) Market Integration and Transformation Program for Energy Efficiency (MAITREE) is a bilateral program with the Ministry of Power, Government of India. MAITREE aims at accelerating uptake of cutting-edge technologies, innovative business models, and end-user engagement, for adoption of energy efficiency at scale. MAITREE works with a range of public sector, private sector, and international partners. Environmental Design Solutions [EDS] is the implementing partner for the program.