Alliance for an™ Energy Efficient Economy

DOUBLING GLOBAL ENERGY EFFICIENCY PROGRESS

How the G20 Can Lead the Way

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Prepared by

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Note to the reader

This report is a deep dive into three of the five high-impact energy efficiency opportunities outlined in the "Strategic Plan for Advancing Energy Efficiency Across Demand Sectors by 2030," developed by the Bureau of Energy Efficiency, Ministry of Power, Government of India, in collaboration with Alliance for an Energy Efficient Economy (AEEE), Sustainable Energy for All (SEforAll), and the International Energy Agency (IEA) during India's G20 Presidency in 2023. These opportunities have strong linkages with the Voluntary Action Plan on Doubling the Global Rate of Energy Efficiency Improvement by 2030, also developed during India's G20 Presidency. It draws upon extensive secondary literature, numerous expert consultations, and rigorous peer reviews by global energy efficiency luminaries. Unveiling insights from best practices, distilling transferable learnings for G20 nations, and delivering actionable recommendations, the focus is on three pivotal energy efficiency opportunities: Rethinking Energy Codes for a Net-Zero Energy World (RENEW), Scaling-up Motor Efficiency for Small and Medium Enterprises (SME^2), and Financing for Aggregating Services and Technologies (FAST). In some instances, the scope and coverage of these opportunities have been expanded to provide a more comprehensive set of recommendations. This report aims to embody the collective expertise and unwavering dedication of the Indian and global energy efficiency community. Its goal is to contribute to the realisation of the global target of doubling energy efficiency improvements by 2030, reflecting the spirit of collaborative determination.

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FOREWORD

In an era of sustainable development and climate action urgency, energy efficiency is critical for transformative progress. It can address 40% of global greenhouse gas emissions by 2030, in alignment with the Paris Agreement. The G20 forum has consistently emphasized energy efficiency's role in environmental protection. A significant milestone was reached during India's G20 Presidency in 2023, with the endorsement of the 'Voluntary Action Plan on Doubling the Rate of Energy Efficiency Improvement by 2030.' The G20 Energy Transitions Ministers' Meeting highlighted energy efficiency as the "first fuel" and its importance in energy transitions, sustainable job creation, reducing household energy costs, and ensuring energy security.

As Global South countries like Indonesia, India, Brazil, and South Africa take on G20 leadership, they have the chance to shape the discourse to reflect their needs and maximize collective impact. Future presidencies must build on this momentum for a harmonized approach to meet the Paris Agreement's ambitious targets and move towards a net-zero world by spearheading initiatives, forming consortiums, and aligning regional policies.

This report explores high-impact energy efficiency opportunities in the "Strategic Plan for Advancing Energy Efficiency Across Demand Sectors by 2030," developed during India's G20 Presidency. It offers insights from best practices, transferable learnings for G20 nations, and actionable recommendations. The report's strategic actions aim to double energy efficiency, leading to transformative change. The focus on policy development and implementation at national and subnational levels highlights a commitment to accelerated progress.

India, with an average energy intensity improvement rate of 2.4% during the period 2011-2020, is poised to lead in doubling the global rate of energy efficiency. This report on *Doubling Global Energy Efficiency Progress: How the G20 Can Lead the Way* by AEEE reflects a commitment to inclusive collaboration and meaningful change on the international platform.

Abhay Bakre
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27 February, 2024


G20
लखनऊ विकास प्राधिकरण
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Executive Summary

Global efforts to maximise energy efficiency gained significant momentum in 2023. Key events include COP28, where 123 countries pledged to double the annual rate of energy efficiency improvements from 2% to over 4% by 2030. The G20 leaders, in their New Delhi Declaration, took note of a 'Voluntary Action Plan on Doubling the Rate of Energy Efficiency Improvement by 2030.' Additionally, the G20 Energy Transitions Ministers' Meeting emphasised the importance of energy efficiency in driving transitions, job creation, reducing energy costs, attracting investments, and ensuring energy security. They agreed to focus on a voluntary roadmap to achieve the Sustainable Development Goal 7.3 target. Furthermore, the IEA's 8th Annual Global Conference on Energy Efficiency saw 46 governments endorsing the 'Versailles Statement,' committing to strengthen energy efficiency actions in line with doubling global energy intensity progress each year until 2030. Overall, these developments underscore the global commitment to enhancing energy efficiency for sustainable development and addressing climate goals.

Energy intensity, generically defined as the amount of energy used to produce a given output or service, is used as the indicator to track progress on energy efficiency (SDG 7.3). The SDG 7.3.1 indicator is specifically measured in terms of primary energy supply and GDP, which is a proxy indicator to track country or global level progress. Per AEEE's analysis, India has consistently improved its energy intensity, at 1.6% p.a. between 1990 and 2010, and at 2.2% between 2010 and 2020. The G20 Energy Transitions Ministers' Meeting Outcome Document and Chair's Summary from July 2023 endorsed doubling the global rate of energy efficiency improvement by 2030, taking into account national circumstances. If India were to match this global target, it would need to ratchet up its annual energy intensity improvement rate from the current 2.2% to 4.6% between 2020 and 2030. In comparison, global energy efficiency improvement rate would need to move up from 1.8% to 3.1% in the same period. The G20 Global South members would require the improvement to increase from 2.1% to 2.5% while G20 Global North members would need to move from 1.9% to 4.4% between 2020 and 2030.

This report is a deep dive into three of the five high-impact energy efficiency opportunities outlined in the "Strategic Plan for Advancing Energy Efficiency Across Demand Sectors by 2030," developed by the Bureau of Energy Efficiency, Ministry of Power, Government of India, in collaboration with Alliance for an Energy Efficient Economy (AEEE), Sustainable Energy for All (SEforAll), and the International Energy Agency (IEA) during India's G20 Presidency in 2023. These opportunities have strong linkages with the Voluntary Action Plan on Doubling the Global Rate of Energy Efficiency Improvement by 2030, also developed during India's G20 Presidency. It draws upon extensive secondary literature, numerous expert consultations, and rigorous peer reviews by global energy efficiency luminaries.

Closing the Gap between Building Energy Code Development and Implementation

Building energy codes have emerged as a common regulatory measure adopted by most G20 countries to avoid locking in the energy and carbon associated with inefficient construction, and unlocking a powerful compounding effect that minimises the energy and carbon intensity of the buildings sector. The scope of the codes and their stringency vary across countries. In addition to energy efficiency building codes, some countries have also expanded the scope of the codes and added more complexities in their endeavour towards net-zero buildings. Net zero and net positive energy building codes aim to ensure that buildings either produce as much energy as they consume or generate surplus energy, contributing positively to the grid. While not universally adopted, some G20 countries, including Germany and France, are pioneers in adopting these codes. Additionally, embodied carbon considerations are gaining importance in building codes, with California, India, and the EU leading efforts to limit emissions associated with materials and construction processes. The EU's Energy Performance of Buildings Directive (EPBD) recast includes mandatory disclosure of embodied carbon for new building construction.

However, various studies have shown that savings from energy codes hinge significantly on robust enforcement mechanisms and high compliance rates. Unfortunately, there is a massive gulf between the quality and stringency of building energy codes development and its enforcement and implementation. The chapter explores diverse enforcement mechanisms for building energy codes in G20 member countries. Local governments predominantly handle code enforcement, with variations in the involvement of third-party assessors. Issues like insufficient funding and disparities in enforcement effectiveness among urban local bodies are noted. Third-party assessors aim to address gaps but concerns about conflicts of interest arise. Onsite inspections, crucial for compliance, differ across countries, impacting the timing and frequency of checks. Certification, through energy performance certificates, helps validate compliance but faces challenges with error rates. Penalties and incentives are powerful motivators, with G20 nations employing diverse strategies. To implement building energy codes effectively, a systems-thinking approach is vital. This involves recognising diverse stakeholders' interactions throughout construction stages, addressing unique resource needs at each phase.

To enhance buy-in and code enforcement, G20 countries should integrate policy-making principles during code development and adoption. To strengthen building energy code enforcement, clear guidelines, such as implementation rules and user guides, are essential. Telangana and Andhra Pradesh in India provide a successful example, offering technical resources to address challenges in meeting code requirements. Additionally, a robust online single window clearance system, exemplified by Uttar Pradesh's Nivesh Mitra and Telangana's TS-bPASS, simplifies the approval process, enhancing transparency and efficiency. In terms of compliance verification, a third-party assessor (TPA) model can be embraced, with government accreditation and random checks to address capacity and resource constraints. Leveraging existing infrastructure of TPAs under programmes like LEED can further support this initiative. The robustness of enforcement checks should be enhanced by linking energy code language to life safety priorities and introducing specified rules for construction checks at key stages. Adopting a combination of remote and on-site inspections, especially demonstrated in First Nations communities in northern Canada, can effectively address resource limitations, providing flexibility and efficiency in compliance verification.

To ensure energy efficiency in new buildings, the adoption of building performance standards (BPS) alongside traditional codes is crucial. Unlike strict prescriptive codes, BPS emphasises performance goals, offering flexibility for builders to achieve energy efficiency targets, fostering innovation and adaptation to diverse contexts. Notable cities like Tokyo, Boulder, Washington DC, and New York City have successfully implemented BPS. Four key components of a BPS policy include the scope of coverage, metrics for performance measurement, associated targets, and compliance time frame and mechanisms. An integrated policy package also incorporates incentives for higher-than-minimum performance, capacity building, and awareness-raising.

Transitioning to More Efficient Electric Motors

Electric motors are identified as the backbone of the industry, consuming a significant portion of global electricity. This underscores a potential for substantial energy savings and environmental benefits through the adoption of high-efficiency motors, particularly medium-sized induction motors, which are widely used across various industries.

The implementation of Minimum Energy Performance Standards (MEPS), harmonised based on International Electrotechnical Commission (IEC) norms, represents a crucial step towards global energy savings. The evolution of MEPS is examined, highlighting a shift towards increasingly stringent efficiency classifications, demonstrating a commitment to reducing energy consumption and emissions among the G20 nations. The European Union, United Kingdom, and Türkiye made four transitions to reach the current MEPS of IE4 in a little more than just a decade. In contrast to the EU, which has made significant strides in expanding the coverage of motors in such a short timeline, the US and Canada have lagged despite being one of the first countries to come out with motor MEPS in 1997. The Chinese and Brazilian economies transitioned to MEPS higher than IE2 for a large range of motors despite the presence of many MSME motor manufacturers. South Korea's Open platform for technology diffusion of IE4 industrial motors and India's National Motors Replacement Programme by Energy Efficiency Services Limited, provide an insight into the national efforts to promote the production of high-efficiency motors among the G20 countries. These case studies highlight the implementation of policies and incentive programmes designed to support industries in transitioning to more efficient technologies. A study of Egypt and Ghana has been included who have been the forerunners among the African Union. Egypt has successfully implemented the IE3 MEPS; Ghana mandated MEPS at IE2, which is commendable for a developing country implementing motor MEPS for the first time.

The proposed policy actions focus on enhancing motor efficiency and promoting energy savings in motor systems. The first set of actions suggests implementing mandatory efficiency requirements for new motors, emphasizing system efficiency over motor efficiency, encouraging the use of Variable Speed Drives (VSDs), and discouraging motor repair below 50 kW. Policies should be developed using an integrated policymaking approach that takes into account the perspectives of all relevant ministries and departments integrated laterally and vertically and considers the value proposition for all actors across the supply chain. Additionally, demand creation strategies involve sensitising procurement officers about life cycle costs of efficient motors (as opposed to first costs) and promoting government-led energy audit programs. Support for small motor manufacturers should be addressed including their raw material sourcing challenges, making technology accessible, and fostering joint ventures with larger manufacturers.

The Role of ESCOs in Advancing Global Energy Efficiency

Investments are crucial for global energy efficiency improvements and the doubling target and G20 countries are actively working to increase such investments. However, energy efficiency projects, focused on operational cost savings, have traditionally received lesser attention due to the challenges of dispersed opportunities and higher transaction costs. To achieve the 2030 goal of doubling energy efficiency through a comprehensive approach involving both operations and capital, Energy Service Companies (ESCOs) are an effective instrument. The current ESCO market represents only a fraction of the total global energy efficiency investments. ESCO market dynamics vary globally, influenced by factors such as market size, growth, business models, and finance sources. The global ESCO market, valued at 38 billion USD, is led by China, the US, and the EU.

The Strategic Plan by the Bureau of Energy Efficiency recommends G20 countries increase ESCO investments to $100 billion by 2030. Achieving this target requires increased investments across diverse G20 countries, each with varying capabilities. This would mean encouraging high-performing G20 countries to maintain their momentum and urging those with lower performance to accelerate their ESCO investments. Successful case studies from Mexico, China, India, and the US provide insights into overcoming barriers to ESCO market growth, through mechanisms such as insurance-based financing, catalytic funds, aggregating demand, and policy-supported energy efficiency programmes.

Achieving a thriving ESCO market encompasses creating demand, building trust, and improving financing capacities. To foster market development, it's crucial to broaden ESCO perspectives, integrating both operational and capital expenditure mindsets. Highlighting non-energy benefits as strategic aims, such as increased asset value and health improvements, can increase participation. Strengthening project development capacities involves addressing the gap between potential and financeable projects through aggregators and alliances with utilities. Progressively stringent energy efficiency mandates and regulations can further boost demand. Financing should involve diverse sources, appropriate financing mechanisms, and de-risking solutions like guarantee funds and insurance products to minimise risk and ensure credit availability. G20 countries can play a pivotal role in advancing global energy efficiency goals through a holistic approach that involves regulation, financial incentives, and trust-building measures. Building trust requires robust Measurement and Verification (M&V) protocols, digitalisation, standardisation, integration of IoT and ease of replicability. Stakeholder consultations have indicated that the implementation of dedicated M&V platforms, utilising internationally recognized protocols like the IPMVP, can automate the validation of performance for both new and retrofit projects. This approach has the potential to enhance the speed, consistency, and transparency of ESCO projects, thereby significantly boosting the ESCO market.

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Introduction

1.1 Doubling the global rate of energy efficiency improvement

Maximizing energy efficiency is crucial for achieving the global clean energy transition and sustainable development goals, aiming to mitigate 40% of global greenhouse gas emissions by 2030 in alignment with the Paris Agreement, while also ensuring universal energy access and optimizing the productive utilization of energy. The momentum to increase the global rate of improvement of energy efficiency gathered pace in 2023:

- **COP28, December 2023:** The heads of state and governments of 123 countries as the participants in the COP28 Global Renewables and Energy Efficiency Pledge noted that the world "must double the global average annual rate of energy efficiency improvements from around 2% to over 4% every year until 2030" (COP28 UAE 2023).

- **G20 New Delhi Leaders' Declaration, September 2023:** The G20 leaders took note of the 'Voluntary Action Plan on Doubling the Rate of Energy Efficiency Improvement by 2030'.

- **G20 Energy Transitions Ministers' Meeting, July 2023:** The G20 Energy Transitions Ministers' Meeting Outcome Document and Chair's Summary from July 2023 noted that the G20 acknowledged "the role of energy efficiency and energy savings, as the "first fuel" and the importance of national energy efficiency and energy savings policies in not only driving the energy transitions, but also contributing to sustainable job creation, reducing energy cost for households, and ensuring energy security." They agreed to "focus on evolving an effective roadmap on a voluntary basis, for achieving the SDG 7.3 target of doubling the global rate of improvement in energy efficiency within this decade taking into account, national circumstances.", and noted the "Voluntary Action Plan on Doubling the Rate of Energy Efficiency Improvement by 2030" prepared by the Indian Presidency (G20 Energy Transition Working Group 2023).

- **IEA's 8th Annual Global Conference on Energy Efficiency, June 2023:** 46 governments participating in the IEA's 8th Annual Global Conference on Energy Efficiency endorsed the 'Versailles Statement: The crucial decade for energy efficiency', agreeing to strengthen energy efficiency actions in line with a doubling of global energy intensity progress each year this decade to 2030 (IEA 2023).

Energy intensity, generically defined as the amount of energy used to produce a given output or service, is used as the indicator to track progress on energy efficiency (SDG 7.3). The SDG 7.3.1 indicator is specifically measured in terms of primary energy supply and GDP, which is a proxy indicator to track country or global level progress[1] (SEforALL n.d.). Per AEEE's analysis based on IEA's data (IEA 2023) shown in Figure 1.1, India has consistently improved its energy intensity, at 1.6% p.a. between 1990 and 2010, and at 2.2% between 2010 and 2020. The G20 Energy Transitions Ministers' Meeting Outcome Document and Chair's Summary from July 2023 endorsed doubling the global rate of energy efficiency improvement by 2030, taking into account national circumstances. If India were to match this global target, it would need to ratchet up its annual energy intensity improvement rate from the current 2.2% to 4.6% between 2020 and 2030. In comparison, global energy efficiency improvement rate would need to move up from 1.8% to 3.1% in the same period. The G20 Global South[2] members would require the improvement to increase from 2.1% to 2.5% while G20 Global North[3] members would need to move from 1.9% to 4.4% between 2020 and 2030.

1 Energy intensity is arguably not a perfect metric to quantify energy efficiency at the level of a country but it is less complicated. Admittedly, quantifying energy efficiency at the level of a country is complex and there is no perfect metric in sight, but as the G20 countries agree on "doubling the global rate of improvement in energy efficiency within this decade taking into account the national circumstances.", it may become necessary to develop parallel metrics to measure energy efficiency progress that capture the nuances of these "national circumstances". For example, a decrease in energy intensity of countries practising austerity in light of a war or a pandemic should not be mistaken for an improvement in energy efficiency since it is important to differentiate between cutting down energy use due to exceptional/undesirable circumstances during which normal operations/services are suspended/compromised and energy efficiency, which implies using less energy to dispense the same service levels. Also, it is important to consider the national distinctiveness in economic structures that will impact countries' energy intensities.

2 G20 Global South: Argentina, Brazil, China, India, Indonesia, Mexico, Saudi Arabia, South Africa, and Türkiye

3 G20 Global North: Australia, Canada, European Union, France, Germany, Italy, Japan, Republic of Korea, Russia, United Kingdom, and United States

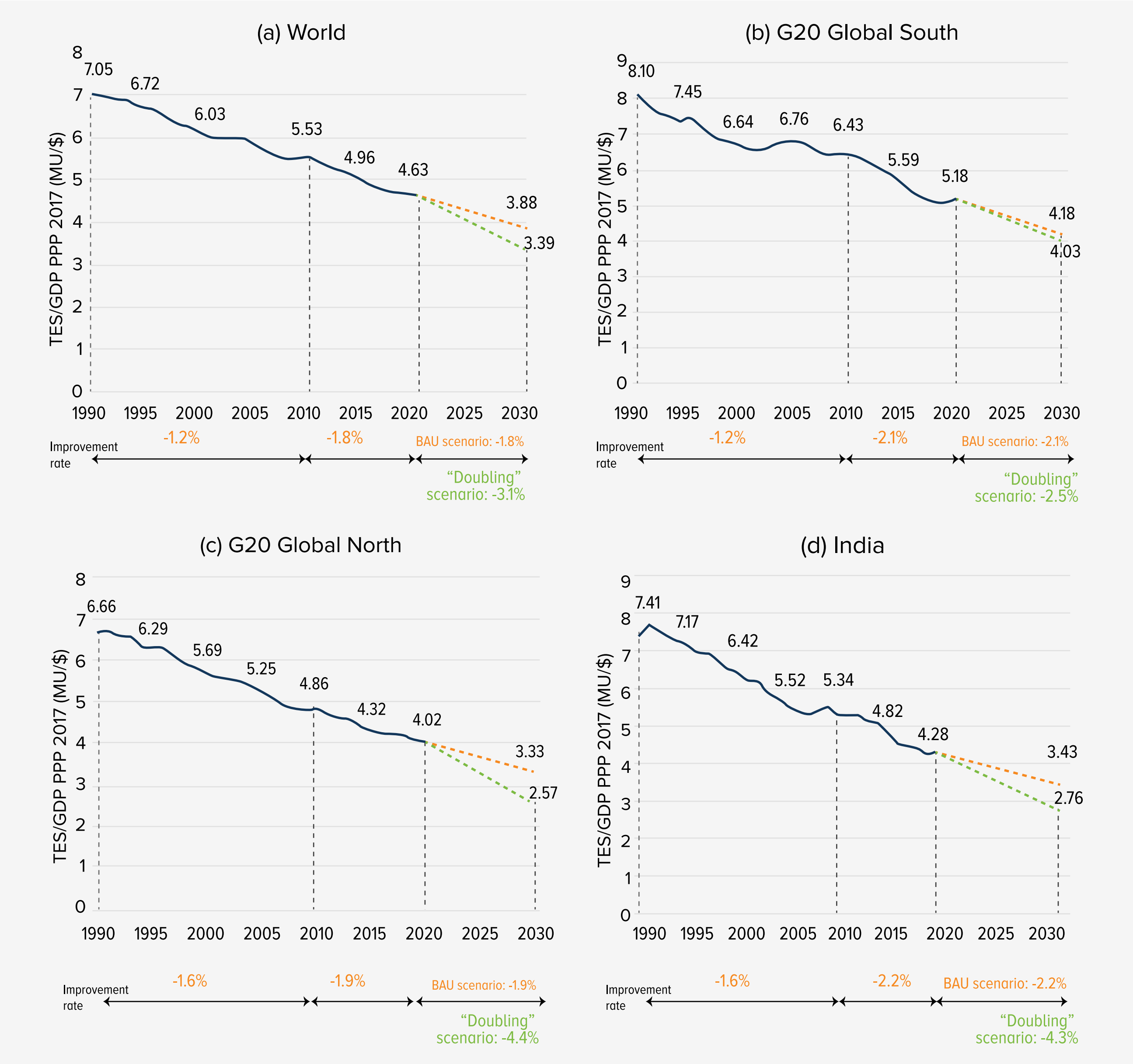

Figure 1.1: EE improvement rate – Business as usual (BAU) scenario v. "Doubling" scenario
Source: AEEE analysis based on data compiled from IEA (2023)

Box 1.1: Energy efficiency and the G20

Energy efficiency has found a significant voice within the G20 intergovernmental forum, where successive presidencies have underscored the pivotal role of energy efficiency in protecting our environment. The first G20 summit in Pittsburgh, USA in 2009, recognized the critical role of energy efficiency in protecting the environment and promoting sustainable growth. Subsequent summits, such as those in South Korea (2010), France (2011), and Russia (2013), echoed the same sentiment and highlighted the importance of international cooperation to improve energy efficiency across sectors. These discussions paved the way for collaborative efforts, culminating in the development of the G20 Energy Efficiency Action Plan- Voluntary Collaboration on Energy Efficiency in 2014 under Australia's presidency (G20 Research Group 2014). Milestones such as the adoption of the Energy Efficiency Leading Program (EELP) in 2016 during China's presidency (G20 Research Group 2016) and the establishment of the Energy Efficiency Hub in 2017 (G20 Research Group 2017) further underscored the commitment to enhancing energy efficiency globally.

The subsequent summits in Japan (2019), Saudi Arabia (2020), Italy (2021), and Indonesia (2022) further emphasised promoting energy efficiency through international collaboration, research, and innovation. Additionally, each summit also highlighted the need for increased investments in energy efficiency across sectors, along with policy frameworks to support innovation. The 2023 G20 Summit in India marked a significant milestone in advancing global energy efficiency, with the recognition of energy efficiency as the 'first fuel' and the adoption of the Voluntary Action Plan on Doubling the Rate of Energy Efficiency Improvement by 2030 (G20 Energy Transitions Working Group 2023).

The recent presidencies by Global South countries such as India, Indonesia and Saudi Arabia, and the upcoming 2024 presidency by Brazil present an opportunity for the Global South to shape the G20 discourse to better reflect their needs. Moving forward, it is crucial for future presidencies to build on existing momentum and avoid parallel goals to ensure maximum collective impact. This collective effort will be instrumental in achieving the targets outlined in the Paris Agreement and advancing towards a net-zero world.

1.2 G20 energy efficiency policy bank

AEEE has created the G20 Energy Efficiency Policy Bank, which compiles energy efficiency policies in G20 countries for three key energy demand sectors i.e., buildings, industries, and transport. It lends itself to policy researchers by offering a detailed list categorized into regulation, market-based, and informational policies. Policymakers can use it to evaluate existing policies, identify overlaps, and make informed decisions. Additionally, educators and the public can access the database for learning, staying informed, and promoting energy efficiency awareness. This section presents an analysis of energy efficiency policies across buildings, industries, and transport, across G20 countries as a whole, the G20 Global North, and the G20 Global South:

- When analysing sector-wise policies (Figure 1.2a), buildings can be seen to have the largest number of energy efficiency policies, followed by industry, and then transport. Policies in the buildings and industry sector predominantly rely on regulatory measures, while the transport sector policies lean towards market-based approaches, highlighting a leaner regulatory framework (Figure 1.2b-d).
- Regional variations emerge when examining policies in the Global North and Global South regions. The G20 Global North commands a significantly larger share of the policies, accounting for approximately 65% of the policies compared to the G20 Global South's share of 35% (Figure 1.2e). This disparity signifies potential differences between the two, with the Global North displaying a stronger emphasis on policy formulation compared to the Global South. It also suggests potential variations in economic capacities, governance structures, or environmental priorities between these regions (Kowalski 2020). However, despite the policy share, both regions exhibit similar proportional allocations across sectors (Figure 1.2h-i).

- The G20 Global North and Global South showcase comparable shares across sectors but diverge notably in the share of policy type instruments. The Global North emphasizes market-based policies, while the Global South demonstrates a stronger reliance on regulatory policies, indicating potential differences in approaches to driving energy efficiency measures. This gap presents an opportunity for knowledge transfer and policy alignment. Greater focus can be directed towards industry and transport sector policies. Also, from Figure 1.2f-g drawing from the Global North's experiences, Global South could be encouraged to adopt more market-based policies. This would help in increasing the existing energy efficiency measures without increasing the regulatory burden.

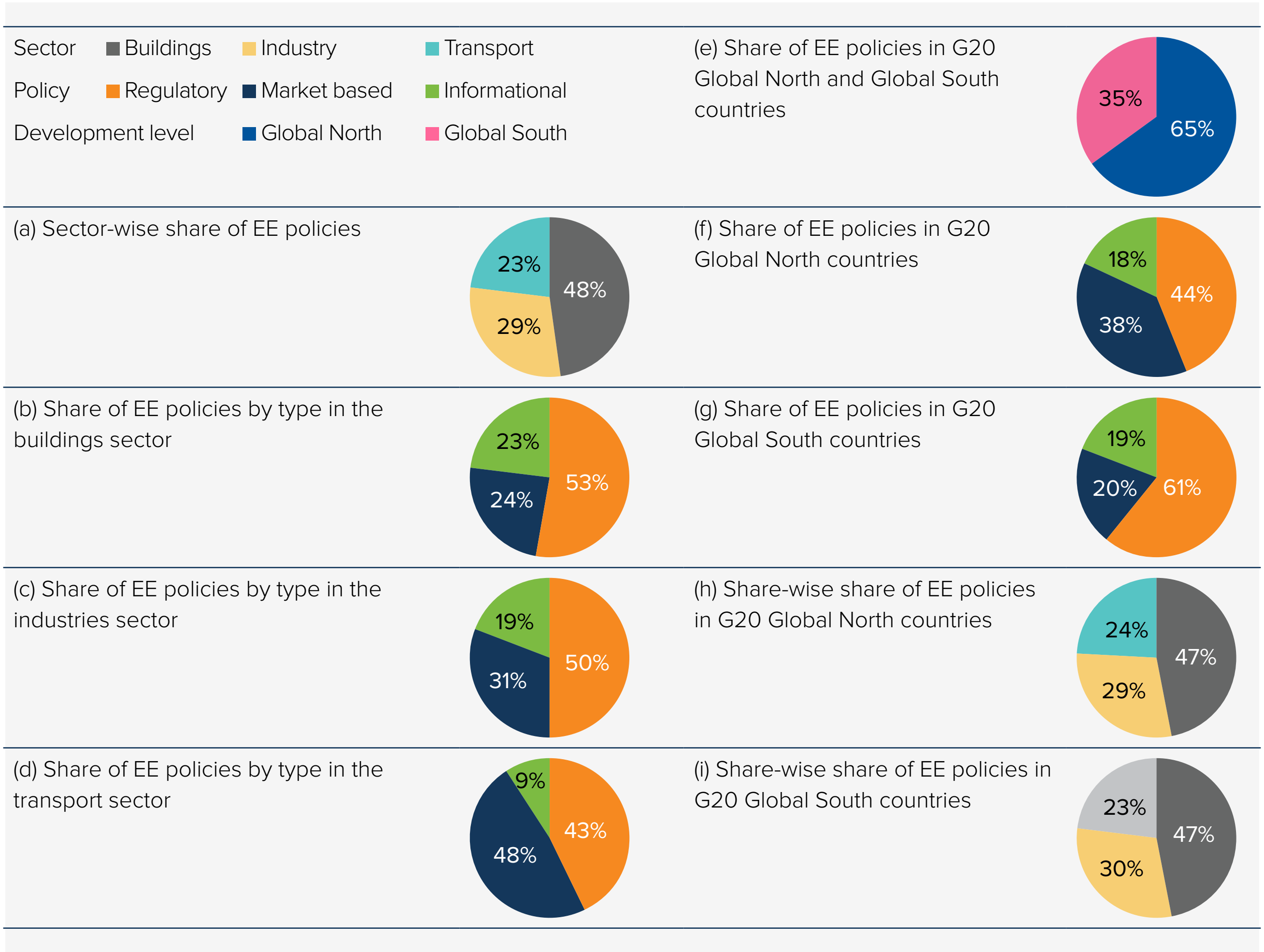

Figure 1.2: Analysis of EE policies in G20 countries
Source: AEEE analysis derived from the G20 energy efficiency policy bank

1.3 High-impact energy efficiency opportunities

The Bureau of Energy Efficiency, Ministry of Power, Government of India identified five high-impact energy efficiency opportunities in its "Strategic Plan for Advancing Energy Efficiency Across Demand Sectors by 2030" (BEE 2023) during India's G20 Presidency in 2023. Three of these high-impact energy efficiency opportunities, which apply to both Global North as well as Global South G20 countries, are as follows. Their linkages with Voluntary Action Plan on Doubling the Global Rate of Energy Efficiency Improvement by 2030 have also been mentioned.

Rethinking Energy Codes for a Net-Zero Energy World (RENEW): To enhance building energy efficiency, we must enforce stricter outcome-based codes at scale, emphasizing technology in compliance checks and performance verification during design. Future codes should shift from energy to carbon metrics and encompass building life cycles, energy systems, renewables, storage, and grid interaction.

- Linkage with the Voluntary Action Plan: "Development or strengthening of building energy codes to encourage that majority of buildings are built to optimal energy efficiency levels."

Scaling-up Motor Efficiency for Small and Medium Enterprises (SME²): Owing to the enormous energy usage in the global motors ecosystem, G20 countries could consider direct policy action with ambitious MEPS goals such as to sell IE class 3 and above efficiency level motors by 2030, while providing an enabling ecosystem and sufficient lead time for the industry, particularly MSMEs, to upgrade their production processes.

- Linkage with the Voluntary Action Plan: "Development of policies and programmes to ensure that new electric motors sold are more efficient and use variable speed drives, where appropriate."

Financing for Aggregating Services and Technologies (FAST): Energy Service Companies (ESCOs) play a crucial role in identifying, financing, and implementing energy-efficient solutions. G20 nations should boost the ESCO sector by mobilizing funds for scaling up energy efficiency investments. This involves establishing a revolving fund for dedicated ESCO financing, fostering knowledge exchange among G20 countries, and allocating budgetary provisions for energy efficiency initiatives.

- Linkage with the Voluntary Action Plan: "Development of policy frameworks to enable innovative financing and business models with lower transaction and capital costs that overcome access barriers to energy efficiency financing; Deployment of de-risking instruments, financing models for SMEs and support for energy service companies (ESCOs); Strategic deployment of public finance to enhance investment in currently underfunded areas, and mobilizing finance from a variety of sources, instruments and channels, especially leveraging larger private sector investments.


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Closing the Gap between Building Energy Code Development and Implementation

The G20 collectively accounted for approximately 89% of the global electricity demand in 2021 (IEA 2023). Among various consumption sectors, buildings stood out as a significant contributor to this demand, with operational electricity use in residential and commercial buildings accounting for more than 34% of the total G20 final electricity consumption (IEA 2023). In other words, buildings in the G20 consumed nearly 30% of the global electricity demand in 2021.

Recognizing the importance of buildings, G20 countries have adopted many regulatory measures to improve buildings' energy efficiency, such as building energy codes, building performance standards, data disclosure and benchmarking policies, and energy performance labelling. Among these, building energy codes have emerged as a common regulatory measure adopted by most G20 countries. This is because population growth and urbanisation are driving unprecedented growth in gross floor area, particularly in developing economies. Considering this, adopting building energy codes provides an opportunity to build right the first time. Building codes also offer a crucial opportunity to integrate cost-effective energy-saving measures during the building phase, which can be more economical than retrofitting later. Consequently, implementing building energy codes stands as a highly impactful solution and can help "in avoiding the energy and carbon lock-in effects associated with inefficient construction, and unlocking a powerful compounding effect that minimizes the energy and carbon intensity of the buildings sector" (National Institute of Urban Affairs and RMI 2022).

There have been several studies indicating the benefits of the adoption of building energy codes:

- **United States:** The US Department of Energy indicated that adopting energy-efficient building codes could result in approximately $138 billion of energy cost savings and avoidance of 900 million metric tons of CO_2 emissions within the country over the cumulative period from 2010 to 2040. To put this into perspective, these savings equate to the annual emissions of 195 million passenger vehicles, the output of 227 coal power plants, and the energy consumption of 108 million homes (Tyler et al. 2021).
- **Saudi Arabia:** Another study in the Gulf Cooperation Council estimated energy savings between 22.7%-39.5% in Saudi Arabia if building energy codes are implemented correctly. Additionally, the study also estimated the impact on cooling load, considering the hot and arid climatic location of Saudi Arabia, and found a 16.4% reduction in annual cooling load for residential buildings if building energy efficiency codes are implemented thoroughly (Elnabawi 2021).

Considering the potential of building energy codes for enhancing energy efficiency in buildings, this chapter takes stock of the status of building code development in the G20 group. Concurrently, the chapter also explores gaps and challenges in implementing building energy codes and highlights best practices in code development and adoption towards G20 countries' updated NDCs and long-term net-zero goals.

2.1 Current status of building energy code development in the G20

Currently, 18 G20 members, including the European Union, have adopted building energy codes. The scope of the codes and their stringency vary across countries. The scope of building codes can be broadly divided into residential and non-residential buildings. Within non-residential buildings, countries also divide the scope of the code into commercial and public buildings. The stringency of the also vary, with some countries employing voluntary or mandatory codes or a combination of the two, with some parts mandatory and others voluntary. Brazil and Argentina have building performance labels. Many countries have both building performance labels and building energy codes, such as the BEE Star Label (voluntary) for commercial buildings in India and NaBERs (mandatory for buildings larger than 100 m^2) and NaTHERs (also used to calculate the mandatory minimum energy performance requirements in the National Construction Code in Australia). A summary of the current status of energy-efficiency building codes for residential and commercial buildings in the G20 member countries is presented in Figure 2.1. In addition to energy efficiency building codes, some countries have also expanded the scope of the codes and added more complexities in their endeavour towards net-zero buildings. Examples of such practices include net zero building codes and codes with embodied carbon considerations, presented in Box 2.1.

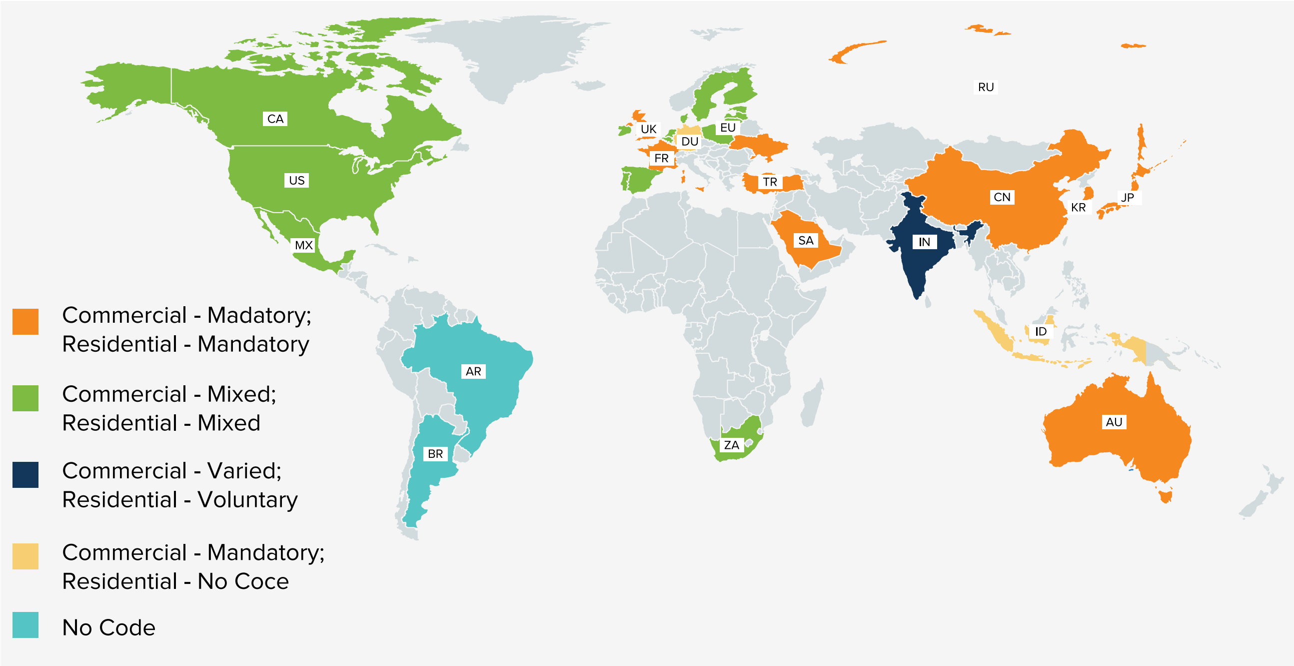


Figure 2.1: Current status of building energy code development in G20 countries
Source: AEEE analysis compiled from various sources such as Building Codes Assistance Project (n.d.), and GBPN (2015)

[Notes: 1. Commercial building energy code in India (Energy Conservation Building Code (ECBC)) is mandatory only after it is included in municipal byelaws after state-level notification. 2. India also has new commercial and residential building codes – Energy Conservation and Sustainable Building Code (ESCBC) in the draft stage, which have new additions such as water and waste management, sustainable building materials, etc. 3. The EU has adopted a major revision of the Energy Performance of Buildings Directive (EPBD) that introduces requirements for member states to significantly improve the energy performance of their building stock (Think Tank European Parliament 2023)]

Box 2.1: Future-looking building codes

Net zero and net positive energy building codes

Net zero and net positive building codes ensure that buildings produce as much energy as they consume or generate surplus energy, contributing positively to the grid, respectively. While not yet universally adopted, some G20 member nations are pioneering this transition. For example, the EU has the Nearly Zero Energy Building (NZEB) requirement in the EPBD, which mandates all member states to have an NZEB code. Following this, members states such as Germany have implemented nearly net-zero energy standards in its building codes, emphasising energy efficiency and onsite renewable energy generation, and has set the target to have Germany's building stock "virtually carbon-neutral by 2050" (Building Codes Assistance Project n.d.). France, another EU member state, has gone further than NZEB by introducing mandatory net-positive energy codes and Bâtiment à Energie Positive 'BEPOS' rating scheme for certifying positive energy buildings (Bordier et al. 2018). However, despite these successes, a common issue identified in the implementation of NZEB provision is that member states often define 'nearly zero' differently (BPIE 2021). While such codes are a step towards reducing the carbon footprint of buildings, efforts in this regard need to be amplified to improve the adoption of such programmes. One way to incorporate net-zero considerations can be to improve the code and raise the minimum performance requirements incrementally towards net-zero building codes (APEC Energy Working Group 2017). Examples of such incremental improvements include the ban on gas connections for new construction in California, New York City and New York state in 2023, contributing to building electrification (McKenna 2023). However, in order to reduce building emissions, one must also ensure that the incremental changes are able to outpace the rate of urbanisation (Ürge-Vorsatz et al. 2020), and are accompanied with a systems-thinking approach. This means that alongside incremental improvements in minimum performance levels, provisions of integrative policy making, capacity building, penalty/incentive mechanisms are also accounted for. In this regard, one of the most recent developments in promoting step changes to drive down building emissions is the 'Buildings Breakthrough' – launched at COP28. The Buildings Breakthrough, launched by France and Morocco along with the UNEP, aims to accelerate transition in the buildings sector, setting the target of making near-zero emission and resilient buildings the new normal by 2030. A few G20 countries such as Canada, US, China, UK, Türkiye and the EU have pledged their commitment to the same, and is a welcome step towards reducing the emissions by the buildings sector, and supporting the Paris Agreement target (Tholot 2023; Wolf 2023).

Codes with embodied carbon considerations

Incorporating embodied carbon considerations into building codes is a crucial step in moving beyond just operational emissions and addressing the total emissions by the buildings. California in the United States, India and the EU have taken a leading role in this regard. California has adopted building codes incorporating embodied carbon requirements, focusing on reducing emissions associated with materials and construction processes. The regulations, which will take effect from July 2024, will aim at limiting embodied carbon emissions in the "construction, remodel or adaptive reuse of commercial buildings larger than 100,000 square feet and school projects over 50,000 square feet". Along with this programme, they have also planned to launch programmes to promote zero-net-carbon literacy and educate professionals, both within and outside of the government, on the new code (Smolar 2023). Similarly, India has also developed new draft for commercial and residential building codes, which include the provision of reporting embodied carbon for new buildings. This approach will help address the full life cycle carbon footprint of buildings and better prepare the upcoming building stock for a net-zero world. The EPBD recast in 2023 in the EU also included mandatory disclosure of embodied carbon for new building construction (Europa 2023).

2.2 Current status of building energy code adoption in the G20

As seen in Figure 2.1, most G20 countries have adopted energy codes with varied levels of scope and stringency to enhance the energy efficiency of buildings. However, various studies have shown that savings from energy codes hinge significantly on robust enforcement mechanisms and high compliance rates (IEA 2021; Harper et al. 2012; Yu et al. 2013; Evans, Roshchanka, and Graham 2017). Unfortunately, there is a massive gulf between the quality and stringency of building energy codes development and its enforcement and implementation, as evidenced by ratings from the Global Building Performance Network (GBPN 2015).

This section evaluates building codes' enforcement procedures in the G20 countries. It maps countries' code enforcement procedures on the following parameters – the type of enforcement, provision of on-site inspections, certification, penalties and incentives, and other provisions to support compliance – inspired by the methodology used by the Global Buildings Performance Network (GBPN et al. 2013) and APEC Energy Working Group (APEC Energy Working Group 2017). Table 2.1 presents the current status of compliance procedures in the G20 nations. It is important to note that while provisions for on-site inspections, penalties, compliance testing, etc., might exist on paper, the extent to which they are followed through can vary across countries and even within them.

Table 2.1: Current status of building energy code compliance procedures in G20 countries

Source: AEEE analysis compiled from various sources, including Building Codes Assistance Project (n.d.), GBPN (2015), Moore and Holdsworth (2019), Shui et al. (2009), Li and Shui (2015), Evans et al.(2017), Fayaz and Kari (2009), Leão et al. (2008), Fiener, n.d.; Young, n.d.)

Countries	Compliance testing	On-site inspections	Certification	Penalties	Incentives
More stringent compliance ↓	Local Enforcement; Local + Third Party	Design; Design + Construction; Design + Pre-occupancy	EPC Present	Fines; Refusal of permission to construct; Refusal of permission to occupy; Loss/Suspension of license	Subsidies/ Tax Rebates; Subsidies + Public Recognition
Australia	[Local + Third Party]	[Design]	[EPC Present]	[Loss/Suspension of license]	[Subsidies + Public Recognition]
California	[Local + Third Party]	[Design + Pre-occupancy]	[EPC Present]	[Refusal of permission to occupy]	[Subsidies/ Tax Rebates]
Canada	[Local + Third Party]	[Design]	[EPC Present]	[Refusal of permission to occupy]	[Subsidies + Public Recognition]
Germany	[Local + Third Party]	[Design + Pre-occupancy]	[EPC Present]	[Refusal of permission to construct]	[Subsidies/ Tax Rebates]
South Africa	[Local Enforcement]	[Design + Pre-occupancy]	[EPC Present]	[Refusal of permission to occupy]	[Subsidies/ Tax Rebates]
United Kingdom	[Local + Third Party]	[Design + Construction]	[EPC Present]	[Refusal of permission to construct]	[Subsidies/ Tax Rebates]
Republic of Korea	[Local + Third Party]	[Design]	[EPC Present]	[Refusal of permission to construct]	[Subsidies/ Tax Rebates]
France	[Local + Third Party]	No data	[EPC Present]	[Fines]	No data
India	[Local + Third Party]	[Design + Pre-occupancy]	[EPC Present]	None	No data
China	[Local + Third Party]	No data	No data	[Refusal of permission to construct]	No data
Mexico	[Local + Third Party]	No data	No data	[Fines]	No data

[Notes: 1. Argentina, Brazil, Indonesia, Italy, Japan, Russia, Saudi Arabia, and Turkiye are omitted from the table due to lack of adequate data. 2. For onsite inspections, India has the provision of HVAC testing post-completion. 3. In India, while ECBC rules (2018) have the provision of penalty, the states have bypassed and omitted penalties while adopting the code at the state level (Shandilya and Ghorpade 2019)]

Type of enforcement (local and/or third party): Code enforcement currently lies in the ambit of local governments in all the G20 member countries. While some nations, like Australia, Canada and China (Bin and Nadel 2012), rely on a mix of local government oversight and third-party assessors to ensure compliance, others, such as South Africa, mandate local government agencies to be solely responsible. Additionally, states in India, such as Telangana and Andhra Pradesh, have also started to embrace third-party assessors for commercial building energy code enforcement (Madan 2023). The choice of enforcement mechanisms significantly impacts compliance effectiveness. Insufficient funding or resources are often cited as the primary reason for local governments being unable to enforce building codes adequately (Evans et al. 2017). Per some experts, enforcement also depends on the size of urban local bodies (ULBs), or their rural/urban demography. In some cases, experts mentioned that smaller ULBs find it easier to monitor new constructions, while larger ULBs often struggle due to their extensive geographical areas. In some other cases it was mentioned that enforcement also differs between rural and urban jurisdictions, where urban jurisdictions tend to take code enforcement more seriously than rural jurisdiction. Moreover, a lack of understanding of building energy codes within the government, as well as in non-government building professionals impedes enforcement. Additionally, insights from Indian experts underscored that a lack of coordination between departments overseeing general construction activities and those responsible for implementing building energy codes at the local level results in insufficient enforcement by local governments. In order to address the gaps mentioned above, third-party assessors have been introduced to help local governments with code compliance. In such cases, it may add an extra layer of impartiality and expertise, ensuring more rigorous scrutiny. However, a major issue associated with third-party inspections is that they frequently replace verification by local government rather than supplementing it, raising concerns about potential conflicts of interest, instances of malpractices, and additional expenses.

Onsite inspections: Onsite inspections are a practical means to ensuring buildings comply with the energy efficiency codes. However, the execution of these inspections varies widely across countries, occurring at different stages: during design, construction, or pre-occupancy. Australia, Canada, Germany, the Republic of Korea, South Africa, the United Kingdom, and several US states conduct inspections during the design stage, followed by inspections during construction or pre-occupancy. It is crucial to ensure that onsite inspections are robust, adequately funded, and conducted by qualified professionals to maintain the integrity of building codes. For example, IEA (2021) writes about how, often, compliance checks are not conducted in enough detail due to staff shortages, lack of training and understanding of the code, lack of capacity to conduct building simulations, and sometimes due to malpractices at the local level. This was found to be the case in all developed and developing countries alike, such as Australia, the US, India and China. Furthermore, the timing and frequency of these inspections are pivotal for effective enforcement. Traditionally, onsite inspections for energy efficiency evolved alongside those for health and safety measures and are presently often conducted simultaneously. However, IEA (2021) research illustrates that these inspections often occur at the foundation or completion stages, missing crucial checks such as insulation and building envelopes. This mismatch in inspection times for energy efficiency and safety reviews poses challenges to ensuring comprehensive compliance with energy efficiency measures. The need for these additional checks can be circumvented through building performance standards.

Certification: Certification, often in the form of energy performance certificates (EPCs), plays a crucial role in validating compliance with the energy efficiency building codes. EPCs have been adopted by many G20 countries, including UK, Canada, France, and South Africa. They typically outline the energy performance of the building and allow the estimation of building energy demand, providing valuable information on the building performance to potential buyers, tenants, and property owners (Y. Li et al. 2019). In this way, energy performance certificates aim to correct information asymmetry regarding the building energy performance between stakeholders such as property builders, owners, potential buyers, and tenants. However, there have been several studies indicating multiple errors in EPC ratings. Study by Hardy and Glew (2019) on open EPC record in the UK found that 27% of EPCs “report at least one flag to suggest it is incorrect”. They further estimate the true error rate of the EPC record, and find it to be between 36% and 62% (Hardy and Glew 2019; Lees 2024).

Penalties and incentives: Penalties and incentives are powerful motivators for increasing compliance with building energy codes. While many countries, such as Germany and the UK, impose fines or deny construction permits or occupancy permits as penalties for non-compliance, a few countries, like Japan, use multiple strategies such as withholding construction and occupancy permits, publishing the building owner's name and/or imposing a fine (Evans et al. 2017). Incentives are also used extensively to promote the adoption of building codes. Incentives act as a market-based mechanism, enabling compliance above the minimum requirement and assisting in pushing the markets to adapt, making compliance easier (IEA 2021). While in most cases, incentives are provided for buildings that get certified (i.e., have attained minimum performance levels), many countries are also establishing stretch codes where higher performance than the minimum performance level are eligible for incentives. The G20 member nations use a variety of approaches to provide incentives for compliance with energy codes such as tax exemptions, low-interest loans, subsidies, etc. Countries also employ provisions of public recognition of high-performing buildings to promote the adoption of building energy codes. For example, many industry associations such as Energy Efficiency Council in Australia award buildings with public recognition which display exemplary energy efficiency or sustainable design practices, and Canada has a rating programme for the public recognition of high-performing buildings. However, per some experts, its more effective to target incentives to high achievers, because incentives for minimum performance might send a message to the market that compliance isn't mandatory. In such cases, apart from monetary/public incentives, incentives can also include getting to jump to the first in the queue for permit applications, which might have a positive impact on the developers.

Simulations: Several G20 countries have introduced additional measures to enhance compliance with energy efficiency and sustainability standards. For instance, France mandates computer simulations for all projects, so that the design phase considers energy efficiency from the outset. Such measures often complement traditional enforcement mechanisms and can be instrumental in advancing sustainability goals. In the US, ASHRAE has introduced a database that allows building designers to select simulated designs meeting code compliance. This comprehensive database encompasses a wide range of potential buildings, substantially lowering compliance costs and ensuring accurate simulations.

Systems-thinking approach: The implementation of building energy codes, as a process, involves a variety of stakeholders interacting with one another at the varied stages of building construction from building design to building commissioning. Each stage involves unique type of resource requirement for code enforcement, and considering this, to effectively implement building energy codes and ensure compliance, their implementation process must be thought with a systems-thinking approach, as followed by a few G20 countries (Danish Energy Agency 2022). This essentially means streamlining the enforcement and compliance process and exploring systemic barriers that hinder compliance at different stages. These can include poor communication among different departments involved in plan approval, lack of resources for implementing building codes, etc. Once these barriers are identified, they can be addressed using technology, external/internal communication, etc.

2.3 Recommendations

Broadly, the building energy codes encompass code development, code adoption, and its enforcement. This section recommends a policy package, broadly along the aforementioned stages, with greater emphasis on the code enforcement and parts of the code development and adoption process that impacts code enforcement.

A. **Follow the principles of integrated policy-making during code development/amendment and adoption for greater buy-in to ensure better code enforcement:** In nearly all the G20 countries, the responsibility of code development lies primarily with the national government. Some countries, such as Australia, incorporate their building code into their main construction code, while other countries, such as India, have a separate code for building energy efficiency. Code adoption, however, sees a larger role played by the local governments. IEA (2021) writes how in most countries with federalist structures such as Australia, Canada, India and the US, code adoption comes primarily in the ambit of subnational governments, and even in countries where the national government has the authority to adopt the code, local governments provide support in the adoption of the same.

Multiple stakeholders play a role in the code adoption process. For example, in the Indian context, following the central government's code development, state-level departments of energy or urban development departments (UDDs) typically facilitates code notification. The responsibility for energy code amendments rests with the energy departments, while the UDDs are tasked with amending town and country planning rules and regulations, as well as building bye-laws, to incorporate the building energy code provisions post notification and amendment at the state level. Although the state energy department is responsible for the code amendment process, involving UDDs in the same has proven beneficial in securing early support during later stages of code adoption. This collaborative approach streamlines the incorporation of building energy code provisions into building bye-laws at later stages, easing the overall process. Such inter-ministerial coordination, or lack thereof in some cases, has eventually impacted code enforcement and has even led to delays in code adoption across a few states in the country (AEEE et al. 2017).

B. Recommendations regarding code enforcement: Building energy codes are enforced during the design and construction stages of the building development. Table 2.2 highlights the typical process of code enforcement in the building construction cycle, and presents stage-wise recommendations based on best practices from G20 countries.

Table 2.2: Stages of code enforcement in the building construction cycle

Stages of code enforcement in the building construction cycle	Description	Recommendations
I. Building design submission for approval	Building design is submitted for approval, along with several documents depending on the approach of compliance (prescriptive/whole buildings)	• Roll out additional documents such as implementation rules for building code enforcement agencies and user guides for demonstrating compliance • Establish robust online single window clearance systems
II. Compliance verification	The documents demonstrating compliance with building energy code norms are verified by a designated enforcement agency in this stage.	• Embrace third party assessor model for inspections and enhance their robustness by establishing official government accreditation for TPA and complementing it by random checks by government officials
III. Building construction	Once the building plans are approved, construction activities commence based on the approved design.	
IV. On-site inspection during building construction	On-site inspections are conducted during the construction phase to ensure adherence to building energy codes.	• Specify rules on when to conduct checks during construction for energy efficiency measures • Adopt/combine remote inspections with on-site inspections where applicable
V. Post occupancy energy efficiency monitoring	Monitor performance of buildings post occupancy to ensure energy efficiency, and update the prescriptive codes according to buildings' actual performance	• Embrace building performance standards

a. **Roll out additional documents such as implementation rules for building code enforcement agencies and user guides for demonstrating compliance:** To strengthen building energy code enforcement, it's crucial to provide clear guidelines for code enforcement agencies and stakeholders. Implementation rules delineate the operational elements of enforcement, and provide roles and responsibilities for all stakeholders engaged in building energy code implementation, ensuring uniformity and consistency in the enforcement process. Similarly, user guides are essential for those directly involved in compliance, offering step-by-step instructions and insights into meeting code requirements for building developers.

   An example from the G20 countries where this was followed is the states of Telangana and Andhra Pradesh in India. Through stakeholder engagement, it was revealed that professionals in the building community faced challenges in meeting code requirements, particularly regarding building materials, testing, and the modelling of mechanical systems due to the technical nature of the code. Responding to this, the governments of both the states developed multiple technical resources to address this capacity issue (Government of Telangana et al. 2017). This challenge was also observed at the national level, prompting the Bureau of Energy Efficiency (BEE) to introduce ECBC Rules in 2018, as outlined by the Ministry of Power. These rules delineated the operational elements of the code, significantly contributing to code compliance. In fact, it was found through expert consultations that states with poor performance in code compliance are frequently observed to not having notified the ECBC rules, leading to a lack of defined responsibilities for specific actors, thereby impacting compliance verification.

b. **Establish robust online single window clearance systems:** Implementing an online single window clearance system simplifies the approval process for building energy code compliance, making compliance easier for builders. This system should offer a centralised platform where builders/developers can submit, track, and receive approvals for their applications. It streamlines the bureaucratic procedures, enhances transparency, and reduces processing times, contributing to more efficient code enforcement. Such single window systems are usually implemented at subnational levels – and while many local governments are following suit, incorporating elements such as helpline number/chat box to assist with the application process, and adding links to application for incentives on the same page to enhance the user experience, can help ease the compliance process for varied stakeholders.

   There are multiple countries following this practice. For example, in India, the states performing well in "Ease of Doing Business" rankings have implemented online single window systems for building construction permits. Examples include Uttar Pradesh's Nivesh Mitra (Government of Uttar Pradesh, n.d.), and Telangana's TS-bPASS (Telangana State Building Permission Approval & Self Certification System - Government of Telangana, n.d.). Similarly, local governments such as Council in the City of Greater Sudbury in Ontario, Canada also implemented a 'Pronto' online portal to ease the process of applying for building permits. Additionally, they have also developed a helpline number to assist the users in submitting their building permit applications online – thereby easing the transition from in-person application submission process (Greater Sudbury 2023).

c. **Embrace third party assessor (TPA) model for inspections and enhance their robustness by establishing official government accreditation for TPA and complementing it by random checks by government officials:** Once the building plan is submitted for approval, compliance verification becomes the next step in the building construction and code enforcement process. As mentioned earlier, countries use a variety of approaches for code compliance – verification by local governments, or third parties or a mix of the both. Countries that use compliance verification by local governments generally either review the plans themselves, or mandate the inclusion of a document stating adherence to the building energy code by either a registered architect (for example, Haryana and Chandigarh in India). However, through expert consultations, it was found that this approach has are dual challenges: capacity constraints, where code officials often lack the necessary training to conduct energy efficiency checks, and resource constraints, as there is often an insufficient number of officials to oversee new construction and verify compliance. TPAs have been introduced in this case to address the capacity and constraint issues. However, this approach also raises concerns of potential malpractices, since the TPAs are generally hired by the developers to review their plans (Yu et al. 2013). While TPAs can help with improving compliance rates, one way to make this process more robust can be to have government accredited third parties to verify compliance, to have a balanced approach between third-party and local government inspections. This essentially means to either have government trained inspection bodies (such as "designated confirmation bodies" in Japan) or government recruited officials (such as "BEE empanelled building energy auditors" in India) (IEA 2021) (BEE 2010).

Existing infrastructure of TPAs under existing building rating programmes such as Leadership in Energy and Environmental Design (LEED) can also support in setting up a robust TPAs programmes in the countries. This approach leverages the experience of individuals with energy efficiency inspections, thereby addressing the capacity constraints many countries face in enforcing building energy codes requirements. A caveat to consider here is that these individuals might have to be trained on the country's energy code requirements before receiving government accreditation for building energy code inspections, but this process will be less resource intensive compared to training individuals with little energy efficiency or building design and construction experience (Yu et al. 2013).

Having established official government accredited TPAs, inspections can be made more stringent by improving the robustness of the TPA model. One way to do this can be to randomly assign TPAs to buildings, compensate them from a common pool, and conduct random retests for accuracy. The random recheck and monitoring can be led by government officials to reduce the instances of malpractices in inspections. In cases where any instance of malpractice has been found, it can lead to the loss of certification or license of the third party. Such an approach, also tested with environmental auditors in Gujarat, India (J-PAL 2018) can help in improving the compliance rates, without increasing regulatory burden.

d. **Enhance the robustness of enforcement checks:** Robust enforcement checks are necessary for improving code compliance. Currently, while enforcement checks are conducted in detail for health and safety measures, they often remain lacking for energy efficiency requirements. In order to enhance the robustness of enforcement checks, the energy code language can be linked to life safety code priorities, considering the climate crisis and building energy code ensuring a means to reduce emissions due to buildings. In addition, introducing specified rules for conducting construction checks at key stages of the building process for energy efficiency requirements would also help in improving the overall effectiveness of inspections. Clear guidelines should outline when these checks are to be conducted, ensuring timely interventions and corrections. For instance, checks can be scheduled during critical construction milestones, such as foundation laying, insulation installation, and HVAC system installation. This strategic approach not only ensures compliance with energy efficiency standards but also streamlines the inspection process, contributing to a more systematic and accountable implementation of energy codes.

e. **Adopt/combine remote inspections with on-site inspections where applicable:** Virtual inspections are being increasingly adopted for checking compliance with building codes. They gained traction initially due to their potential to cut down time and expenses, but their adoption surged during the COVID-19 pandemic. They bring numerous benefits, notably saving time and money, especially when the distance to construction sites is significant. An example is the First Nations communities in northern Canada, where inspections have become more feasible with reduced travel costs and time. Combining remote inspections with onsite ones can effectively tackle resource limitations, such as staff shortages (IEA 2021).

C. **Embrace building performance standards (BPS):** Each of the measures mentioned above contributes to enhancing overall compliance with existing codes, thus bringing us one step closer to ensuring the energy efficiency of new buildings. However, building construction represents only one phase of the entire building cycle. To guarantee that buildings operate in an energy-efficient manner, outcomes associated with building operations are equally crucial. Building performance standards become important in this context. Building performance standards are regulations or policies that emphasize the desired building performance goals by requiring "building owners to meet some performance benchmark or target, generally an energy performance rating or energy or carbon intensity". This approach prioritises measurable energy performance improvement over comparing a building's energy characteristics to a benchmark baseline (Hinge and Brocklehurst 2021). As pointed out by some experts, prescriptive codes, alone, resemble strict regulations, whereas complementing them with building performance standards offer increased flexibility in how builders achieve energy efficiency targets of a building, encouraging innovation and adaptation to diverse building types and contexts. This flexibility contributes to improved compliance rates. The importance of adopting building performance standards becomes especially evident when considering the ongoing challenge of assessing the effectiveness of prescriptive codes in real world practice. Notably, a few progressive cities in the G20 nations like Tokyo in Japan, Boulder, Colorado, Washington DC, New York City in US, and UK have implemented BPS for varied building types (Nadel and Hinge 2020).

There are four key components to establishing a BPS policy: "1) The scope of the policy in terms of the buildings that it covers 2) The metrics used to measure performance 3) The associated performance targets and 4) The compliance time frame and implementation mechanisms" (ASHRAE and United States 2023). Aside from these elements, several other aspects will also go into the development of building performance standards to ensure an integrated policy package (APEC Energy Working Group 2017). An integrated policy package will also include incentives to help stimulate better energy performance of buildings by rewarding the achievement of higher than minimum performance requirements and provisions for capacity building and awareness raising (APEC Energy Working Group 2017). Some of the key elements for a BPS policy are summarised in Box 2.2.

Box 2.2: Key elements for a building performance standards policy

- **Metering and monitoring infrastructure:** A robust metering infrastructure to capture energy consumption of buildings is an important backend requirement for implementing BPS. It is pertinent to enhance metering capabilities to measure and monitor energy consumption in buildings accurately. This infrastructure is critical for tracking actual performance against established objectives.

- **Data disclosure and benchmarking:** Buildings' energy use data disclosure and benchmarking is a key element in developing and implementing building performance standards. Benchmarking compares a building's energy performance to a similar set of buildings or its simulated performance (Evans et al. 2014). Either process requires data capabilities and a robust backend infrastructure to collect and process buildings' energy data. In addition to this, implementation of BPS also requires standardised protocols for data measurement, monitoring, and reporting. This includes developing standard data collection templates that capture relevant information about energy use for each building type, and specifying the frequency of reporting. Establishing standards for these processes will create consistency and simplify the comparison of energy performance data among different types of buildings (National Centre for Disease Control 2023). An example of robust energy data infrastructure is the Super Low Energy Building (SLEB) Smart Hub, launched in 2019 by the Buildings Construction Authority in Singapore (BCA 2020). An extensive data compendium such as SLEB enables building owners in identifying opportunities for improvements in their buildings' energy performance, contributing towards the "building sector's environmental sustainability transformation" (BCA 2020).

- **Defining performance metrics:** Choosing the performance metric for measuring compliance is a crucial step in establishing any performance standard. The decisions made in the latter stages of BPS, such as defining the targets, are closely tied to and influenced by the metric/s selected for performance measurement. When selecting a metric for BPS, it is essential to consider factors such as alignment with current building energy-related policies and the goals of the jurisdiction, as well as the metric's clarity and ease of understanding (ASHRAE and United States 2023).

- **Defining performance targets:** Another crucial element in implementing building performance standards is defining performance targets for different building types. These performance targets are clear and quantifiable KPIs tailored to diverse building types. These targets must also be normalised to account for variances in building functions, sizes, climates, and operational characteristics. There are different approaches to setting targets, as explained by ASHRAE and United States (2023). These include a) targets derived from benchmarking data (applicable for jurisdictions with energy benchmarking ordinances), targets derived from sector-level goals (applicable for jurisdictions with explicit building sector level emission/energy-use targets) c) targets based on published sources and d) targets based on modelled performance (c&d – both applicable for jurisdictions lacking building energy performance data) (ASHRAE and United States 2023). Additionally, for building performance standards to be effective, these targets should be periodically revised to further constraint building-use energy and carbon emissions, moving closer to net-zero. The revisions in performance targets should also reflect technological advancements, building usage patterns, and emerging best practices. This process requires continual evaluation and adaptation to ensure that the performance goals remain relevant, achievable, and aligned with evolving sustainability standards and technological advancements within the building industry.

- **Enforcement mechanisms:** The current code enforcement methods primarily revolve around issuing a certificate of occupancy (CO) upon the completion of construction, lacking a mechanism to address ongoing building performance. Various alternative enforcement mechanisms beyond the completion phase can be employed to tackle this issue. These include strategies such as temporary or conditional COs, annual inspections, fee-bates, public disclosure of building performance, utility rate adjustments, mandatory retro-commissioning, among others (Frankel 2012). Each strategy ensures ongoing compliance and improved building performance.

- **Integration with prescriptive codes:** Highlighting the complementary nature of BPS and prescriptive codes, it was suggested by many experts, that energy savings from building performance standards can be the highest if implemented alongside prescriptive codes. This is primarily because asset compliance is easier with prescriptive codes, allowing for addressing potential inefficiencies during construction and pushing the supply chain toward delivering more sustainable components. Hence, while traditional prescriptive codes cannot be ruled out because they are the basis of having compulsory elements such as onsite solar, heat pumps, and electrification in the buildings, BPS should be integrated with existing prescriptive codes, if feasible, to achieve maximum savings.
- **Awareness and capacity building:** An integrated policy package for building codes will also include provisions for awareness generation and capacity development among various stakeholders. Considering the multi-stakeholder process of code enforcement, engagement from design, trade and supply communities is essential for successful energy code deployment. This would ensure that code strategies are understood, and equipment and components needed to meet code requirements are available for building developers. Launching educational initiatives targeting building owners, stakeholders, and professionals in the construction industry can assist in improving code compliance for BPS. These initiatives can include disseminating information about the significance of energy performance in buildings and strategies for optimising building performance and meeting energy targets.

3

Transitioning to More Efficient Electric Motors

More than 50% of all electrical energy is used by electric motor systems globally, giving rise to around 6,800 million tonnes of CO_2 emissions (IEA, 2016). Three-phase, medium-size induction motors (0.75-375 kW) comprise 10% of the global stock but account for 68% of the energy motors use (UNEP, 2017). For small (less than 0.75 kW) and large (375-1000 kW) motors, the share is 90% and 0.03% of the global stock, respectively, while the energy use share is 9% and 23%, respectively.

Using energy-efficient motor systems in new installations, and replacing existing inefficient motors with more efficient ones, is a high-impact strategy to reduce energy consumption, cut down emissions, and reduce operational energy costs. Transitioning to energy-efficient motor systems can lessen the associated electricity demand by 20%-30% in 2030 (UNEP, 2017). Many countries are putting measures into place to phase out low-efficiency motors gradually.

3.1 Motor MEPS across the G20

Minimum Energy Performance Standards (MEPS) and electric motor labelling programs are in place in many G20 countries. Initially, motor efficiency tests and standards across countries reflected national ambitions and aspirations, creating a disharmonised global motor market. However, these MEPS are now harmonised based on International Electrotechnical Commission (IEC) standards. Most motor efficiency regulations around G20 countries are limited to AC induction motors, which represent 80% of the global motors stock in use (Fortune Business Insights n.d.).

According to IEC, the harmonized MEPS for electric motor systems is defined using the IEC 60034-2-1 test standard and the IEC 60034-30-1 classification scheme comprising four levels of motor efficiency (IE code): IE1 Standard Efficiency, IE2 High Efficiency, IE3 Premium Efficiency, and IE4 Super Premium Efficiency. Introducing IE code and its clear definitions and nomenclature has helped minimise trade obstacles (IEC). These international IE codes serve as a reference for national governments to specify the MEPS applicable in their country. The adoption and ratcheting of MEPS across the G20 economies have followed different timelines for different motor sizes (power rating), as depicted in Table 3.1. Many countries have consciously transitioned to ambitious MEPS to avoid becoming dumping grounds for low-efficiency motors manufactured in countries with higher MEPS.

Table 3.1: The evolution of motor MEPS in the G20

Source: AEEE analysis complied from IEC, de Almeid et al. (2023), de Almeida et al. (2017), CLASP (2023), ABB (2016), ABB (2021), WEG (2018), WEG (2021), UNEP (2017), and Creamer Media (2023)

	1997	2001	2008	2009	2010	2011	2012	2013	2015	2017	2018	2020	2021	2023	Current status of motor MEPS
European Union (including France, Germany, and Italy)						IE2 (0.75-375kW)			IE3 (7.5-375 kW) IE2 (7.5-375 kW) if fitted with VSD	IE3 (0.75-375kW) IE2 (0.75-375 kW) if fitted with VSD			IE3 (0.75-1000 kW) IE2 (0.12-0.75 kW)	IE4 (75 kW-200kW)	IE4 (75 kW-200kW) IE3 (0.75-1000 kW) IE2 (0.12-0.75 kW) IE2 (0.75-375 kW)(VSD)
United Kingdom						IE2 (0.75-375kW)			IE3 (7.5-375 kW) IE2 (7.5-375 kW) if fitted with VSD	IE3 (0.75-375kW) IE2 (0.75-375 kW) if fitted with VSD			IE3 (0.75-1000 kW) IE2 (0.12-0.75 kW)	IE4 (75 kW-200kW)	IE4 (75 kW-200kW) IE3 (0.75-1000 kW) IE2 (0.12-0.75 kW) IE2 (0.75-375 kW)(VSD)
Türkiye						IE2 (0.75-375kW)			IE3 (7.5-375 kW) IE2 (7.5-375 kW) if fitted with VSD	IE3 (0.75-375kW) IE2 (0.75-375 kW) if fitted with VSD			IE3 (0.75-1000 kW) IE2 (0.12-0.75 kW)	IE4 (75 kW-200kW)	IE4 (75 kW-200kW) IE3 (0.75-1000 kW) IE2 (0.12-0.75 kW) IE2 (0.75-375 kW)(VSD)
United States	IE2 (0.75-375 kW)					IE3 (0.75-375 kW)			IE3 (small polyphase 0.18-2.2 kW)						IE3 (0.75-375 kW) IE3 (small polyphase 0.18-2.2 kW)
China			IE1 (0.75-375 kW)				IE2 (0.75-375 kW)						IE3 (0.12-1000 kW)		IE3 (0.12-1000 kW)
Brazil				IE1 (0.75-375 kW)			IE2 (0.75-375 kW)					IE3 (0.12-370 kW)			IE3 (0.12-370 kW)
Canada	IE2 (0.75-375 kW)						IE3 (0.75-375 kW)								IE3 (0.75-375 kW)
Japan									IE3 (0.75-375 kW)						IE3 (0.75-375 kW)
Republic of Korea			IE2 (0.75-375 kW)						IE3 (0.75-375 kW)						IE3 (0.75-375 kW)
Mexico					IE3 (0.75-375 kW)										IE3 (0.75-375 kW)
Saudi Arabia									IE2 (0.75-375 kW)		IE3 (0.75-375 kW)				IE3 (0.75-375 kW)
India								IE2 (0.37-375 kW)		IE1 banned					IE2 (0.37-375 kW)
Australia		IE2 (0.73-184 kW)													IE2 (0.73- 184 kW)
South Africa														No MEPS yet, but IE3 (0.75-375 kW) proposal rolled out in October 2023 for review	No MEPS yet, but IE3 (0.75-375 kW) proposal rolled out in October 2023 for review
Argentina															No MEPS
Indonesia															No MEPS
Russia	Insufficient data														

Notes based on Table 3.1:

- Since 2011, the EU, UK, and Türkiye have worked hard to improve the efficiency of motors. They moved from lower efficiency standards (IE2) to higher ones (IE3) and expanded rules to cover more types of motors and performance ratings. For instance, in 2021, they required IE3 efficiency for motors up to 1000 kW. In 2023, the EU took a global lead by introducing regulations for even higher efficiency standards (IE4). In 2015, the EU allowed motors with variable speed drives (VSD) in the 7.5-375 kW range to meet IE2 efficiency. This was later updated in 2017 to include motors in the 0.75-375 kW range.
- China and Brazil have transitioned to MEPS higher than IE2 for an extensive range of motors despite the presence of many MSME motor manufacturers in their economy.
- The US and Canada were the first countries to develop MEPS for motors in 1997 at IE2 efficiency. The current MEPS for the US and Canada is at IE3 efficiency for medium-size motors. In contrast to the EU, which has made significant strides in expanding the coverage of motors in such a short timeline, the US and Canada have lagged despite being one of the first countries to come out with motor MEPS. In Europe, upgrading from IE1 to IE2 and eventually IE3 for 0.75-1000 kW motors required a major industry overhaul. Manufacturers were reluctant to produce more than two efficiency classes simultaneously. European manufacturers hesitated bypassing IE2 to transition to IE3, due to a lack of technological expertise compared to the US, which had experience with motor equivalents to IE3 a decade earlier than the EU. In 2015, the situation flipped. European manufacturers were prepared for IE4 with Permanent Magnet (PM) and reluctance technologies, but the US industry was not ready.

Box 3.1: Situational analysis of MSME motor manufacturers in India

Micro, Small, and Medium Enterprises (MSMEs)[4] are crucial to India's economic development. MSMEs are significant growth drivers for job creation, innovation, and social cohesion. The MSME sector consumes about 25% of the total energy consumed by the industries in India; out of this total energy consumed by MSMEs, 15% is electric energy (TERI, 2022). The MSME sector is sometimes equipped with obsolete technologies and poor operating practices, which offers significant potential for deploying energy efficiency through technology upgradation and adoption of best operating practices in manufacturing processes (BEE, 2019).

As part of the Strategic Plan for Advancing Energy Efficiency across Demand Sectors by 2030 (BEE, 2023), scaling up motor efficiency for SMEs has received considerable importance. The Indian MSME motor manufacturers accounted for 35%-40% of the total motor market share in 2019 (generally in the low-tension induction motors market) (ICA, 2019). These MSME manufacturers usually operate in South clusters (Coimbatore, Tirupur, etc.), Gujarat clusters (Ahmedabad, Rajkot, Valsad, Vadodara, Surat, etc.), and Maharashtra clusters (Mumbai, Nagpur, Nashik, Ahmednagar, etc.), which accounted for 90% of motors manufactured by the MSME sector in 2019 (ICA, 2020). They supply low-cost products and sell directly to customers (45%), OEMs (30%), distributors (20%), and engineering, procurement, and construction (EPC) contractors (5%). Before the ban on IE1 efficiency motors in 2017, IE1 motors had a share of around 88% of the total MSME motor production. While the share of IE2 class motors was close to 12%, and IE3 motors were negligible in production share (<1%). Some small local manufacturers, relying on obsolete technology and traditional sequence of handwork, are centres for sales, repair, maintenance, assembly, and installation.

According to the market survey conducted by the International Copper Association, post the ban on the IE1 motors in 2017, which was introduced as a non-tariff barrier to control the high import of motors, MSME motor manufacturers have been struggling to sustain continued market relevance since they were primarily operational in IE1 efficiency motors manufacturing. As of 2019, nearly 25% of the motors they manufactured were special purpose motors of IE1 efficiency class sold directly to informal OEMs. Some MSME enterprises are in the process of applying for licenses to manufacture IE2/IE3 motors.

As part of a survey conducted by the International Copper Association India, close to 70% of the significant MSME motor manufacturers[5] could not manufacture IE3 motors as per IS 12615. Moreover, the MSME manufacturers manufacturing IE3 motors were still not producing the complete range of kW ratings. Per extensive stakeholder consultations, some of the key barriers faced by the MSME manufacturers include:

- Inconsistent supply of required grade of raw material
- Difficulties in managing R&D cost and skilled workforce needed for developing electrical designs for IE3 motors
- Challenges in designing the mechanical components used in IE3 motors, such as components manufactured using stamping, die casting, etc.
- The equipment required for testing IE3 class motors is 3-5 times more expensive than testing equipment needed for IE2 class motors, along with the necessary skilled labour to operate the equipment
- Investment for tooling
- Insufficient demand for high-efficiency motors from their customers
- BIS certification process
- Double compliance with BEE and BIS regulations
- The overwhelming influence of large motor manufacturing in policy decisions
- Lack of awareness of bulk procurement programmes such as EESL's National Motor Replacement Programme or other government assistance schemes

4 Different countries define MSME differently, owing to diverse economic, social and regulatory environments. Also, these definitions are shaped by policies and compliances related to taxation, profitability, count of employees, etc. According to the Government of India, the MSME sector is defined as follows:

Classification	Micro	Small	Medium
Manufacturing and services enterprise	Investment in plant and machinery or equipment not more than INR 1 crore Annual turnover not more than INR 5 crores	Investment in plant and machinery or equipment not more than INR 10 crores Annual turnover not more than INR 50 crores	Investment in plant and machinery or equipment not more than INR 50 crores Annual turnover not more than INR 250 crores

5 These manufacturers are contract manufacturers of other large motor manufacturing companies.

3.2 Notable case studies from the G20

Open platform for technology diffusion of IE4 industrial motors in South Korea: The Electric Machine and Drive Research Center of Korea Electrotechnology Research Institute (KERI) successfully developed IE4 industrial electric motors (three-phase induction motors of power rating less than equal to 15 kW) in Korea (KERI Information 2023). KERI created an "open platform" that enabled SMEs to use its technologies by providing electric motor designs, material utilization, and the production process database. The research team of KERI established a web-based open platform (URL: iexdesign.com) in partnership with the Korea Electronics Technology Institute and an engineering software company, Clew.

- **Impact:** While achieving high efficiency with expensive materials is easy, KERI focused on securing market competitiveness for domestic SMEs. SMEs face many hurdles in manufacturing high-efficiency motors, like R&D investment, expert design skills, and expensive software. KERI provided an open platform at a lower cost to expand and apply IE4-class motors to SMEs' industrial sites. During the project period (2019-2022), the participating companies' annual sales of electric motors increased by more than 20% on average (KERI Information 2023).

National Motors Replacement Programme (NMRP) by Energy Efficiency Services Limited (EESL) in India: EESL launched its National Motor Replacement Program (NMRP) (EESL, n.d.) to accelerate and adoption for Higher Efficiency Motors (HEMs), specifically IE3, through upfront investment, awareness creation, capacity building of manufacturers and developing success cases to convince decision-makers. It is to be noted that as per the purchase tendering process of EESL, 25% of the total quantity of the tender is earmarked for Micro and Small Enterprises (MSEs) (EESL, 2023). The operating model of NMRP is as follows:

- Demand aggregation from industry (end-user)
- EESL procures motors through tender from the participating vendors
- The participating vendors supply motors to the sector (end-user)
- EESL initiates payment to the vendor
- The industry initiates payment to EESL as per two financial models, which minimises the financial burden on the customer

- **Impact:** The preferential purchase arrangement of NMRP served as a crucial incentive in manufacturing IE3 class efficiency motors by MSEs. The NMRP is also expected to enhance the Indian motor manufacturing's design capabilities towards the global best practice level of IE3, provide economies of scale in enhanced market reach pan India and higher exports, and Government of India co-branding (EESL, n.d.).

3.3 Forerunners from the African Union

Egypt: In a transformative move, Egypt implemented IE3 efficiency standards for electric motors nationwide in May 2022, following the signing of a Decree by the Minister of Trade and Industry in September 2020. This milestone culminated in the six-year Smart Technology and Energy Efficient Production (STEP) project, spearheaded by the International Finance Corporation (IFC) and supported by the Ministry of Trade and Industry, to propel Egypt's domestic manufacturing sector. The STEP initiative meticulously crafted a comprehensive seven-point roadmap, ensuring the successful implementation of MEPS for motors. Noteworthy stages included establishing leadership, formulating technical standards, consensus-driven timing scenarios, private sector consultations, effective market surveillance planning, and supporting initiatives to upgrade supply chains. The Egypt case study offers valuable lessons for other emerging economies, emphasizing the importance of transparent communication, evidence-based approaches, early stakeholder engagement, inter-organizational collaboration, and the need for adaptability based on context and culture in promoting energy efficiency standards (Tait, et al. n.d.).

Ghana: Electric motors account for 30%-40% of Ghana's total electricity consumption. The market for electrical motors in Ghana has two main underlying characteristics. Firstly, motors are predominantly supplied by global imports into the country, meaning that there is no significant manufacturing industry available. Moreover, many countries have introduced MEPS for IE3 motors, particularly the European Union, which is one of the primary sources of imported motors. Secondly, a large proportion of electrical equipment in Ghana is second-hand imports (around 40 % of the imported motors into Ghana are second-hand) (Damian 2021). According to a study conducted in 2021, owing to a large second-hand import of motors into Ghana, it was realised that any standard below IE3 might cause the exporting countries to try to offload old and less efficient motors to Ghana because they were not banned by any regulation (Damian 2021). Also, as part of its recommendation, in order to avoid Ghana becoming a "dumpsite" for less efficient motors, a regulation prohibiting importation and sale of all motors below IE3 efficiency level and complete ban on import of second-hand motors seemed the most appropriate approach.

In November 2015, Ghana developed its National Energy Efficiency Action Plan (NEEAP), which introduced standards and labels for electric motors. Ghana, till 2021, had no motor MEPS in place and only included test and safety standards and a regulation concerning the waste of motors. Accordingly, the Energy Commission (Energy Efficiency Standards and Labelling) (Electric Motors) Regulations 2022 mandated MEPS at IE2, which is commendable for a developing country implementing motor MEPS for the first time. However, a gradual transitioning to higher MEPS of IE3 and above would be significant for a long-term impact.

3.4 Recommendations

A. Policy action:

a. **Ratcheting motor MEPS:** Introduce mandatory efficiency requirements for new motors following an integrated policymaking approach that takes into account the perspectives of all relevant ministries and departments integrated laterally and vertically and considers the value proposition for all actors across the supply chain. IE3 would be the global benchmark now, with Europe already going to IE4 between 75 and 200 kW but accepting IE2 for motors below 0.75 kW. Focusing on general-purpose three-phase induction motors of 0.75 kW to 375 kW and the systems driven by these motors would be helpful. Gradually, policies can be expanded to cover additional motor sizes and types. Higher MEPS regulations should be supported by a robust monitoring, verification, and legal enforcement framework.

b. **System efficiency v. motor efficiency:** Electric motor systems include a number of energy using products, such as motors, drives, pumps or fans, compressors, blowers, etc. Focus on system efficiency rather than just motor efficiency, which would include the correct sizing of a good combination of motor and application (pump, fan, compressor, etc.). Voluntary policies addressing motor systems as a whole, which could have a higher potential for energy savings, should be implemented in conjunction with the MEPS policies and regulations.

c. **Variable Speed Drives (VSDs):** Use of VSDs should be encouraged through policy action in cases where considerable load variations are required without increasing the friction in the system. Further energy savings can be achieved by using a VSDs in place of mechanical gearboxes between the motor shaft and the driven equipment where a constant torque across a speed range is required.

d. **Motor repair policies:** Rewinding of motors below 50 kW should be discouraged. Throughout their lifetime, motors are repaired up to three times, which can lower their energy performance. Repair quality labels, standards, and certification/accreditation programmes can be implemented.

B. Demand creation:

a. **Life cycle costs v. first costs:** Public and private sector procurement officers should be sensitised about the long-term benefits of high-efficiency motors, and how life cycle costs (as opposed to first costs) should be incorporated into their purchase decision-making matrix.

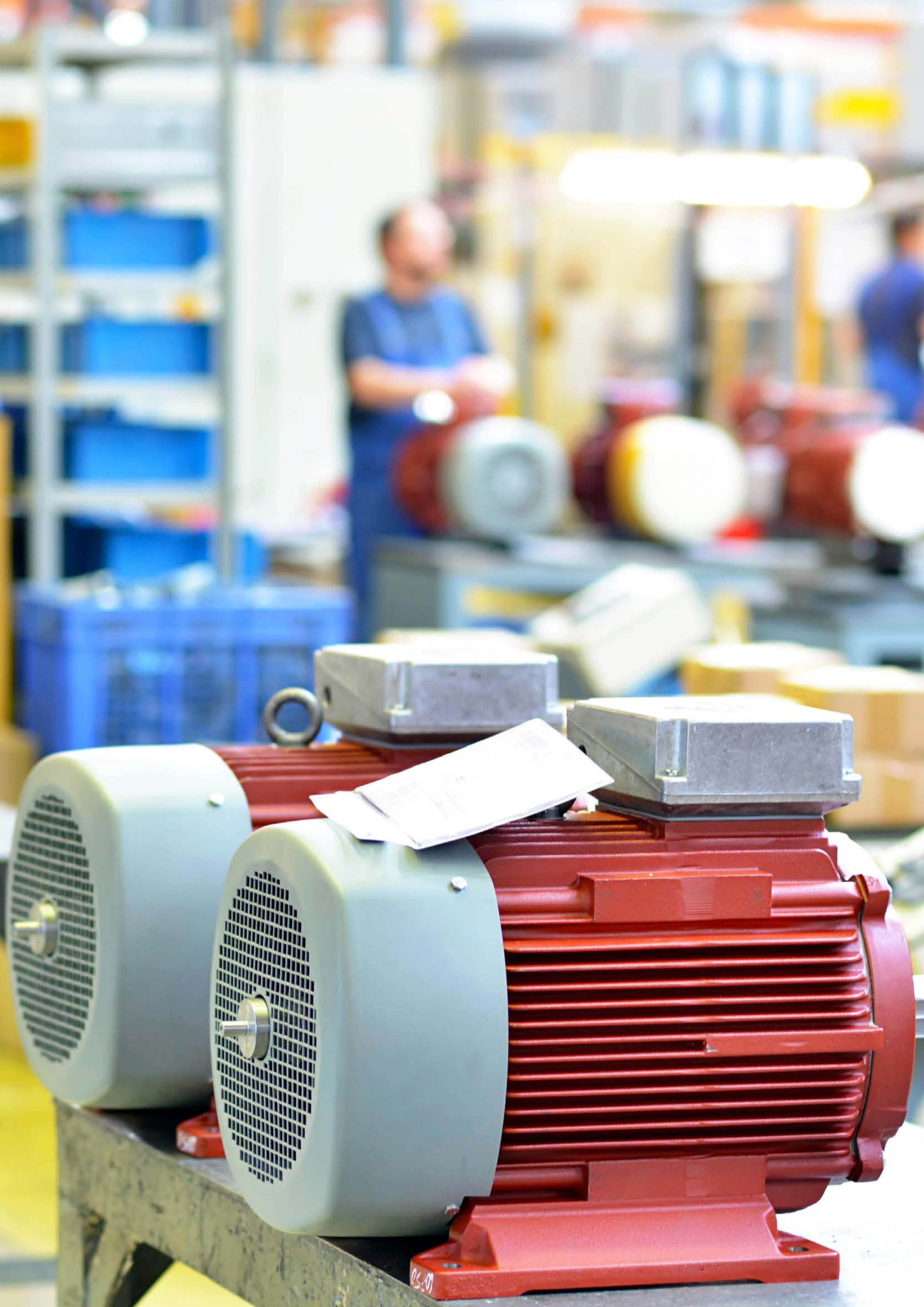
b. **Energy Audit:** Encouraging government-led energy audit programmes for motor systems can identify energy leaks and raise replacement-driven demand for higher efficiency motors.

C. Enabling support for small motor manufacturers:

a. **Raw material sourcing:** Small domestic manufacturers may not be able to source high grades of copper, steel, and other raw materials due to the constraints on domestic manufacturing, cash crunch pockets, low supply, and high import restrictions. Impetus needs to be given by policymakers to the small manufacturers in the form of financing and targeted policy formulation to ease their raw material procurement capabilities.

b. **Making technology accessible:** Inadequate access to technology for designing and manufacturing high-efficiency motors hampers the adoption of energy-efficient motors and motor systems. This entails the lack of adequate testing capacities, equipment, technical facilities, etc., to verify the energy performance. These bottlenecks can be eliminated by providing open-source designs and guidelines, particularly to SME motor manufacturers. An adequate testing infrastructure should be established to help the small motor manufacturers.

c. **Joint ventures with large manufacturers:** SME manufacturers can consider having joint ventures with leading motor, VSD, and pump manufacturers that already produce high volumes of premium products domestically.

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4

The Role of ESCOs in Advancing Global Energy Efficiency

Energy efficiency investments play a pivotal role in expediting global energy efficiency improvements. G20 countries have been actively working towards increasing energy efficiency investments to expedite global energy efficiency improvements (G20 EETG 2017). IEA's Net zero by 2050 scenario requires around 4% global reduction in primary energy intensity of GDP between 2021 and 2030 (IEA 2022). Between 2020 and 2023, the global direct and indirect energy efficiency investments together surged to 1 trillion USD. The global governments directed 270 billion USD in direct public spending towards energy efficiency-related investments, mobilising an additional 740 billion USD of indirect spending in the sector (IEA 2022). This necessitates global energy efficiency investments to rise three times from an average of 270 billion USD to 840 billion USD annually between 2026-30 (IEA 2022).

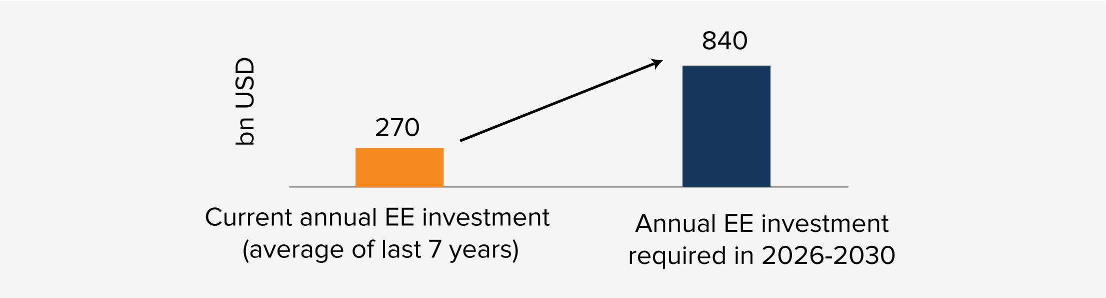

Figure 4.1: Growth in EE investments needed to support a 4% global reduction in primary energy intensity of GDP between 2021 and 2030
Data source: IEA (2022)

Energy efficiency projects, with their main financial benefits accrued from operational energy cost savings, have traditionally received less attention compared to projects that expand operations and broaden markets. The dispersed project opportunities in smaller facilities or small and medium enterprises (SMEs), and resultant higher transaction costs have made these investments less attractive and harder to implement. However, in order to meet the new target of doubling energy efficiency progress by 2030 will entail reimagining energy efficiency and redefining the role of ESCOs in the coming era to include technological modernization, product diversification, and industrial restructuring besides just operational energy savings. Therefore, the artificial divide between the two natures of investments (i.e. Bottomline investments that reduce operational energy costs and top line investments that modernize processes and technologies and thereby expand operations and markets) is dropped and their combined impact in saving energy and reducing energy intensity is considered from a financing point of view. Such an approach would broaden and deepen the market for ESCOs.

4.1 An overview of the global ESCO market

Energy Service Companies (ESCOs) mobilise financing of energy efficiency improvements for improved energy intensity, climate change mitigation, increased energy security, and more/better energy access. The energy performance contracts (EPCs) utilised by ESCOs are an important contributor to the investments in "core"[6] energy efficiency globally. Although EPCs achieved a cumulative value of 24 billion USD in 2015 (G20 EETG 2017) , they formed only 10% of the larger "integrated" energy efficiency investment market.

The global ESCO market itself is currently about 38 billion USD (IEA 2022). The market is led by larger economies such as China, the US and the EU (IEA 2021). China has continued to be a main player with its share in global sales of ESCO services increasing from 52 % to 59% between 2015-2020 (Filiutsich 2023). The "Strategic Plan for Advancing Energy Efficiency Across Demand Sectors by 2030" report, prepared by India's Bureau of Energy Efficiency (BEE), recommends that G20 countries ramp up their investments in ESCOs to 100 billion USD by 2030 (BEE 2023).

The major ESCO markets of Europe, the US and other emerging economies have either stagnated or have been witnessing a decline since 2020 (Filiutsich 2023). However, Europe's energy crisis owing to the war in Ukraine has refuelled the conversation on energy efficiency. The pandemic has been leveraged into an opportunity to improve business models through digital tools such as smart sensors and big data in countries such as China and increase awareness towards co-benefits such as improved indoor air quality, safety, and increased productivity from enhanced energy efficiency in low energy cost countries such as Saudi Arabia (Filiutsich 2023). This diversity in market size and growth is also translated into variations in the business models, sources of finance, and sectors of implementation from economy to economy.

Contract type: ESCOs employ various types of contracts in their operations (Figure 4.2). Two widely used EPC models are as follows. These models are often adapted to local circumstances.

- **Guaranteed savings contracts:** The guaranteed savings model is more prevalent in advanced G20 economies. Under this contract, ESCOs assume responsibility for performance and design risk[7] but are unlikely to take on credit risk (Team E3P n.d.). Since customers often assume the investment repayment risk, a well-established banking system with an understanding of energy efficiency projects, a strong grasp of project financing, and sufficient technical expertise are some prerequisites for the success of this model (Team E3P n.d.). In a nascent energy efficiency market, this model might lower the incentive for ESCO compared to where ESCO can guarantee lower cost savings and obtain the bonus.

6 Investments in core energy efficiency refers to placing primary focus on optimising and enhancing energy performance through dedicated investments, technologies, and policies that specifically target energy efficiency measures.

7 Design risk appears due to wrong estimation of energy savings during the design phase of the project by the ESCO.

- **Shared savings contracts:** In many G20 Emerging Markets and Developing Economies (EMDEs), particularly those with emerging ESCO markets, a shared savings model is commonly adopted as an initial approach. This model avoids customers taking financial risks and prioritizes projects with shorter payback periods (Team E3P n.d.). Therefore, this model avoids projects with deeper energy savings as the ESCOs focus on lower payback energy conservation measures (ECMs). Third party leasing is an attractive option for smaller ESCO projects involving discrete capital equipment, e.g., efficient heat recovery boilers, chillers, motors, etc., under shared savings contracts. Shared savings contracts are rarely used in mature ESCO markets. As ESCO markets mature, there's a transition away from the shared savings model toward alternatives like the guaranteed savings model, reflecting a shift in ESCO strategies towards value-based offerings and transferring investment risks to consumers.

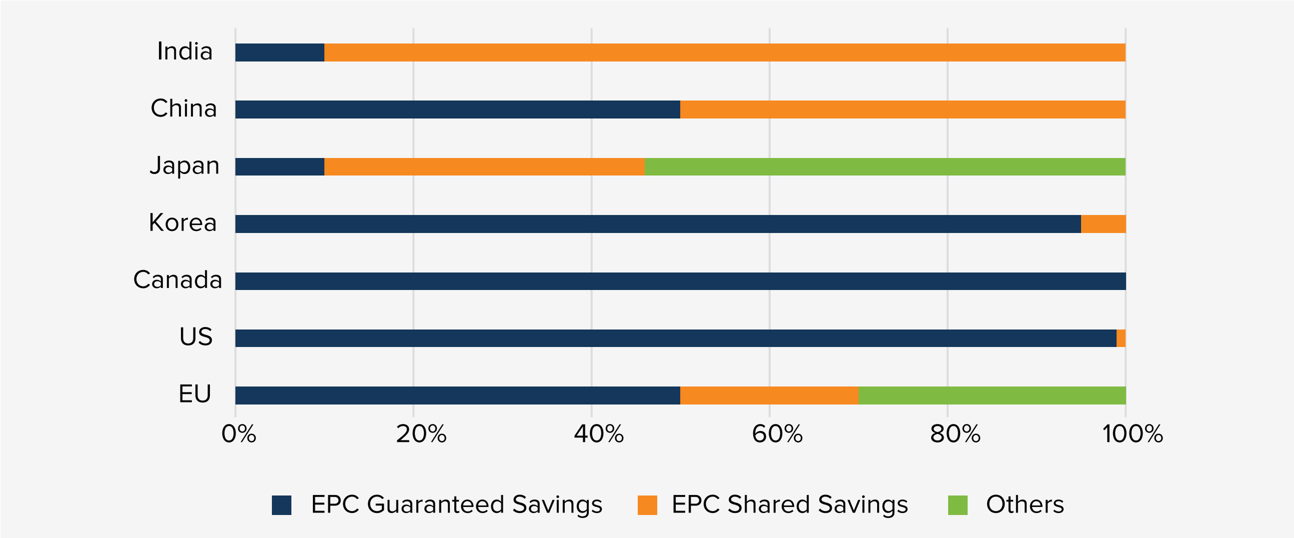

Figure 4.2: ESCO revenues by contract type in 2018[8]
Data source: IEA (2018)

8 Ablaza, Liu, and Llado (2020) considers guaranteed savings as the dominant ESCO model in India

Box 4.1: Energy as a Service (EaaS) business model

Evolving energy efficiency business models

The energy efficiency landscape is witnessing a dynamic evolution, marked by the emergence of diverse business models tailored to address specific barriers. Energy as a service (EaaS) is one of the prominent emerging variations of the service contract approach (Better Buildings Financial Allies n.d.). Unlike ESPCs, EaaS involves a third-party contractor covering the upfront project cost and owning the equipment responsible for generating energy savings. The service provider continues to own and operate the equipment during the contract term. The customer, in turn, pays the service provider for the realized savings (pay-for-performance) determined based on the annual M&V report. At the conclusion of the contract, the customer has the option to purchase the equipment at market value, extend the contract, or return the equipment. The EaaS model, therefore, usually shifts both financing and performance risks associated with an energy asset from the customer to the service provider.

Typically, the services offered under EaaS are targets specific systems rather than the whole building. A notable example is the Lighting as a Service (LaaS) model, which has experienced global growth (ACEEE n.d.). The Energy Efficiency Services Limited's (EESL) LED programme utilized a simplified version of EaaS with a fixed payment structure based on "deemed savings" instead of variable payment (Makumbe, et al. n.d.). The downside to deemed savings is that it must be accompanied by a spot survey arrangement in ensure that the energy efficiency equipment/service is being always deployed and is operational and at the load factor specified at the time of the EaaS contract signing. While accurate metering is not required, it should not result in a situation where savings computed is greater than the savings actually achieved.

Cooling as a Service (CaaS) in which the service provider/ESCO designs, installs and operates more efficient cooling service exhibits great potential given the escalating global cooling. Looking ahead, as-a-service models should aim to encompass a broader spectrum of energy services. Several other models such as Efficiency Services Agreement (ESA), Managed energy service agreement (MESA) and Metered Energy Efficiency Transaction Structures (MEETS) are emerging approaches, although they have yet to achieve scale.

End-use sector: When it comes to the end-use sectors utilising ESCO services, different countries again behave differently (Figure 4.3). ESCO markets in advanced G20 economies and more mature markets are largely concentrated in the public buildings sector. However, in emerging G20 economies such as India and Mexico, the industrial sector is observed to have more ESCO activities, followed by commercial buildings. The less affluent middle class of emerging economies do not see similar ownership of energy-intensive appliances to the same extent as their counterparts in advanced economies.

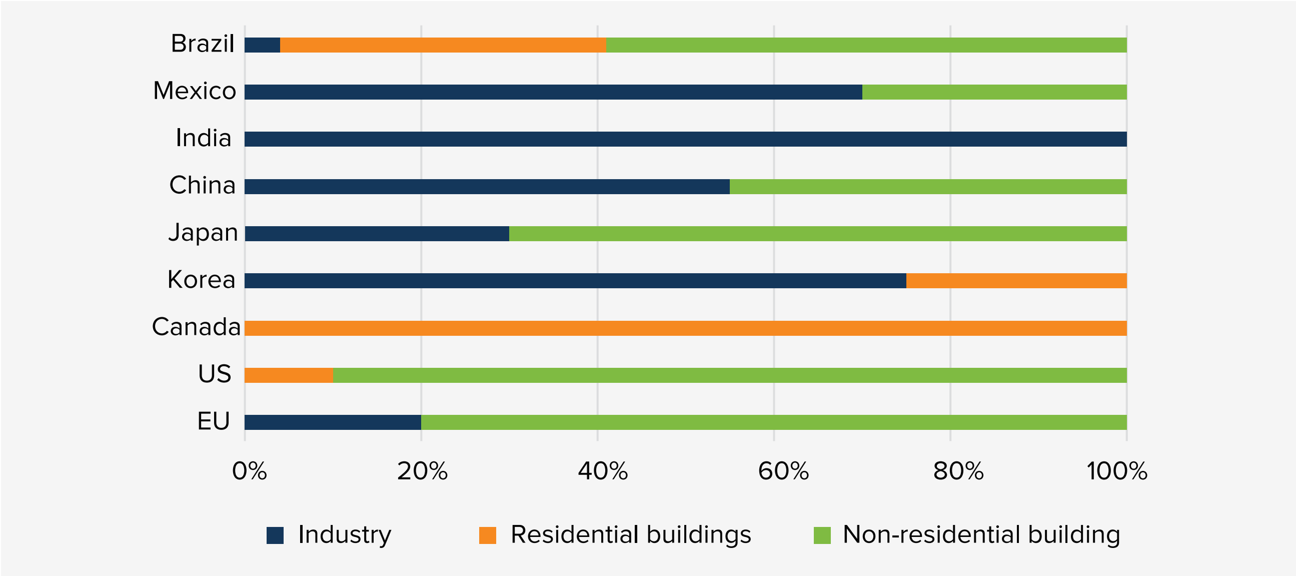

Figure 4.3: ESCO revenues by end-user sector in 2018[9]
Data source: IEA (2018)

Public v. private market: ESCOs are more prevalent in the public sector of more advanced G20 economies such as the US and EU while the ESCOs dominate the private sector market, especially in emerging G20 economies such as India, Brazil and Mexico (Figure 4.4). It should also be noted that the private sector is a major player in the ESCO market of East Asian economies. This trend may be influenced by many factors including the relatively shorter average payback period in the more energy-intensive economies.

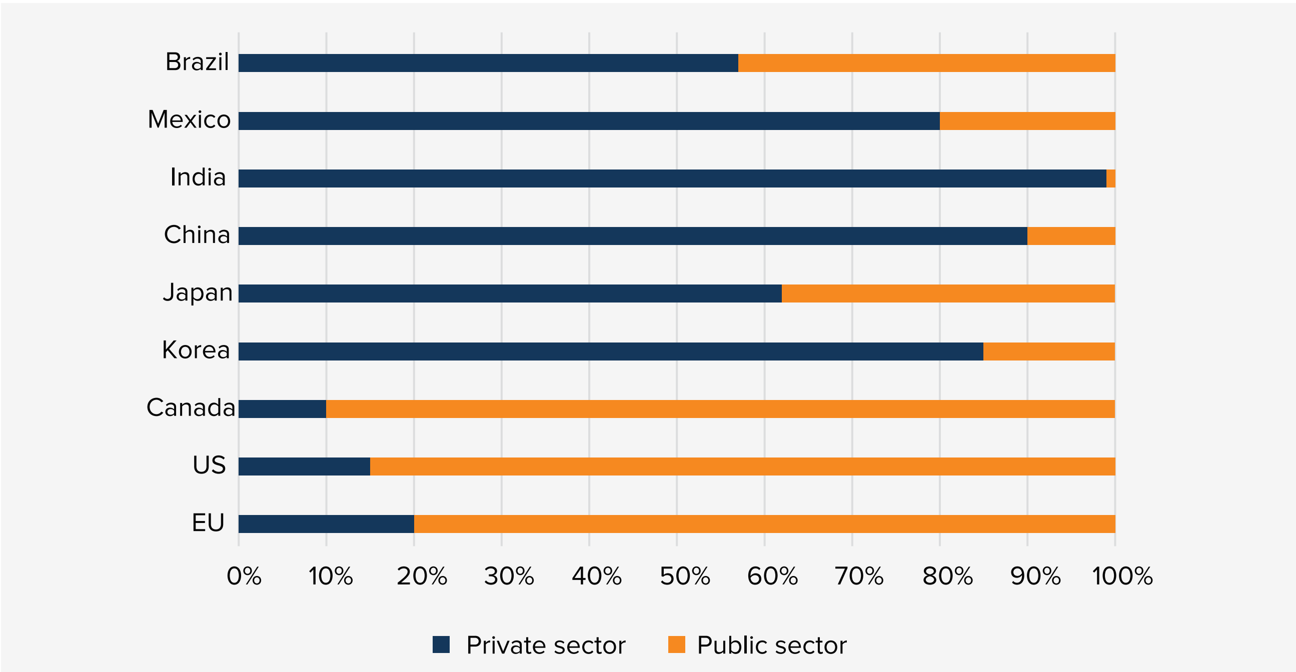

Figure 4.4: ESCO revenues by public versus private market in 2018[10]
Data source: IEA (2018)

9 India's reported data may not fully reflect the actual conditions on the ground

10 India's reported data may not fully reflect the actual conditions on the ground.

Box 4.2: Super ESCOs as a market facilitator

Super ESCOs are designed for markets where the traditional ESCO market has not taken off (World Bank 2018). Often owned or driven by the government, they can deal with both public and private clients. An ideal Super ESCO drives energy efficiency improvements required in the public sector while facilitating the growth of the private ESCO market. They come in many forms and can aggregate projects, develop standardization contracts and processes, arrange finance at scale, drive market transformation and promote capacity development in the sector. If utilised to their full potential, they can improve trust, overcome the barrier of high transaction costs and transform the ESCO ecosystem.

Globally, several countries have created Super ESCOs either to promote energy efficiency in public sector, promote private ESCOs or both. The U.S. Federal Energy Management Program is often mentioned as the predecessor of Super ESCOs. Saudi Arabia's Tarshid, India's EESL and China's Fakai are some notable Super ESCOs from G20 countries. The Africa Super ESCO programme funded by the African Development Bank has been launched with an overarching objective of catalyzing private sector investments in EE among African countries. Egypt, Kenya and Senegal have embarked on setting up Super ESCOs. Three of seven UAE Emirates have operative Super ESCOs. Private Super ESCOs SOFIAC in Canada ($200 million, to increase to $500) and France (250 million Euros) and Climargy in the Philippines recently became operational, which emphasizes that Super ESCOs can now be established as a private entity.

Though ESCO can be financed through public or private sources, the modes of financing vary. The diverse forms of financing can cater to specific sectors or in general to all sectors appropriately. Wu, Singh, and Tucker (2018) conceptualised a ladder of different modes of finances advancing from public financing to commercial financing. The range of finances include grants, budget financing, On-bill financing, revolving funds, credit lines with development and commercial banks, partial risk guarantees, bonds, vendor or leasing finance and cash-flow financing. There are a range of potential sources nascent ESCO markets can target such as green financing groups, Private and public investors, Trade allies (ie. equipment manufacturers), multilateral development banks and other banks. However, the data on their share and involvement in the ESCO market is limited.

While some of the above observations on the nature of ESCO markets can be generalised, there is no one-size-fits-all rule to explain the diversity in the ESCO market. The ESCO pathways in each country depend on their potential for efficiency improvements, availability of finance, and market maturity. As a result, ESCO experiences and learnings differ across countries. However, these varied experiences can be harnessed through knowledge sharing among G20 countries to enhance the energy efficiency of these major global economies.

4.1.1 An overview of the Indian ESCO market

India, a major global energy consumer with a 3.7 trillion USD economy (or 15 trillion USD in PPP[11] terms) as of 2020, holds significant untapped energy efficiency potential. India is the world's fifth-largest economy with the highest GDP growth rate of over 7% and is slated to move to third place by 2027. The ESCO market in India is on the rise, currently valued at 0.9 billion USD[12] (BEE n.d.), due to several favourable policy shifts. Beginning in 2008, the Bureau of Energy Efficiency in India initiated the empanelment process, involving grading[13] by rating agencies accredited by the Securities and Exchange Board of India (SEBI). The number of empanelled ESCOs has grown from 30 in 2008 to 135 by the end of 2023.

11 Purchasing Power Parity

12 Date unclear

13 The ESCO grades represent the evaluation by credit agencies of the capability of the graded ESCOs to execute energy efficiency projects in India.

The following are the key drivers for India's ESCO market:

- A very large market of industrial companies exists, which can significantly improve their energy utilization through the adoption of energy-efficient technologies and practices.
- There is a ready supply of highly educated technical and managerial expertise needed by ESCOs to implement energy savings technologies and processes on behalf of customers.
- The Government of India has committed to reducing the emission intensity of the country's GDP by 45% by 2030, from 2005 levels, as a key measure to advance decarbonization and set the trajectory for meeting its net zero goal by 2070.
- Presence of high energy prices in the industrial sector (among the highest in the G20 countries).
- The economy is stable and embarked on a programme of sweeping reform (e.g., Aatmanirbhar Bharat) aimed at making India more open and competitive on the global stage.
- A democratic political system exists, which is receptive and supportive of improvements in energy efficiency.
- There is a strong belief by Indian companies who are part of the growing ESCO industry that the market is promising; these companies are prepared to invest considerable resources on a sustained basis.

EESL has significantly contributed to India's energy efficiency market by fostering an increase in manufacturing capacity, improving the financial viability of energy-efficient measures, and ultimately facilitating energy demand market transformation. Currently, EESL is spearheading a fan market transformation with plans to deploy 10 million energy-efficient fans across India. In continuation of this, EESL is inviting the first bid of 20 lakh fans, under a programme titled Energy Efficient Fans Programme (EEFP) (PIB Delhi 2023). However, per certain players in the Indian ESCO market, there is a strong desire for EESL to strengthen the technical and financial capacities of private ESCOs, and directly impact the growth and viability of the local ESCO market.

Another notable initiative that is driving ESCO market growth is the Partial Risk Sharing Facility introduced in 2015 through collaboration among key stakeholders such as the World Bank, BEE, and Small Industries Development Bank of India (SIDBI). The facility seeks to mobilise commercial finance and promote ESCO-based projects. Measures under PRSF include the provision of Sub-Guarantees, the development of energy efficiency markets, and the execution of Monitoring and Verification (M&V) activities. Notably, the credit guarantee coverage stands at 75%[14], a strategic measure intended to alleviate the perceived risks associated with providing credit to ESCOs or energy efficiency projects. Under the facility, SIDBI has supported 77 energy efficiency projects with a total project cost of INR 81032 lakh (125 million USD) and issued risk guarantee coverage worth INR 35363 lakh (54 million USD) risk guarantee coverage. Importantly, more than 50% of these projects have directly benefited MSMEs by supporting the implementation of energy efficiency measures in their units. The projects demonstrate a clear preference for specific models within each sector: MSMEs prefer the guaranteed savings model, streetlights and buildings favour the shared savings model, while large industrial projects opt for the deemed savings model. The success of this initiative makes a strong case for scaling and replication, especially by establishing revolving funds at the state level using State Energy Conservation Fund (SECF).

Despite these developments, the ESCO market has not realised its full potential in India, in part, due to the following barriers:

- ESCOs, notwithstanding their growth over the past decade and a half, are still a new concept in India; shared savings contracts are also a new concept and need to be adapted to conform to Indian tax, legal, and business practices.
- High cost of financing

14 75% of the default risk faced by Participating Financial Institutions (PFI) are covered by the scheme

- High transaction cost for smaller ESCO projects
- Energy price subsidies, specifically in the low-income domestic and agricultural sectors, make the application of ESCOs in these segments impossible.
- There is a lack of utility-driven ESCO models barring a few exceptions among distribution utilities in metros like Delhi and Mumbai.
- The absence of a credible and simplified Measurement & Verification (M&V) mechanism
- There is a lack of trust and cynicism regarding data sharing owing to low awareness of the energy efficiency projects or contract enforcement processes.

4.2 Current and future ESCO markets in the G20

In a business-as-usual (BAU) scenario, the ESCO market within G20 countries would grow to about 50 billion USD using the historical CAGR growth. BEE's Strategic Plan calls for the G20 to collectively increase their cumulative annual ESCO market size to 100 billion USD (BEE 2023) from the current market of 34 billion USD under the "Tripling scenario" (Figure 4.5). It is crucial to explore the unique growth paths of different member countries. This section is dedicated to exploring the potential growth paths of three major global ESCO markets (China, US, EU), India, and the remaining G20 countries ("Rest G20"). Different G20 members can aspire to collectively contribute to this "tripling" endeavour based on their growing capabilities and market drivers. Figure 4.6 proposes target ESCO market sizes in 2030.

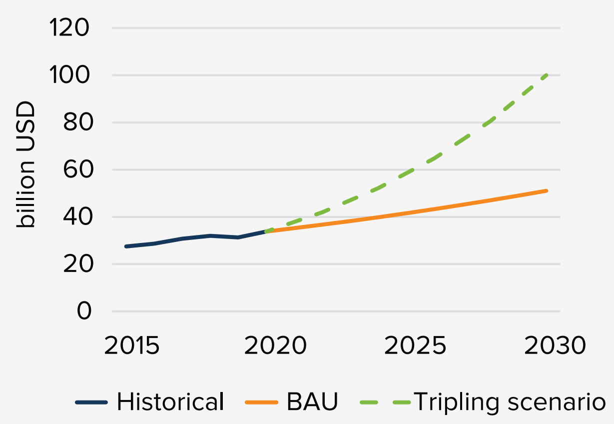

Figure 4.5: Potential growth of G20 ESCO market to 100 billion USD

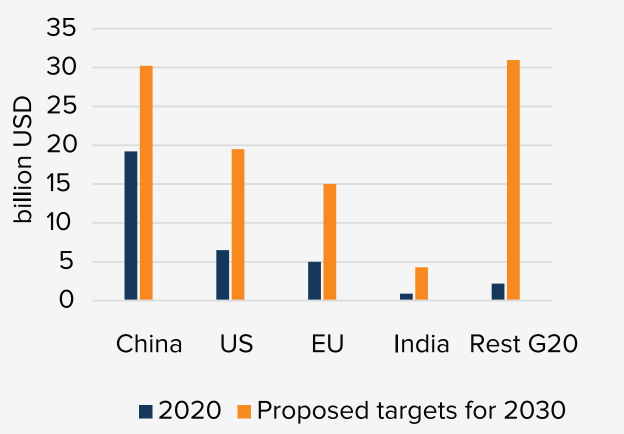

Figure 4.6: Current and future ESCO markets in the G20

Source: AEEE's analysis[15]

4.3 Success stories from the G20

Considering the varied ESCO experiences observed across G20 countries, it would be prudent not to rigidly adhere to a single approach. Instead, a more effective strategy would involve adopting best practices drawn from successful case studies and adapting them to local contexts. This section discusses some of the barriers and enablers (Figure 4.6) to ESCO markets and successful case studies from a few G20 countries (Figure 4.7, Table 4.1).

15 It is assumed that China's ESCO market will continue to grow per historical trends. While The US and the EU would require tripling their ESCO market size by 2030. India's ambitious 2030 target market is estimated based on its 2030 projected GDP, energy efficiency progress per the "doubling" scenario, and assuming that ESCOs will comprise 10% of India's 2030 energy efficiency market.

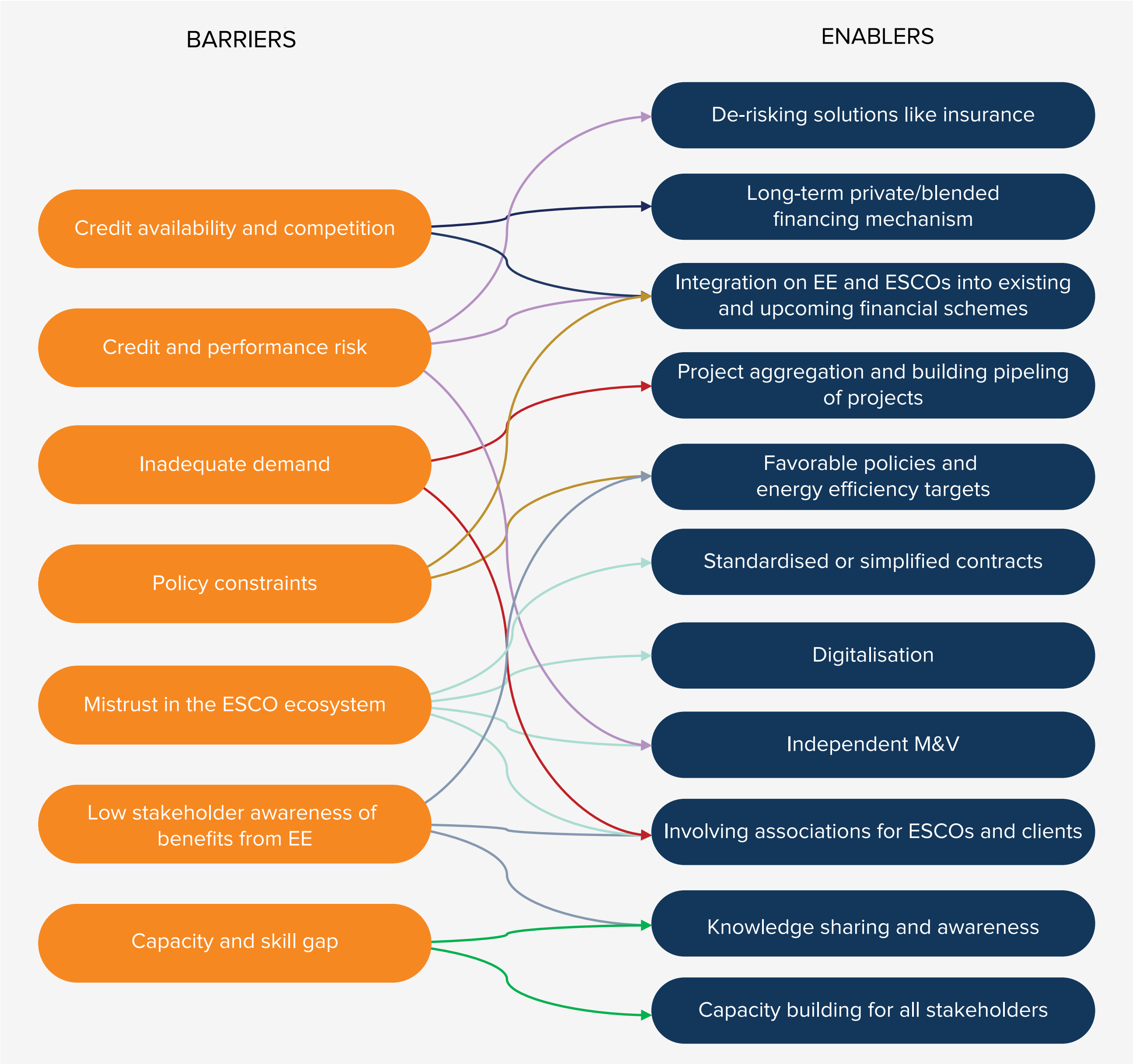

Figure 4.7: Barriers and enablers to ESCO market growth
Source: AEEE analysis compiled from various sources including AEEE (2017), Hofer, Limaye and Singh (2016), The Global ESCO Network (2022), Filiutsich (2023)

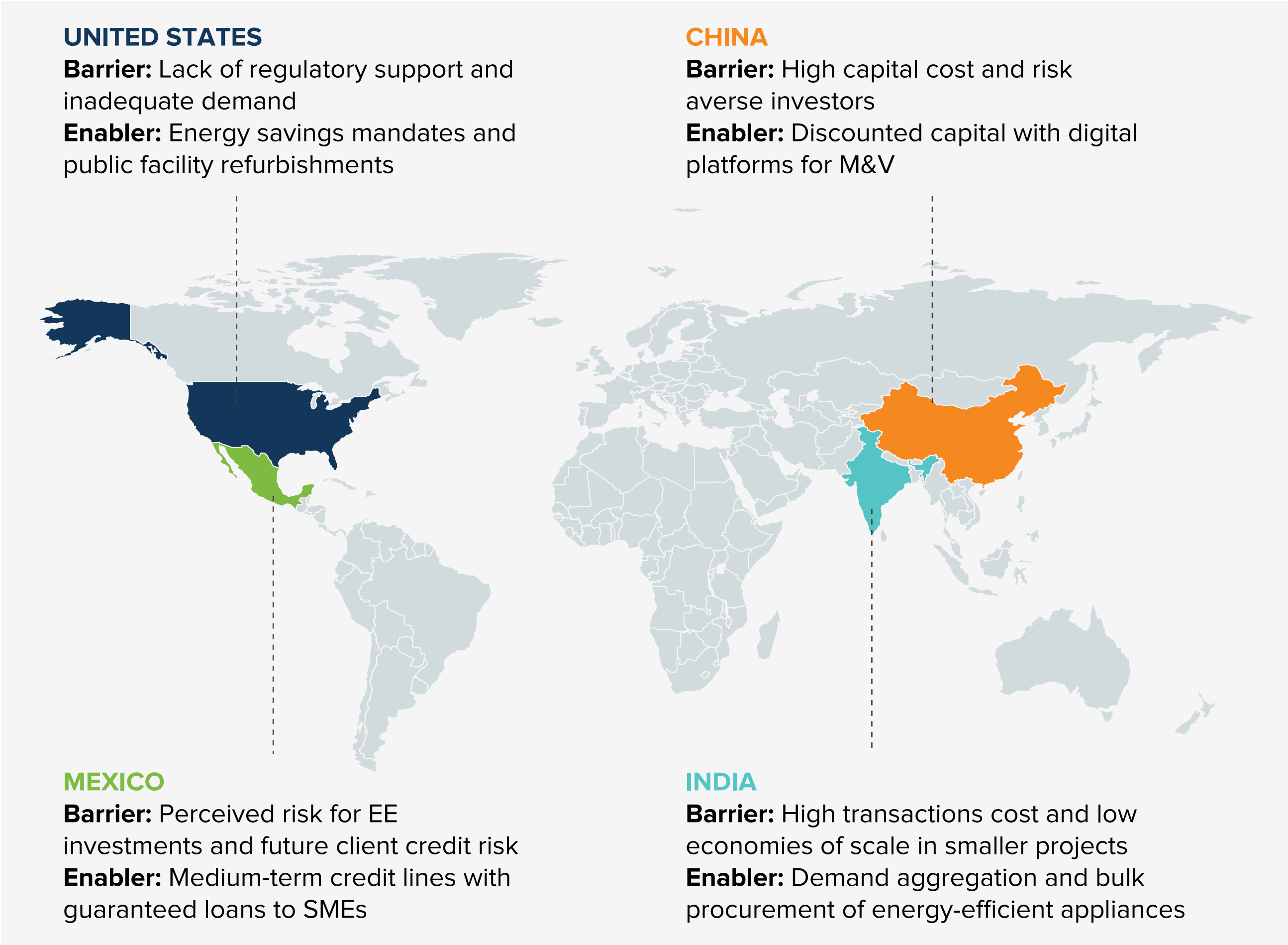

Figure 4.8: ESCO success stories from select G20 countries
Source: AEEE analysis compiled from various sources including GFL (n.d.), Jenny, et al. (2020), Sundararajan and Sarkar (2020), Hofer, Limaye and Singh (2016), ACEEE (2020), Green Finance LAC (n.d.)

Table 4.1: ESCO success stories from select G20 countries

Country	Programme	Impact	Barriers	Enablers	Success factors	Limitations
Mexico, Columbia, and other Latin American countries	Insurance-based integrated financing mechanism to alleviate the twin problems of risk and unavailability of capital: Energy Savings Insurance	As of February 2021, Agriculture-Related Trust Funds (FIRA) has financed 12 projects in the agro-industrial sector through the technology guarantee system, representing an investment of approximately USD 3 million (GFL n.d.).	Credit and performance risk: Credit risk of long-term lending to SMEs which lack collateral and sufficient credit rating	De-risking solutions like Insurance: FIRA guaranteed loans, reducing credit risks, easing collateral requirements, and providing a hedging instrument post-validation.	1. The financing strategy combining medium and long-term loans with risk mitigation tools has potential. 2. De-risking mechanisms and tailored messages boosted confidence. 3. Coordination by FIRA identified and alleviated gaps	Such a programme suits early-stage markets with limited trust and scalability
			Credit availability and competition: Energy efficiency was viewed as too risky and therefore received low priority for investments	Long-term private financing mechanism supported by the government: The Inter-American Development Bank (IDB) provided 8-year credit lines via FIRA to local banks, with the requirement that they match the funding with technology payback periods and support long-term loans for SMEs. This approach involved thorough project assessment, monitoring, and verification of the feasibility of investment proposals.		
			Low stakeholder awareness of benefits from EE: Limited awareness of the energy efficiency opportunity among end-users leading to low readiness	Knowledge sharing and awareness: Efforts were made to create awareness in the agroindustry and among local financial institutions. Additionally, there was dissemination of success cases in events and electronic platforms.		

Country	Programme	Impact	Barriers	Enablers	Success factors	Limitations
China	Revolving fund for long-term ESCO financing: Shandong Green Development Fund (SGDF)	The total fund for the project is 1.5 billion USD with 400 million USD of seed capital from International Financial Institutions (IFIs) and a 1:5 leverage ratio[16]. The project anticipates a reduction of 3.75 million tons per year in CO2 equivalent emissions by 2030 and aims to directly build resilience for 7.5 million people in Shandong Province by 2040 (Jenny, et al. 2020).	Credit and performance risk: High upfront capital costs and associated transaction cost dissuades entities from carrying out ESCO projects	Integration of EE and ESCOs into existing and upcoming financial schemes: The fund offers loans at discounted interest rates compared to what commercial banks typically provide for energy efficiency projects. It can help make the ESCO projects more financially viable, especially for those who are risk-averse.	A catalytic fund from ADB that fed into funds blending IFIs and public finance in a revolving manner mobilises more than its equal amount of private-institutional-commercial (PIC) investments.	Competition with renewable energy investments can be a major drawback in the event of a climate change fund over a dedicated energy efficiency fund. The SGDF's portfolio distribution provides only a 5% allocation for energy efficiency.
			Credit availability and competition: Traditional financing sources are disinclined to support energy efficiency investments that require longer repaying terms, flexible structuring, and competitive pricing.	Long-term private financing mechanism supported by the government: The fund improves access to the capital market and mobilises private, institutional, and commercial (PIC) finance using the seed fund from ADB and other IFIs.	Digitisation of project development and monitoring and evaluation ensures a guaranteed return on the investments in ESCO projects. The revolving nature of the fund can ensure longer tenor in sectors where the payback period is less attractive, due to lower energy intensity or energy costs.	
			Inadequate demand: Smaller energy efficiency projects lack economies of scale, and investors are risk-averse.	Building a pipeline of projects, digitalisation, independent M&V: The fund promotes the use of SOURCE, a digital platform for accelerating quality infrastructure project delivery that helps aggregate and prepare a pipeline of bankable projects. Additionally, INDEX, a management system for monitoring, evaluation, reporting, and verification, ensures proper accounting of energy savings, improves transparency and thereby mitigates risk aversion.		

16 Ratio of public finance to private finance

Country	Programme	Impact	Barriers	Enablers	Success factors	Limitations
India	Project aggregation: Energy Efficiency Services Limited's (EESL) LED programme	Under its LED initiative, called UJALA, EESL has successfully deployed over 366 million LED bulbs, avoiding the need for 9,500 megawatts of new generation capacity (Sundararajan and Sarkar 2020)	Inadequate demand: Despite substantial potential, small public/residential energy efficiency projects often take a backseat due to the high transaction costs associated with their fragmented nature.	Project aggregation and building a pipeline of projects: EESL works towards aggregating demand and procuring projects in large volumes. This strategy encourages the scaling up of energy efficiency projects, making them more cost-effective and attractive to investors.	EESL effectively executed aggregation of demand in the residential sector where energy efficiency potential is fragmented and low. Mobilizing a large number of households using incentives and promising energy bill reduction through involving utilities with a wide established network ensured a huge market. The affordability of replaceable LED bulbs triggered a transformation of the market through a lowering of the market price.	Instead of addressing the limited penetration of private ESCOs, EESL decided to implement the programme using non-ESCO bulk distribution models. The electricity subsidies in certain Indian states along with the bureaucratic barriers existing in municipal/public energy efficiency projects impacted the payback and thereby EESL's balance sheets. There was no exit strategy employed.
			Credit availability and competition: Lack of upfront financing options for ESCOs	Long-term private blended financing mechanism supported by the government: Upfront financing is provided through a combination of equity capital, loans from development partners, and commercial lenders. This multi-faceted approach ensures that financing is available for energy efficiency projects from various sources.		
			Mistrust in the ESCO industry: Concerns related to quality assurance, reliability, and limited adoption of energy efficiency options during building refurbishment.	Project aggregation, capacity building: To tackle these issues, EESL emphasizes quality control during procurement to guarantee the reliability and effectiveness of energy-efficient products. It also drove LED market transformation by lowering prices, encouraging domestic manufacturing, and achieving significant energy savings.		
			Mistrust in the ESCO industry: The presence of mistrust towards the ESCO industry and limited market adoption of energy efficiency measures limits ESCO activities	Standardised or simplified contracts: EESL introduced the Deemed Savings Measurement and Verification (M&V) approach and the Pay-as-you-Save (PAYS) model. This has paved the way for private ESCOs to make use of such contractual models. Simultaneously, these measures have increased the credibility of ESCOs and encouraged wider adoption of energy efficiency initiatives (Hofer, Limaye and Singh 2016).		

<table>
<tr><th>Country</th><th>Programme</th><th>Impact</th><th>Barriers</th><th>Enablers</th><th>Success factors</th><th>Limitations</th></tr>
<tr><td rowspan="3">United States - California</td><td rowspan="3">Favourable government policies and ESCOs in public institutions</td><td rowspan="3">ESCOs invested $14 million in energy efficiency loans in California's state facilities in 2019. In 2019, ESCO projects resulted in over 6 million kWh in annual energy savings. Total energy savings seen in 2019 from all prior years' ESCO projects combined equal approximately 57 million kWh (ACEEE, 2020).</td><td>Policy constraints: Limited penetration of ESCOs in industries with low incentives to improve energy efficiency</td><td>Favorable policies and energy efficiency targets: Public Utilities Code Section 388 allows state agencies to enter into energy savings contracts (ACEEE, 2020).</td><td rowspan="3">Federal and state-level support for Energy Savings Performance Contracting (ESPC) pushed public facilities and K-12 school buildings to undertake energy efficiency projects.

Creation of model contracts, M&V guidelines and ESPC project benchmarking at the federal level disseminated information and created trust.

Public facilities with accumulated deferred maintenance repurposed their wasted energy and maintenance bills through ESCO projects.</td><td rowspan="3">A majority of ESCO projects in the US occur in public facilities. Despite the considerable potential within the private commercial and industrial sectors, ESCOs have had limited success in penetrating such markets.</td></tr>
<tr><td>Mistrust in the ESCO industry: Lack of information about the future performance of ESCOs creates an atmosphere of low trust, especially among public institutions with risk aversion.</td><td>Independent M&V, Standardised contracts: The Department of General Services (DGS) has developed a pool of qualified ESCOs, developed model contracts, and cleared necessary obstacles to fast-track ESCO projects at state facilities (ACEEE, 2020).</td></tr>
<tr><td>Credit and performance risk: The high upfront cost of energy efficiency technology often disincentivises ESCOs who work with public institutions.</td><td>Integration of ESCOs into upcoming financial schemes: The state of California offers several financial incentive programmes such as the Bright Schools programme, Proposition 39 K-12 Program, and the Energy Conservation Assistance Act. These programmes are either grants or low-interest loans and compensate for credit risk (ACEEE 2022).</td></tr>
</table>

4.4 Recommendations

A. Create demand for energy efficiency projects

a. **Broaden and deepen the scope and application of ESCOs:** To foster ESCO market development, it is essential to adopt a dual perspective encompassing both operational expenditure (OpEx) and capital expenditure (CapEx) mindsets. The former is the typical approach of viewing energy efficiency investments through an operational angle that involves retrofits to save energy. The latter is to view energy efficiency investments through a multilayered approach that combines technological modernization, product diversification and industrial restructuring. Integrating both perspectives helps recognise that energy efficiency is a fundamental element for comprehensive business capitalisation and growth. The overarching goal should be to create a sustainable environment for ESCO projects rather than a narrow, project-based approach.

b. **Introduce co-benefits as a strategic aim of ESCOs:** The non-energy benefits of energy efficiency projects (increased asset value, increased capacity, health, less O&M, better IAQ in buildings, etc.) must also be highlighted to the clients. These can be much more influential in getting decision-makers to invest in energy efficiency than just energy cost savings or carbon reductions. It is important to explore further whether the co-benefits due to energy efficiency projects have been sufficiently quantified to influence ESCO investments and what the nature and characteristics of the business models that capture the co-benefits of energy efficiency are.

c. **Strengthen the capacity to develop projects:** Addressing the development gap between energy efficiency potential and financeable projects is crucial. This involves not only boosting the demand for such projects but also enhancing the capacity to develop and finance them. To ensure a steady stream of energy efficiency projects that can be scaled up, it is imperative to have a pipeline of initiatives ready at the initiation of larger schemes. This can be effectively achieved through an aggregator, such as a super ESCO or a dedicated financing facility. The resultant cost-savings have the potential to ensure increased participation of SMEs in implementing ESCO projects. Additionally, business and institutional alliances between utilities and ESCOs should be developed to create demand. This involves employing ESCOs as service agents of utilities for the delivery of energy efficiency services to customers and for meeting utility demand-response load objectives.

d. **Enforce stricter energy efficiency thresholds through regulation:** Demand generation can also be effectively done by bringing in energy reduction mandates and further lowering energy consumption thresholds that would require smaller energy end-users to comply with stricter regulations. The government can also require and subsidise more detailed energy audits to foster pipeline generation.

B. Create trust in the system

a. **Measurement and Verification (M&V):** Robust M&V protocols such as the IPMVP anchored and localised for the national market should be prioritized. Stakeholder consultations have indicated that the implementation of dedicated M&V platforms, utilising internationally recognized protocols like the IPMVP, can automate the validation of performance for both new and retrofit projects. This approach has the potential to enhance the speed, consistency, and transparency of ESCO projects, thereby significantly boosting the ESCO market.

b. **Digitalisation:** Integrating Internet of Things (IoT) and cloud platforms into M&V processes can increase transparency and reduce transaction costs.

c. **Standardisation:** Simple and replicable contracts between parties developed through a consultative process, user-friendly interfaces and fast decision-making processes can improve standardisation and promote quick dispute resolutions.

d. **Replicability:** Conducting benchmark analysis on existing projects and portfolios across ESCOs and market segments can help persuade more clients to take the ESCO route. Creating platforms or systems to archive, track, document and share the performance of these projects can be very helpful in creating that trust (e.g., FEMP's eProjectbuilder).

C. Improve the capacity to finance energy efficiency projects and increase the volume of finance available to fund these projects

a. **Utilise diverse finance mechanisms:** Implement blended finance strategies by combining catalytic funds and seed funds from International Financial Institutions (IFIs) or public sources. This approach can effectively attract private finance for energy efficiency improvements and Energy Service Companies (ESCOs). Increase awareness among commercial banks and financial institutions about the returns from ESCO projects, encouraging a shift toward cash-flow financing to support these initiatives. Simultaneously, reduce dependence on commercial banks by creating innovative financial structures and vehicles to attract non-bank equity capital for ESCO projects.

b. **Explore diverse capital sources:** Establish a robust banking and financial system capable of meeting the debt capital requirements and working capital needs of ESCO projects. Explore diverse capital sources such as green financing, private and public investment funds, trade allies (e.g., equipment vendors), credit and guarantee funds, development banks, bilateral donors, Export-Import Bank (EXIM), Overseas Private Investment Corporation (OPIC), sovereign wealth funds, and third-party leasing arrangements to ensure comprehensive financial support for ESCOs.

c. **Introduce de-risking solutions[17]:** Guarantee funds and insurance products should be introduced to provide covers to mitigate two types of risk: Customer credit risk and energy (savings) performance risk. Care should be taken that the costs of premiums do not kill the financial viability of a debt-financed or equity investment.

Table 4.2 presents a prioritisation exercise based on the recommendations listed above that can help develop ESCO markets by end-use sector. It is complemented by high-level operational frameworks in Figure 4.2. This exercise draws from extensive secondary literature, many expert consultations, and in-house experiences.

17 The Energy Efficiency Financing Toolkit goes beyond ESCOs and covers all types of financing instruments; it uses the model of 'derisking tools' and 'transaction enablers'. It was developed for the Arab market but reviews energy efficiency financing instruments globally including the super ESCOs. The Underwriting Toolkit is designed to build capacity in the financial sector to understand value and risks of energy efficiency.

Table 4.2: End-use sector-wise prioritization of recommendations
Source: AEEE analysis based secondary literature, expert consultations, and in-house experiences

End-use sector	Demand creation	Aggregation	Financing	M&V
SMEs	Identify technologies with the most EE potential, cluster-wise; create awareness among SMEs and local FIs with the support of SME associations; incentivise (non-subsidy) SMEs through measures such as tax benefits, non-monetary benefits or product-linked incentives	Establish an SME consortium to aggregate projects, create pipelines, and compile lists of ESCOs with effective information intermediation	Implement credit guarantee funds credit guarantee funds for SMEs to secure collateral-free loans	Empower a facilitator/ consortium to formulate standardised contracts with simplified third-party M&V requirements, recommended ECMs and a dispute resolution forum
Large industries	Project developer (preferably government-backed entity) to (i) identify sector-wise technologies with the most energy efficiency potentials, (i) select target firms at the state level and institute an awareness campaign on gains from EE projects along with the list of empanelled ESCOs specific to industrial sector, and (iii) institute progressively stringent mandates to improve energy efficiency	Cloud-based platform with eligible projects and ESCOs	ESCO procure or leases out the identified equipment, installs it and maintains it for the contract period; commercial financing from the local bank or vendor financing is to be employed	Employ IoT retrofits to minimize cost and maximise accuracy; industrial associations can explore training to develop instrumentation capabilities for accurate annual M&V report
Buildings	Utilities as facilitators, encouraging consumers to participate in energy efficiency campaigns; they also publicise the advantage of ESCO-based retrofitting and a list of locally present ESCOs	Utilities to bring together demand for retrofitting from different clients and create a pipeline of projects	Revolving funds or dedicated credit lines through local banks to utilities; utilities provide clients with financing while they pay back via a surcharge on electricity bills	Project-wise independent M&V making use of smart meters and sub-meters installed by utilities
Municipalities	Government mandates or notifications to promote energy efficiency at state facilities; this can be followed by an energy audit and tendering process making ESCO grade a priority consideration for selection	Department-wise project pipeline creation through online portals facilitated by a super ESCO	Grants, budget financing, repurposing maintenance expenditure	Seasonal M&V tracking through the online portal and adequately improve performance; create process-specific M&V guidelines at the national level if required

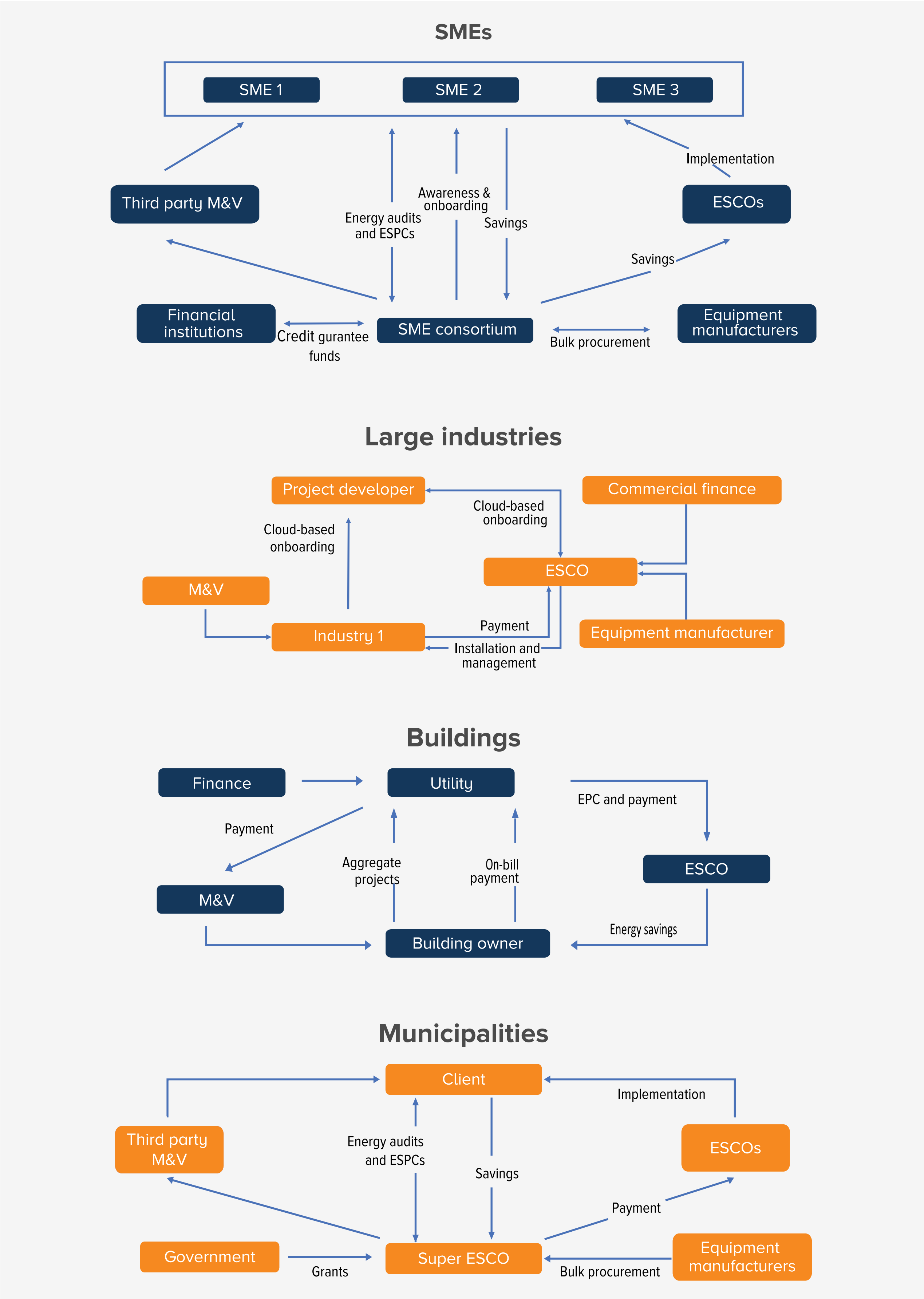

Figure 4.9: High-level operational frameworks to catalyse ESCO markets by end-use sector
Source: AEEE analysis based secondary literature, expert consultations, and in-house experiences

References

ABB. 2016. "EU MEPS: Efficiency requirements for low voltage motors."

ABB. 2021. CN MEPS China national standard GB18613 and CEL007-2021 setting new requirements for low voltage motors. ABB.

Ablaza, Alexander, Yang Liu, and Mikhael Fiorello Llado. 2020. *'Off-Balance Sheet Equity: The Engine for Energy Efficiency Capital Mobilization'.* Working Paper 1183. ADBI Working Paper. Tokyo: Asian Development Bank Institute. https://doi.org/10.1007/978-981-16-3599-1_2.

ACEEE. 2020. "Energy Savings Performance Contracting." American Council for an Energy Efficient Economy. July. https://database.aceee.org/state/energy-savings-performance#:~:text=If%20the%20necessary%20encouragement%2C%20leadership,energy%20service%20company%20(ESCO).

ACEEE. 2022. "State and Local Policy Database - California." American Council for an Energy Efficient Economy. https://database.aceee.org/state/california.

ACEEE. n.d. "Energy as a Service." ACEEE. https://www.aceee.org/sites/default/files/eo-energy-as-service.pdf.

ADB. 2023. "China, People's Republic of : Shandong Green Development Fund Project." Asian Development Bank Website. Accessed September 12, 2023. doi:51194-001.

AEEE, NITI Aayog, and BEE. 2017. "Roadmap to Fast Track Adoption and Implementation of Energy Conservation Building Code (ECBC) at the Urban and Local Level." https://aeee.in/our_publications/kumar-s-singh-m-kachhawa-s-pandey-a-2017/.

AEEE. 2017. "Transforming the Energy Services Sector in India – Towards a Billion Dollar ESCO Market." Delhi: Alliance for an Energy Efficient Economy.

APEC Energy Working Group. 2017. "Opportunities for Collaboration to Improve Building Energy Codes in APEC Economies." *APEC Energy Working Group*, August.

ASHRAE, and United States, eds. 2023. *Building Performance Standards: A Technical Resource Guide*. Building Decarbonization Guide Series. Peachtree Corners, GA: ASHRAE : U.S. Department of Energy.

BCA. 2020. "SLEB Smart Hub to Accelerate Green Technology Adoption I BuildSG Magazine." BCA Corp. September 28, 2020. https://www1.bca.gov.sg/buildsg-emag/articles/sleb-smart-hub-to-accelerate-green-technology-adoption.

BEE. 2010. *Procedures for Accreditation of Energy Auditors and Maintenance of Their List under the Energy Conservation Act, 2001*.

BEE. 2019. Energy Conservation Guidelines for MSME Sector. Bureau of Energy Efficiency.

BEE. 2023. *"Strategic Plan for Advancing Energy Efficiency Across Demand Sectors by 2030."* Delhi: Bureau of Energy Efficiency, Ministry of Power (MoP), Government of India.

BEE. n.d. "ESCOs." Accessed November 17, 2023. https://beeindia.gov.in/en/programmes/escos-0.

Better Buildings Financial Allies. n.d. "Understanding the differences between Efficiency-as-a-Service and ESCOs." Better Buildings Solution Centre, USDoE. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/BBC%20Financial%20Allies%20Resource%20ESPC%20vs.%20EaaS%201.8.2021.pdf.

Bin, Shui, and Steven Nadel. 2012. "How Does China Achieve a 95% Compliance Rate for Building Energy Codes?: A Discussion about China's Inspection System and Compliance Rates." American Council for an Energy- Efficient Economy.

Bordier, Romain, Niousha Rezaï, and Charlotte Gachon. 2018. "EBPD Implementation in France."

BPIE. 2021. "Policy Briefing - Nearly Zero: A Review of EU Member State Implementation of New Build Requirements." https://www.bpie.eu/wp-content/uploads/2021/06/Nearly-zero_EU-Member-State-Review-062021_Final.pdf.pdf.

Building Codes Assistance Project. n.d. "Commercial Code Status."

Carbon Trust. n.d. "An SME guide to financing energy efficiency projects."

CLASP. 2023. "World's Best MEPS: Identifying Top Energy Efficiency Standards for Priority Appliances."

CLASP. 2023. Getting Appliances Back on Track: Assessing Progress Towards Global Energy Efficiency Commitments. CLASP.

COP28 UAE. 2023. "COP28: Global Renewables and Energy Efficiency Pledge." https://www.cop28.com/en/global-renewables-and-energy-efficiency-pledge.

CPI. n.d. "Energy Savings Insurance." Climate Finance Lab. Accessed December 7, 2023. https://www.climatefinancelab.org/ideas/energy-savings-insurance/.

Creamer Media. 2023. Compulsory electric motor efficiency regulation to reduce electricity use. https://www.engineeringnews.co.za/article/compulsory-electric-motor-efficiency-regulation-to-reduce-electricity-use-2023-11-03#.

Damian, Pascal. 2021. "Preparatory Study for the Development of Energy Efficiency Standards for Electric Motors in Ghana."

Danish Energy Agency. 2022. "Roadmap for an Energy Efficient, Low-Carbon Buildings and Construction Sector in Indonesia." Danish Energy Agency.

de Almeida, Anibal T., Fernando J.T.E. Ferreira, and João Fong. 2023. "Perspectives on Electric Motor Market Transformation for a Net Zero Carbon Economy." Energies (Energies).

de Almeida, Anibal T., Joao Fong, Hugh Falkner, and Paolo Bertoldi. 2017. “Policy options to promote energy efficient electric motors and drives in the EU.” Renewable and Sustainable Energy Reviews.

Economidou, M., V. Todeschi, P. Bertoldi, D. D’Agostino, P. Zangheri, and L. Castellazzi. 2020. “Review of 50 Years of EU Energy Efficiency Policies for Buildings.” *Energy and Buildings* 225 (October): 110322. https://doi.org/10.1016/j.enbuild.2020.110322.

EESL. n.d. National UJALA Dashboard. Accessed December 8, 2023. http://ujala.gov.in/.

Elnabawi, Mohamed H. 2021. “Evaluating the Impact of Energy Efficiency Building Codes for Residential Buildings in the GCC.” *Energies* 14 (23): 8088. https://doi.org/10.3390/en14238088.

Energy Efficiency Services Limited (EESL). 2023. “Detailed Invitation for Bid(IFB).” NIT Bid Document No: EESL/06/2023- 24/NMRP/OTE/232409019. New Delhi: Energy Efficiency Services Limited (EESL), 06.

Energy Efficiency Services Limited. n.d. National Motors Replacement Programme. https://motor.eeslindia.org/about_nmrp.

Europa, Bellona. 2023. “European Parliament Passes EPBD Recast with Historic Embodied Carbon Text.” Bellona.Org (blog). March 14, 2023. https://bellona.org/news/cities-and-transport/2023-03-european-parliament-passes-epbd-recast-with-historic-embodied-carbon-text.

Evans, Meredydd, Mark Halverson, Alison Delgado, and Sha Yu. 2014. “Building Energy Code Compliance in Developing Countries: The Potential Role of Outcomes-Based Codes in India.”

Evans, Meredydd, Volha Roshchanka, and Peter Graham. 2017. “An International Survey of Building Energy Codes and Their Implementation.” *Journal of Cleaner Production* 158 (August): 382–89. https://doi.org/10.1016/j.jclepro.2017.01.007.

Fawkes, Steven. n.d. ‘An Overview of the ESCO Industry’. LinkedIn. Accessed 5 February 2024. https://www.linkedin.com/pulse/overview-esco-industry-dr-steven-fawkes-u4cfe/?utm_source=share&utm_medium=member_ios&utm_campaign=share_via.

Fayaz, Rima, and Behrouz M. Kari. 2009. “Comparison of Energy Conservation Building Codes of Iran, Turkey, Germany, China, ISO 9164 and EN 832.” *Applied Energy* 86 (10): 1949–55. https://doi.org/10.1016/j.apenergy.2008.12.024.

Fiener, Charles A. n.d. “THE EVOLUTION TOWARD R-2000: PAST EXPERIENCE AND CURRENT DIRECTIONS OF THE CANADIAN ENERGY CONSERVATION EFFORT.”

Filiutsich, Ivan. 2023. An Overview of the Best Practices of ESCO Market Design and Recommendations for Ukraine. Kyiv: UNDP.

Fortune Business Insights. n.d. “Induction Motor Market Size, Share, & Forecast 2032.”

Frankel, Mark. 2012. “Establishing a Pathway to Outcome-Based Codes Policy.” New Buildings Institute, November.

G20 EETG. 2017. G20 Energy Efficiency Investment Toolkit. G20 Energy Efficiency Finance Task Group (EEFTG).

G20 Energy Transition Working Group. 2023. *“G20 Energy Transitions Ministers’ Meeting Outcome Document and Chair’s Summary.”*. G20 2023.

G20 Research Group. 2014. “2014 Brisbane Summit Communiqué.” November 16, 2014. http://www.g20.utoronto.ca/2014/2014-1116-communique.html.

G20 Research Group. 2016. “2016 G20 Energy Ministerial Meeting Beijing Communiqué.” June 29, 2016. http://www.g20.utoronto.ca/2016/160629-energy.html.

GBPN, Niamh McDonald, and Jens Laustsen. 2013. "A Comparative Analysis of Building Energy Efficiency Policies for New Buildings."

GBPN. 2015. "Compare Dynamic Energy Efficiency Policies for New Buildings." Interactive Tool. 2015. https://library.gbpn.org/library/purpose-policy-tool-new-buildings.

GFL. n.d. "ESI programme in Mexico." Green Finance for Latin America and the Carribean. Accessed December 7, 2023. https://greenfinancelac.org/our-initiatives/financial-mechanisms-for-sustainable-energy/esi-mexico/.

Government of Telangana, NRDC, ASCI, Greater Hyderabad Municipal Coperation, International Institute of Information Technology, and Telangana State Renewable Energy Development Corporation. 2017. *Telangana Energy Conservation Building Code (TSECBC) Guidelines*.

Government of Uttar Pradesh. n.d. "Nivesh Mitra." Accessed January 31, 2024. https://niveshmitra.up.nic.in/.

Greater Sudbury. 2023. "Online Portal Allows for Faster and More Convenient Building Permit Process." June 27, 2023. https://www.greatersudbury.ca/city-hall/news-and-public-notices/2023/online-portal-allows-for-faster-and-more-convenient-building-permit-process/.

Green Finance LAC. n.d. ESI Program in Mexico. Washington.

Hardy, A., and D. Glew. 2019. "An Analysis of Errors in the Energy Performance Certificate Database." *Energy Policy* 129 (June): 1168–78. https://doi.org/10.1016/j.enpol.2019.03.022.

Harper, Betsy, Leslie Badger, Jennifer Chiodo, Glenn Reed, Robert Wirtshafter, and Wirtshafter Associates. 2012. "Improved Code Enforcement: A Powerful Policy Tool- Lessons Learned from New York State."

Hinge, Adam, and Fiona Brocklehurst. 2021. "Building Energy Codes and Other Mandatory Policies Applied to Existing Buildings."

Hofer, Kathrin , Dilip Limaye, and Jas Singh. 2016. Fostering the Development of ESCO Markets for Energy Efficiency. Brief, World Bank Group.

IEA. 2016. "World Energy Outlook."

IEA. 2018. "ESCO revenues by contract type." December 3. https://www.iea.org/data-and-statistics/charts/esco-revenues-by-contract-type.

IEA. 2018. ESCO revenues, public vs. private sector. December 3. https://www.iea.org/data-and-statistics/charts/esco-revenues-public-vs-private-sector.

IEA. 2018." ESCO revenues by end-use sector. December 3. https://www.iea.org/data-and-statistics/charts/esco-revenues-by-end-use-sector.

IEA. 2021. "Best Practices for Building Energy Codes Compliance."

IEA. 2021. Financing Clean Energy Transitions in Emerging and Developing Economies 2021. Paris: IEA.

IEA. 2022. Energy Efficiency 2022. Paris: IEA.

IEA. 2022. World Energy Investment 2022. Paris: IEA.

IEA. 2023. "Energy Efficiency 2023." IEA, Paris. https://www.iea.org/reports/energy-efficiency-2023, License: CC BY 4.0.

IEA. 2023. "Energy End-Uses and Efficiency Indicators Data Explorer." Energy Statistics Data.

International Copper Association India. 2019. Market Study for 3 Phase LT Induction Motors. International Copper Association India.

International Copper Association India. 2020. Short Survey on Understanding IE3 Motor Manufacturing in MSME Sector. International Copper Association India.

International Electrotechnical Commission. n.d. "Electric motors."

Ionescu, Constantin, Tudor Baracu, Gabriela-Elena Vlad, Horia Necula, and Adrian Badea. 2015. "The Historical Evolution of the Energy Efficient Buildings." *Renewable and Sustainable Energy Reviews* 49 (September): 243–53. https://doi.org/10.1016/j.rser.2015.04.062.

Jenny, Hubert, Frédéric Asseline, Yihong Wang, Anouj Mehta, Bharat Dahiya, and Michael Lindfield. 2020. Catalyzing Climate Finance with the. Policy Briefs, Asian Development Bank.

J-PAL. 2018. "Strengthening Third-Party Audits to Reduce Pollution." *The Abdul Latif Jameel Poverty Action Lab (J-PAL)* (blog). October 2018. https://www.povertyactionlab.org/case-study/strengthening-third-party-audits-reduce-pollution.

KERI Information. 2023. "Super premium' industrial motor that benefits both business and the environment."

Kowalski, Arkadiusz. 2020. "Global South-Global North Differences." In *No Poverty*, by W. Leal Filho et al. (eds.), 1–12. Encyclopedia of the UN Sustainable Development Goals.

Leão, Marlon, Wolfgang Müsch, Manfred N Fisch, Érika B Leão, and Ernesto Kuchen. 2008. "678: The Evolution of Energy Efficiency Policy in Germany and the EnEV 2007."

Lees, Martina. 2024. "Why Misleading EPC Ratings Are a National Scandal," February 1, 2024, sec. times2. https://www.thetimes.co.uk/article/why-misleading-epc-ratings-are-a-national-scandal-ztc5ss2b0.

Li, Jun, and Bin Shui. 2015. "A Comprehensive Analysis of Building Energy Efficiency Policies in China: Status Quo and Development Perspective." *Journal of Cleaner Production* 90 (March): 326–44. https://doi.org/10.1016/j.jclepro.2014.11.061.

Li, Y., S. Kubicki, A. Guerriero, and Y. Rezgui. 2019. "Review of Building Energy Performance Certification Schemes towards Future Improvement." *Renewable and Sustainable Energy Reviews* 113 (October): 109244. https://doi.org/10.1016/j.rser.2019.109244.

Madan, Prima. 2023. "More States Adopt Building Energy Codes in India." April 10, 2023. https://www.nrdc.org/bio/prima-madan/more-states-adopt-building-energy-codes-india.

Makumbe, Pedzi, Debbie K. Weyl, Andrew Eil, and Jie Li. n.d. "Proven Delivery Models for LED Public Lighting: Super-ESCO Delivery Model Case Study EESL in Vizag, India." ESMAP. https://www.esmap.org/sites/esmap.org/files/DocumentLibrary/EESL%20-%20Proven%20LED%20Delivery%20Models8_Optimized_Final.pdf.

McKenna, Chris. 2023. "Natural Gas Ban: NY Bans New Building Hookups. What Happens to Stoves?" Lohud. May 8, 2023. https://www.lohud.com/story/news/politics/2023/05/08/natural-gas-ban-ny-bans-new-building-hookups-whats-next/70184293007/.

Micale, Valerio, and Jeff Deason. 2014. Energy Savings Insurance - Phase 2 Analysis Summary. CPI.

Moore, Trivess, and Sarah Holdsworth. 2019. "The Built Environment and Energy Efficiency in Australia: Current State of Play and Where to Next." In *Energy Performance in the Australian Built Environment*, edited by Priyadarsini Rajagopalan, Mary Myla Andamon, and Trivess Moore, 45–59. Green Energy and Technology. Singapore: Springer Singapore. https://doi.org/10.1007/978-981-10-7880-4_4.

Nadel, Steven, and Adam Hinge. 2020. "Mandatory Building Performance Standards: A Key Policy for Achieving Climate Goals."

Nandi, Paritosh, and Sujay Basu. 2008. "A Review of Energy Conservation Initiatives by the Government of India." *Renewable and Sustainable Energy Reviews* 12 (2): 518–30. https://doi.org/10.1016/j.rser.2006.03.016.

National Center for Disease Control. 2023. "Towards Climate-Smart Hospitals: Insights from a National Hospital Energy Consumption Survey."

National Institute of Urban Affairs, and RMI. 2022. "From the Ground Up: A Whole-System Approach to Decarbonising India's Buildings Sector." National Institute of Urban Affairs and RMI. https://rmi.org/insight/wholesystem- approach-to-decarbonize-indias-buildings/.

PIB. 2023. "Energy Efficient Fans Programme launched, One crore energy-efficient fans to be distributed in initial phase." Press Information Bureau, November 2.

Rosenberg, Shirene A., and Harald Winkler. 2011. "Policy Review and Analysis: Energy Efficiency Strategy for the Republic of South Africa." *Journal of Energy in Southern Africa* 22 (4): 67–79. https://doi.org/10.17159/2413-3051/2011/v22i4a3230.

Shandilya, Nandini, and Ashish Rao Ghorpade. 2019. "ECBC Compliance in Indian Cities - Handbook (Supporting Sustainable Mobility under Smart City Mission)." : ICLEI- Local Governments for Sustainability, South Asia (ICLEI South Asia).

Shui, Bin, Meredydd Evans, and Sriram Somasundaram. 2009. "Country Report on Building Energy Codes in Australia." PNNL-17850, 978548. https://doi.org/10.2172/978548.

Smolar, Aaron. 2023. "California Adopts First-in-Nation Building Code Revision to Reduce Embodied Carbon | Architectural Record." Architecture News. Architectural Record. August 10, 2023. https://www.architecturalrecord.com/articles/16420-california-adopts-first-in-nation-building-code-revision-to-reduce-embodied-carbon.

Sundararajan, Satheesh, and Ashok Sarkar. 2020. "Transforming India's energy efficiency market by unlocking the potential of private ESCOs." World Bank Blogs. December 2. https://blogs.worldbank.org/ppps/transforming-indias-energy-efficiency-market-unlocking-potential-private-escos.

Tait, J, M Omar, H Elghazaly, V Letschert, R Russo, A Streicher, and F Tadros. n.d. "Egypt Mandates IE3 Energy Efficiency Standards for Electric Motors." https://geowb.maps.arcgis.com/apps/MapJournal/index.html?appid=64f7067fe99e451eabc622201852.

Taylor, Robert P., Chandrasekar Govindarajalu, Jeremy Levin, Anke S. Meyer, and William A. Ward. 2008. FINANCING ENERGY EFFICIENCY. Washington: The World Bank.

Team E3P. n.d. "Energy Performance Contracting." Eurpoean Energy Efficiency Platform. Accessed December 7, 2023. https://e3p.jrc.ec.europa.eu/articles/energy-performance-contracting.

Telangana State Building Permission Approval & Self Certification System - Government of Telangana. n.d. "TS-bPASS." About TS-bPASS. Accessed February 1, 2024. https://tsbpass.telangana.gov.in/.

TERI. 2022. "Financing Low Carbon Transition for India's MSME Sector."

TERI. 2022. Financing Low Carbon Transition for India's MSME Sector. The Energy and Resources Institute (TERI).

The Global ESCO Network. 2022. "Regulatory Barriers for Energy Service Companies. UNEP Copenhagen Climate Centre." https://c2e2.unepccc.org/wp-content/uploads/sites/3/2022/05/regulatory-barriers-for-energy-service-companies-perspectives-based-on-feedback-from-national-esco-associations.pdf.

Think Tank European Parliament. 2023. “Revision of the Energy Performance of Buildings Directive: Fit for 55 Package.” January 19, 2023. https://www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2022)698901.

Tholot, Almas. 2023. “COP28: ‘Buildings Breakthrough’ Global Initiative Launched For Near-Zero Emission Structures By 2030 - MEP Middle East.” December 6, 2023. https://www.mepmiddleeast.com/news/cop28-buildings-breakthrough-launched.

Tyler, Matthew, David Winiarski, Michael Rosenberg, and Bing Liu. 2021. “Impacts of Model Building Energy Codes – Interim Update.” PNNL-31437, 1808877. https://doi.org/10.2172/1808877.

UNEP. 2017. “Accelerating the Global Adoption of Energy-Efficient Electric Motors and Motor Systems.”

Ürge-Vorsatz, Diana, Radhika Khosla, Rob Bernhardt, Yi Chieh Chan, David Vérez, Shan Hu, and Luisa F. Cabeza. 2020. “Advances Toward a Net-Zero Global Building Sector.” Annual Review of Environment and Resources 45 (1): 227–69. https://doi.org/10.1146/annurev-environ-012420-045843.

WEG. 2018. “W21 MEPS Korea.” https://static.weg.net/medias/downloadcenter/hda/ha9/WEG-w21-three-phase-induction-motors-meps-korea-south-korea-ie3-korean-market-50072929-brochure-english-web.pdf.

WEG. 2021. Global MEPS Guide For Low Voltage Motors. WEG.

Wolf, Justin. 2023. “28 Countries Sign Buildings Breakthrough Agreement at COP28.” GreenBuildingAdvisor. December 21, 2023. https://www.greenbuildingadvisor.com/article/28-countries-sign-buildings-breakthrough-agreement-at-cop28.

World Bank. 2018. “Transforming Energy Efficiency Markets in Developing.” World Bank Group.

Wu, Yun, Jas Singh, and Dylan Karl Tucker. 2018. Financing Energy Efficiency, Part 2: Credit Lines. World Bank, Washington, DC. https://doi.org/10.1596/30386.

Young, Rachel. n.d. “Global Approaches: A Comparison of Building Energy Codes in 15 Countries.”

Yu, Sha, Meredydd Evans, Pradeep Kumar, Laura Van Wie, and Vatsal Bhatt. 2013. “Using Third-Party Inspectors in Building Energy Codes Enforcement in India.” PNNL-22155, 1063732. https://doi.org/10.2172/1063732.