SOUTH AFRICA: FRAMEWORK FOR ENERGY EFFICIENCY DEMAND SIDE MANAGEMENT

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ACEEE	American Council for an Energy-Efficient Economy
CPUC	California Public Utilities Commission
DFFE	Department of Forestry, Fisheries and the Environment
DG	Distributed Generation
DMRE	Department of Mineral Resource and Energy
DR	Demand Response
DSM	Demand Side Management
EE	Energy Efficiency
EEDSM	Energy Efficiency Demand Side Management
EAF	Energy Availability Factor
EEPBIP	Energy Efficiency in Public Buildings and Infrastructure Programme
GHG	Greenhouse Gas
GSL	General Service Lamp
IDM	Integrated Demand Management
IEA	International Energy Agency
IEE	Integrated Energy Efficiency (DMRE unit responsible for EE)
IPP	Independent Power Producer
IRP	Integrated Resource Planning
M&V	Measurement and Verification
NDC	Nationally Determined Contribution
NEES	National Energy Efficiency Strategy
NESP	National Energy Screening Project
NERSA	National Energy Regulator of South Africa
PCC	Presidential Climate Commission
RD	Revenue Decoupling
RE	Renewable Energy
S&L	Standards and Labelling
SANEDI	South African National Energy Development Institute
TRC	Total Resource Cost

Executive Summary

Overview

In July 2022, President Cyril Ramaphosa announced an emergency response plan to address the growing electricity crisis in South Africa, which included the necessity for customers of Eskom, South Africa's primary electricity supplier, to implement demand-side energy efficiency measures. This report is the second of two reports that provides the foundation for a strategic Demand-Side Management (DSM) approach to reduce load shedding and maximize energy savings in South Africa, though inter-governmental collaboration and increased coordination of energy efficiency activities. The first report focuses on the experience of Eskom's rate-funded Integrated Demand Management (IDM) programme, from its beginning in 2004 to today, highlighting the factors that led to failed support for the programme. This second report focuses on addressing the challenges identified in the first report and describes the elements of a policy framework to develop a sustained DSM program to meet the government's energy efficiency goals in terms of greenhouse gas emissions reduction and social equity and inclusion to achieve a just transition.

The load shedding experienced in the first four months of 2023 (up to 4th of May 2023) exceeded the total amount of load shedding in 2022, which itself was the highest on record. As a result, in March of 2023, the President appointed a Minister of Electricity, tasked with overseeing all aspects of the country's response to the ongoing electricity crisis as a temporary arrangement.

Eskom and the national government are addressing the imbalance between generation and demand through two simultaneous solutions: 1) stimulating private sector investment in new generation capacity; and 2) targeting more effective plant maintenance to increase energy availability to 70% or higher in the long term (South Africa Government, 2022). As highlighted in the companion to this report, DSM has an important role to play in alleviating the electricity supply deficit, as demonstrated by Eskom's successful IDM programme between 2010 and 2015. However, the current two-fold national plan is not adequately recognizing the value of DSM to increase grid reliability and reduce costs of integrating variable renewable energy and is not prioritizing DSM in investment plans and resource allocation.

This report begins with an explanation of DSM, then considers the enabling conditions needed for an effective DSM programme, next highlights the multiple benefits of EE and the importance of climate and inclusivity goals, and concludes with findings and recommendations to support South Africa's commitment to a just energy transition.

Demand-Side Management Programmes

DSM can be described as programmes that use financial incentives, regulations and / or customer education and awareness to modify energy demand from consumers, on the assumption that the cost of implementing the programme is lower than the cost of increasing energy supplies. Utility customers reduce their demand from grid power either overall or at certain times of day, helping the utility to defer the need for new sources of power. DSM programmes also provide market flexibility that reduces price volatility and allows variable renewable energy sources, such as solar and wind power, to be more reliably integrated into the energy supply. In South Africa, coal accounts for over 80% of total electricity generation. However, the coal plant and transmission infrastructure is unreliable due to deferred maintenance issues; generators break down and go offline at short notice, causing hardship and economic losses for customers. Plants also cannot ramp up or down efficiently enough to deal with the intermittency of renewable energy feeding into the grid." DSM programs can provide vital services that increase the reliability and flexibility of the grid.

The primary types of DSM programmes include energy conservation, energy efficiency, demand response, distributed generation, and energy storage. These approaches reduce energy use on the demand side (customer side) of the electric meter and help to balance electricity supply and demand, reduce costs, and achieve policy objectives such as greenhouse gas (GHG) emissions reduction. The first approach, energy conservation, is the decision and practice of using less energy, such as turning off lights or walking instead of driving. The second approach, energy efficiency (EE), is complementary to energy conservation. Through technology improvements, EE reduces energy consumption while providing the same or increased level of energy services. Consumers are encouraged to participate in EE programmes via rebates for purchasing efficient equipment, bill discounts, equipment replacement, and other incentives. EE programs can target stakeholders along the entire product value chain, from manufacturers, to distributors to end customers. The third DSM approach, demand response, uses price signals or financial incentives to encourage customers to modify energy usage patterns by time of day or in response to a triggering event, such as a surge in energy demand from increased space heating and hot water on cold days. Electric load reductions can be achieved through energy storage, building energy load control devices, process adjustments, and other strategies. The fourth approach, distributed generation, uses small-scale electricity generation units which may or may not be connected to and synchronised with the main electricity network. The fifth and final approach, energy storage, uses battery, heat or cold storage or other technologies to convert grid-connected electricity into another form of energy that is held for later use and released as electricity when required. Customers are incentivized to buy and store electricity when it is plentifully available or when prices are low, and dispatch the stored energy when the grid is overtaxed or prices are high. DSM is a proven mechanism and has been utilized effectively in multiple countries since the 1970s.

Enabling Conditions

For the full benefits of EE to be achieved in South Africa, the current regulatory framework must evolve to shift its objectives from selling more electricity to selling clean and affordable energy services. Based experience in the EU, US and some key emerging countries like India and Brazil, this shift depends on the following enabling conditions:

- **Energy Efficiency Demand-side Management (EEDSM)[1] Policy Frameworks –** Recognising EE as an integral, highly valuable, and long-term energy resource requires mandatory energy savings goals, the development of regular studies of EE potential, and for DSM to be a core resource component of future electricity needs in integrated resource plans.
- **Cost Recovery** – Mechanisms must be identified to recover the costs of implementing EEDSM programmes, such as through rates applied to customer bills.

[1] DSM refers to the full range of energy savings mechanisms or types, with EE being one of them. For the purposes of these two reports, EEDSM refers to the range of EE interventions associated with a broader DSM programmes. In South Africa, DR has dominated the utility's IDM programme since 2015 and thus the need to be explicitly mention EE in the EEDSM programme.

- **Utility Business Model** – The model must be aligned with energy saving goals while still allowing the utility to succeed financially. This can be achieved through cost recovery mechanisms, revenue decoupling, and performance incentives.
- **Administration** – Appropriate oversight and accountability must be established for EEDSM programmes, whether through the utility, a third party, a government agency, a Super ESCO, or a hybrid approach.

Climate, Equity, and Inclusion

Recognizing the important role the electricity sector needs to play in both mitigating emissions and adapting to climate change, globally policy makers and regulators in the EU and US have sought to align utilities' incentives for EE with overarching climate mandates and equity goals. EE has environmental, social, and economic benefits that should be recognized and integrated into EEDSM programmes, including reduced GHG emissions, improved access to energy services, and the creation of new jobs.

Research Findings and Recommendations

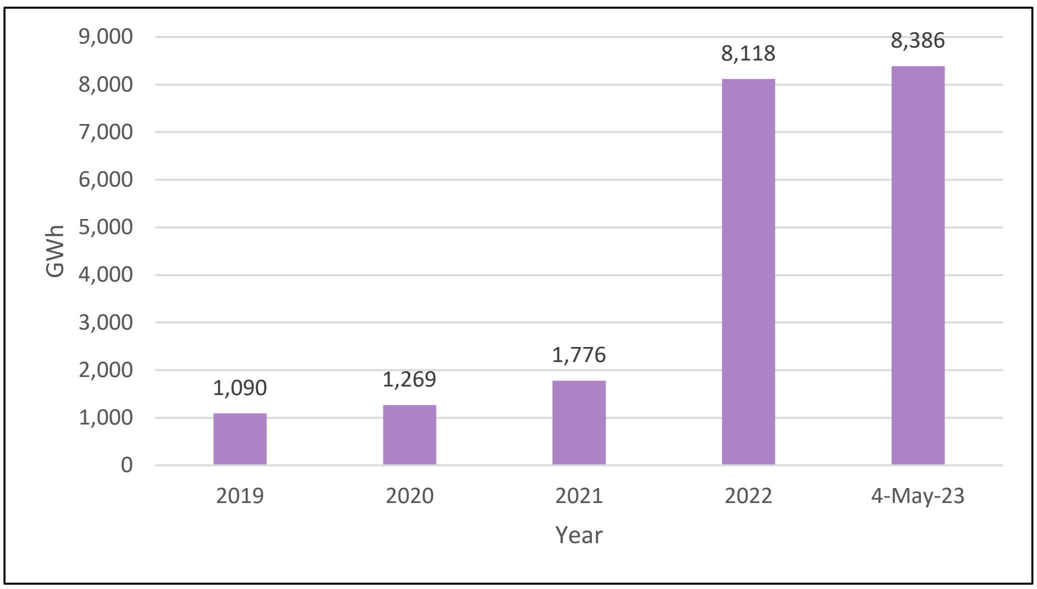
EEDSM as an energy resource is underutilised in South Africa and has the potential to meet multiple short- and long-term national objectives. To maximise the energy savings available from EE, the identified market barriers must be addressed through a cohesive approach by The South Africa Department of Mineral Resource and Energy (DMRE) that incorporates policy, regulations, market incentives, and public information / awareness. This study's analysis will help senior policy developers decide how best to revive the existing initiatives, including the post-2015 NEES, to achieve EE goals in an efficient and cost-effective manner. South Africa has access to an entire toolbox of approaches for increasing EE throughout the country, and applying some of these approaches would lower utilities' required investment in infrastructure and fossil energy sources, contribute to climate goals and further the country's desire for a just and efficient energy future for all.

1. Introduction

Report 1 analysed the country's EE policy framework and traced Eskom's Integrated Demand Management (IDM) programme from its inception in 2004 to its height in 2013 and then its decline in 2015 to today (Covary & de la Rue du Can, 2023). In 2013, the IDM was a multi-million-rand initiative that delivered 4 gigawatts (GW) of energy savings. With recent growing interest from national government to implement Demand Side Management (DSM), this report provides a timely overview of what is required to create a long-term sustainable DSM approach, that connects current EE initiatives and enhance coordination and inter-governmental collaboration, with the aim of decreasing load shedding and maximizing energy savings. The objective of this second report is to show the need for South Africa to ramp up its support of DSM programmes.

The load shedding experienced in the first four months of 2023 (up to 4th of May 2023) exceeded the total amount of load shedding in 2022, which itself was the highest on record as shown in ***Figure 1***. Put simply, in 2023 South Africans did not have electricity for an average of 6.2 hours per day (2.3 hours in 2022), or 26% of the day (BusinessTech, 2023).

Figure 1. Load shedding per year (GWh)

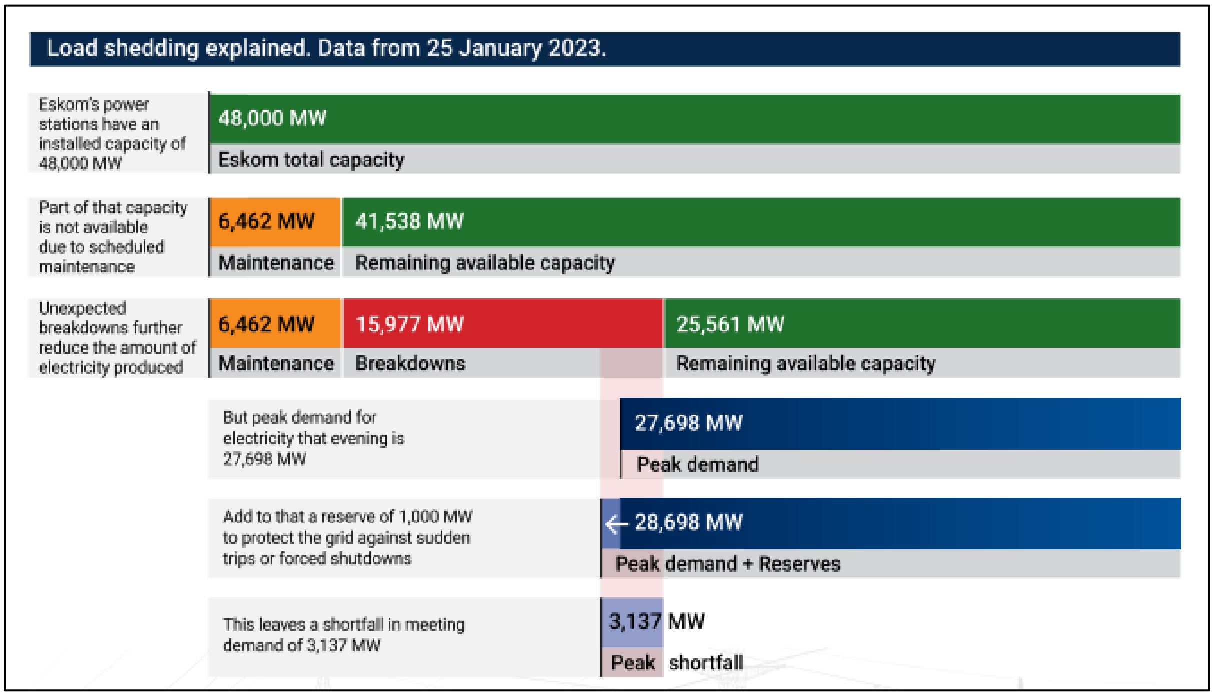


Source: (Minnaar, 2023)

On the 9th of February 2023, in his state of the nation address, South African President Ramaphosa announced changes to his executive branch by creating a new Minister of Electricity position based in the Presidency, and appointing Kgosientsho Ramokgopa to the post. The minister oversees the country's response to the long-running electricity crisis. The minister's duties include leading the National Energy Crisis Committee (NECOM) and working to significantly reduce the frequency of load shedding by having direct authority over the Energy Action Plan. The Energy Action Plan was developed by the Presidency through extensive consultation and endorsed by energy experts as providing the best and fastest path towards energy security (South Africa Government, 2022). The electricity minister position is not intended to be permanent; the minister is only to remain in office until the crisis is dealt with (GCIS, 2023).

One of the main factor of the energy crisis is the decline in the energy availability factor (EAF) of South Africa installed capacity (48 GW), of which 80% is from coal fired generation plants: 78.6% (2016); 71.8% (2018); 66.9% (2019); 65.0% (2020); 61.8% (2021); 58.0% (2022) and 52.9% for the first thirteen weeks of 2023 (EEBI, 2023). Depending on the season, day of the week, and time of day, total electricity demand fluctuates between 25 and 34 GW. However, with unplanned breakdowns typically between 16 and 20 GW, and planned maintenance at 4 GW or more (Eskom, 2023), the system is currently experiencing an almost permanent generation deficit of between 1 and 6 GW, and this is managed through a combination of rotational load shedding—which is why the stages of load shedding fluctuate daily—and other measures such as pumped storage, diesel peaking plants, and demand response (DR), which are not always available. For example, diesel stocks may run low, pumped storage must be replenished, and DR opportunities may be limited. Figure 2 provides a graphic representation of the state of the electricity system on the 25th of January 2023, illustrating the factors that contributed to the supply deficit.

Figure 2. Overview of South Africa's supply and demand shortfall



Source: (South Africa Government, 2023)

Eskom and government are addressing the imbalance between generation and demand through two simultaneous solutions. The first seeks to stimulate private sector investment in new generation capacity, through long term power purchase agreements[2] under the existing independent power producer (IPP) programme with expedited approval processes (Sguazzin, 2023), and investments in own use generation, such as rooftop solar. Here, the licensing restrictions have been removed and a tax incentive has been introduced for PV installations for both business and household installations[3] (NT, 2023). The second

[2] Power purchase agreements are legal contracts between electricity generators and buyers. In South Africa, PPAs play a crucial role in facilitating the development and growth of the renewable energy sector. However, PPAs are subject to specific legal considerations and requirements.

[3] For businesses, a 125% tax incentive applies in terms of section 12B of the Income Tax Act – for new and unused energy assets (wind, solar PV, concentrated solar, hydropower and biomass). Businesses receive an upfront, higher-than-cost deduction of 125% as opposed to the current 100% incentive, claimed over three years (50%; 30% and 20%). The incentive applies for two years – between 1 March 2023 to 28 February 2025. Individual taxpayers receive a tax rebate to the value of 25% of the new PV panels, capped at R15 000 - between 1 March 2023 to 29 Feb 2024.

intervention targets more effective plant maintenance to materially decrease breakdowns and reverse the downward EAF trend to achieve 60% in the medium term, and work towards 70% or higher (SANews, 2022). Whilst both interventions are underway the lead time to commission independent power plants can take up to three years or longer. South Africa is in a dire situation where difficult decisions must be made between the impact on the economy, and the impact on the environment.

DSM can contribute to closing the electricity supply deficit, by reducing energy consumption and lowering peak demand. Between 2010 and 2015, Eskom's IDM programme contributed to reduce more than 4GW of energy demand through energy efficiency measures as described in report 1 (Covary & de la Rue du Can, 2023). However, to avoid repeating the previous experience of ending a successful programme, DSM must be embedded in national policy. Moreover, additional benefits to the nation should motivate DSM programme prioritization in national policy. EE, a component of DSM as explained in Section 2 of this report, is a low cost and reliable demand-side resource that saves money for customers. By reducing energy use, energy efficiency lowers energy bills and makes energy more affordable for businesses and households. When targeted to low income households, these benefits translate in reducing the burden of paying for energy and therefore reducing energy poverty. EE is also a key climate change mitigation strategy, considered as one of the fastest and most broadly available options (IEA, 2021b; IPCC, 2022). EE also contributes to create local jobs. Many of the measures taken to implement EE are labour intensive (IEA, 2020a). In the United States, for example, EE added more jobs than any other area of the U.S. energy sector and now employs twice as many workers as all fossil fuel industries combined (E4TheFuture and E2, 2022). A coordinated DSM programme can also improve grid stability and reduce the costs of integrating variable renewable energy (RE).

It is thus critical to analyse the potential for DSM measures to address South Africa's electricity supply crisis in the short-term and medium-term tens to assist the transformation of its electricity supply to cleaner technologies over the longer term. In recent years the role of DSM, and especially EE, has not been adequately recognised in national energy investment plans and resource allocation (RSA, 2022). Importantly, this oft-overlooked resource has recently been brought back to the attention of policy makers and Eskom formally launched a revised DSM programme offering in April 2023 (Eskom, 2023). The new electricity minister noted in a recent press conference the opportunity of DSM related to hot water energy consumption:

> "*Necom will run an aggressive demand side management campaign aimed at reducing demand on the grid. It is possible to reduce demand by 1 000MW and reduce load shedding by one stage through simple measures"*, Dr. Kgosientso Ramokgopa (News24, 2023)

Section 2 of this report explains the concept of DSM and how it has evolved over time. Section 3 then considers the enabling conditions needed for an effective DSM programme, focussing specifically on EE which is specified by the reference to an EEDSM[4] programme. Section 4 highlights the multiple benefits of EE and the importance of climate and inclusivity goals. The report then concludes with findings and recommendations. To gain maximum benefit from this research, it is recommended that this report be read with the companion report.

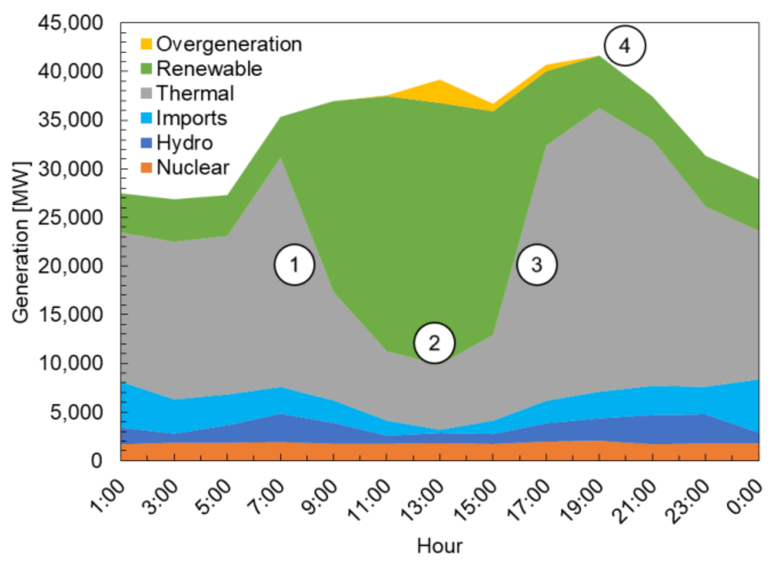
[4] DSM refers to the full range of energy savings mechanisms or types, with EE being one of them. For the purposes of these two reports, EEDSM refers to the range of EE interventions associated with a broader DSM programmes. In South Africa, DR has dominated the utility's IDM programme since 2015 and thus the need to be explicitly mention EE in the EEDSM programme

2. Demand-Side Management Programmes

The definition of DSM has evolved over time. However, based on the literature, it can currently be described as programmes that use financial incentives and / or awareness to modify energy demand from consumers, on the assumption that the cost of implementing the programme is lower than the cost of increasing energy supplies (Gellings, 1985; Meyabadi & Deihimi, 2017; Warren, 2015). Utility customers are encouraged to reduce their demand for grid power either overall or at certain times of day. A DSM programme's primary objective is to defer the need for new and / or additional sources of power.

DSM programmes are especially important as more variable RE is integrated into the energy supply (Alstone et al., 2017; IEA, 2021a; Langevin et al., 2021; Potter et al., 2018). The intermittent nature of wind and solar energy can make it challenging for grid operators to continuously balance generation and demand at the lowest cost and with the fewest environmental impacts. Traditionally, the imbalance of demand and supply has been met with costly dispatchable generators that also produce greenhouse gas (GHG) emissions. Ensuring the reliability of power systems that incorporate large amounts of RE will have to consider demand flexibility to cater for the rapid ramping up and down of the variable RE and meet demand during times when it might not be available, especially at times of daily system peak (Gallo et al., n.d.; Seel et al., 2018; Wiser et al., 2017). Figure 3 shows the power mix under a scenario of 50% variable RE integration in California with limited flexible Demand. The numbering shows the different stage of supply to meet demand (Aghajanzadeh & Marshall, 2018). The number 1 shows the ramp up of renewable energy supply at the beginning of the day, 2 shows the maximum RE supply with overgeneration, 3 the rapid ramp up of thermal generation needed to displace reduction of RE supply and 4 shows the evening peak demand. DSM programmes can help reduce the need of dispatchable at each point and offer the dual benefits of 1) reducing total demand; and 2) delivering market flexibility that facilitates the integration of variable RE and contributes to decarbonization at the lowest cost (Crossley, 2013).

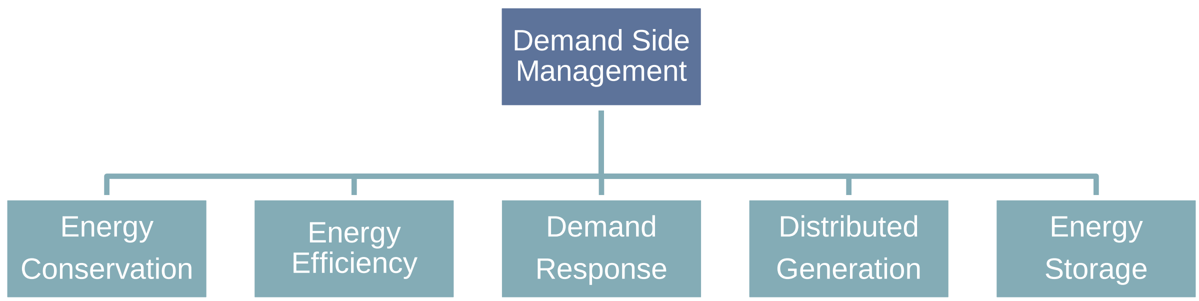
Figure 3. Load flexibility for RE Integration



Source: (Aghajanzadeh & Marshall, 2018)

The primary types of DSM programmes include energy conservation, energy efficiency, demand response, distributed generation, and energy storage as described in Figure 4 which are further detailed in the following sections.

Figure 4: Types of Demand-Side Management Programmes



2.1 Energy Conservation

Energy conservation (EC) is the decision and practice of using less energy. Turning off the light when you leave the room, unplugging appliances when they're not in use, and walking instead of driving are all examples of EC.

Notwithstanding their complementarity and that they may often overlap, EE and EC are fundamentally different. EE, through technical performance improvements, uses less energy to perform the same task without compromising comfort or performance. Success for both depends on behavioural changes and user buy-in, and especially so with EC, but can also incorporate technology such as motion sensors and automatic switch-off after a pre-determined period of idle activity. Typically, EC presents the cheapest form of energy savings.

2.2 Energy Efficiency

EE is the use of less energy to perform the same task or produce the same result.

One approach to DSM is through EE (EEDSM), which has been recognised as one of the fastest, cheapest, and most broadly beneficial options for mitigating climate change (IEA, 2021b; Sorrell, 2015). The advantage of EE is that it does not only displace demand but permanently reduces it. EE's multiple benefits include reducing energy costs, energy poverty, and GHG emissions, whilst increasing economic development, manufacturing competitiveness, and energy security (IEA, 2014; Kerr et al., 2017; Ürge-Vorsatz et al., 2016). EE is achieved by upgrading equipment, improving building envelopes, and implementing better energy management practices, all of which reduce excess energy consumption. Typically, DSM programmes complement policies by incentivizing measures that go beyond the performance levels demanded by mandatory equipment EE standards or building codes (Iea, 2017). Government regulations on their own are often insufficient to reduce the demand for energy, and energy prices and incentives have a significant role to play.

Incentive programmes can be implemented by government agencies, consumers, energy service companies (ESCOs), non-government organizations (NGO), manufacturers / suppliers, or other private sector organizations. They are driven by regulations as well as incentives or other types of financial support made available by the programme administrator, whose goal is to acquire demand-side resources to meet the energy saving goals set by national policy and provide an alternative to building power supply capacity.

Programme administrators have various types of mechanisms available to encourage customers to participate in investing in EE, including rebates, bill discounts, replacement of old equipment, financing assistance, as listed in Table 1. Programme designs in different countries and regions vary significantly and are determined by various elements, such as the efficiency level targeted, the amount of incentive offered, the recipients of the incentive, the form of incentive instrument, eligibility criteria, and whether the programme includes a recycling component (de la Rue du Can et al., 2014). The key challenge of EE incentive programme design is to achieve durable market transformation that results in the widespread adoption of EE products and services (York et al., 2022). By increasing the market penetration of more efficient technologies, incentive programmes reduce their cost of production and distribution. Incentive programmes can complement mandatory standards by accelerating market penetration of products that are more efficient than the level set by regional or national standards, thereby preparing the market for future standards revision.

Financial incentives can be provided at different points along a product value chain. Programmes targeting consumers are referred to as "downstream" programmes, programmes targeting retailers and distributors are referred to as "midstream," and programmes targeting manufacturers are referred to as "upstream." In South Africa, the residential mass roll-out and standard products were designed by Eskom in the IDM program to target single technologies spread out across many users. This programme consisted of several interventions of which the replacement of incandescent lightbulbs with compact fluorescents (CFLs) helped delived a large share of the total savings of the entire programme, see report 1 for more details (Covary & de la Rue du Can, 2023).

Standard offer programmes offer incentives to a wide range of contractors, service companies, community agencies and other organizations for the realization of verified energy savings. Incentives are paid to contractors at a fixed price for each kW and kWh of savings produced by installing EE measures in homes, businesses, and industry. As described in Report 1, this is was applied in south Africa by Eskom's IDM program (Covary & de la Rue du Can, 2023).

Table 1. EE DSM Programme Financial Incentive Design Main Categories

Form	**Typical recipient**	**Description**
REBATE	Customers, businesses	Reduces expense of purchasing new EE equipment
UPSTREAM	Manufacturers	Technology procurement: Provides subsidies to manufacturers, to bring down wholesale price of EE equipment
REPLACEMENT	Customers, businesses	Replaces inefficient residential equipment, before end of their useful lives, with significantly more efficient appliances
STANDARD OFFER	ESCOs, Aggregators, NGOs	Offer purchasing rate, expressed in Rand /kWh or Rand/kW, represents the rate offered to acquire energy savings

ON-BILL FINANCING	Customers, businesses	Allows consumers to spread out the up-front cost of buying EE equipment and financing to be paid off from revenue saved as a result of energy savings

2.3 Demand Response

Demand Response (DR) is defined as a measurable change in electrical demand by customers or load providers in response to a load reduction notice.

DR encourages customers to modify their energy usage patterns in response to a price signal or financial incentives such as a rate discount, credit, or payment. Incentive-based programmes include direct load control, curtailable programmes, demand bidding, and a capacity market. Price-based programmes may apply to different tariffs depending on the time of day or a triggering event. Price-based programmes set tariffs that are as close as possible to the true cost of electricity in real time, for example time-of-use rates, critical peak pricing, and real-time pricing (Abedrabboh & Al-Fagih, 2023; Albadi & El-Saadany, 2008). By curbing the system load, utilities can avoid high capital investments in generation, and especially in expensive peak power. For example, the cost for Eskom's open-cycle gas turbines to generate emergency peak power is more than R3.30/kWh ($0.18/KWh) (Eskom, It costs R10-million per hour to run all open cycle gas turbines at once - Eskom, 2021), but they are required to sell it for less than R1.50/kWh (2021 megaflex tariff).

As the supply of variable RE increases in the electricity generation mix, DR becomes a valuable resource to ensure reliability at the lowest cost. Analysts and system operators have started to consider additional DR programme categories to encompass a diverse set of flexible load options. Table 2 describes the four most common categories used to estimate DR: Shape, Shed, Shift, and Shimmy (Alstone, 2017).

Table 2. DR Programme Categories

Service	Objective	DR Applications
Shape	Reshapes the underlying load profile through relatively long-run price responses / behavioural campaigns.	Time-of-use rates and critical peak pricing.
Shift	Encourages the movement of energy consumption from times of high demand to times of day when there is a surplus of renewable generation.	Behind-the-meter storage, rescheduling flexible batch processes like EV charging fleets, electric hot water control, or pre-cooling with HVAC units.
Shed	Curtails load occasionally to provide peak capacity and support the system in emergency or contingency events.	Interruptible processes, advanced lighting controls, air-conditioner cycling, and behind-the-meter storage
Shimmy	Adjusts demand on the system to alleviate short-run ramps and disturbances at timescales ranging from seconds to an hour.	Advanced lighting, fast-response motor control, and charging

Adapted from: (Alstone et al., 2017)

2.4 Distributed Generation

Distributed energy (DG) or on-site generation is power generation near to the point of consumer load

DG involves small-scale generation units, which may or may not be connected to and synchronised with the main electricity network. DG may be operated in several ways. The units may be dispatched to meet system needs, dispatched to support the local grid, operated by the customer to control utility bills, or installed as an off-grid solution. Changes in load achieved by deploying demand-side generation may reduce the need for large scale generation and network capacity.

2.5 Energy Storage

Crossley (2013) defines energy storage (ES) as a technology to convert grid-connected electricity into another form of energy, hold it for later use, and, when required, release it as electricity.

Whereas transmission and distribution systems move electricity over distances, ES systems move electricity through time, providing it when and where it is needed. Energy storage systems can help manage system load; balance supply shortages and variable renewable generation; and if properly deployed and integrated, help increase the reliability of the electricity network.

ES is a viable solution to overcome challenges from generation intermittency (supply shortfalls, unreliable generation, and variations in renewable energy). Participating in their own intelligent energy management, customers are engaged to buy and store electricity when it is plentifully available or when prices are low. Customers can reduce their consumption by storing power through batteries installed with solar home systems, electric cars, hot water (geysers), and fixed or mobile batteries.

3. EEDSM Enabling Conditions

The development and sustainability of EEDSM programmes relies on context-appropriate implementation models, underpinned by enabling market conditions. The traditional regulatory framework which has shaped the business model of utilities must evolve beyond simply selling more electricity to the objectives of selling clean and affordable energy services. This section of the report provides an overview of the key building blocks that collectively result in embedding EEDSM in national policy to deliver meaningful, cost effective, and sustainable energy reduction. It commences with enshrining EE into policy; then it explores funding (cost recovery); reviews the impact of EE on utilities, especially pertinent to South Africa under its vertically integrated utility model which remains largely intact; and concludes with socio-economic and climate considerations.

3.1 Policy Frameworks

In South Africa, EE has not been viewed consistently as a meaningful energy resource that is regularly assessed and integrated into energy resource planning. As detailed in the first report, EEDSM (Section 4.1) featured prominently in the 2010 Integrated Resource Plan (IRP) but was then excluded in 2019. EEDSM needs to be recognised as an integral, highly valuable, and long-term energy resource; this requires mandatory energy savings goals, regular studies to identify and assess the EE potential across the various sectors, and for DSM to be a core resource component of future electricity planning, namely the IRP. Here, three mechanisms are key.

Energy Saving Obligations

In many markets throughout the world, government legislatures have set goals to consistently save energy. The EU's Energy Efficiency Directive (2012/27/EU) compels EU countries to set up an EE strategy that requires energy companies to achieve yearly energy savings of 1.5% of their annual sales to final consumers (EU, 2012). In the United States, many state governments have established EE resource standards that require utilities or other entities to obtain a percentage of their future electricity and natural gas needs from a variety of DSM measures, which includes EE (Berg et al., 2022; EPA, 2022; Nadel, 2013). Such legislation places an obligation on energy providers or utilities to deliver a specified energy saving outcome, without prescribing the mechanisms and measures to be used. These mandatory targets are continuously assessed to increase the contribution of EE in national resource planning, which in turn provides market certainty and stimulates further market investment.

Studies of DSM Potential

EEDSM studies quantify the achievable and cost-effective potential of EE and DR measures (EPA, 2007a). They are important for assessing the current market penetration of identified EE technologies and practices, the extent to which these technologies and practices can be improved, and the cost-effectiveness of increasing their penetration. In addition to providing important data to inform energy-saving goals, the studies also help estimate the funding levels required to achieve the estimated potential.

Integrated Resource Plans

The IRP is an electricity capacity plan that aims to provide an indication of the country's electricity demand, how this demand will be supplied, and what it will cost. It should consider both supply and demand side resources, and this DSM potential is then incorporated in decisions regarding investments in national energy planning (EPA, 2011). EE, often referred to as the least-cost resource, is typically prioritised for this reason as its implementation is significantly lower and faster than the cost of constructing new capacity. EE should be mandatory in the IRP as it lowers the cost of energy services to customers and the many other benefits that have been detailed in earlier sections of this report.

3.2 Cost Recovery

Policies that direct utilities or agencies to undertake EEDSM programmes must identify a mechanism to recover the implementation costs. These include, but are not limited to, costs associated with programme administration, implementation, contracting, financial incentives, evaluation, and measurement and verification of energy savings by independent organizations (ACEEE, 2018; EPA, 2007b, 2022). Clarity with respect to the funding mechanism deployed is essential to ensure programme effectiveness and sustainability and to reduce uncertainty regarding the process and timing of implementation. A cost recovery mechanism is essential no matter who administers the EEDSM programme. National and / or regional programmes require large capital transfers, and it is therefore critical to ensure transparency and validation of results which demonstrate the benefits of funding allocations. A fund can be established within the framework of prioritizing EEDSM in integrated resource planning, in order to deliver EEDSM where it is cost-effective.

Funding for this fund generally comes electricity tariff, and the EEDSM program is referred as rate funded programme. A small charge or levy is applied to the electricity tariff, which then supplements a public benefit fund used to support the programmes. The levy is usually a fixed amount per kWh administered for a number of years, as determined either by legislation or a regulatory process. Most states in the United States use a public benefit charge on customer bills to recover costs. In India, regulations allow state utilities to use their annual revenue requirement petitions to apply consumer tariffs to recover the net incremental costs of their programmes (Sarkar, Mukhi, et al., 2016). In South Africa, funding for the EEDSM program is determined during the of the Multi-Year Price determination (MYPD) (see Report 1).

In a competitive electricity market, programme costs are recovered through utilities' cost of doing business. The amount that is passed on to customers depends on the market and competitive pressure. The United Kingdom's Carbon Emissions Reduction Target programme, which requires large gas and electricity utilities to achieve targets for reducing carbon emissions from domestic premises, assumes costs will be passed on to consumers without regulating the amount (IEA, 2017).

As countries develop carbon markets to meet climate commitments, an increasing number of governments earmark a part of the proceeds from selling carbon credits to fund EE programmes. Carbon market can therefore provide an additional or alternative source of funding for implementing EE and achieving energy savings. An example is the Regional GHG Initiative (RGGI) cap and trade scheme, which covers nine states in the United States, and which allocates more than a third of its carbon revenue to EE (RGGI, 2022).

Some countries have created EE funds that collect money from alternative sources. Germany's EE Fund was established in 2011 using a special allocation from the German Federal Ministry of Economic Affairs and Energy, therefore using general government budget. The EE Fund is part of Germany's "Energiewende," which seeks to reduce primary energy consumption by 20% by 2020 and 50% by 2050 (EPATEE, 2017). In Tunisia, Law N°2005-106 introduced a national fund for EE, which in 2013 was renamed the Energy Transition Fund. The fund collects money primarily from the tax on a car's first registration, tax revenue from energy products, and electricity and gas bills.

In addition to establishing a consistent way to enable costs to be recovered in a timely manner, policy makers should consider providing incentives for the successful management of EE programmes and for achieving energy saving targets as explained in the following section.

3.3 Utility Business Model

The utility business model is generally based on volumetric throughput, whereby kWh charges predominantly recover fixed costs and operational expenses while providing some profit. This billing approach is simple for consumers to understand; aligns with the assumption that the consumer only pays for what they use; and if required, enables large users to subsidise the system costs of smaller (poorer) users (Sotkiewicz, 2007). Under this business model, a tariff is set above the marginal cost, so that profits increase with sales volume, creating a misalignment between the utility's business interest and national agendas of EE and conservation (Brucal & Tarui, 2019). The three primary disincentives to utility investment in EE programmes are (York et al., 2013):

- **Additional costs:** EE programmes incur costs and therefore constitute financial losses to utilities unless costs are recovered through tariffs or fees.
- **Removal of the throughput incentive**: Investments in EE decrease the revenues and profits that could be derived from higher sales volumes.
- **Lack of opportunities for shareholders to increase earnings**: Generation plants are capital assets that provide a return on investment. EE programmes lessen the need for such investments and therefore reduce opportunity to increase earnings. Regarding the context of South Africa, which has an electricity supply deficit, reducing total demand provides an opportunity to deliver an un- or less-interrupted supply, protect revenues, maintain a strong relationship with customers, and support economic growth. However, if not properly implemented, the utility will face this disincentive once supply levels have recovered.

Collectively, these factors create a disincentive for utilities to implement EE programmes. This disincentive must be addressed to motivate utilities to help achieve energy-savings goals. The American Council for an Energy Efficient Economy (ACEEE) has identified three regulatory tools that have worked best in the United States (Molina & Kushler, 2015; York & Kushler, 2011). These mechanisms work together to align a utility's business model with reaching energy-savings goals. The three components are: (1) programme cost recovery (as described in the previous subsection 3.2); (2) revenue decoupling; and (3) performance incentives. It is important to incorporate all three of these components because efficiency programmes are most successful when the utility or third-party programme operator has a financial incentive to succeed. At a minimum, the utility or third-party programme operator should not be harmed financially. Moreover, providing these mechanisms is especially important, if not essential, where challenging targets (savings of 1.5% per year or greater) are adopted. Cost recovery was discussed in the previous section; the following paragraphs consider revenue decoupling and performance incentives.

Revenue Decoupling

Revenue decoupling (RD) aims to sever the link between utility profits and volume of electricity sales. Decoupling mechanisms, when properly designed, minimise this link by ensuring that a utility can collect an authorised level of revenue each year, regardless of the amount of electricity sold, thereby dampening or eliminating the effect of increased EE (Cappers et al., 2020) Under RD, the (volumetric) electricity rate increases, so that the required revenue is still earned. ***Table 3*** depicts an example in which utility electricity sales (kWh) are 1% lower than originally forecast primarily, but not exclusively, because of DSM activities. In this case, RD has the potential to improve the utility's financial situation and lower its risk. A decoupling allowance is applied to adjust tariffs to compensate for the difference between allowed and actual revenue. In this case, utilities can recover their allowed fixed cost through the rate-making process, either by paying a surcharge where there is a shortfall or by providing a refund to customers where utility revenues exceed the amount required to recover fixed costs.

Table 3: Example of Revenue Decoupling

	No RD	RD
Service provider's revenue requirement (based on expenses, taxes, etc.)	115 384 615	
Sales forecast (kWh)	1 000 000 000	
Actual sales	990 000 000	
Tariff (cents/kWh)	0.1154	0.1166
Decoupling allowance	-	0.0012
Actual revenue	114 230 769	115 384 615

Source: (Brucal & Tarui, 2019)

RD represents a proven mechanism to address many of the barriers that utilities and electricity distributors face with EE implementation. However, decoupling policies apply only in regulated markets. In the United States, 31 states have established decoupling mechanisms; 20 through regulatory procedures and 11 through legislation (Specian et al., 2022)

Performance Incentives

In a regulated electricity market, utilities are allowed to earn a return on their assets. Revenue decoupling is designed to compensate for revenue lost due to lower electricity sales but it does not address the disincentive of decreased earnings from owning generation plants. To place investments in EE on an equal basis with investments in supply-side resources, regulators needs to consider efficiency programme costs as capital expenditures and allowing a return on equity for demand-side investments, just as with investments in supply-side infrastructure. By allowing a return on EE investments, regulators can enable a shift in utilities' business models. EE can become a core part of a utility's business model, increasing executives' interest in devoting organizational resources toward achieving EE goals (ACEEE, 2018).

ACEEE's nationwide assessment (United States of America) showed that performance incentives contribute more towards achieving greater savings than to set goals (Baatz et al., 2016). U.S. states have developed four categories of EE performance incentives for utilities, as described in (Nowak et al., 2015) and outlined in Table 4.

Table 4. Performance Incentives for Utilities

Shared net benefits incentives	Utilities can earn a percentage of the savings from their successful EE programmes.
Energy savings based incentives	Utilities can earn a reward for meeting established energy savings goals.
Multifactor incentives	Utilities can earn rewards for meeting established goals based on multiple metrics such as energy savings, demand savings, or energy savings for low-income communities.
Rate of return incentives	Utilities can earn a rate of return on efficiency spending comparable to what they receive from traditional investments, sometimes with requirements for energy-savings performance.

Adapted from (Nowak et al., 2015)

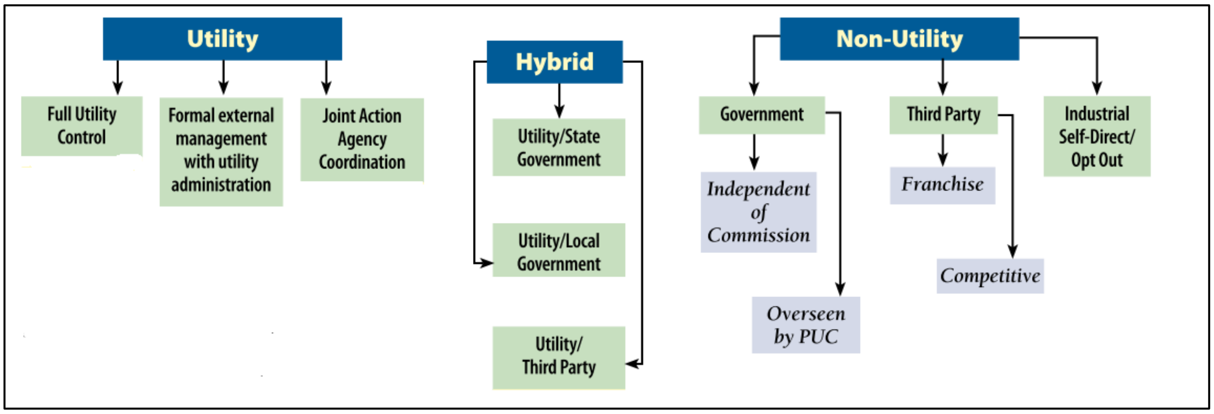
The mechanisms outlined in Table 4 mitigate the economic disincentives regulated utilities traditionally face to investing in EE. Financial rewards or earnings opportunities for programme administrators, utilities, and shareholders are provided in return for achieving energy savings. The above business and policy models present tangible solutions to overcome utilities' disincentives toward EE.

Although the performance incentives described above have been implemented recently in Australia and Northern Ireland (Warren, 2019), they are most widely applied in Northern America, with 27 of the 50 U.S. states having adopted incentives based on cost-effective achievement of energy-savings targets (ACEEE, 2018). Given that South Africa's electricity system is predominantly state owned and highly regulated, RD is worth considering.

3.4 Administration

Government can mandate utilities, government agency/ies, or a third party to achieve energy savings goals. A review of ratepayer-funded EE models in the United States identified three administrative approaches (Sedano, 2011); see Figure 5. Regardless of the model selected, accountability and oversight are indisputably the most crucial success factors. And although the state regulator remains involved, typically as an independent and final authority in dispute resolution, an oversight board that has broad representation can be established to provide accountability and oversight. Board members may range from state officials to industry experts; non-governmental organizations; and other specialists (utility, regulatory, and environmental), all of whom can provide the expertise to deal with complex issues such as program design, M&V, budgeting, ratepayer tariffs, and consumer benefits.

Figure 5: Administrative Structures for Consumer-Funded Energy-Efficiency Programmes



Source: (Sedano, 2011)

Utilities

Electric utilities often are selected to administer EEDSM programmes because of their direct link to energy consumers and their access to valuable data on energy usage patterns. In this approach, the utility's existing relationship with the customer base provides multiple advantages, including trust, client profiles, and a direct communication channel. Utilities are well placed to identify, design, and deploy energy saving opportunities for their clients and can leverage implementation of EE as a key ingredient in their cost-effective energy transitions. Given the growth of renewables, improved demand management through EE and flexibility also contributes to utilities' operational performance and supply reliability. Promoting EE is not an obvious business for utilities to undertake, however, because when consumers use less electricity, utility revenues are negatively impacted, especially for energy providers that require growth for their profitability. This dynamic can exist under both traditional cost-of-service regulatory regimes and competitive retail market regimes unless regulatory or market mechanisms are established to compel or reward energy provider participation. Some U.S. states have developed market regulations to remove utilities' disincentive to conserve energy. Such regulations may decouple revenue and electricity sales or provide shareholder incentives to achieve EE, as explained above.

In some cases, the responsibility for meeting savings goals is delegated to a third party or government agency that implements the programmes.

Non-Utility (Third Party)

The key advantages to having an EEDSM programme handled by an independent (non-utility) or non-governmental organization include the elimination of utilities' mixed financial motives, reaching all consumers (not just a utility's client base), and providing consistency. The third-party approach can unlock a higher level of compatibility with broader public policy goals at a lower cost by eliminating redundant administrative costs. Regardless of who implements EE programmes, however, the risk to utilities' sales remains, and utilities may take measures to protect revenue streams, which then undermines agency programmes. A common solution requires utilities to be bound by long-term integrated resource plans that incorporate EE targets.

Government

Using a government agency to administer EEDSM programmes necessitate to overcome the bureaucratic nature and lack of agility of the organisation structure, especially when it comes to contracting and procurement. Barriers can also include a frequent inability to attract the necessary technical skills, cumbersome hiring and procurement procedures, and low pay levels.

Hybrid

A hybrid approach is founded on the decision to divide responsibilities among multiple administrators. Specialist institutions may be used for specific sectors, such as public building stock or low-income users. In California, the hybrid model allows communities to operate their own EE programmes. Regulators directed utilities to make up to 20% of EE funds available to sound proposals from communities to do EE (Sedano, 2011).

Super ESCOs

A Super ESCO is an entity established by a government or via a public-private partnership to function as an intermediary between the government, facility owners and ESCOs to coordinate the large-scale implementation of energy efficiency projects (World Bank, 2018). In India, Energy Efficiency Services Limited (EESL) was established in 2009 as a state-owned ESCO and has emerged as an important entity financing and delivering EE solutions, especially in the residential and public sectors(Sarkar, Neha Mukhi, et al., 2016). EESL's approach involves aggregating demand for EE appliances and equipment, providing up-front financing and using competitive bulk procurement to improve affordability while ensuring the quality of high-efficiency appliances. EESL has been able to mitigate up-front financing risks for its customers by making the entire up-front capital investment, through PAYS under an on-bill financing approach.

3.5 Climate, Equity, and Inclusion

Recognizing the important role the electricity sector needs to play in both mitigating emissions and adapting to climate change, policy makers and regulators in the UK and the US have sought to align utilities' incentives for EE with overarching climate mandates and equity goals.

Climate Benefits

An emerging body of evidence demonstrates the significant opportunity for decarbonizing through demand side measures (Creutzig et al., 2021; IEA, 2021a; Langevin et al., 2021). EE lowers electricity use, which in return reduces the need for burning coal to produce power, thereby reducing GHG emissions. The IEA projects that by 2040 EE can reduce global emissions by 40% (IEA, 2020b). Integrating climate benefits into DSM programmes requires moving from a short-term energy-savings perspective to longer-duration reductions in GHG that consider the full life cycle of the measure implemented. It also requires shifting utility business models to measure success based on GHG reductions to help meet national carbon reduction targets.

Social Benefits

South Africans spend on average 14% of their monthly incomes on energy needs (SEA, 2014). A full 43% of the population is energy-poor, given that they spend more than 10% of their income on energy needs (SEA, 2014), with this percentage increasing as electricity tariffs have increased in real terms and a stagnant economic growth since then (UCT, 2021). Adequate and affordable access to energy services is essential for social inclusion and economic development. Individuals' energy burdens can be lowered by reducing energy waste through measures such as LED lighting, proper insulation, efficient cooling equipment, and distributed renewable energy such as solar water heaters. Home renovation strategies help people save money on energy bills while providing healthier living conditions. By reducing the energy burden, EE also means that the savings can be spent in more beneficial and productive ways, which in return contributes to economic growth and prosperity in South Africa.

Economic Benefits

EE creates jobs in two primary ways. First, investments made to improve homes directly generate opportunities for workers in the construction sector and industries that support it. Such jobs are local and diverse. They cover a spectrum of expertise, from installers, builders, and technicians to architects, engineers, auditors, operators, and managers. EE investment in industries and businesses also creates opportunities for the development of ESCOs, consulting groups, and manufacturers of efficient products. In the United States, for example, it is estimated that EE directly supported 2.2 million jobs in 2022, almost three times more than jobs in the RE industry (E4TheFuture and E2, 2022; EESI, 2021). Figure 6 provides a summary of the primary environmental, social, and economic benefits of EE.

Figure 6. Environmental, Social, and Economic Benefits of Energy Efficiency

Environmental Benefits	Social Benefits	Economic Benefits
• Reducing GHG emissions • Improving air quality • Increasing resilience to climatic effects • Promoting a sustainable lifestyle	• Reducing the energy cost burden • Improving access to energy services (lighting, refrigeration, cooling, etc.)	• Creating jobs • Freeing income for more beneficial and producitve uses • Providing energy security • Increasing productivity

Integrating Benefits into EEDSM Programmes

Recognizing the benefits outlined above, many countries have enacted programmes that prioritise an affordable, equitable, clean energy future. One method is to allocate a percentage of the budget specifically to programmes targeting disadvantaged communities. Brazil's Law 9.991/2000, for example, requires an energy utility to allocate not less than 0.75% of net operational revenue to consumer-oriented EE programmes, 60% of which must be implemented in low-income communities (da Costa Junior et al., 2019; De Souza Silva et al., 2017). In New York State, a senate bill required that at least 35% of spending on clean energy and EE programmes benefit disadvantaged communities (NCSL, 2019).

Other countries set EE goals that maximise GHG reductions and support equity. This approach moves away from goals based on annual savings of kilowatt-hours to target lifetime reductions of GHG and equity distribution (e.g., stipulating a percentage of participants who have specific demographic and socioeconomic characteristics or energy savings that depend on participants' energy burdens, housing conditions, and energy access). Such approaches often require updating the criteria for what can be included in a DSM programme and establishing metrics for what *performance* looks like (Specian et al., 2022). For example, on May 20, 2021, the California Public Utilities Commission (CPUC) reformed its approach to setting goals, evaluating programmes, and planning EE endeavours to include lifetime GHG reduction and equity considerations (CPUC, 2021). The EU Energy Efficiency Directive 2012/27/EU requires member states to include the need to reduce energy poverty in the EE obligations imposed on utilities (EU Commission, 2020).

Changes also have been made in cost-effectiveness metrics to increase the representation of non-energy benefits. The typical cost/benefit metric used in the United States to assess the societal benefit of an EE programme is the total resource cost (TRC). Although TRC can include GHG emissions reductions, it often excludes societal benefits such as economic development or improved air quality. According to the National Energy Screening Project (NESP), the treatment of non-energy benefits in TRCs varies greatly, making it difficult to compare states (NESP, 2017). For example, California recently developed a “total system benefit” to include the lifecycle energy, capacity, and GHG benefits of a utility’s EE programme (CPUC, 2021). Meanwhile, the state of Maine now requires state agencies to develop data relating to low-income households to enable the Maine Efficiency Trust to evaluate the effectiveness of its EE programmes (Baker et al., 2022).

4. Research Findings and Recommendations

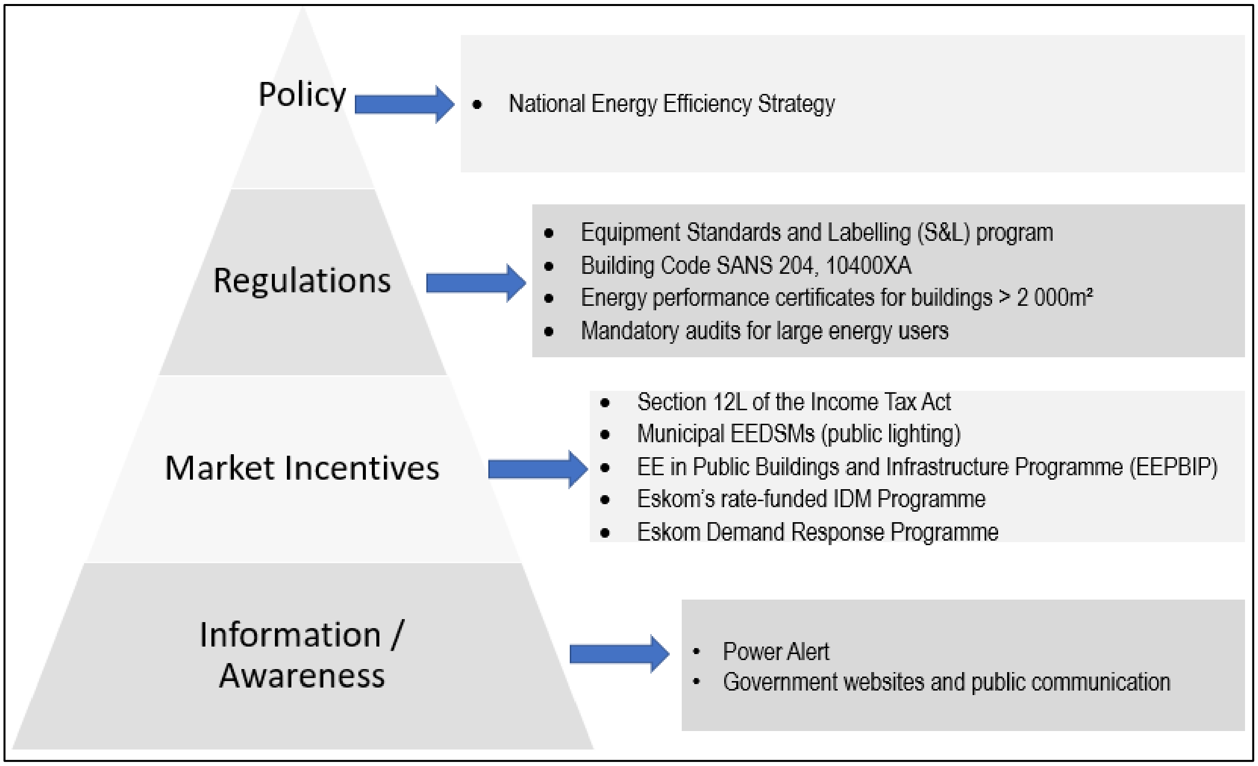
EEDSM as an energy resource is underutilised in South Africa and has the potential to meet short- and long-term national objectives. EEDSM is a proven mitigation mechanism that can meet the country’s urgent short-term goal to eliminate the crisis of persistent and chronic electricity supply shortages. The effectiveness of EEDSM was demonstrated by Eskom’s IDM programme between 2010 and 2015 as well as other mechanisms and programmes from South Africa’s national government, as detailed in Report 1 and consolidated in Figure 7 below. However, as support for EEDSM waned after 2015, the annual savings and other benefits have steadily declined. The recent revival of all DSM types (Figure 4) from national government presents a timely opportunity to also achieve long-term objectives, namely, long-term sustainability. This report identifies the key success factors and mechanisms to establish the enabling environment needed to entrench and expand EE to reap the multiple benefits it offers. The two reports thus respond to the rationale of the study, as defined by the DMRE EE officials:

> *To provide a summarised, evidence-based study that provides senior policy makers, some of whom may not be familiar with recent global developments in DSM, with information that will lead to EE prioritisation and acceleration. Simultaneously, the report seeks to contain sufficient detail to provide DMRE officials with practical guidelines and actions for consideration.*

The research has demonstrated that maximising the energy savings available from EE is premised on addressing identified market barriers that prevent an economy from reaching its full cost-effective EE potential. Some of these barriers are generic whilst others are unique or context specific. Importantly, the widespread adoption of EE is not organic, and it should not be assumed to be such; as with any other transition or policy intervention it requires careful planning, targeted activities and policies that institutionalize and prioritize EE for the long term. Thus, a range of policies and programmes that are regularly reviewed, strengthened, or adjusted are needed to remove present and future barriers. Moreover, successful EEDSM implementation requires the simultaneous removal of all disincentives; it is insufficient to target a limited number. This can only be achieved through a cohesive approach which is led by the policy owner (DMRE) knowing that they enjoy the full support of key government stakeholders, including the Regulator, National Treasury, the utility, distributors and other ministries who must promulgate regulations or implement support programmes.

South Africa's EE and DR efforts, past and present, were detailed in Report 1 and are represented in **Error! Not a valid bookmark self-reference.** within four major categories: policy framework, regulations, market incentives and information / awareness. The first category comprises the national policies that govern the implementation of EE programmes; the second category consists of regulations that standardise and mandate EE performance; the third category entails the market incentives that stimulate private and public investment; the fourth and final category seeks to modify behaviour and influence decision-making.

Figure 7. South Africa's EE and DR Programmes



As has been articulated in the post-2015 NEES, various types of policies are needed to address specific market barriers and to create an enabling environment favourable to obtaining EE investment from households, companies, and the public sector(DMRE, 2016). The NEES provides a pathway for realizing reduction targets through a package of policies, regulations, and programmes. Many of the programmes suggested in the NEES have yet to be implemented, however, and many of those that have been developed need more implementation support to achieve their potential effects. However, the post-2015 NEES is still awaiting Cabinet approval. This straightforward step would demonstrate political will and prioritization of the policy framework that elevates DSM to the 'first fuel" in the country's energy mix.

The experiences of other countries have been analysed in this study and important and appropriate concepts have been detailed to help guide senior policy developers in their decision-making process of how best to revive and strengthen the existing initiatives in a manner that is cost-effective and efficient to maximise energy savings. The fundamental conflict (cost recovery and threat to future sales) that EEDSM presents utilities and why these programmes cannot be sustained on their own is a textbook case study with the Eskom experience, and the decline of existing EEDSM programmes is also a concern. However, the mechanisms included in this report to address these challenges provide proven solutions for consideration. In conclusion, South Africa has access to an entire toolbox of approaches for increasing energy efficiency throughout the country. Applying some of these approaches would address South Africa's climate goals, lower utilities' required investment in infrastructure and fossil energy sources, and further the country's desire for a just and efficient energy future for all.

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