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THE BUILDING EMISSION REDUCTION POTENTIAL OF SOUTH AFRICAN RESIDENTIAL BUILDING EFFICIENCY TOOLS – A REVIEW

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ABSTRACT

The building sector's levels of greenhouse gas emissions and energy consumption are a significant contributor to South Africa's overall carbon emissions. This influences the country's ability to meet its commitments to the Paris Agreement, which aims to limit the effects of global climate change. This review article focuses on the climate change mitigation strategies that are employed by the building sector, specifically the potential impact of mandatory and voluntary building energy efficiency regulations, standards, initiatives, and certifications common to South Africa's residential market. International research on the impact of green building tools tends to focus on the commercial rather than the residential sector, due to limited energy data availability. Within this context and given the exploratory and evaluative nature of the present research endeavour, substantial reliance has had to be made on grey literature for this research. A review of the South African building efficiency tools shows that there is potential for a 16% reduction in the energy intensity of the residential sector by 2030. This will, however, be offset by the projected increased building floor area and is as such insufficient to meet South Africa's commitments to the Paris Agreement. Thus, more ambitious targets are required. Given the growth of the residential sector and the potential impact of the various tools, a focus on improved and timeous mandatory regulations for new builds is crucial, in order to meet our climate commitments.

Keywords: Building energy efficiency tools, climate change mitigation, green buildings, residential sector

ABSTRAK

Die energieverbruik en kweekhuisgasvrystellings deur die boubedryf lewer 'n beduidende bydrae tot Suid-Afrika se algehele koolstofvrystelling en beïnvloed ons vermoë om ons verbintenisse tot die Parys-ooreenkoms na te kom, wat daarop gemik is om klimaatverandering te beperk. Hierdie oorsigartikel ondersoek die versagtingsmaatreëls wat in die boubedryf gebruik word om klimaatverandering te bekamp, en spesifiek die potensiële energie-besparende impak van verpligte en vrywillige energie-doeltreffendheid of groenbou-instrumente wat in die Suid-Afrikaanse residensiële mark gebruik word. Internasionale navorsing is tipies toegespits op die impak van groenbou-instrumente op die kommersiële eerder as op die residensiële sektor, as gevolg van beperkte beskikbaarheid van energiedata in die residensiële sektor wêreldwyd. Gegewe hierdie konteks, en die verkennende en evaluerende aard van die navorsing, moes daar aansienlike vertroue op 'n aantal grysliteratuur vir hierdie navorsing gemaak word. Na 'n hersiening van die Suid-Afrikaanse residensiële groenbou-instrumente, is daar 'n potensiaal vir 'n afname van 16% in die energie-intensiteit van die residensiële sektor teen 2030. Hierdie afname word egter teengewerk deur die geprojekteerde toename in algehele residensiële vloeroppervlakte en is sodanig onvoldoende om aan ons verbintenisse van die Parys-ooreenkoms te voldoen. Meer ambisieuse teikens word dus benodig. Gegewe die groei in die residensiële sektor en die potensiële impak van die verskillende groenbou-instrumente, is tydige en verbeterde verpligte regulasies vir nuwe geboue uiters belangrik om aan ons klimaatverbintenisse te voldoen.

Sleutelwoorde: Energiebesparings, groenbou-instrumente, groen geboue, klimaatverandering, residensiële sektor, versagtingsmaatreëls

1. INTRODUCTION

The World Health Organization (WHO, 2015: online) views climate change as "the greatest threat to global health in the 21st century". This may necessitate a global response to the climate change crisis, akin to that required of the COVID-19 pandemic (Bir, 2020).

According to the special report of the Intergovernmental Panel on Climate Change (IPCC), disadvantaged and vulnerable populations, especially the poor in Africa and Asia, will be hardest hit by climate change, with an increased risk to their "health, livelihoods, food security, water supply, human security, and economic growth" (IPCC, 2019: 11). Globally, cities are responsible for more intensive resource use, and 70% of carbon dioxide emissions (UN-Habitat, 2016: 1). This, coupled with continuous urbanisation, will lead to a "deadly collision between urbanization and climate change" (UN-Habitat, 2011: 183). Cities can thus be viewed as major environmental culprits. However, they can also dramatically contribute to mitigating the effects of climate change (UN-Habitat, 2016: 17).

This, of course, has many ramifications, but the focus, in this instance, is on the building sector in cities, since this sector presents the most significant opportunity for low-cost emissions and energy-use reductions (WRI, 2016: 17). Given that buildings last for generations and have long renovation cycles, there is a "need for early and rapid investment to prevent locking in carbon intensive investments" (CBI, 2017: 12).

Since the International Energy Agency (CBI, 2017: 10) has projected that residential floor area would increase by 75% between 2015 and 2050, this article focuses specifically on the residential building sector in South Africa. Part of South Africa's attempt to meet its climate change commitments is to employ building efficiency tools, which include several mandatory and voluntary regulations, standards, initiatives, and certifications. This article thus aims to describe and especially evaluate the potential impact on emissions reduction of such tools, specifically in the formal residential sector.

2. METHODS AND REVIEW APPROACH

The review provides both an international and a South African background to the impacts of, and responses to climate change. First, the climate change mitigation commitments made under the Paris Agreement are summarised, and the scope and impact of these commitments clarified. Secondly, the carbon emissions impacts of the building and residential sectors are discussed, creating the impetus to focus on this area. Thirdly, the climate change mitigation tools used in the building sector and their impact on the mitigation of climate change are reviewed.

Qualitative research methods were employed for this article, primarily through the application of desktop research and secondary data analysis. Relevant materials used in this review consisted of articles, theses, reports, and other documents obtained from the University of the Witwatersrand's Library database and the internet. As an initial search, relevant documents were identified through the application of a database keyword search for terms associated with the climate change mitigation potential of green building tools. Search terms included climate change, Paris Agreement, building sector, residential sector, green building tools, and building efficiency. The primary search was performed between 15 October 2019 and 30 November 2019, with supplementary supporting information sourced between 24 February 2020 and 19 April 2020. Preference was given to more recent literature so as to reflect current research on, and approaches to the topic. To expand the relevant literature for review, several of the references used in the initial texts were additionally evaluated for their relevancy to this topic.

It was evident from the initial search for relevant academic material that international research on the impact of green building tools tends to focus on the commercial rather than the residential sector. This may be because residential energy consumption data are limited across the world (CBI, 2017: 8). This worldwide trend of limited energy data availability, and subsequently research output, is also evident in South Africa. The paucity of relevant literature, and the exploratory and evaluative nature of the present research endeavour, required a heavy reliance on grey literature for its review. This documentation primarily consists of reports and policy documents from both governmental and non-governmental agencies, which were identified and sourced either through internet search terms, or because they were referenced or referred to in the sourced journal articles.

It is important to note that this review utilises sources with varying degrees of credibility, and this may influence the final accuracy and validity of the results obtained. For example, statistics and assessment reports by the IPCC are considered highly credible, as the IPCC assesses and summarises published climate change research that has been undertaken worldwide. This could be contrasted with statistics provided by state-owned entities regarding residential energy and electricity consumption, which are inconsistent (UNEP-SBCI, 2009: 25, 31). Thus, educated assumptions need to be made regarding which data to use. Data obtained from Statistics South Africa and the Quantum database, which were used in this study, are accurate, although they may contain some unknown biases.

In the discussion section, the building efficiency tools utilised or proposed in South Africa are evaluated, within the context of the carbon footprint of our national energy supplier, and the residential sector's energy demand, composition, and growth projections. This is done by considering the tools' areas of impact (energy efficiency, carbon footprint of energy supply, carbon footprint of building materials), and ultimately their potential reduction in the energy intensity of the residential building.

3. KEY ISSUES

3.1 The Paris Agreement and nationally determined contributions

The impacts of global warming on natural and human systems have already been observed (Scholes, Scholes & Lucas, 2015: 51-52), and some of the projected impacts may be long-lasting or even irreversible. Disadvantaged and vulnerable populations will be hardest hit by climate change (IPCC, 2019: 20), and countries in Africa would need to devote 5% to 10% of their Gross Domestic Product (GDP) simply to adapt to these negative impacts (DPW, 2018: 63).

These global warming (and climate change) risks and impacts can be addressed through increased, accelerated, and far-reaching climate mitigation action (IPCC, 2019: 7). The Paris Agreement (Climate Focus, 2015: 1; UN, 2015: 1) was adopted by parties at the UN Framework Convention on Climate Change (UNFCCC) on 12 December 2015, with 195 countries having ratified the Paris Agreement by October 2019 (United Nations Treaty Collection, [n.d.]). This Agreement aims to hold "global average temperature to well below 2°C above pre-industrial levels" and to pursue "efforts to limit the temperature increase to 1.5°C above pre-industrial levels" (UN, 2015: 3). In addition, greenhouse gas emissions are intended to peak as soon as possible, with a rapid reduction afterwards (UN, 2015: 4).

All parties to the Paris Agreement were to develop their own country-specific climate mitigation plans and commitments and provide progressively more ambitious nationally determined contributions (NDCs) every five years (Climate Focus, 2015: 1). Intended NDCs (INDCs) were submitted by 97% of the parties to the UNFCCC by 18 April 2016, which represented 94.6% of carbon dioxide (CO_2) emissions worldwide (UNFCCC, 2019).

South Africa ratified the Paris Agreement on 1 November 2016, having already provided its INDC by 25 September 2015. The main targets of the INDC (Government of South Africa, 2015: 6) are that:

- emissions will range within 398 and 614 Mt CO_2-eq[1] between 2025 and 2030;
- the emission profile will peak between 2020 and 2025, plateau for a decade and then decline in absolute terms from there onwards, and
- targets apply to all sectors of the economy.

In 2018, South Africa released the draft Climate Change Bill for comment (DEA, 2018: 4), which seeks to establish a legal framework to determine a national emissions reduction trajectory and to set carbon budgets and sectoral emissions targets (DEA, 2019: 75). While South Africa is one of the few countries to provide absolute targets in its INDC, the commitment is nevertheless insufficient to place the country on a pathway that will limit warming to +2 °C or less (Climate Action Tracker, 2019).

This is consistent with the findings in the report by the United Nations Framework Convention on Climate Change (UNFCCC), which states that the aggregate effect of all the INDCs by countries worldwide is insufficient to meet the target warming level limit (UNFCCC, 2016: 13). Similarly, another study (Fawcett, Iyer, Clarke, Edmonds, Hultman *et al*., 2015:

1 Mt CO_2-eq denotes 'metric tons of carbon dioxide equivalent', which is used to quantify the global warming impact of emissions from different greenhouse gases, standardised to that of one unit mass of carbon dioxide.

1169) concludes that a continuation of current weak policies that target a 2% annual improvement in CO_2 emissions per unit of GDP provides zero chance of limiting warming to +2°C. Whilst current NDCs pledge stabilising the total yearly global CO_2 emissions, they provide only an 8% probability of limiting warming to +2°C. If the NDC pledges are "progressively tightened" from 2030 onwards, as per the intent of the Paris Agreement, the probability increases to 30%.

No sector-specific targets or plans are provided in South Africa's INDC, beyond the recognition of the large impact of the energy sector and the need for a lower-carbon supply. A United Nations Environment Program (UNEP) report (2018b: 15) notes that South Africa's current 2030 upper emissions target would be reached only if the country's future energy mix decarbonises, as per the 2019 Integrated Resource Plan (DMRE, 2019: 42), which came into effect in October 2019. South Africa's INDC refers specifically to the significant impact of our energy sector on our current Greenhouse Gas (GHG) emission levels, and that substantial investment in transforming the sector away from coal is required (Government of South Africa, 2015: 9).

3.2 The climate change impact of the building sector

Global levels of urbanisation have increased rapidly from approximately 29% to 49% in the past half century, and South Africa was already 66% urbanised by 2018 (Statista, 2020). Global emissions from fossil-fuel burning have increased by almost 500% in the same period, with 2016 being the hottest year in recorded history, exceeding 2019's level by 0.04°C. Cities are essential in the conversation about global emissions, as they account for between 60% and 80% of the world's energy consumption and generate 70% of the human-induced greenhouse gas emissions (UN-Habitat, 2016: 1).

The construction and operation of buildings is a leading contributor to these emissions, accounting for 36% of the world's energy use and 39% of the carbon dioxide emissions in 2017, as illustrated in Figure 1 (IEA & UNEP, 2018: 11). The residential sector accounts for 22% of worldwide energy consumption and roughly 17% of global emissions.

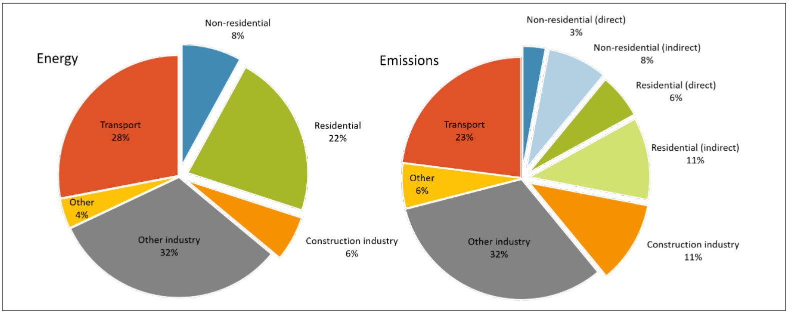


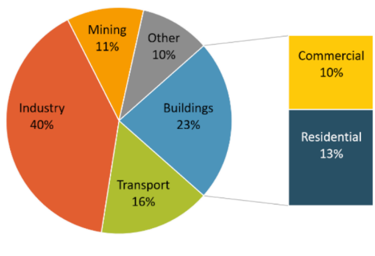
Figure 1: Global share of buildings and construction final energy and emissions in 2017.

Source: Adapted from IEA & UNEP, 2018: 11

The picture in South Africa is similar, with the residential sector responsible for 20% of the electricity consumption (Deloitte, 2017: 20) and 13% of the country's total greenhouse gas emissions (UNEP-SBCI, 2009: 33), as per Table 1.

Table 1: The building sector and the residential market's carbon emissions in 2006

South African CO_2 emissions per sector in 2006	%
Commercial	10%
Residential	13%
Building sector subtotal	**23%**
Transport	16%
Industry	40%
Mining	11%
Other	10%
Total	**100%**



Source: Adapted from UNEP-SBCI, 2009: 33

The International Energy Agency (CBI, 2017: 10) has projected that residential floor area will increase by 75% between 2015 and 2050, with similar growth levels projected for non-residential buildings. Africa, Asia and India are expected to show particularly rapid building growth, with floor area in Africa expected to more than triple by 2060.

The South African housing market is becoming more formalised at a rate that is higher than the average population growth rate, with the number of formal dwellings increasing by an average of 3.1% per year (Quantec, 2018). Despite improved energy efficiency of buildings globally, the energy needs of the building sector as a whole continue to increase, due to the floor area growth outpacing the reduced energy use per square metre that has been achieved (CBI, 2017: 10; UNEP & IEA, 2017: 7). With the massive increase in floor area projected in non-OECD countries, in part due to the significant housing deficit currently experienced, a focus on high-performing new builds should be prioritised in these regions (UNEP, 2011: 344).

The built environment can be viewed as high-inertia infrastructure, where investment and construction decisions made currently can lead to a detrimental lock-in of carbon-intensive investments for decades to come (Akerman & Hojer, 2006: 1953; UNEP & IEA, 2017: 13). The reason for this is that buildings tend to last decades, sometimes generations, with the thermal envelope[2] and roofs being very infrequently renovated during the usable life of buildings (CBI, 2017: 12).

3.3 Mitigating the climate change impact of the building sector

As urbanisation brings about fundamental changes in cities' production and consumption patterns, cities can be both part of the problem of, and the solution to climate change. They offer many opportunities to develop mitigation and adaptation strategies, with the economies of scale making it less expensive and easier to take action, in order to minimise both emissions and climate-related hazards (UN-Habitat, 2016: 17). As illustrated in Figure 2 (WRI, 2016: 17), bottom-up studies have shown that, compared to other sectors, the building sector presents the most substantial opportunity for cost-effective energy and emission reduction by 2030.

In the WRI's (2016: 56) report titled "Accelerating building efficiency: Eight actions for urban leaders", the first four of the eight actions identified as ways to deliver accelerated building efficiencies are Building Efficiency Codes and Standards; Efficiency Improvement Targets; Performance Information and Certifications, and Incentives and Finance. These speak directly to the building efficiency tools that are the focus of this article and are elaborated on in the ensuing subsections. These priorities broadly align with the key strategies identified by other institutes, including the roadmap provided by the Global Alliance for Buildings and Construction (UNEP & IEA, 2017: 13).

3.3.1 Building Efficiency Codes and Standards

Voluntary and mandatory energy codes or certification schemes for the building sector have been in use in over 80 countries worldwide for the

2 In countries where there is a large temperature difference between the inside and the outside of buildings, thermal insulation of the envelope elements such as walls, roofs and windows, becomes a key means of passively reducing the energy required to maintain comfortable temperatures inside (Szokolay, 2014).

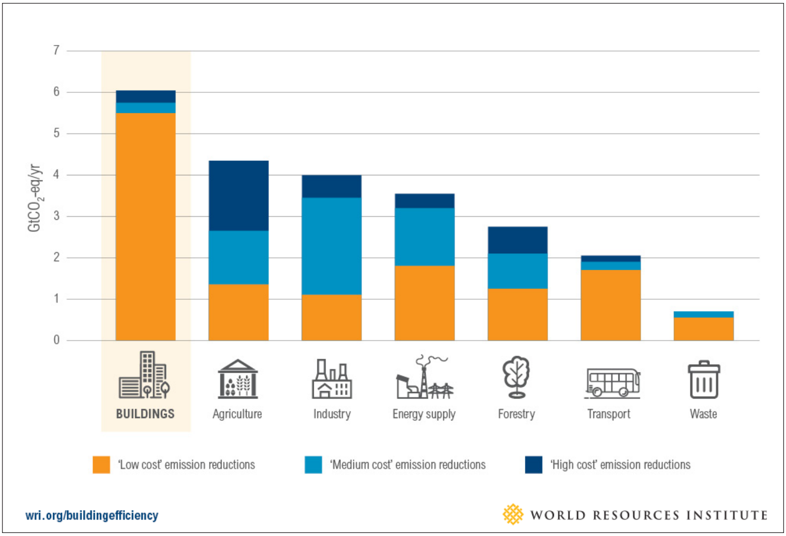


Figure 2: Estimated economic mitigation potential by sector in 2030
Source: WRI, 2016: 17

past 30 years (Wong & Kruger, 2017: 310; IEA & UNEP, 2018: 20), with this rise being correlated to the oil crisis of the 1970s (Caceres, 2018: 1). A precursor to building certification and energy rating schemes was the implementation of household appliance efficiency ratings, which provide accurate energy consumption information of appliances (Wong & Kruger, 2017: 310).

As of 2018, 69 countries worldwide have mandatory or voluntary building energy codes or standards, but this still leaves two-thirds of countries without either of these (IEA & UNEP, 2018: 20). Over half of the new buildings expected to be constructed between 2020 and 2060 are projected for so-called 'developing countries' that do not have *any* mandatory building codes requiring minimum energy efficiency levels in place (UNEP & IEA, 2017: 8).

In September 2011, the South African National Building Regulations (NBRs) were updated to include a section on energy efficiency, designated 'Part XA – Energy Usage in Buildings'. This section requires that all new buildings or major refurbishments be designed and built so that their passive design (orientation, shading, services, and the building envelope) ensures efficient use of energy, and that at least 50% of hot water generation (by volume) takes place without the use of electric resistance heating.[3] The intent is that this standard is updated every five years to become gradually more stringent (Ecolution Consulting, 2019: 30), although there are suggestions that even the best-practice norm of 3 to 5 years between updates is not optimal (Gray & Covary, 2015: 16).

The update of the NBRs is currently overdue, as eight years have passed since the promulgation of the previous version, with the Department of Public Works (DPW) stating that an update is “urgently needed” (DPW, 2018: 15). In January 2020, a draft version of the updated standard was released for public comment, with the window for comments closing on 24 March 2020. While the maximum annual energy consumption of commercial buildings is set to be reduced significantly if the standard is implemented in its current form, it is yet unclear to what extent the proposed update will influence the energy intensity of residential buildings (SANS, 2020).

3.3.2 Energy Efficiency Improvement Targets

Of the 194 NDCs submitted as part of the Paris Agreement, only 70% referenced the building or construction sectors (Figure 3), despite these sectors contributing to nearly 40% of the global greenhouse gas (GHG) emissions (UNEP, 2018a: 13). No sector-specific targets or plans are provided in South Africa’s NDC.

Over 50% of NDCs referenced building energy efficiency, while 26% mentioned low carbon energy supplies (IEA & UNEP, 2018: 18), and only 5 NDCs (2.5%) mentioned low carbon construction, despite this providing a third of the carbon reduction potential (CBI, 2017: 7). Most of these NDCs do not provide specific targets or policy actions on reducing the impact of buildings, even for those countries that have such policies in place (UNEP & IEA, 2017: 18). The lack of targets was identified as a critical gap to be addressed as part of the support provided by the Global ABC to countries in the update to their NDCs (IEA & UNEP, 2018: 9).

3.3.3 Building Efficiency Performance Information and Certifications

Quality building performance information can provide stakeholders with the ability to make informed decisions on actions to improve their buildings’ efficiency. Certifications, which are often voluntary, can provide public recognition and increased value to highly efficient buildings (WRI, 2016:

3 The conventional approach to water heating for domestic use uses an electrical element inside a geyser to heat water (‘electric resistance heating’). SANS 10400–XA Regulations require that all new buildings utilise other means of heating at least 50% of the water, such as solar water heaters, heat pumps and gas geysers.

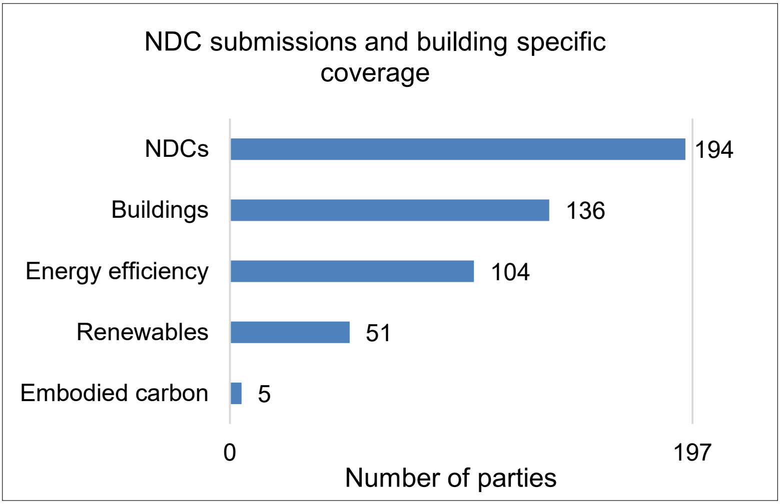


Figure 3: NDC and buildings policy coverage for 2017-2018
Source: Adapted from IEA & UNEP, 2018: 18

74). Green building rating tools or certifications are used in 85 countries and focus on evaluating the design (expected) or operational (measured) energy use of buildings. They are broadly voluntary outside of the European Union (EU), but the uptake is growing among the high-end building sector (IEA & UNEP, 2018: 23). Where building codes typically provide the minimum (often mandatory) building standard, several voluntary rating tools offer certification against best-practice standards (DPW, 2018: 12).

Energy Performance Certificates (EPCs) provide performance information as well as certification and have been used across the world to improve building energy efficiency and inform stakeholder decisions since the 1990s (Pasichnyia, Wallinb, Levihnc, Shahroknia & Kordasa, 2019: 486). EPCs serve to benchmark buildings against regulatory standards or industry benchmarks and to establish a database of building energy performance. EPCs provide either estimated ratings based on building features, or measured ratings determined through energy meter readings. The intent is to provide accurate and valuable information with regard to building energy performance (Caceres, 2018: 2), and a true reflection of this can only be obtained through energy consumption data. Studies have shown that design ratings are rarely an accurate reflection of energy performance, although more accurate estimates are possible based on the estimation methodology used (Wong & Kruger, 2017: 321).

Mandatory EPCs have been implemented in all 28 EU member states (BPIE, 2014: 6), and are used worldwide, including in the United States of America, Australia, Singapore, Japan, Brazil, Turkey, and India. In the EU, EPCs are required when buildings are newly constructed or advertised for rent or sale, and must be placed in a visible location in public buildings (Wong & Kruger, 2017: 320). South Africa's Department of Energy published draft EPC regulations for public comment in 2018 (Parliamentary Monitoring Group, 2018). The proposed mandatory EPCs (SANS, 2014: 3) are not required in the residential sector and are for existing commercial buildings used for entertainment, public assembly, theatres, indoor sports arenas, places of instruction, and offices only.

EPCs have been shown to not only improve the energy efficiency of buildings, but highly efficient buildings also attract a sales premium of up to 10%, thus acting as economic incentives for developers to innovate further (Wong & Kruger, 2017: 316). An EPC's effectiveness in reducing energy intensity can be increased through the provision of cost-effective recommendations on how to improve the building's energy efficiency (Wong & Kruger, 2017: 321; Caceres, 2018: 3), something that is not required in the current South African scheme.

Globally, green building certifications are typically voluntary, and they intend to promote and reward environmental sustainability in buildings (Yigit & Acarkan, 2016: 4840). The World Green Building Council (WorldGBC) has approximately 70 member Councils worldwide, which together administer 54 different green building rating tools (WorldGBC, 2019b). Internationally, several additional tools are used that are not managed by WorldGBC member Councils.

In the South African residential market, the EDGE ('Excellence in Design for Greater Efficiencies') Residential tool has had the largest uptake of the residential green building certifications available. The EDGE certification and other 'design' ratings derive their rating levels from estimated or modelled energy performance based on building features, which is poorly correlated to actual operational performance or emission intensity and has been criticised on this basis (CBI, 2017: 38; Wong & Kruger, 2017: 321; Khosla & Janda, 2019: 4). Given consistent energy modelling assumptions, 'design ratings' do, however, allow for the comparison of the relative potential energy efficiency of different building designs (Mey, 2020: 19).

'Operational' or 'measured' green building ratings such as Net Zero Carbon, which validate their energy performance or emission intensity through actual energy meter readings, are considered preferable to design ratings (CBI, 2017: 26; Wong & Kruger, 2017: 321). Net Zero certifications carry additional support in that they are compatible with the rapid decarbonisation of the building sector to meet the targets of the Paris Agreement (CICERO, 2015; CBI, 2017: 17; WorldGBC, 2017).

The WorldGBC launched a 'Net Zero Carbon Buildings Commitment' in September 2018, intending to achieve a 40% reduction in embodied carbon emissions by 2030 and 100% net zero carbon emissions by 2050. As of September 2019, the commitment has been signed by 63 organisations, including 31 businesses, 6 states and regions, and 26 cities (WorldGBC, 2019a), representing over 130 million people globally (IEA & UNEP, 2018: 10). Regions include Catalonia in Spain and Yucatan in Mexico, with Johannesburg, Tshwane, eThekwini and Cape Town in South Africa having also committed to actions that target improved energy efficiency in both commercial and municipal buildings (WorldGBC, 2019a).

3.3.4 Building Efficiency Incentives and Finance

Incentives and financing promote the uptake of green new builds and the energy-efficient retrofitting of existing buildings, by alleviating the burden of the additional upfront costs, whose benefits tend to only accrue over time (WRI, 2016: 7).

Financial incentives can take the form of grants (such as the German 'Kfw Energy-Efficient Renovation' programme), rebates (Singapore's 'Design for Efficiency Scheme'), tax incentives (Brazil's 'Qualiverde Program'), and green mortgages (pilot by 37 European banks) (Climate Action, 2018).

The EU's building stock is dominated by existing buildings, and improving the energy efficiency of existing residential homes is considered essential to achieving their carbon emission targets (UK, 2019). As part of this, green mortgages are being piloted to encourage residential retrofits and improve their energy efficiency.

The minimum performance threshold for new builds is 'nearly net zero' buildings, or a 20% improvement over national standards, or a 30% energy demand reduction for renovations (WorldGBC, 2018b).

In South Africa, no national incentives exist, although two banks are offering 'green loans'. Nedbank is offering an extension to their home loan product, where renewable and energy-saving products from a specific supplier can be rolled into homeowners' home loans (Nedbank Limited, 2019). Most recently, ABSA and Balwin Properties have announced the 'Absa Eco Home Loan', which provides preferential interest rates on the 16,000 EDGE-certified homes under development by Balwin Properties (Engineering News, 2020).

Green bonds are financial instruments that allow the raising of debt to finance eligible green projects or activities. Of the $46 billion capital that has been raised on the green bond market, 28% has been allocated to the building sector. In South Africa, three bonds have been issued under the Johannesburg Stock Exchange's green bond requirements since its launch in late 2017, of which one was for a certified green building portfolio (CSS, 2019: 6). Green bonds benefit the issuer in that they are often oversubscribed, allow a company to market its 'green credentials', and can often be sold at a premium. In return, the proceeds are ringfenced for socially responsible activities, as per the bond mandate (Bagnoli & Watts, 2020: 1). Non-financial incentives are often aimed at developers of new builds in high-density cities, where green features or energy efficiency measures are encouraged. The incentive can take the form of allowing extra height or floor area, such as Delhi's 'Sustainable Buildings Incentive Scheme', which can award a bonus 1% to 4% coverage (WRI, 2016: 80-82).

Internationally, 2017 saw a slowdown in the rate of energy efficiency investments, with a 4.1% increase (2.5% adjusted for inflation), compared to the 6%-11% annual growth rates from 2014 to 2016. Overall energy efficiency accounts for only roughly 8% of total spending on buildings, with residential buildings receiving only half of the total investments, despite contributing to three-quarters of the global building energy use (IEA & UNEP, 2018: 26).

4. DISCUSSION

In order to decarbonise the building sector and stay within the +2°C limit,[4] the CBI advocates a focus on 'total building emissions', not simply on improved energy efficiency. The IEA states that only approximately a third of the required carbon reduction can be achieved through building efficiency alone (net zero buildings and deep renovations). The remaining two-thirds reduction requires a low carbon energy supply and the use of low carbon building materials (CBI, 2017: 7).

The mandatory and voluntary building efficiency tools are discussed individually in the ensuing sections, first, to see with which of the three 'total building emission' reduction areas they align; secondly, to discuss their reach, and finally the targeted energy intensity reduction and calculated achievable impact.

4.1 Impact of individual mandatory tools from the National Energy Efficiency Strategy

The post-2015 National Energy Efficiency Strategy (NEES) was developed to respond to the dual scenario of increased energy demand and a

4 The Paris Agreement aims to hold "global average temperature to well below 2°C above pre-industrial levels" and to pursue "efforts to limit the temperature increase to 1.5°C above pre-industrial levels" (Paris Agreement, 2015: 29).

commitment to a reduced environmental footprint, as per South Africa's National Development Plan 2030 and its Paris Agreement commitments. The post-2015 NEES aims to "encourage continued growth by 'reducing energy inefficiency as a barrier' to future progress" (emphasis in original), through the promotion of energy efficiency as a 'first fuel'[5] (DEA, 2016: 3). The post-2015 NEES document addresses several sectors and, for the residential sector, provides a targeted overall energy intensity reduction of 33% by 2030, using 2015 as the baseline.

The overall target of 33% comprises a targeted 20% improvement of the average energy performance of the residential stock overall, and a 33% improvement in the energy efficiency of new household appliances. Measures to improve the energy performance of the residential stock include the progressive tightening of the building efficiency standards; the issuance of energy performance certificates; financial incentives for improving the thermal performance, and educational programmes. The measures related to household appliances include mandatory labelling; the successive tightening of minimum energy performance standards; energy endorsement labels, and a scrappage scheme for old, inefficient appliances. Table 2 provides an overview of the potential impact of the NEES.

4.1.1 The impact of mandatory national building regulations and standards

Successive tightening of the building efficiency regulations and standards constitutes a large portion of the NEES' targeted 20% improvement in the average energy performance of the residential sector, as it is based on a 38% tightening of the South African National Building Regulations (NBRs) energy efficiency standards by 2030. This is discussed in terms of focus area, reach, target, and achievable impact.

Focus area – The National Building Regulations and Standards' primary focus is 'energy efficiency', as the 'Environmental Sustainability' portion (part X) of the national standards currently pertains only to 'Energy usage in buildings' (part XA), specifically the efficient use of energy. The embodied energy of the material used in construction is not addressed, and the

5 The 'first fuel' concept is one that evolved from considering energy efficiency as a 'hidden fuel source', as the ability to use energy more efficiently allows the unused portion to be applied to other needs. As the energy use avoided by IEA member countries in 2010 was larger than any one fuel source, including coal, energy efficiency can be considered as the 'first' or largest fuel (IEA, 2014: 29).

Table 2: Potential energy intensity reduction by mandatory building efficiency tools, as per the NEES

	Tool	*Focus area: Energy efficiency*	*Focus area: Low carbon energy source*	*Focus area: Embodied energy*	*Achievable impact based on the reach of the tool*	*Potential energy intensity reduction*
Mandatory tools: National Efficiency Strategy (post-2015 NEES)	National building regulations	Yes	Limited to water heating	No	7.6% reduction in the energy intensity of the 2030 residential building stock, if ambitious targets are met	7.6%
	Thermal retrofits incentives	Yes	No	No	12% improvement of the energy intensity of the 2030 residential building stock, if ambitious targets are met. 1% reduction in the energy intensity is considered a more achievable target	1%
	Energy performance certificates	Yes	Promotes low carbon energy sources such as PV solar as its use lowers overall energy consumption and improves certificated rating	No	Most of the properties could have EPC by 2030, although energy intensity improvements will only be noticed later. A national database of residential energy intensity, track the impact of building policies, and implementation of minimum energy efficiency requirements	~
	Appliance minimum energy performance standards	Yes	No	No	15% MEPS tightening by 2021 would result in a 4% to 6% reduction in residential energy intensity by 2030	4% to 6%
	Educational programmes	Yes	Yes	No	Not quantified	~

carbon intensity of the energy used is only viewed as part of the hot water heating requirement.

Reach – The NBR requires that all new buildings or major refurbishments be designed and built so that their passive design (orientation, shading, services, and building envelope) ensure efficient use of energy, and that at least 50% of hot water generation (by volume) takes place without the use of electric resistance heating.[6]

Target – To achieve its targets, the NEES (DEA, 2016: 22) states that it requires a 38% reduction in household energy consumption in new builds, by tightening the current National Building Regulations (NBRs) energy efficiency standards by 2030, assuming that at least 20% of all buildings in 2030 will be built after 2015 or the introduction of the new standard.

Achievable impact – To achieve an overall reduction of 38%, a significant tightening of the NBR is required, as it currently mandates only efficiency requirements for hot water systems and the passive design (orientation, shading, services, and building envelope insulation). As water and space heating accounts for only 53% of the energy consumed in urban medium- and high-income households (UNEP-SBCI, 2009: 29), it would require an average efficiency improvement of 72% for these two systems to meet the 38% target.

The NBR is applicable only to formal dwellings. An evaluation of South African housing data (Quantec, 2018) indicates that 33% of formal households projected to have been built by 2030, will be built post-2015. With medium- and high-income households responsible for 89% of total electricity consumption (UNEP-SBCI, 2009: 29), the homes built from 2016 will constitute 29% of the total household electricity consumption. Thus, in order to achieve the requisite minimum 20% of formal new housing for the target, the NBR standards must be tightened by the proposed 38%, by 2021 at the latest. If the target is met, it could result in a total impact of 7.6% reduction of energy consumption per square metre of 2030 residential building stock (excluding plug loads) (Mey, 2020: 55). It is important to note that raising the minimum standards of the NBR by the proposed 38% would not guarantee an equivalent energy consumption reduction in the new homes implementing the improved standard. The reason for this is that implementing the requirements of the standard would only ensure that the notional energy use of buildings is improved, but no measurements are required to confirm or prove expected savings.

6 The conventional approach to water heating for domestic use uses an electrical element inside a geyser to heat water ('electric resistance heating'). SANS 10400–XA Regulations require that all new buildings utilise other means of heating for at least 50% of the water, such as solar water heaters, heat pumps, and gas geysers.

4.1.2 The impact of thermal retrofits incentives

As of 2014, low-cost state-subsidised housing has been required to meet NBR standards as well, after the release of the improved norms and standards for stand-alone residential dwellings built by the government (DHS, 2014: 1). For the past 20 years, these houses were constructed without insulated ceilings and weather-proofing, thus providing inferior thermal insulation to the homes. The updated standard requires the installation of ceilings and insulation, plastering or rendering of walls, and smaller windows with energy efficiency safety glass panes (SEA, 2017: 79).

Focus area – As an interim measure for existing buildings or built before the proposed NBR update, financial incentives are proposed to encourage the undertaking of thermal retrofits.

Reach and target – The NEES targets a 15% improvement for existing homes, which would amount to roughly 80% of the residential building stock in 2030.

Achievable impact – Globally, the typical renovation rates are approximately 1% to 2% of the building stock per year, with an overall energy intensity improvement of 10% to 15% from multiple improvement measures (GlobalABC & UNEP, 2016: 16; IEA & UNEP, 2018: 37). It is thus unlikely that the 15% improvement of the total existing stock would be achieved by 2030. If met, it would result in an overall impact of 12% reduction of energy consumption, which conflicts with a report, cited in the NEES, stating that the potential for energy intensity improvements from passive thermal design is limited to 5% (DEA, 2016: 12). In order to achieve the target of 15% improvement, it would require a 65% reduction in the electricity expended on space heating, as space heating accounts for only 23% of households' average electricity consumption (UNEP-SBCI, 2009: 29).

Assuming an optimistic average renovation rate of 2% per year, with a 10% energy intensity improvement starting in 2020, a more realistic, if bullish, target for South Africa is a 1% improvement in the residential stock's energy intensity, due to thermal retrofits (Mey, 2020: 57).

4.1.3 The impact of energy performance certificates

South Africa's Department of Energy published draft Energy Performance Certificates (EPCs) regulations for public comment in 2018 (Parliamentary Monitoring Group, 2018). EPCs would allow landlords to systemically analyse their building's stock energy performance, while populating a country-wide energy intensity database of the building sector and supporting the government's national energy efficiency strategy.

The proposed mandatory EPCs (SANS, 2014) are not required in the residential sector and are for existing commercial buildings used only for entertainment, public assembly, theatres, indoor sports arenas, places of instruction, and offices. EPCs are, however, used extensively in the residential sector in several countries, and they may also be extended to the residential sector in South Africa in the future, as per the measures to be assessed for feasibility under the post-2015 NEES.

Focus area – Energy performance certificates (EPCs) report on the energy intensity of a property and serve as an informative tool for both owners and occupiers, in terms of the energy efficiency of a building. Because EPCs have been shown to improve the sales and rental price of properties, they drive improvement in energy efficiency and alternative energy sources (Wong & Kruger, 2017: 316; Caceres, 2018: 3).

Reach and target – The NEES envisions the use of EPCs for both newly constructed and existing residential stock, with different strategies for owners and renters. As per the 2017 Household Survey (Stats SA, 2017), 56% of households own the dwellings they occupy, while 30% rent and 14% occupy rent-free. For owners, the NEES may explore the use of incentives such as rebates on transfer duty, if made voluntary, or making EPCs mandatory upon transfer of a property. If it is assumed that South African tenure trends are similar to those of other countries (Moon & Miller, 2018; GBCSA, 2018), it takes between 10 and 20 years for properties to change hands, the point at which a mandatory EPC on transfer would be required. The majority of properties could thus feasibly have an EPC by 2030, although the energy intensity impact may only be felt later as the market matures its response to EPC ratings (DEA, 2016: 20). EPCs may have to be made mandatory for rentals (up to 44% of the market), due to the split incentive that exists, as the tenant receives the benefits from lower utility bills, instead of the owner (Mey, 2020: 58).

Achievable impact – International studies show a broad band of possible impacts of implementing EPCs, with the most conservative in the range of 2% to 3% energy consumption reduction (Wong & Kruger, 2017: 316). The NEES provides no targeted energy intensity improvement as a result of EPC implementation. This may be due to the difficulty in separating the impact, due to policies and standards, or wholly due to the market incentive created by the EPCs. As EPCs serve as a national source of information on the energy intensity of properties, they can also be a tool used to track the impact of building policies and the implementation of minimum energy efficiency requirements (BPIE, 2014: 8).

4.1.4 The impact of appliance minimum energy performance standards

The NEES intends to transform the market for household appliances to more energy-efficient models, through the application of both push-and-pull strategies. The four specific strategies are minimum energy performance standards (MEPS) that are successively tightened; a scrappage scheme for old inefficient appliances (the ‘push’ strategies); mandatory labelling, and energy endorsement labels (the ‘pull’ strategies).

Focus area – Energy efficiency only, with this measure not seeking to address any of the other focus areas.

Reach and target – Minimum Energy Performance Standards (MEPS), combined with energy labels, have been shown to be an effective method to encourage appliance energy efficiency (Götz, Tholen, Adisorn & Covary, 2016: 8). Up to 77% of electricity is consumed by lighting and appliances used for water heating, cooking, cold storage, and laundry in urban high-medium income households in South Africa (UNEP-SBCI, 2009: 29). The MEPS and energy labels target this large segment, with the NEES targeting an overall 33% reduction in average specific energy consumption of new household appliances purchased by 2030 (with a 2015 baseline) (DEA, 2016: 22).

Achievable impact – As appliances typically have a lifespan of between 7 and 20 years (CBI, 2017: 12), the shorter lived appliances have only one or two upgrade cycles between 2020 and 2030. Recently purchased appliances with long lifespans may not be replaced by 2030 at all. To reach the 33% NEES target, it is proposed that two successive tightenings of the MEPS take place before 2030. Assuming a uniform distribution of appliance lifespans and purchase dates, 75% of the current appliances will be replaced at least once by 2030.

A study by Götz *et al*. (2016: 8) on the impact of the South African MEPS that came into effect in 2015, showed that the vast majority of appliances had already met the minimum standard by 2014, indicating that no further efficiency gains can be expected, unless the current standard (2015 MEPS) is raised. On the assumption that a 15% tightening of the MEPS takes place by 2021, 54% of equipment in households by 2030 will be based on the new MEPS, resulting in an average specific energy consumption reduction for appliances of 8%. Given that 77% of total household energy consumption is from appliances in urban high-medium income homes, the improved MEPS could result in a 6% reduction in residential energy intensity by 2030. With 30% of energy consumption in these homes due to water heating (UNEP-SBCI, 2009: 29), there may be an overlap and double counting of the savings targeted under the improved MEPS and the improved NBR discussed in section 4.1.1. Discounting any improvements in the water-heating category to account for possible overlap in savings would then provide a potential 4% reduction in residential energy intensity by 2030, due to improved MEPS.

4.1.5 The impact of educational programmes

According to the NEES, campaigns to provide energy conservation and sustainable energy information should continue, so that consumers can positively respond to market signals such as the labelling of energy-efficient appliances. It does, however, recognise that these programmes are often aimed at middle- and upper-income groups, and suggest that municipalities develop programmes specifically aimed at low-income groups. These groups often spend a disproportionate amount of household income on energy and suffer from the health consequences associated with using biomass for cooking and heating (DEA, 2016: 21; SEA, 2017: 1).

However, it is often impossible to separate the energy improvement, due to behavioural changes from equipment replacement (Lopes, Antunes & Martins, 2012: 4095), and the NEES does not set an energy intensity reduction target based on this proposed measure.

4.2 The impact of voluntary, market-driven energy efficiency strategies and tools

Table 3 summarises the findings regarding the potential impact of voluntary, market-driven Energy Efficiency strategies and tools, before providing a review of this information.

4.2.1 The impact of small-scale embedded generation (PV solar)

The pace of newly installed small- and medium-scale private generation of solar electricity in South Africa is increasing, with 150 to 200 MW_p capacity[7] estimated to have been installed in 2018, from an overall installed capacity of roughly 430 MW_p in 2017. This is due to two key factors, namely the above-inflation increases of electricity prices of over 300% in the past decade, and the fall in the international price for solar PV installations to approximately a quarter of what they were seven years ago. Locally, the cost of PV for both residential and commercial (sub-utility) is projected to drop below the cost of an ESKOM supply by 2020 (GreenCape, 2019: 10).

7 MW_p, which denotes megawatt peak, is a typical measure of a solar PV plant generating capabilities under standard test conditions.

Table 3: Potential energy intensity reduction by voluntary and market-driven building efficiency tools

	Tool	*Focus area: Energy efficiency*	*Focus area: Low carbon energy source*	*Focus area: Embodied energy*	*Achievable impact based on the reach of the tool*	*Potential energy intensity reduction*
Voluntary tools: Market-driven energy efficiency strategies commonly utilised in South Africa	Solar PV	Not a focus area, but typically encouraged as energy efficiency reduce costs of PV installs	Yes	No	Up to 1% reduction in residential energy intensity by 2030.	1%
	Green building certification - EDGE	Yes	Not required, but encourage to achieve EDGE Advanced or EDGE Zero	Yes Refurbishes get recognised for material re-use	Up to 0.5% reduction in the energy intensity of the sector by 2030.	0.5%
	Green building certification - Net Zero	Yes	Yes	Not current certification focus, but will be included in future versions	Up to 0.25% reduction in the energy intensity of the sector by 2030.	0.25%
	Green home loans	Yes	Yes	No	Facilitates the investment into technologies that reduce the sector's energy intensity, impact not quantified	~
	Green bonds	Yes	Yes	Yes	Facilitates the investment into technologies that reduce the sector's energy intensity, impact not quantified	~

Focus area – While the installation of solar PV or other alternative energy sources does not equate to improved energy efficiency, energy-efficiency improvements are often promoted as the first step before progressing to solar energy. Lower energy consumption, due to energy efficiency improvements, reduces the size and cost of the alternative energy system required (Vieira, 2006: 2; Matt Power for Green Builder Media, 2016; SEA, 2017: 4; GBCSA, 2019: 48; D'Agostino & Mazzarella, 2019: 2470).

Reach – Solar PV has a much better business case in commercial applications than in residential applications, due to a mismatch between residential peak electricity demand and peak solar power generation, with some local suppliers advising against a solar system if it is not grid-tied (Green Energy Solutions, 2019). Solar PV is also more common with owner-occupied properties than with rental properties, as the benefit primarily accrues to the occupant. Some commercial property developers and managers in both the residential and non-residential sector do, however, install PV solar on their properties for on-selling the solar energy to the tenant, and to improve the 'green' characteristics and marketability of the property.

Achievable impact – Depending on the system size and tariff structure, residential solar PV projects can have a typical payback period of between 12 and 20 years. Commercial projects typically have a payback period of 10 years or less, making PV solar projects in this sector a more reasonable business case. Due to these factors, residential Small-Scale Embedded Generation (SSEG) market penetration tends to be low, with world leader Australia having achieved a penetration rate of 15% by 2015, while Belgium has a rate of 7% (SEA, 2017: 223).

While Section 12B of the Income Tax Act allows companies to accelerate capital depreciation of renewable energy assets, there are currently no tax incentives aimed at the homeowner in the residential market. A potential residential SSEG consumer can either be incentivised or discouraged through the SSEG tariff structure that municipalities develop, but a cost-reflective SSEG does not pose a significant threat to a municipality's financial sustainability, even at penetration rates as high as 20% (SEA, 2017: 226).

The IRP 2019 currently places a cap of 500 MW additional SSEG capacity per year (DMRE, 2019: 42), and the market is expected to grow to this saturation point from the current rate of approximately 200 MW of new systems per year (GreenCape, 2019: 21). If this point is reached in the next five years, the overall installed SSEG capacity will be roughly 5 GW in 2030, equating to 6% of the total installed generating capacity in the country. Assuming the residential sector remains at 15% of the installed systems (GreenCape, 2019: 22), it would represent a 1% reduction in the energy intensity of the residential sector by 2030.

4.2.2 The impact of EDGE certification

EDGE certification, developed by the International Finance Corporation to stimulate the uptake of energy-efficient buildings in developing countries, is used in 140 countries worldwide. EDGE positions itself as both a free online assessment tool and a certification system, so that architects and engineers can quickly identify low-cost, high-return design alternatives before (or instead of) committing to perusing certification. EDGE can thus help determine, at a concept level, the financial viability of a project's green building initiatives early in the design stage (GBCSA, 2017).

The online assessment tool has been localised for South Africa concerning the local climate, utility costs, standard construction and system specifications, in addition to building regulations, thus allowing it to accurately calculate a building's inputs and consumption (IFC, 2018b: 2). The EDGE assessment tool presents the building's potential utility savings and reduced carbon footprint against a base case (IFC, 2018a).

Focus area – To pursue certification, the EDGE standard of 20% less energy use, 20% less water use, and 20% less embodied energy in materials compared to a base case building[8] must be achieved, which is then independently verified and certified. This makes EDGE one of the only green building certification schemes that explicitly address the embodied energy or 'upfront carbon' of constructing buildings. In 2019, additional levels of certification became available in the form of EDGE Advanced and EDGE Zero Carbon, which require 40% less energy use and 100% carbon neutral, respectively. Low carbon energy sources are not required for the standard EDGE certification, although achieving EDGE Zero Carbon would involve either renewable energy sources or carbon offsets.

Reach and achievable impact – Many local residential EDGE certifications are being pursued by developers in the affordable or gap housing market, primarily due to the social co-benefits that have attracted funding by development finance institutions, but also for market differentiation. The International Housing Solutions Fund II has enabled the development of 5 000 EDGE certified residential units, of the nearly 10 000 certified units between 2017 and 2019 (CSS, 2019: 11). With between 40 000 and 50 000 residential buildings being completed annually, EDGE certified units could represent up to 10% of all new homes being constructed annually.

8 EDGE models its saving projections as a function of exceeding the consumption of a base case building with the same overall dimensions, which in South Africa would be a building that meets the National Building Regulation requirements.

By 2030, 32% of the formal housing would have been built after 2030 (Quantec, 2018), meaning that up to 3% of the total housing stock could be EDGE certified. As EDGE certification requires buildings to be at least 20% more efficient than the local building codes, it could equate to a 0.5% reduction in the energy intensity of the sector by 2030.

4.2.3 The impact of Net Zero certification

Net Zero Carbon buildings have net zero emissions, typically by being a highly energy-efficient building with very low energy demand, the remainder of which is met through zero carbon energy sources such as PV solar. While there are a variety of definitions for Zero Energy or Zero Carbon buildings (D'Agostino & Mazzarella, 2019: 2471), they typically all require that a building produces at least as much emissions-free energy as it uses from emission-production sources (CBI, 2017: 34; GBCSA, 2019: 13; WorldGBC, 2019c). The South African National Development Plan Vision 2030 (NDP 2030) set the objective of creating a national zero emission building standard by 2030, through the progressive strengthening of energy efficiency standards of the National Building Regulations (Government of South Africa, 2012: 288). The GBCSA's Zero/Net Positive certification programme launched in 2017 aims to accelerate the transformation of the market towards this goal. Projects in South Africa can pursue Net Zero certification as part of other certifications offered by the GBCSA, such as Green Star or EDGE, or as a stand-alone submission.

Focus area – Energy efficiency and low carbon energy are generally required for Net Zero certifications, which will typically set a minimum level of energy efficiency. Only once this level is reached can the remainder of the energy needs be produced from low carbon energy sources, such as PV solar, or by purchasing carbon offsets. Embodied energy is not currently included as a focus area in most of the Net Zero certifications, although it may be included in future versions (WorldGBC, 2019d).

Reach and achievable impact – To meet the 2-degree goals[9] provided by the IPCCC, net zero emissions for all sectors must be reached by 2050 or earlier. In support of this, several organisations are calling for net zero buildings, with typical targets set as 2030 for all new builds and 2050 for existing buildings (GlobalABC & UNEP, 2016: 18; WorldGBC, 2018a). Currently, net zero new builds make up less than 5% in most of the markets (IEA & UNEP, 2018: 37). While the South African National Development Plan Vision 2030 set the objective of creating a zero-emission building

9 The Paris Agreement (2015: 29) aims to hold "global average temperature to well below 2°C above pre-industrial levels" and to pursue "efforts to limit the temperature increase to 1.5°C above pre-industrial levels".

standard by 2030, the post-2015 NEES targets only a 38% energy consumption reduction, due to improved NBR requirements.

In the absence of specific government-mandated net zero requirements for the residential market, it is assumed that South African new builds will not exceed the typical 5% penetration rate. As PV solar is typically key to generating the energy in net zero building, it is assumed that the residential versus non-residential split in net zero buildings will be similar to that of the PV spread in South Africa, where only 15% is due to the residential market.

Thus, a residential penetration of net zero is assumed as reaching a maximum of 0.75% of the market. An evaluation of South Africa's housing data (Quantec, 2018) indicates that 33% of formal households, projected to have been built by 2030, will be built after 2015, meaning up to 0.25% of all formal houses could be net zero in 2030. As Net Zero certification requires a building to produce as much emission-free energy as it consumes, it could equate to a 0.25% reduction in the energy intensity of the sector by 2030.

4.2.4 The impact of green financing

Internationally, there is a robust appetite for green bonds, which is evident in the scale of oversubscription and other benefits when they are issued (CBI, 2017: 13; CSS, 2019: 3; Walker, 2019). These bonds are accessed by aggregators, including residential property investors and home loan providers such as banks and home loan companies (CSS, 2019: 34). Green home loans and green bonds facilitate the investment into technologies that reduce energy intensity, whether through energy efficiency, renewable energy, or thermal envelope upgrades. Some have argued that, in the absence of a global carbon pricing scheme, green bonds are key to financial climate change mitigation projects (Blanding, 2019). Still, questions have been raised as to whether those projects would not have taken place, despite the availability of green bonds (Walker, 2019). The impact of green financing is thus poorly defined, and no energy intensity reduction is quantified based on this measure.

Figure 4 summarises the key findings of the preceding review of the common residential building efficiency tools used in South Africa and an interpretation of their impact within this context.

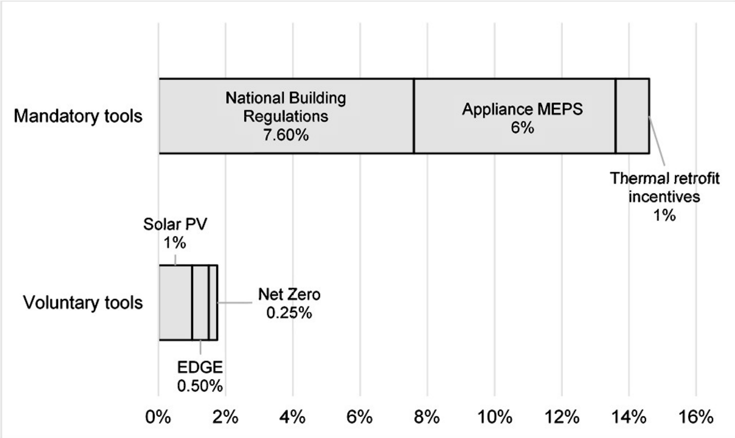


Figure 4: Energy intensity reduction potential of different building efficiency tools commonly used in South Africa
Source: Author's own

Given the review of the current proposed energy efficiency improvements as per the post-2015 NEES and commonly used voluntary tools in the residential market, it is possible that, by 2030, there could be up to a 16% reduction in the energy intensity of the residential sector (see Figure 4).

If the South African residential market continues to grow at its current pace of roughly 2% per year (Quantec, 2018), the housing market will be nearly 40% larger in 2030 than it was in 2015. This means that the projected potential of a 16% reduction in the energy intensity (measured as energy consumed per square metre) will be more than offset by the increased building floor area. This shows that the current targets are insufficient to meet the peak, plateau and decline trajectory of our INDC as they relate to building emissions specifically, and that more ambitious targets must be set and implemented within a reasonable time frame.

The projected massive growth in the South African housing market over the next decade and beyond shows that tools focused on the new residential market are critical. Over 80% of the total potential for energy intensity reduction can be derived from the mandatory tools that focus on the new build sector, namely the National Building Regulations and minimum performance standards for appliances.

5. CONCLUSION

What then is the building emission reduction potential of South African residential building efficiency tools? The dominance of the potential impact of mandatory tools seems to confirm what others have stated, namely that voluntary green building certifications do not directly contribute to a significant change in the residential sector's emissions, although they are becoming more common and demonstrate the tangible feasibility of low or zero carbon buildings (IEA & UNEP, 2018: 36). Mandatory regulations must thus continue to be updated timeously, with standards (based on scientifically obtained targets) being tightened, and enforcement strengthened. These areas are often sorely lacking in South Africa, where draft documents can linger in limbo, and they are no longer able to provide the desired positive impact.

While the projected energy reduction (due to small-scale embedded solar) is relatively small in the medium term, the impact of a decarbonised electricity grid is significant. If the IRP 2019 is followed, coal-generated electricity will contribute 60% of the energy mix in 2030, down from the current level of 90%. This could result in a 35% reduction in the carbon emissions of the residential sector, due to fuel switching alone (Mey, 2020: 73).

Finally, despite providing a third of the potential carbon reduction potential, the embodied energy of materials remains a poorly understood and a largely ignored improvement area, featuring in only two of the voluntary tools and not in any of the mandatory tools. Accordingly, in late 2019, the World Green Building Council launched a “Bringing Embodied Carbon Upfront” campaign to create a conversation around embodied energy and to further stimulate embodied carbon reductions. This is an area that deserves additional focus by all, given its large untapped potential.

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