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Methodology for development of a MACC for the eThekwini Municipality

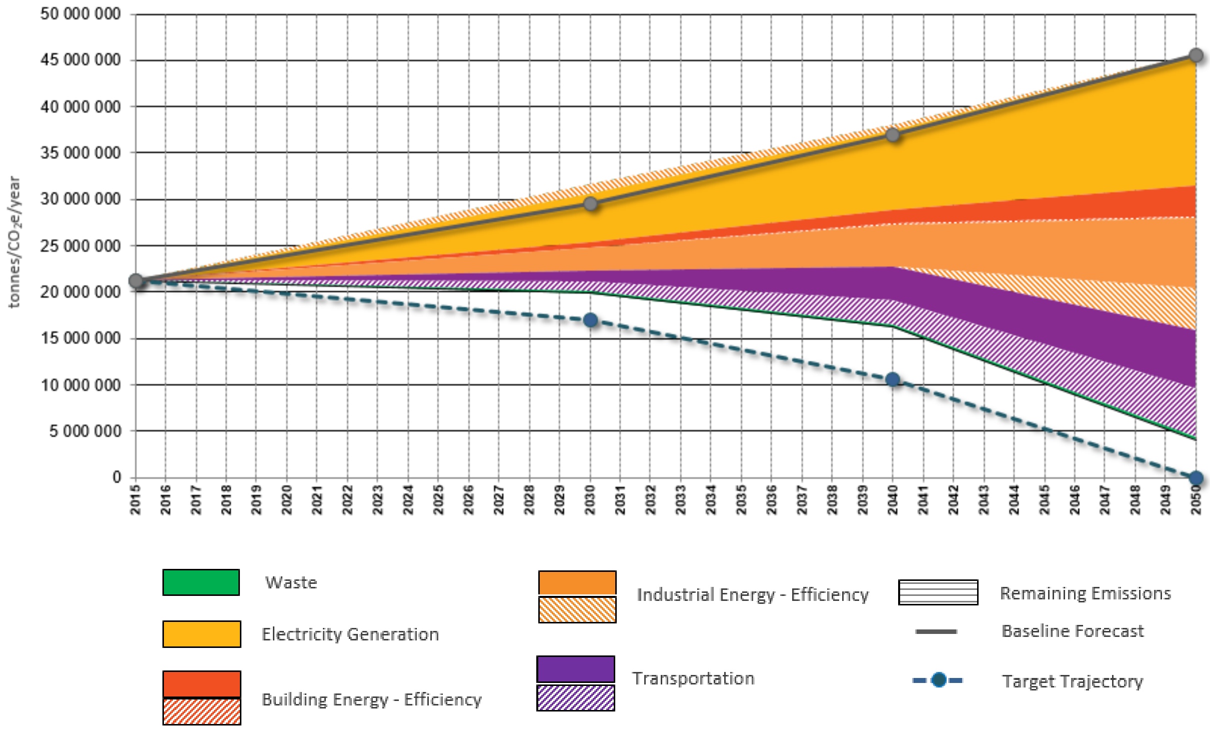
The MACC established in this study takes the assessed mitigation potential analyses from the eThekwini Municipality's Climate Action Plan (CAP) report and further quantifies the cost of reducing GHGs per intervention.[1]

Mitigation potential assessments require extensive analyses of baseline inventories to model a series of future emissions trajectories based on current emission reduction trends (baseline case) and on enhanced emission reduction futures, where the projections are based on estimated population and economic growth.[2] The data inputs require establishing the detail within scenarios that would describe the GHG reducing interventions, and its projected applicability and market uptake of intervention within its sector.[1,2] As part of the CAP[1] assessment, a detailed model was produced that described emissions growth scenarios within various sectors up until 2050. The CAP's emissions growth projections are built on the 2015 baseline of emissions provided by the eThekwini Municipality's GHG accounting report[3] that uses guidelines for GHG reporting from the Greenhouse Gas Protocol (GPC)[4]. Growth factors used in the CAP[1] were based on population and economic growth assumptions to inform future changes in the sectors analysed. Gross domestic product (GDP) per capita is used as an indicator for economic growth, and while it is acknowledged that this measure should not be solely used to make conclusions about the state of a nation, it is a relatively simple indication of real and inflation adjusted growth for sectors within an economy.[1]

Supplementary figure 1 presents the emissions reduction potential within sectors in the Municipality. Displayed by the topmost line, the upper end of the trajectory illustrates emissions increase without any further mitigating interventions being implemented while the lower end of the trajectories shows the emissions projections where maximum mitigation efforts have been implemented.[1] The difference between the upper and lower scales on the graph indicate the ranges for mitigation potential for each sector.

Mitigation potential of sectors can be modelled through individual or a combination of a technical potential approach that explores the potential reductions in GHG emissions through interventions based on existing and available technologies, an economic potential approach that accounts for potential GHG reductions and the associated costs through a cost benefit analyses, and a Market Potential Approach whereby the potential of the market that would adopt a GHG reducing intervention or technology is analysed.[2]

This study builds on the eThekwini Municipality's CAP report and applies a financial consideration to the reduction of GHGs by producing a MACC.[4] The sectors covered in this assessment of a MACC aligns with the approach used within the CAP that employs a technical and market-based approach. It is common to utilise a combination of approaches to determine mitigation potentials and MACCs. In the CAP, a market potential approach was used for certain building typologies for example, HVAC interventions were not considered for low-income houses and alternative methods of water heating were not considered for commercial warehouse buildings.[2] A technical potential approach was used for the remaining building typologies.[2]



Supplementary figure 1: Emission reduction potential within the eThekwini Municipality, 2015–2050.[1]

In 2016, South Africa published country-wide mitigation potential analyses that included a series of MACCs[2], that modelled the GHG emissions reduction potential of each sector, the associated net costs and social benefits in this analysis and included a combination methodology of the technical and market potential approaches to calculate the mitigation potential and its associated costs for sectors, as did the IPCC's 4th Assessment Report[5]. From the modelled results of the CAP[1], it must be noted that the Municipality falls short of reaching zero emissions by 2050.

This provides impetus for the Municipality to fast track climate action and to prioritise low-cost interventions in reducing GHG emissions, as cost increasingly becomes an issue in addressing climate change.

As there may be more than one intervention with differing lifetime periods, consistency in comparing lifetime costs is important and can be achieved by annualising the costs of each intervention.[6] Net annual costs that consider the capital costs, operational costs, and any the associated costs minus the energy savings and/or revenue that may arise through the implementation of the intervention on an annual basis can be utilised.[2,6] The costs are annualised to allow for comparison between other interventions, where the interventions may have different life spans, and therefore differing net annual costs.[2]

The input data used for this study were derived from a range of sources, including the local market and national market rates. National market rates for technical interventions were obtained from South Africa's national mitigation potential analyses[2] with local costings for the waste and transport sectors obtained from existing research to provide a more localised and specific context[7,8].

Limitations of model

Power: Grid decarbonisation

In spite accounting for a significant portion of the mitigation potential identified within this sector of the CAP Mitigation Analyses, this measure is excluded from this marginal abatement cost study due to current legislated limitations to generating power.

Local Authorities in South Africa are limited to the amount that power that they can generate independent from Eskom, the national utility. Electricity is currently generated solely by parastatal Eskom with a small but increasing share of Independent Power Producers adding to South Africa's electricity supply. South Africa's draft Integrated Resource Plan (IRP), which is a plan of the country's future electricity capacity, apportions 200MW annually for embedded generation that is limited to between 1MW to 10MW for a single customer.[9]

It is however apparent that a long-term solution would mean that cities should become generators as businesses and residences move off the grid and in turn reduce revenues from electricity sales within the city.

Further to this, there are inherent complexities in calculating net annual costs for the integration of large amounts of varied decentralised renewable power into the existing grid. To calculate the capital costs would require conducting a study on the applicability of the types of renewable energy sources that should be used - where the location of these power sources would substantially influence their input costs. The eThekwini Municipality has begun the process by producing a set of research for long term diversification and sustainability of energy supply contained within the Energy Strategic Road Map.[10] Similarly, the determination of the operating costs would also vary per energy source.[10] Significant importance should be consideration to the tariffs and energy charges that the Municipality will need to consider to ensure feasibility of these additions to the grid, which is included in the net annual costs as the returns or savings amount of the intervention. It is recommended that municipalities determine their energy futures strategically, to ensure a more stable and a cleaner energy grid.

Industry: Industrial efficiency and industrial fuel switch

Following the GPC's BASIC method of reporting, this study did not include industry and AFLOU sectors. A large aspect of this omission is due to the lack of data from the eThekwini Municipality, however, these figures were estimated and modelled into the CAP.[3,1] The lack of data stems from the complexities in collecting data from a broad range of differing industrial companies. The data is vital to understand the GHG emissions contribution from the industrial sector and resulting reductions and also of detailing the costs involved to reduce GHGs.[2] Within the Industry sector, mitigation potential analyses would include industrial equipment efficiency and fuel efficiency shifts for industrial facilities located within the eThekwini Municipality.[1] Evaluating this sector would require a meaningful understanding of industries' processes and equipment used in order to best evaluate their technical potential mitigation.

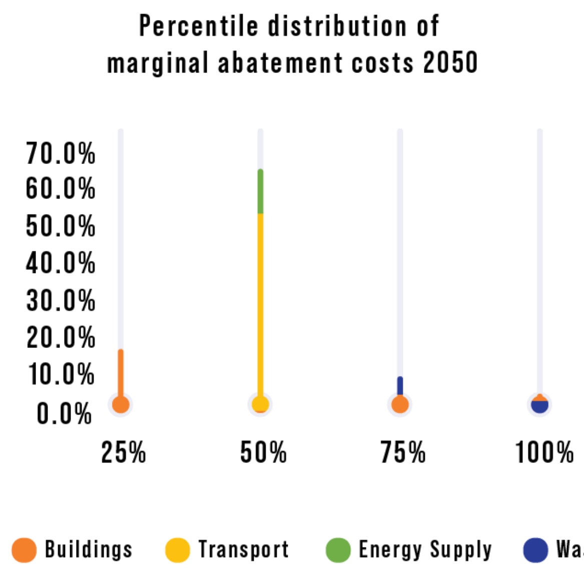
Waste: Treatment of Wastewater

The treatment of wastewater is omitted from this study due to the CAP mitigation potential study including the anaerobic digestion of wastewater without biogas capturing as a necessary environmental intervention which however then results in an increase in the amount of GHG emissions released, compared to conventional aerobic wastewater treatment processes. The treatment and disposal of sewage sludge are part of key design aspects for wastewater treatment plants because of the high costs associated with treating and safely disposing of this waste in accordance to legislation.[11] Anaerobic wastewater treatment processes significantly reduce the volume of sludge produced, which then reduces the amount of treatment required to handle the sludge without being a health hazard.[11] Since there is no mitigation potential for GHGs relating to wastewater treatment[1], this measure was not assessed for its marginal abatement cost to reduce GHGs, however it is important to note that anaerobic digestion processes for wastewater treatment has many environmental benefits, and the increased output of GHGs can be mitigated through interventions such as gas to electricity, and also in creating useful products such as fertilisers.[11]

Percentile results

A MACC is intended to be used as part of an array of evidence that would inform effective investment into long-term and workable climate change mitigation programmes. A MACC provides insights into the net cost of an intervention that would mitigate a tonne of carbon emissions.[2]

Varying percentiles of marginal abatement cost per sectors analysed for 2050 are presented in Supplementary figure 2. The use of percentiles has several advantages that include highlighting the values that fall within the most cost-effective bracket of below 25% and noting the interventions that increase in costs through its categorisation in the following percentiles. Interventions falling under the 25% category refers to the 'easy-wins' or low-cost interventions going up to the year 2050.



Supplementary figure 2: 2050 split of marginal abatement costs displaying percentile distribution and percentage of mitigation potential of analysed intervention.

Supplementary table 1 presents the results from the CAP Mitigation Potential Analyses[4] with the MACC findings arising from research conducted in this paper and includes sectors that have been omitted from the marginal cost abatement calculations. The table further details the interventions used within mitigating GHGs in sectors and the percentage of emissions reductions for 2030, 2040, and 2050.

The building sector to offer significant GHG emissions reductions at the lowest marginal abatement cost. The building sector can be described as one that is integral to people's safety and living. Buildings are immovable and fixed assets – unlike the energy behaviours and demands of its occupants. Buildings as structures last for well beyond a hundred years, and therefore constructing these buildings to be net-zero carbon from the on-set will ensure that the building stock of the future is low carbon.

Supplementary table 1: Total interventions used within mitigating GHGs in sectors and the percentage of emissions reductions for 2030, 2040, and 2050

Sector	Sub-sector	Interventions	2030 %Total emissions reduction	2030 Marginal abatement cost (ZAR/$KtCO_2e$)	2040 %Total emissions reduction	2040 Marginal abatement cost (ZAR/$KtCO_2e$)	2050 %Total emissions reduction	2050 Marginal abatement cost (ZAR/$KtCO_2e$)
Energy	Power	Electricity: distributed renewables	1.6%	13.98	2.9%	17.46	2.45%	20.49
Energy	Power	Grid decarbonisation	51.7%	Not calculated	38.9%	Not calculated	31.70%	Not calculated
Industry	Buildings	Residential: lighting efficiency LED only	<1%	-1.60	<1%	-2.45	<1%	-2.48
Industry	Buildings	Residential: building insulation: new and redeveloped	1.4%	0.09	1.2%	0.18	1.97%	-0.17
Industry	Buildings	Residential: efficient water heating	<1%	0.12	<1%	-1.76	<1%	-1.84
Industry	Buildings	Commercial: lighting efficiency LED only	2.4%	-0.52	2.4%	-0.83	2.46%	-1.15
Industry	Buildings	Commercial: efficient water heating	<1%	0.25	<1%	0.15	<1%	-1.34
Industry	Buildings	Commercial: efficient HVAC (new build)	<1%	-0.04	<1%	-0.01	1.1%	-0.01
Industry	Buildings	Commercial: efficient HVAC (existing build)	1.1%	1.07	1.7%	5.76	1.8%	-2.12
Industry	Buildings	Other: equipment efficiency, space heating, cooking	2.1%	Not calculated	2.3%	Not calculated	2.51%	Not calculated
Industry	Industrial	Industrial equipment efficiency	25.1%	Not calculated	22.1%	Not calculated	18.20%	Not calculated
Industry	Industrial	Industrial fuel switch	-11.0%	Not calculated	-2.5%	Not calculated	10.70%	Not calculated
Transport	Road	Mode shift: Bus Rapid Transit	4.1%	35.06	9.5%	7.65	13.30%	3.04
Transport	Road	Fuel efficiency: passenger and transit vehicles	19.0%	Not calculated	20.4%	Not calculated	14.00%	Not calculated
Waste	Wastewater	Shift to anaerobic digestion	-1.1%	Not calculated	<-1%	Not calculated	<-1%	Not calculated
Waste	Municipal solid waste	Landfill gas to electricity	2.6%	0.10	<1%	0.11	<1%	0.11
Waste	Municipal solid waste	Food and garden composting	<1%	0.62	<1%	0.67	<1%	0.68
Waste	Municipal solid waste	Paper recycling	1.0%	0.04	1.1%	0.05	<1%	0.05

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