ENERGY SCENARIOS FOR CAPE TOWN

EXPLORING THE IMPLICATIONS OF DIFFERENT ENERGY FUTURES FOR THE CITY UP TO 2050

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EXECUTIVE SUMMARY

The Energy Scenarios for Cape Town project was undertaken by Sustainable Energy Africa and the Energy Research Centre at the University of Cape Town for the City of Cape Town to support and extend the Cape Town Energy and Climate Action Plan (ECAP), which was adopted by Council in May 2010. The ECAP is made up of 11 key objectives under which programme areas that support the move to a secure energy future are identified. The Energy Scenarios for Cape Town project provides an in-depth energy sector analysis and projections to 2050, as well as an up-to-date set of energy consumption data, electricity supply options, costs of different alternatives and environmental and employment impacts of different development paths.

The objective of the project is to clarify a way forward for the energy sector in Cape Town such that:

- The City's economy is robust in a future where carbon emissions are constrained and taxed;
- Energy costs for the City into the future are optimised;
- Energy service provision is not compromised so that welfare and economic activity is not constrained by lack of energy;
- Employment creation is maximised;
- Opportunities for the economic development of energy related industries is optimised;
- The City's carbon emissions profile is in line with national and international obligations

The Energy Scenarios for Cape Town project modelled the implications of implementing different energy supply mixes and energy efficiency interventions in all sectors. A base year of 2007 was used. The modelling showed that if the City does not adopt any significant measures to change the future energy consumption and supply (i.e. continues with Business As Usual), energy demand is set to almost quadruple by 2050. This will also result in an untenable rise in carbon emissions, which is contrary to national and international pressure to reduce these emissions.

Based on the modelling of a range of different scenarios, an Optimum Energy Future is modelled which supports the energy security goal of the city, as well as maximising employment creation, optimising energy costs into the future, and promoting economic development. Through this exercise the Optimum Energy Future extends the existing Energy and Climate Action Plan (ECAP).

The core motivations for the Optimum Energy Future and the set of interventions associated with it are embodied in the following key issues:

1. Proceeding along a Business As Usual trajectory has significant risks, including
    - High energy expenditure for the City's occupants;
    - An increasingly inefficient economy;
    - Reduced jobs in the energy sector;
    - A vulnerability in a carbon-constrained future;
    - Peak oil vulnerability;
    - Losing any market advantage around being a green city

2. The overall cost to the City's inhabitants of a low carbon future is slightly higher than the Business As Usual Scenario due mainly to the costs associated with substantial public transport infrastructure, but the efficiency gains and economic benefits resulting from the interventions far outweigh the extra costs.

3. All electricity efficiency interventions that are recommended for implementation in the residential, commercial, industrial and local government sectors are financially sensible and pay themselves back over the lifetime of the implementation programme. This leads to a more efficient economy.

4. A high renewable energy supply component, associated with a robust future, results in significant increases in jobs created, although this will require the proactive development of a renewable energy industry to maximise jobs in Cape Town.

5. The Electricity tariff design will need to change in future to promote energy efficiency while still preserving the City of Cape Town's revenue base.

6. The inevitability of steep oil price hikes as global demand exceeds supply capacity ('peak oil') provides additional motivation to implement the Optimum Energy Future with its emphasis on public transport and vehicle efficiency. Key to enabling an effective public transport system is city densification, as the cost of providing public transport infrastructure and services is prohibitive in low density cities such as Cape Town

A major component of achieving an energy secure future is through the implementation of energy efficiency (demand-side) interventions. As mentioned earlier, most of these programmes are cost-effective to implement and lead to a more efficient economy. It is important to note that the City of Cape Town has direct influence over the implementation of these energy efficiency measures, and thus can proceed quickly without significant regulatory and bureaucratic barriers.

Way Forward

Next Steps to move toward implementation of the Optimum Energy Future are listed below:

- Engage with key City Departments and other players to ensure buy-in
- Undertake a revision of the ECAP to include key aspects of the Optimum Energy Future not currently in the ECAP
- Development of business plans for key projects, including definition of responsibilities, financing sources, timeframes and key players to be involved
- Explore the design of tariff systems which promote energy efficiency
- Exploration of financing needs for an effective public transport system and how such financing may be sourced
- Further analysis of the implications of a growing poor population on the city's ability to provide basic services and the longer-term impact of this trend on city coffers
- Research on measures to maximize local job creation potential while pursuing a low carbon development path
- Detailed electricity sector analyses, including:
    - Promotion of renewable energy supply, including engaging with national government, NERSA and Eskom around the city's role in this regard
    - Potential for demand-side (efficiency) measures to reduce infrastructure upgrading or development costs, and the resulting impact on cost-benefit of efficiency measures

- Strategic planning around demand management, including future investment in pumped storage

Funding has been secured from the British High Commission by Sustainable Energy Africa and the City to support the City with the implementation of the Optimum Energy Future for Cape Town. This support will run until March 2011 and will take the above work areas further, as well as providing general technical support and capacity building of city departments where appropriate and engaging in further research in selected areas. However the above list is beyond what the British High Commission funding can undertake, and thus extra funding will need to be secured.

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Acronyms and Definitions

BAU	Business As Usual – the expected course of events if there are no significant changes to current practices
Carbon footprint	A calculation of greenhouse gas emissions (carbon and carbon equivalent) from all energy consumption in Cape Town – irrespective of where the energy is sourced or generated (i.e. electricity use in Cape Town from coal-fired power stations in Mpumalanga are still part of Cape Town's carbon footprint).
CCGT	Combined-Cycle Gas Turbine
CF	Capacity Factor – the average output of a generation plant divided by the total output if the plant was running at full capacity all the time
Demand-side	The end-user energy consumption for the sectors (e.g. residential, commercial etc). Energy efficiency interventions are applied to demand-side.
ECAP	The City of Cape Town Energy and Climate Action Plan
EE	Energy efficiency
GWh	GigaWatt-Hour – a thousand Megawatt-hours (**MWh**) and a million kilowatt-hours (**kWh**)
HVAC	Heating, Ventilation and Air-Conditioning
LTMS	Long-Term Mitigation Scenarios. The National scenario development and modelling exercise completed in 2007 to model the carbon future for the country and to define the carbon trajectory required by science to stabilise climate change and align with international climate change targets
LEAP	Long-range Energy Alternatives Planning – a computer model used to analyse the energy sector in this project
LED	Light-emitting Diode – a very efficient form of lighting increasingly coming into the market
PBMR	Pebble-Bed Modular Reactor – a form of 'modular' nuclear reactor which Eskom was developing a few years ago. Currently not considered viable.
Peak Oil	The situation where the demand for oil exceeds extraction and thus prices increase, potentially steeply (prices are expected to become unstable at least). Peak oil is predicted with the next decade or two.
PWR	Pressurised Water Reactor – the currently preferred nuclear generation option
RE	Renewable Energy

REFIT	Renewable Energy Feed-In Tariff – the incentive tariff currently offered by government to promote renewable energy
Supply-side	The energy supply component of the energy sector (in this project mostly electricity generation and supply, as the city has little influence over liquid fuels supply) – as opposed to the demand or consumption aspects.

BACKGROUND

Cape Town has been one of South Africa's pioneering cities regarding the establishment of an Energy and Climate Change Strategy in 2006 as well as the implementation of institutional reforms to support this initiative. In addition to this, a State of Energy for the City Report was completed in 2003 and updated in 2007 and initial energy modelling (Cape Town Energy Futures) was undertaken in 2005 for the City to assess the implications of different future development paths for the energy sector. In response to these strategies and report, the City has developed an Energy and Climate Action Plan (ECAP), which was adopted by Council in May 2010. This Action Plan is made up of 11 key objectives, comprising of programme areas consisting of individual projects, currently underway or planned, extending over a three year period. These have been taken through an initial prioritisation process, however, additional information regarding consumption patterns, costs, trends, risks, etc. was required to underpin this Action Plan and thereby verify the prioritisation, assist with the setting of targets and extend the plan into the longer term. The current work, termed the Energy Scenarios for Cape Town, provides a more in depth energy sector analysis and projections than has been done previously; based on an extended and up-to-date set of energy consumption data, supply mix options, costing and trends. The Energy Scenarios cover the period up to mid century (2050), which is necessary when considering longer-term issues such as climate change mitigation and impact.

Amongst the key imperatives for this work are the fast increasing price of electricity and volatility in liquid fuel prices, as well as exponential concerns and associated obligations regarding global warming emissions – as the National Long-Term Mitigation Scenarios (LTMS) make clear. All players within the country's energy sector, cities in particular, need to reconsider the implications of particular development paths for the sector, as the risks of excessive costs, untenable emissions levels and associated economic and social decline are very real if the sector is not directed sensibly. Many of these decisions need to be taken within the next few years to avoid potentially serious consequences, as changing the fundamental energy and global warming emissions profile of any city takes decades. This report will highlight these issues and risks for Cape Town, and propose an optimum direction for a secure energy future.

The Energy Scenarios work has been undertaken as part of the research being conducted under the City's Danida-funded Climate Change Think Tank (CC Think Tank), which consists of a partnership between the African Centre for Cities (University of Cape Town), Sustainable Energy Africa and the City of Cape Town. The overall focus of the programme is to better understand and prepare for climate change, including both mitigation and adaptation aspects. Various research projects are being undertaken under the banner of CC Think Tank, with the Energy Scenarios for Cape Town project being the key mitigation project.

THE EXISTING ENERGY AND CLIMATE ACTION PLAN (ECAP)

The ECAP forms the basis on which the City of Cape Town prioritises, budgets for, implements, monitors and evaluates its energy and climate change programme. The overarching goal of energy security and the criteria used in the ECAP for selecting and undertaking an initial prioritisation process is outlined below in Figure 1.

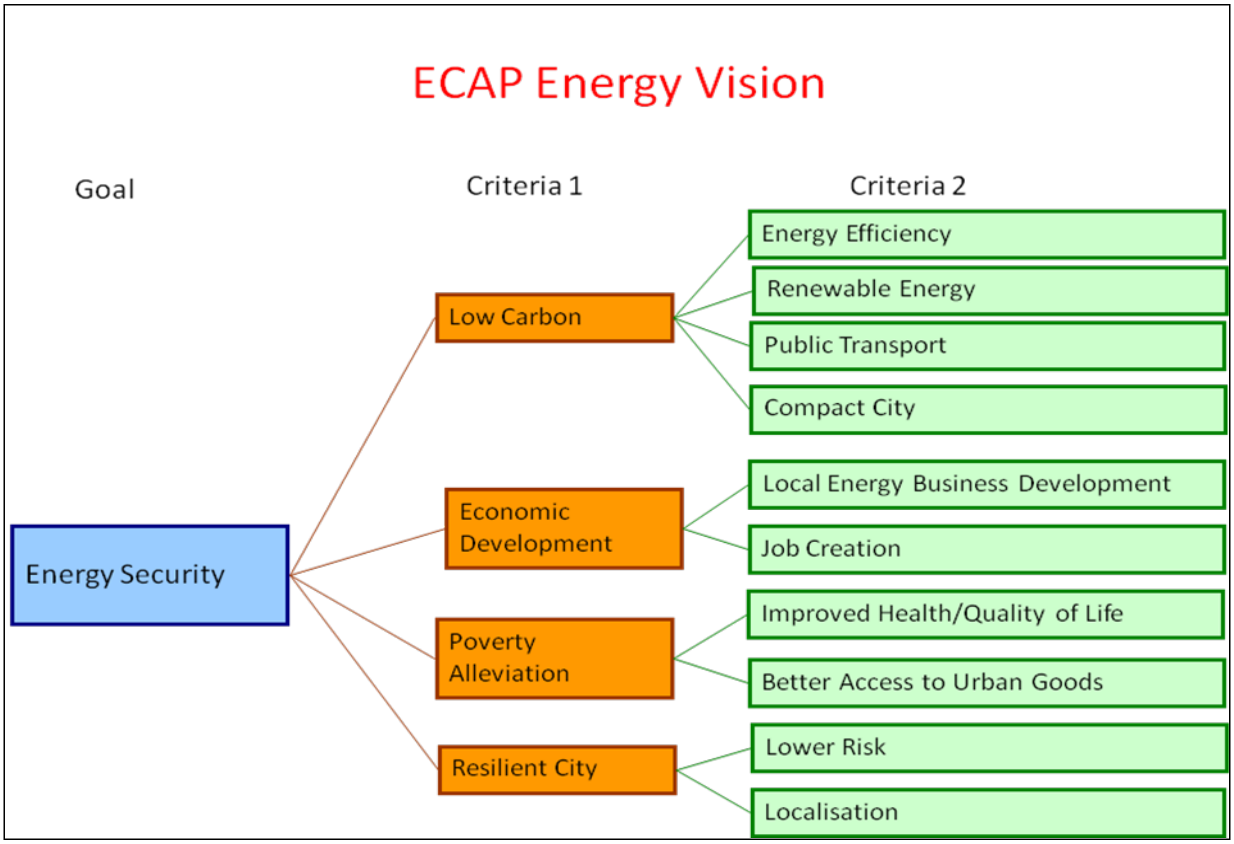


FIGURE 1: OVERALL GOAL AND PRIORITIZATION CRITERIA FOR THE ENERGY AND CLIMATE CHANGE ACTION PLAN (ECAP)

Based on the criteria in Figure 1, ECAP identifies key energy and climate change objectives of the City of Cape Town, and details associated activities. These were based on, and are in line with the City's energy and climate change strategies, as well as taking national policies into account. The ECAP objectives are listed below in Table 1.

Table 1: Energy and Climate Change Objectives as per ECAP	
Objective 1	City-wide: 10% reduction in electricity consumption on unconstrained growth by 2012
Objective 2	10% Renewable and cleaner energy supply by 2020; all growth in electricity demand to be met by cleaner / renewable supply
Objective 3	Council operations : 10% reduction in energy consumption on unconstrained growth by 2012; all growth in demand to be met by cleaner / renewable supply
Objective 4	Compact resource efficient city development
Objective 5	Sustainable transport system
Objective 6	Adapting to and building resilience to climate change impacts (city wide)
Objective 7	More resilient low income / vulnerable communities
Objective 8	Development of carbon sales potential
Objective 9	Local economic development in energy sector
Objective 10	Awareness: energy & climate change communications and education programmes (driven by Objectives 1 – 9)
Overall	Energy & climate change research & development; monitoring and evaluation

These eleven objectives contain 43 programme areas and over 100 projects. These projects are either underway or, through the initial prioritisation process, been identified for implementation in the short-term. The Energy Scenarios project serves as a useful tool, not only to identify any gaps in the ECAP, but to assist with the setting of targets that are both attainable and effective in terms of a secure energy future.

Extending the ECAP: The 'Energy Scenarios for Cape Town' Project

The Energy Scenarios project is primarily intended to inform and extend the ECAP. It draws on the approach used in the National LTMS project which was completed in 2007 to model the carbon future for the country and to define the carbon trajectory required by science to align with international climate change targets. It identified electricity supply and energy demand interventions to promote energy efficiency and cleaner energy supply. The National LTMS has been endorsed by Cabinet. The Energy Scenarios project builds on this work to propose an optimum way forward for a secure energy future for Cape Town and key actions to be embarked upon to pursue this path.

The objectives of the project draw directly from the ECAP Energy Vision, and are to clarify an optimum way forward for the energy sector in Cape Town such that:

- The City's economy is robust in a future where carbon emissions are constrained and taxed;
- Energy costs for the City into the future are optimised;
- Energy service provision is not compromised so that welfare and economic activity is not constrained by lack of energy;
- Employment creation is maximised;
- Opportunities for the economic development of energy related industries is optimised;
- The City's carbon emissions profile is in line with national and international obligations

The main output of the Energy Scenarios project is a proposed set of activities and focus areas to build on the existing ECAP for the City to meet the above objectives optimally.

Energy Scenarios Methodology

The project included a detailed data collection exercise and built on previous work carried out on the State of Energy for Cape Town Report completed in 2003 and updated in 2007, and the 2005 Cape Town Energy Futures Report on policies and scenarios for sustainable city energy development.

The Long-Range Energy Alternatives Planning (LEAP) simulation tool was used to examine a number of possible future energy scenarios for the City of Cape Town from a base year of 2007, up to 2050. For each scenario a combination of specific interventions were chosen to explore the implications on the future of the City.

Data was collected for the five sectors that were analysed within this projects; namely

- Residential Sector –disaggregated according to electrified and non-electrified households and by income category;

- Commercial Sector – included retail and office buildings, tourism activities, education facilities, hospitals and other non-industrial activities;

- Industrial Sector – industrial activities disaggregated into Textiles, Food and Beverage, and Non-Food Manufacturing Sectors as well as fourth category covering all other industrial activities;

- Local Government – This covered all City of Cape Town operations (municipal operations), including all Council buildings, street lights and traffic lights, water and waste-water treatment works and the City of Cape Town's vehicle fleet

- Transport – both freight and passenger transport was covered in this section, although they are modelled separately. Passenger transport looks at both private vehicle travel and public transport associated with bus, mini-bus taxi and train use.

A number of different scenarios have been modelled using LEAP to explore different Energy Futures in Cape Town. The following scenarios have been used in the model:

Key Assumptions (Business As Usual) used in the modelling

- Household growth : 1.7%
- Informal household growth: 13% from 2007, 8% after 2010[1]
- Population growth : 4%[2]
- Energy growth (incl elec) 2.9% corresponds to 3.4% GDP growth)
- Costing:
    - All costs real (in Today's Rands)
    - Discount rate : 5%[3] (real)
    - Electricity tariff real increases (linked to 'new build' program):
        - 4.9% from 2007
        - 6.7% from 2020
        - 4.5% from 2030 onwards

[1] Source: Knowledge Management Department, City of Cape Town

[2] Population figures were sourced from the Knowledge Management Department in the City of Cape Town. The population growth rates are taken from Dorrington's Population Projection Study for Cape Town (commissioned in 1999). There are however some uncertainties regarding these projections and an updated study have not yet been undertaken. For modelling purposes, household growth rates are used instead of population growth for the residential sector.

[3] A discount rate of 5% was used throughout the model as this was considered an appropriate average discount rate for projects. For projects to be undertaken by the private sector this is too low, and for public projects undertaken by government it could be argued that 0% is more appropriate. Hence 5% is considered a reasonable generic rate for such hi-level modelling. In later work where more detailed business plans are developed, discount rates more directly appropriate to the specific implementer will be used.

- The Business-As-Usual – what the situation would look like if no significant change of course takes place and current growth trends continue;

- The Policy Scenario– the situation if we meet the renewable energy and energy efficiency targets, based on the City of Cape Town's Energy and Climate Change Action Plan;

> - Liquid fuel costs linked to inflation (except in 'Peak Oil' Scenario
>
> - Transport : Private Vehicle Growth : 3.4%
> - Transport : Public Transport Growth : 2.9%
>
> (NOTE: these assumptions may change in specific scenarios modelled)

- Economic Growth (high and low growth rates)
    - Impact on the future of high economic growth (3.6% energy growth – linked to a GGP growth of 4.6%[4])
    - Impact on the future of low economic growth (1.9% energy growth – linked to a GGP growth of 2.9%)
- The National LTMS – the electricity supply options, including new nuclear and renewables and energy efficiency interventions required to meet the nationally endorsed carbon reduction profile
- Peak Oil Scenario – what are the implications of a 5% increase from 2016 and a 7% increase from 2020 (above inflation) in liquid fuel prices on the cost of the city energy system
- Carbon Tax Scenario – what are the implications of a R100[5] per tonne carbon tax (escalating) on different future energy scenarios
- Cape Town Optimum Energy Future – the proposed optimum mix of energy efficiency interventions and low carbon supply options. This will be discussed in more detail at a later stage in the report.

A technical report is available which includes details of the data collection, assumptions, modelling and analysis undertaken.

The Energy Situation in Cape Town in 2007

The current energy picture of Cape Town is still dominated by the Transport Sector which consumes approximately 50% of all energy in the city, followed by Residential (18%), Commercial (17%) and Industrial (14%) sectors. Figure 2 represents the energy consumption per sector in Cape Town for 2007, the base year. Figure 3 shows the carbon dioxide emissions associated with each of the sectors for 2007. It should be noted that although the transport sector consumes 50% of the energy in the City, it is only responsible for 27% of the carbon emissions. This is due to emissions associated with different types of fuels and in particular the fact that South Africa electricity is largely coal-generated, which renders it very carbon intensive.

[4] The relationship between GDP and energy demand growth was taken from the 2010 Integrated Resource Plan Parameter Sheets

[5] Taken from the 2010 Integrated Resource Plan Parameter Sheets

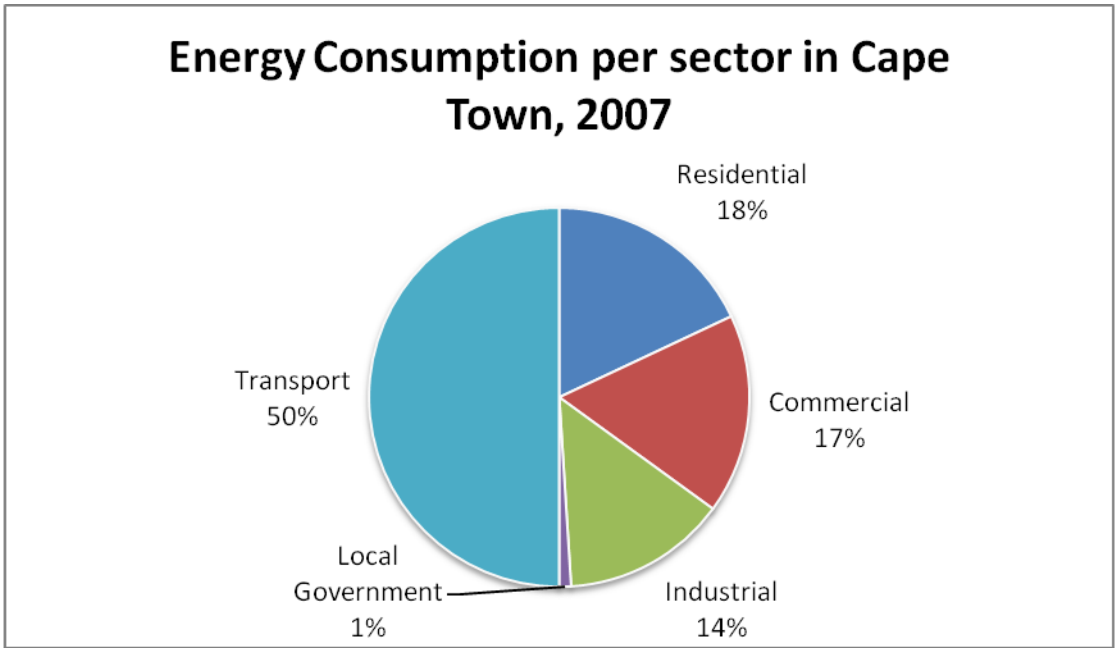


FIGURE 2: ENERGY CONSUMPTION PER SECTOR IN CAPE TOWN, 2007

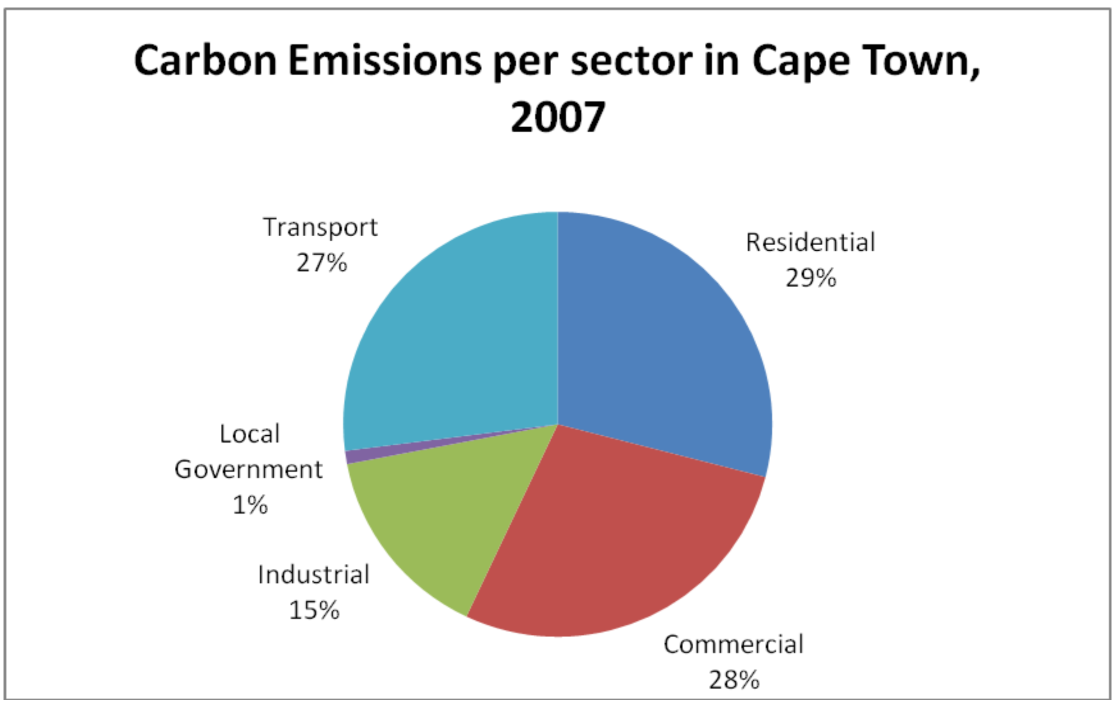


FIGURE 3: CARBON EMISSIONS PER SECTOR IN CAPE TOWN, 2007

A LOOK AT THE FUTURE…

Figures 4 and 5 shows that, if current trends around energy generation and consumption continue, Cape Town's energy consumption will almost quadruple by 2050 and greenhouse gas emissions will rise steeply, contrary to national and international pressures to reduce such emissions.

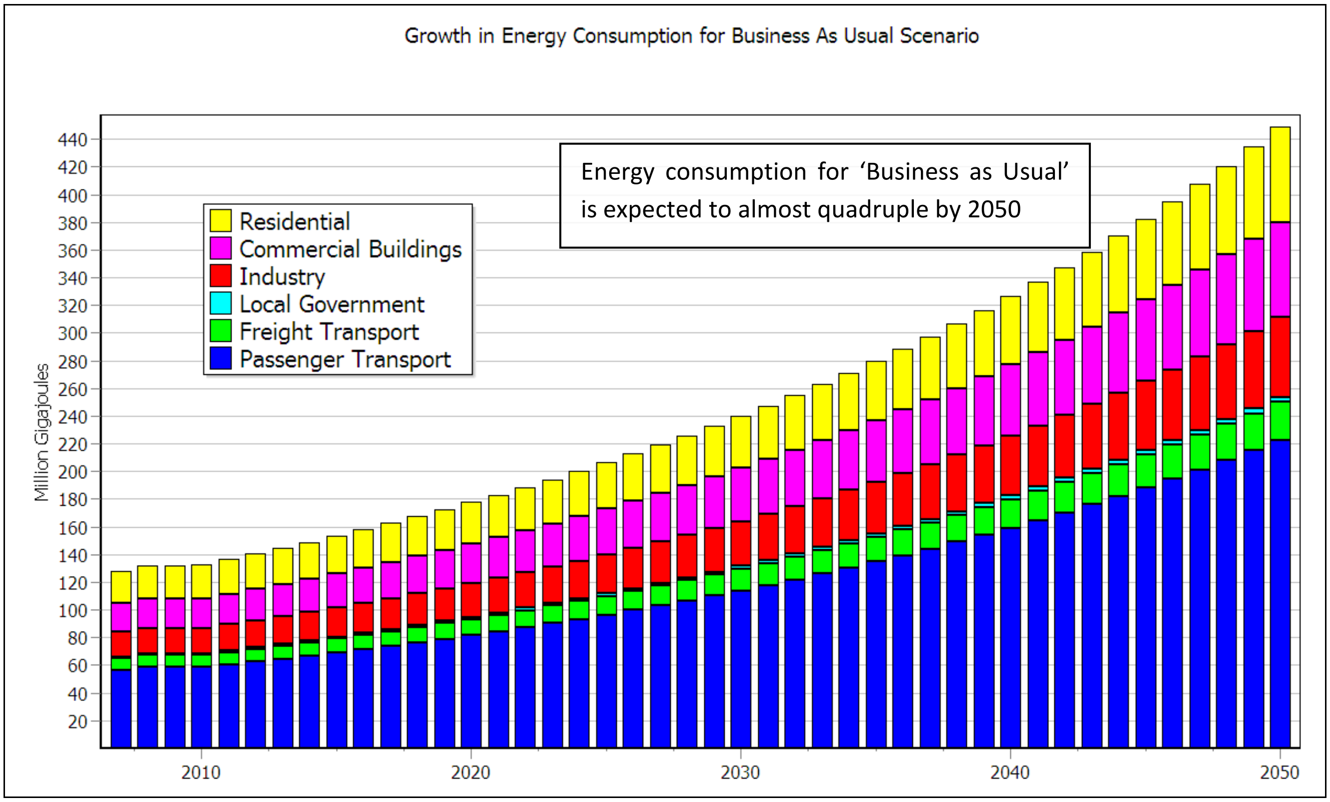


FIGURE 4: GROWTH IN ENERGY CONSUMPTION PER SECTOR FOR BUSINESS AS USUAL SCENARIO

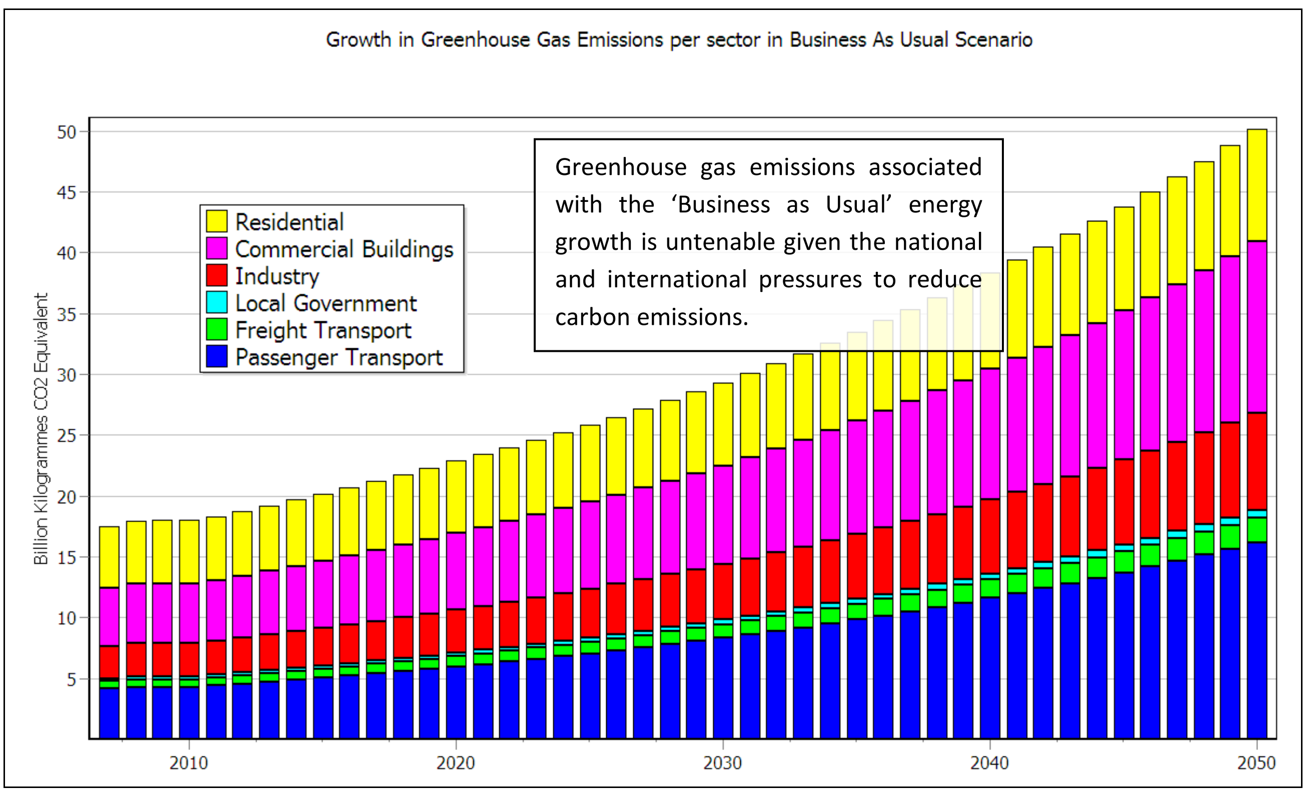


FIGURE 5: GROWTH IN GREENHOUSE GAS EMISSIONS PER SECTOR IN BUSINESS AS USUAL SCENARIO

A Proposed 'Optimum Energy Future' for Cape Town

Having explored the implications of different scenarios, or sets of interventions, on the future of Cape Town, the following actions are considered an optimum way forward for Cape Town (called the 'Optimum Energy Future' in this report). This builds on the existing Cape Town ECAP Energy Vision in that it achieves or promotes the following:

1. significant employment creation
2. a vibrant, efficient economy, robust in a carbon constrained future
3. lower overall cost of energy for the city, with no compromise in energy services provided
4. a carbon profile for the city in line with national and international obligations
5. a 'green' city

The core motivations for the Optimum Energy Future and the set of interventions associated with it are embodied in the following key issues:

- Key Issue 1: Proceeding along a Business As Usual Scenario has significant risks, including:
    - A vulnerability in a carbon constrained future
    - Peak Oil vulnerability
    - High energy expenditure for the city's occupants
    - An increasingly inefficient economy
    - Reduced jobs in the energy sector
    - Losing any marketing advantage around being a green city
- Key issues 2: The overall cost to the City's inhabitants of a low carbon future is slightly higher than the Business As Usual Scenario due mainly to the costs associated with substantial public transport infrastructure, but the efficiency gains and economic benefits resulting from the interventions far outweigh the extra costs.
- Key Issue 3: The cost of an electricity supply mix that includes a strong component of renewable energy is higher than Business As Usual (mainly coal based), but not significantly higher
- Key Issue 4: Nuclear is part of the national LTMS mix but needs to be approached with caution – construction delays, long lead-in times and large cost overruns are very common for nuclear projects. There is also a lot of public contention around nuclear energy
- Key issue 5: All electricity efficiency interventions that are recommended for implementation in the residential, commercial, industrial and local government sectors are financially sensible and pay themselves back over the lifetime of the implementation programme. This leads to a more efficient economy.
- Key issue 6: A high renewable energy supply component, associated with a robust future, results in significant increases in jobs created, although this will require the proactive development of a renewable energy industry to maximise jobs in Cape Town.

These motivations are described in more detail in the 'Key Issues' section later.

The Optimum Energy Future includes the following energy efficiency interventions:

Table 2: Energy Efficiency interventions included in Optimum Energy Future for each sector modelled	
Sector	**Interventions for Cape Town LTMS**
Residential	Energy efficient lighting in low, medium, high and very high income households
	Energy efficient water heating technologies implemented in medium, high and very income households : either solar water heaters or heat pumps, Geyser blankets and efficient showerheads in medium, high and very high income households
Commercial	Efficient Heating, Ventilation and Air Conditioning (HVAC) systems in new build and existing buildings
	Efficient water heating technology (either solar water heaters or heat pumps) in new and existing buildings
	Efficient lighting implemented in new and existing buildings
Industrial	Efficient machine drives installed, where feasible
	Efficient HVAC systems implemented
	Energy Efficient Lighting options implemented to replace conventional inefficient (incandescent) lighting
Local Government	Government Buildings • efficient lighting • efficient HVAC systems
	Street Lighting – replacement of mercury vapour lamps with high pressure sodium lamps
	Traffic lights – replacement in incandescent and halogen lamps with LED lamps
	Vehicle Fleet – improved fuel efficiency through the purchase of more efficient diesel and petrol options and the implementation of behavioural changes to support further fuel efficiency
Freight Transport	Shifting freight transport from road to rail-based transport
Passenger Transport	Improved fuel efficiency of private vehicles and the inclusion of hybrid and electric vehicles in the private vehicle mix
	Improved public transport vehicle efficiency, including a shift to diesel mini-bus taxis and more fuel efficient (EURO IV) buses
	A modal shift from private vehicles to public transport

The Electricity Supply Mix for the Optimum Energy Future is made up of the following electricity sources:

Table 3: The Electricity Supply Mix for Optimum Energy Future		
Electricity Supply	2020 (%)	2050 (%)
Municipal Waste	1%	3%
Solar Thermal Electricity	0%	8%
Wind	9%	26%
New Nuclear	2%	9%
New Fossil Base (coal)	4%	48%
New Gas Turbines (Peak)	2%	4%
Existing Hydro	2%	2%
Existing Gas Turbines (Peak)	3%	0%
Existing Fossil Base (coal)	75%	0%
Existing Nuclear	2%	0%

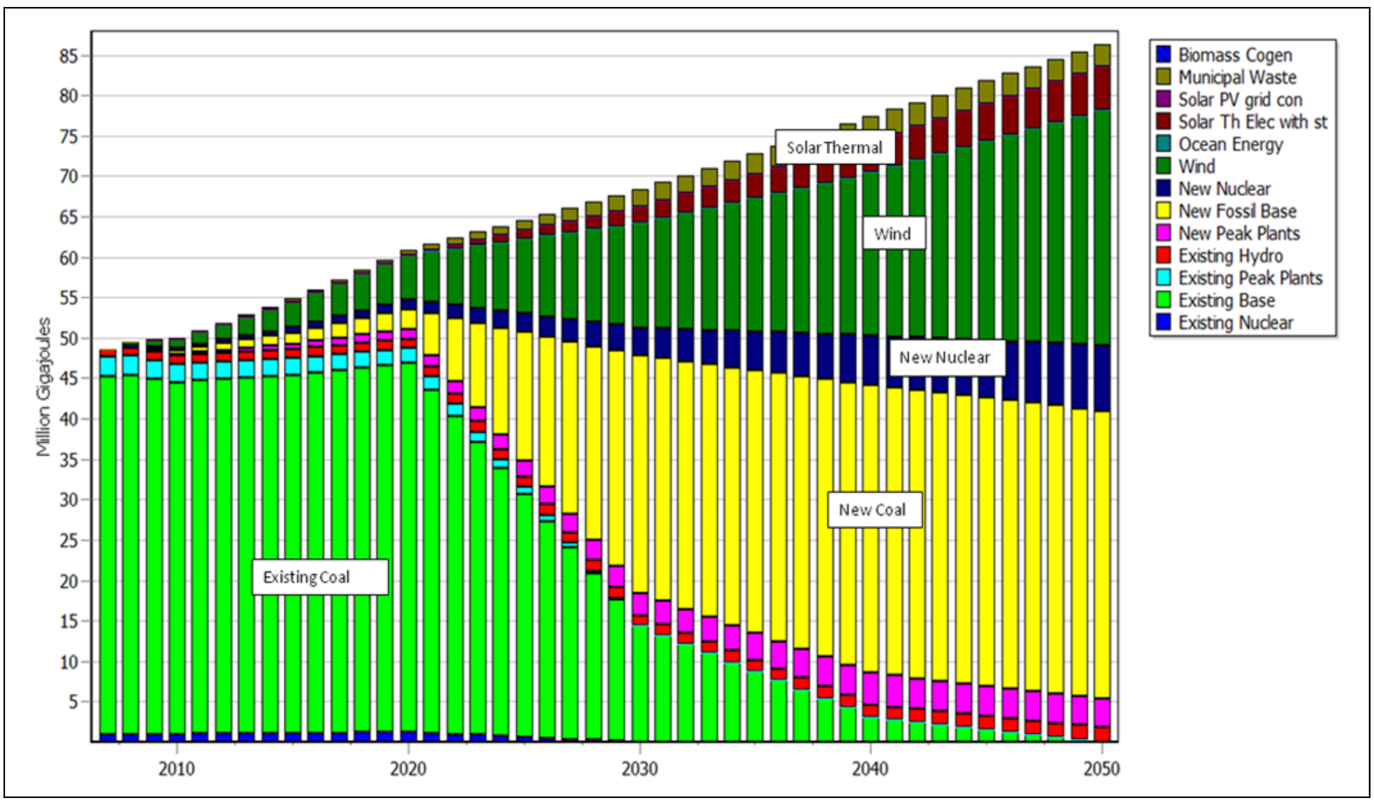


FIGURE 6: CAPE TOWN OPTIMUM ENERGY FUTURE SUPPLY MIX (NEW COAL, NEW NUCLEAR AND RENEWABLES)

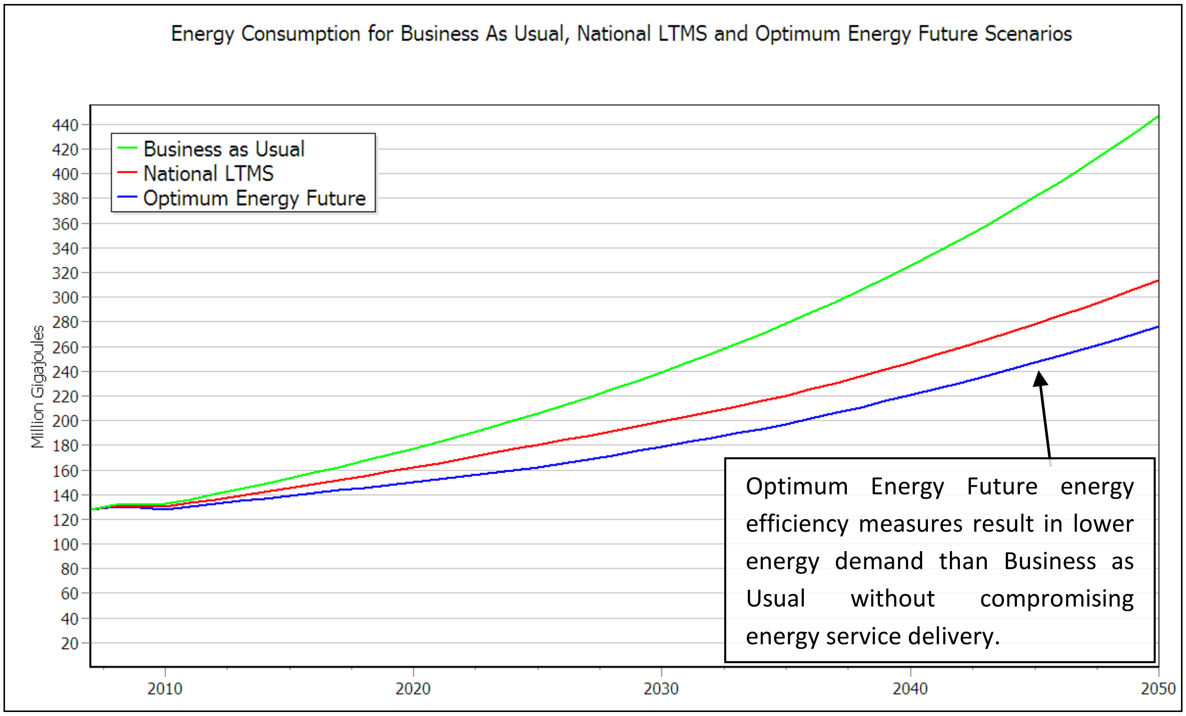


FIGURE 7: ENERGY CONSUMPTION FOR BUSINESS AS USUAL, CAPE TOWN OPTIMUM ENERGY FUTURE AND NATIONAL LTMS[6] SCENARIOS

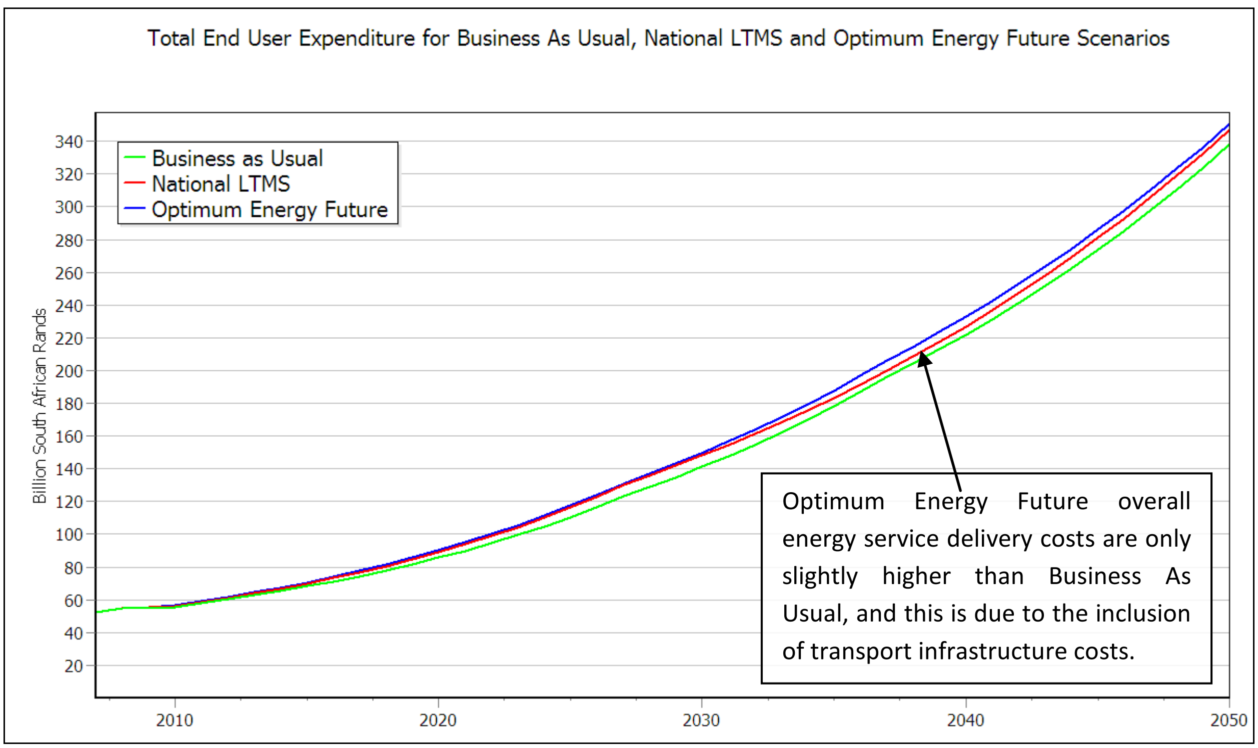


FIGURE 8: TOTAL COSTS FOR BUSINESS AS USUAL, CAPE TOWN OPTIMUM ENERGY FUTURE AND NATIONAL LTMS SCENARIOS

[6] The National LTMS scenario is one where the interventions specified in the National LTMS are mirrored in the Cape Town energy demand and supply interventions.

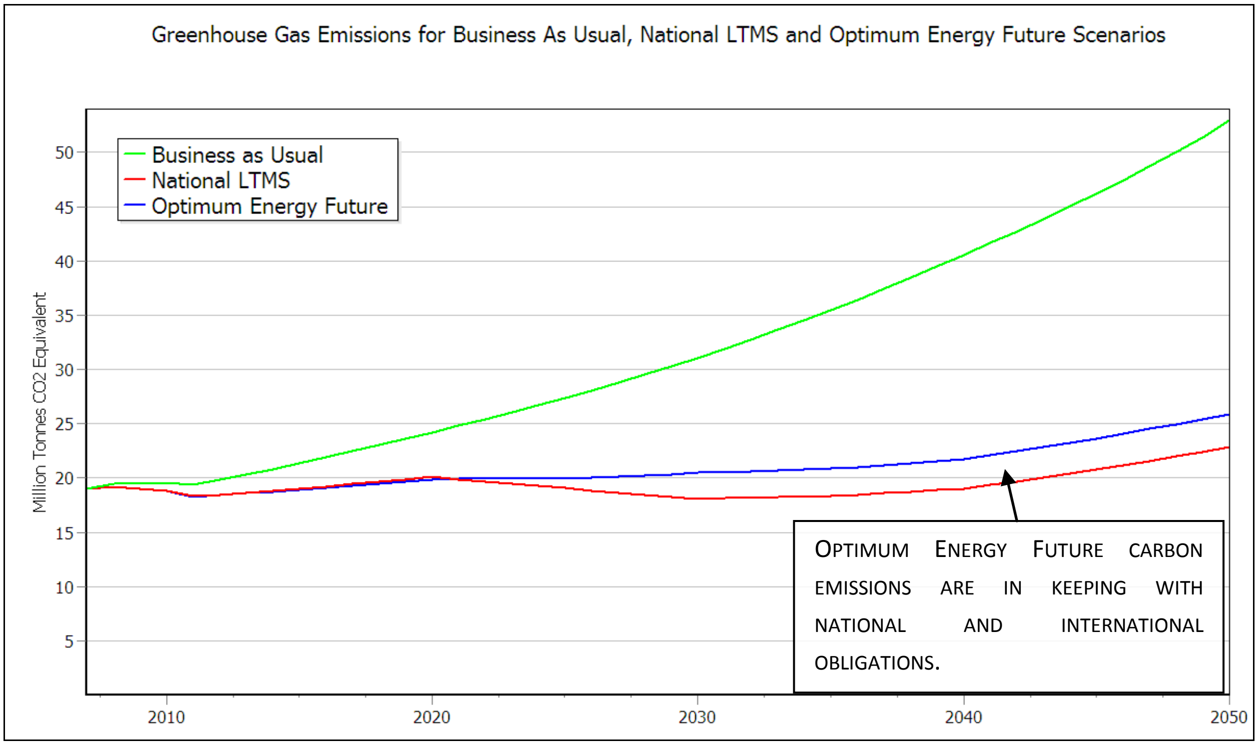


FIGURE 9: CARBON PROFILES FOR BUSINESS AS USUAL, CAPE TOWN OPTIMUM ENERGY FUTURE AND NATIONAL LTMS SCENARIOS

Carbon footprint

Greenhouse gas (GHG) emissions ("carbon footprint") that are produced by the Cape Town community[7] were quantified. This quantification covers GHG emissions from sources within the city's jurisdiction. Community level data comprised of data for energy use, transportation (including the impact of the aviation and maritime sectors), industry and solid waste management. Energy used within the geographic boundaries of Cape Town was accounted for. This means that even though the electricity used by Cape Town's residents is produced elsewhere, the energy and GHG emissions associated with its production and consumption were included in determining the city's GHG carbon profile. In the calculations, all electricity imported from the national grid is assumed to have the national generation mix proportions – i.e. mainly coal, and a small amount of nuclear, hydro and gas turbines.

There is work being undertaken internationally to establish standards for city carbon footprinting, and draft methodologies for this have been proposed[8]. Because of lack of standards, and possibly equally importantly, lack of data for many cities, it is still often difficult to compare carbon footprints directly. However, while carbon footprinting methods vary slightly between individual cities, emissions calculation protocols all adhere to the same scientific guidance provided by the IPCC when assembling a community inventory. Therefore, emissions coefficients and methodology used in the Cape Town GHG emissions are consistent with the standards established by the IPCC . Table 4 shows the carbon footprint for Cape Town in 2003 as given in the State of Energy Report for Cape Town for that year and the calculated carbon footprint

[7] 'community' refers to the people of Cape Town, and emissions from the 'community' therefore covers all social and economic activities engaged with by the people of the City.

[8] See Draft International Standard for Determining Greenhouse Gas Emissions for Cities, UNEP/UNHabitat/World bank, 23 March 2010.

for Cape Town 2007 as informed by the LEAP modelling exercise. The table also provides an overview of the emission coefficients and fuel types used in the calculation of emissions. Electricity is by far the largest source of GHG emissions.

Methane (CH_4) emissions from Wastewater Treatment Works also form a component of the carbon footprint of Cape Town, but this information has not been included in this assessment as detailed information is currently not available for most of the wastewater treatment works[9].

Table 4: Carbon Footprint comparison for Cape Town in 2003 and 2007					
	2003			2007	
Fuel	GJ	CO_2	Conversion Factor[10]	GJ	CO_2
Electricity	38,835,284	11,256,863	0.3056	48,576,102	14,844,856
Paraffin	2,448,796	175,579	0.0717	2,830,399	202,939
LPG	684,970	43,153	0.063	1,750,168	110,260
Coal	3,831,352	361,680	0.0944	3,055,991	288,485
Petrol	40,687,369	2,815,566	0.0692	39,392,694	2,725,974
Diesel	20,127,757	1,487,441	0.0739	27,874,053	2,059,892
HFO	4,695,842	362,519	0.0772	4,116,143	317,766
Wood	920,417	-	0	49,574	-
Sub-Total CO2e (energy, excl aviation and maritime)	110,231,787	16,502,801		127,645,128	20,550,175
	Population	3,154,000		Population	3,497,100
Carbon/Capita (energy only, but excl aviation and maritime fuels)		5.23			5.88
Solid Waste (landfill)		No data			2,665,110
Aviation Fuels	Not calculated	Not calculated	0.072	16,082,323	1,153,103
Maritime Fuels	Not calculated	Not calculated	0.078	38,237,320	2,990,158
TOTAL CO2e				181,964,771	**27,358,547**
Carbon/Capita					**7.82**

The figure below enables the Cape Town figures to be contextualised internationally. Overall emissions are slightly more than Delhi, while per capita emissions are higher than Tokyo, but lower than London, New York and Bangkok.

[9] Interestingly, sewage methane is also not included in several other detailed carbon footprinting exercises for cities around the world (see Methodology for Inventorying greenhouse gas emissions from global cities, Energy Policy 38, 2010, Kennedy et al)

[10] The Conversion Factors used in the 2003 and 2007 calculations are taken from the IPCC

Graphic from *Nature* (Oct. 20, 2010; based on Kennedy et al., 2009)

KEY ISSUES

The Key Issues discussed in this section of the report are divided into three broad categories that discuss the implications of moving to a secure, lower carbon energy future. These categories look at issues that (1) motivate for the implementation of the Cape Town Optimum Energy Future, (2) provide rationale for the implementation of key actions of Cape Town Optimum Energy Future and (3) highlight issues that will need to be considered in future planning exercises.

MOTIVATION FOR CAPE TOWN OPTIMUM WAY FORWARD

KEY ISSUE 1: PROCEEDING ALONG A BUSINESS AS USUAL SCENARIO HAS SIGNIFICANT RISKS

Cape Town is highly dependent on external national and international energy sources – our predominant electricity source is from coal power stations, and most of our liquid fuels are imported, although some is produced at Sasol plants from coal. The dependence of the country and cities such as Cape Town on fossil-fuel based energy sources result in a very high carbon footprint. Energy consumption is dominated by four main sectors, namely transport, the commercial sector, the industrial sector and the residential sector. The transport sector remains dominant, using 50% of total energy, mainly due to the City's sprawling nature and its poor public transport system and associated high use of inefficient private vehicles.

The Business As Usual Scenario shows continued energy growth at 2.9% for most sectors. Figure 10 shows the impact of a continued unconstrained energy growth. The energy demand by the transport sector stands to quadruple between 2007 and 2050 and similar growth will take place in the residential, commercial and industrial sectors.

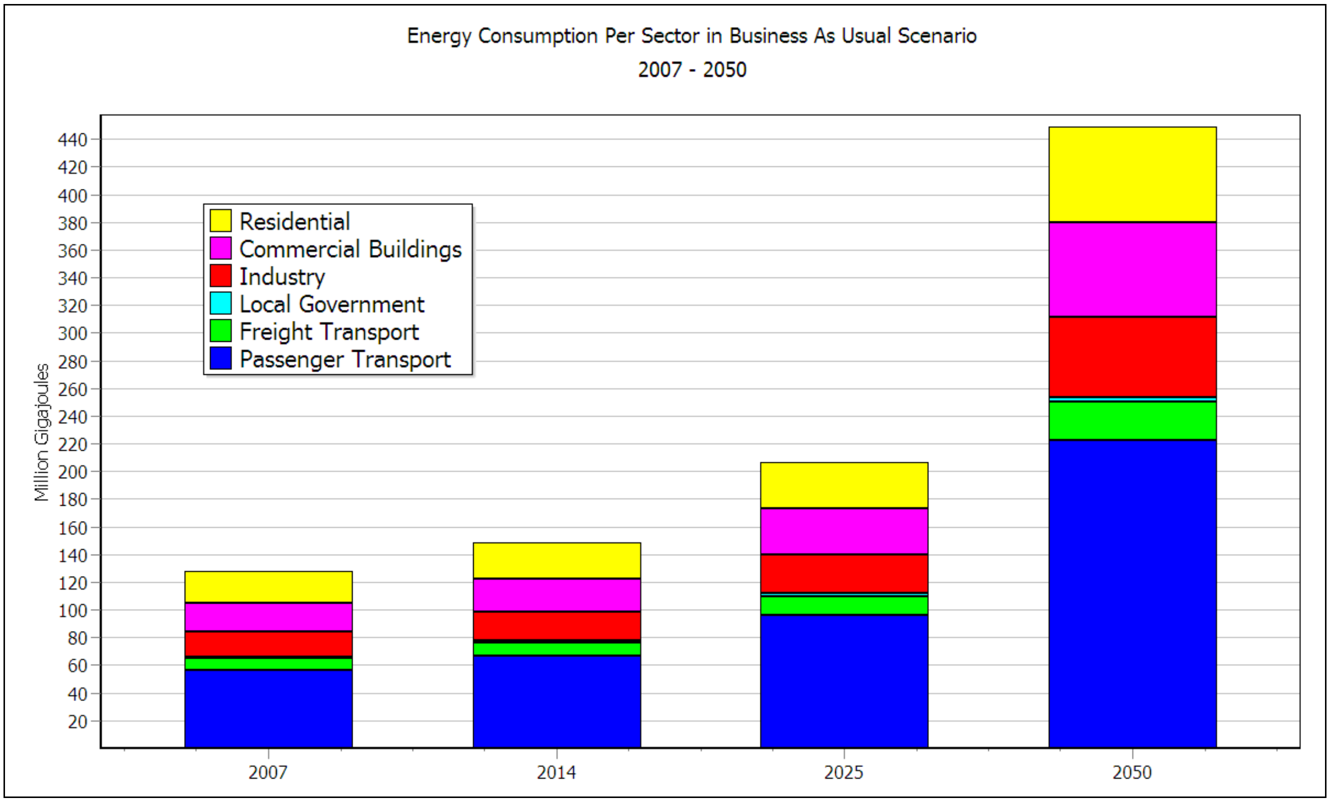


FIGURE 10: ENERGY CONSUMPTION PROJECTIONS PER SECTOR IN THE BUSINESS AS USUAL SCENARIO (2007 - 2050)

There are significant risks associated with this future energy path, including

- A vulnerability to a carbon constrained future: Having high carbon emissions levels in the future is likely to impact on economic competitiveness. A carbon tax on electricity generation has been mooted and the impact of a tax of R100 per ton, escalating, could have serious direct financial implications to a fossil fuel based supply mix (see Figure 11).

- Peak Oil Vulnerability – the growth in the transport sector, in particular, is of concern when looking at the implications of a post-peak oil economy. The implications of Peak Oil will substantially increase the costs associated with transport fuels, in particular private passenger transport, but also freight transport, which is predominantly road-based. This will be discussed in more detail under Key Issue 10.

- High energy expenditure for the city's occupants – An unconstrained growth in electricity demand (as opposed to widespread implementation of energy efficiency) will result in the overall city system paying more for electricity services than necessary. This is particularly significant in the light of the steep electricity price increases expected in the years to come.

- Inefficient economy – Without a concerted application of energy efficiency, the economy will need to spend more on energy for the same output. This becomes increasingly significant as energy prices rises steeply.

- Reduced jobs in the energy sector – large coal-fired and nuclear generation plant result in less jobs per unit energy produced than for renewable energy. In contrast, a strong renewable energy industry can boost employment significantly. This is discussed in more detail under Key Issue 6.

- Losing any marketing advantage around being a green city – Cape Town is viewed as a long-haul destination in the international arena, and is considered to be one of the greener cities around the world due to its impressive natural environment and the programmes that have been implemented to protect this environment. This marketing advantage is, however, at risk if unconstrained energy demand continues and the City is seen to be carbon 'dirty' in the future.

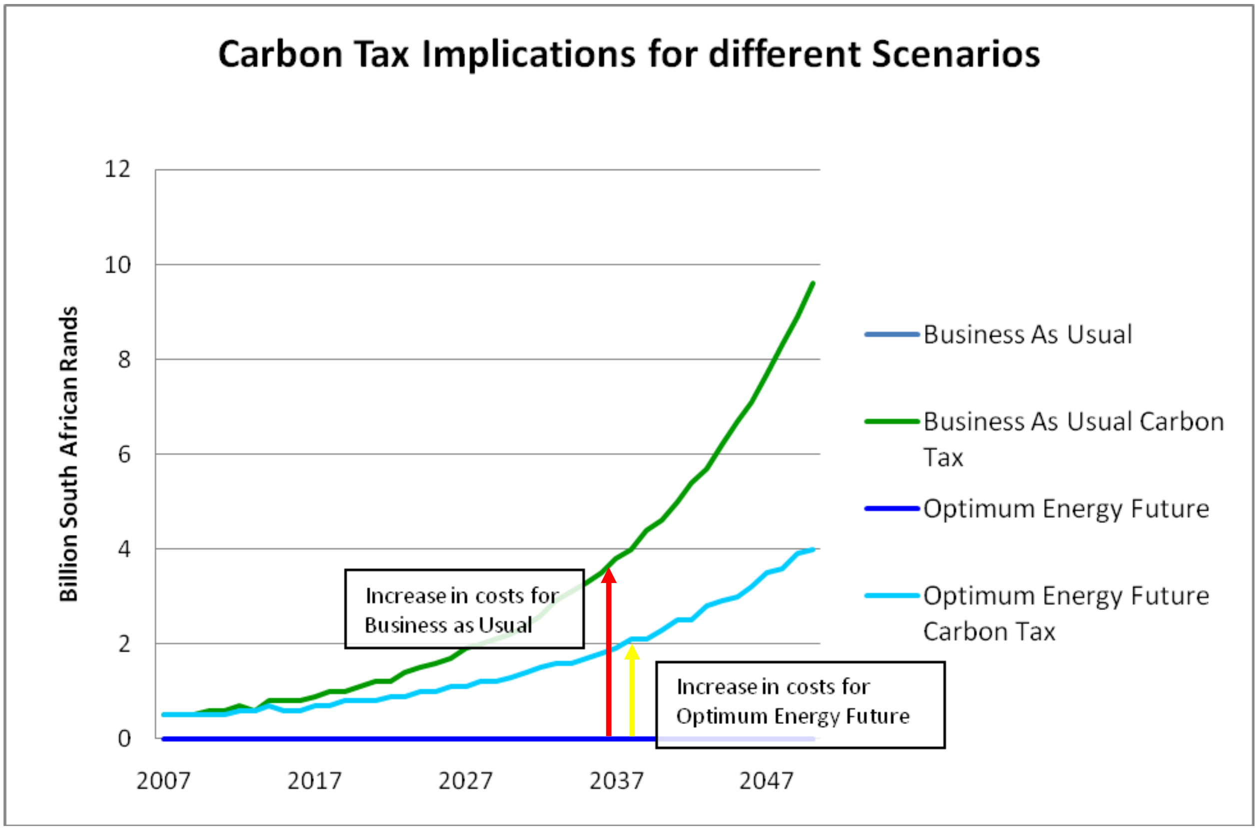


FIGURE 11: IMPACT OF A CARBON TAX (R100 PER TON ESCALATING) ON TOTAL COST OF ENERGY SYSTEM IN CAPE TOWN

KEY ISSUE 2: THE OVERALL COST TO THE CITY'S INHABITANTS OF A LOW CARBON WAY FORWARD IS SLIGHTLY HIGHER THAN THE BUSINESS AS USUAL SCENARIO (DUE TO THE INCLUSION OF PUBLIC TRANSPORT INFRASTRUCTURE COSTS)

The Optimum Energy Future's suite of low-carbon implementation measures covers both strong demand-side measures (energy efficiency) as well as supply side interventions – mainly through the implementation of significant renewable energy options. While the renewable energy options increase supply costs to some degree (see Key Issue 3), the electricity efficiency measures reduce total costs to the extent that overall costs to the city's inhabitants for the same level of electricity service delivery is reduced. However one of the key demand side measures is a modal shift towards public transport which will require a significant investment in public transport infrastructure. These costs have been added to the total cost of the optimum energy future, and the expected result is that the Optimum Energy Future scenario is only slightly more expensive than the Business As Usual Scenario with the inclusion of these massive public transport infrastructure investments.

Figure 12 shows that the Business As Usual scenario, which is a predominantly coal-based supply option (and the cheapest supply mix) has the lowest total cost when compared to the other scenarios as the Optimum Energy Future and National

LTMS Scenarios both include a significant public transport infrastructure cost to facilitate the modal shift to public transport.

Figure 13 shows the costs of the scenarios excluding the public transport infrastructure costs associated with the modal shift to public transport. This shows that the Business As Usual scenario has the highest total cost and this is due to the high growth in energy demand and the fact that few efficiency interventions have been put in place to reduce the demand.

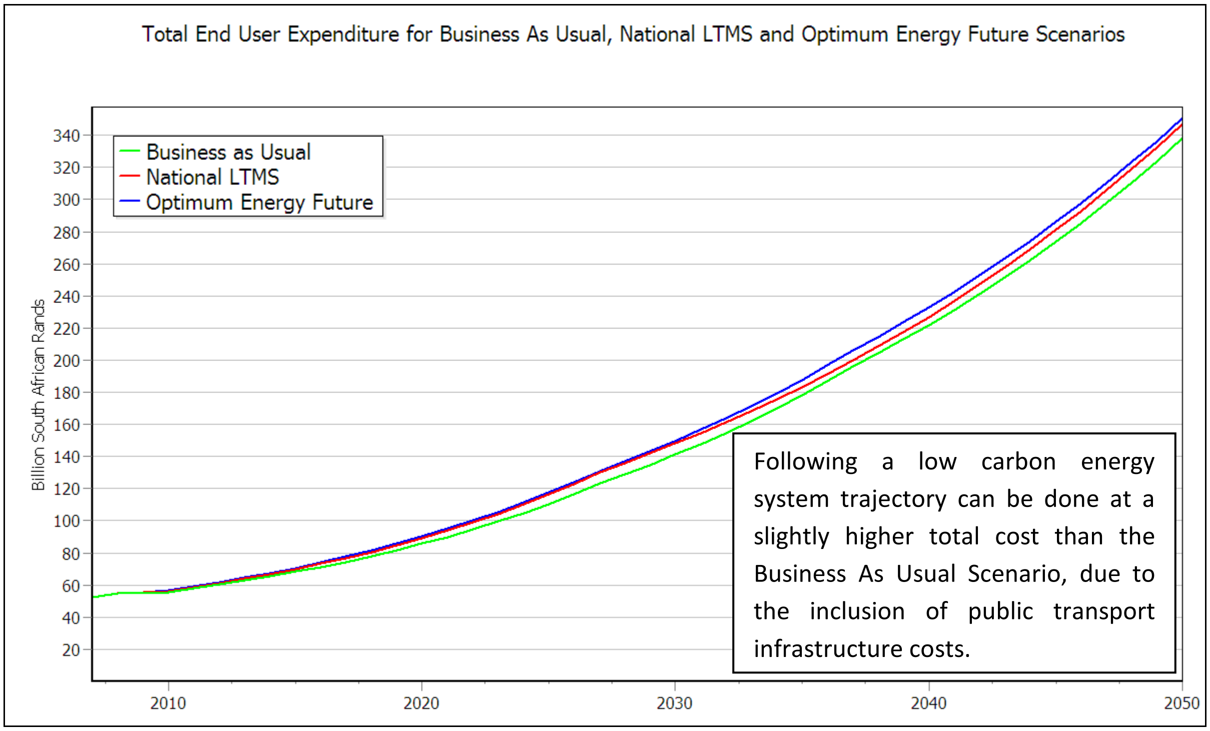


FIGURE 12: TOTAL COSTS (SUPPLY AND DEMAND) FOR ALL SCENARIOS, INCLUDING SIGNIFICANT PUBLIC TRANSPORT INFRASTRUCTURE COSTS

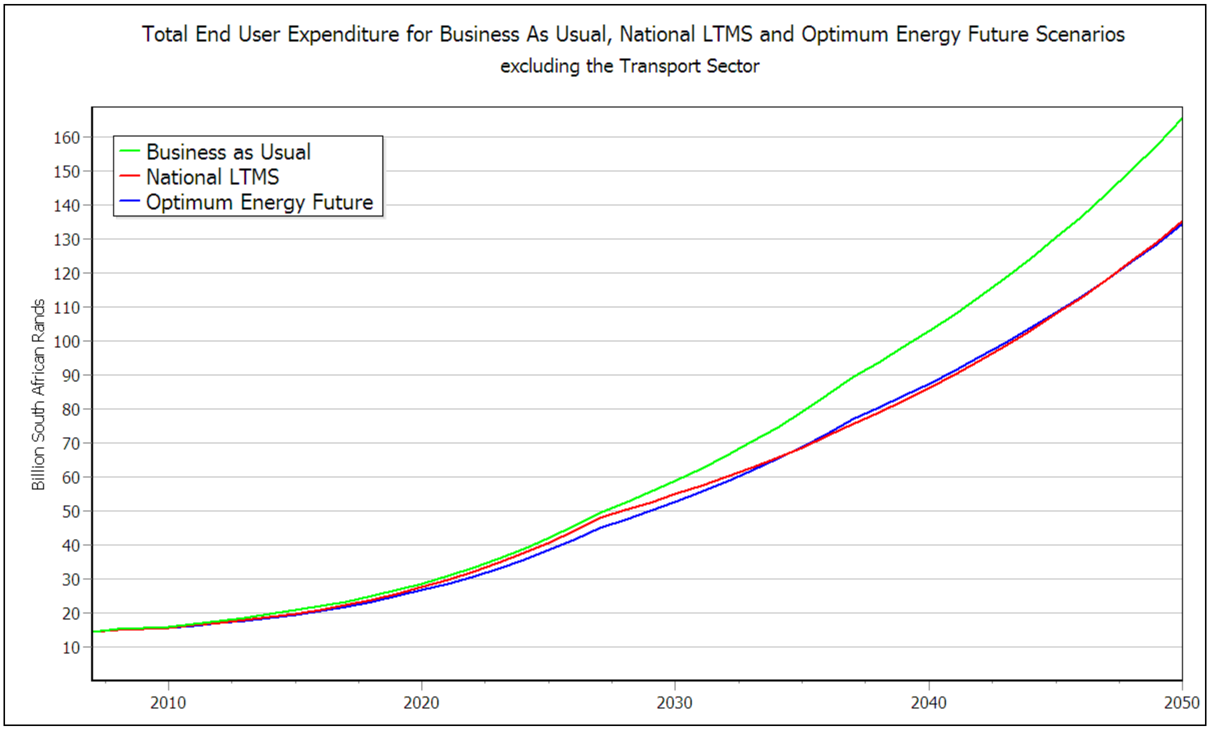


FIGURE 13: TOTAL END USE EXPENDITURE FOR ALL SCENARIOS EXCLUDING THE TRANSPORT INFRASTRUCTURE COSTS ASSOCIATED WITH A PUBLIC TRANSPORT MODAL SHIFT

KEY ISSUE 3: THE COST OF AN ELECTRICITY SUPPLY MIX THAT INCLUDES A STRONG COMPONENT OF RENEWABLE ENERGY IS HIGHER THAN BUSINESS AS USUAL (MAINLY COAL BASED), BUT NOT SIGNIFICANTLY HIGHER

Table 5 shows the electricity generation costs for each scenario and the different supply mixes associated with the scenarios. These scenarios are each made up of a different supply mix, with the Business As Usual Scenario being predominantly coal-based, the National LTMS Scenario including new nuclear and new renewables and the Optimum Energy Future focusing on renewable electricity with a smaller proportion of nuclear (see Key Issue 4 for a more detailed discussion on nuclear energy in the supply mix).

Table 5: Generation mixes and costs for different scenarios in 2050						
	Scenario: Business As Usual		Scenario : Optimum Energy Future		Scenario : National LTMS	
	% mix	R/kwh	%	R/kwh	%	R/kwh
Municipal Waste	0%	R 0.44	3%	R 0.44	2%	R 0.44
Solar Thermal Electricity	0%	R 1.50	8%	R 1.50	10%	R 1.50
Wind	9%	R 1.00	26%	R 1.00	20%	R 1.00
New Nuclear	2%	R 0.69	9%	R 0.69	32%	R 0.69
New Fossil Base	82%	R 0.42	48%	R 0.42	32%	R 0.42
New mid and peak (Gas Turbines)	5%	R 3.40	4%	R 3.40	4%	R 3.40
Existing Hydro	2%	R 0.10	2%	R 0.10	0%	R 0.10
Existing mid and peak (Gas Turbines)	0%	R 3.40	0%	R 3.40	0%	R 3.40
Existing Base	0%	R 0.20	0%	R 0.20	0%	R 0.20
Existing Nuclear	0%	R 0.69	0%	R 0.69	0%	R 0.69
Average Generation Costs		**R 0.62**		**R 0.80**		**R 0.85**

While generation costs for the Optimum Energy Future are higher than for the Business as Usual scenario due largely to the higher component of wind energy, they are not significantly higher, and when weighed up against the benefits of a resilient city in a carbon constrained future are not prohibitive (in fact the energy efficiency programme associated with the Optimum Energy Future more than offsets the extra supply costs to result in a cheaper overall cost of electricity to Cape Town than the Business as Usual).

KEY ISSUE 4: NUCLEAR IS PART OF THE NATIONAL LTMS MIX BUT NEEDS TO BE APPROACHED WITH CAUTION – CONSTRUCTION DELAYS, LONG LEAD-IN TIMES AND LARGE COST OVERRUNS ARE COMMON FOR NUCLEAR PROJECTS. THERE IS ALSO A LOT OF PUBLIC CONTENTION AROUND NUCLEAR ENERGY.

The National LTMS includes cleaner (supercritical) coal, renewables and new nuclear as the key components of its supply mix. It specifies 27% of electricity dispatched by 2030 is to come from nuclear energy, either from Pebble Bed Modular Reactors (PBMR) or from conventional pressurized water reactors (PWR). The scenario is also based on the assumption that no new nuclear capacity can be commissioned before 2013, when the first PBMR can be commissioned with the PWR to follow in 2015. However the deadlines for such a commissioning schedule has passed as nuclear lead-in times are typically well over 5 years. Also, construction delays and large cost overruns are very common in nuclear projects around the world (see reports such as World Nuclear Industry Status Report 2009[11]). A reduced nuclear component from the national LTMS (i.e. below 27%) is therefore seen as appropriate in the Optimum Energy Future scenario.

[11] World Nuclear Industry Status Report 2009, German Federal Ministry of Environment, Nature Conservation and Reactor Safety

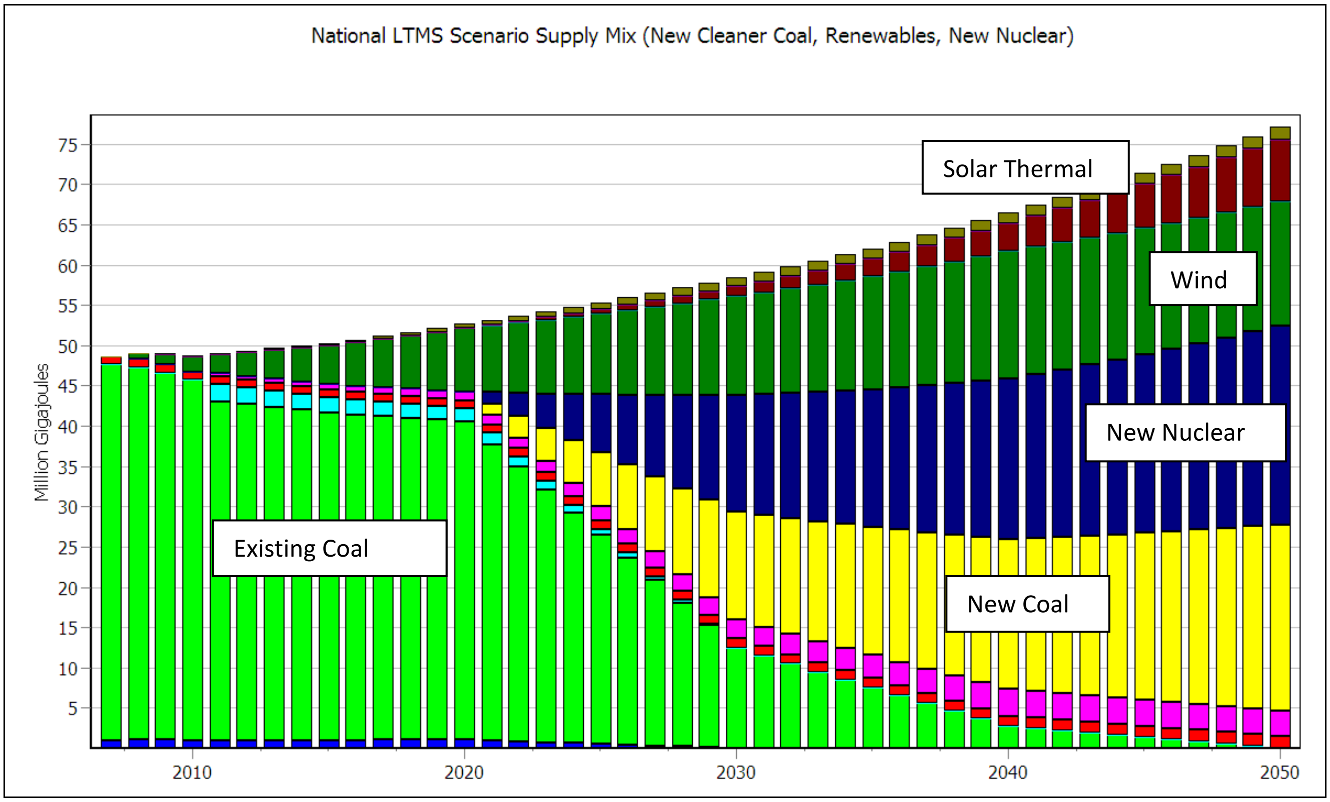


FIGURE 14: THE NATIONAL LTMS SUPPLY MIX (INCLUDING NEW COAL, NEW NUCLEAR, AND RENEWABLES)

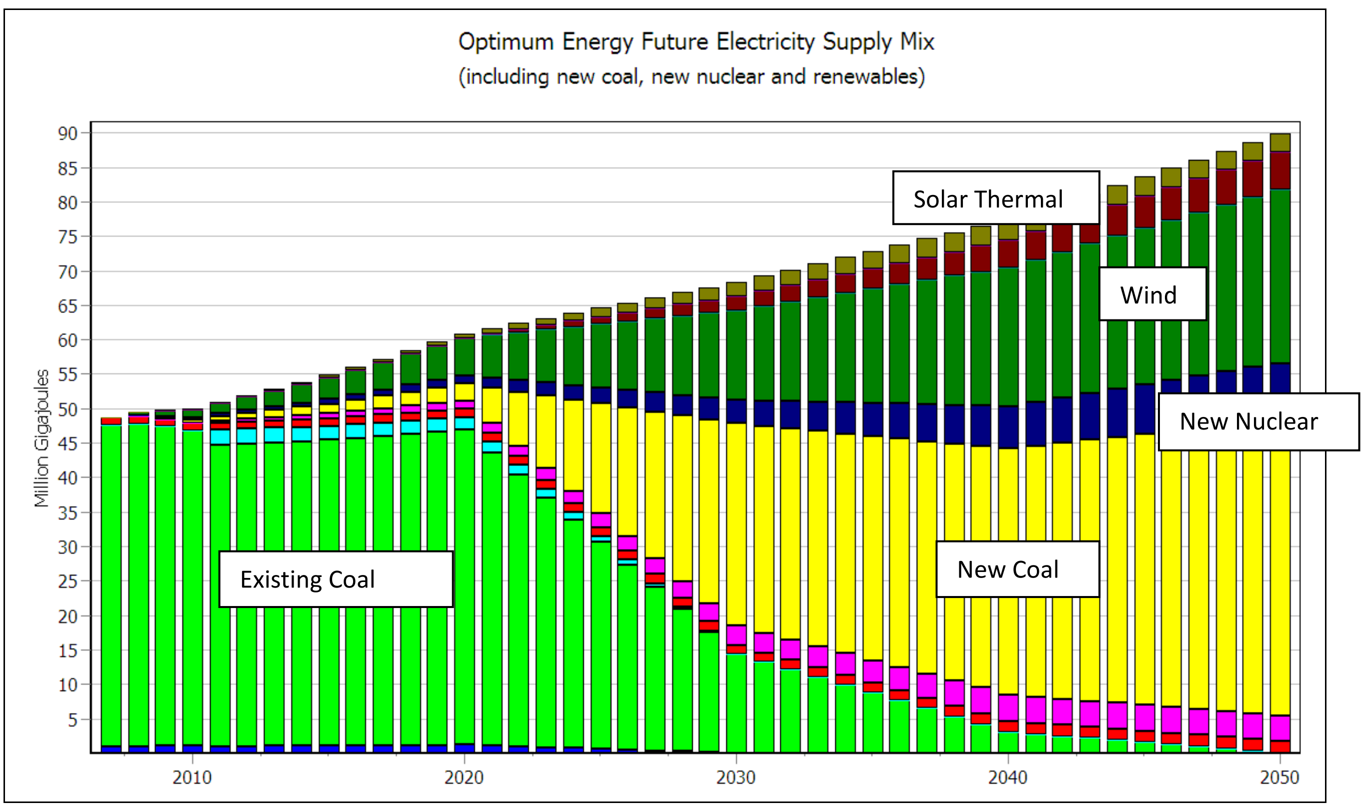


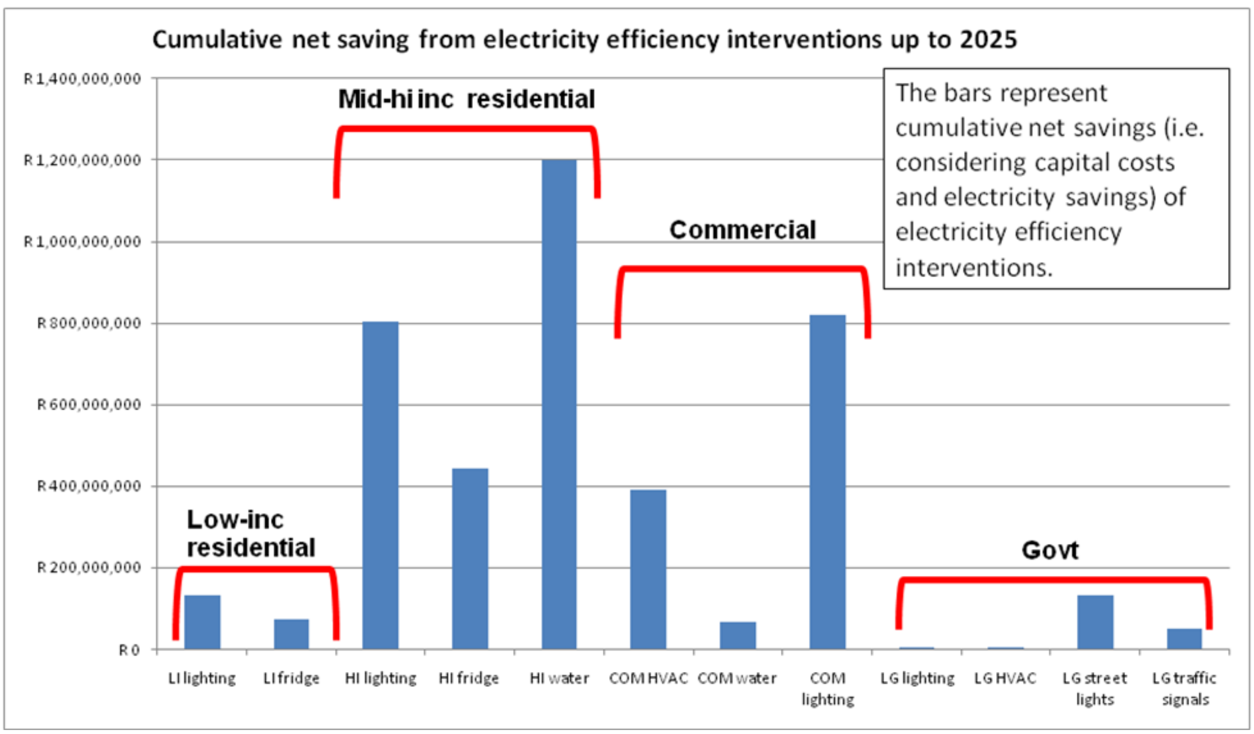
FIGURE 15: CAPE TOWN OPTIMUM ENERGY FUTURE SUPPLY MIX (INCLUDING NEW COAL, NEW NUCLEAR AND HIGH PROPORTION RENEWABLES)

Nuclear Energy is a highly debated energy source in South Africa, with some players arguing that it is a low-carbon energy source and the only viable option for base-load electricity for South Africa if the country is to move towards a low carbon economy. Others point out that the true cost of nuclear to the country is excessive, particularly when looking at decommissioning and long-term disposal of waste.

KEY ISSUE 5: ALMOST ALL ELECTRICITY EFFICIENCY INTERVENTIONS ARE FINANCIALLY SENSIBLE AND PAY THEMSELVES BACK, LEADING TO A MORE EFFICIENT ECONOMY

A number of energy efficiency interventions were analysed to determine their financial and energy impact, and in particular to assess their financial feasibility[12].

In Figure 16, each of the interventions is assessed in terms of the cost of implementing the programme (e.g. the cost of implementing solar water heaters in mid-hi-income households). These costs are the total cost of the programme, not costs incurred by the City (unless measures are implemented at City facilities). The figure shows that all programmes realise a financial savings over the analysis period, and therefore contribute to an efficient city and economy[13].



[12] A full list of interventions considered is in Annexure A, including a rationale for why this group of interventions were chosen for the Optimum Energy Future.

[13] Industry interventions are difficult to capture because of the diversity of operations, and they often have slow payback periods compared with the above (although still positive). They have therefore not been included in the graph. But in general the level of disaggregated industrial energy data available throughout South African cities remains problematic and results in impact assessments which are often more indicative than accurate.

FIGURE 16: NET CUMULATIVE FINANCIAL SAVINGS ASSOCIATED WITH EACH INTERVENTION IN 2050[14].

Transport projects have not been included in this graph, as the cost implications of public transport infrastructure are orders of magnitude higher, and benefits are largely not financial, therefore such investments need to be considered separately (see Key Issue 8).

KEY ISSUE 6: A HIGH RENEWABLE ENERGY FUTURE RESULTS IN A SIGNIFICANT INCREASE IN JOBS CREATED

One of the key benefits of implementing a high renewable energy supply mix is the resulting job creation – renewable energy technologies have much higher employment per unit of energy than do conventional coal and nuclear generation options. The table below estimates the employment opportunities (in job-years) associated with the different scenario supply mixes (see Key Issue 3 for more discussion around this topic). The most significant job creation technologies are wind energy and solar water heating implementation.

Table 6: Job estimates for Western Cape from different electricity sources

Job creation	Job-years/GWh	Proportion in W Cape*	BAU	Optimum Energy Future	Nat LTMS
Municipal Waste	12.2	90%	0	123,231	120,579
Solar Thermal Elec with storage	8.7	10%	0	23,078	21,040
Wind	9.1	70%	280,397	844,967	806,994
New Nuclear	0.1	50%	320	1,667	5,992
New Fossil Base	0.7	0%	0	0	0
New mid and peak	0.4	40%	4,858	3,873	3,777
Existing Hydro	1.0	30%	4,891	4,451	4,361
Existing mid and peak	0.2	30%	454	429	427
Existing Base	0.5	0%	0	0	0
Existing Nuclear	0.1	60%	499	286	286
Total jobs from generation			**291,418**	**1,001,981**	**963,455**
SWHs	31.5			799,828	799,828
Energy Efficiency	0.23			11,329	11,329
TOTAL ALL			**291,418**	**1,813,138**	**1,774,612**

* - The above table estimates the proportion of jobs that might be created in the Western Cape should adequate incentives be put in place. However, these are only rough estimates and need more detailed research before they can be considered accurate.

[14] Costs calculated on a 'new build' scenario. Assumption is that over the life of the programme, the targets can be predominantly met by replacement of current technologies as they fail coupled with the growth in the various sectors, therefore there will be relatively few retrofits necessary. In phase2 of this project, when business plans are developed, the proportion of retrofits required will be factored into costing calculations.

The National LTMS and Cape Town Optimum Energy Future both have high renewable proportions which provide a significant number of jobs. However it should be noted that only some of the total number of jobs linked to a supply option will be local – some may even be created internationally rather than locally. For example, around 60% of jobs linked to wind generation are associated with component manufacturing, and many of these jobs would be lost to the country if no effort was put into incentivising such manufacture locally. It is important that a more detailed analysis is undertaken to understand how to maximise local jobs.

Next steps…

- Undertake detailed analysis on job creation potential of different energy supply options and how to provide incentives or other measures to maximise local job creation.

Key Issues regarding implementing the Optimum Energy Future

Key Issue 7: Infrastructure costs linked to public transport modal shift are high. The city may struggle to find this money, yet significantly improved public transport facilities are essential to a sustainable city.

Increased reliance on the private vehicle and ineffective public transport systems remains Cape Town's biggest mobility challenge, and fragmented responsibilities and poor coordination between the spheres of government involved in transport provision have been a key factor in this unsatisfactory situation. Poor integration between different modes of public transport as well as issues of safety on public transport reinforces the trend of private car usage.

To improve access and mobility in the City, there is a need to transform and restructure the current transport system, and to improve public transport. An effective and affordable public transport system is key to reducing the dependence of the city on fossil fuels and lowering the carbon footprint, in addition to having important social benefits. The cost of an upgraded public transport system is however high as can be seen from the estimated R4.2 billion investment in only Phase 1A of the Integrated Rapid Transit (IRT) in Cape Town.

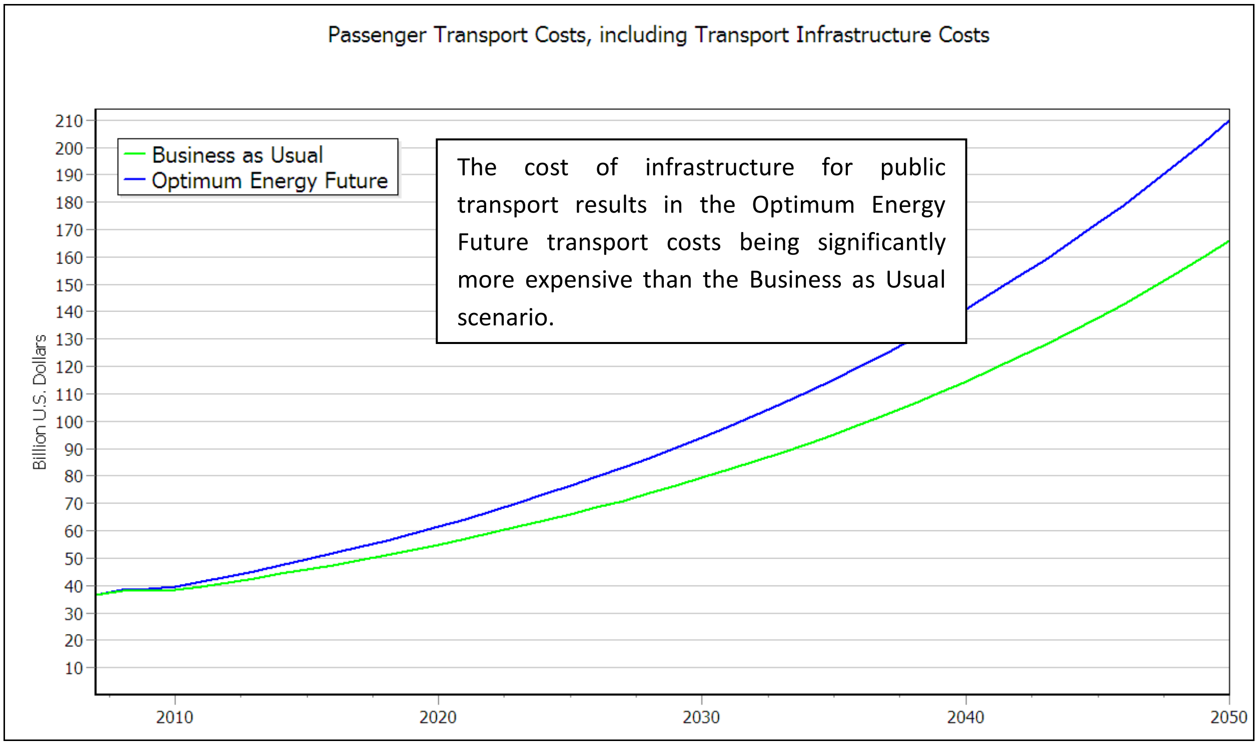


FIGURE 17: PASSENGER TRANSPORT COSTS FOR BUSINESS AS USUAL AND CAPE TOWN OPTIMUM ENERGY FUTURE (INCLUDING TRANSPORT INFRASTRUCTURE COSTS FOR PUBLIC TRANSPORT)

Figure 17 shows the impact including the cost for the new IRT bus system and a rail system, taking into consideration costs associated with the construction of the infrastructure, such as the dedicated lanes and new rail services, as well as the operations and maintenance costs. These costs are based on an average occupancy of 30%[15] on the public transport services. In Key Issue 11, the implication of a higher occupancy will be discussed.

Currently the funds required to upgrade public transport systems have come from a number of sources, including National Government, International Funders and local government. It has not been stated who will take responsibility for the costs of implementing the remainder of the IRT system in Cape Town and how the operation costs of the system will be covered and whether a subsidy will be required. A number of funding sources have been investigated, and this will need to continue, including opportunities associated with selling carbon. Finding the necessary money remains a challenge however.

KEY ISSUE 8: THE CITY IS CURRENTLY A 'TAKER' OF THE NATIONAL ELECTRICITY MIX, BUT IT MAY BE ADVISABLE FOR THE CITY TO MOVE TO A LOW CARBON MIX MORE PROACTIVELY TO REDUCE THE RISK OF HAVING AN ENERGY SYSTEM INCOMPATIBLE WITH A CARBON CONSTRAINED FUTURE.

Currently the city generates very little electricity itself (other than some peaking gas turbine plant) and sources very little electricity independent from the national grid (other than the Darling wind farm IPP agreement), so is effectively a 'taker'

[15] International studies, give average public transport occupancy for low density cities (such as Cape Town) as 30%. This occupancy figure was used as the baseline for representing the low density currently experienced in Cape Town.

of the national electricity supply mix. If the national mix into the future is therefore not moving towards low-carbon fast, this represents a risk for the sustainability of the city in the likely future where carbon constrains will burden the economy severely. If the imminent national Integrated Resource Plan (IRP – the national electricity planning exercise) does not show adequate shift to a more sustainable future the city may want to take a more proactive route and explore sourcing cleaner energy more directly such as through IPP arrangements.

The REFIT (Renewable Energy Feed-in Tariff)

The REFIT is the mechanism whereby renewable generators obtain an added incentive to sell energy into the grid. While significant, it is only available through the Single Buyer Office (effectively Eskom at present) and thus separate IPP arrangements entered into by the city may not be able to access the REFIT thereby making such power expensive and potentially unfeasible for the city and/or the IPP. This would need further investigation. There is also currently a cap of 400MW for wind energy (the most promising renewable resource in the short and medium-term) for the REFIT, which is very little and hardly allows for its use to change the carbon profile of a city, let alone the country, but this is likely to be increased in the new IRP.

In the REFIT discussion document REFIT Phase 2 may make provision for traders (e.g. municipalities) to aggregate renewable energy purchases from embedded generators and recovers costs from the Single Buyer. It is currently unclear whether or how this will be enacted, or what the implications for the city energy mix might be.

The MFMA (Municipal Finance Management Act)

The MFMA requires that municipalities source goods as cost-effectively as possible. Since a lower carbon electricity supply inevitably increases the cost of electricity (all the major low carbon options are more expensive than coal-based electricity – wind, solar and nuclear) this may be interpreted as being contrary to the MFMA. However, low-carbon electricity may also be interpreted as being a different product to normal 'dirty' electricity – which is how Nelson Mandela Municipality is viewing the situation – which removes the potential MFMA constraint.

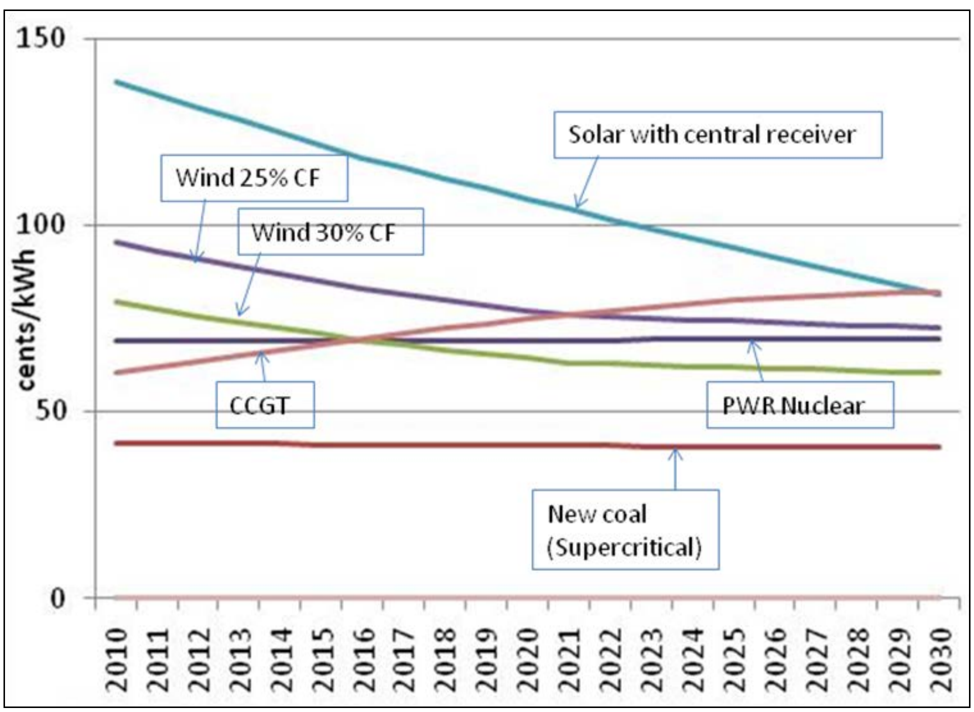


FIGURE 18: COST OF GENERATION FROM DIFFERENT ELECTRICITY SUPPLY OPTIONS (FROM SNAPP ELEC SUPPLY PLANNING MODEL, ENERGY RESEARCH CENTRE, UCT)

Generation mandate

The city is able to undertake generation of electricity in terms of their constitutional mandate (in fact some cities own substantial power stations as Cape Town used to do with the Athlone coal-fired plant), although their main function is distribution.

Willing buyer

Another option for the city to increase their renewable energy component and potentially avoid the REFIT/Single Buyer institutional constraints mentioned above is for them to find willing buyers of renewable energy within the city (at a premium), and facilitate the supply of energy from a renewable Independent Power Producer (IPP) to the willing buyer.

Next steps…

- It is proposed that the City await the outcome of the current IRP process and if the proposed future generation mix is considered too great a risk in terms of a high carbon future, then the above issues be further explored to determine a feasible way forward for a lower carbon future.

KEY ISSUE 9: ELECTRICITY TARIFF DESIGN WILL NEED TO CHANGE IN FUTURE TO PROMOTE ENERGY EFFICIENCY AND AT THE SAME TIME TO PRESERVE THE CITY'S REVENUE BASE.

> The practice of designing tariffs so that they promote energy efficiency while maintaining revenue flows is termed '***decoupling***' – de-linking increasing income by increasing sales/consumption.

Electricity revenue not only supports the electricity department's operations and infrastructure maintenance activities, but generates a large surplus which is a significant contributor to overall City coffers. While in the long-term a redesign of the city's revenue system might be pursued so that electricity does not cross-subsidise other city functions, this is unlikely in the near future. Preserving the revenue contribution from electricity is therefore important. To this end, the increased focus on energy efficiency, and electricity efficiency particularly, can raise concerns around revenue reductions – since currently electricity revenue is directly linked to consumption. It is therefore important that tariffs are designed such that they support electricity efficiency yet at the same time preserve the City's revenue base. A number of utilities around the world have significant experience with such tariffs and show that they can be very successfully applied so that they actively promote efficiency while maintaining revenue streams. South Africa has no experience in this area however, and therefore tariffs still effectively facilitate increases in consumption as opposed to efficiency. This is an important area to address, as efficiency is arguably the most critical component of a low carbon strategy.

Next steps…

- Explore the design of tariffs which promote energy efficiency and preserve revenue, possibly drawing on international experience in this area (such as via the Regulatory Assistance Programme).

KEY ISSUES THAT NEED TO BE CONSIDERED IN FUTURE PLANNING EXERCISES

KEY ISSUE 10: PEAK OIL HAS POTENTIALLY HUGE FINANCIAL IMPLICATIONS FOR THE ECONOMY AND A RADICAL MODAL SHIFT FROM PRIVATE TO PUBLIC TRANSPORT IS NEEDED TO CHANGE THIS

While it is uncertain precisely when global oil production will peak and what the post-peak rate of oil reserve depletion will be, available evidence suggests that global oil production could decline between 2007 and 2020, with a significant risk of rapid decline thereafter, resulting in increasing prices and general price instability.

Because oil is an input into most economic activities (including food production) and forms the basis of the modern transport system, shortages of oil will have significant impacts on all aspects of the economy, not just transport systems. South Africa imports approximately 66% of the oil (most of the remainder coming from SASOL's coal to liquid fuel plants).

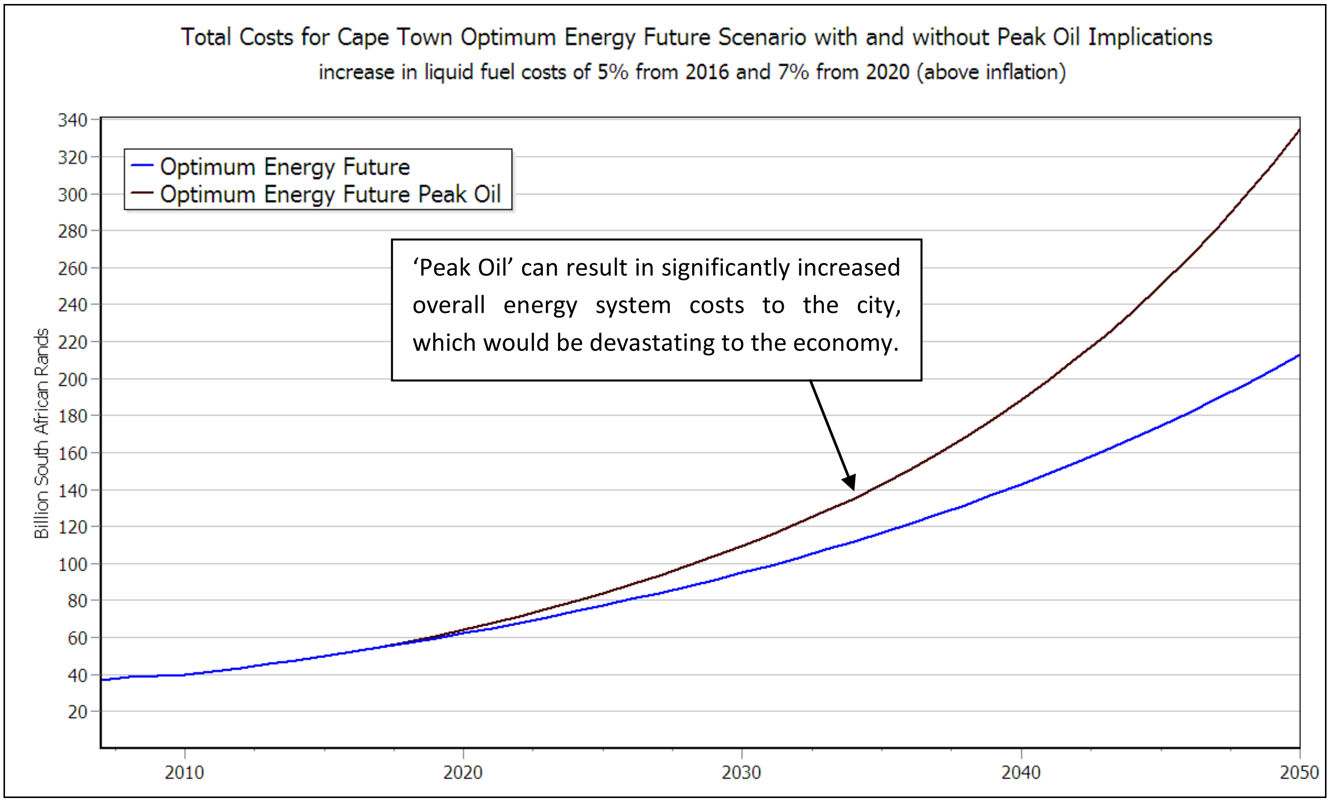


FIGURE 19: TOTAL COSTS (DEMAND AND SUPPLY) FOR CAPE TOWN OPTIMUM ENERGY FUTURE SCENARIO WITH AND WITHOUT PEAK OIL COST IMPLICATIONS

The impact of an increase in oil price can be seen in Figure 19. The costing information used in this graph (as an illustration of the impact, rather than an accurate prediction of the Peak Oil future) shows that there is a significant increase in cost of the energy system associated with Peak Oil – between 50% to 100% by 2050. This would be devastating to the economy.

KEY ISSUE 11: DENSIFICATION OF THE CITY MAKES PUBLIC TRANSPORT MORE FEASIBLE AND THEREFORE HAS A KEY ROLE TO PLAY IN MOVING TO A LOW CARBON CITY

In Cape Town, low density urban sprawl has had a particular impact on the City's perimeter to the north, east and northeast, and has resulted in increased dependence on private vehicles and a less energy efficient city (in addition to other impacts such as a loss of valuable agricultural land, increasing commuting times, increasing pollution and the loss of some natural resource areas and cultural landscapes). Public transport is an essential component of a sustainable, low carbon city, yet providing such services is unviable in low density cities. Experience in South American cities indicates that costs of public transport are double per passenger-km in sprawling cities compared with dense cities.

In Key Issue 7 the transport infrastructure costs used were based on a 30% occupancy figure for public transport facilities. By creating a denser city over a period of 30 years, it is estimated that the occupancy on public transport could increase to 60% and the cost per passenger-km will therefore decrease, reducing the capital requirements for an effective public transport system to manageable levels.

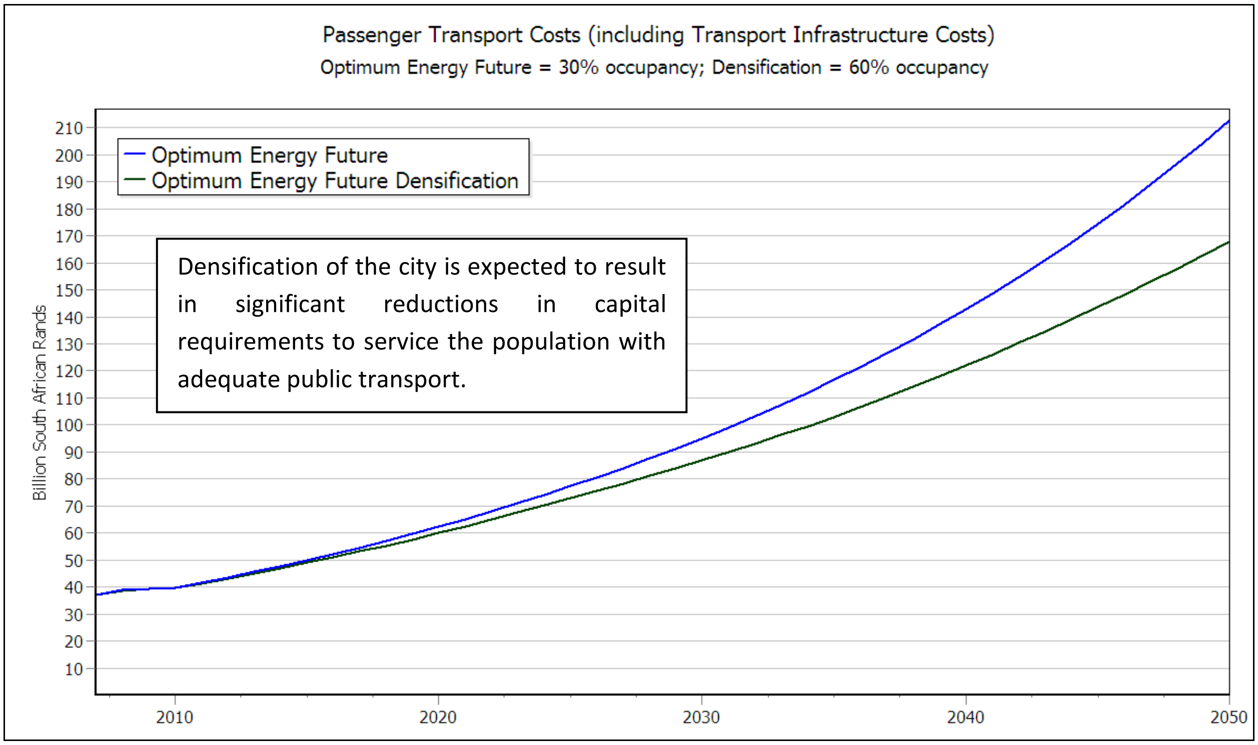


FIGURE 20: COST FOR CAPE TOWN OPTIMUM ENERGY FUTURE AND BAU SCENARIOS COMPARE TO HIGHER DENSIFICATION SCENARIO

Figure 20 shows that the Densification Scenario (based on reaching 60% public transport occupancy by 2035) cost is significantly less than the Cape Town Optimum Energy Future scenario for the same level of service to city inhabitants. Strong support for densification is therefore important for a sustainable city.

KEY ISSUE 12: SIGNIFICANT COMPONENTS OF RENEWABLE ENERGY (RE) INTO THE ELECTRICITY SUPPLY MIX INTRODUCES THE ISSUE OF VARIABILITY OF SUPPLY INTO PLANNING, AND BALANCING THE GRID NEEDS TO BE CAREFULLY CONSIDERED IN THIS LIGHT (E.G. NEED MORE REGIONAL HYDRO OR PUMPED STORAGE).

Because the key renewable electricity supply options – mainly wind in the short-term – are 'variable' as opposed to base-load, introducing large components of them into the national grid mix requires due consideration for grid balancing. The national generation mix has historically included largely base-load plant which can run 24/7, and therefore a change of approach is necessary for large RE (variable) components in the mix. This is not necessarily a problem, and there are precedents around the world showing how it can be done – including ensuring that your wind resources are spread geographically to benefit from different weather conditions in different parts of the country, and arrangements with a spread of 'quick start-up' generation options regionally, such as hydro.

The issue of grid balancing is likely to be more of a national planning issue than a consideration for the City however, but some thinking in this regard may be necessary to obtain national buy-in if the City proactively pursues a much greater RE component than the national mix targets.

Next steps…

- If the city is to pursue a large component of RE in the electricity supply mix beyond the national intentions (discussed in Issue 8), research may need to be done and a position developed around this issue.

KEY ISSUE 13: CITY SERVICE DELIVERY PLANNING AND BUDGETING WILL NEED TO CONSIDER THE FACT THAT THE INFORMAL, LARGELY UNELECTRIFIED HOUSEHOLD SECTOR IS CURRENTLY GROWING FAST, AND WILL PLACE INCREASING DEMANDS ON THE CITY'S ABILITY TO PROVIDE SERVICES AND WILL CONTRIBUTE LITTLE TO REVENUE.

Informal unelectrified households are growing fast – currently at 13%[16] (as opposed to formal households growing at 1.7%). Should similar trends continue informal housing will become the biggest residential subsector. This will increasingly strain the City's resources to provide basic services to them, with very little revenue return.

[16] Source: Knowledge Management Department at the City of Cape Town

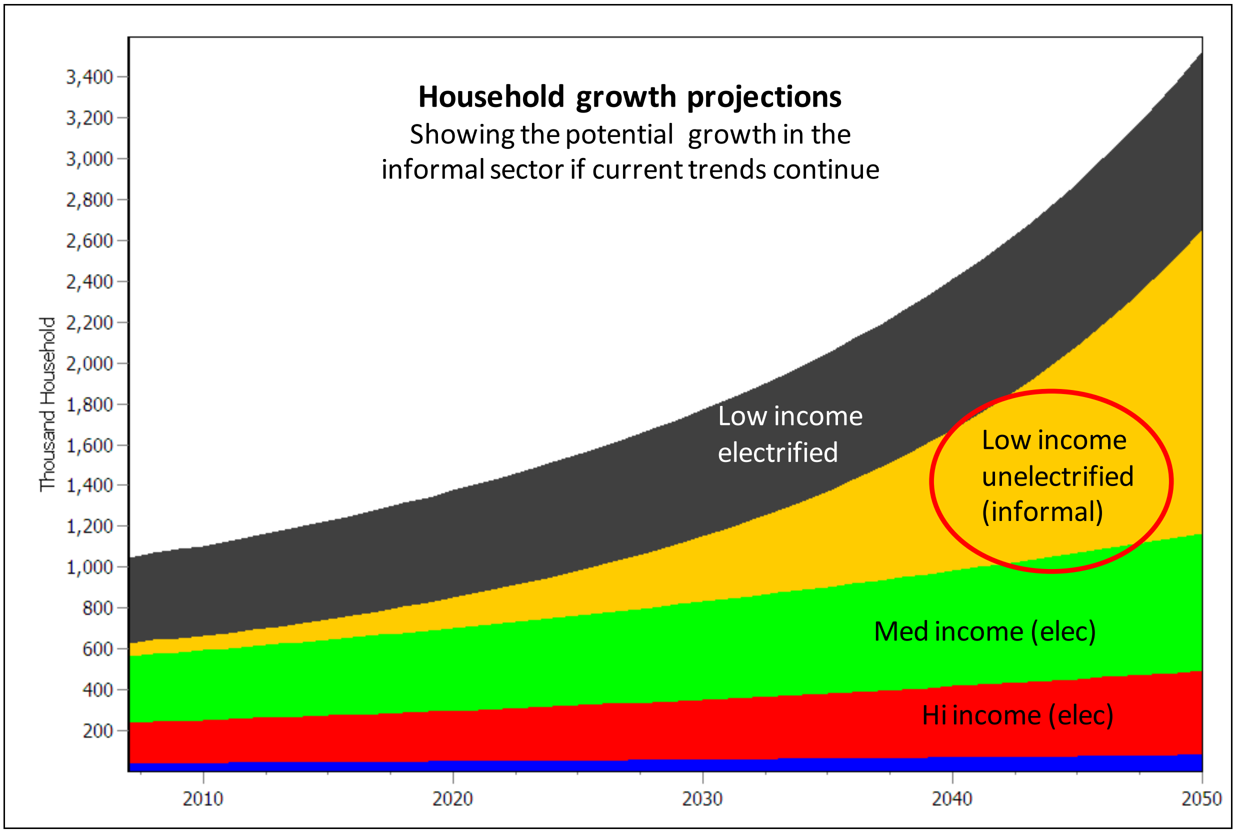


FIGURE 21: HOUSEHOLD GROWTH PROJECTIONS - SHOWING THE POTENTIAL GROWTH IN THE INFORMAL SECTOR IF CURRENT TRENDS CONTINUE

Next steps…

- Undertake a more detailed assessment of the situation and the implications into the future, and consider mechanisms to provide services without crippling city coffers.

A SUMMARY OF THE POTENTIAL IMPACT OF THE OPTIMUM ENERGY FUTURE ON CITY COFFERS

The expected impact (both positive and negative) of the Optimum Energy Future (OEF) on city coffers, as indicated in the Key Issues presented above, are the following:

Potential reduction in electricity revenue

Reduced electricity consumption through significant efficiency programmes can reduce city revenue generation, which is potentially a huge problem given the reliance on this source of revenue for cross-subsidising other important city functions.

Electricity consumption still grows with OEF, although significantly less than with the BAU scenario. Also, changes do not occur overnight, giving the city time to adapt the financial profile to ensure overall soundness. In addition, the electricity tariff structure can be modified to protect revenue flows from this sector. Already the city is using a Rate of Return methodology (on a pilot basis) for tariff design, which protects revenue to some extent, although it may not protect revenue adequately because it allows for a return % over and above all expenses – if the overall 'pie' is smaller due to efficiency then the % will be smaller in absolute terms. This notwithstanding, it is likely that the city will be able to adjust to the changes because they will be gradual, demand growth will still take place, and tariffs can compensate for revenue problems which might arise.

Increased public transport infrastructure investment requirements

A secure and sustainable city into the future must have a mobility system based on public transport. While national and provincial government spheres have a clear role in this sector, at least a part of this infrastructure funding can be expected to come from the city (particularly if the city is being more proactive in this move). This will involve significant additional capital expenditure and probably loans – with resulting interest repayments. This will place strain on city finances. Also, the city has no easy way of raising funds for this – e.g. through taxes (whereas provincial and national spheres can levy taxes for this purpose – such as an additional fuel tax). It is thus important that such planning is done in conjunction with provincial and national government. It would be difficult for the city approach this alone.

Positive revenue impact of improved OEF economic efficiency

Overall city revenue is strongly linked to the state of the local economy through sale of services (such as electricity) and tax revenue. The BAU economy of Cape Town is expected to be less efficient and vibrant compared with the OEF economy. This is because of the general resource efficiency of the OEF (e.g. reduced energy expenditure per unit GDP) as well as the more efficient transport system (the 'blood flow' of the city). Thus the OEF is expected to have a positive influence on the city revenue base.

FUTURE FACTORS AFFECTING REVENUE BUT NOT LINKED TO THE OEF

Carbon taxes and increased electricity prices

Electricity price increases are already in place, and a doubling in power prices in the next few years is anticipated. In addition, experts consider that a carbon tax is inevitable, which will further increase electricity prices and labour the economy. A slowed economy will add more stress on the city coffers.

Peak Oil

It is widely acknowledged that liquid fuel prices will escalate substantially in the next few decades as planetary demand exceeds supply ability (although there is debate around exactly when such a 'peak oil' point will be reached). If the city is not public-transport based at this time the economy will suffer and there will be a knock-on impact on city coffers.

The growing low-income and informal sector

The growth of the low-income and informal residential sectors is of concern, although not linked to the OEF. This is because these sectors are the fastest growing amongst the city, and welfare imperatives require them to be serviced. They thus demand expenditure for service provision, but contribute little to city coffers (see Key Issue 13). This situation places increasing strain on the city's ability to maintain financial integrity, and is expected to worsen in the decades ahead. National government support here appears essential if service delivery ability is to avoid a downward spiral.

SUMMARY

- It appears that the stress on city revenue due to mass electricity efficiency programmes is not a serious concern, will be very gradual and may be easily addressed through modified tariff structures.

- Public transport infrastructure financing is likely to be a problem for the city to carry by itself, and the strong involvement of provincial and national government here is likely to be necessary to move forward.
- The positive impact of the OEF on the local economy is likely to boost city financial robustness.
- In addition, there are several other factors not linked to the implementation of the OEF which are likely to be significant financial stressors for the city revenue base, such as carbon taxes, peak oil and fast growth in the low-income sector, and suitable plans need to be made to negotiate these factors successfully.

WAY FORWARD

Next steps to implement the Optimum Energy Future

The Optimum Energy Future includes a number of recommended energy efficiency and electricity supply interventions to achieve a robust energy future and low carbon profile for Cape Town, enabling the City to be sustainable in the face of the serious challenges that face us.

Sector	Interventions for Optimum Energy Future	Next steps
Residential	Energy efficiency lighting in low, medium, high and very high income households	There is no specific programme in ECAP and this should be included in the next version of the Action Plan. Liaise with Eskom regarding the efficient lighting programme.
	Energy efficient water heating technologies implemented in medium, high and very income households (either solar water heaters or heat pumps)	Continued implementation through Programme 1.2 Solar Water Heating in ECAP.
Commercial[17]	Efficient Heating, Ventilation and Air Conditioning (HVAC) systems in new build and existing buildings	There is no specific programme in ECAP and this should be included in the next version of the Action Plan. ECAP Programme 1.5- Green Building can guide the development of new buildings in the commercial sector.
	Efficient water heating technology (either solar water heaters or heat pumps) in new and existing buildings	There is no specific programme in ECAP and this should be included in the next version of the Action Plan. Programme 1.5 - Green Building can guide the development of new buildings in the commercial sector.
	Efficient lighting implemented in new and	There is no specific programme in ECAP and this

[17] The assumption is made that new buildings in the commercial sector will be built at higher efficiency levels than existing buildings

	existing buildings	should be included in the next version of the Action Plan. Programme 1.5 Green Building can guide the development of new buildings in the commercial sector.
Industrial	Efficient motors, where feasible	There is no specific programme in ECAP and this should be included in the next version of the Action Plan. Further research into efficiency opportunities for the industrial sector including details on the size and scope of the sector. Engage with Eskom DSM to determine suitable cooperation and activities.
	Efficient HVAC systems implemented	There is no specific programme in ECAP and this should be included in the next version of the Action Plan. Further research into efficiency opportunities for the industrial sector including details on the size and scope of the sector. Engage with Eskom DSM to determine suitable cooperation and activities.
	Energy Efficient Lighting options implemented to replace conventional inefficient lighting	There is no specific programme in ECAP and this should be included in the next version of the Action Plan. Further research into efficiency opportunities for the industrial sector including details on the size and scope of the sector. Engage with Eskom DSM to determine suitable cooperation and activities.
Local Government	Government Buildings • efficient lighting • efficient HVAC systems	Government buildings are addressed under programme 3.1 (building retrofit) of ECAP - this programme to be continued.
	Street Lighting – replacement of mercury vapour lamps with high pressure sodium lamps	Street lighting are addressed under programme 3.6 (street and traffic lighting retrofit) of ECAP.
	Traffic lights – replacement in incandescent and halogen lamps with LED lamps	Traffic lights are addressed under programme 3.6 (street and traffic lighting retrofit) of ECAP.
	Vehicle Fleet – improved fuel efficiency through the purchase of more efficient diesel and petrol options and the implementation of behavioural changes to support further fuel efficiency	Government vehicle fleet are addressed under programme 3.8 (Greening the Fleet) of ECAP.
Freight Transport	Shifting freight transport from road to rail-based transporting	There is no specific programme in ECAP and this should be included in the next version of the Action Plan. Requires lobbying national government as this is their mandated area.
Passenger	Improved fuel efficiency of private vehicles,	There is no specific programme in ECAP. Vehicle

Transport	including TDM, and the inclusion of hybrid and electric vehicles in the private vehicle mix	efficiency is addressed in a number of national Policies and Strategies and there interventions should be held at a national level. Travel Demand Management Programmes (TDM) are covered under programme 5.3 (Travel Demand Management).
	Improved public transport vehicle efficiency, including a shift to diesel mini-bus taxis and more fuel efficient (EURO IV) buses	There is no specific programme in ECAP and this should be included in the next version of the Action Plan.
	A modal shift from private vehicles to public transport	Programme 5.1 Integrated Rapid Transport covers the modal shift from private vehicles to bus transport, but movement within and to other modes of public transport are not covered and should be addressed in the next version of the Action Plan.
Electricity Supply Mix	The Cape Town Optimum Energy Future electricity supply mix includes a large proportion of renewable energy (wind, municipal waste and solar thermal), which differs to the current Business As Usual supply mix	The imminent national Integrated Resources Plan (IRP) will need to be reviewed once it has been released to decide on an appropriate way forward for the City.

Next Steps to move toward implementation of the Optimum Energy Future are listed below:

- Engage with key departments and other players:
    - Engage with all key departments within the City to take the implementation forward
    - Engage with other key players, such as industry, residents and commercial sector and the energy supply industry
- Extend the ECAP:
    - Undertake a revision of the ECAP to include key aspects of the Optimum Energy Future not currently in the ECAP
    - Use the modelling work to inform implementation targets to be contained within the next revision of the ECAP
    - Prioritisation of ECAP implementation activities
- Extend the modelling exercise to include additional interventions and explore the impact of various future scenarios as requested by the City
- Development of business plans for selected projects, including definition of responsibilities, financing sources, timeframes and key players to be involved
- Design of tariff systems which promote energy efficiency
- Exploration of financing needs for an effective public transport system and how such financing may be sourced

- Further analysis of the implications of a growing poor population on the city's ability to provide basic services and on city coffers
- Research on maximizing local job creation potential while pursuing a low carbon development path (develop city economic development strategy based on OEF)
- Detailed electricity analyses:
  - Promotion of renewable energy supply, including engaging with national government, NERSA and Eskom around regulatory and technical issues
  - Potential for demand-side (efficiency) measures to reduce infrastructure upgrading or development costs, and the resulting impact on cost-benefit of efficiency measures
  - Analysis of electricity transmission system capacity implications of increased local renewable energy generation
  - Strategic planning around demand management, including future investment in pumped storage
  - Clarifying the issue of grid electricity supply variability with high proportions of renewable energy, and any implications for the City of pursuing a high renewable electricity objective.

Funding has been secured from the British High Commission by Sustainable Energy Africa and the City to support the City with the implementation of the Optimum Energy Future for Cape Town. This support will run until March 2011 and will take the above work areas further, as well as providing general technical support and capacity building of city departments where appropriate and engaging in further research in selected areas. However the above list is beyond what the British High Commission funding can undertake, and thus extra funding will need to be secured.

Annexure A

RATIONALE FOR SELECTION OF DEMAND-SIDE INTERVENTION SCENARIOS

Intervention	Impact potential*	Used?	Notes
Residential			
Replacement of incandescents with CFLs	Significant	Yes	Technology available and cost effective
Replace CFLs and incandescent with LEDs	Potentially significant in longer-term	No	Availability of suitable technology at affordable cost uncertain in future. Consider for future modelling.
Replacement of geyser with SWH or heat pumps	Significant	Yes	Technology available and cost effective
Efficient showerheads	Medium / low	No	Unclear impact in conjunction with efficient water heating interventions. Consider for future
Ceilings (low income)	Low	No	Likely to improve comfort levels on houses but energy saving uncertain
Smart meters /	Unclear - probably low	No	Mainly demand (rather than energy) intervention, and impact and rollout practicalities and costs not clear.
ToU tariffs / ripple control	Low	No	Just demand, not energy intervention
Geyser blankets	Medium / Low	No	Data on impact, penetration and geyser stock existing efficiency not easily available. Consider estimating for future models.
Geyser pipe insulation	Low	No	Not significant, and savings unclear. Implementation can be included with geyser pipe insulation program.
Cooking to gas	Low	No	Medium/hi impact on electricity, but less so on energy – fuel switching. Consider for future modelling.
Hotboxes	Low	No	Very effective for household but small overall impact in sector and uptake rate uncertain.
Efficient fridges	Potential for significant improvement in fridge efficiency	No	Introduction rate, impact and cost implications not clear. Consider for future modelling.
Behavioral	Potentially significant if effective awareness campaign launched	No	Difficult to quantify. Consider for future model revisions.
Commercial			
Efficient HVAC System	Significant	Yes	Although conflicting info around impact exists, this is such a high component of building energy use it needs to be addressed. Behavioural impact alone is often big.
Efficient Water Heating	Medium/low	Yes	Data on water heating in sector is available and the sector is a target for SWHs and efficient water heating programmes.
Efficient Lighting	Significant	Yes	Technology readily available and cost effective.
Motor eff	Low	No	Impact not easily quantifiable for sector.
VSDs	Medium	No	Impact not easily quantifiable for sector. Consider for future.
Industrial			

HVAC	Low	Yes	Data on impact available – easily modelled
Lighting	Medium	Yes	Data available and a focus of the national EEDSM programme
Compressed air	Medium	No	Data for modelling not available. Consider for future.
Motor eff	Medium	Yes	A target of the Eskom programme
VSDs	Low	No	Data unavailable, and impact secondary to motor efficiency
Boilers (heating eff)	Low (Eskom)	No	Data for modelling not available. Consider for future.
Local Government			
Efficient HVAC System	Significant	Yes	Although conflicting info around impact exists, this is such a high component of building energy use it needs to be addressed. Behavioural impact alone is often big.
Efficient Water Heating	Low	No	
Efficient Lighting	Significant	Yes	Technology readily available and cost effective.
Efficient Street Lights	Significant	Yes	Data available and programme in progress
Efficient Traffic Lights	Medium	Yes	Data available and programme in progress
Efficient Vehicle Fleet	Medium	Yes	Data available and fleet efficiency a focus of the city
Transport: Freight			
Modal Shift (Road to Rail)	Medium	Yes	Broad data available and this option is a focus nationally and locally
Transport: Passenger			
Modal Shift (Private to Public)	V. Significant	Yes	Modelled as shift from private vehicles to bus and train
Efficiency in Private Vehicles (dies & petrol), incl: Electric vehicles Hybrid vehicles More fuel eff cars	Significant	Yes	In model reflects as overall improvement in private vehicle fuel efficiency
TDM / Eco driving / behavioural	Medium	No	Modelled in 'efficient private vehicles' above (has same fuel reduction characteristics)
NMT	Low	No	Low and very uncertain impact

* - References:

Eskom DSM municipal briefing v7 (23/05/2008)
Sustainable Energy Africa Energy Efficiency Spreadsheet for Cape Town EE Awareness Programme
City Energy Support Unity (CESU) Energy Efficiency Tool

ENERGY SUPPLY INTERVENTIONS

Energy supply option	Potential*	Used?	Notes	Role of city
Biomass Cogeneration	Low	No	Generation from forest waste only considered. Detailed resource information lacking.	
Municipal Waste	Low	Yes	Although overall impact relatively low, included because City already moving to implement landfill gas projects and sell carbon credits.	Can implement all aspects of project
Solar PV grid con	Low	No	Still too expensive, though	Facilitate individual net-metered

			individuals may install capacity	connections
Solar Thermal Elec with storage	Significant	Yes	Best resources not local, but could buy solar power. Still more expensive than wind, but promising in medium-term.	Potential for city to buy green power (depends on national 'single-buyer' rules and REFIT applicability)
Ocean Energy		No	Not proven technology	
Wind		Yes	Good local potential and cost effective option. % mix of total supply considered a limitation, but scope for several '000 MW before this needs to be considered.	Potential for city to buy green power – and even generate (depends on national 'single-buyer' rules and REFIT applicability)
New Nuclear		Yes	Included in the National LTMS scenario (to be consistent with the national LTMS generation mix)	Not under city influence
New Fossil Base	Significant	Yes	Coal-fired power plant already commissioned (Medupi), and Kusile on the cards.	Not under city influence
New Peak Plants	Medium	Yes	Turbines are diesel at present but some may use natural gas in future, but still reasonably expensive.	Generally will be an Eskom decision to build these – not City.
New Hydro	Low (locally)	No		

* - References:

- A Proposed Renewable Energy Plan of Action for the Western Cape: Resource Assessment, Scenarios, Proposed Objectives and Actions - Department of Environment Affairs and Development Planning, Provincial Government of the Western Cape (May 2007)
- National LTMS Documentation