system could potentially be linked as an administrative tool for financial support mechanisms to be established or to monitoring of compliance with mandatory purchase or supply mechanisms.

4.1 Importing and exporting of renewable Energy

Based on the summary above (and scenarios below), it may not be the most cost effective route to get all renewable energy from within the Western Province. It may be better to import some renewable energy. Options for this include:

- Biodiesel (Angola, Free State, other areas)
- Biomass generated electricity or as a feedstock for biofuels production(KZN, Mpumalanga, other areas)
- Solar generated electricity from higher solar radiation regions (especially solar thermal electric)
- Wind generated electricity– west coast, southern cape coast, Northern Cape, Namibia
- Hydro generated electricity

The import of power from neighbouring countries is a possibility although it is currently not encouraged at the national level, based on requirements for integration of national rules into more sophisticated frameworks for regulation of the trade.

Decisions must be taken on linking physical power traded to the renewable energy certificates. The latter tracks trade of the renewable attributes of energy supply as a commodity separated from the physical power itself. It is anticipated that the necessary regulatory and trading mechanism will be established in the next few years. This is an important area for the provincial government to lobby and take a lead in establishing the appropriate frameworks.

Whilst it will be important to ensure that the Western Cape meets its clean energy targets through the appropriate strategy (energy use reduction alongside energy supply from inside and outside of the Province) it will be imperative to ensure that whilst problems are solved for the Province, problems are not created elsewhere. The key leadership strategies adopted in the Integrated Energy Strategy require the Provincial Government to demonstrate energy leadership whilst taking into account responsibility for the full value chain behind its decisions. Full Cost Accounting is a principle adopted in the Sustainable Development Implementation Plan and will be taken into account as the strategy and provincial energy mix is implemented.

It is of course possible that some renewable energy generated within the Western Cape is purchased (using TRECs or similar) by parties outside of the Western Cape (exporting the renewable energy attributes). In this case, the energy generated can *not* be credited to any Western Cape targets. This would however have very strong benefits for Western Cape renewable energy industry and of course leads to an economic inflow.

5 Non-renewable Energy Resources

Renewable Energy resources are obviously supplied within a energy environment that makes extensive use of fossil based resources primarily: coal, oil and gas, nuclear. Of these, only nuclear and gas have significant Western Cape production potential. All others are imported (although there is extensive oil refining capability).

5.1.1 Nuclear Energy

Nuclear energy has not been addressed in detail in the report for the following main reasons:

- It is an area of national competence and concern. Although the Western Cape has a key role to play in the evolving nuclear debate in South Africa – it is an issue that will need to be dealt with at national level.
- Extensive other parties engage actively in both pro and anti-nuclear debates. This plan chose instead to focus on the potential contribution for renewable energy.
- Nevertheless, it is critical for the emerging renewable energy to understand the economics of nuclear energy. If nuclear energy is significantly cheaper than renewable alternatives, this will obviously have an impact on the potential market for renewable energies.
- Furthermore, even if nuclear energy is more expensive, if capacity is increased (driven by national decisions) this will obviously have significant impact on the nascent renewable energy industry.
- There is a risk that decision makers could opt for an almost exclusively nuclear dominated energy growth path. However, given international trends, as well as environmental and economic regional concerns, this seems highly unlikely.

Without engaging extensively in the debates, the strategy has simply postulated that there would be an additional 220 MW of nuclear energy inserted into the Western Cape mix in 2020. The costs of this nuclear energy are as indicated in Table 16. Including more or less nuclear energy in the scenarios would not in our opinion significantly alter the value of the scenarios. Note: as discussed in section 6.8.4, if this nuclear plant is part of the national energy mix, then the 180 MW represents the Western Cape share of the new installed capacity in the country. In other words, if by then the Western Cape is using 10% of the total national plant output, this implies that the new plant installed in 2020 is 2200 MW.

5.1.2 Gas options for electricity generation

Eskom (in a 2006 press insert, Eskom 2006) noted that three gas options are being considered at the moment:

- A mid-merit Combined Cycle Gas Turbine (CCGT) plant at Coega in the Eastern Cape will support growth in the Eastern Cape, but will not do much to alleviate the Western Cape situation.
- The Kudu gas station which is being developed by Namibia's Nampower, is planned to bring 800 MW on line by 2011. The project's low capital requirements and the transmission support it would give enhances its attractiveness despite its capacity not being enough to meet the latest projected load growth in the Western and Eastern Cape.
- A potential 1 600 MW CCGT plant at Saldanha would address capacity constraints in both the Western and Eastern Cape while also providing support for capacity constraints in the North. Project lead times are a challenge at present with a multitude of approvals and decisions needed in the next two months if the plant is to be operational by September 2008. It is also expected that Saldana will become expensive to run in the long term due to the availability of other generation options.

6 Energy Supply Scenarios for the Western Cape

This chapter presents a number of energy supply scenarios for the Western Cape electricity needs. These scenarios are illustrations of what could be done. We have deliberately not selected a specific scenario or highlighted it as a 'plan'. It would be necessary to undertake more detailed economic and resource modelling (and undertake more detailed discussion) prior to formalising scenarios such as these at a level such as that which would be required of a formalised Integrated Resource or Integrated Energy Plan.

Nevertheless, we believe these scenarios provide plausible illustrations of paths along which the Western Cape could choose to manage its energy supply. Table 17 summarizes the scenarios used for the electricity generation investigations. More detail on each scenario is provided in the sections following.

Table 17 Scenario Descriptions

Short name	Longer description	Comments
BARD BAU Ref Demand	Business as usual, reference demand	Continued reliance on fossil fuels, demand growth as per demand study *reference* case
BAEC: BAU Engy Cons	Business as usual, energy conscious demand	Continued reliance on fossil fuels, demand growth as per *energy conscious* scenario discussed in section 2
PRRD: Prog Ren Ref Dem	Progressive Renewable, reference demand	Progressive renewable energy planning, demand growth as per *reference* scenario
PREC: Prog Ren Engy Cons	Progressive Renewable, energy conscious demand	Progressive renewable energy planning, demand growth as per *energy conscious* scenario
HRRD: High Ren Ref Dem	High Renewable, reference demand	High promotion of renewable energy, demand growth as per *reference* scenario
HREC: High Ren Eng Cons	High Renewable, energy conscious demand	High promotion of renewable energy, demand growth as per *energy cosncious* scenario

6.1 Energy prices used for the scenarios

In each of the scenarios below, we assume particular mixes of renewable energy contribution. In the case of the electricity production scenarios, a significant portion of the energy would come from Eskom, as the national supplier. The price of power from the national supplier is the primary financial benchmark against which alternative generation technologies will be considered. The primary resource for future grid electricity costs is likely to be the 3rd National Integrated Resource Plan (currently under preparation by

NERSA). However, results from this are not yet available. The most detailed study looking into the future that we have been able to locate is Heath et al (2005). This indicates that electricity annual real price increases would be in the range 1.23 to 2% up to 2022, and about 1.3% up to 2054. Heath at el indicate current costs of the order of 21.5 c/kWh, climbing to 37 c/kWh by 2054. The generation component of these costs goes from 8.94 c/kWh to 21.24 c/KWh for the particular scenario reviewed. Note- these price assumptions are for the combined electricity output of all plants - both old and new plant required.

Indications from the NERSA IRPIII study are that costs of power could increase significantly. (Preliminary results presented in Woolhouse 2007 indicate possible future coal generated power costs of R525/MWh (52.5c/kWh) – a three fold increase in cost of coal power generation).

Reasons for these price increases include:

- A gradual change in the generation mix, as new power plants (which have not yet had their capital costs written off) become a growing proportion of the total electrical energy supply;
- High global rates of expansion for new power plants;
- Steel and other commodity price increases;
- Increasing environmental requirements;
- Increased fuel costs for both coal and gas powered plants, as the high oil price continues to have a knock on effect on other energy commodities (that can in principle be converted to oil).

Recent articles indicate that the price of peak power produced by Open cycle Gas Turbines is likely to be of the order of R1.60 (Engineering News, Feb 2007). Note that these plants will be using diesel, which has to be procured at international oil prices.

The cost assumptions used in the scenario are summarized in Table 16. For existing plant, they start at 12c/kWh for base load, and 55 c/kWh for the mid/peak load category. This gives an average price of 18c/kWh for existing generation plant. New plant power prices start at 28c/kWh (base) and 78 c/kWh (mid-merit).

Cost assumptions for the renewable energy technologies are given in Table 16, and Figure 19 to Figure 21.

6.2 Portfolio vs least cost planning

The scenarios presented here are *not* least cost energy planning scenarios. The approach adopted is to plan to have a particular energy mix over time, seeking to achieve a number of targets including:

- reasonable costs;
- low, progressive and high contributions by renewable energy (in the *reference*, *progressive*, and *high renewables* scenarios respectively);
- a mix of different electricity generation technologies is postulated. This is particularly important in the early years, as there is as yet insufficient knowledge to clearly choose the best long term technology path;
- A diversity of technologies helps to reduce problems associated with intermittency of renewables;

- Cost reduction paths of different technologies is impossible to predict accurately, but exposure to a range of technologies allows for more clear choices later as costs firm up

The above risk mitigation strategies highlight the need for a set of plans such as these to be regularly revised as improved information on technology costs as well as of resources becomes available. The above guides are in line with the following excerpt from the Provincial Sustainable Energy Strategy report (2006):

> The Provincial Government has adopted an approach that attempts to address these disparities and which is proving itself in a number of countries. The *portfolio-based approach*[12] to energy planning and development requires that a rapidly developing and vibrant economy that wishes to secure its long term sustainable development returns and hedge itself against unforeseeable future risks (supply short falls, power outages, volatility in fossil fuel prices, rising costs of fossil fuel extraction, carbon taxes, climate change, etc) should invest in a portfolio of secure energy management and generation options. These options include both demand and supply side options, but focus on the development of a number of supply side options that support the move towards ensuring greater share of the energy supply mix comes from clean and/or renewable energy options that run alongside traditional sources of supply.

6.3 Limitations to the modelling used

As noted in section 3.12, a key limitation of the modelling approach used is its ability to accurately determine peak load requirements, and to model the interplay between renewable resources, fossil resource, grid transmission, storage and load. This type of analysis will be required in future, especially as the mix of renewable energy resources to fossil fuel generation resources changes.

6.4 Business as usual scenario

The business as usual scenario assumes very little emphasis on renewable energy, and continued reliance on fossil fuel. Note, that in our opinion this scenario is unlikely to develop, as renewables are becoming cost competitive, and carbon mitigation carries a cost advantage- thus at least some measure of renewable energy inclusion is likely. It will be noted that this scenario does not specifically list new plant types by technology. This is because we have assumed that the 'business as usual' route will be a mix of generation plant primarily controlled and managed as a national entity (effectively Eskom). It thus represents a mix of many different generation plants supplying into the grid. The exact proportions of different technologies that will be used are at present unknown (and depend on the outcome of national planning processes which have not yet been concluded).

In order to clearly differentiate renewable energy from the rest of the mix, it has been assumed that:

- Existing base load power (sourced from Eskom) has a small renewable energy component (about 1%, as some of the energy is from hydro resources);
- 5.9% (2006) of the existing base load plant is sourced from Nuclear energy (Koeberg's contribution to the national energy supply is about 5.9%, and although the plant is located in the Western Cape – it is seen as nationally owned and managed asset, and thus its low carbon benefit is shared with all users of national power;

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[12] Awerbuch, 2003, Cooper, 2006

- All new base load capacity added is assumed to be coal;
- All new mid-merit/peak plant capacity is assumed to be gas or oil fired;
- A nationally owned (e.g. Eskom) nuclear plant becomes operational in 2020 – but only 10% of its capacity (180 MW) is 'credited' to the Western Cape from a carbon balance point of view (as per the above argument for Koeberg)

6.4.1 Installed capacity required

Figure 22 shows the installed capacity required for the business as usual, reference demand scenario.

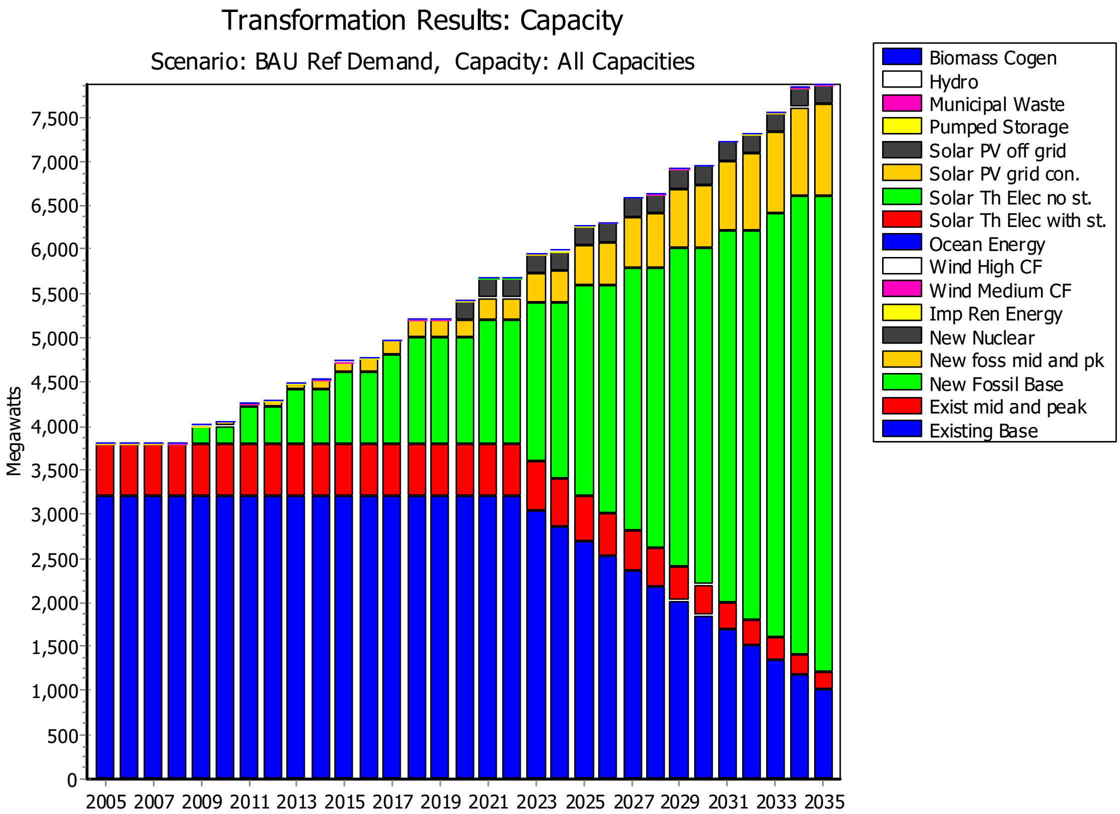

Figure 22 Installed capacity required for the business as usual (reference case)

From the above it can be seen that new capacity is included from 2009. Note, although the increments in base load units included are only 200 MW units, given that the Western Cape benefits from shared base load plant installed in other parts of the country, 200 MW could for example be 10% of a 2000 MW plant installed – but distributing power to other provinces as well.

6.5 Progressive Renewable Energy Scenario

The 'progressive renewable' scenario is one in which renewables are actively promoted, but not with the 'all out vigour' proposed in the 'high renewables' case. The scenario remains well within the renewable energy resource assessments, and although industry growth required in some segments is very significant, it is possible to achieve. There are two demand scenarios, the *reference demand,* and the *energy conscious demand.* Both assume the same level of renewable industry growth. However in the *reference demand* scenario there is obviously a much greater requirement for new fossil fuel plant to satisfy the increased demand.

6.5.1 Installed capacity, and capital requirements

Figure 23, below illustrates the possible installed capacity – again using the reference case demand curves. Note that the total installed capacity is higher than in the business as usual case, because renewable energy options are an intermittent source.

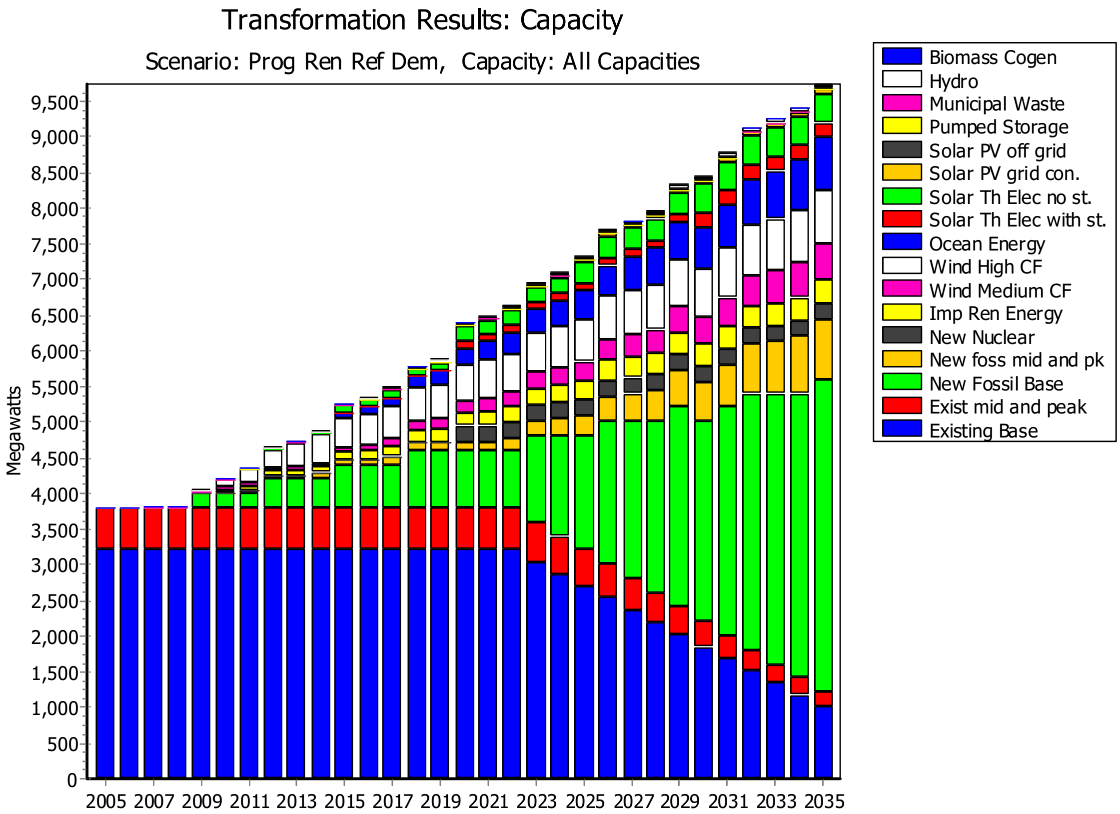

Figure 23 Progressive Renewable installed capacity

The installed capacity would require overnight capital expenditure of the order indicated in Table 18. (Note, that **cumulative** figures take account of capex for plant added in the years not shown, but care needs to be taken when reading the data from the non cumulative rows as capex can occur in say year 2017 which is not shown). Based on the cumulative figures, we see that for this scenario the new investment in fossil fuel technologies still outstrips the investment in renewable energy technologies.

Table 18 Overnight capital expenditure estimate by year for the Progressive Renewable/Reference Demand scenario[13]

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2030	2035
Biomass Cogen	0	134	132	3	2	2	2	2	2	2	2	2	2
Hydro	0	0	0	22	0	0	22	23	23	23	23	23	0
Municipal Waste	0	6	6	3	3	3	3	3	2	2	0	0	0
Pumped Storage	0	0	0	0	0	0	0	0	0	0	0	0	0
Solar PV off grid	3	3	3	2	2	2	2	2	2	1	1	1	1
Solar PV grid con.	0	4	10	10	12	24	28	13	79	61	52	45	41
Solar Th Elec no st.	0	0	0	0	0	0	0	0	1,520	1,240	1,060	910	0
Solar Th Elec with st.	0	0	0	0	0	0	0	0	0	1,850	0	1,370	0
Ocean Energy	0	0	66	106	112	108	103	99	593	483	415	357	322
Wind High CF	0	47	91	668	774	581	608	585	127	117	108	103	98
Wind Medium CF	0	0	0	445	0	0	0	0	0	156	145	139	132
Imp Ren Energy	16	16	146	142	105	102	99	96	134	124	100	55	24
New Nuclear	0	0	0	0	0	0	0	0	0	5,698	0	0	0
New foss mid and pk	0	0	0	0	172	0	0	180	0	0	204	212	224
New Fossil Base	0	0	3,720	0	0	3,900	0	0	4,080	0	4,500	0	9,960
Exist mid and peak	0	0	0	0	0	0	0	0	0	0	0	0	0
Existing Base	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	19	209	4,174	1,401	1,184	4,722	867	1,003	6,562	9,757	6,611	3,216	10,803
Cummulative	**39**	**248**	**4,422**	**5,822**	**7,006**	**11,728**	**12,595**	**13,599**	**20,161**	**38,511**	**62,622**	**97,907**	**141,772**
Renewable Technologies	19	209	454	1,401	1,012	822	867	823	2,482	4,059	1,907	3,004	619
Cummulative Renewabl	**39**	**248**	**702**	**2,102**	**3,114**	**3,936**	**4,803**	**5,627**	**8,109**	**16,373**	**21,884**	**27,949**	**31,246**

6.5.2 Energy Production from the different resources

For this scenario, the energy production from the different resources would be as per Figure 24

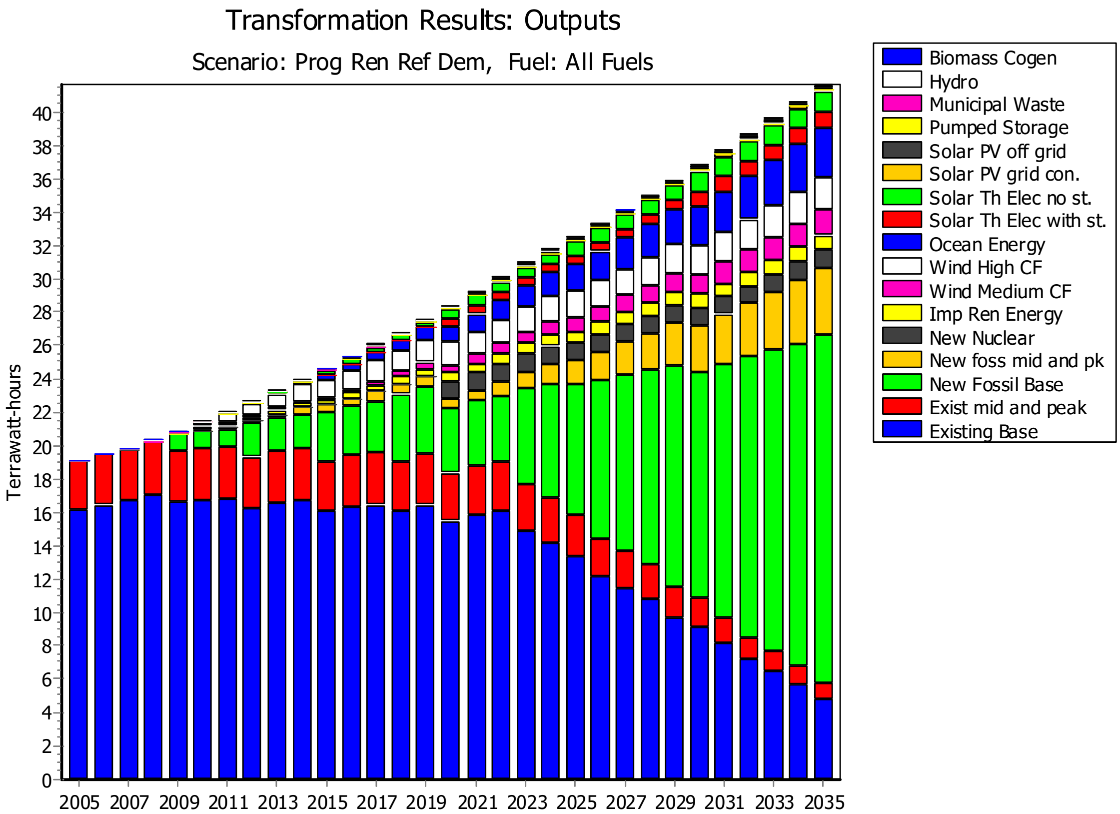

Figure 24 Progressive Renewables - energy contribution by technology (reference demand)

[13] Although the graphs and tables show a 'pumped storage' line, the model used was not able to take proper account of pumped storage. As a result this should be ignored.

The contribution of renewable energy technologies to the electricity supply mix for this scenario is shown in Figure 30 and reaches 8% by 2014, although by 2020 it is at 16.8%. Also note that the category *Imported Renewable Energy* contributes more than 10% of this renewable energy by 2014, the assumption being that consumers of electricity in the Western Cape are prepared to purchase green electricity certificates, and that this energy will be available from elsewhere.

6.6 Progressive Renewable Energy Conscious

As discussed above, a more energy conscious approach to demand growth is advocated. With the energy conscious demand curve, the progressive renewable energy contribution is as per Figure 25, and the renewable energy contribution to the electricity supply mix reaches 9% by 2014, and 20.4% by 2020. Note that this scenario assumes the same build rate for *renewable energy* plant as the *progressive renewable reference demand* scenario, but because of the lower overall electricity demand growth, it allows for a lower contribution from fossil plant.

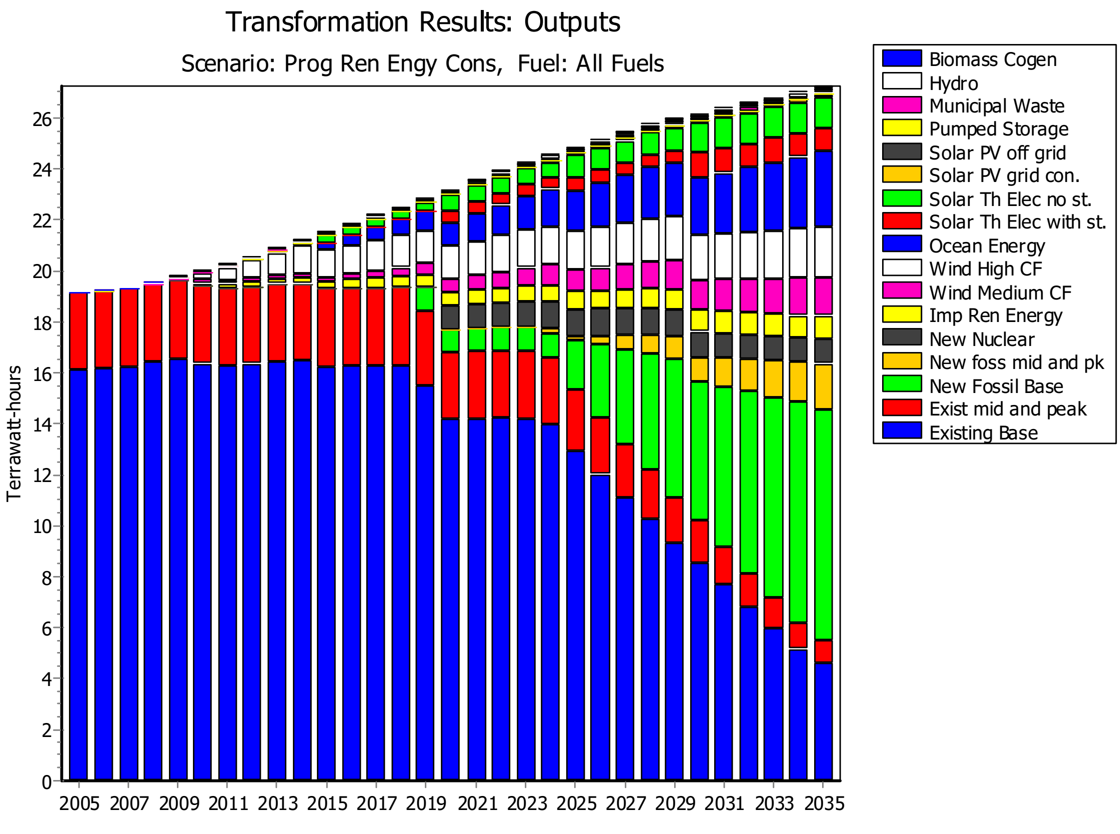

Figure 25 Energy contributions by technology (Progressive Renewables, Energy Conscious)

Table 19 shows the installed capacity of plant required to achieve the above energy outputs. It will be noted that the existing capacity (2007) is lower than may be expected, given the peak of about 3800 MW experienced at times, and projections of peak demand at 4100 MW provided in Eskom 2006. This relates to difficulties in modelling the peak demand capability of the Western Cape system, and simplifications needed given that it is part of a much larger system (section 3.12). The effect of these modelling limitations on *new* capacity requirements is however limited.

Table 19 Installed Capacity (MW) by Technology: Progressive Renewable, Energy Conscious Scenario

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	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2030	2035
Biomass Cogen	0	6	12	12	12	12	12	13	13	13	14	14	15
Hydro	1.5	1.5	2	4	4	4	6	8	10	20	31	42	50
Municipal Waste	0.0	1.5	3.0	3.8	4.6	5	6	7	8	10	12	12	12
Pumped Storage	0	0	0	0	0	0	0	0	0	0	0	0	0
Solar PV off grid	0.6	0.7	0.7	0.8	0.8	0.9	0.9	1.0	1.0	1.3	2	2	2
Solar PV grid con.	0	0	1	1	1	2	3	4	7	22	38	53	69
Solar Th Elec no st.	0	0	0	0	0	0	0	0	100	200	300	400	400
Solar Th Elec with st.	0	0	0	0	0	0	0	0	0	100	100	200	200
Ocean Energy	0	0	3	8	14	19	25	30	64	236	407	579	750
Wind High CF	0.0	5.0	15	90	180	250	325	400	417	500	583	667	750
Wind Medium CF	3	3	3	53	53	53	53	53	53	165	277	388	500
Imp Ren Energy	3.3	5.0	21	37	49	62	74	86	104	192	269	313	333
New Nuclear	0	0	0	0	0	0	0	0	0	220	220	220	220
New foss mid and pk	0	0	0	0	0	0	0	0	0	0	40	200	400
New Fossil Base	0	0	0	0	0	0	0	0	0	200	400	1,200	2,000
Exist mid and peak	600	600	600	600	600	600	600	600	600	600	508	354	200
Existing Base	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	2,692	1,846	1,000
Total	3,809	3,823	3,860	4,009	4,118	4,208	4,305	4,401	4,575	5,680	5,892	6,490	6,901

Table 20 shows the overnight capital expenditure required to achieve this scenario. It will be noted that the renewable portion is identical to that for Table 18. However, the cumulative capex required for new fossil plant is far lower, as a result of the assumed energy efficiency measures. (Note, that **cumulative** figures take account of capex for plant added in the years not shown, but care needs to be taken when reading the data from the non cumulative rows as capex can occur in say year 2017 which is not shown).

Table 20 Annual overnight capital costs (R million) for the new capacity required (Progressive Renewable, Energy Conscious)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2030	2035
Biomass Cogen	0	134	132	2.5	2.46	2.42	2.39	2.354	2.3195	2.146	2.043	1.996	1.9387
Hydro	0	0	0	21.8	0	0	21.8	23.1	23.097	23.1	23.1	23.1	0
Municipal Waste	0	6.3	6.15	3.2	3.2	3.12	3.12	3.04	1.85	1.75	0	0	0
Pumped Storage	0	0	0	0	0	0	0	0	0	0	0	0	0
Solar PV off grid	2.85	2.71	2.57	2.45	2.32	2.21	2.1	1.99	1.89	1.465	1.255	1.08	0.925
Solar PV grid con.	0	3.61	10.3	9.78	12.4	23.5	27.9	13.25	78.599	60.82	52.4	44.91	40.547
Solar Th Elec no st.	0	0	0	0	0	0	0	0	1520	1240	1060	910	0
Solar Th Elec with st.	0	0	0	0	0	0	0	0	0	1850	0	1370	0
Ocean Energy	0	0	66.3	106	112	108	103	99	593.14	483.4	414.9	356.6	322.29
Wind High CF	0	47	91	668	774	581	608	585	126.67	116.7	108.3	103.3	98.334
Wind Medium CF	0	0	0	445	0	0	0	0	0	156.4	145.2	138.5	131.81
Imp Ren Energy	16.2	15.7	146	142	105	102	99.2	95.55	134.27	123.7	100.1	54.56	23.6
New Nuclear	0	0	0	0	0	0	0	0	0	5698	0	0	0
New foss mid and pk	0	0	0	0	0	0	0	0	0	0	0	0	224
New Fossil Base	0	0	0	0	0	0	0	0	0	0	4500	0	0
Exist mid and peak	0	0	0	0	0	0	0	0	0	0	0	0	0
Existing Base	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	19	209	454	1401	1012	822	867	823.3	2481.8	9757	6407	3004	843.44
Cummulative	**38.7**	**248**	**702**	**2102**	**3114**	**3936**	**4803**	**5627**	**8108.5**	**26311**	**36522**	**61919**	**85760**
Renewable Technologies	19	209	454	1401	1012	822	867	823.3	2481.8	4059	1907	3004	619.44
Cummulative Renewable Capex	**38.7**	**248**	**702**	**2102**	**3114**	**3936**	**4803**	**5627**	**8108.5**	**16373**	**21884**	**27949**	**31246**

6.7 High renewable Energy Scenario

The high renewables scenario shows a more aggressive approach to renewable energy development in the province (but still staying within practical limits as discussed in section 3 above).

Again, two scenarios have been developed and are shown in the summary results (section 6.8). Details of the '*energy conscious'* demand scenario are shown below.

6.7.1 Installed capacity and capital requirements

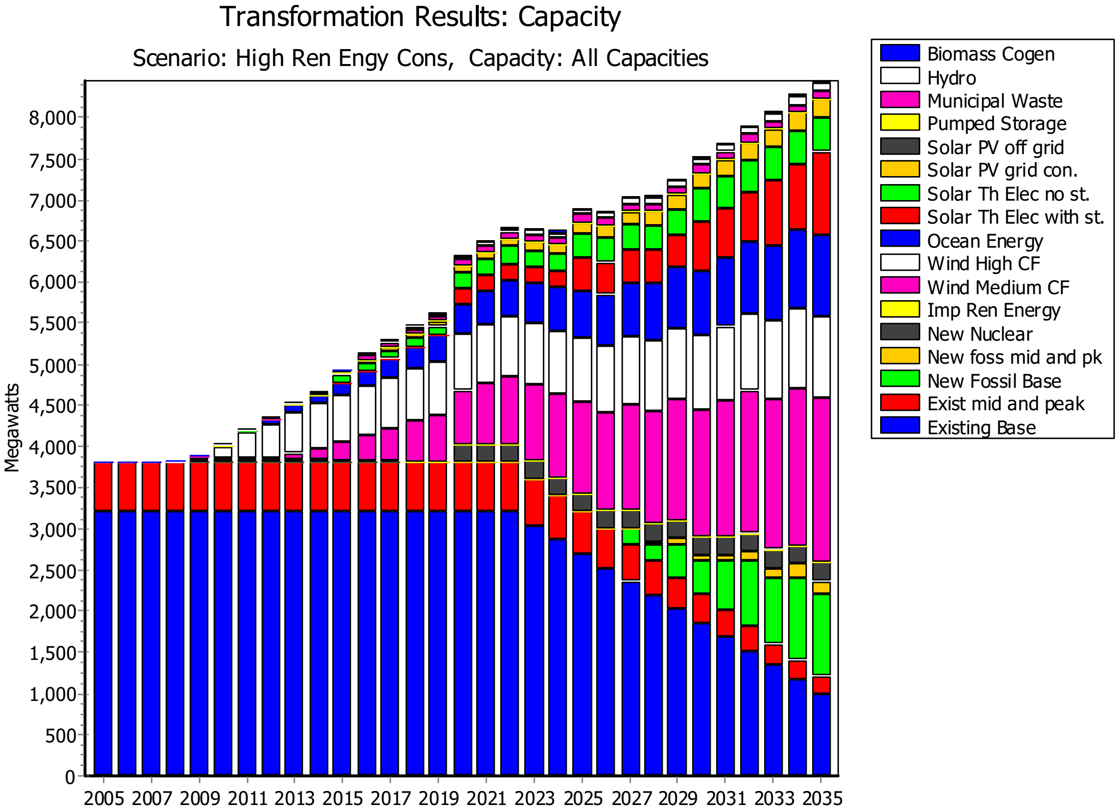

Figure 26 Installed Capacity by technology for the High Renewables *Energy Conscious* scenario

Table 21 Installed Capacity by technology, High Renewables Energy conscious Scenario

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	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2030	2035
Biomass Cogen	0	6	12	12.6923	13.3846	14.0769	14.7692	15.4615	16.1538	19.6154	23.0769	26.5385	30
Hydro	1.5	1.5	2.5	3.5	5.5	7.5	9.5	13.1818	16.8636	35.2727	55	80	100
Municipal Waste	0	3	6	7.2	8.4	9.6	10.8	12	12	69.7778	92	92	92
Pumped Storage	0	0	0	0	0	0	0	0	0	0	0	0	0
Solar PV off grid	0.8667	1.05	1.2333	1.4167	1.6	1.7833	1.9667	2.15	2.3333	3.25	4.1667	5.0833	6
Solar PV grid con.	0.1	0.5	1	2	4	6	7	9	20.0476	75.2857	130.5238	185.7619	241
Solar Th Elec no st.	0	0	0	0	0	0	0	0	100	200	300	400	400
Solar Th Elec with st.	0	0	0	0	0	0	0	0	0	200	400	600	1,000.00
Ocean Energy	0	0.75	4	14	20	46.6667	73.3333	100	142.8571	357.1429	571.4286	785.7143	1,000.00
Wind High CF	3.2	8.2	25	125	300	400	500	550	571.4286	678.5714	785.7143	892.8571	1,000.00
Wind Medium CF	3.2	3.2	28.2	28.2	28.2	28.2	78.2	128.2	217.3333	663	1,108.67	1,554.33	2,000.00
Imp Ren Energy	3.3333	5	21	37	37.75	38.5	39.25	40	33.3333	0	0	0	0
New Nuclear	0	0	0	0	0	0	0	0	0	220	220	220	220
New foss mid and pk	0	0	0	0	0	0	0	0	0	0	0	80	160
New Fossil Base	0	0	0	0	0	0	0	0	0	0	0	400	1,000.00
Exist mid and peak	600	600	600	600	600	600	600	600	600	600	507.6923	353.8462	200
Existing Base	3,200.00	3,200.00	3,200.00	3,200.00	3,200.00	3,200.00	3,200.00	3,200.00	3,200.00	3,200.00	2,692.31	1,846.15	1,000.00
Total	**3,812.20**	**3,829.20**	**3,900.93**	**4,031.01**	**4,218.83**	**4,352.33**	**4,534.82**	**4,669.99**	**4,932.35**	**6,321.92**	**6,890.58**	**7,522.29**	**8,449.00**

Table 22 Overnight Capital requirements, High Renewable, Energy Conscious Scenario (R million)

2007/04/25 23:36	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2030	2035
Biomass Cogen	0	134	132	15	15	15	14	14	14	13	12	12	12
Hydro	0	0	11	11	22	22	22	40	40	40	55	55	0
Municipal Waste	0	13	12	5	5	5	5	5	0	16	15	0	0
Pumped Storage	0	0	0	0	0	0	0	0	0	0	0	0	0
Solar PV off grid	10	10	9	9	9	8	8	7	7	5	5	4	3
Solar PV grid con.	0	14	17	33	62	59	28	53	278	215	186	159	144
Solar Th Elec no st.	0	0	0	0	0	0	0	0	1,520	1,240	1,060	910	0
Solar Th Elec with st.	0	0	0	0	0	0	0	0	0	3,700	3,180	2,740	2,480
Ocean Energy	0	17	72	212	122	523	501	480	741	604	519	446	403
Wind High CF	16	47	153	890	1,505	830	810	390	163	150	139	133	126
Wind Medium CF	0	0	228	0	0	0	405	390	677	624	579	553	526
Imp Ren Energy	16	16	146	142	6	6	6	6	0	0	0	0	0
New Nuclear	0	0	0	0	0	0	0	0	0	5,698	0	0	0
New foss mid and pk	0	0	0	0	0	0	0	0	0	0	0	0	0
New Fossil Base	0	0	0	0	0	0	0	0	0	0	0	0	0
Exist mid and peak	0	0	0	0	0	0	0	0	0	0	0	0	0
Existing Base	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	42	251	780	1,317	1,746	1,467	1,799	1,385	3,441	12,306	5,749	5,011	3,694
Cummulative	**86**	**336**	**1,116**	**2,433**	**4,178**	**5,645**	**7,444**	**8,829**	**12,270**	**31,924**	**43,994**	**64,443**	**90,988**
Renewable Technologies	42	251	780	1,317	1,746	1,467	1,799	1,385	3,441	6,608	5,749	5,011	3,694
Cummulative Renewable Capex	**86**	**336**	**1,116**	**2,433**	**4,178**	**5,645**	**7,444**	**8,829**	**12,270**	**26,226**	**38,296**	**49,025**	**60,566**

6.7.2 Energy Production from the different resources

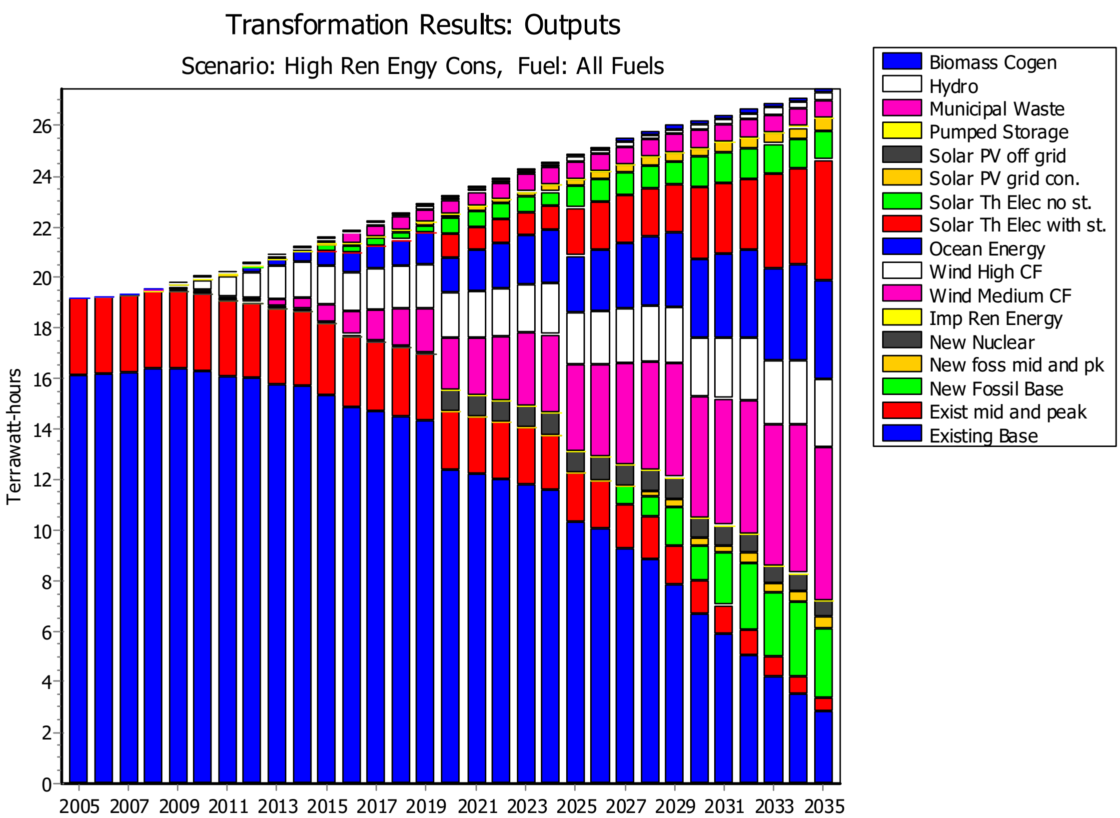

Figure 27 High Renewables (Energy Conscious) Electricity output

6.8 Key comparisons between the scenarios

6.8.1 Capital Investment required

Figure 28 shows the *annualized* cost of capital for the different scenarios[14]. From this we can see that the *BAU energy conscious* scenario, which does not have a significant shift to renewable energy, has by far the lowest capital investment requirements. The BAU reference case, and the two energy conscious renewable cases have similar capital requirements. Overnight and cumulative capital requirements for selected scenarios are presented in Table 18, Table 20 and Table 22.

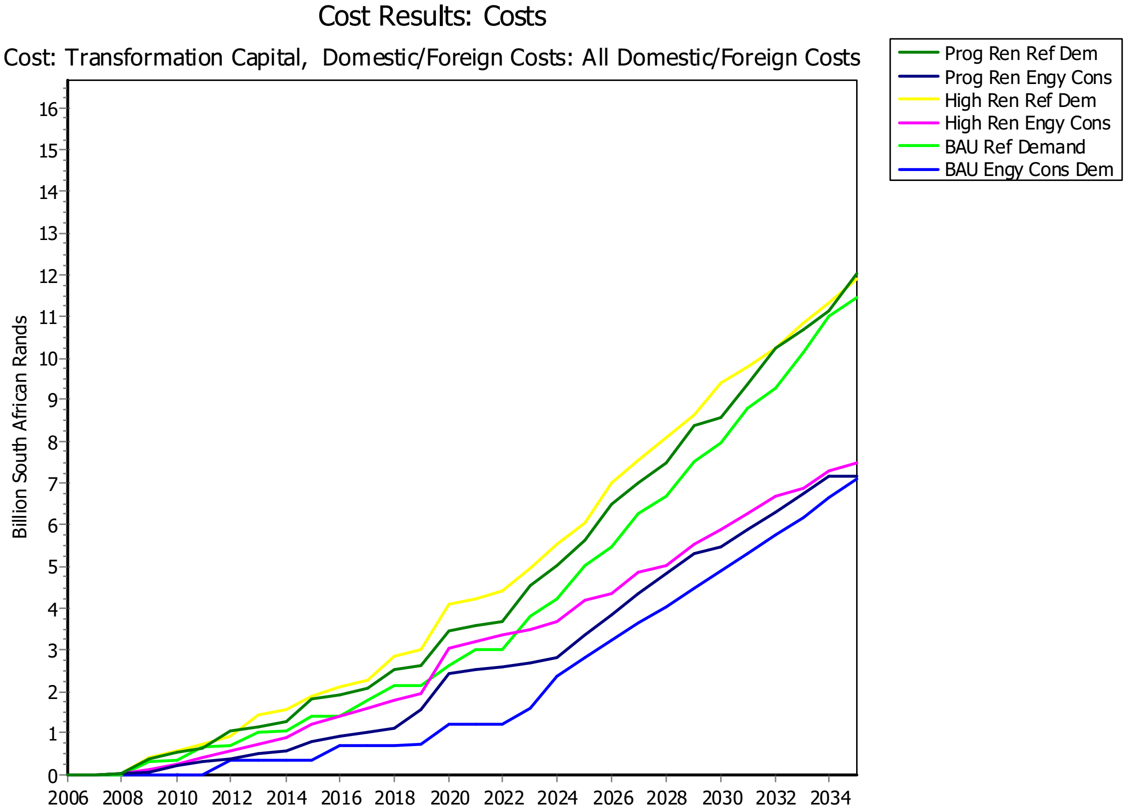

Figure 28 Annualized cost of capital for the electricity supply scenarios

6.8.2 Cost of Electricity generated as a result of the different energy mixes

Figure 29 and Table 23 show the average cost of generated electricity for the different scenarios (taking into account capital and operational costs, with capex amortized at an 8% discount rate).

The cost of energy for the different scenarios shows significant differences in the short and medium term (with the business as usual case energy conscious scenario having the lowest costs in the short term, but the renewables options having lower costs from 2025 onwards).

[14] In other words, the capex for new plant is annualized over the life of the plant. This results in an annual capital charge which is similar in nature to a capital depreciation charge in a conventional income statement

Table 23 Cost of electricity for the different scenarios

Scenario \ Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2030	2035
Prog Ren Ref Dem	19.2	19.6	21.1	21.8	22.6	24.1	24.6	25.2	27.0	31.8	36.4	41.3	46.0
Prog Ren Engy Cons	19.2	19.6	20.1	20.9	21.6	22.2	22.8	23.4	24.4	30.4	33.5	38.9	42.9
High Ren Ref Dem	19.2	19.6	21.3	22.0	22.8	23.6	25.4	25.9	26.9	32.6	35.7	40.9	42.4
High Ren Engy Cons	19.2	19.7	20.3	21.1	21.9	22.7	23.6	24.3	25.5	31.2	33.4	36.4	37.8
BAU Ref Demand	19.2	19.6	21.0	21.5	22.8	23.3	24.6	25.0	26.2	30.8	36.9	42.5	47.9
BAU Engy Cons Dem	19.2	19.6	20.0	20.4	20.8	22.2	22.6	23.0	23.6	28.3	34.4	41.1	47.5

Note also that the costing does not assume any credit for CO2 emission reductions or trading of renewable energy certificates. The cost differential could possibly be reduced or eliminated altogether if a CO2 externality cost were added to the fossil fuel prices (the equivalent of reducing the effective cost the renewable energy fuels through a TREC or CDM type trading mechanism). For example, at an average emission of 1 kg CO2/kWh, a CDM credit of 10$/ton generates an effective premium of 1 USc/kWh or R0.07/kWh. The CO2 market remains uncertain, but it does represent a real value add for low CO2 emitting technologies such as renewable energy generation plant.

On the other hand the scenarios do not adequately take into account the additional costs of energy storage and load shifting that might be required if in particular the high renewable scenario is followed. Additional pumped storage facilities would almost certainly be required- detailed modelling of which is unfortunately beyond the scope of this study. Section 3.12 discusses issues around determining the need for storage capacity, on a regional and national level.

The main reasons for these cost shifts are:

a) there is a gradual shift from existing plant to new plant
b) new fossil fuel plant is likely to be significantly more expensive than older plant
c) new renewable energy technologies are expected to compete more effectively, as their costs reduce.
d) Fossil fuel operational costs are likely to increase as fuel prices increase (see section 3.13)

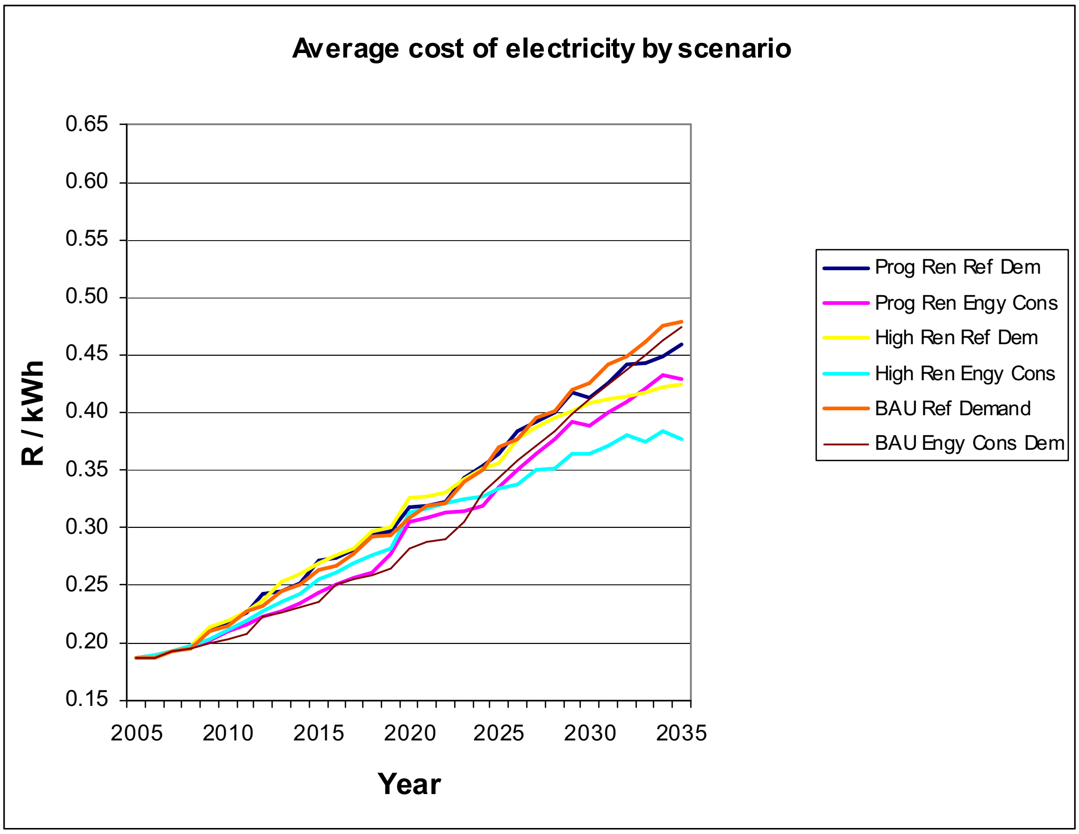

Figure 29 Average cost of generated electricity by year for the different scenarios

6.8.3 Renewable Energy Contributions to the electricity supply mix

As discussed in section 4, not all renewable energy generated in the Western Cape may be credited to the province, and it is also possible for renewable electricity generated elsewhere to be credited. Much depends on how the accounting is done.

The graphs below use the following assumptions:

- That existing base load power (sourced from Eskom) has a small renewable energy component (about 1%, as some of the energy is from hydro resources)
- 5.9% (2006) of the existing base load plant is sourced from Nuclear energy (Koeberg's contribution to the national energy supply is about 5.9%, and although the plant is in the Western Cape – it is seen as nationally owned and managed assets, and thus is low carbon credit is shared with all users of national power
- All new renewable energy generated as per the scenarios *is* credited to the Western Cape. (If this electricity was purchased using TRECs by for example a Gauteng based consumer, then it should *not* be credited to the Western Cape targets).
- The Imported Renewable Energy listed in the progress and high renewable scenarios is generated elsewhere, but is credited to the Western Cape as a result of purchasing by entities (un-defined as yet) within the province).

The above assumptions must be qualified- in that it is quite probable that a significant portion of any renewable energy generation plant *installed and operated* in the Western Cape may have their production effectively sold to other parts of the country (or in the longer term even internationally) through the mechanism of TRECs. Even if no formal trading takes place, if the plant is constructed and operated by a national entity (such as Eskom), the Western Cape would only be able to claim a portion of this energy – as it should be distributed to all Eskom consumers in the same manner as for Nuclear energy above.

Figure 30 shows the percentage renewable energy in the provincial electricity supply mix that would be achieved for each of the scenarios. Table 24 shows the specific numbers in more detail, especially for early years. From this it can be seen that only in the high renewables, energy conscious scenario, is the contribution of renewable electricity to the total provincial requirement close to 15% by 2015. Also note that the high percentage of renewable energy generation shown in later years of this scenario would be modified through export, as well as network limitations.

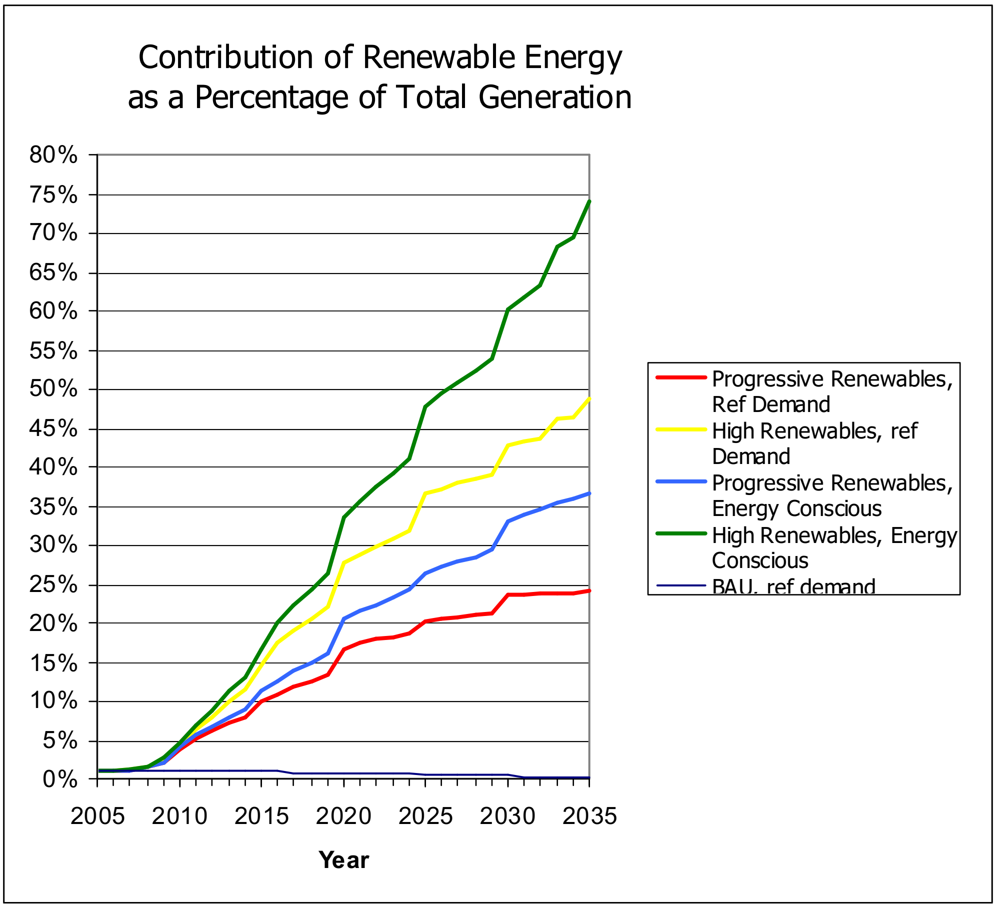

Figure 30 Percentage renewable energy in the electricity supply mix

Table 24 Percentage of electricity supplied in the province that is from renewable resources

Scenario/year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2030	2035
Progressive Renewables, Ref Demand	1.1%	1.4%	2.0%	3.9%	5.2%	6.1%	7.1%	8.0%	9.9%	16.8%	20.1%	23.6%	24.0%
High Renewables, ref Demand	1.2%	1.6%	2.6%	4.2%	6.4%	8.0%	10.1%	11.6%	14.5%	27.6%	36.6%	42.9%	48.8%
Progressive Renewables, Energy Conscious	1.1%	1.5%	2.1%	4.2%	5.6%	6.7%	7.9%	9.0%	11.4%	20.4%	26.3%	33.1%	36.6%
High Renewables, Energy Conscious	1.2%	1.6%	2.8%	4.5%	7.0%	8.8%	11.2%	13.0%	16.6%	33.7%	47.8%	60.3%	74.0%
BAU, ref demand	1.1%	1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	1.0%	0.9%	0.8%	0.6%	0.4%	0.2%

6.8.4 Carbon Foot Print

One of the main reasons for promoting a strongly renewable energy component for the Western Cape energy consumption is to reduce the green house gas emissions from use of electricity. Figure 31 shows the relative emissions from each of the electricity scenarios discussed above

As for 'renewable energy' contribution, these graphs assume the following:

- All fossil plant is treated as emitting 0.85 kg CO2/kWh[15]
- All new renewable energy generated as per the scenarios *is* credited to the Western Cape – and is assumed to have zero net emissions (a simplification but within the bounds for this study).
- The Imported Renewable Energy listed in the progressive and high renewable scenarios is generated elsewhere, but is credited to the Western Cape as a result of purchasing by entities (undefined) within the province, and is assumed to have zero emissions.

The above approach is consistent with emissions being allocated to the region in which the electricity is *used*, not where it is generated (in the north of the country in the case of coal).

Of particular concern is that if the energy supply mix were to remain similar to current, and demand were to grow inline with the reference demand curve – by 2035 the Western Cape electricity sector would be responsible for more than double the current CO2 equivalent emissions. The graph clearly shows the significant impact of energy efficiency measures, with the BAU Energy Conscious Demand Curve reducing final emissions from just over 34 million tonnes to about 22 million tonnes (but still leaving emissions higher than they are in 2007).

Despite the very significant contributions made through use of renewable energy in the *Progressive Renewable Reference Demand Scenario,* (where renewable energy contribution reaches over 50% by 2035), it will be noted that emissions still increase, as a result of increased overall demand in electricity. Note also that emissions in the non-electricity sector are likely to increase as well. The *High Renewables Reference Demand* scenario approaches stabilisation, but it must be remembered that this requires very aggressive renewable energy promotion.

The only scenarios which show a net reduction in emissions are the *progressive renewable energy conscious* scenario, and the *high renewables energy conscious scenario.* The *progressive renewable energy conscious* in particular shows the power of energy efficiency combined with active support of renewable energy to achieve mitigation objectives.

[15] This is on the low side for some coal plants, and a high estimate if a significantportion of gas generation is used.

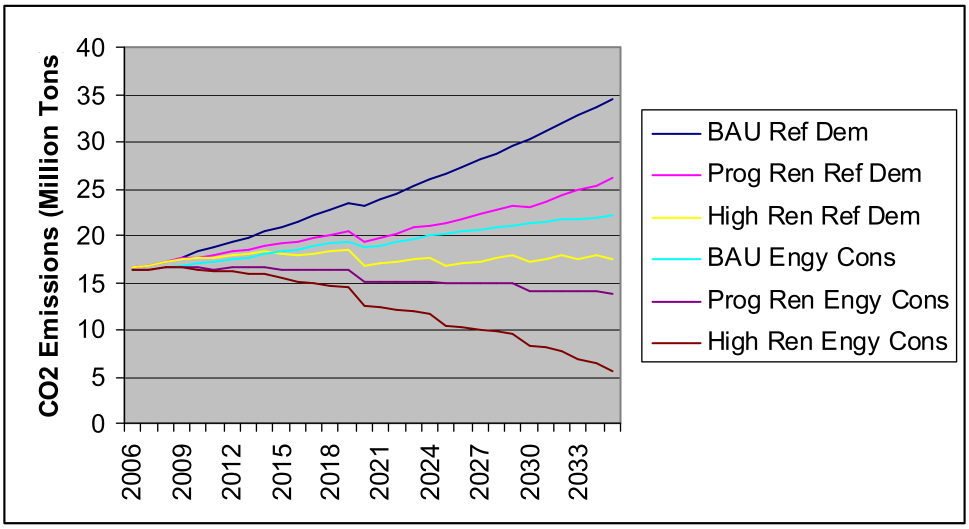

Figure 31 CO2 equivalent emissions for the different electricity supply scenarios

6.8.5 Jobs created

Most renewable energy technology options require a higher number of employed persons per MW installed (or kWh generated) than large scale fossil fuel alternatives. Table 25 indicates factors for different technologies, based on SECCP (2003).

Based on these numbers, Figure 32 shows the total number of jobs required for the different scenarios. The jobs created were determined as the product of electricity generated by various technology (MWh) and the direct jobs created per kWh for each technology type (Jobs/MWh

Table 25 Direct employment potential of electricity generation (adapted from SECCP 2003)

Conventional Energy Technology	No. jobs	
	/MW	/GWh
Coal (current)	1.7	0.3
Coal (future)	3	0.7
Nuclear	0.5	0.1
Pebble Bed Modular Reactors	1.3	0.2
Gas	1.2	0.1
Petroleum based Liquid Fuel (Paraffin, Diesel)[16]		0.1

Renewable Energy Technology	No. jobs	
	/MW	/GWh
Solar thermal	5.9	10.4
Solar Panels	35.4	62
Wind	4.8	12.6
Biomass	1	5.6
Landfills	6	23
Hydro[17]		1
Pumped Storage[18]		1
Ocean Energy[19]		1

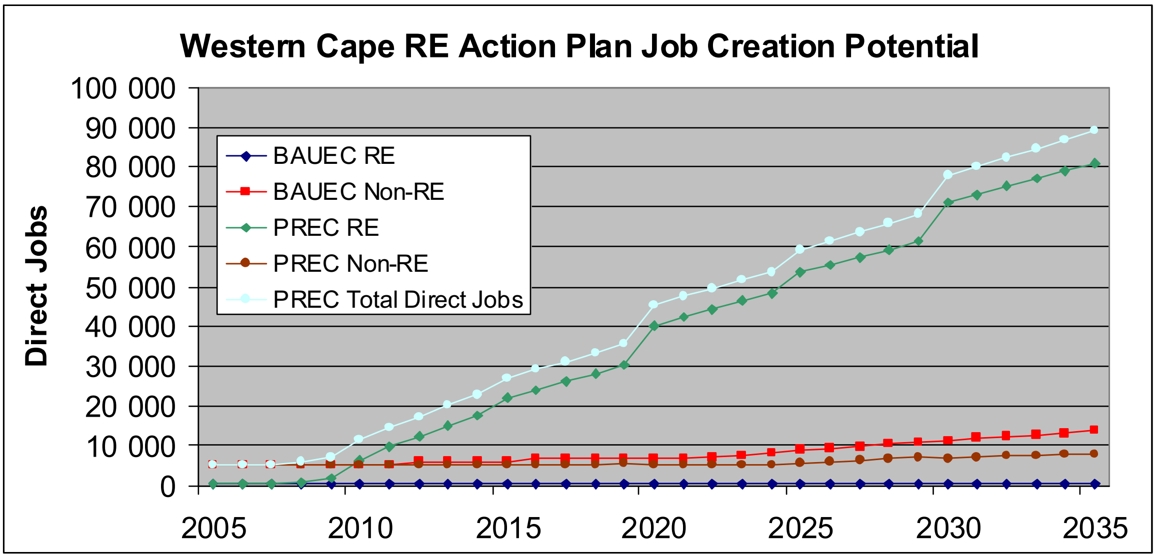

Figure 32 Western Cape renewable energy job creation potential

[16] Not explicitly included in the SECCP 2003, assumed to be as for gas for this study.

[17] Not explicitly included in the SECCP 2003, assumed to be 1 direct job per GWh generated for this study.

[18] Not explicitly included in the SECCP 2003, assumed to be 1 direct job per GWh generated for this study.

[19] Not explicitly included in the SECCP 2003, assumed to be 1 direct job per GWh generated for this study.

The business as usual (BAUEC) total jobs curve has not been plotted above as it essentially coincides with the BAUEC non-renewable energy jobs created (the renewable energy jobs created being negligible). The progressive renewable energy, energy conscious scenario (PREC) indicates a net job benefit of 16 000 by 2014 and 75 000 by 2035 over the business as usual scenario. The High Renewables scenario would obviously show an even greater number of new jobs created.

6.9 Energy change scenarios that the Western Cape Provincial Government could implement directly

The Provincial Government of the Western Cape has committed itself to developing a sustainable energy system (Sustainable Energy Strategy, 2006). A number of key leadership areas have been identified and require of the government to demonstrate leadership if it believes that all stakeholders should be committing themselves to developing a cleaner energy future. Initiatives such as the pilot Solar Water Heating Initiative are examples that the PGWC will be setting in order to begin the process of putting the strategy into practice. Key opportunities are discussed below.

6.9.1 Western Cape Government Fleet

The Provincial Government has indicated its intends to purchase 15% of its electricity from renewable energy sources. The following is an assessment of the implications if province was to purchase up to 20% percentage of the electricity energy that government uses from renewable resources

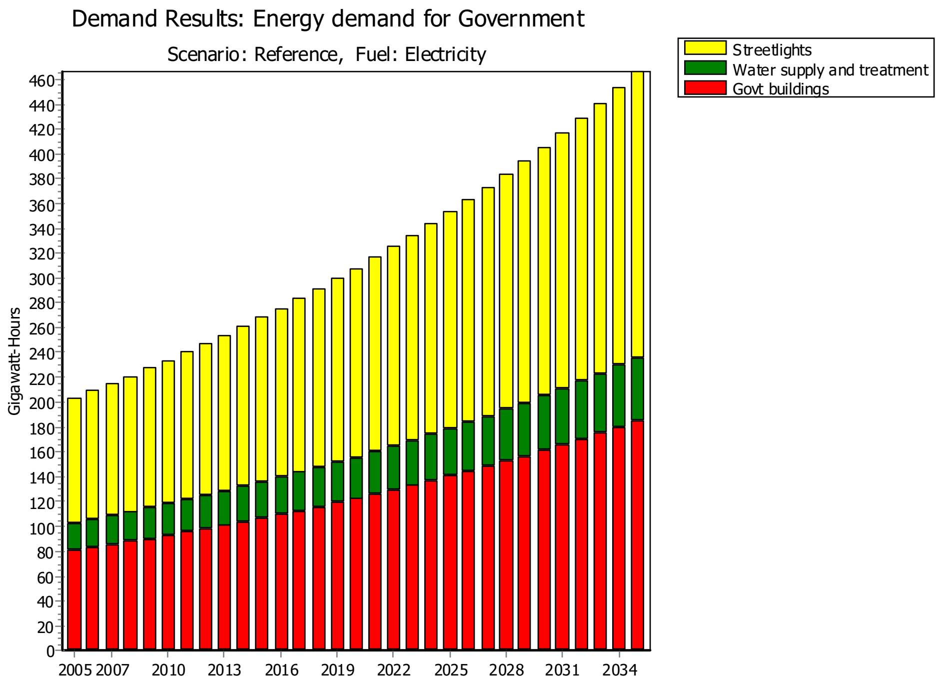

Figure 33 Electricity demand by Government buildings, streetlights and water treatment in the Western Cape, reference scenario

The Western Cape Government currently uses approx 200 GWh electricity per annum (as shown in Figure 33). As per the reference scenario this will increase to 460 GWH by 2034. This increase could be limited to a total of 425 GWh if the energy efficiency measures proposed in the Demand Side strategy are implemented. As shown in Table 26, it is highly feasible for the provincial government to purchase a significant proportion of their electricity from renewable energy resources. If this electricity was purchased from a wind farm, which had an effective capacity factor of 25%, then the wind farm would need to have almost 23 MW of installed turbines operational by 2014. A contribution of 5% to the provincial governments own demand by 2008 will require, for example, a 5 MW wind farm.

Table 26 Scenarios illustrating the feasibility for the province to purchase renewable electricity

Year	Units	2008	2009	2010	2011	2012	2013	2014
Electricity consumed	GWh	218	223	228	233	238	243	249
Prof Govt RE pruchase %	% RE	5%	8%	10%	13%	15%	18%	20%
Renewable elec purchased	GWh	11	17	23	29	36	43	50
Cost premium for RE	(c/kWh)	35	35	35	35	35	35	35
Additional cost	Rands	3,809,302	5,843,171	7,966,862	10,183,218	12,495,157	14,905,670	17,417,824
Inst.Wind required @ 25% cap. Fact.	MW	5.0	7.6	10.4	13.3	16.3	19.4	22.7

While the above impacts would be very important in terms of the Provincial government taking a lead by example, the overall contribution is relatively small. It is thus very clear that a range of other activities will be needed within industries, and distribution utilities to achieve either the *progressive renewable* or the *high renewable* scenario.

6.10Conclusions drawn from the scenarios

6.10.1 Electricity

Based on the assessment of renewable energy resources, conversion technologies, growth in demand and presented in the above scenarios, the following conclusions can be drawn:

- Energy efficiency is clearly shown as a critical tool to reducing CO2 emissions (section 6.8.4)
- There is significant potential in the medium to long term to generate a high proportion of electricity needs from renewable resources, and *based on the cost change assumptions used here,* the cost differential compared to a business as usual scenario is reasonable (section 6.8.2).
- 12% *locally* generated renewable electricity by 2015 is just achievable (as per the scenarios investigated) if a highly aggressive renewable energy plan is implemented and strong energy efficiency is practiced – the High Renewables Energy Conscious scenario.
- There is some scope to import renewable generated electricity from other regions, however, by 2015, this amount available is may not be sufficient to achieve a 15% target.
- The *progressive renewable* and *high renewable* scenarios (coupled with *energy conscious demand*) illustrate the possible contributions that could be achieved (based on our models). These are summarized in Table 27 below:

Table 27 Percentage of electricity supplied in the province that is from renewable resources

Scenario/year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2030	2035
Progressive Renewables, Ref Demand	1.1%	1.4%	2.0%	3.9%	5.2%	6.1%	7.1%	8.0%	9.9%	16.8%	20.1%	23.6%	24.0%
High Renewables, ref Demand	1.2%	1.6%	2.6%	4.2%	6.4%	8.0%	10.1%	11.6%	14.5%	27.6%	36.6%	42.9%	48.8%
Progressive Renewables, Energy Conscious	1.1%	1.5%	2.1%	4.2%	5.6%	6.7%	7.9%	9.0%	11.4%	20.4%	26.3%	33.1%	36.6%
High Renewables, Energy Conscious	1.2%	1.6%	2.8%	4.5%	7.0%	8.8%	11.2%	13.0%	16.6%	33.7%	47.8%	60.3%	74.0%
BAU, ref demand	1.1%	1.1%	1.1%	1.1%	1.0%	1.0%	1.0%	1.0%	0.9%	0.8%	0.6%	0.4%	0.2%