Kwa Zulu Natal Bioenergy Action Plan

FINAL REPORT

Prepared on behalf of:

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CSIR
our future through science

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INTRODUCTION

The strong scientific evidence for climate change and particularly its effects on African economies has driven the need towards the development of low carbon economies. To meet the challenge of climate change carbon needs to be saved in every sector of the economy, with decarbonizing the production of energy being one of the best ways of achieving this.

The development of renewable energy is not only critical in terms of lowering greenhouse gas emissions but forms the backbone of achieving provincial energy security and self-sufficiency; improved access to energy among the poor and stimulating decent and sustainable job creation. The bioenergy economy in Kwa Zulu Natal forms a critical pillar in the renewable energy basket. In 2011 a Green Economy Strategy was developed for the province whereby the vision was outlined that by 2030 KZN will be a province where the economy provides opportunities for all its residents to prosper; where natural resources are enhanced supporting basic needs and "green" economic growth. The basis of the strategy was one of a partnership model between government, labour and business. The principal aim of the strategy was to support and direct the re-orientation and growth of the KZN economy to become increasingly resilient and competitive by:

- Increasing resource use efficiency in business and government infrastructure development
- Increasing the supply of renewable energy
- Secure the supply of ecosystem services from the provinces natural assets
- Reduce the emissions and climate related risks and in so doing create sustainable jobs for local people; reduce poverty and address social equity

The rollout of renewable energy forms a critical component of this approach and given the lack of success the province has had in other form of renewable energy, the bioenergy economy can potentially be used to unlock this sector.

KwaZulu Natal (KZN) is a province which has substantial biomass resources in its boundaries. Provincially the development and promotion of renewable energy is one of the key focus areas within the Provincial Growth and Development Strategy, with critical energy generation and energy efficiency targets having been set. KZN has had difficulty in attracting large and small scale renewable energy generation projects within its boundaries. The potential of the bioenergy sector to assist with this has not been fully explored, therefore dedicated research and budgetary input needs to be made into the bioenergy sector.

GOALS OF THE KZN BIOENERGY ACTION PLAN

The goals and objectives of developing a KZN Bioenergy Action Plan is to assist unlocking this sector, by firstly providing an overview of what biomass resources exist in the province. Secondly it is to identify which opportunities can be developed into a roll out of pilot projects and thirdly to identify what are the key initiatives that provincial government can implement to assist the sector.

The overarching goal of the Bioenergy Action Plan is:

"***To stimulate economic development and job creation in rural and urban areas of Kwa Zulu Natal by identifying opportunities and implementing projects that will unlock the increased sustainable energy production from biomass resources in the province***."

In attaining to this goal the following objectives will also be met:

- Implementation of funding mechanisms to stimulate deployment of cost effective and sustainable bioenergy technologies.
- Stimulate community based bioenergy projects and ownership
- Increase diversion of biomass from landfills
- Increase the share of energy derived from renewable sources in KZN
- Implement research into a transportation regime that incorporates the roll out of biofuels
- Development of strong partnerships between government and business in the bioenergy sector
- Reduction of GHG emissions in particular CO^2 and CH^4 (especially in sectors such as long haul transport where other opportunities are limited)
- Improvement in energy security by diversifying energy supply and reducing exposure to fluctuating global energy markets and import dependency which would have a positive impact on the balance of payments

GLOBAL DEVELOPMENTS IN THE BIOENERGY FIELD

Recent communication released by the International Energy Agency in 2017 highlighted the 4 key areas below as having an impact on the uptake of bioenergy. They are as follows:

1. A growing urgency for the need to tackle climate change through dramatic reductions in GHG

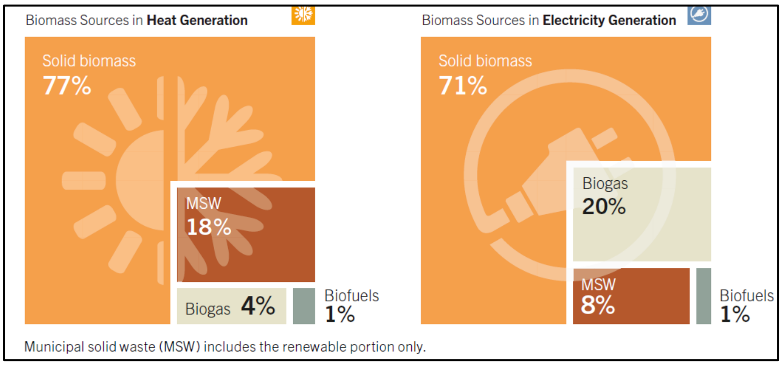
2. Increased competition from fossil fuels at prices lower than anticipated

3. Good progress in the development and deployment of complementary technologies such as electric vehicles

4. Growing appreciation of bioenergy's role in the broader bio-economy. This includes the possibilities for the production of a wider range of biomass based products and chemicals in addition to the traditional production of food and wood-based products.

The latest REN21 2016 report on the status of renewable energy globally, showed that bioenergy contributed more to primary global energy supply than any other renewable energy source, with demand supplied from biomass totalling 60 exajoules (EJ) in 2015.

Figure 1: Global Biomass Resources Used in Heat and Electricity Generation



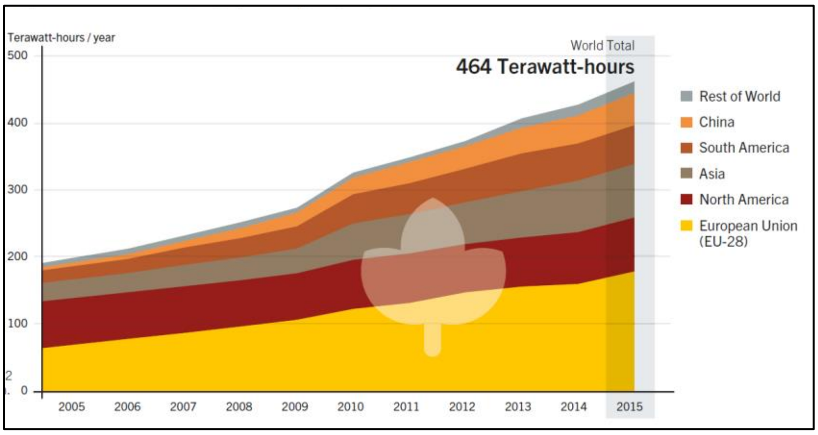
Source: REN21 2016

The solid biomass sector is one in which the most global trade occurs. This is mainly in the form of wood pellets, with trade patterns varying annually as the demand for pellets is affected by each country's regulations and financial support. Until recently the European Union has been one of the major importers of wood pellets but since 2014 Japan and Republic of Korea have emerged as strong global players. Historically the United States has always been a strong player in this field, with it exporting more than 4.5 million metric tonnes of wood pellets in 2015 with 84% of this going to the United Kingdom (REN21 2016).

Biogas being identified as the second biggest biomass resource in electricity generation also continued to expand globally. The 2015 data suggests that most of the biogas production is taking place in the United States and Europe, however the east is also showing signs of increased uptake. The REN21 report shows that anaerobic plants are being used more widely to treat liquid effluents and wastes in developing countries such as Thailand and Indonesia. During 2015 South Africa saw its own launch of the Bronkhorstspruit Biogas Plant. This is a 4.4 MW plant and generates electricity that is exported via the grid to BMW as the off-taker. The plant makes use of cattle waste as the feedstock and is one of the largest Anaerobic Digestion plants to have been commissioned in South Africa.

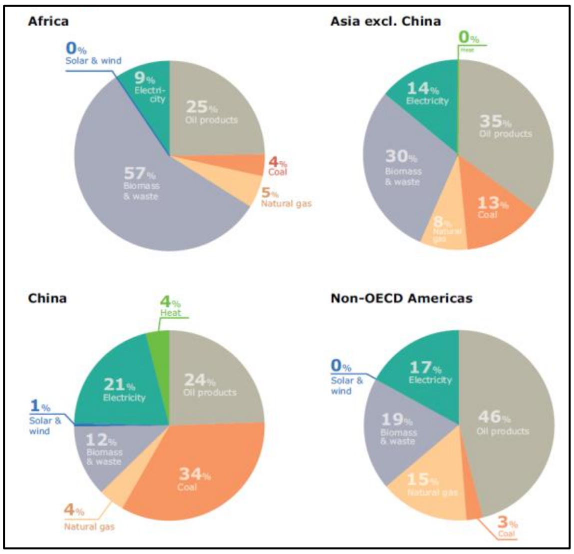
Figure 2 shows the global bio-power generation by country/region for the period 2005-2015. What is evident is that the generation of power has been increasing steadily and significantly, with the European Union remaining the biggest player in power generation from biomass. A comparison between figure 2 and figure 3 shows that although Africa is not a role player on a global scale in terms of volumes of electricity produced from biomass, within Africa itself biomass and waste make up 57% of total final energy consumption. This indicates that as a continent, there are potentially many opportunities that need to be unlocked in the bioenergy sector.

Figure 2: Bio-power Global Generation, by Country/Region 2005-2015



Source: REN21 2016

Figure 3: Share of Bioenergy in Total Final Consumption for Developing World Regions in 2011



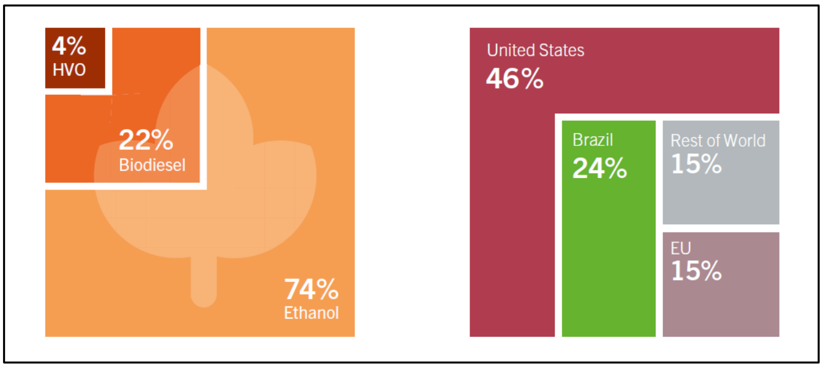
Source: IEA 2014

The biofuels sector makes up a key pillar in the global bioenergy sector in terms of its contribution to sustainable transportation. Global trends show that there is continued creation of new markets for biofuels with aviation emerging as a significant role player in the biofuel market. According to REN21 (2016) Egypt, Japan, Mexico, the Netherlands and the United States all made announcements of aviation biofuel supply agreements or plans to integrate aviation biofuel into future flights during 2015. United Airlines became the first US airline to move beyond demonstration to regular operations using biofuels. In terms of Research and Development in biofuels there is also a significant focus on innovation around woody biomass and municipal waste and its application to the jet fuel market.

REN21 (2016) show that in 2015 global biofuels production increased by around 3% compared to 2014, reaching 133 billion litres. The demand continued to be consistent due to blending mandates in various countries which sheltered biofuel markets from the potential impacts of relatively low gasoline and diesel fuel prices. Geographically, the global production of biofuels was dominated by the United States and Brazil, with these two countries producing 72% of all biofuels followed by Germany, Argentina and Indonesia. An estimated 67% of biofuel production was fuel ethanol and 33% was biodiesel (REN21 2016). Trade data for fuel ethanol in particular showed that net exports made from the United States increased by 28% during 2014/2015 to 2.5 billion litres. Most of these shipments were made to Brazil, Philippines, India and the Republic of Korea. The Chinese market for ethanol imports has grown rapidly and has influenced global trade patterns significantly (REN21 2016).

Data for biodiesel production shows that it is more geographically diverse than ethanol, with production spread among a number of countries. The top 5 producers are the United States, Brazil, Germany, Argentina and France). Figure 4 shows the biofuels global production by type and country/region. It is evident that Ethanol production far outweighs that of biodiesel and that the United States is the key role player in the biofuels market.

Figure 4: Global Biofuels Production by Type and Country/Region 2015



Source: REN21 2016

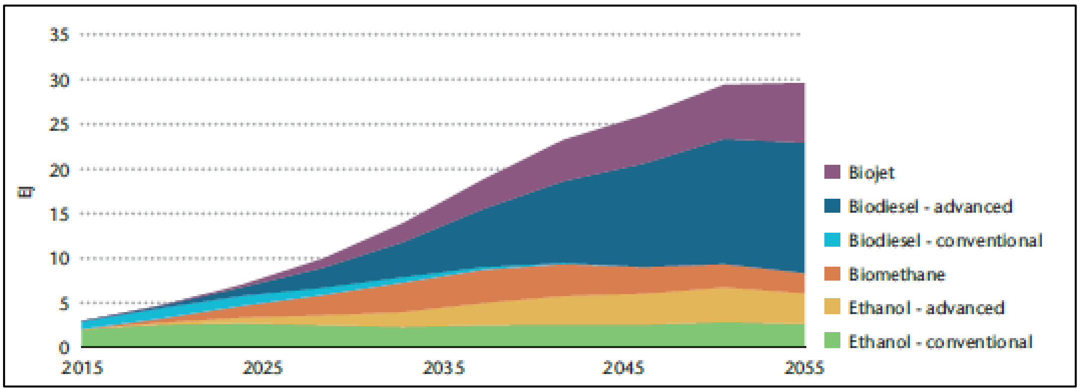
The cost of biofuels and the policy landscape are two critical influencing factors for its adoption and increased use as a transportation fuel. The projected use of biofuels in global transportation networks could avoid around 2.1 gigatonnes of CO^2 emissions per year when produced sustainably

Globally, biofuels are providing a way for regions to decarbonise their transport sector and to shift to low-carbon, non-petroleum fuels often with minimal changes to vehicle stocks and distribution infrastructure. However currently the data is showing that biofuels are still more costly than conventional fuels and that there are questions around sustainability that need to be taken into consideration in their development. The recent reduction in prices of fossil fuels has also set back the biofuels development slightly. However research shows that there is scope for cost reductions that will help to improve competitiveness with fossil fuels and drive commercial deployment. These can be summarised in the three points below:

- ✓ Capital costs are expected to come down as a result of scaling up deployment. Co- location with existing biofuel plants, power plants or other industrial facilities reduces capital costs and can bring further benefits such as more efficient use of by-products.
- ✓ Conversion costs can be brought down through scaling up and technology learning. Further improvement of conversion efficiency and energy efficiency should also help to reduce costs.
- ✓ Feedstock costs cannot be predicted and are subject to agricultural commodity prices, oil prices and other factors. Enhancing feedstock flexibility will create access to a broader range of biomass sources with potentially lower costs and reduced price volatility. Improving and creating transport infrastructure, for distribution purposes could further reduce biomass supply costs.

Figure 5 below shows the projected energy demand by fuel type until 2055. Projections indicate that advance biodiesel together with biojet fuel are to be the dominating forms of biofuel going forward. It is predicted that biofuels will make up 40% of air transport fuel by 2060 and 30% of bunker fuel for shipping by 2060.

Figure 5: Biofuels final transport energy demand by fuel 2055



The South African policy context for biofuels has shown signs of promise but has had limited success over the last two years. The National Biofuels Industrial Strategy initially focused on a short term five year pilot programme to achieve a 2% penetration of biofuels in the national liquid fuel supply or 400 million litres per year to be based on local agricultural and manufacturing production capacity. However since then progress in the development of the country's biofuels industry has been very modest, especially in terms of investment. No commercial biofuel plants have been established in the country. The only biodiesel currently being produced for the transport market is through 200 small-scale initiatives that use recycled vegetable oil, most of which were established long before the strategy was released in 2007 (WWF 2014).

Another important consideration to the development of the bioenergy sector is contextualising it within the confines of the bio-economy. According to the Department of Science and Technology's Bio-economy Strategy 2013, the term "Bio-economy" encompasses biotechnological activites and processes that translate into economic outputs, particularly those with industrial application. Within the South African context these may include, but are not limited to technological and non-technological exploitation of natural resources such as:

- ✓ Animals,
- ✓ Plant biodiveristy,
- ✓ Micro-organisms and minerals

These science-based "bio-solutions" can be used to:

- ✓ Manufacture high-value protein products such as biopharmaceuticals and vaccines
- ✓ Produce biofuels
- ✓ Improve and adapt crops
- ✓ Remedy industrial and municipal waste

Rapid advances in biotechnology are enabling a number of economic sectors to use more biomass. The OECD has predicted that by 2030 the bio-economy could contribute 2.7% of GDP across OECD countries. Analysis by the OECD also suggested that the potential of industrial biotechnology and bio-based products to cut carbon dioxide emissions could range between 1bn and 2.5bn tCO ^{2}e/yr. The bio-economy and in particular South Africa's Bio-Economy Strategy provides an important context for the development of any bioenergy implementation plan.

Linked to the concept of the bio-economy is that of bio-refineries. Current research by the IEA suggests that to achieve a truly sustainable bioenergy sector one requires the co-production of bioenergy and bio-products. This is where the bio-refinery concept plays a role. The bio-refinery concept is analogous to the basic concept of conventional oil refineries to produce a variety of fuels and other products from a certain feedstock. The economic competitiveness of the operation is based on the production of high-value, low volume co-products in addition to comparably low-value biofuels. Bio- refineries can process different biomass feedstocks into energy and a spectrum of both intermediate and final marketable products such as food, feed materials and chemicals. A bio-refinery can consist of a single unit or it can also be formed by a cluster of single facilities that process by-products or wastes from neighbouring facilities.

Two main categories can be defined:

- ✓ **Energy-driven** bio-refineries, which include biofuel plants
- ✓ **Product driven** bio-refineries which focus on producing food, feed, chemicals and other materials and might create power or heat as a co-product

Another important national policy and strategy that has a direct bearing on the development of a bioenergy sector is the National Waste Management Strategy (NWMS). This strategy has outlined a number of key sustainability goals including the promotion of waste minimisation, re-use, recycling and recovery of waste and the growth of the contribution of the waste sector to the green economy. In this regard the following National targets have been set for 2016 as follows:

- ✓ The diversion of 25% of recyclables from landfill sites for re-use, recycling or recovery
- ✓ The implementation of separation at source programmes in all metropolitan municipalities, secondary cities and large towns
- ✓ The creation of 69 000 new jobs created in the waste sector with 2600 additional SMME's and cooperatives participating in waste service delivery and recycling

The strategy further states that "municipalities will take responsibility for diverting organic waste which they can compost or use in biogas digesters. All municipalities are required to develop integrated waste management plans to ensure that efficient and effective collection, processing and recycling of waste takes place. This strategy has clear inputs for the development of bioenergy sectors within municipalities and should be one that is consulted during this research.

Based on this global and national review of the bioenergy sector it is clear that this KZN Bioenergy Action Plan should set out to:

1. Harness the market opportunities presented by bioenergy in order to achieve economic growth, development and job creation
2. Increase the awareness of the value of bioenergy opportunities to society
3. Ensure that bioenergy developments do not adversely impact the environment

SUMMARY OF KZN'S KEY BIOENERGY RESOURCES

The status quo report gives a more detailed outline of how bioenergy is defined, however the following is a summary of what was outlined. **Bioenergy** is the term given to all energy that is converted from biomass. This energy can be in the form of**:**

- ✓ Electricity
- ✓ Heat
- ✓ Gas
- ✓ Liquid transportation fuel

The main **feedstocks** for bioenergy can be categorised as follows**:**

- ✓ Animal waste
- ✓ Plant residues produced on farms and in forests
- ✓ Energy crops (crops grown specifically to produce energy)
- ✓ Food waste
- ✓ Waste water treatment facilities
- ✓ Landfill waste

Many factors impact the selection of a biomass feedstock for delivering energy services. Some of these would be:

- ✓ The total delivered cost
- ✓ Availability of the biomass (including seasonal variations)
- ✓ The quality required by the conversion process which may align with one biomass type better than with another
- ✓ Underlying requirements for sustainability (i.e. land and water requirements)

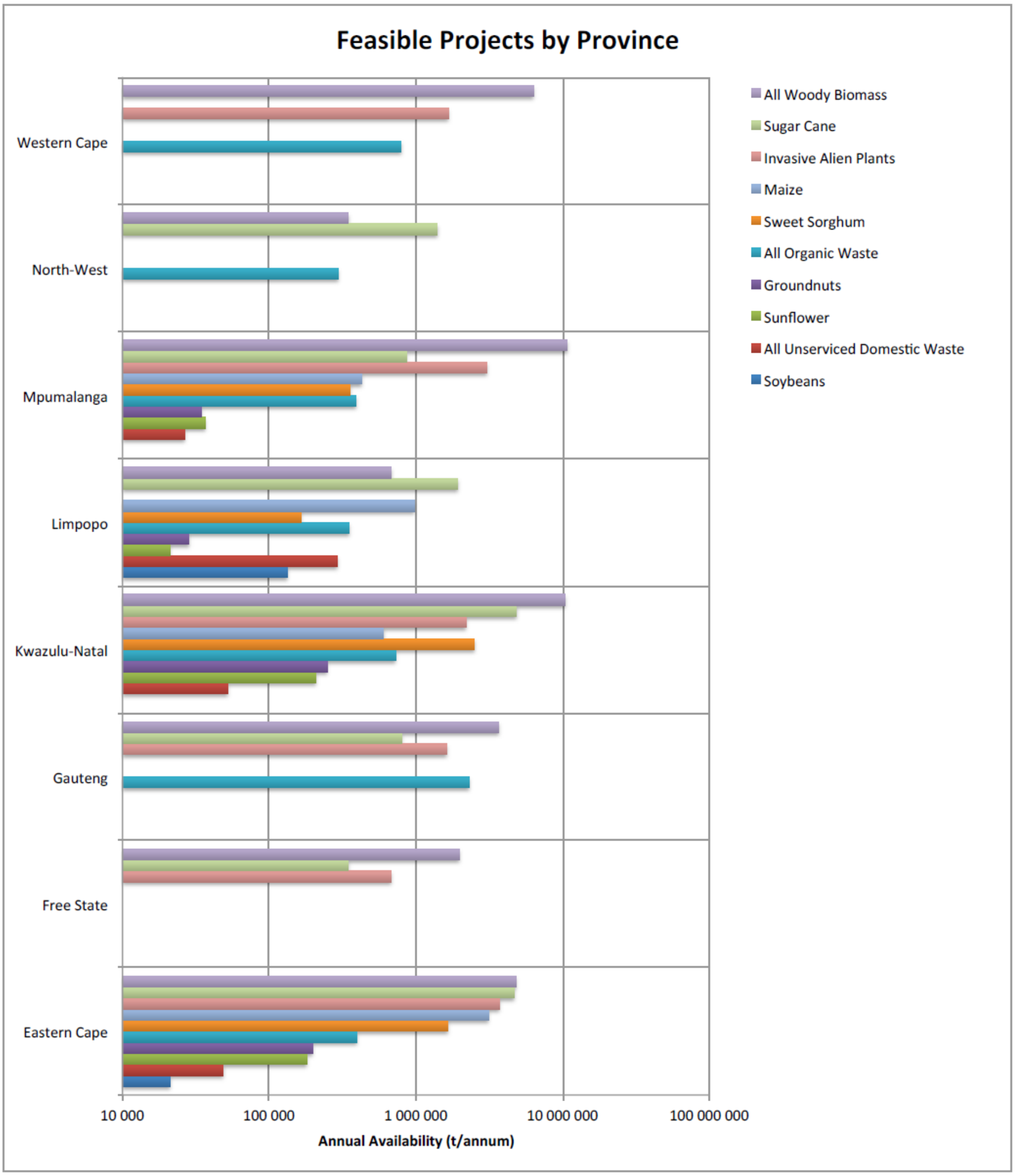
While biomass can be used to produce power, gas or liquid fuels, the balance between these uses will depend on markets, public policy choices and the development of new technologies. When underpinned by sufficient primary feedstock resource to allow for meaningful electricity generation levels, the potential exists for bio-power to be a base load renewable energy resource. Moreover, given its dispatchability, it may also introduce flexibility in peak-tariff periods to offset costs from conventional generation options. There are varying technologies that can be used to process different biomass resources and the conversion technologies are in various stages of development. Some technologies are in commercial or pre-commercial production, making them cost-competitive while others are still in the research and development phase.

From the status quo assessment the following key factors regarding KZN were established. KZN's top biomass resources are as follows:

- ✓ Forestry residue
- ✓ Sugar cane
- ✓ Sweet Sorghum
- ✓ Organic Waste

Figure 6 below shows that compared to other provinces, it is Kwa Zulu Natal and the Eastern Cape that have a rich diversity of biomass feedstocks, with woody biomass, sugar cane, alien invasive plants and organic waste being in the top four in terms of quantity. This provides the rationale for choosing these as sectors to focus on.

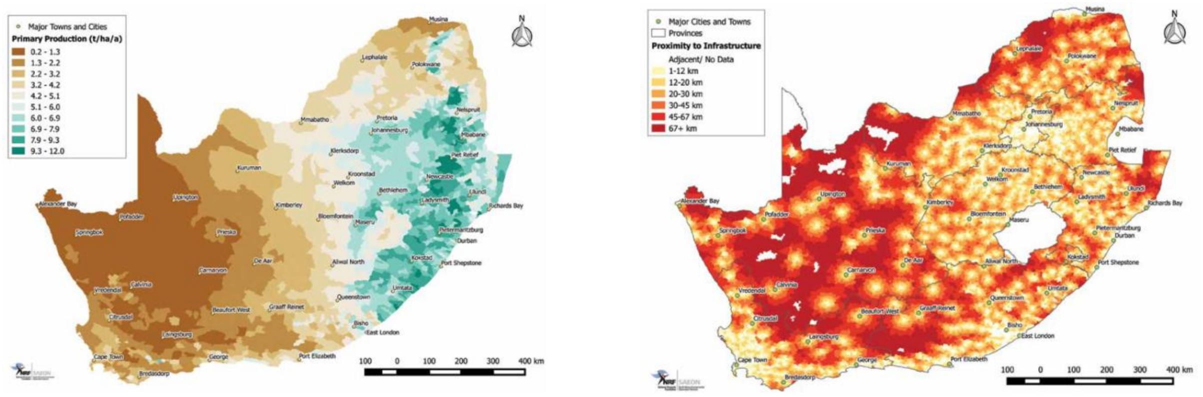
Figure 6: **Distribution of feedstocks for projects by province and feedstock source**



Source: Bioenergy Atlas

Transportation of feedstock is one of the key factors in determining viability of bio-energy projects and is often an element that is overlooked. This is one of the key positive factors for KZN as most of the biomass resources are found in close proximity to infrastructure areas. This is graphically show in figure 7 below.

Figure 7: National biomass resource and location of basic transportation infrastructure



Source: South African Bioenergy Atlas (Summary document)

The status quo assessment showed that when focusing on electricity from Bioenergy, the following are the main feedstock sources:

1. Sugar – Mills and Biogas Opportunities
2. Forestry
3. Waste Water Sludge
4. Food Waste

SUGAR INDUSTRY RESOURCES

Bioenergy Opportunities in Sugar can be broken into 3 aspects**:**

1. **Electricity Production through Cogeneration**- takes place at the mills and makes use of bagasse, which is the fibrous matter that is left behind after the sugar cane has been crushed.
2. **Biofuels in the form of Ethanol**- makes use of the sugar cane juice or molasses.
3. **Biogas** – can either be converted to liquefied gas or electricity and makes use of the tops and trash that is left in the fields after harvesting. This is very often burnt at present.

Figure 8 below shows the potential energy generation at the mills in the sugar industry.

Figure 8: Potential Energy Generation from Sugar Industry

DESCRIPTOR	RENEWABLE SUGARCANE COGENERATION TECHNOLOGY
Primary Renewable Fuel	Sugarcane fibre (includes bagasse and leaves)
Typical Sugarcane Harvest Season	April - December
Proposed MW Allocation	1000
Total MW as per current projects	780.5
No. of projects	14
Total Project Cost (ZAR million)	18,847
Total Revenue – real (ZAR million)	111,693
Local content value – Construction (ZAR million)	11,795
Local content % - Construction	62.6
Job creation – Construction Phase	12 972
Job creation – Operations Phase	433
Job creation – Fuel Phase	20 701
Total Jobs	34 106
Job creation per plant during construction phase (Job/MW)	16.8
Job creation per plant during fuel phase (Job/MW)	26.8
Total job creation per plant (Job/MW)	44.1
Socio-Economic Development (ZAR million)	1,400
Enterprise Development (ZAR millions)	2,300

Source: South Africa Sugar Association 2013

Currently in the sugar mills, co-generation is mainly used to power on-site operations. Further large scale investment is required to allow these mills to produce excess energy and this will only be undertaken if a guaranteed tariff framework or Power Purchasing Agreement is put in place. The Sugar Industry in South Africa has been advocating for this framework with national government for the last 5 years. The potential for large scale cogeneration driven primarily by the timber and sugar cane industry is estimated at being between 1000 MW and 1500 MW. This is a significant amount of electricity and equates to 1 gigawatt. The total South African electricity demand is 40GW in size. The new coal power plants of Medupi and Kusile were about 4000MW in size, to give an indication. In the absence of achieving this tariff framework at a national level, local regions can actively pursue opportunities together with big business to become the off takers of some of this power. If innovation occurs as to when the energy from the mills is fed into the grid, local municipalities may be able to make significant financial gains from procuring local, compared to the peak tariffs they have to pay the national utility for energy at those times.

Historically the market has signalled that biomass tariffs should be in the range of R1, 20-R1.80/kWh to allow projects to become bankable and to stimulate investment. This has proven to still be relatively expensive in comparison to other energy generating technologies. Research in the sugar industry shows that part of the tariff required is to compensate for the large job creation potential that those investments will generate. It is a labour intensive process and technology that produces more jobs per kilowatt hour than any other technology. This provides an opportunity for local government and the sugar industry to collaboratively agree on a tariff that is workable for both, with the job creation element factored in.

Preliminary research suggests that if power is substituted by sugar mills during Eskom peak times there is an incentive for municipalities to buy local power, particularly during winter. For this to work in the case study area the following parameter need to be taken into account. The MFMA (municipal financing act) prevents municipalities from signing contracts that are longer than 3-5 years, whereas the sugar industry is looking for 20 year power purchasing agreements. The possible innovative options that could be implemented to address this barrier, would be the following:

Sugar mills could enter into 3-5 year agreements with the municipalities for part of the output at a set tariff. This can be done within the longer term framework of both the municipalities and the sugar industry, jointly approaching national treasury to invoke section 33 of the MFMA which gives municipalities the exemption and allows for longer contracting periods for catalytic projects. This also provides the sugar industry and opportunity to collaborate across its value chain of growers and millers. There is an opportunity for the sugar industry either to contribute to co-generation through its mills, or alternatively in the form of biogas through its growers. Energy provision may therefore also be used as a catalyst to strengthen stakeholder engagement within the Sugar industry and open up the sugar industry to broader community resource ownership.

Sugar mills could enter into offtake agreements with end user industrial customers directly. EThekwini has a large industrial user base which may be interested in procuring green power. In this arrangement the municipality will take on the role of pure grid operator and take a fixed grid charge fee for the usage of the grid, to wheel the power from the mills to the end customer.

EThekwini and iLembe together with the industrial and commercial sector could examine the option of developing an energy trading market. In this market energy generators can place their power capacity onto the market and a bidding system can be put in place for buyers to purchase the electricity. This would not be limited to biomass but could apply to all power generation technologies. This is the approach that has been followed on a much larger inter-country scale in Europe. Biomass technologies would have to be able to compete on a cost competitive basis with other energy technologies.

If a local biofuels regime were to be considered the fastest implementation could be linked to diversion of export sugar into fuel ethanol production and the sustainable expansion of sugarcane agriculture. The sugar industry produces 600 000 to 1 million tons of surplus sugar and this could potentially be converted to 360 to 600 million litres of bioethanol. Research studies have shown that 100 tons of sugarcane produces approximately 13 tons of sugar and 15 tons of bagasse. The sugar to ethanol conversion process is estimated at around 44% meaning that of the 13 tons of sugar, 5,7 tons of ethanol can be produced. This implies that approximately 5500 litres of ethanol can be produced from one hectare of sugar cane.

Although there are technologies in place for conversion of biomass to biofuels, as with the electricity conversion, an endorsed national framework to allow the biofuels industry to flourish is still awaited This is especially so in a context of lagging indicators in significant spatial areas of the case study area with high unemployment and poverty levels. Potential new opportunities exist for small farmers to enter into the formal market, new supply chains to be developed and support for socio-economic development. The initial South African National Biofuels Industrial Strategy released in 2007 envisaged a five-year pilot phase, covering 2008 to 2013, during which a 2% penetration level of biofuels in the national liquid fuels pool was to be achieved. The original pilot period of 2008 to 2013 was then shifted to 2015 -2020. Initially sugar cane was left out as a feedstock in the biofuels strategy, however the Department Of Energy released a revised strategy that included both sugar and sorghum as a feedstock. Two other provinces namely Mpumalanga and the Eastern Cape are sugar producers. In KwaZulu-Natal the sugar industry could make a significant contribution to this strategy. At full processing capacity and with a potentially expanded sugarcane agricultural industry, the industry could produce in the order of 1 150 500 m^3/annum or 9% of the national petrol pool (SASA 2014). A phased approach for participation of the sugar industry in a local biofuels industry would be considered. Faster implementation could be linked to diversion of export sugar into fuel ethanol production and the expansion of sugarcane production.

The additional revenue stream and re-optimisation of the value chain will incentivise the sugarcane industry to re-establish lost production, secure at least 28 000 direct jobs currently under threat and re-create approximately 18 500 direct jobs, as well as a significant number of indirect jobs (SASA 2014). The new areas now used as sugarcane plantations would largely benefit:

- ✓ small scale growers
- ✓ beneficiaries of land restitution and land redistribution

✓ communities and growers who reside on communal land

It is important to note that there are two scales at which biofuels can be implemented. The bioethanol and biodiesel processes will take place at a large scale milling operational level, with processes invariably being owned by large corporations. Whereas other biofuels such as biogas and the production of bioethanol gel allow for the possibility of the complete ownership of the value chain by the local community. These production models promote fuel sovereignty by allowing communities to own their entire value chain from production to local end use. Furthermore local prodution of biogas and bioethanol gel can be incorporated into sustainable practices such as nutrient recylcing of the biogas digester slurry. This is further elaborated on in the section below.

The opportunities resulting from biogas is the area within the sugar cane industry that presents real opportunities for the development of the canegrowers. According to SA Canegrowers Association there are 22 000 cane growers. Of these 19 000 are on 1-4ha of land and in need of energy interventions if they want to develop to the next level of agriculture. Tables 1 & 2 below, provides the breakdown of the grower segments as well as a breakdown of some of the key issues that are present in the biogas segment in the sugar industry.

Table 1: Classification of the 22 000 Cane Growers and their Energy Needs

Number of Growers	Energy Needs
18 000 1-2 Ha	• 2kW for Homestead support • 400kg of feedstock per day • 50L Biogas digester- cost of R20 000 per household VS aggregation model (formation of larger co-operatives) to suit 30-100kW digester
2000 2-20Ha	• 4kW for Household Support • 800kg of feedstock per day • Aggregation to feed into a 30-100kW digester (500 cubic meters)
1000 200-400Ha	• Dry Land Commercial Farmers • 12-20kW energy demand for operations • 30-100kW digester (500 cubic meters)
30 200-400Ha	• Commercial Irrigated Farmers • 50-150kW energy demand for operations • 30-100kW digester (500 cubic meters)

Source: CSIR research

Table 2: Summary Points for Developing Biogas in the Sugar Industry

30-100kW (500 cubic meters)	• Potential immediate market size of around 30 -100 digesters • Another potential 200-300 if aggregator model is pursued • Costing of R5-R7 million per digester	Potential Minimum Funding Opportunity of R700 million	✓
Biogas vs Electricity Production	• Fuel is a higher value energy good vs electricity, may be simpler • Have a R13/l opportunity cost to work with for fuel, R1,40 for electrici • Need accurate costing of Biogas cleaning technology • Opportunity for government/sugar industry off takers	Creation of a Sugar Industry Value Chain	✓
Opportunities of diversification	• Sugar Cane farmers need to start letting land lie fallow • Perfect opportunity to plant crop to complement sugar cane waste • Sweet Sorghum, maize, kikuyu grass	Symbiosis in fallow land requirements & digester feedstock	✓
Potential New Revenue Streams	• Production of Fertilizer by product as an offset revenue stream • R300-R500/ton for digestate • Potential of 7 tons per day from 500m3 system	Offset Revenue Streams from Digestate	✓

Source: CSIR research

What is evident from tables 4 & 5 is the following:

- ✓ The first two segments of cane growers represent 19 000 growers and are in real need for energy interventions. A scoping needs to be done if one applies household level intervention or if one pursues an avenue of aggregating the growers into larger demand pools and build larger digesters. If they are linked to larger digesters they would be able to access more energy.
- ✓ Research suggests that the ideal size digester for the cane growers in KZN is 30-100kW
- ✓ Minimum potential of a building of 100 digesters which represents a minimum of R700 million in investment. If the 19000 cane growers are aggregated there is a potential of another 200-300 digesters.
- ✓ Potential new revenue streams for the cane growers from the fertilizers that are produced as a by-product from the digesters.
- ✓ Greater use of farm land by using the fallow land to grow additional feedstock for the digesters.
- ✓ Biogas presents the opportunity to convert to electricity or gas for fuel, assessment needs to be done as to which offers the best benefit and least legislatively inhibited route.

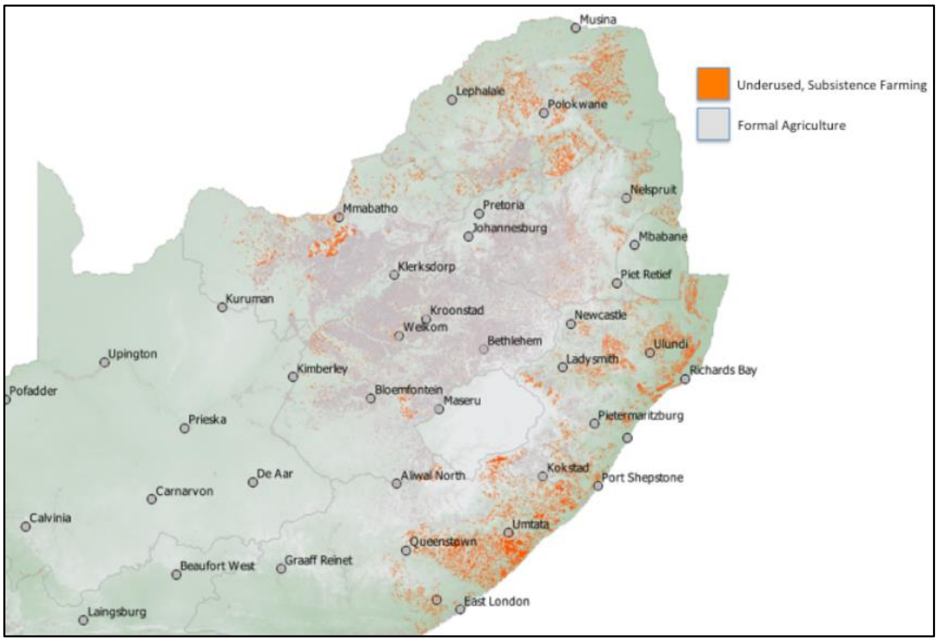
What was evident from this preliminary research in to biogas opportunities is that energy needs of small scale and developing farmers are critical both in terms of a cost perspective and growth potential of their operations. Research done by UNEP 2011 showed that it is estimated that close to one-third of the world food supply is lost in the supply chain. These losses occur at every step of the food supply chain, including harvesting, processing, preservation, storage, transportation and cooking. It is energy and poor access to it that is among the most important factors responsible for these limitations. By improving such access, bioenergy development could play a crucial role in preventing crop and food losses.

A study of 15 small-scale bioenergy projects in 12 countries, 5 from Africa drew the following conclusions:

- Natural resource efficiency is possible in small-scale bioenergy initiatives
- Local and productive energy end uses develop virtuous circles
- Longer term planning and regulation has a crucial role if small-scale bioenergy projects are to succeed
- Flexibility and diversity can also reduce producer risk
- Collaboration in the market chain is key at start-up
- Long local market chains spread out the benefits
- Moving bioenergy resources up the energy ladder adds value
- Any new activity raising demand will raise prices, even those for wastes
- Cases do not appear to show local staple food security to be affected

One of the findings that has come out of the preliminary research of the potential of biogas in the KZN sugar industry, is the opportunities around diversifying crop usage on the agricultural land. The results showed that of the 22 000 cane growers, around 18 000 could be classified as subsistence level farmers. Figure 9 below is taken from the national bioenergy atlas and shows the areas in the country that are classified as underutilised subsistence farming. It is evident that the bulk of these areas are found in the Kwa Zulu Natal and Eastern Cape regions.

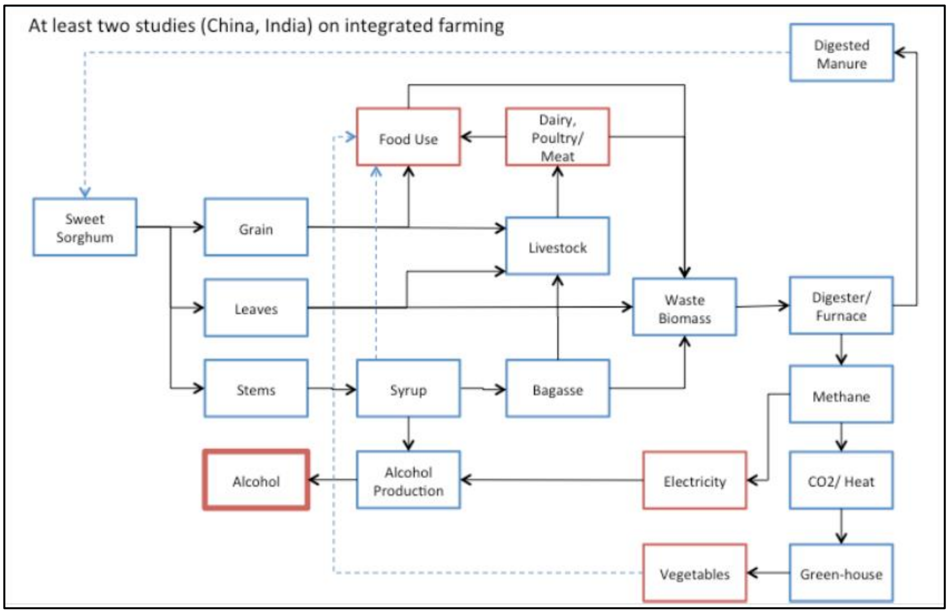
Figure 9: Underutilised Agricultural Land in South Africa 2011



Source: Bioenergy Atlas

Figure 10 below, shows a case study that was taken from India and looked at the opportunities and value chains that could be achieved with sweet sorghum. What the diagramme shows is that from one crop one can really assist the establishment of an integrated farming system and diversify the value chains and revenue streams from agricultural products to energy as well. This model can be applied to the biogas opportunities with cane growers in KZN. It is evident that a lot of them are at a subsistence level, are in need of energy to be able to expand their operations and biogas will provide them with opportunities to not only cater for their energy requirements but also allow them to diversify their crop mix and other activities on the farm land.

Figure 10: Sweet Sorghum Case Study of Integrated Farming



Source: Bioenergy Atlas

In a workshop held with financiers to explore potential funding opportunities for a sugar cane biogas programme in KZN, the key imperative that was highlighted was scalability and replicability. Financing is always one of the key elements to the successful roll out of these opportunities, especially in situations where project equity may be a problem and funding of pre-financial close costs. Possible sources of financing for biomass to energy projects would be the following:

- ✓ **Own Equity:** This was highlighted in the workshop as a potential stumbling block for the biogas roll out in the small scale cane grower's areas. More opportunities around the setting up of more co-operatives to address this concern.
- ✓ **Development Finance mechanisms:** Many of the international donor financing institutions have green/climate funding available. Therefore if this can be marketed as a greenhouse gas reduction programme there may be appetite.
- ✓ **Investment by technology supplier:** The technology supplier has interests in seeing the project development succeed therefore the supplier may be willing to offer loans at interest rates lower than the banks can offer.
- ✓ **Build-Operate-Transfer:** In this model a third party takes responsibility for financing, designing, building infrastructure and operating the plant for a fixed period
- ✓ **Private Equity Funds:** Capital for private equity is raised from retail and institutional investors and can be used to fund new technologies. The majority of these funds consist of institutional investors who can commit large sums of money for long periods of time.

Figure 11 below depicts a good summary of the differences between corporate financing and project financing of biomass projects. It is evident that from a start up financing and risk point of view it often is more suitable to finance these projects, through a project finance mechanism whereby the cash flows from the project pay off the loan amount.

Figure 11: Differences between Project Finance & Corporate Finance

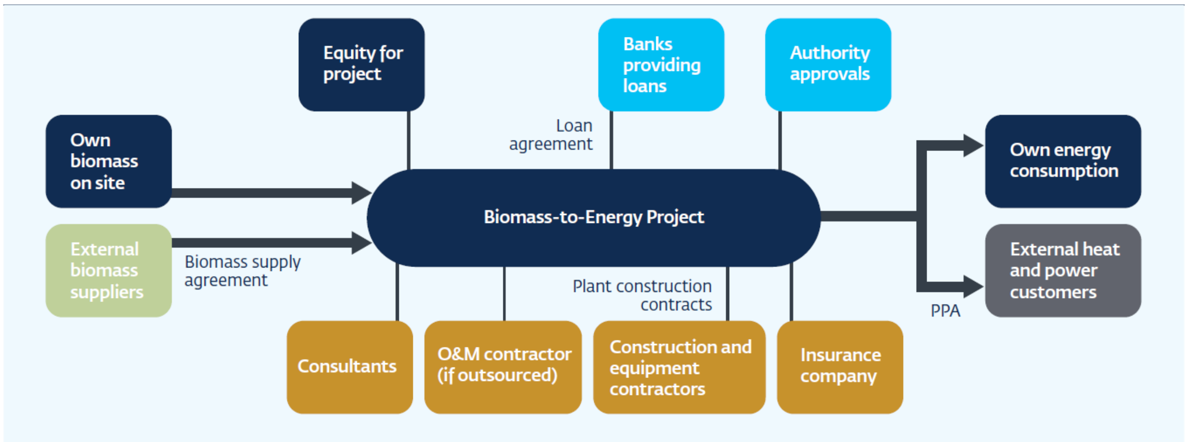
BIOMASS-TO-ENERGY PROJECT FINANCING

PROJECT FINANCE	CORPORATE FINANCE
Cash Flow Projection	
Is known before disbursement	Less relevant
Control & Monitoring of Cash Flow	
Very close	Can be performed if needed
Collateral	
The Biomass-to-Energy Project	Non-project related collateral
Control over Collateral	
Very close	Not so tight
Leverage to Sponsor in case of multiple Biomass-to-Energy Projects	
Enables multiple lending as only project assets are used as guarantee	Limited to sponsor's other assets and wealth
Type of Financing	
Non-recourse	Recourse
Credit Risk	
On Biomass-to-Energy Projects cash flow (easy to estimate)	On sponsor's other businesses' cash flow (hard to estimate)
Start-up Financing	
Yes	No

Source: NREL

Figure 12 below shows the main contracts and stakeholders that are usually in place for a biomass to energy project. Although there are different ways to structure each biomass project this diagramme reinforces the point made in the introduction of the need for a multi-collaborative effort to make a success of these projects.

Figure 12: Main contracts for a biomass to energy project



Source: NREL

Figure 13 below shows the potential partners that can be put together for the roll out of the feasibilities for the proposed biogas installations in the KZN sugar industry.

Figure 13: Proposed partners for KZN Biogas Programme in the Sugar Industry

FORESTRY INDUSTRY RESOURCES

In the Status Quo report the amounts of forestry biomass was quantified for Kwa Zulu Natal. The following data adds to what was outlined in the Status Quo Report and identifies specific options that can be pursued. Table 3 below shows a summary of the woody biomass in terms of Alien Invasives per province. As has been highlighted before, Kwa Zulu Natal is very closely in line with the Eastern Cape as the two provinces with the most abundance of biomass and in particular Woody Biomass. When quantifying Invasive Alien Plants it should be remembered that the control of these plants includes reducing their regrowth to a minimum over time with each successive operation. Therefore in quantifying the available feedstock it implies that biomass from Alien Invasives should be quantified as a stock variable, rather than an annual flow variable.

Table 3: Summary of the woody biomass (millions of Mg) available by Province

Province	Acacia	Eucalyptus	Pine	Poplar, willow & *Prosopis*	Total
Eastern Cape	28.7	9.4	5.5	3.8	47.3
Free State	0.8	7.2	1.1	3.6	12.6
Gauteng	1.5	7.7	0.4	0.9	10.5
KwaZulu-Natal	15.1	16.5	2.7	0.7	35.0
Limpopo	1.1	3.7	0.8	0.7	6.4
Mpumalanga	6.4	18.1	2.8	3.6	30.9
Northern Cape	-	-	-	2.9	2.9
North West	0.4	3.1	0.1	0.5	4.1
Western Cape	6.6	2.8	8.5	0.4	18.3
Total	60.6	68.5	21.9	17	168.1

Source: Bioenergy Atlas

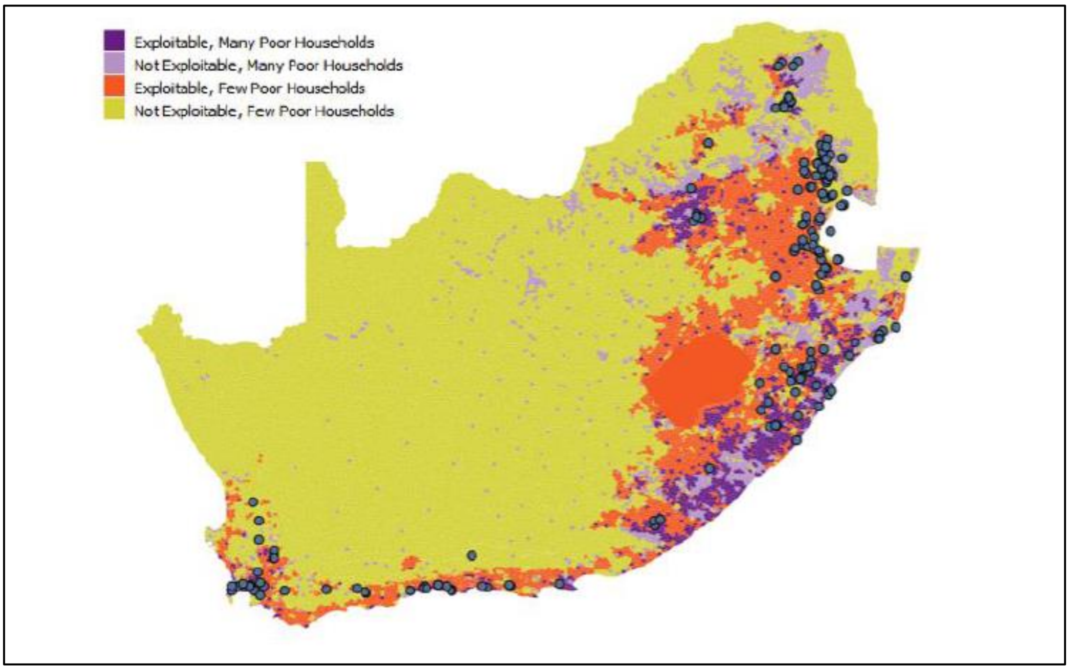
Table 4 below shows the results obtained from the national survey on alien invasive plants, with the plants highlighted in bold showing the most potential to yield usable woody biomass. This table combined with other results from the survey, suggest that the most available biomass will come from invasions by the Acacia and Eucalyptus species. If one combines this with the data shown in table 6 above, it becomes evident that Kwa Zulu Natal has a real advantage in these two species and therefore the exploration of using alien invasive as a feedstock for the bioenergy sector becomes a key outcome for provincial government to pursue. If one further combines this with data represented in figure 12 below it is evident that the opportunities to use this sector for job creation and local economic development in Kwa Zulu Natal are exploitable. Figure 14 shows the relationship between the location of alien invasive species relative to poor households and saw milling infrastructure. The map highlights that in many areas of Kwa Zulu Natal these three components are found in close proximity to one another and therefore present opportunities which have perhaps not been explored enough up until now.

Table 4: Results from the National Survey on Alien Invasive Plants

Species or species group	Growth form	Suitable for woody biomass	Accessibility of invasions	Biomass yield	Biomass estimate available?
Acacia cyclops	Medium tree	y	Easy: coastal plains	High	Yes
Acacia melanoxylon	Tall tree	y	Difficult: riparian, forest, montane areas	High	Yes
Acacia mearnsii/ dealbata/ decurrens	Tall tree	y	Easy to difficult: dryland, riparian, widespread	High	Yes
Acacia saligna	Medium tree	y	Easy: coastal plains	High	Yes
Agave spp.	Succulent	n	Easy: inland plains	Low	No
Arundo donax	Bamboo	p	Easy to difficult: riparian, widespread	High	No
Atriplex nummularia	Succulent	n	Easy: inland plains	Low	No
Caesalpinia decapetala	Scrambler	p	Difficult: riparian, forest, montane areas	Moderate	No
Cereus jamacaru	Succulent	n	Easy to difficult: savanna	Low	No
Cestrum spp.	Shrub	n	Easy to difficult: savanna, coastal	Low	No
Chromolaena odorata	Scrambler	n	Easy to difficult: savanna	Moderate	No
***Eucalyptus* spp.**	Tall tree	y	Easy to difficult: riparian, widespread	High	Yes
Hakea spp.	Shrub	y	Mostly difficult: montane fynbos	Moderate	Yes
Jacaranda mimosifolia	Medium tree	y	Moderate to difficult: savanna, forest	Moderate	No
Lantana camara	Scrambler	p	Easy to difficult: widespread	Moderate	No
Melia azedarach	Medium tree	y	Moderate to difficult: savanna, forest	Moderate	No
Opuntia spp.	Succulent	n	Easy: inland plains, widespread	Low	No
***Pinus* spp.**	Tall tree	y	Mostly difficult: montane areas	High	Yes
***Populus* spp.**	Tall tree	y	Easy to difficult: riparian, widespread	High	Yes
***Prosopis* spp.**	Medium tree	y	Easy: inland plains and floodplains	Moderate to low	Yes
Psidium guajava	Medium tree	y	Easy to difficult: savanna, forest	Moderate	No
Rosa rubiginosa	Scrambler	n	Mostly difficult: montane grassland areas	Low	No
Salix babylonica	Tall tree	y	Easy to difficult: riparian, widespread	Moderate	No
Senna spp.	Shrub	n	Easy to difficult: savanna, forest	Low	No
Sesbania punicea	Shrub	y	Easy to difficult: riparian, widespread	Moderate	No
Solanum mauritianum	Shrub	p	Easy to difficult: widespread	Moderate	No
Tamarix chinensis	Medium tree	y	Easy to difficult: riparian, mainly Nama	Moderate to low	No

Source: National Survey of Alien Invasive Plants

Figure 14: Relation of Invasive Species Distribution to Poor Households (Point Data represents sawmill infrastructure)



Source: Bioenergy Atlas

Table 5 and 6 below show the geographical distributions of Sawmills in South Africa as well as the rand value made from each product in the forestry value chain in South Africa.

Table 5: Geographical distribution of production by Sawmill Category

Region	Formal		Informal (estimate)		TOTAL	
	No. of mills	Approx. volume produced (m^3)	No. of mills	Approx. volume produced (m^3)	No. of mills	Approx. volume produced (m^3)
Mpumalanga, Limpopo & NW	16	659 558	34	214 438	50	873 996
KwaZulu-Natal *	12	358 790	26	213 373	38	572 163
Western/Northern Cape	5	161 382	23	102 347	28	263 729
Eastern/Southern Cape & Border	5	256 845	7	42 410	12	299 255
TOTAL	38	1 436 575	90	572 568	128	2 009 143

(* includes Swazi mills)

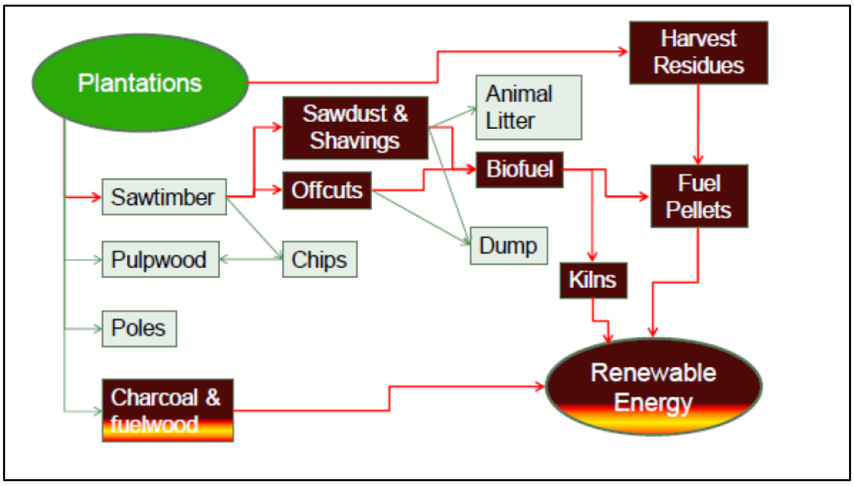
Table 6: Rand values of Products Produced in Forestry Sector

PRODUCT	Value (Rands)
Sawn and Planed timber	4 035 769 666
Wooden poles	520 655 316
Mining timber	345 709 572
Wood-based panel products	1 499 055 725
Woodpulp, Paper and Paper Products	12 862 207 370
Firewood	1 189 214
Wood chips (from roundwood)	1 533 332 923
Mill residues	73 086 729
Charcoal	218 460 809
Other timber products	317 682 819
Total	**21 407 150 143**
Roundwood in transit (not processed by plant)	21 681 272

Source: Bioenergy Atlas for South Africa Synopsis Report 2015

There are two key points to be taken from the above tables, firstly that Kwa Zulu Natal is well positioned in terms of quantity of saw mills and hence revenue generated from them and secondly there are further bioenergy opportunities that have yet to be fully utilised from these saw mills. Figure 15 below shows some of the pathways that can be followed in the production of renewable energy from forest by-products. Statistics indicate that of the total wood volume entering the sawmilling process, approximately 35-50% is by-product in the form of sawdust, chips or bark. These are significant volumes to work with as feedstock for bioenergy projects.

Figure 15: Pathways for the conversion of forest products into renewable energy



The focus area of wood pellets and wood chips is one that has received global attention with the usage of wood pellets becoming a significant game changer. This has particularly been the case in Europe where wood pellets are viewed as a lower carbon emitting source to replace fossil fuels. Their usage has largely been in co-fired coal electricity generators as well as in the residential, commercial and industrial sectors for thermal needs. Up until recently the wood-pellet industry has largely been considered as an industry that is in its infancy, however global projections in demand are changing this rhetoric. It is projected that wood pellet demand is to grow from an estimated 23 million tonnes in 2014 to 50 million tonnes in 2024. The composition of wood pellets, shows that approximately 69% of the raw material used for their production comes from sawmill residues. The relatively high energy density of wood pellets allows for their long-distance shipment especially as marine freight. In 2015 over half of global wood pellet production was traded internationally. As a result wood pellets are used in countries without sufficient national forestry resources.

Given the saw milling infrastructure in Kwa Zulu Natal which has been shown in the tables above, the opportunities for the increased production and possible exporting of wood pellets is an area that should be explored. Another possible synergistic relationship that can be explored is between the sugar and forestry industry in the province. A large part of the sugar industry's co-generation battles have been hindered by the off season that the mills face, where no sugar cane is harvested. It has been suggested that during these periods coal should be used as a co-firing feedstock, however this would not make it a purely renewable form of energy. The costings and potentials of using wood pellets and chips as an alternative co-firing feedstock for the sugar industry's co-generation plans is a definite intervention that needs to be taken up.

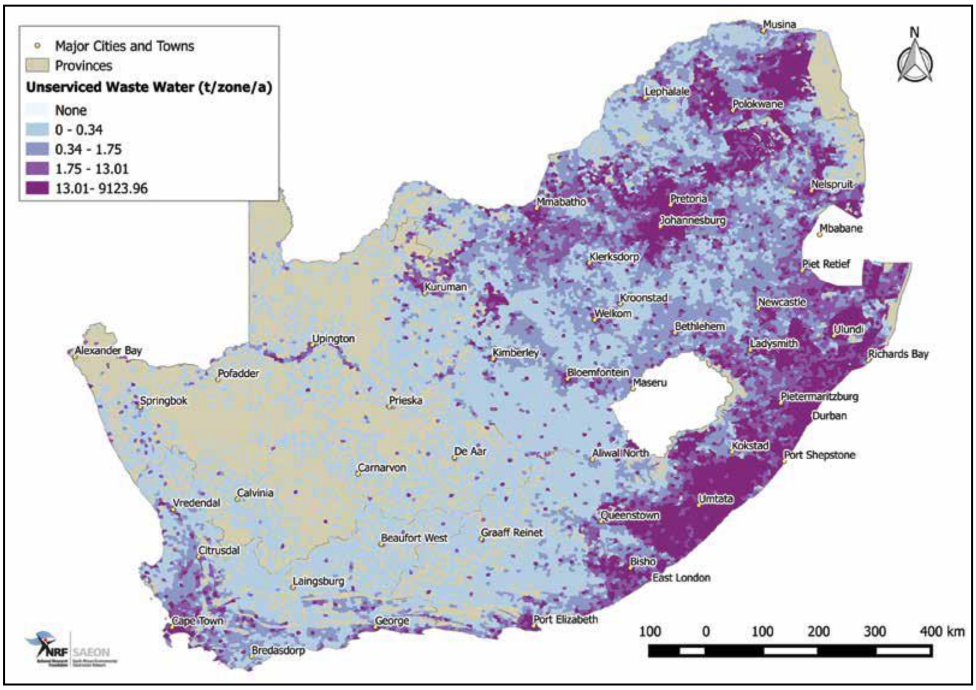
The second area of opportunity linked to the forestry sector is around mill sludge which the CSIR is currently in the process of researching. Mill sludge is a by product produced by the paper and pulp mills during the milling process and is currently largely disposed of through landfilling. This is not a sustainable solution due to many landfill sites reaching their capacities and the dumping of the sludge has environmental impacts such as releasing chemicals both into the air and ground water. It also has sustainability issues in relation to costs. It currently costs one mill approximately R2.5million per annum to transport the sludge to a landfill site. Some of the mills capex expenditure in the last 12 years has exceeded R35 million in trying to remove the sludge.

If one examines the content of the mill sludge one finds that it is composed of 60% organic material and 40% inorganic material. The research the CSIR has been undertaking as part of their bio refinery initiative shows that sludge contains high amounts of reject fibres that can be converted into nanocrystalline cellulose (NCC). NCC are rod-like crystals made-up from the crystalline structure of cellulose through chemical treatment. NCC particles have impressive mechanical properties, comparable with stainless steel and thus have potential as reinforcing (or load-bearing) components in composites. Mill sludge can also be converted into biopolymers such as Polylactic acid (PLA) using microorgnanisms and enzymes. This polylactic acid (PLA) is currently not produced locally and it is estimated that the global market for PLA is worth R31 billion. The area of bioplastics will be elaborated on later in the report. It is evident from the above that there are potentially two new bioenergy value chains and economic opportunities that can be pursued and developed based on a resources that is currently being disposed of.

WASTE WATER TREATMENT FACILITIES RESOURCES AND FOOD WASTE

As part of the Bioenergy Action Plan, eThekwini municipality was chosen as a pilot/case study area for the potential for bioenergy facilities at waste water treatment works. According to the Bioenergy Atlas, the eThekwini region ranks highly in comparison to other regions nationally in terms of un-serviced wastewater as shown in the figure below.

Figure 16- Biomass Availability (Un-serviced wastewater sludge production)



Source: Bioenergy Atlas for South Africa Synopsis report 2015

The Status Quo report showed that EThekwini Municipality owns and operates a number of wastewater works in the greater Durban metropolitan area. Table 7 below shows a list of eThekwini’s wastewater treatment works and shows their capacity in million litres (ML) per day.

Table 7: Wastewater Treatment Works in eThekwini Municipality

Treatment Plant	System Design Capacity (ML/day)	Capacity Utilisation
Amanzimtoti	30	78.33%
Cato Ridge	1	50%
Central	135	62.96%
Craigieburn	1	160%
Dassenhoek	5	54%
Fredville	2	25%
Genazzano	1.8	77%
Glenwood Road	0.04	100%
Hammarsdale	27	28.5%
Hillcrest	1.20	77.5%
Isipingo	18.8	78.1%
Kingsburgh	7.2	72.2%
KwaMashu	65	83%
KwaNdengezi	2.4	62.5%
Magabheni	1.3	19%
Mpumalanga	6.4	35%
New Germany	7	18%
Northern Works	70	90%
Phoenix	25	87%
Southern	230	60%
Tongaat Central	12.5	72%
Umbilo	23.2	62%
Umdloti	2.4	45%
Umhlanga	6.8	86%
Umhlatuzana	14.8	79%
Umkomaas	1	56%
Verulam	13	44%

Source: Green Drop Report 2013

SALGA (2015) indicate that it is viable to implement biogas projects at larger Waste Water Treatment Works (WWTW), particularly where the inflow is in excess of 15ML/day. A WWTW with a flow of less than 15ML/day would most likely not be able to produce sludge in sufficient quantities to prove financially viable based on the amount of electricity it could generate. They also show that even WWTW with flows of higher than 15ML/day could in fact produce less than viable quantities of sludge depending on the specific waste water treatment processes implemented by those works. The data in the table above shows that there would be approximately 8 water treatment plants within the Ethekwini region that would be viable for a biogas project.

Table 8 below shows the total number of wastewater treatment plants in Kwa Zulu Natal and shows that there are about 9-13 sites that could be suitable for anaerobic digesters.

Table 8: Waste Water Treatment Works In KZN

	MICRO SIZE <0.5 Mℓ/day	SMALL SIZE 0.5-2 Mℓ/day	MEDIUM SIZE 2-10 Mℓ/day	LARGE SIZE 10-25 Mℓ/day	MACRO SIZE >25 Mℓ/day	Undetermined	Total Mℓ/day
No of WWTPs	39	37	34	18	9	3 (2)	140
Total Design Capacity* (Ml/day)	7.673	33.55	127.43	249.1	673	3 (2)	1090.8
Total Daily Inflows (Ml/day)	0.895	16.019	49.973	123.74	550.68	74 (29)	741.3

**ADWF = Average dry Weather Flow,*
WWTP = Wastewater Treatment Plants,
(2013 figures)

Source: Green Drop Report 2013

Improving the wastewater service coverage area would involve building wastewater treatment works that would create new jobs or secure existing jobs within construction companies completing the projects. Where possible, building services are awarded according to a tender process typically designed to strengthen local economic development. Under typical construction and operations contracts, local suppliers may be found for piping, basic building materials, cement, pump casings, impellers, and valves (noted as other in the figure below). For each newly-constructed wastewater plant, anywhere up to 30% of the total construction costs may be clearly allocated to local suppliers thereby sustaining their development. Based on international experience, typical construction costs for a wastewater treatment plant are in the region of 12 Million USD (170 million ZAR) for a facility that processes approximately 40 million litres per day reducing total nitrogen content from 8 mg/l down to 3 mg/l. (ICF International 2007)

Based on these estimates, the scope for "local content" on the construction phase should be in the region of 50 million ZAR. The production of methane gas may be used as an additional value stream. Under ideal digester conditions, a methane production yield may be in the range of 300-350 Nm^3/ton of ordinary dry matter (IEA Energy Technology Network 2015). The methane production may be used to cover part of the energy demand from the wastewater treatment which may make up approximately 5-10% of the operational costs of the wastewater treatment plant. The diagram below also shows the typical energy end use categories where surplus methane may be used to enhance profitability of wastewater treatment works.

Figure 17: Typical cost components of wastewater plant

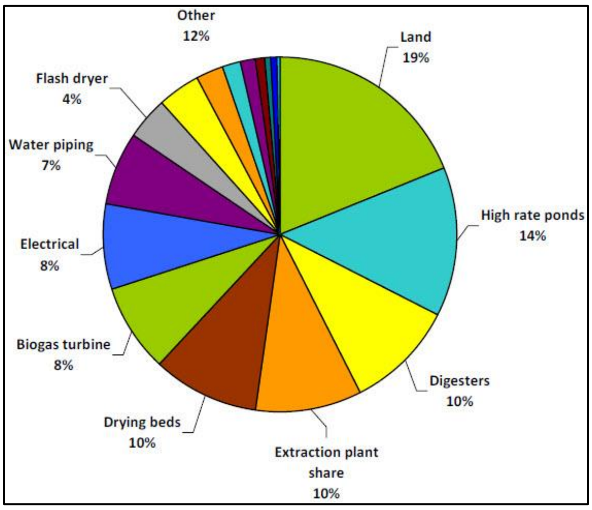
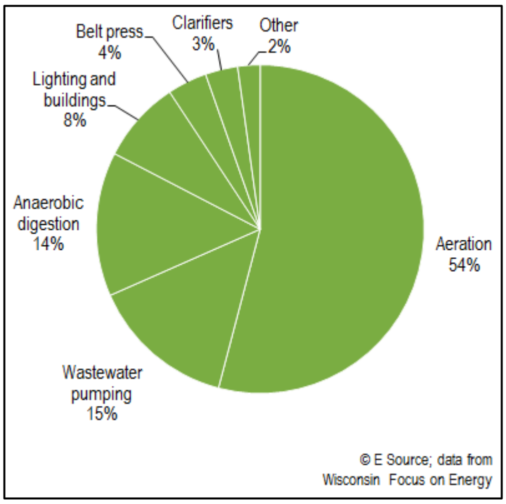


Figure 18: Energy uses in wastewater



In addition to the direct impact in terms of job creation, local enterprise development, and reducing the net energy purchases on the sites of the treatment works, additional positive economic effects accrue from improved water quality and the resultant improvements in public health. Conceptually, biogas from the wastewater treatment plants may be used for electricity production and fed into the local distribution grid and sold at the prevailing feed-in tariff. This approach would need to be investigated on a case-by-case basis since any electricity generation would require a substantial upfront capital investment and the amounts of methane or electricity produced would need to be high enough to justify the capital outlay. Basic feasibility calculations have already been performed by eThekwini Municipality which demonstrate the following (ASSAF/eThekwini Municipality 2013):

- ✓ EThekwini municipality produces over 500 ML/day of sewage and over 100 tons of sludge per day.
- ✓ All of which is treated by 27 Wastewater Treatment works (WWTW)
- ✓ Sludge is commonly treated by anaerobic digestion, which produces methane gas (biogas) as a by-product.
- ✓ Of the 27 WWTWs, 10 operate anaerobic digesters; it is the aim of EWS to convert the methane produced into electricity.
- ✓ Approximately 50% of the power used by the treatment works can be supplied by the methane

These outcomes show that electricity production in this manner mostly yields economic benefits at the micro-level at the individual wastewater operations. At the macro level, the impact would be felt by the municipality in the form of lost gross-margin revenue on electricity sales to the treatment works that will be one of the electricity customers to the local municipality. Using basic research from the Water Research Commission in 2013, the Durban North (approx. 50 million litres per day) and Durban South (approx. 150 million litres per day) Wastewater Treatment Works have electricity production of up to 3000 MWh/yr. and 17000 MWh/yr. respectively. Extrapolating this to cover the 500 million litres per day across the entire eThekwini area points to potential electricity generation in the range of 30000–50000 MWh/yr. This aggregate generation level, assumes that the wastewater composition processed is similar across all treatment works. The development of biogas facilities at these waste water treatment plants should definitely form part of the implementation and action plan for the province. The opportunities do not only exist in eThekwini but throughout the province as was shown in the analysis in the Status Quo Report.

The other key opportunity within the urban context is that of urban biogas projects which could focus on food waste, other organic waste and even combine feedstocks with sludge from waste water treatment plants. Economies of scale are a critical element in many bioenergy projects and the generation of electricity. Research shows that there are opportunities to combine municipal solid waste and sewage sludge to increase the availability and improve the economies of scale of electricity production. This is referred to in the literature as co-digestion, with some of the main benefits of this approach being:

- Stable and reliable digestion performance and good-quality fertilizer from the digestate
- An enhanced digestion of materials that are difficult to digest
- A increased and more stable biogas production throughout all seasons
- Additional fertilizer as by-product(soil conditioner)

Table 9 below shows the different biogas production potentials from the different types of waste that can be used for a digester.

Table 9: Biogas Production Potential from Different Wastes

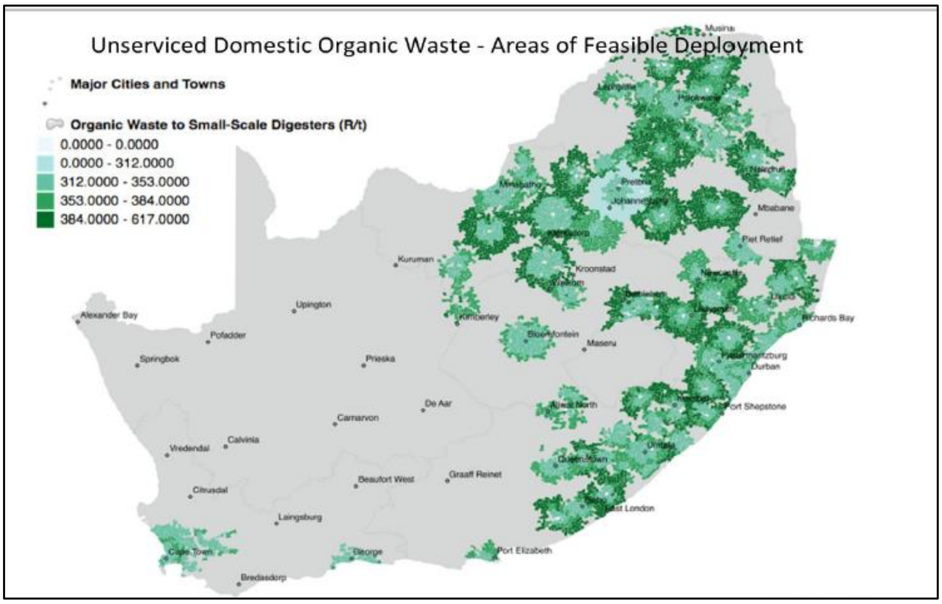
Raw Material	Biogas Production Litres/kg	Methane Content In Biogas (%)
Cattle Dung	40	60
Green Leaves	100	65
Food Waste	160	62
Bamboo Dust	53	71.5
Fruit Waste	91	49.2
Bagasse	330	56.9
Dry Leaves	118	59.2

One of the wastes that is an ideal complement to WWTW sludge as a digester feedstock is food waste. This can be obtained from places such as shopping malls, hospitals, hotels, restaurants and old age homes. These facilities all produce large quantities of food waste that has a high biogas yield potential. This type of waste is normally collected by the municipality and taken to landfill as part of Municipal Solid Waste activities but it would be beneficial for biogas generation if municipalities collected this waste separately and directed it to biogas production plants (SALGA 2015). IRENA (2013) indicate that approximately 33% of the global food supply goes to waste annually. This yields a total of around 1.3 billion tonnes of food waste worldwide. If this waste were to used for biogas production, it could yield up to 367m^3 of biogas per dry tonne at approximately 65% methane with energy content 6.25kWh/m^3.

This would therefore be a key pilot project to explore around setting up an urban biogas facility which collects from households and major food waste outlets. The issue around closing the loop could also be explored if the transportation of the waste to these facilities could be run off the gas produced from the facility. Different ownership models, community shares, feed in tariffs and private public partnerships can also be explored in such an arrangement. In Europe such a pilot project was set up called the Urban Biogas Project whereby urban waste was used for the production of biomethane for transportation in urban areas.

Figure 19 below which is taken from the Bioenergy Atlas shows the potential for biogas digesters in servicing the domestic organic waste component in South Africa. It again clearly highlights that Kwa Zulu Natal has a lot of feedstock and potential for this. This is further supported by figure 20 and 21 below which show the organic waste break down per province and more specifically the food waste compositions. Again in both these areas Kwa Zulu Natal is seen to have fairly significant resources for feedstock. This is therefore a key area that needs to be prioritised for the development of pilot projects and a further roll out implementation plan.

Figure 19: Unserviced Domestic Organic Waste- Biogas Digesters

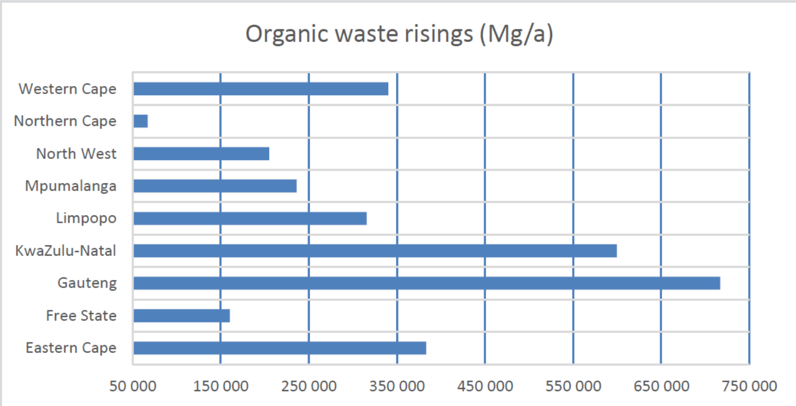


Source: Bioenergy Atlas Synopsis 2015

Figure 20: Domestic Organic Solid Waste Component per province

Published Data In Respect of Domestic Organic Solid Waste Component

Province	Organic waste risings (Mg/a)
Eastern Cape	383 249
Free State	160 353
Gauteng	716 747
KwaZulu-Natal	599 650
Limpopo	315 665
Mpumalanga	235 948
North West	204 995
Northern Cape	66 923
Western Cape	340 070
Total	**3 023 600**



Source: Bioenergy Atlas Synopsis Report 2015

Figure 21: Food Waste Generation per province in South Africa (2011)

Province	Food waste
Western Cape	246 750
Eastern Cape	346 058
Northern Cape	58 225
Free State	152 130
KwaZulu Natal	472 164
North West	173 695
Gauteng	510 203
Mpumalanga	178 500
Limpopo	243 371
Total	2 381 096

The geographic location of urban biogas digester projects which would be heavily reliant on food waste becomes a critical component in the success of the project. This is because in South Africa due to the varying difference in the socio-economic profile of cities it results in varying quantities of waste streams. The composition and volume of waste varies according to income profiles from approximately 0.3-1.2kg/capita/day. The composition also varies with waste from less affluent areas containing more biodegradable or organic waste, while the more affluent areas a higher content of recyclable material such as paper, plastics, aluminium and cans, glass and rubber. This is reinforced in table 10 below which shows the income levels in South Africa and the different composition of waste they produce as well as comparing it to global standards.

Table 10: Factors Influencing Domestic Solid Waste Production and Composition

Factors influencing Domestic Solid Waste Production and Composition

Location	Income Level	Income Lower Bound (USD)	Household Size	Production (kg/cap/d)	Organic	Paper	Plastic	Glass	Metal	Other	Ref
Global [7]	Low Income	$1 035		0.6	64	5	8	3	3	17	[3]
Global [7]	Lower Middle Income	$4 085		0.79	59	9	12	3	2	15	[3]
Global [7]	Upper Middle Income	$12 615		1.2	54	14	11	5	3	13	[3]
Global [7]	High Income	$24 000		2.1	28	31	11	7	6	17	[3]
South Africa	Low Income	$1 284		0.55	45.75	13.5	11	9.25	5.25	15.25	[8]
South Africa	Medium Income	$2 661		0.9	46.5	18	12.5	7	6.25	10	[8]
South Africa	Medium High Income	$8 203		1.15	38.5	20.5	14.25	8.5	6.75	11.5	[8]
South Africa	High Income	$368 640		1.85	43.5	17.5	12.5	8.25	6.25	12.25	[8]

Source: Bioenergy Atlas Synopsis Report 2015

The bioenergy atlas shows that the overall percentage of food waste in the total household waste stream in South Africa per income group is on average 18.08% for low income, 10.98% for medium income and 9.58% for high income amounting to about overall 15% of the domestic waste generated in South Africa.

The opportunities in setting up urban biogas projects, also will allow municipalities to address some of the key policy debates that are happening around waste in municipalities. Makinta (2012) indicate that other feasible alternative funding mechanisms for waste management in South Africa needs to be re-examined whereby incentive measures can be used to make waste attractive to municipalities as a revenue generating sector. They show that at present some of the key policy issues surrounding waste are the following:

- ✓ The implications of classifying waste management as a free basic service
- ✓ The lack of standardised approach for setting appropriate and equitable tariff structures for waste management services
- ✓ Ring- fencing funds from the municipal infrastructure grant for capital expenditure on specific infrastructure
- ✓ Poor optimisation of operational and maintenance costs of waste management projects in municipalities
- ✓ Lack of clear guidance on sources and requirements for alternative financing of waste management projects

There is also work to be done around tariffs and budget for waste at a municipal level. Makinta (2012) indicate that at present:

- ✓ Centralised tariff systems for all services mean little relationship between waste revenue and waste expenditure
- ✓ Generally tariffs are not linked to the volume of waste generated. While considered best practice, this linking is very difficult to implement and requires sophisticated weighing equipment and revised billing system, which translates into increased technical costs.
- ✓ Budget increases do not mirror waste volumes handled
- ✓ Using the Municipal Infrastructure Grant (MIG) to fund solid waste-related capital investments is a challenge because of the MIG funding restrictions.

At present the three main financing mechanisms usually used for financing MSWM are municipal taxes (property tax), user charges and grants.Most households are willing to pay for the services, but they normally do not pay the full cost of solid waste management, while estimating the actual cost is a challenge (Makinta, 2012).

Makinta (2012) indicate that some of the different financing options that could be considered for solid waste management are:

- ✓ Tax system(special purpose tax for using landfill)
- ✓ User fee system (where municipalities set certain fees and charges residents for residual waste per household, per m^2 living space)
- ✓ Deposit system (for certain waste types such as glass or plastic bottles)
- ✓ The full cost-recovery system (which covers all services and certain waste types and the producer responsibility for packaging, where municipalities partly pay and the system pays part of the cost)

This type of thinking reflects the move toward using economic instruments (EI's) to control waste management at a municipal level. International experience suggests that the use of EI's can assist in promote more efficient and cost-effective integrated waste management systems and waste hierarchies for the collection, transfer, transportation, recycling, treatment and disposal of waste. The list of current EI's in South Africa's National Waste Management Strategy are:

- ✓ Deposit refund schemes
- ✓ Waste disposal taxes
- ✓ Product taxes
- ✓ Tax interventions on hazardous waste disposal
- ✓ Tax rebates and benefits
- ✓ Levies of specific waste streams
- ✓ Solid Waste Project development and finance

In the development of Urban Biogas pilot projects, these types of policy and tariff issues need to be included to provide innovative solutions as to how one can structure the funding, collection of waste and returns of the biogas pilot. An example would be to calculate if there is room in the system for household to receive rebates from their municipal bills if they contribute waste to a biogas project, rather than sending it to municipal landfill.

In KZN there are a number of options for the use of the dried sludge which require further investigation including on-site power generation and sale of sludge to industrial users. One example of an industrial user would be the major cement producer in the region (Natal Portland Cement) which could use sludge as a substitute for coal in their kiln located in Port Shepstone. This is just one example whereas Kwa Zulu Natal has an abundant presence of diverse industrial activities. A few examples of these activities would be:

- Automotive assembly (Toyota, Man Trucks, Bell Equipment)
- Chemical plants
- Packaging (Nampak)

- Sugar Refining (Tongaat Huletts)
- Food Production (Tiger Brands)
- Beverages Production (ABI, SAB Miller)
- Cosmetics/Hygiene Products (Palmolive, Colgate)
- Steel Refinement

These are industries that could contribute resources towards anaerobic digestion and make use of the energy that results from the digesters. Economies of scale are a critical element in many bioenergy projects and the generation of electricity. Research shows that there are opportunities to combine municipal solid waste and sewage sludge to increase the availability and improve the economies of scale of electricity production. This is referred to in the literature as co-digestion, with some of the main benefits of this approach being:

- Stable and reliable digestion performance and good-quality fertilizer from the digestate
- An enhanced digestion of materials that are difficult to digest
- A increased and more stable biogas production throughout all seasons
- Additional fertilizer as by-product(soil conditioner)

When developing anaerobic digestion/biogas projects, each one would have unique features that have to be researched and components identified to make it a feasible project. The following are some of the key generic points that need to be included in any WWTW biogas project:

- Design capacity and current flows
- Plant operational process
- Sludge generation process
- Current quantity of sludge produced
- Current quantity of biogas produced
- Existing biogas capture infrastructure if any
- Sludge disposal procedures
- Licensing requirements for project

One of the key determinants of the viability of a biogas project is the ownership model that is adopted. SALGA (2015) research shows that the optimum outcome would be for municipalities to retain full owernship not only of the actual process plant but also of all the waste streams sourced for the project. In this context with full municipal ownership the project will not require any of the following:

- a private public partnership (PPP) to be set up
- a Power Purchase Agreement
- generating license and a wheeling agreement

This would result in much simplification and reduced time frames required for setting up a biogas project. This in turn could improve the Return on Investments (ROI's) of these type of projects (SALGA 2015). Implementing such a project within a municipality will require a cross departmental team to allow for effective implementation. In certain instances private participation in these types of projects may be helpful in order to bring in specific project development expertise or to mobilise private capital (SALGA 2015).

PROJECT OPPORTUNITIES RECOMMENDATIONS AND CHALLENGES

As part of the development of the bioenergy action plan a list of potential pilot projects and opportunities was to be developed, as well as opportunities and challenges to be highlighted.

CHALLENGES

A summary of the key challenges facing the bioenergy sector as a whole are as follows:

1.) Lack of a national biofuels policy and pricing plan: research has shown that this sector has only developed through the implementation of mandates. In the absence of national directive KZN can develop local policy opportunities both for government operations and sector plans for certain industries such as the sugar industry.

2.) **High Upfront Investment costs:** Bioenergy projects require large upfront investment costs therefore investor confidence is key in this sector. To achieve this there needs to be a predictable policy framework for investors to engage with and one way to achieve this is through the public-private partnership route.

3.) The monetization of economic and social benefits of bioenergy: many policy frameworks/market incentives fail to take into consideration the other social, environmental and economic benefits in their pricing mechanisms for bioenergy. These benefits need to be monetized in the policy/incentive framework going forward. This needs to be done with proper and accurate full life cycle costing of project opportunities.

4.) Lack of proper pricing/feed in tariff regime for electricity produced from bioenergy: during the development of this Bioenergy Action Plan there were negative developments with the national Renewable Energy Independent Power Producers Procurement Programe (REIPPPP) whereby the signing of contracts by government has been halted. In the absence of this there are very few other options for the establishment of feed in tariffs for electricity produced from bioenergy. Therefore it is imperative that local solutions are developed.

5.) Lack of awareness of all components required to build a successful business case to get bioenergy projects off the ground. This knowledge gap is especially pertinent for persons in rural areas who have no access to professional support services. The awareness on potential commercially viable uses for biomass/bioenergy may be present from the side of the offtake industries in the urban or industrial centres but potential suppliers in the more rural areas may not be aware of all the available offtakers, opportunities, and business case components.

6.) Lack of understanding of how transportation costs affect the viability of energy supply via bioenergy: There is a need to develop develop a transportation costs framework for different bioenergy options. This would reduce the burden on potential suppliers in paying consulting firms to determine such costs. Linked to this is also the lack of understanding of the full potential of government driving a biofuels regime with their own transportation/fleet requirements.

7.) Specifications for how bioenergy should be delivered: Supporting bioenergy will require participation from the industry and other offtakers for indications as to the potential for adopting of bioenergy sources**.** This would include parameters such as energy density, moisture content, allowable impurities, to name a few. These specifications then start to inform the pre-processing steps and appropriate technologies for delivering the bioenergy in a form that is readily usable for the major market players.

THREATS

The following is a list of some of the threats that the bioenergy industry is facing:

1.) Relatively low electricity/energy supply costs: In terms of costing bioenergy is still one of the more expensive options of electricity provision when compared to both conventional fossil fuels generation options, as well as other renewable energy sources such as wind and solar. That is why the monetization of the other social, environment and economic benefits of bioenergy is critical. For example in terms of job creation opportunities bioenergy is the leading renewable energy provision technology.

2.) Reluctance of major industrial companies to shift their dependency to another energy source that is not well established: This alternative bioenergy feedstock would have to be supplied in the correct quantities as well as in compliance which specifications given by the offtaker. Reliable supply of biomass/bioenergy might be dependent on some uncontrollable medium term weather conditions. For example, a season of severe drought as South Africa has experienced over the last 1-2 years may lead to lower yields on biomass. This uncontrollable risk, as mentioned earlier, may reduce the appetite from industry for this alternative energy source.

3.) Food vs Fuel Debate: the issue of safguarding any productive land for food production is a huge priority for the department of Agriculture. There is often a misconception around bioenergy projects taking away valuable land for this purpose. There is therefore a strong need for an educational drive and a working together to correct some of these misconceptions.

OPPORTUNITIES/PILOT PROJECTS

The overarching requirement for all the opportunities that have been identified are two aspects of gathering the correct role players around the table and secondly the sharing of accurate and up to date data. It is therefore recommended that first and foremost a KZN Bioenergy Action Plan Forum is established with a proper mandate and deliverables. The following is a list of roll players that should sit on this forum:

- ✓ Agricultural Bodies (SASA and PAMSA, South African Cane Growers Association)
- ✓ Food Industry and Retailers
- ✓ Muncipal Waste Water Treatment Units from Municipalities and Waste Divisions from Municipalities
- ✓ COGTA
- ✓ Department of Economic Development, Tourism and Environmental Affairs
- ✓ SALGA

- ✓ Oil Industry Associations
- ✓ KZN Manufacturing Cluster
- ✓ Donor Financing Institutions/International Partners
- ✓ Department of Science and Technology/CSIR
- ✓ Working for Water and Waste Programmes
- ✓ Government Agencies (DTI, TIKZN)

This forum will be responsible for the development of the following opportunities and pilot projects:

1.) Develop a fully co-ordinated cross-government/entity information and educational awareness programm: to provide high quality bioenergy technology and opportunities information to the public to raise awareness and acceptance of bioenergy technologies. This will also incorporate a web based presence with relevant information for stakeholders and more importantly project developers. This website will contain all the relevant data on biomass resources and their geographical location. The national Bioenergy Atlas can be used as an existing platform to build onto for KZN purposes.

2.) Small Scale Biogas Programme in the Sugar Industry: This pilot project opportunity requires the sourcing of feasibility funding and the pulling together of key partners on this project. The initial potential has been scoped in this action plan as found on page 19-25 of this document. What is required now is for funding to be obtained and for provincial government to pull together the relevant roll players required on this pilot. Key roll players to lead this project would be TIKZN/DTI together with SASA and South African Canegrowers to pull together the relevant funding opportunities for this project from Donor Finance Institutions. Other key Agricultural fundind and programmes can also be brought into this pilot as it also presents an opportunity for the composting/fertilizer value chain as well as complementing programmes that are encouraging diversification of crop and land use in agriculture.

3.) Scoping of Wood Pellets and Wood Chips Pilot Projects- the wood pellet and wood chips market has been identified as a potential for the setting up of pilot projects. There are two opportunities in this pilot, firstly to collaborate with the sugar industry and identify the opportunities that exist to use wood chips as a complementary product to the sugar cane residue that is used in co-generation. This is particularly in the months where sugar cane is not harvested. This route would ensure that co-generation would be a completely renewabl energy source. The second opportunity would be for a detailed scoping of existing wood pellet operations in KZN and the identification of export opportunities, based on the global demand projections given in this action plan. Here again organisations such as TIKZN together with DTI could play an integral roll in driving this pilot. These two opportunities for wood pellets can be driven out of the Bioenergy Action Plan Forum.

4.) Waste Water Treatment Plant Pilot Programme: this action plan has identified 9 potential sites within eThekwini municipality and 13 other potential sites in KZN that have the potential for bioenergy facilities at their water treatment plant. Here the Bioenergy Action Plan Forum needs to use its stakeholders of municipalities to sourcing funding for the installation of plants. Critical roll players would be COGTA where potential infrastucture funding could be sourced as well as DTI/TIKZN to explore DFI funding. This needs to be explored in conjunction with the potential to add food waste to these particular sites.

5.) Heat Pilot Project in eThekwini: This would first involve an assessment of the process heat requirements across the municipality (i.e. the market size for heat supply), the potential for introducing local bioenergy primary resources to cover that demand, the reduction in energy imports that would occur, and the impact of using those savings to stimulate local manufacture of boilers, pyrolysers and other basic processing units to support growth of the local bioenergy industry. Under such an initative, eThekwini (as the industrial hub) may position itself as the key offtaker for biomass from across adjacent areas. This would require the key involvement and partnering of industrial users within the municipality, which could potentially be achieved through the exisiting manufacturing clusters. As part of the pilot an appropriate approved heat tariff from NERSA can be pursued for the pilot purpose. This pilot would also assist in linking specific biomass production sites to selected end-users as off-takers.

GOVERNMENT LEADERSHIP AND POLICY DELIVERABLES

The following is a list of actions that can be taken by provincial government to unlock areas in the bioenergy sector. These actions should be driven the interdisciplinary Bioenergy Action Plan Forum.

1.) Biofuels Policy Directive: provincial government should scope all government activities (including municipalities) fuel spend and make a policy directive that this fuel spend be diverted to biofuels, both in terms of ethanol, biofuels or liquefied natural gas produced from biogas. This would also have downstream manufacturing spin offs in terms of conversion technologies for vehicles and the manufacturing of the biogas digester technologies. A relationship with NERSA (National Energy Regulator) can be set up so that all legislative requirements and licensing be upheld. Certain industries which make use of substantial transportation fleets should also be brought into this, as KZN has a large logistics sector. As part of this development a specific mandate should be set for biofuels uptake in the province.

2.) Municipal Energy Purchasing Task Team- This team would lead the process with national treasury to unlock section 33 of the MFMA which will allow longer contracting periods for energy projects. This team would also do the tariff calculations to assess when municipalities should be buying local electricity from sugar and implement and manage these contracts.

3.) Trading Market/Platform- This would be set up to allow energy generators from all technology sources and consumers to be able to buy and sell electricity. This would be a platform to get industry off taker buy in for electricity, heat and fuel.