SA Bioenergy Atlas

Looking at the availability of biomass in South Africa

Invasive alien species represent a significant woody biomass resource

South Africa has a limited potential in bioenergy when taking into account rainfall constraints, food security and variability of supply. There will be some niche applications for cultivated energy crops, but the most attractive sources are organic waste and invasive alien plants (IAP).

IAPs can be supplemented by agricultural residues, plantation residues and sugarcane field residues, but these sources are not well understood in terms of sustainable extraction rates.

Paper and pulp mill residues, sawmill residues and sugarcane bagasse are already use to generate power, and power generation can be increased through improved efficiency.

The assessments made are subject to conservative assumptions.

Energy-bearing biomass comes from a wide range of sources that South Africa has in differing quantities. Photo courtesy DST

Agricultural residue: Depending on the safe extraction rate assumptions (at present only residue in excess of three tonnes per hectare), biomass availability could be increased. The relaxed assumption is that 50% more can be extracted over and above the conservative extraction rate. Bear in mind that the variability of production of rain-fed agriculture in South Africa is significant — up to 50% inter-annual variation.

Sugarcane residues: These are not available due to current practice (burning cane before harvest). Changing practice to "green" harvesting will make some of the residue available — say, 50% — but will have a significant negative impact on rural livelihoods, since green harvesting is largely automated.

Sugar cane bagasse, sawmill waste, fuelwood, black liquor, and pulp and paper residue: All of the resource is currently used for low-efficiency energy generation. If efficiency can be improved from 33% to 50% through capital investment in new technology, the value shown is the equivalent biomass that will be liberated for additional energy generation.

Plantation residue: No additional potential is thought to exist.

Invasive species: The current estimate is based on a low annual increment of approximately 3% of standing biomass. There are significantly higher increments in the more productive areas of the country, and these are generally also more exploitable. Hence a relaxed assumption of a higher limit of 4.5% annual increment is defensible.

"Dry mass basis" throughout these tables refers to air-dried biomass. In South Africa, average temperatures are high and humidity is low relative to most of the developed world, and air-dried lignocellulose materials have a moisture content of between 10% and 20%.

The moisture content of woody biomass against oven-dried wood can be estimated using a ratio of energy densities.

Organic fraction of domestic solid waste: It's reported here as the total available, minus an estimated 10% that is currently used for composting, electricity generation or biogas manufacture. Legal and service provision constraints on exploitability are discussed below.

Municipal wastewater: The same applies to municipal sewage sludge.

Purposely cultivated crops: These are reported for the best available options in respect of biomass, but this may not be feasible to process on techno-economic grounds. As stated before, the estimate takes only subsistence farmland into account. Figure 5 summarises the results of the evaluation of purposely cultivated crops as a feedstock for biofuels.

Municipal solid waste: This is a sizable resource, but has partial immediate potential for electricity generation, largely because of the low percentage of sites with proper permits, and because solid waste removal is not formalised for a sizable percentage of the population. Likewise, wastewater treatment works do not serve all of the population with water-borne sewage. This leads to three main considerations:

- Combination of sewage sludge and solid waste organic component to increase the availability and improve the economy of scale of electricity generation from these sources;
- There is significant upside potential should service delivery and permit processing improve in future; and
- Options exist for deployment of community or domestic digesters.

Several crop candidates (maize, sorghum, sweet sorghum, soybeans, groundnuts, sunflower and sugarcane) were evaluated. The potential availability of these crops (most of which are in competition for the same land) varies.

Maize, while constrained by policy in respect of application as an energy feedstock, shows significant potential for biofuel generation due to good yields, and availability of suitable, underutilised farmland. Utilising improved yields from subsistence farmland to displace maize grown for cattle feed could open up additional sources of commercially produced maize for food and energy purposes.

Of oil-producing crops, groundnuts and soy oil are good candidates from a raw potential point of view, but oil and oilcake have a high alternative market value. Sunflower oil and oilcake have lower market values, and sunflower has a large area of potential cultivation.

Sugar from sweet sorghum can potentially be produced in sufficient quantities, but it may be difficult to establish a new industry in subsistence farming areas.

Conservation agriculture may contribute significantly to future greenhouse gas emission reduction by improving the amount of soil carbon sequestered and reducing the need for fertiliser application.

Water use of crops grown for bioenergy is a concern. Recent work has estimated the extent to which energy crops exceed the water footprint of natural vegetation it displaces. On this basis, crops such as sweet sorghum, maize and sunflower are generally better choices.

Electricity generation from residues at sawmills and sugar mills has some potential, but is unlikely to contribute much beyond the needs of the industry itself, unless capital is invested in improved efficiency. Sawmills, in particular, are already utilising a sizable proportion of residue biomass to supply internal energy needs.

Invasive alien species represent a significant woody biomass resource, and programmes such as Working for Water and Working for Energy seem to be natural vehicles for a wider, energy-directed effort to utilise the biomass and control the problem. Options include:

- Pelleting or chipping of lignocellulose biomass in areas close to existing coal-fired power stations, with a view to co-firing;
- Supplementing or replacing coal- and gas-based refinery feed with lignocellulose biomass feedstocks; and
- Development of small electricity-generating capacity in areas of poor provisioning and extensive rural firewood use, or replacement of fuelwood use by pelleted fuel and efficient pellet-burning stoves.

A combination of feedstocks should also be considered. All lignocellulose biomass (invasive alien plants, sawmill and sugar mill residues, plantation residue and agricultural residue) can be used as a combined feedstock for electricity generation, lignocellulose fuel production, or gas-to-liquid and coal-to-liquid feedstock replacement. Larger-scale organic waste production installations can combine the organic streams from wastewater and solid waste to generate electricity or biogas for vehicle fleets.

Availability of biomass for energy applications

	Estimates of availability or potential										
Source	Potential (dry mass) Tg/a	Allocated already (dry mass)			Not available (dry mass) Tg/a	Available now (dry mass) Tg/a	Potential additional availability (dry mass) Tg/a		Energy density (PJ/Tg) (10)	Moisture content estimate (%) (11)	Energy equivalent available now (PJ/a)
		Re-use (Tg/a)	Unavailable (Tg/a)	Energy use (Tg/a)							
Agricultural residues	36.22		30.42		30.42	5.80	2.90	1	10.00	42%	57.95
Sugar cane field residues	5.06		5.06		5.06	0.00	2.53	2	10.00	42%	0.00
Sugar can bagasse	5.35	0.2		4.54	4.74	0.60	2.34	3	10.00	42%	6.02
Plantation residue	6.70		5.20		5.20	1.50	0.00	4	12.50	30%	18.75
Pulp and paper mill residues	0.69			0.69		0.01	0.35	5	12.50	30%	0.09
Black liquor	1.50			1.49	1.49	0.00	0.77	6	6.30	59%	0.00
Sawmill waste (bark included)	3.10	0.15		2.00	2.15	0.95	1.03	7	10.40	40%	9.88
Invasive species	11.30		3.23		3.23	8.07	1.16	8	14.70	20%	118.63
Fuelwood	14.00			10.00	10.00	4.00	12.00	9	14.70	20%	58.80
Organic solid waste component	6.47			0.65	0.65	5.82	0.00	12	10.00	20%	58.23
Organic sewage sludge	2.53			0.25	0.25	2.28	0.00	13	10.00	20%	22.77
Purposely cultivated crops	9.26				0.00	9.26	0.00	14	14.70	42%	136.12
Total	83.91	0.35	43.91	18.72	62.97	20.92	23.08				487.24