Opportunities for Bioenergy and biomass supply in South Africa

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CSIR

IEA Bioenergy e-workshop

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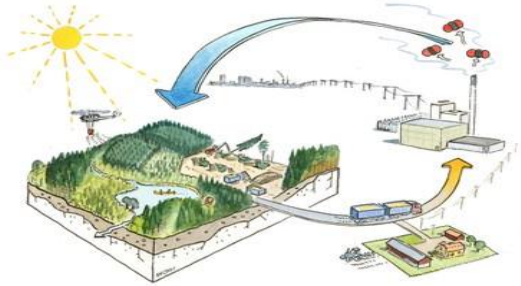
science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA



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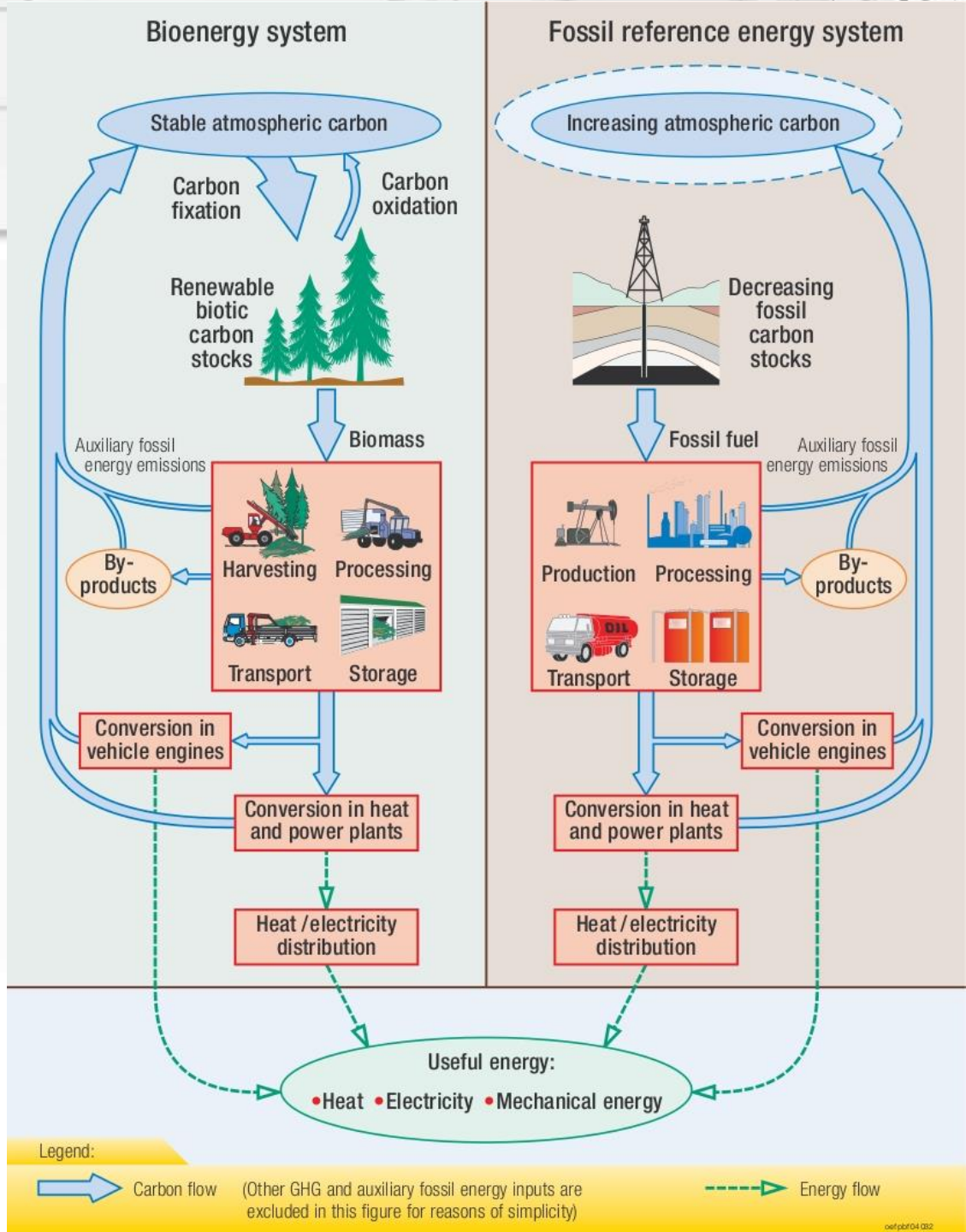
Bioenergy

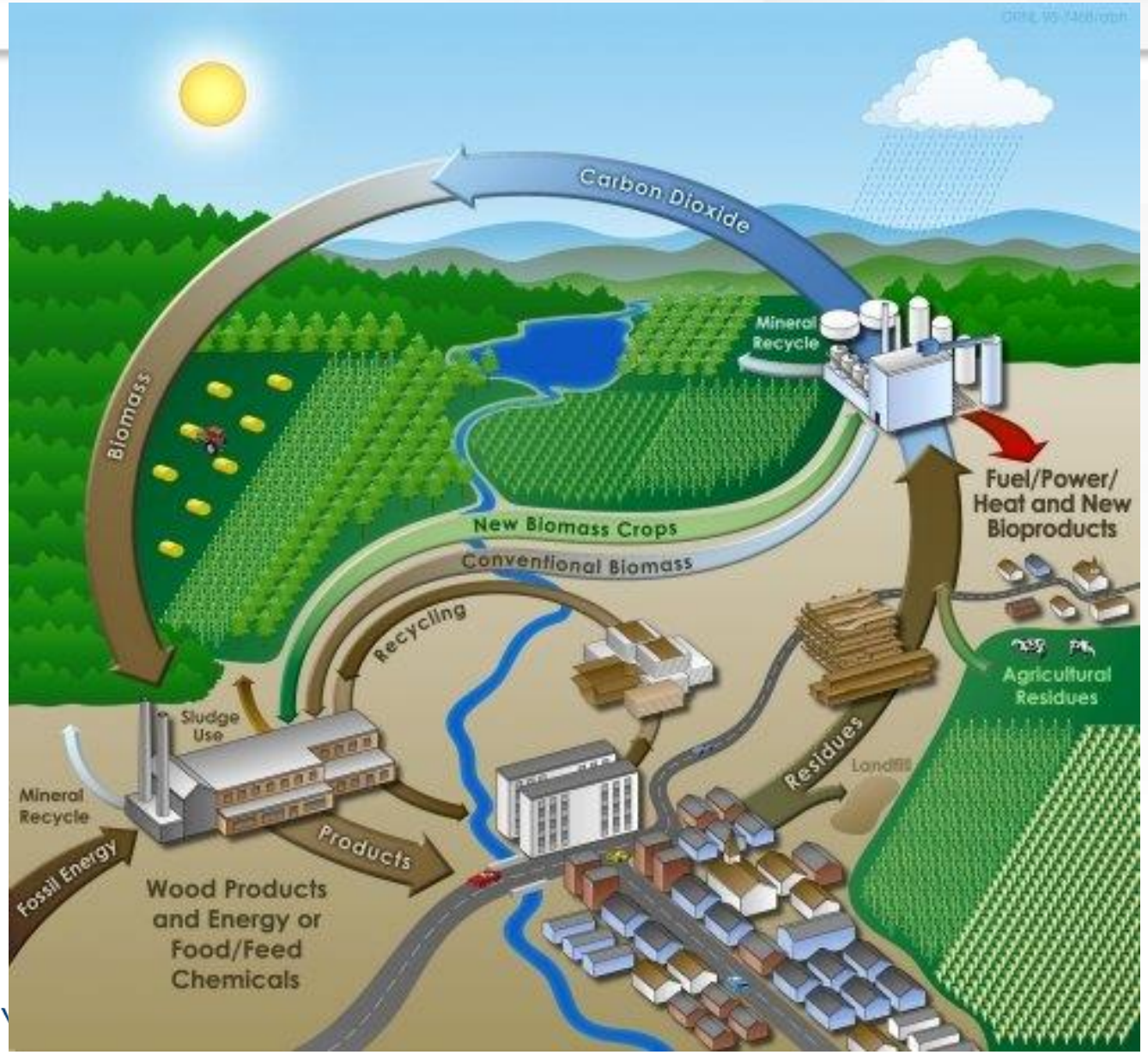
Benefits of bioenergy:

- Carbon emission reductions
- Lower emissions of air pollutants and waste
- Socio-economic benefits, such as green jobs with biomass cultivation and supply

BUT Bioenergy needs to be compared to the reference system (BAU) and risks in biomass supply and bioenergy mitigated and managed



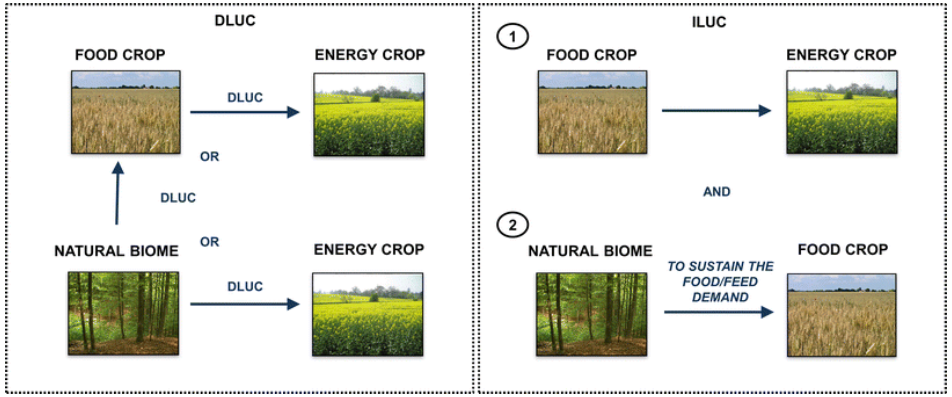
Bioenergy Life cycle



Can be carbon neutral….

Depends on:

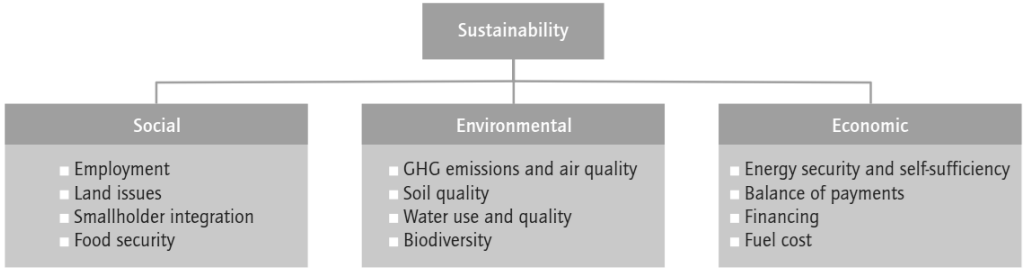
- **Lifetime of products** (carbon cycling)
- **Energy inputs** in the bioenergy life cycle
- **Land-use change** (LUC and iLUC)



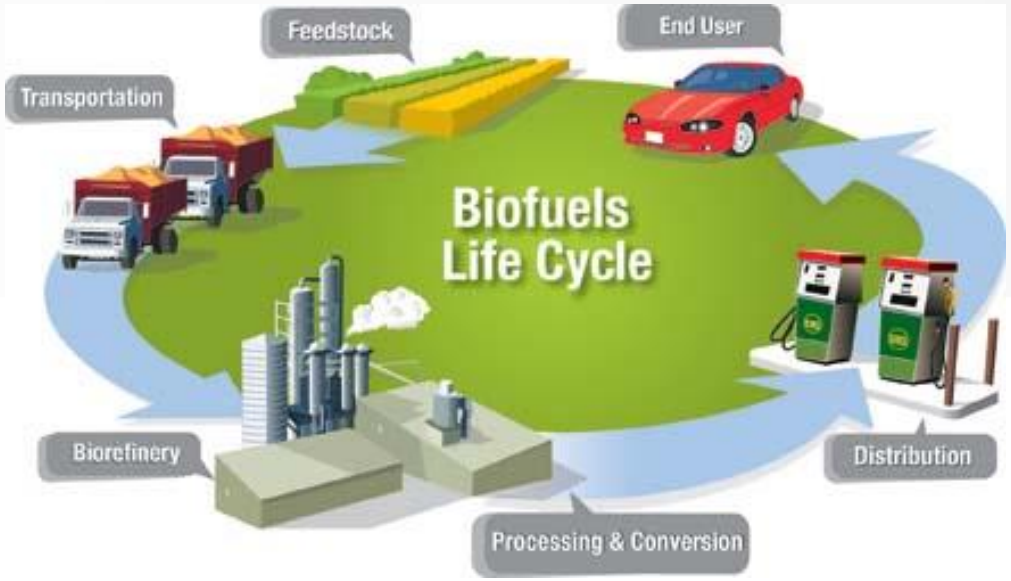
Bioenergy Sustainability assessment

Bioenergy Life cycle

Assessment with social, economic and environment criteria **integrated** to guide *sustainable development*

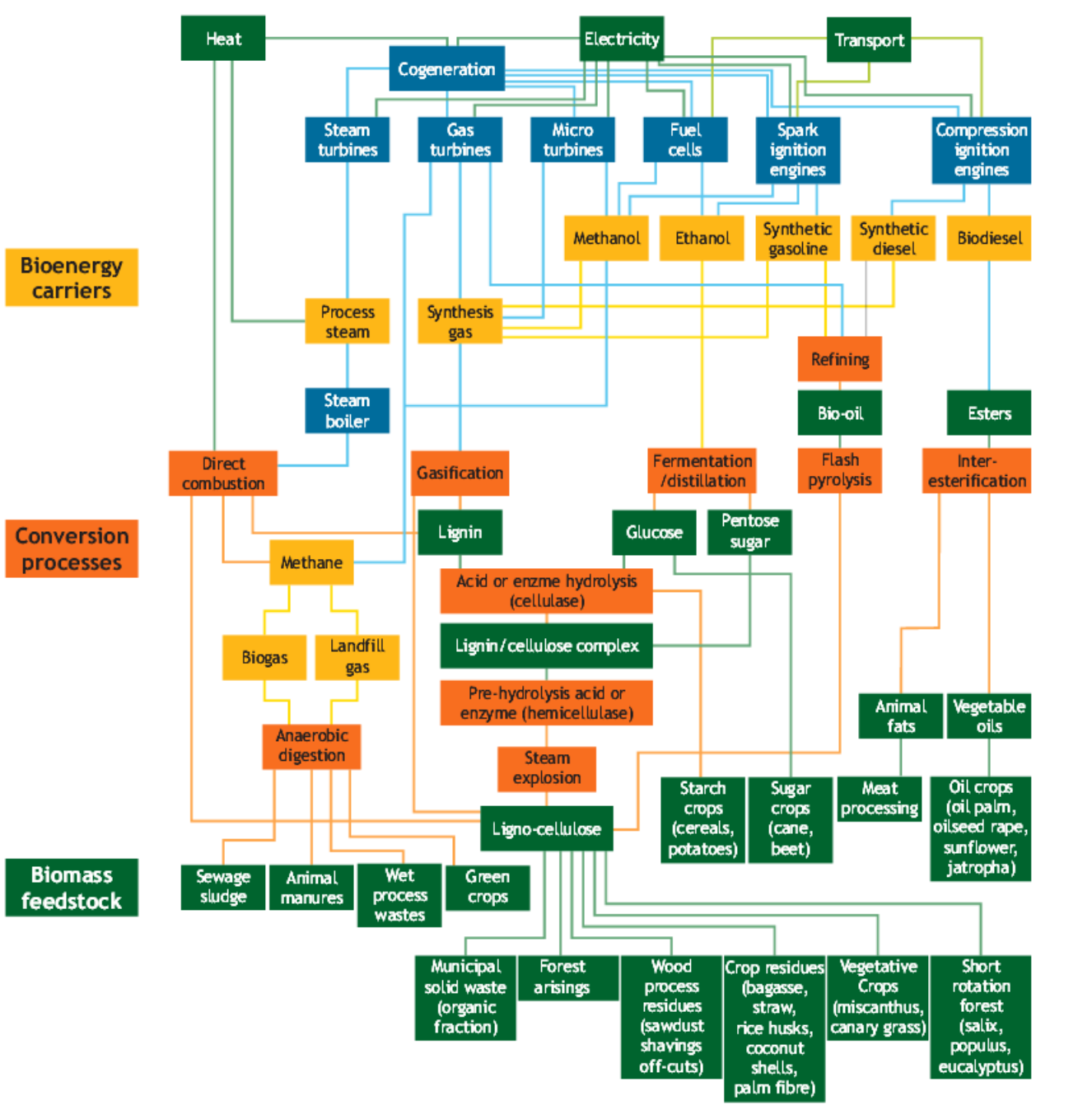


Impacts assessed across the whole **product life cycle-** from raw materials, manufacturing, distribution and end-use (**Life Cycle Assessment, LCA** ISO 14040 and 14044)



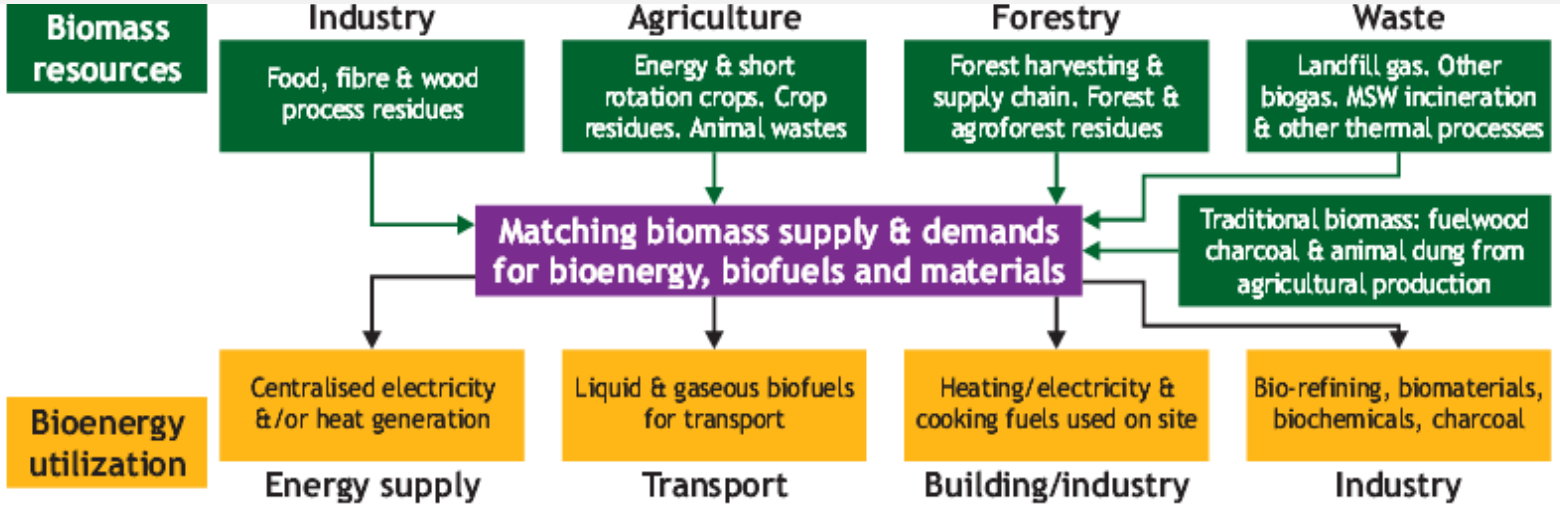
Complexity of many Bioenergy pathways

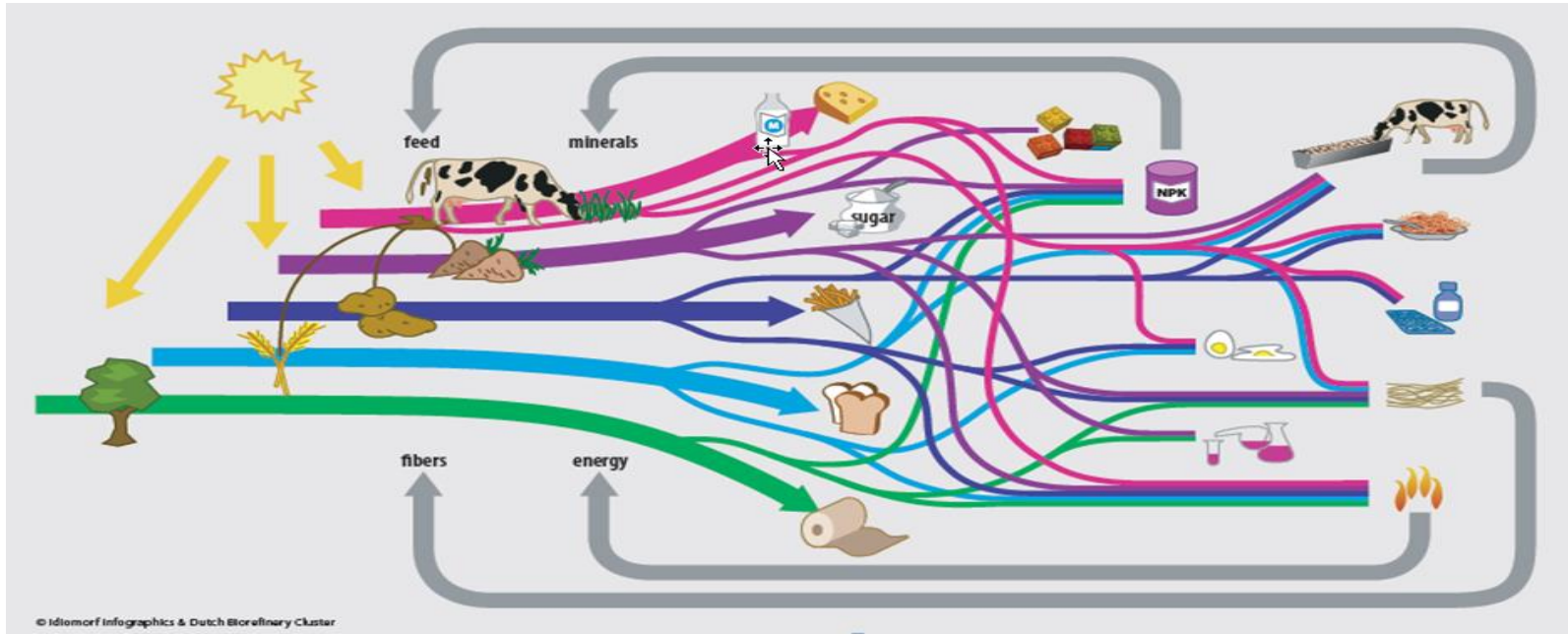
- Several **biomass resources, technology processing and energy carriers**
- Bioenergy provides **energy services**:
  - heating and cooling,
  - mechanical/transport
  - electricity
- Technology selection to **suit resource and energy service**
- Technology **readiness, maturity and cost**



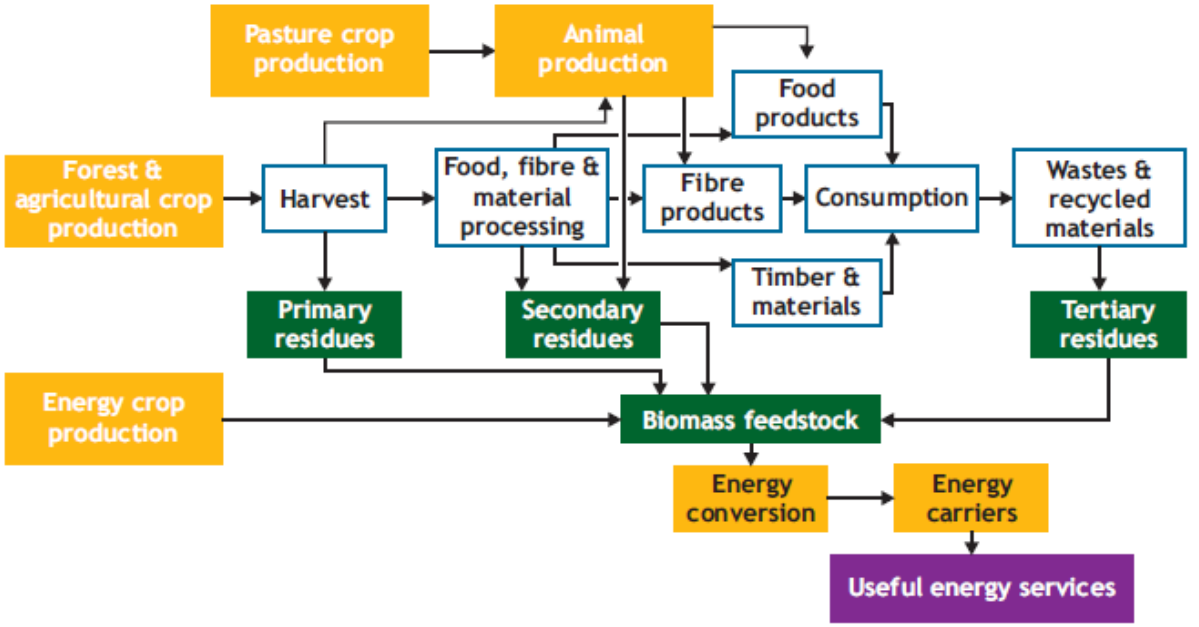
Complex, competing value chains

Range of biomass resources to meet energy demands of various sectors





Multiple biomass resources
from dedicated energy crops to residues and wastes



The solid or liquid biomass feedstock can be converted using numerous technologies to provide more convenient energy carriers in the form of solid fuels (*e.g.* wood chips, pellets, briquettes), liquid fuels (*e.g.* methanol, ethanol, biodiesel, bio-oil), gaseous fuels (synthesis gas, biogas, hydrogen) or direct heat (Figure 5).

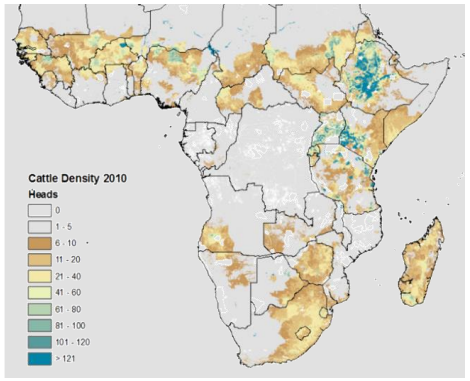
Dedicated bioenergy crops:

AEZ methodology is a standardized framework for alternative uses of agro-resources (land, water, technology) for producing **food and energy**, while preserving environmental quality

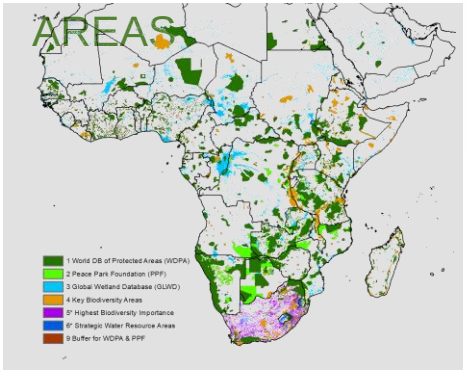
The **production potentials** of land and **water limitations** provides insight into current **yields and production gaps** and their causes.

Forest, Cropland, Grazing Land, Environment excluded

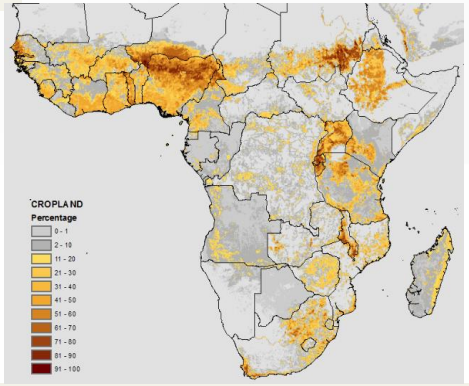
GRAZING LAND



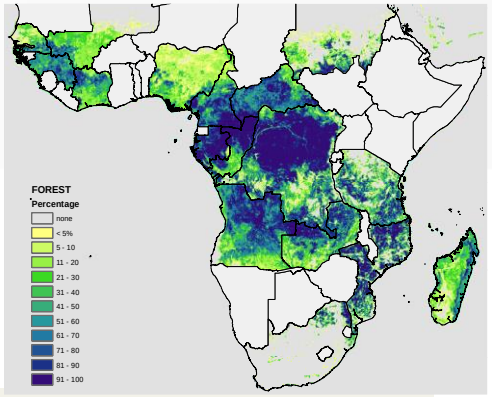
ADDITIONAL PROTECTED AREAS



CROPLAND



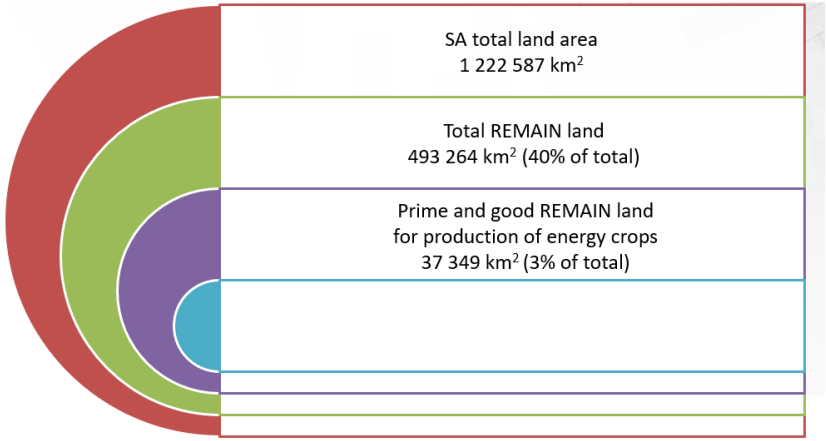
FOREST



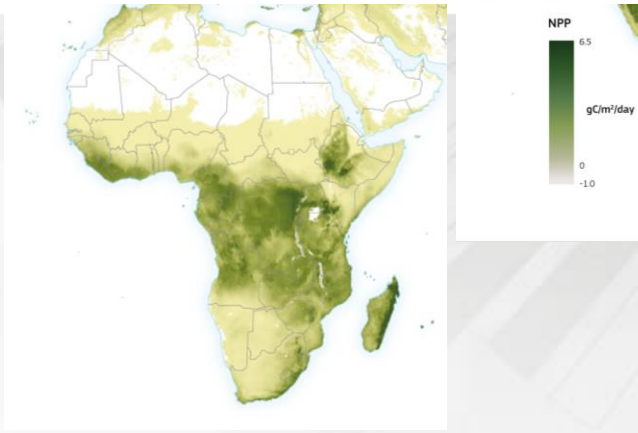
Dedicated bioenergy crops:

Agro-ecological suitability of rain-fed ethanol feedstock crops on REMAIN land

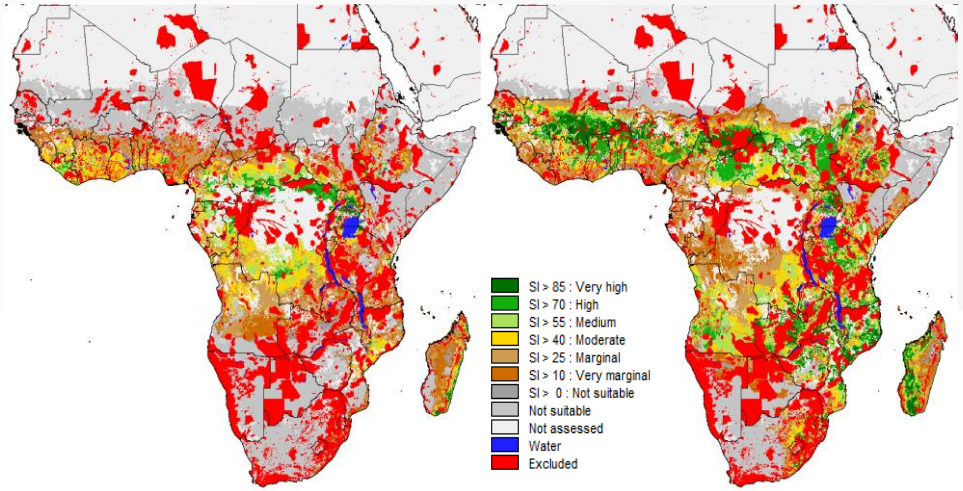
Avoiding food-fuel conflicts, protecting conservation areas and ensuring agr-ecological suitability reveals a **limited potential for dedicated bioenergy crops in South Africa**



Net primary production (NPP)



(a) rain-fed sugar cane (b) rain-fed maize



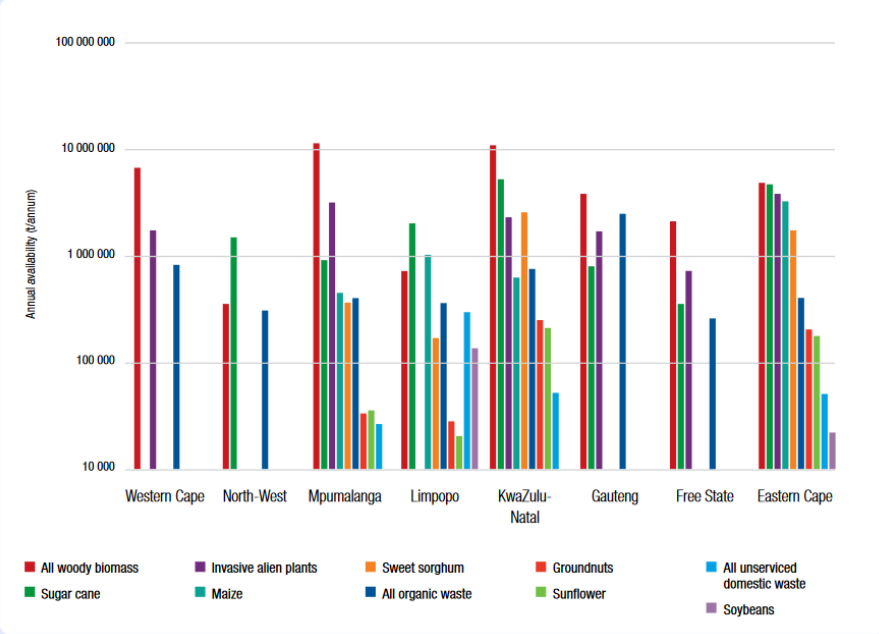
Agro-ecological suitability of rain-fed ethanol feedstock crops on REMAIN land

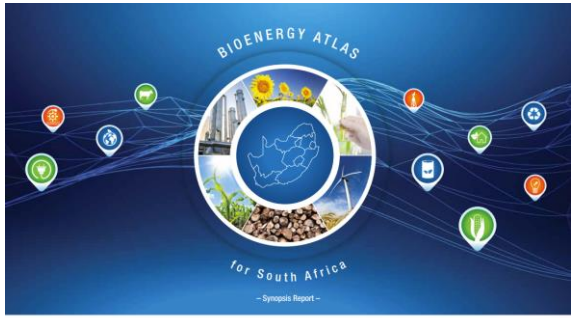
Source: WWF and RSB: Assessing sustainable biofuel potential in Sub-Saharan Africa

Biomass for bioenergy in South Africa

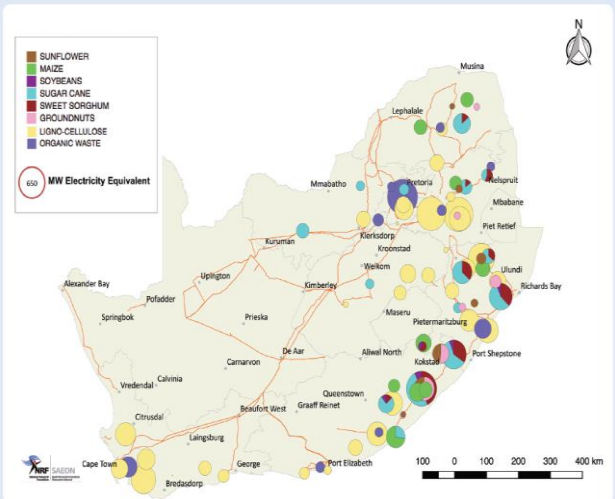
Biomass supply for bioenergy is **limited due to arable land, rainfall and food security constraints**.

- Best biomass feedstock is **urban organic waste and lignocellulose waste** (comprising a mix of harvested **invasive alien plants** and some **residues** from agricultural and forestry).
- Socio-economic concerns with **energy crops**, especially if also used for food and feed





Source: Bioenergy Atlas
https://www.saeon.ac.za/wp-content/uploads/2021/02/Bio-Energy-Atlas.pdf



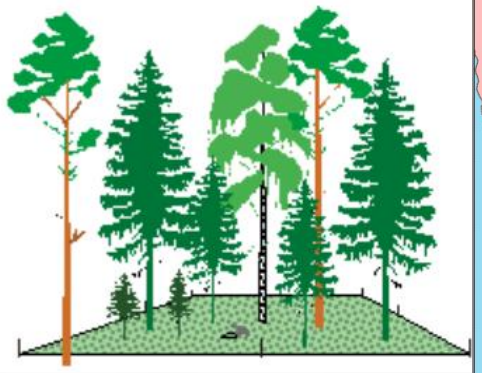
Estimation of biomass resources in South Africa

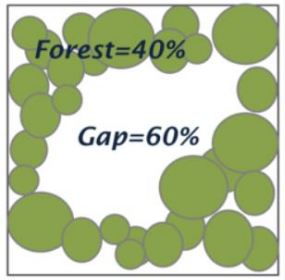
THE STATUS OF BIOLOGICAL INVASIONS AND THEIR MANAGEMENT IN SOUTH AFRICA

Amount of *invasive alien plant* biomass?

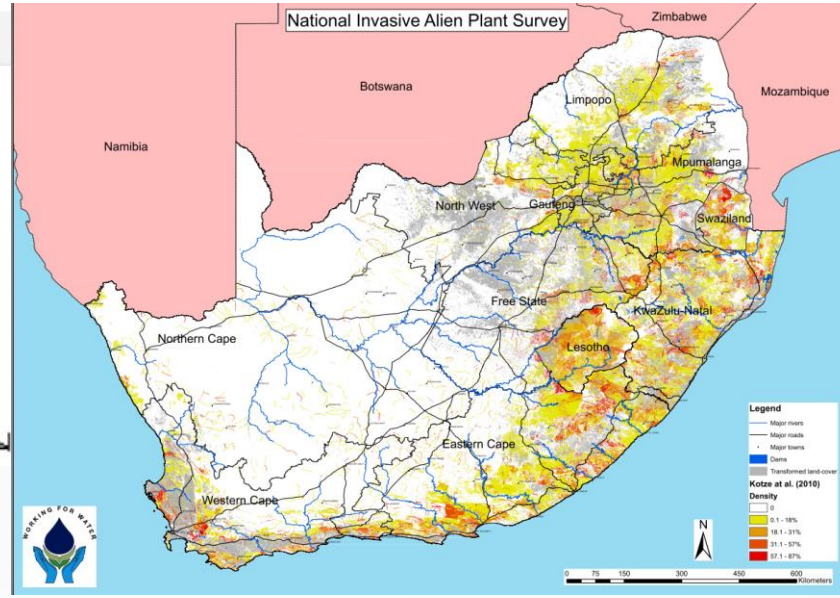
❖ Identify IAP tree species:

Aerial mapping **NIAPS 2010**
Kotze et al. 2010
http://bgis.sanbi.org/EDRR/NIAPS.asp





10 ha of 40%=
4 ha condensed

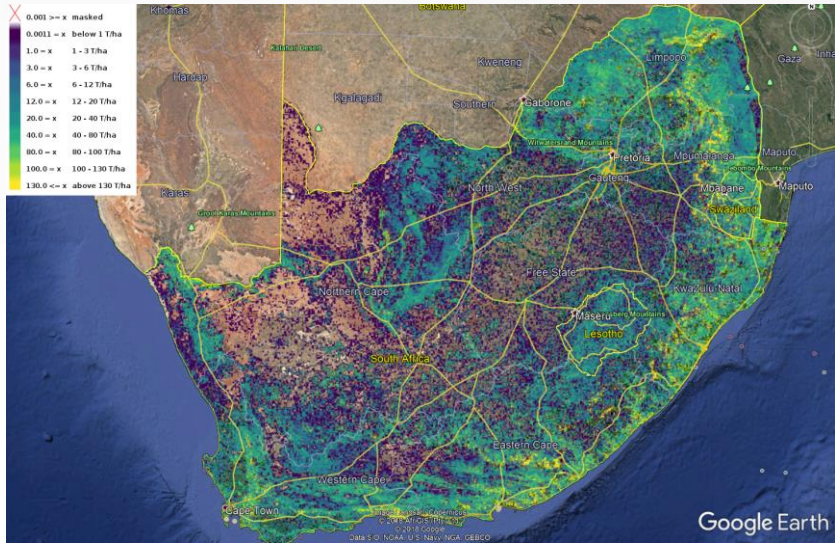


❖ Estimate IAP biomass:

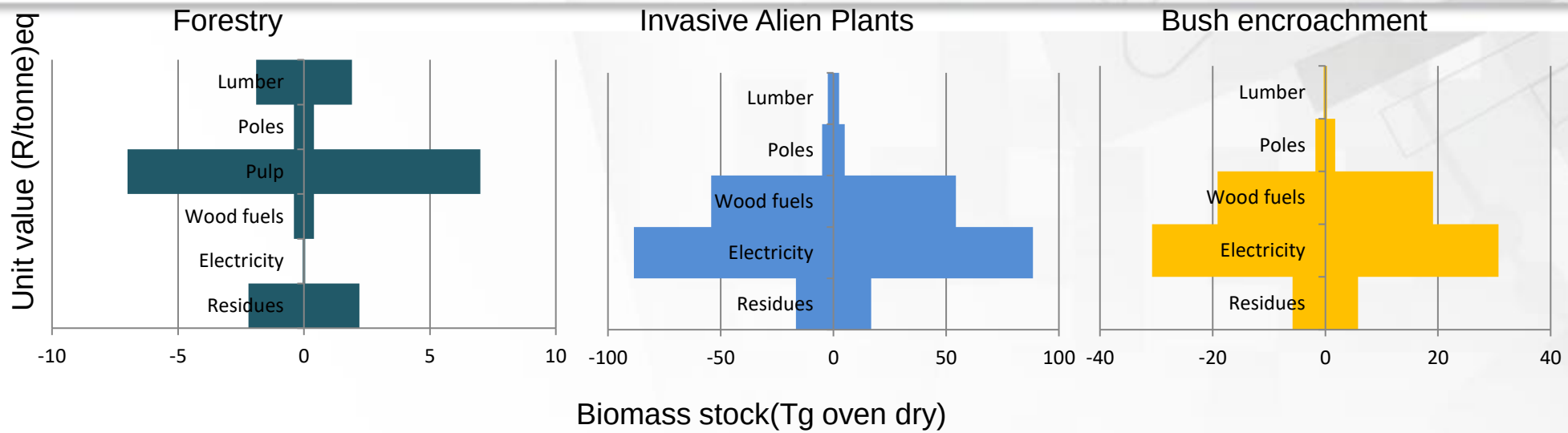
Tree cover, Tree density (condensed area),
Tree height, Biomass
Biomass data 2010,2018,2019- **CSIR_AGB**

Above Ground Biomass based on cal-val of ALOS-PULSAR

Data used for Carbon sinks Altas
https://www.dffe.gov.za/sites/default/files/reports/nationalterristerialcarbonsink_assessment2020.pdf

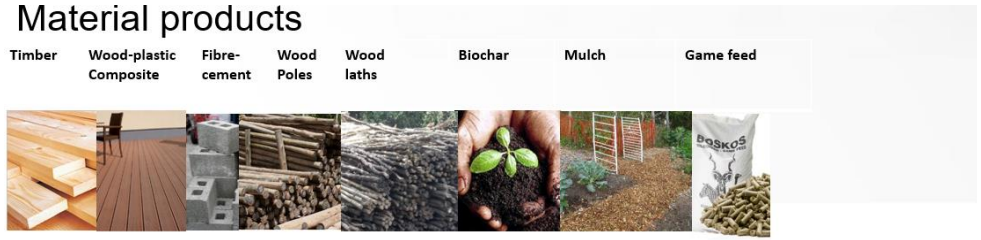


Available biomass for bioenergy:
Competing uses of woody biomass resources?



Forestry industry: 12Tg, IAPs: 167 Tg, Bush encroachment: 58 Tg

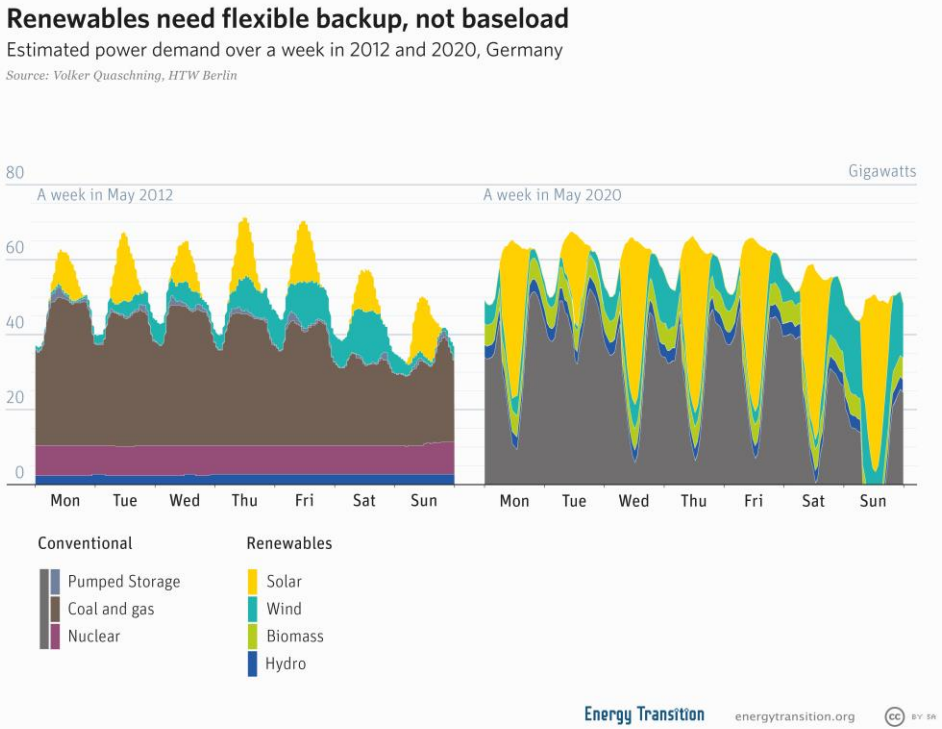
Techno-economics: Suitability of the biomass for products(s), conversion technology and value-adding opportunity will determine the optimal use of biomass



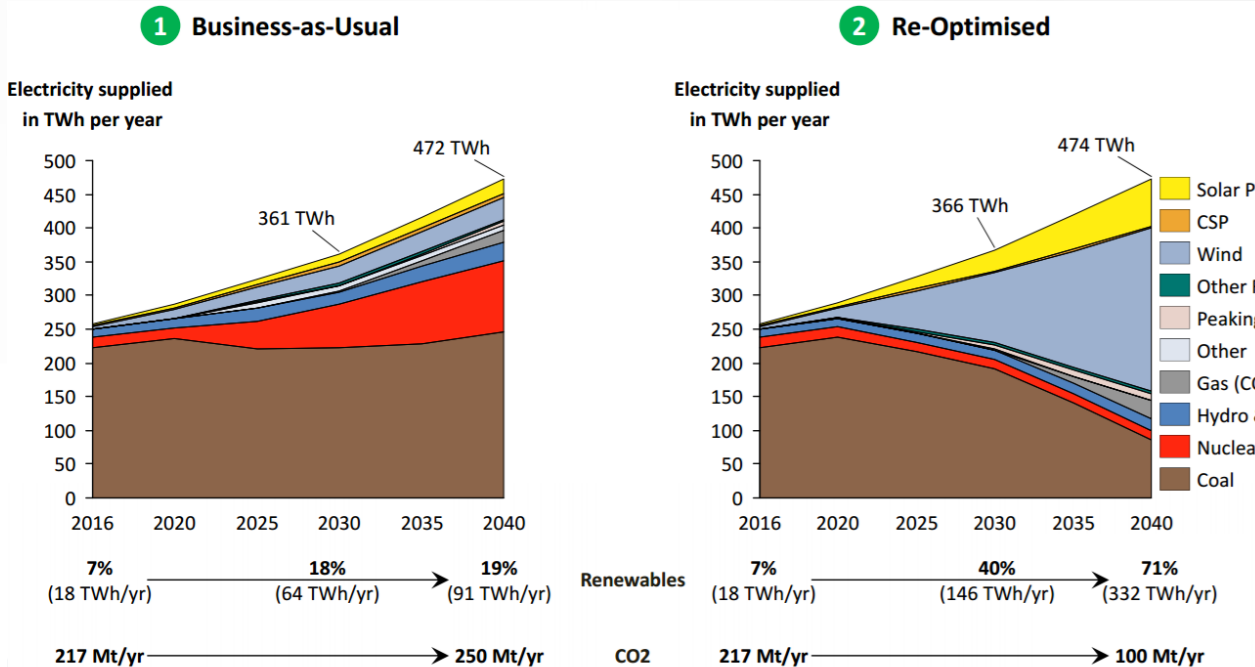
Bioenergy: biomass for electricity

Bioenergy can provide grid flexibility- maintains balance between generation and load under uncertainty ie peaking, dispatchable and baseload power. Avoids the need for other similar power options in the future National Electricity mix (ie coal, gas and nuclear) and provides **grid stability**

Sustainable bioenergy can be used to generate **3-6% of South Africa's future Electricity mix** (CSIR study, Bioenergy Atlas)



Integrated resource plan for Electricity, IRP-2



Bioenergy: biomass for regional electricity

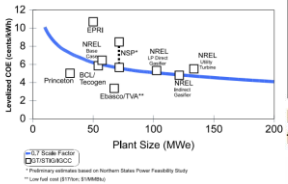
Regional biomass gasification power stations **100-200 KWe feasible, as determined by NPV up to +US$2.7million, (compared to diesel generators with –US$2.3 million)**

Conditions:

- **Invasive Alien Plant biomass** feedstock price is R400 (US$28.57) per green tonne. Requires **sharing of cost for biomass supply.**
- **Electricity market price** of **R1.60/kWh** (US$0.11/kWh)
- Internal rate of return of **16%** for the bioenergy entrepreneur

Including water and carbon benefits substantially increases feasibility

Wood biomass gasifier



Electricity

Heat

Household wood fuels

Biochar

	kWe	Biomass cost: DEA:NRM contribution	Biomass cost: bioenergy entrepreneur contribution	IRR	NPV (sale of electricity and biochar)	NPV/unit	NPV (electricity and biochar sales and water and carbon externalities)
		US$/green tonne	US$/green tonne	%	US$	US$/MWhe	US$
Volvo 212	239	0	0		-1 038 209	-18.40	-1 131 838
Scania 400	450	0	0		-1 319 788	-12.40	-1 477 697
Volvo 560	630	0	0		-2 101 344	-14.10	-2 330 015
SJG250	198	38.86	-10.28	16.0 %	409 917	8.75	751 905
SJG500	396	28.59	-0.01	16.0 %	718 359	7.67	1 401 839
SJG1000	792	26.56	11.01	16.0 %	1 346 623	7.19	2 713 583

ELSEVIER

Ecosystem Services

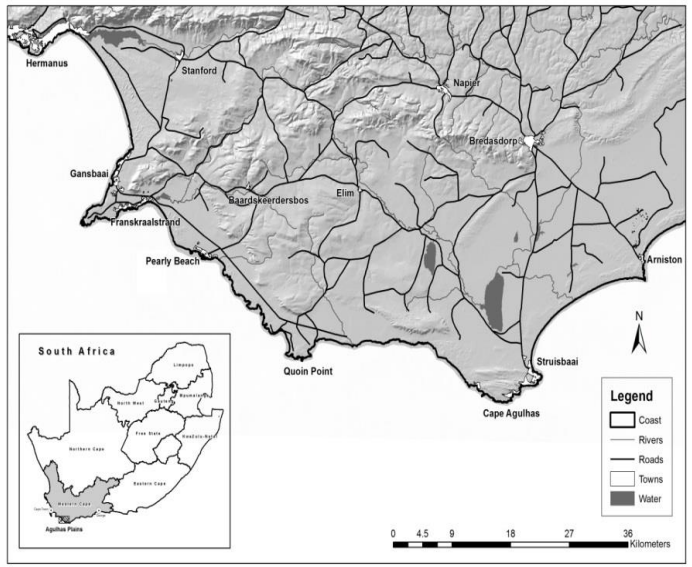
Volume 27, Part B, October 2017, Pages 224-231

Reducing landscape restoration costs: Feasibility of generating electricity from invasive alien plant biomass on the Agulhas Plain, South Africa

William Stafford [a, b], James Blignaut [c, d]

Show more

https://doi.org/10.1016/j.ecoser.2017.04.008



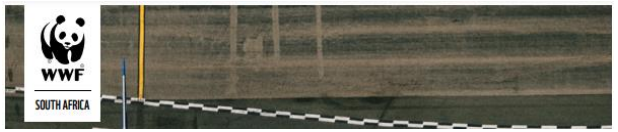
Agulhas plains:

Southern most tip of Africa, 270 000ha and approx. 40 000 peo

Bioenergy: Biomass for Sustainable Aviation Fuel (SAF)

- South Africa can produce **3.2 billion litres of SAF (bio-jet) pa**. Introducing green hydrogen into the SAF manufacturing process extends **4.5 billion litres pa**. SAF can **replace domestic use of 1.2 billion litres pa conventional jet-fuel, while also providing 2–3.3 billion litres pa for export**.
  - **Sugarcane A-molasses** is quickest and **cheapest** route to SAF 1G alcohol-to-jet with 300 million litres pa
  - **Invasive alien plants (IAPs)** is **largest biomass resource** and 2G F-T 1.8–3 billion litres pa
  - **Plant oils from tobacco seed** (Solaris) and HEFA could produce 1.1 billion litres of SAF pa.

Feedstock	Potential availability	Reference
Solaris	5,2 million tonnes of seed per annum	Fischer et al., 2019
A-molasses	165 000 tonnes per sugar mill per annum	Dogbe et al., 2020
Industrial off-gas	3,34 million tonnes per annum	Own research based on off-gas producers' reports
Cleared IAPs	215 million oven-dry tonnes on less-than-35% slopes	Stafford et al. (2021) (available on request)
Garden waste	170 000 tonnes per annum at two municipal depots (Johannesburg and Eden)	Integrated Pollutant and Waste Information System (IPWIS)



https://wwfafrica.awsassets.panda.org/downloads/fuel_for_the_future.pdf?39122/fuel-for-the-future

Bioenergy for Sustainable development…..

- Assess whole **bioenergy life cycle assessed for impacts (LCA)**
- Bioenergy opportunities to consider **environmental impacts, economic viability and social protection. Sustainability certification of products (ie RSB)**
- Reduce project and socio-economic risks through **supply chain management- aggregating supply** and **securing biomass supply and long-term off-take agreements**
- Multi-stakeholder engagement and community participation to **balance local market opportunities and needs with international market opportunities**

Thank you

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