South Africa from Zero to Pilot Project and Offshore Assessment

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Contents

South Africa’s Energy Profile

South Africa’s Carbon Capture and Storage Programme

Offshore Assessment

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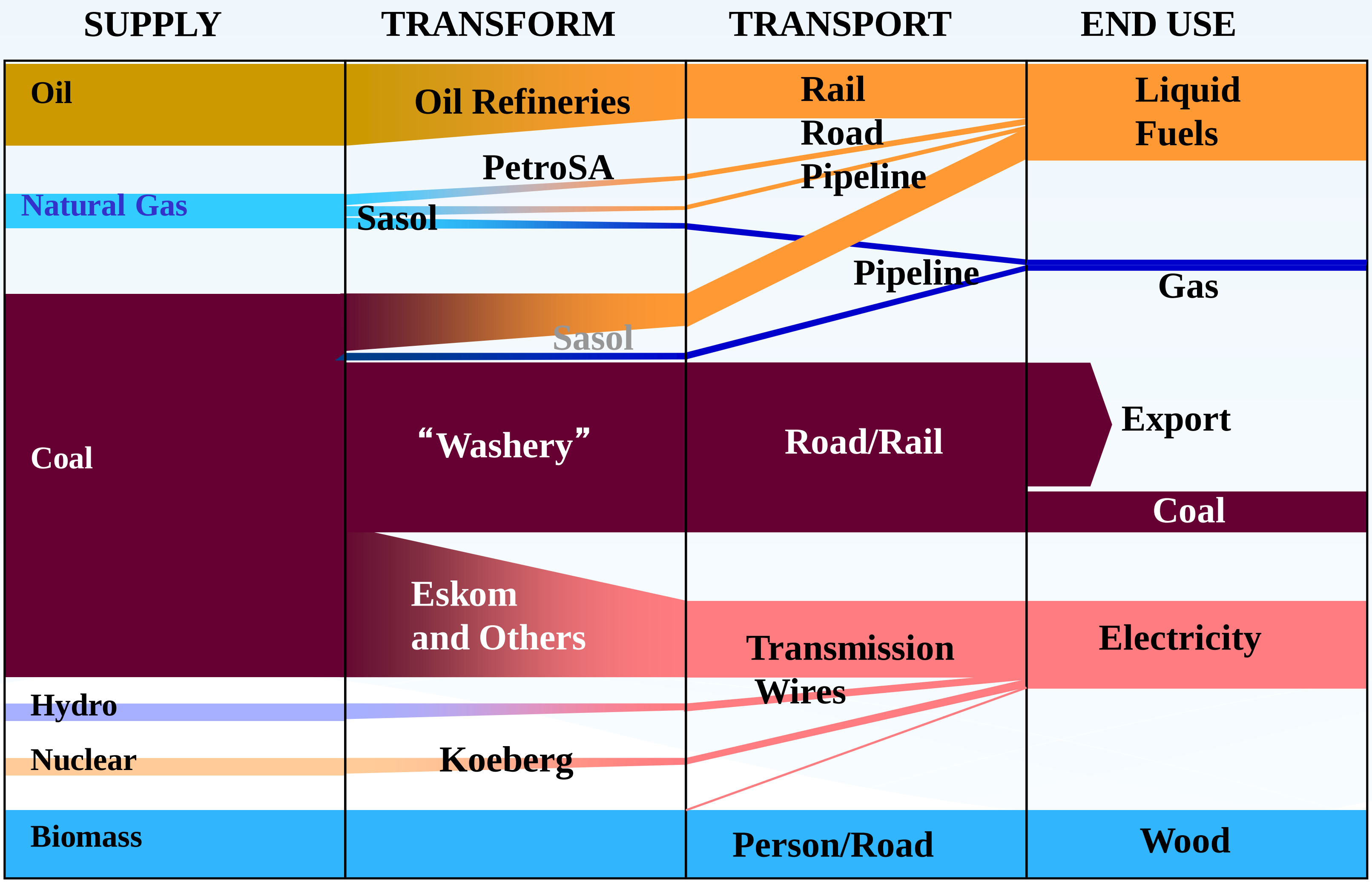
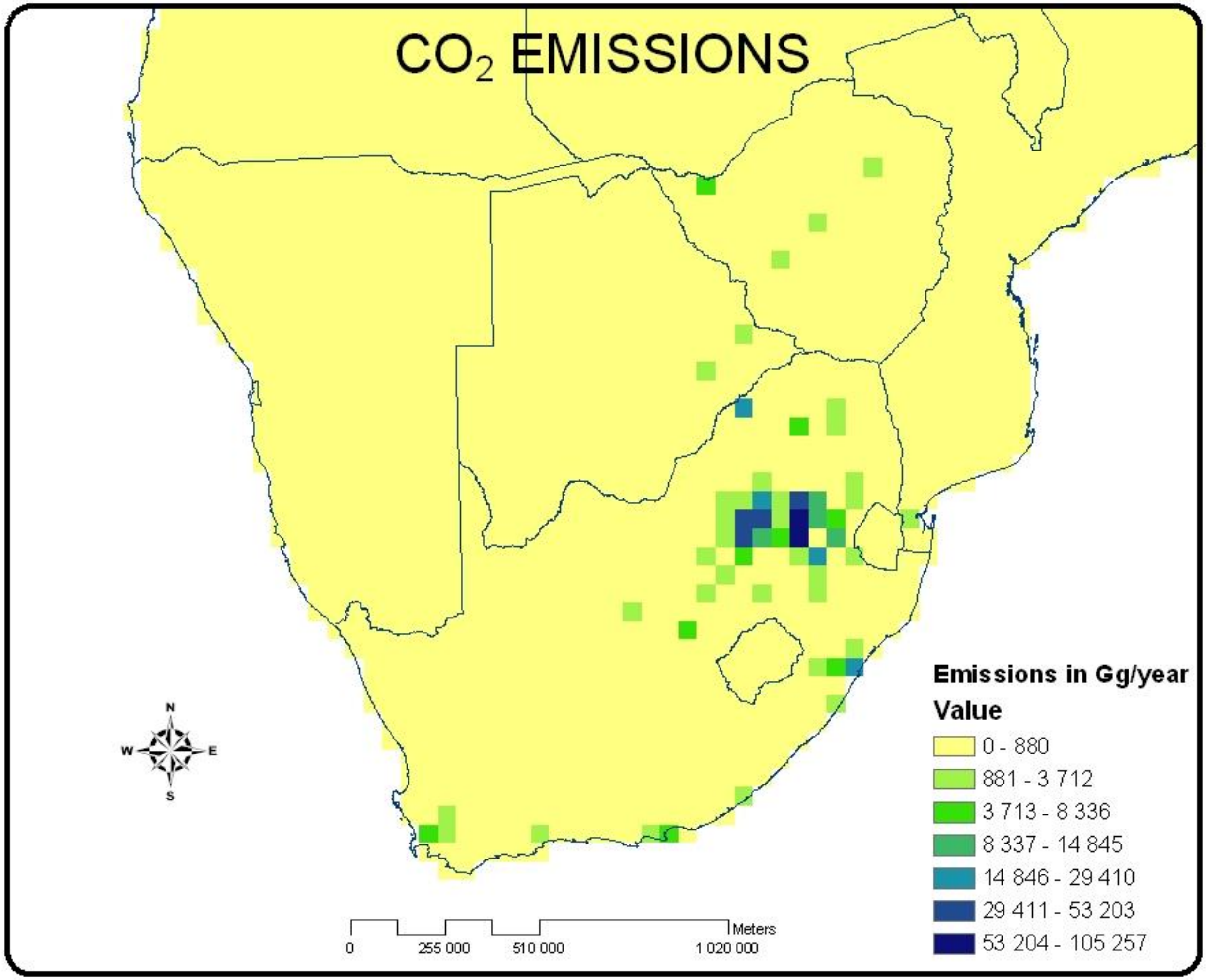
South African Energy Chain



CO_2 Emissions



CO_2 Emissions Quantification

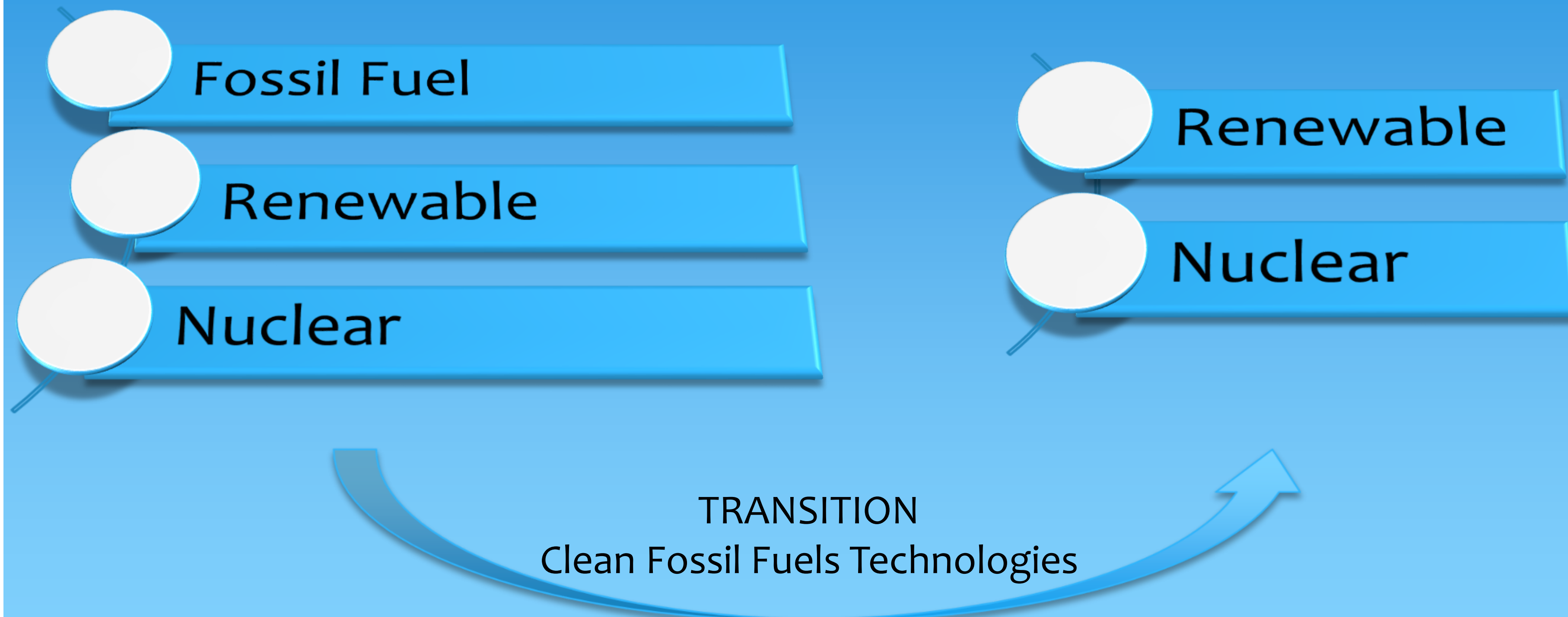
	Mt	% Emission		
SEQUESTRABLE				
Electricity	161	65		
Industrial	28	11	**249 Mt**	**61 %**
Other Energy	30	12		
Manufacturing	30	12		

Synfuel Industry ~30 million tonnes ~95% CO_2

	Mt	% Emission		
NON-SEQUESTRABLE				
Waste	10	6		
Agriculture	48	27		
Fugitive	42	24	**159 Mt**	**39 %**
Transport	22	21		
Heat Production	37	21		
Total	**408**			

SOURCE: CSIR/DME

Carbon Capture and Storage is a Clean Coal Technology



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Carbon Capture and Storage in South Africa

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Carbon Capture and Storage: Mandate

CCS is a part of the Long Term Mitigation Scenarios - DEAT

CCS is a Flagship Programme of the White Paper on Climate Change Response Strategy   DEA

Cabinet endorsed the CCS Road map May, 2012

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Objectives: Pilot CO_2 Storage Project

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- Demonstrate safe and secure CO_2 storage in South African conditions [“Proof of Concept”]
- Increase the South African human and technical capacity
- Raise awareness of the potential importance of CCS
- Platform for government to develop a South African CCS legal and regulatory environment

FOCUS ON ZULULAND ON-SHORE BASIN

Time/Scale for Carbon Capture and Storage in South Africa

2004: CCS Potential - Done

2010: Carbon Atlas - Done

Launched by Minister Oct 2010

2017: Pilot CO_2 Storage Project -

Planned [10 to 50 thousand tonnes]

2025: Integrated Demonstration Plant -

Planned [100's thousands tonnes]

2035: Commercial Operation -

Planned 2025 [millions tonnes]

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Pilot CO_2 Project Tangible Outputs

South African CCS Road Map

2004: CCS Potential - Done

2010: Carbon Storage Atlas - Launched by Minister Oct2010

2017: Pilot CO_2 Storage Project - Planned [10 to 50 thousands of tonnes]

2025: Integrated Demonstration Plant - Planned [100s thousands of tonnes]

2035: Commercial Operation - Planned [millions of tonnes]

PCSP Tangibles

2016: Existing data Analysis

REVIEW

2017: Exploration

REVIEW

2019: Pilot Project Injection

REVIEW

2022: Pilot Project Conclusion

REVIEW

2025: Closure

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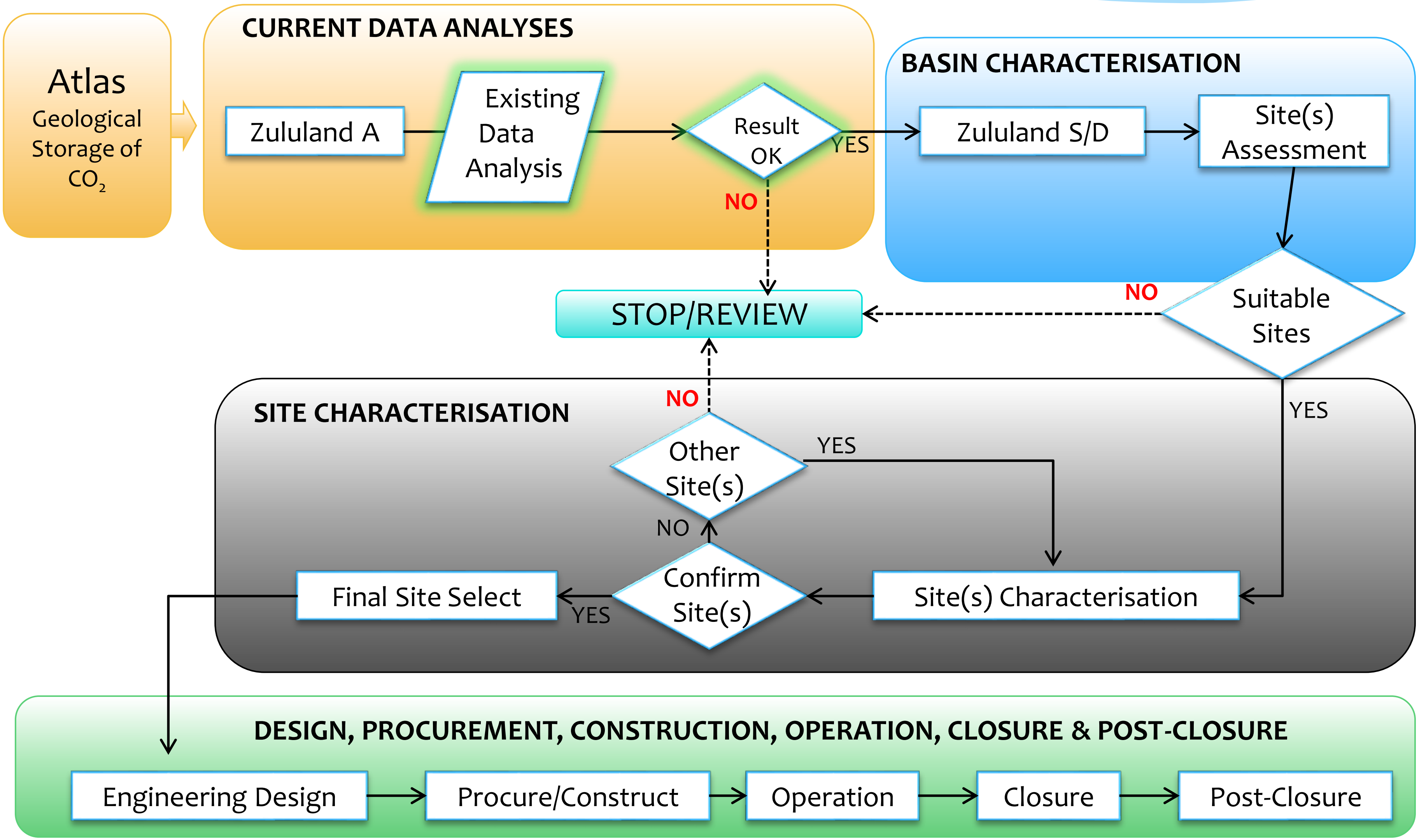
The Development of the Pilot CO2 Storage Project



Stakeholder Engagement

* Afford Stakeholders an opportunity to raise concerns / issues and make suggestions; and
* Treat them with respect.

Funding

- South African Government – Department of Energy

- World Bank CCS Trust Fund

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Offshore Assessment

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Potential for Carbon Dioxide Storage in South Africa

- Atlas indicated a Storage Potential:
  - 150 Giga tonnes
  - At an “effective level”
  - 98% off-shore

- Need:
  - 4 Giga tonnes
  - To store 40 million tonnes
  - For 100 years

Storage capacity (off-shore and on shore)

Based on the SACCCS Roadmap, the final part of the CCS programme in South Africa will be to implement a programme of Carbon Capture and Storage on a commercial scale. This will be at a Low Case involving 20Mt/a or a High Case involving 40Mt/a, beginning around 2025.

The purposes of this study was to identify Basins and Sub-basins that might be suitable for the storage of CO2 captured in the Commercial Operation.

The three main offshore basins considered were the Durban Zululand, the Outeniqua and the Orange basin. A number of sub basins in the Outeniqua Basin, the Bredasdorp, the Pletmos-Infanta and the Algoa-Gamtoos were also considered.

A screening exercise to assess the suitability of these Basins and Sub-basins was undertaken using the Bachu methodology, with the criteria adapted to the specific requirements of the Commercial Operation in the South African context.

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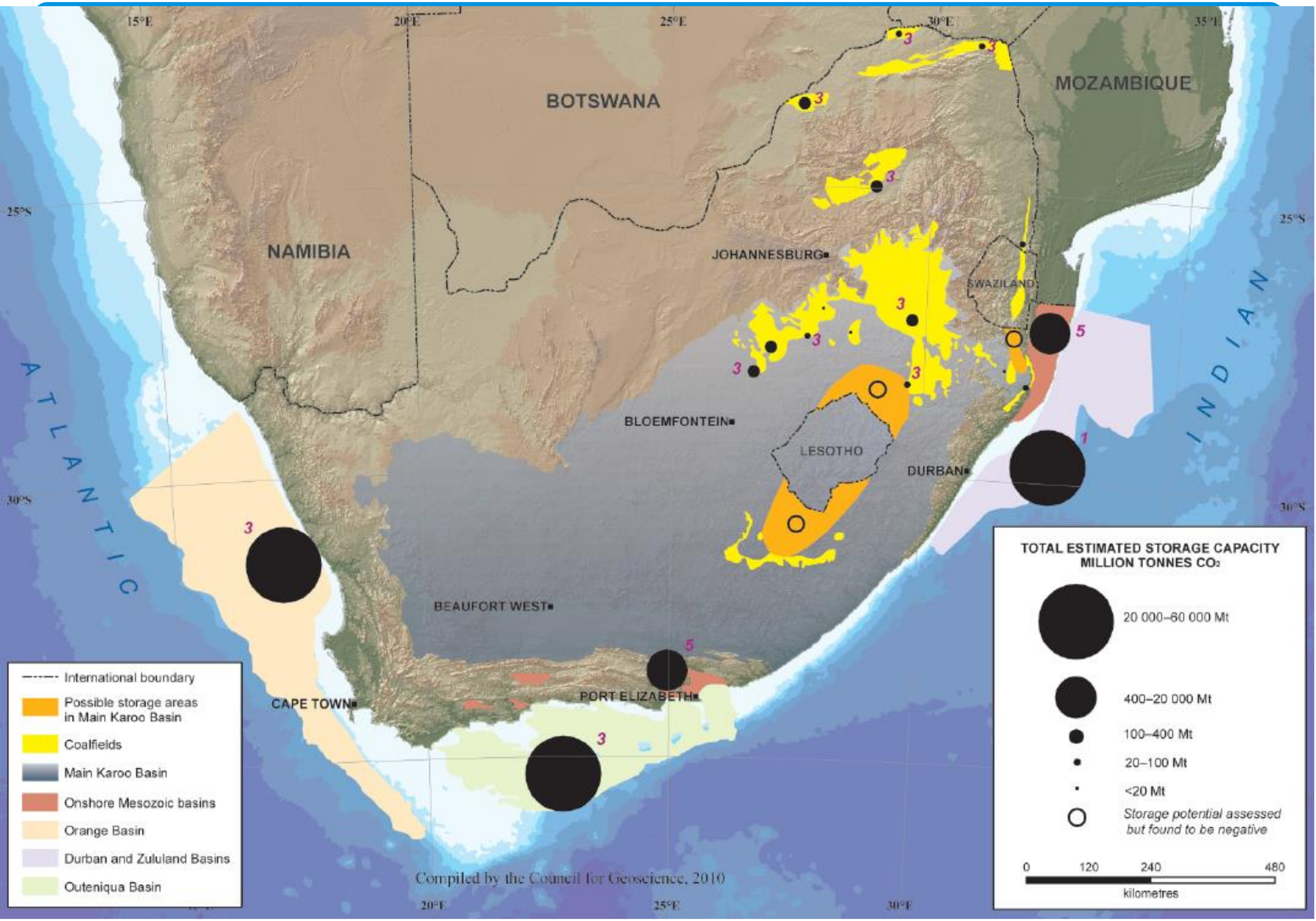
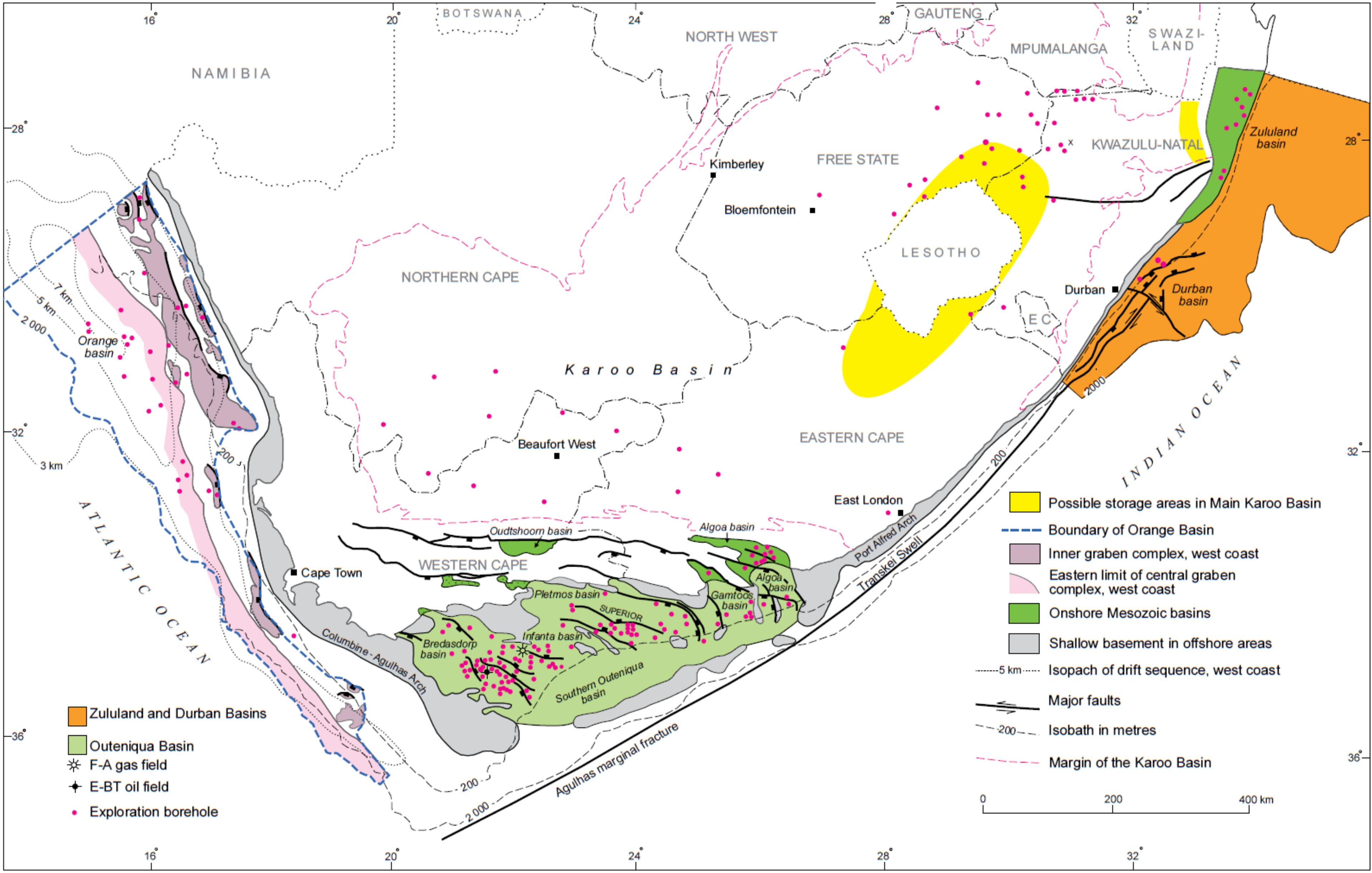


15°E
20°E
25°E
30°E
35°E
25°S
30°S
BOTSWANA
MOZAMBIQUE
NAMIBIA
JOHANNESBURG
SWAZILAND
BLOEMFONTEIN
LESOTHO
DURBAN
BEAUFORT WEST
CAPE TOWN
PORT ELIZABETH
ATLANTIC
INDIAN
International boundary
Possible storage areas in Main Karoo Basin
Coalfields
Main Karoo Basin
Onshore Mesozoic basins
Orange Basin
Durban and Zululand Basins
Outeniqua Basin
TOTAL ESTIMATED STORAGE CAPACITY MILLION TONNES CO2
20 000–60 000 Mt
400–20 000 Mt
100–400 Mt
20–100 Mt
<20 Mt
Storage potential assessed but found to be negative
0 120 240 480
kilometres
Compiled by the Council for Geoscience, 2010



Possible CO_2 storage opportunities in South Africa (Cloete, 2010, Viljoen et al., 2010)

Basin Screening and Ranking

- Based on Stefan Bachu (2003) methodology (commonly accepted by the CCS community)
  - Screening and ranking of sedimentary basins for sequestration of CO_2 in geological media in response to climate change
- Modified by CO2CRC in 2008
- Utilised and modified by Viljoen et al (2010)
- Modified by SLR for Nova Scotia, Baltic Sea and South Africa
- Study Commissioned by SACCCS and undertaken by SLR

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	Suitability Criterion	Suitability Threshold	Weight
1	Seismicity (Tectonic setting)	< High (i.e., not in subduction zones)	0.06
2	Size	> 2 500 km^2	0.06
3	Depth	> 800 m	0.07
4	Faulting intensity and dolerite dykes and sheets	Low to moderate	0.07
5	On-/Offshore	Onshore to shallow offshore	0.09
6	Reservoir: seal pairs	At least one major extensive and competent seal	0.08
7	Pressure regime	Not overpressured	0.05
		TOTAL	**0.46**

Minimum criteria for consideration of sedimentary basins for CO_2 Storage

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	Potential Criterion	Poor Potential	Good Potential	Weight
1	Hydrogeology	Shallow, short	Deep and/or long	0.08
2	Geothermal	Warm	Cold	0.09
3	Hydrocarbon potential	None	Large	0.08
4	Maturity	Poor	Mature	0.06
5	Coal seams	Too shallow or too deep	Between 400 and 1 000 m depth	0.04
6	Evaporites	None	Beds	0.01
7	Accessibility	Difficulty	Good	0.03
8	Infrastructure	None or poor	Moderate or developed	0.05
9	CO_2 sources	At >500 km distance	At <500 km distance	0.08
10	Coal rank	Anthracite - Lignite	Sub-bituminous - Bituminous	0.04
			TOTAL	**0.54**

Proposed secondary qualifiers for assessing potential of sedimentary basins for CO_2 storage

Criterion		Increasing CO_2 Storage Potential				
		Classes				
		1	2	3	4	5
1	**Seismicity (tectonic setting)**	Very high (e.g. subduction)	High (e.g., syn-rift, strike-slip)	Intermediate (e.g. foreland)	Low (e.g. passive margin)	Very low (e.g. cratonic)
2	**Size**	Very small (< 1000 km^2)	Small (1000 – 5000 km^2)	Medium (5000 – 25000 km^2)	Large (25000 – 50000 km^2)	(> 50000km^2)
3	**Depth**	Very shallow (< 300 m)	Shallow (300 – 800 m)		Deep (>3500 m)	Intermediate (800 – 3500 m)
4	**Faulting intensity**	Extensive		Moderate		Limited
5	**Hydrogeology**	Shallow, short flow systems, or compaction flow		Intermediate flow systems		Regional long-range flow systems; topography or erosional flow
6	**Geothermal**	Warm basin (>40ºC/km)		Moderate (30 – 40ºC/km)		Cold basin (<30ºC/km)
7	**Reservoir – seal pairs**	Poor		Intermediate		Excellent
8	**Coal seams**	None	Very shallow (<300 m)		Deep (>800 m)	Shallow (300 – 800 m)
9	**Coal rank**	Anthracite	Lignite		Sub-bituminous	Bituminous
10	**Evaporites**	None		Domes		Beds
11	**Hydrocarbon potential**	None	Small	Medium	Large	Giant
12	**Maturity**	Unexplored	Exploration	Developing	Mature	Super-mature
13	**Onshore / offshore**	Deep offshore		Shallow offshore		Onshore
14	**Climate**	Artic	Sub-artic	Desert	Tropical	Temperate
15	**Accessibility**	Inaccessible	Difficult		Acceptable	Easy
16	**Infrastructure**	None	Minor		Moderate	Extensive

Criteria for screening sedimentary basins or sub-basins for geological storage of CO_2 (CO2CRC, 2008)

Basins	Characteristics	Ranking
Bredasdorp Sub-basin	The Bredasdorp Sub-basin is a candidate for CO_2 storage based on its low seismicity (tectonic setting), favourable depth, limited faulting and fracturing, excellent reservoir/seals, hydrostatic pressure regime and regional long-range saline flow systems. The sub-basin has no evaporites.	0.74
Orange Basin	The offshore Orange Basin is a candidate for CO_2 storage based on its low seismicity (tectonic setting), favourable depth, limited faulting and fracturing, excellent reservoir seal pairs, hydrostatic pressures, regional long-range saline flow systems. The basin is unsuited for CO_2 storage because its inaccessibility, no infrastructure and no evaporites.	0.69
Durban Zululand Basin	The offshore Durban Zululand Basin is a candidate for CO_2 storage based on its low seismicity (tectonic setting), favourable depth, limited faulting and fracturing, hydrostatic pressures and regional long-range saline flow systems. The basin is unsuited for CO_2 storage because it is no infrastructure and no evaporites.	0.6
Pletmos-Infanta Sub-basin	The Pletmos-Infanta Sub-basin is a candidate for CO_2 storage based on its low seismicity (tectonic setting), favourable depth, excellent reservoir/seals, hydrostatic pressures and regional long-range saline flow systems. The sub-basin is unsuited for CO_2 storage because of its inaccessibility, no infrastructure and no evaporites.	0.57
Algoa - Gamtoos Sub-basin	The Algoa and Gamtoos Sub-basin is a candidate for CO_2 storage based on its low seismicity (tectonic setting), favourable depth, hydrostatic pressures and regional long- range saline flow systems. The sub-basin is unsuited for CO_2 storage because it is unexplored, inaccessibility, no infrastructure and no evaporites.	0.53

Conclusions

- Bredasdorp Sub-basin ranked the highest as it is the location of the offshore Mossel Bay oil and gas fields.
- Orange and Durban Zululand ranked relatively high, with the former scoring somewhat higher, possibly on account of the higher level of hydrocarbon exploration providing better data.
- Durban-Zululand Basin- favours the Durban Basin, as much more of the offshore Zululand Basin is in very deep water.
- The only viable option for the Commercial Operation is the offshore Durban Basin assuming sufficient storage capacity can be identified. The pipeline route is much shorter (550km) and has the advantage of existing pipeline corridor routes
  - Note:
    - If demonstration is needed to prove up commercial storage they will need to be at the same location

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Dynamic capacities

Individual sites	Code Names	Dynamic Capacity 30 years (Mtn) Low (P30)	Base (P50)	High (P70)	Utilisation
Durban & Zululand	DZL	2,000	4,000	6,000	Large
Onshore Zululand	OZL	30	40	60	Small
Orange	ORG	6,000	12,000	18,000	Large
S Outeniqua	STQ	900	1,200	1,500	Small
Bredasdorp	BRD	600	1,500	2,000	Small
Pletmos & Infanta	PLT	1,000	1,200	1,500	Small
Algoa & Gamtoos	ALG	200	400	600	Small
Onshore Algoa	OAG	50	90	120	Small
Total		10,780	20,430	29,780	

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Annual injections and injection rates

		Annual Utilisation Rate (Mtpa)			Well Injection Rate (Mtpa)		
Individual sites	Code Names	High (P30)	Base (P50)	Low (P70)	High (P30)	Base (P50)	Low (P70)
Durban & Zululand	DZL	110	110	110	0.10	0.25	0.50
Onshore Zululand	OZL						
Orange	ORG	210	210	210	0.25	1.00	2.50
S Outeniqua	STQ	5	5	5	0.25	0.50	1.25
Bredasdorp	BRD	5	5	5	0.10	0.50	1.25
Pletmos & Infanta	PLT	5	5	5	0.25	1.00	1.25
Algoa & Gamtoos	ALG	5	5	5	0.10	0.25	1.00
Onshore Algoa	OAG	5	5	5	0.25	0.25	0.25

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