Modelling Growth Scenarios for Biofuels in South Africa's Transport Sector

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in Collaboration with UNU-WIDER

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Outline

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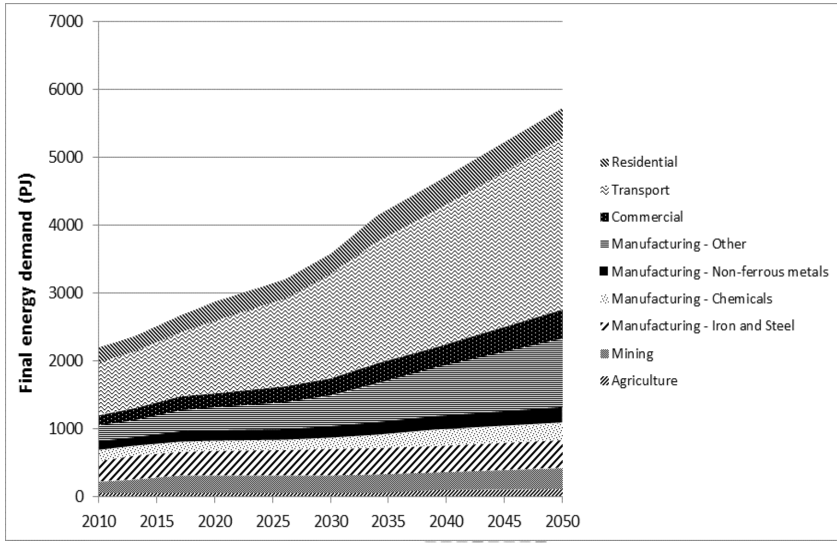
1. Purpose and Rationale

Purpose of this paper::

- Estimate the range of potential demand for biofuels in transport in South Africa till 2050
- Understand magnitude of land requirements and potential for trade

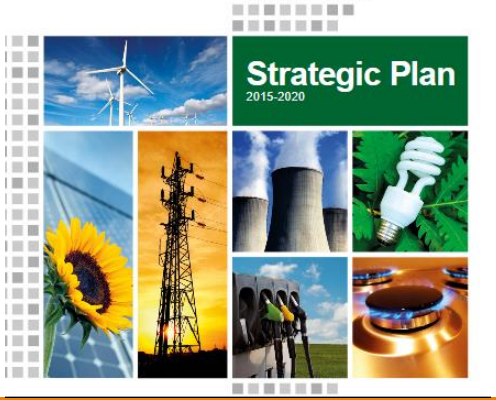


<u>Rationale</u>

1.. Transport in South Africa account 28% of final energy consumption. Options for decarbonising in transport sector?

2. In the medium term, demand for fuel is in South Africa , but neighbours have considerable production potential with resources of land and labour in the region Mozambique, Malawi and Zimbabwe

2015-2020 DoE Strategic Plan *"We would also look at opportunities of sourcing these [biofuel] projects from the SADC region to meet our demand"*

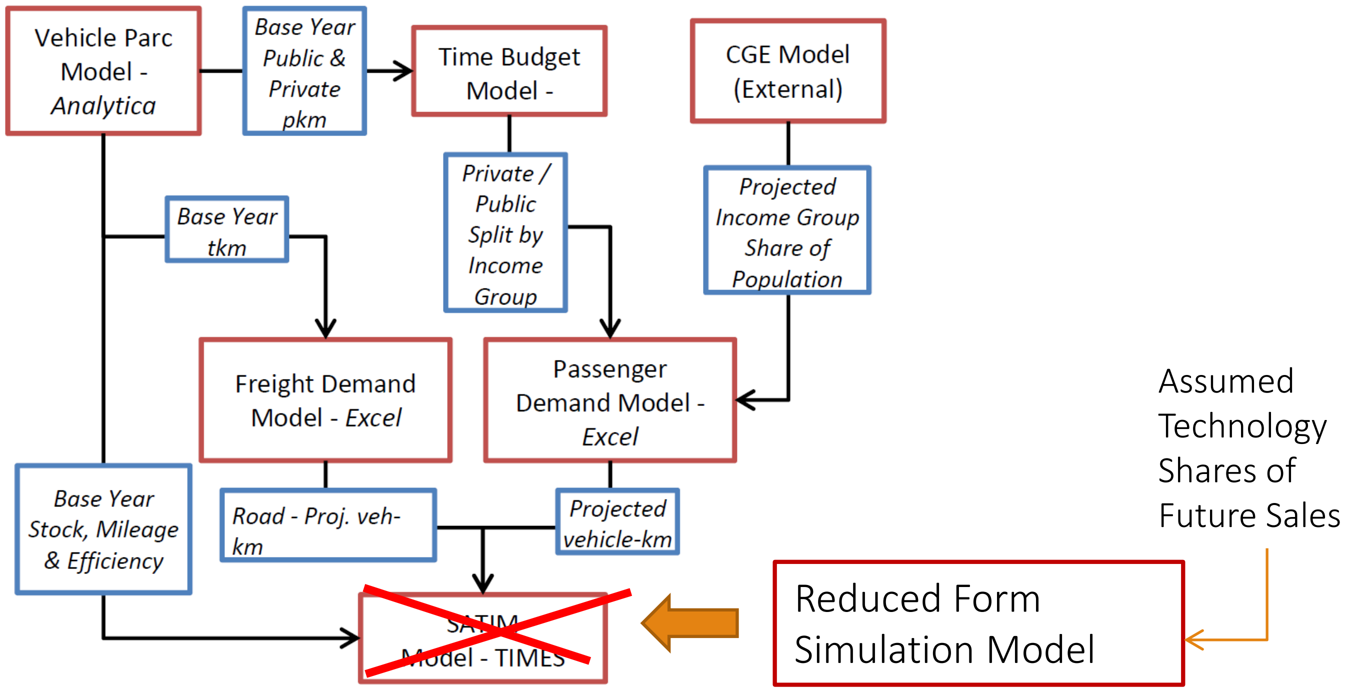


1. Background – Biofuels Policy Landscape

- Pre-2007 Research in early 2000s established that biofuels were viable in RSA under certain conditions (e.g. oil at US$65/bbl) and price support thereunder.
- 2007 - Official targets were set in 2007 - Biofuels Industrial Strategy - along with incentives: a 50% rebate on general fuel levy and accelerated depreciation of plant but failed to stimulate significant production
- 2012 The Mandatory Biofuels Blending Regulation (R671 of 2012) gasoline and diesel targets between <u>E2 and E10</u> for bio-ethanol and B5 for biodiesel. Promulgated to come into effect 1 October 2015 (R719 of 2013)
- 2014 - Draft Position Paper on the South African Biofuels Regulatory Framework, sets the pricing and subsidy mechanism - January 15, 2014
- Final Position Paper and thus final subsidy scheme is not released so developers won't risk capital. Construction times are around 2 years so deadline passed.
- 2015 – Fall in oil price led to revisiting the approach to the subsidy in August 2015 : from 'first come first serve' to competitive approach. No update on policy front since.

2. Methodology – Adaptation of SATIM framework

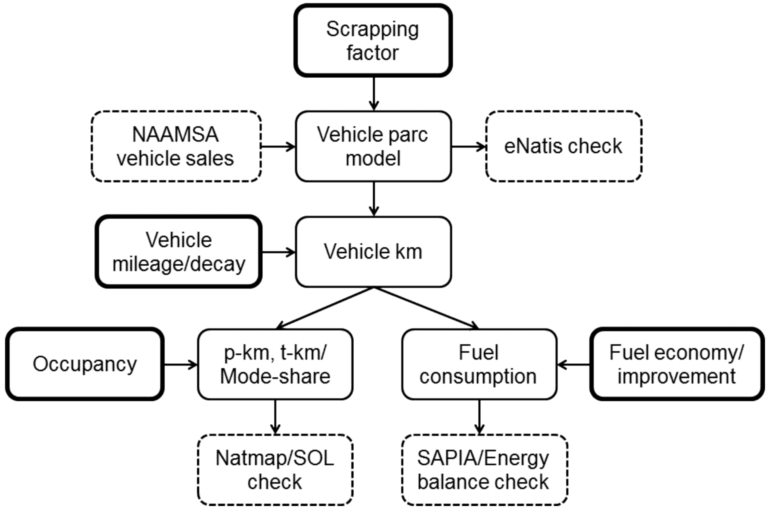
1. Growth in energy demand is driven by the exogenous demand for vehicle km as determined by the time budget model which takes assumptions from the CGE model.

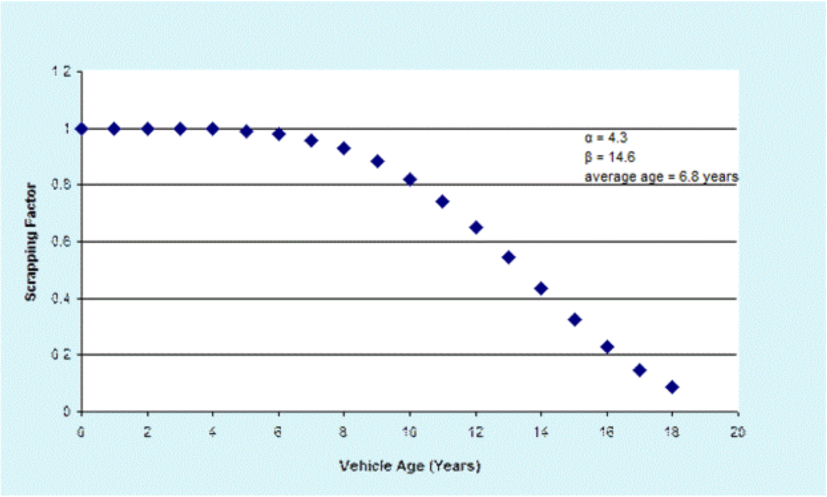


- See - Merven, B., Stone, A., Hughes, A., & Cohen, B. (2012). Quantifying the energy needs of the transport sector for South Africa: A bottom-up model. ERC Working Paper. Energy Research Centre (ERC), University of Cape Town.

2. Methodology – Features in Reduced Form Model

1. Includes scrapping factors for vehicles and annual mileage decay curves with age.
   - These assumptions are calibrated over 6 years vehicle parc model (backward looking)
   - The reduced form model (forward looking) is excel based and compacted to 5 year bins.
2. Additionally fuel economy can be deteriorated with age.
3. Growth in energy demand is driven by the exogenous demand for vehicle km as determined by the time budget model which takes assumptions from the CGE model.



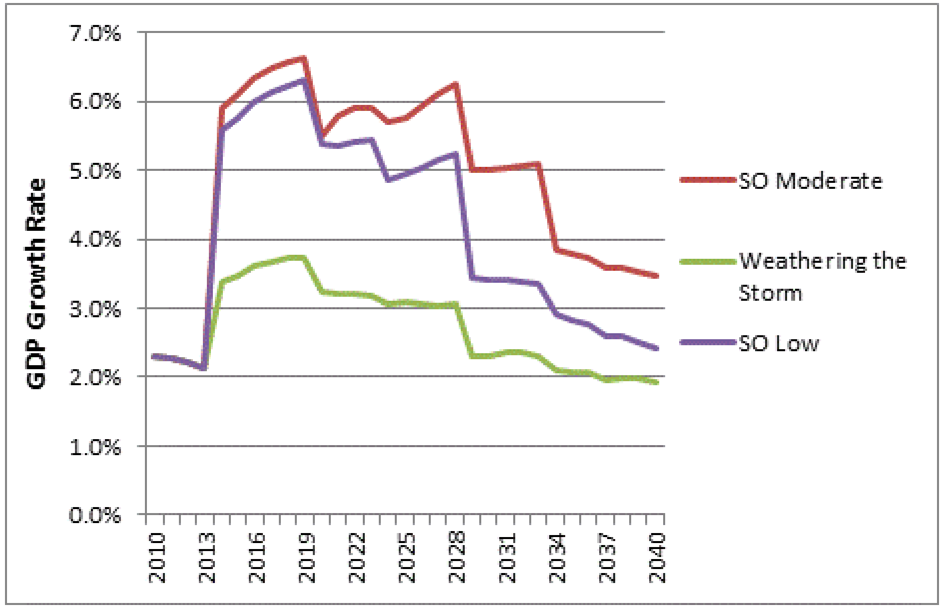


3. Assumptions around growth and demand for passenger transport

SATIM framework includes data on household incomes:

- Higher GDP=higher incomes=higher demand for passenger car use
- No behaviour-based switching onto public transport considered for this exercise
- Growth scenarios adopted from the national electricity expansion plan in the DoE's Integrated Resource Plan (IRP).

IRP scenario	2040 Growth (%)	2007–2040 Avg growth (%)
High- SO moderate	3.5	4.7
Medium SO low	2.4	4.0
Low - Weathering the storm	1.9	2.7



4. Scenarios - Technology Pathways

The technology pathways that were considered for biofuels to supply transport energy services were as follows:

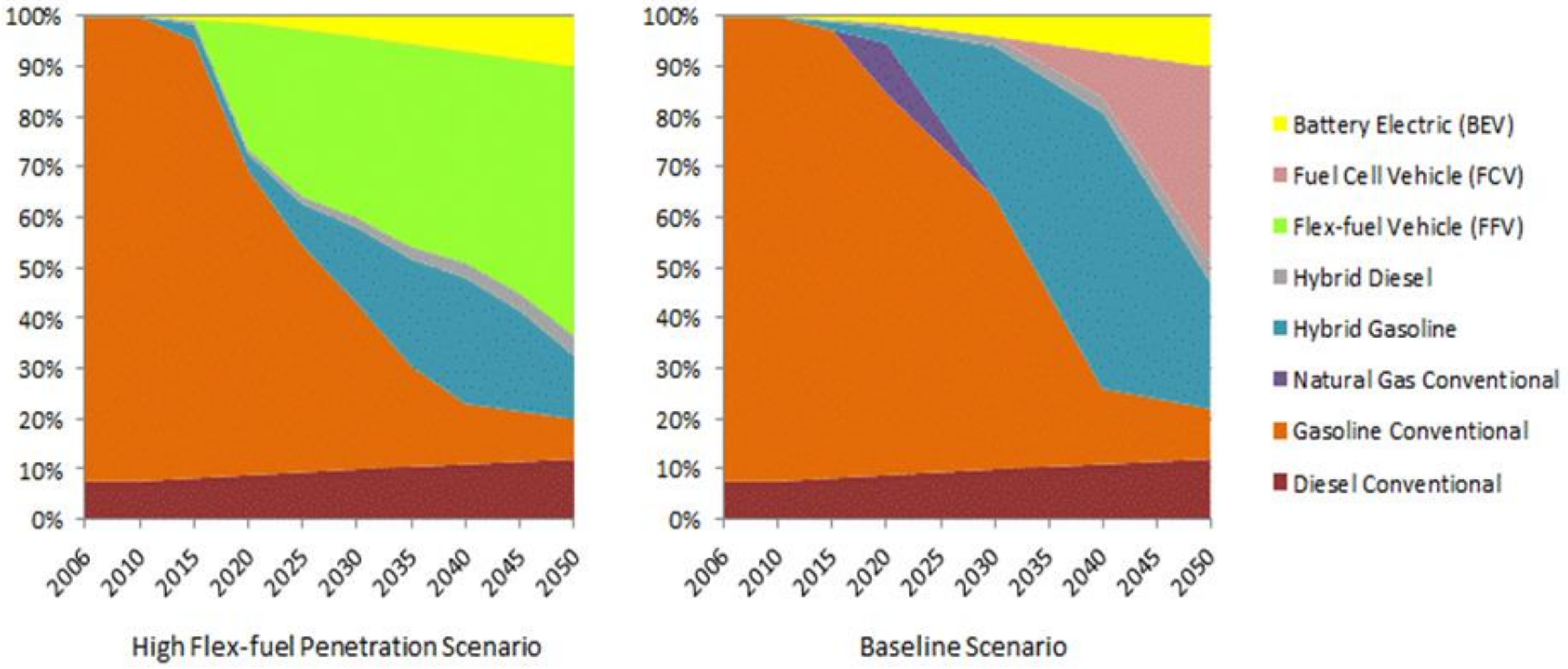
1. Conventional gasoline and hybrid engines fuelled by a blend of gasoline and between 2% bioethanol (E2) and 10% bioethanol (E10) as per R671. for **passenger** and **light freight vehicles**
2. Conventional diesel and hybrid engines fuelled by a blend of diesel with 5% biodiesel (B5) as per R671
3. So-called **flex-fuel** internal combustion technology fuelled by a blend of gasoline and 85% bioethanol (E85). These vehicles can operate on conventional gasoline and a range of ethanol gasoline blends but were assumed to use E85 exclusively.
4. Aviation biokerosene making up 10% of a blend with conventional aviation fuel .

4. Assumed Blend Penetration Rates of Biofuels into Gasoline, Diesel & Kerosene

Blend	2006	2010	2015	2020	2025	2030	2035	2040	2045	2050
Bio-Ethanol in Gasoline	0%	0%	0.5%	10%	10%	10%	10%	10%	10%	10%
Biodiesel in Diesel	0%	0%	0.5%	5%	5%	5%	5%	5%	5%	5%
Bio-kerosene in Aviation Kerosene	0.0%	0.0%	0.1%	10%	10%	10%	10%	10%	10%	10%

[1] This research was based on a version of SATIM with a 2006 base year. This therefore does not include 2010 energy balance data.

4. Scenarios – Technology Penetration (% of Sales)



4. Scenarios – Matrix

High Flex Fuel (FF) Penetration Scenario

- FF is 25% pass. car sales by 2020
- FF is 40% pass. car sales by 2035
- FF (E85) displaces electromobility technologies and conventional
- E10 & B5 in conventional

'IRP Weathering the Storm'
2.7% GDP Growth

'IRP SO Low'
4.0% GDP Growth

'IRP SO Moderate'
4.7% GDP Growth

Baseline Scenario

- Only E10 & B5 in conventional
- No Flex-fuel (E85)
- Electromobility technologies dominate sales after 2035

'IRP Weathering the Storm'
2.7% GDP Growth

'IRP SO Low'
4.0% GDP Growth

'IRP SO Moderate'
4.7% GDP Growth

'Low Ambition' Scenario

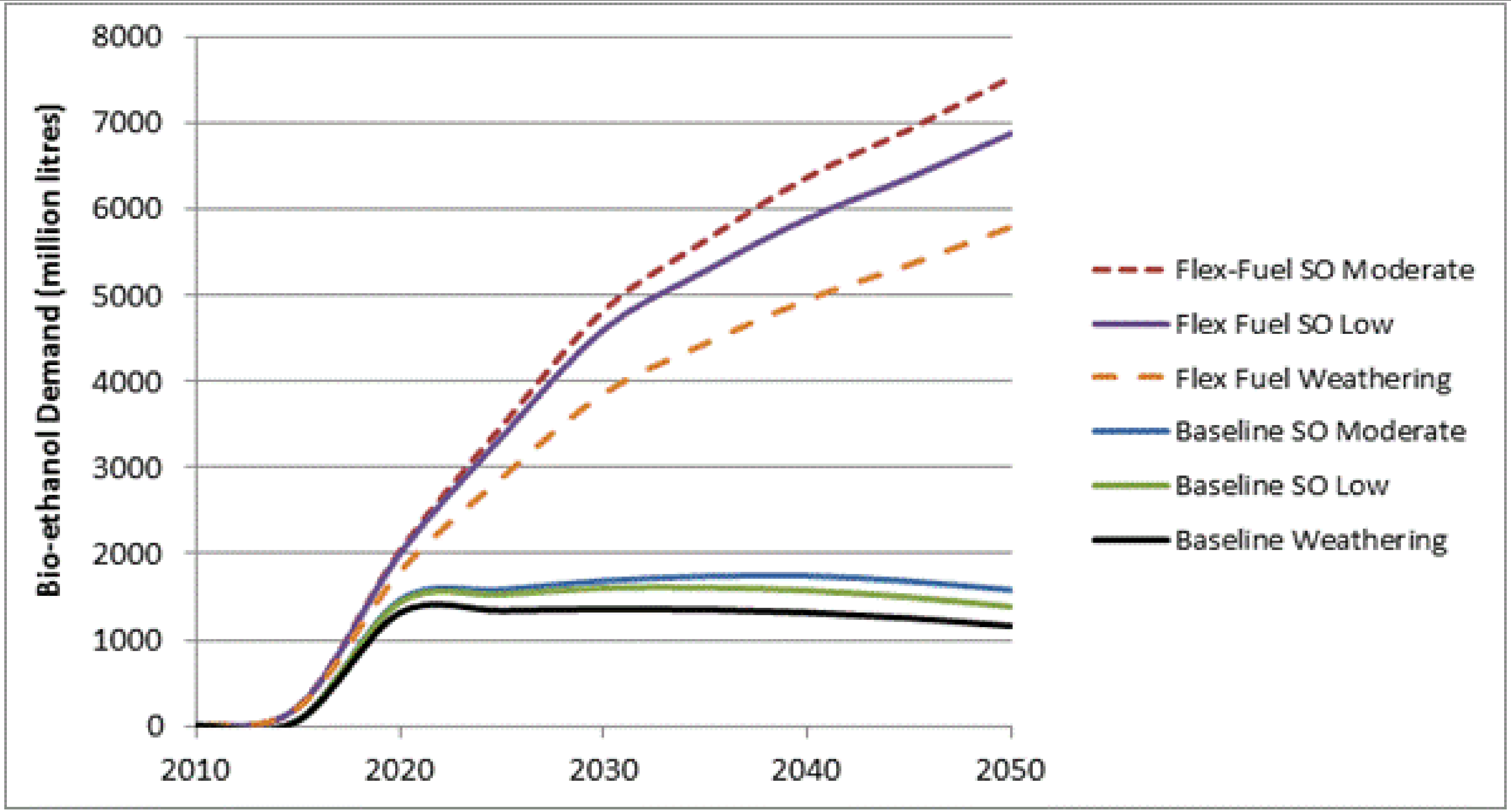
- Only E2 & B5 in conventional
- No Flex-fuel (E85)
- Electromobility technologies dominate sales after 2035

'IRP Weathering the Storm'
2.7% GDP Growth

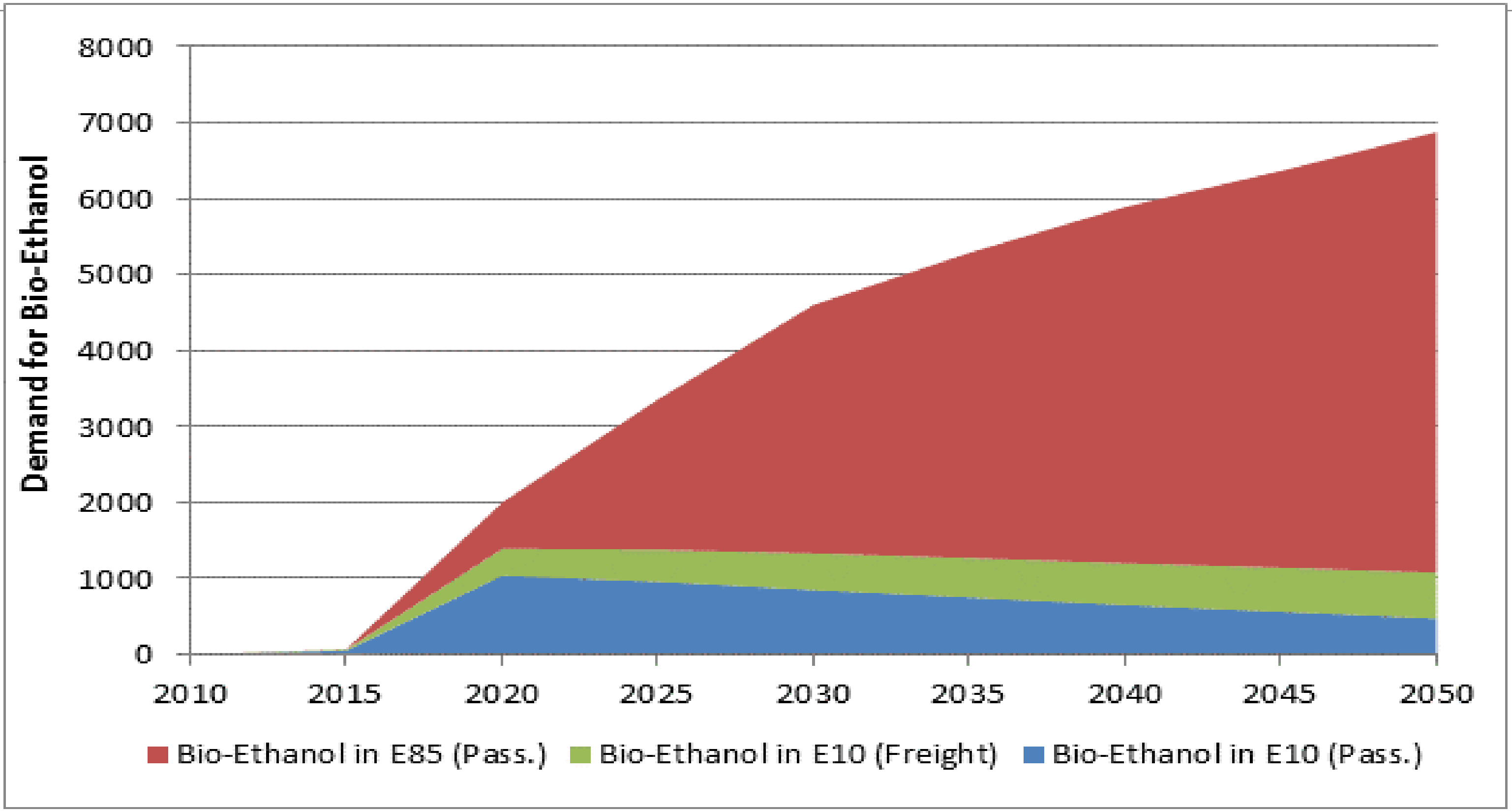
'IRP SO Low'
4.0% GDP Growth

'IRP SO Moderate'
4.7% GDP Growth

5. Results – High Flex Fuel Bioethanol vs Baseline

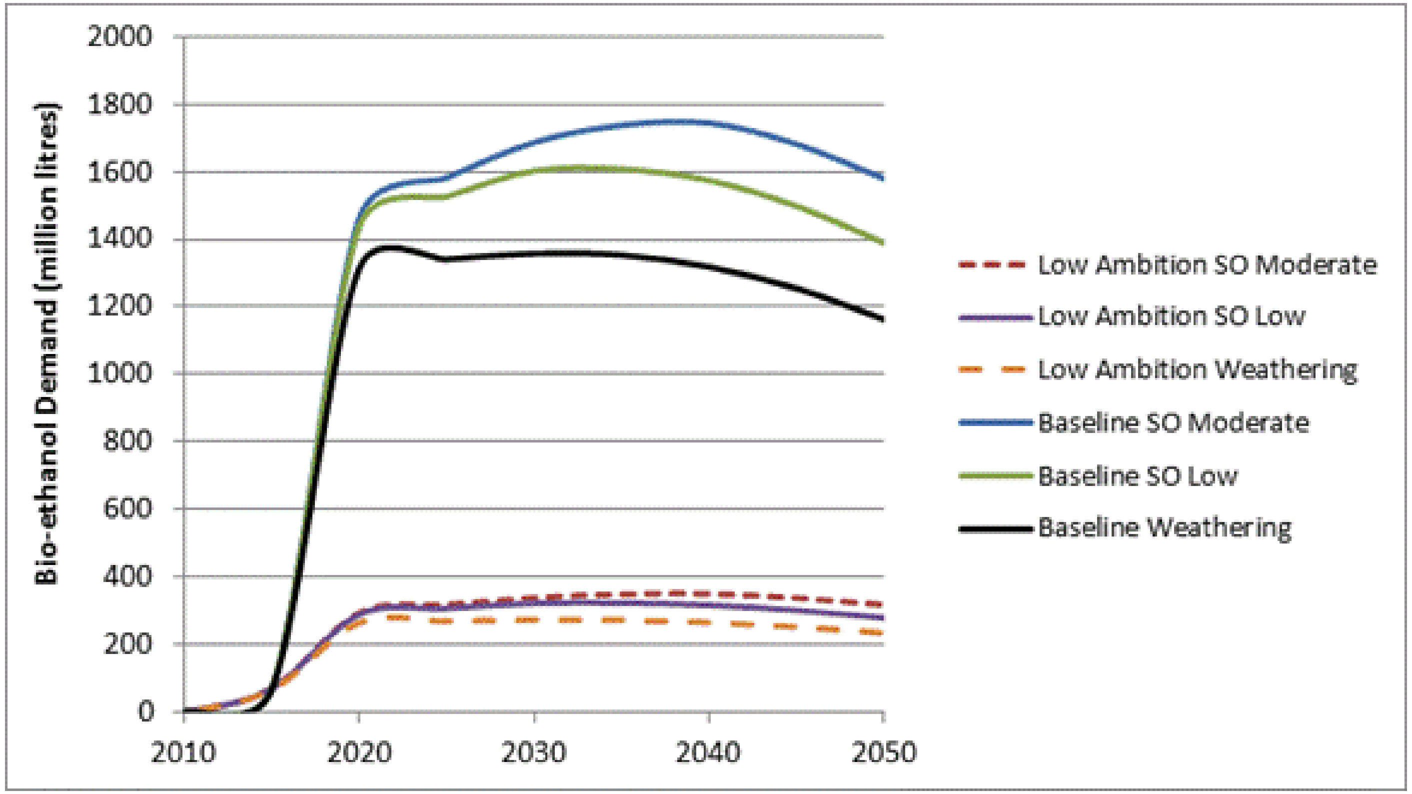


5. Results – High Flex Fuel Bioethanol by Mode



Demand for Bioethanol by Fuel Blend and Mode for the SO Low Economic Growth Case of the High Flex-Fuel Penetration Scenario

5. Results – Low Ambition Bioethanol vs Baseline



Estimated Demand for Bio-ethanol from Road Passenger and Freight Modes for the baseline scenario (E10) compared to Low Ambition Scenario (E2) for 3 economic growth scenarios

6. Findings (fuel)

- At E10 and zero E85, by 2035, bioethanol demand is expected to be between 1353– 1738 million litres c. 4-5x present expected volumes (c.400 million litres).
- Under mandated levels of consumption, biofuel use will peak at 6.5% (E10) of all fuel consumption between 2020-2030.
- Beyond meeting current mandates, important questions remain on penetration of flex-fuel cars, land use, trade and new technologies

6. Findings - Land Implications of Bioethanol Scenarios

Context - At present, the area under sugarcane production in South Africa is c.380,000 ha

14% of arable land lying fallow could potentially be utilised for 1st gen biofuels?

The Biofuels Industrial Strategy is more conservative assuming 300,000 hectares or 1.4% of arable land is required for an E2 policy

Under a zero E85 scenario i.e. meeting the blending requirements alone, South Africa will need to **either** divert large volume of sugar to biofuels, **or** import from abroad. If the market for flex-fuel cars develops, imports will be essential.

Area of land (has) under different economic scenarios in 2035			
	Weathering	So Low	SO Moderate
Low yield (7000 l/ha)			
Zero E85; E10 mandatory blend	193,286	228,571	248,286
High penetration of E85	634,429	742,857	805,571
High yield (10,000 l/ha)			
Zero E85; E10 mandatory blend	135,300	160,000	173,800
High penetration of E85	444,100	520,000	563,900

6. Conclusions

1. Substantial variation in demand for biofuels exists depending on evolution of transport sector and economic growth.

2. Main drivers of variation is whether flex-fuel vehicles are introduced or not;

3. With little change, demand for biofuels not expected to require large land change

4. But Significant flex fuel uptake will likely require imports from the region

Thank you

2. Methodology – Compacting the Parc Model

If we condense our time horizon into bins of size s and;

$N_{t,k,j}$ = The number of vehicles in technology segment t of vintage bin j still operating at the end year of bin k.

$VKM_{t,j}$ = The demand for vehicle km from service provided by technology segment t at end year of bin j

$\lambda_{t,n}$ =The scrapping coefficient technology segment t of age n

$M_{t,n}$ = The annual mileage of vehicles in technology segment t of age n

then:

$$N_{t,k,j} = \frac{VKM_{t,j} - \sum_{[i=1\ to\, j-1]}(N_{t,i} M_{t,i})}{\sum_{[n=1\ to\, s]}(\lambda_{t,n} M_{t,n})} \times \sum_{n=[s(k-j+1)-1]\, to\ s(k-j)]} \lambda_{t,n}$$

Without mode switching, VKM is driven by household income and population for passenger travel and by GDP with an elasticity of 0.8 for freight

1. IEA 2nd Generation Potential Study

Biofuel option	Production				Number of plants			
	Actual material flow		Unused residues		Actual material flow		Unused residues	
	million l_{ge}/yr*	PJ/yr	million l_{ge}/yr*	PJ/yr	Small scale**	Large scale**	small scale**	Large scale**
Based on primary residues								
Bio-SNG	4 680	156.8	375	12.6	252	34	20	3
BTL	3 297	110.4	264	8.9	30	8	2	1
Bioethanol	3 251	108.9	261	8.7	244	20	20	2
Based on secondary residues								
Bio-SNG	2 209	74.0	225	7.5	119	16	12	2
BTL	1 556	52.1	158	5.3	14	4	1	0
Bioethanol	1 534	51.4	156	5.2	115	9	12	1

Remark: Biofuel options are calculated using 100% of actual material flow and 100% of unused residues for each option.

* Assumed conversion factors – BTL: 217 lge/t_{DM}; ethanol: 214 lge/t_{DM}; bio-SNG: 307 lge/t_{DM}

**Based on typical plant sizes – Bio-SNG: 23-170 $MW_{biofuel}$; BTL: 130-500 $MW_{biofuel}$; bioethanol: 15-185 $MW_{biofuel}$ (DBFZ, 2008)

From Eisentraut, A. (2010). Sustainable Production of Second-Generation Biofuels Potential and perspectives i major economies and developing countries. Paris, France: International Energy Agency (IEA)

BTL – Biomass to Liquid Diesel