MAPS
Mitigation Action Plans & Scenarios

ENERGY MODELLING FOR LIQUED FUELS / GAS SUPPLY

A summary of the SATIM methodology

TECHNICAL // Fuels Supply

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Introduction

Petroleum refining (refining crude oil, natural gas and coal[1]) is an extremely complex process which deploys numerous discrete processing units operating in close interaction. These processing units produce a range of energy and non-energy products and have unique energy requirements (in the form of ancillary energy services). As a result caution needs to be exercised when modelling the operation of refineries. In the case of coal to liquids (CTL) and gas to liquids (GTL) refineries, the modelling process is complicated because these plants add a number of input commodities to the energy chain. Although the main interest of energy modelling is on energy inputs and outputs, it is crucial to include non-energy products like lubricants in the modelling process so that the energy they used can be accounted for in the model. The supply of gas by pipeline from neighbouring countries, by the import of Liquefied Natural Gas (LNG) or locally mined from shale gas deposits are competing options for industrial and even residential energy supply in South Africa. Including these primary energy supplies and the technologies like pipelines and terminals that could supply them is part of a current research project on this sector.

1 South African liquid supply industry uses coal, gas and crude oil as their feedstock

Purpose

Energy economy environment models such as TIMES are often used to look at opportunities and costs of reducing greenhouse gases (GHGs). The South African TIMES model (SATIM) has been developed for this purpose and its methodology is documented online. This document presents an overview of the SATIM liquid fuels and gas supply sector methodology. South Africa has one of the more diverse refining industries in the world, as its liquid fuels are produced from crude oil in conventional refineries and from coal and gas in so-called synthetic fuel refineries. The SATIM methodology is therefore a potentially useful reference for modellers in countries that produce their own liquid fuel supply.

The full SATIM methodology is available on the Energy Research Centre website http://www.erc.uct.ac.za/

Data assumptions

Public data for detailing the existing fleet of liquid fuel refineries is scarce and industry reports to which the Energy Research Centre have access (e.g. Lloyd, 2001) are now quite old. The planning of future infrastructure has also been a less public process in the semi-regulated privately owned liquid fuels sector than in the electricity supply sector which is dominated by a public company. Therefore there is not the same wealth of data for characterising future technologies in SATIM. Nevertheless, due to its importance the sector is modelled in some detail.

Model structure and modelling decisions

The SATIM modelling framework includes three process aspects of a refinery, namely energy (which considers energy commodities input and the associated energy products output), steam supply and non-energy output products. These basic process aspects are quantified in energy terms for the four types of refineries currently operating in South Africa modelled as distinct technologies.

- Refinery Crude Oil Coastal Existing (Sapref, Enref, Chevref refineries)
- Refinery Crude Oil Inland Existing (Natref refinery)
- Refinery GTL Existing (PetroSA refinery)
- Refinery CTL Existing (Secunda refinery)

The model also accounts for two future refineries, namely New CTL and New Crude Oil Refinery which are constrained in the model to come online in 2018 at the earliest, with a life span of 50 years. These future refineries are generic refineries included in the model to account for the shortfall of future liquid fuel supply. The New Crude Oil Refinery has emulated the capacity data for the planned Mthombo refinery to be in the Eastern Cape while the New CTL refinery has emulated the capacity data from the discontinued Mafutha CTL refinery project. The parameters used to model these refineries are summarised below:

- input and output commodities
- investment costs (new refineries only) and running costs
- refinery availabilities and efficiencies
- CO_2 & CH_4 emissions
- constraints on input and output shares (Lloyd, 2001)

The plant parameters in the model excluding the input commodities and product slate are presented in Table 1.

TABLE 1:
SUMMARY OF EXISTING AND NEW REFINERY TECHNOLOGY CHARACTERISTICS

		EXISTING TECHNOLOGIES			NEW TECHNOLOGIES		
	UNITS	CTL EXISTING (SASOL)	INLAND CRUDE EXISTING	COASTAL CRUDE EXISTING	PETROSA GTL	NEW CTL[1]	NEW CRUDE[2]
Capacity	bbl/day	150 000	108 000	405 000	45 000		
Capacity in terms of outputs	PJ/annum	246	212	874	59		
Overall efficiency	%	44	93	95	78	49	97
Availability	%	96	96	96	96	96	96
Plant life	Yrs					50	50
Running costs per unit of output[3]	mR/PJ	30	11	11	25	30	11
Investment cost[3]	mR/[PJ/annum]	0	0	0	0	305	66
Lev. cost of production (in 2006)	R/GJ	41	88	87	46	66	91

Lev. Cost of production (with IRP/100$/bbl)	R/GJ	57	128	121	95	80	129
CO_2 emissions	(kt/PJ)	118.88	6.87	2.90	0.00[4]	118.88	6.18
CH_4 emissions	(kt/PJ)	1.49	0.00	0.00	0.00[4]	1.49	0.00

1: Based on data for proposed Mthombo project
2: Based on data for proposed Mafutha project
3: mR: currency unit - million South African Rands
4: These are unknown but thought to be low

South Africa's LTMS

The Long Term Mitigation Scenarios (LTMS) was a cabinet-mandated process from 2005-2008, led by the then South African Department of Environmental Affairs and Tourism, to establish the evidence base for a national low carbon development path. Key to the process was its unique blend of facilitated stakeholder engagement and rigorous research.

The LTMS arose out of the realisation that South Africa would need to contribute its fair share to greenhouse gas mitigation. Greenhouse gas emissions in South Africa come mainly from energy use and supply. Moving to a low carbon development path would require a major shift in thinking and in action. Hence a blend of process and research was critical when assessing mitigation potential within the country. Having accurate numbers would build confidence, but equally important was that a wide range of key stakeholders within South Africa agreed that the numbers were credible.

The LTMS research was peer-reviewed and found to be of best practice. Reviewers recommended sharing the experience with other developing countries. From this recommendation the MAPS Programme was born. For more information see http://www.erc.uct.ac.za/Research/LTMS/LTMS_project_report.pdf.

As can be seen above, the CTL refinery technology has very high greenhouse gas emissions and low energy conversion efficiency but operates at a low cost of production because coal is locally cheap. This along with the dominance of coal in the electricity supply sector is one of the determining factors in South Africa's carbon intensive economy and presents both a challenge and an opportunity to mitigation initiatives. The model outputs for this sector will therefore be very sensitive to an emissions constraint.

The detailed data for technologies in this sector is available in the full methodology document.

Conclusion

The SATIM liquid fuel supply sector methodology will be useful for all countries that have identified significant mitigation potential in their liquid fuels and gas sector, particularly if a complex mix of technologies exists as is the case with South Africa.

References

CLloyd, P. (2001). The South African Petroleum Industry: A Review. Cape Town: Report by Industrial & Petrochemical Consultants (Pty) Ltd - selected extracts forwarded in personal communication by Philip Lloyd.

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MORE ABOUT MAPS

Mitigation Action Plans and Scenarios (MAPS) is a collaboration amongst developing countries to establish the evidence base for long term transition to robust economies that are both carbon efficient and climate resilient. In this way MAPS contributes to ambitious climate change mitigation that aligns economic development with poverty alleviation.

Central to MAPS is the way it combines research and stakeholder interest with policy and planning. Our participative process engages stakeholders from all sectors within participating countries and partners them with the best indigenous and international research.

MAPS grew out of the experience of the Government mandated Long Term Mitigation Scenarios (LTMS) process that took place in South Africa between 2005 and 2008. The LTMS, with its home-grown stakeholder-driven approach, its reliance on scenarios and the rigour of its research and modelling were key to its approach. The LTMS informed South Africa's position for Copenhagen and is the base of much of the country's domestic policy.

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