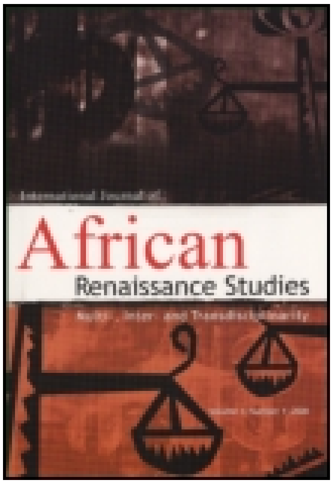

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Peak Oil as a stimulus for a green economy transition in South Africa: Alternative liquid fuel and transport options

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Peak Oil as a stimulus for a green economy transition in South Africa: Alternative liquid fuel and transport options

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Abstract

While the arguments in favour of a green economy often rest on the need to reduce environmental damage, mitigate climate change and create environmentally friendly jobs, this article argues that the inevitable and possibly imminent peak and decline in world oil production provides another strong rationale for green economy policies and investments in South Africa. The South African economy has a high degree of reliance on imported petroleum fuels and evidence suggests that oil price and supply shocks – resulting from diminishing world oil exports and a decline in the energy return on investment for oil globally – are likely to have a debilitating socioeconomic impact under business-as-usual policies and behaviour patterns. Two broad strategies for mitigating the impact of increasing world oil scarcity and oil price shocks are considered. The first evaluates the prospects for developing indigenous sources of liquid fuels, including coal-to-liquids, gas-to-liquids and biofuels, and finds that there are significant resource and environmental risks associated with these options. The second strategy involves short-term measures to reduce demand for liquid transport fuels together with a long-term shift toward electrified mass transport, supported by accelerated investments in renewable energy. The latter strategy is argued to be compatible with and necessary for a societal transition towards a green economy.

Key words: Energy security; green economy transition; liquid fuels; oil price shocks; peak oil; sustainable transport.

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Introduction

The concept of a 'green economy' has gained increasing traction both internationally and within South Africa since the global recession of 2008-2009. A popular definition provided by UNEP (2011: 16) sees the green economy as 'one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities'. Nevertheless, the concept has varied interpretations in the literature, which is a contested terrain (see Allen and Clouth 2012). By way of illustration, Death (2014) identifies four distinct green economy discourses, which vary in the degree of change they advocate for existing socio-political and economic systems. These four discourses are: *green revolution* (a radical reconfiguration of socio-economic structures in accordance with environmental limits and ethics); *green transformation* (a realignment of prevailing growth trajectories according to the principles of sustainable development such as those expounded in the Brundtland Report (WCED 1987); *green growth* (emphasising new markets and technological opportunities for improved economic efficiency); and *green resilience* (reactionary responses to threats posed by climate change and resource scarcity).

Conventional arguments in favour of a green economy include environmental issues (such as the need to mitigate and adapt to global climate change, conserve biodiversity and protect ecosystems) as well as social issues such as the creation of 'green' jobs in activities that help to preserve or restore environmental quality and promote decarbonisation (UNEP and ILO 2008). In this article we provide another strong rationale for green economy policies and investments in South Africa (and indeed the world at large), namely, the urgent need to reduce dependence on a (globally) depleting, non-renewable resource: oil.

Oil is the master resource that fuels the world economy, providing almost a third of global primary energy supply, supplying 95 per cent of the energy powering global transport systems, and providing feedstock for diverse petrochemical industries (IEA 2013). Since the Second World War, growth in the world economy has been strongly correlated with growth in oil consumption (Hirsch, 2008). Similarly, South Africa's transport system depends on liquid petroleum fuels for almost all of its energy supplies. The country currently relies on imports of crude oil and refined fuels for more than two-thirds of its liquid fuel needs, and the economy is vulnerable to global oil price hikes. If not adequately mitigated, the depletion of global oil supplies and in particular a looming decline in net world oil export volumes is likely to have very serious repercussions for South Africa's economy and society.

This article presents a partial summary of results and recommendations drawn from a doctoral dissertation which sought to address the dearth of attention given to this issue of oil dependence and vulnerabilities in South African energy, economic and policy discourses (see Wakeford 2012). The research has attempted to understand the implications of global oil depletion for the South African economy and to propose viable strategies and policies for mitigating and adapting to potential negative impacts, and thereby contribute towards a transition to a sustainable society and green economy.

The research is based on a multidisciplinary approach drawing on theories derived from ecological and biophysical economics, macroeconomics, and the literatures on societal transitions and sustainable development. The methodology involves primarily literature reviews and policy analysis, supported by analysis of secondary data drawn from publicly available international and local sources.

The remainder of the article is organised as follows. Section 2 provides an overview of the so-called 'peak oil' phenomenon, namely the inevitable (and possibly imminent) peak and decline in the rate of global oil production, and its implications for international crude oil prices. Section 3 focuses on South Africa's liquid fuel-related vulnerabilities and the likely implications of pursuing a business-as-usual pathway. Section 4 considers the main alternatives to reliance on imported petroleum, including options for domestic liquid fuel production and a shift to more energy-efficient and electrified transport systems. The concluding section interprets the oil depletion predicament as an important motivation for a societal transition towards a green economy that includes both 'transformation' and 'resilience' dimensions.

The peak and decline in world oil production

The International Energy Agency (IEA 2012) has forecast that global demand for oil could grow by 14% by 2035, with all of the net additional demand projected to come from emerging economies, driven almost entirely by increasing use of motorised transport for both passengers and freight. However, the historical trend of increasing supplies of oil cannot continue indefinitely. This is because oil (like other fossil fuels), having been formed in the geological past, is a finite resource subject to depletion (Aleklett and Campbell 2003). This finiteness necessarily implies that, at some point in time, the annual production of oil at a global scale must reach an all-time maximum and begin an irreversible decline (Hubbert 1956); in other words, oil output will rise to a 'peak' and thereafter decline inexorably.

The publication of a seminal article by Campbell and Laharrère (1998), warning of an impending peak in world conventional oil production early in the twenty-first century, sparked a vociferous debate in both public and academic circles (for a comprehensive review of the contesting positions see Wakeford 2012). Over the years, the debate has increasingly focused not on *whether* the peak will occur (as mentioned above this issue is unarguable), but *when* – and whether the precise timing will be determined by geological, economic or political events.

The peak oil phenomenon has already been observed to occur in the majority of individual oil producing countries and in large regions such as North America and Europe (Hirsch 2008; Sorrell et al. 2010). Considerable evidence suggests that the world is nearing the global oil production peak. Global new oil discoveries reached a maximum in the 1960s and have been on a declining trend ever since, despite remarkable improvements in exploration, drilling and extraction technologies, and record high prices in recent years (ASPO Ireland 2009). Annual world oil consumption has exceeded the annual volume of new discoveries every year since 1981. Indeed, the IEA (2012) states that conventional crude oil production – oil from wells accessed using typical drilling techniques – most likely reached its all-time peak in 2008.

In recent years there has been a slight increase in production of all liquid fuels, which includes unconventional oil, natural gas plant liquids (NGPLs – hydrocarbons such as ethane, propane and butane, which have limited uses and cannot be converted into diesel fuel for transport), coal-to-liquids, gas-to-liquids and biofuels in addition to conventional crude oil. Nevertheless, the average annual supply increase of 0.4 mbpd between 2005 and 2013 has been substantially below the trend increase of 1.2 mbpd recorded between 1983 and 2005, despite the record high prices which have acted as a strong incentive for oil companies to boost exploration and production.

Much of the new oil brought on-stream in recent years has come from unconventional resources such as Venezuela's heavy oil, Canada's oil sands, and shale or 'tight' oil from the United States (IEA 2012; Wakeford 2012). All of these unconventional oil resources require special extraction and refining techniques. Technically recoverable resource estimates for unconventional oil vary widely but are generally very large. However the *economically recoverable reserves* are substantially smaller than total geological resources. Furthermore, the crucial issue is actually the annual *flow rate* of production, rather than the size of the reserves. This flow rate is constrained by a number of economic, physical and environmental factors. First, the hugely capital intensive nature of these production processes means that marginal production costs for unconventional oil are much higher than those of conventional oil. Secondly, the environmental impacts of unconventional oil production are significantly worse than those of conventional oil: the fresh water demands are much greater, the carbon dioxide (CO_2) emissions can be up to twice as high per barrel of oil, and hydraulic fracturing and oil sand production may pollute fresh water sources (Hughes 2011). Thus Aleklett (2012) likens unconventional oil reserves to a large tank with a small tap. For example, Aleklett (2012) notes that the oil industry itself does not expect production from Canada's oil sands to exceed 5 mbpd by 2030, up from approximately 1.2 mbpd in 2011 (see also Soderbergh et al. 2007). Thus while unconventional oil production has allowed total world oil production to continue to expand slowly in recent years while conventional oil output has stagnated, it has come with a substantially higher economic and environmental cost. Furthermore, these unconventional sources are unlikely to offset the depletion of conventional oil production for more than a few years (Robelius 2007; Aleklett et al. 2010). Two independent reports based on analysis of data from thousands of 'tight oil' fields in the US came to the conclusion that tight oil production is likely to peak around 2017 and decline rapidly thereafter (Hughes 2013; Zittel et al. 2013). Several analysts are warning that the global production of all types of oil might begin to decline by the end of this decade (e.g., Aleklett et al. 2010; Sorrell et al. 2010; UKITPOES 2010; Hirsch et al. 2010). The post-peak rate of decline in oil production could be between two and five per cent per annum, depending on a complex combination of geological, economic and political factors (Hirsch 2008).

Not only is the quantity of oil available on world markets set to diminish, but the quality of available oil (e.g., ease of access and refining) is also deteriorating. This is principally because the easier to access oil deposits, typically discovered decades ago, are being rapidly depleted and the frontier for new oil has moved into more remote areas such as deep off-shore wells, polar regions and unconventional oil sources, that are economically more costly and technically more difficult to access and process (Gagnon, Hall and Brinker 2009). Thus the energy return on (energy) investment (EROI) for oil, which measures the ratio of energy delivered by the process of oil exploration and extraction to the energy input, is diminishing in the world as a whole and in most individual countries (Guilford et al. 2011). Furthermore, the EROI for unconventional oil resources such as oil sands and shale oil (as well as most biofuels) is estimated to be less than 5:1 (Murphy and Hall 2010). Thus the net energy surplus (i.e., the energy output minus the energy input) yielded by oil is set to decline at a faster rate than the gross energy delivered by oil. This will put further upward pressure on oil prices.

For net oil importing nations such as South Africa, and for international crude oil prices, the quantity of oil traded on international markets is of more immediate significance than total world oil production. World oil exports constituted approximately half of total world oil production in 2010 (EIA 2014a). Data from the United States Energy Information Administration (EIA 2014a) show that world oil exports reached a peak of 43.4 mbpd in 2005, and had declined to 40.0 mbpd by 2009 before recovering slightly to 42.8 mbpd in 2010 (see Figure 1). This declining trend in world oil exports is arguably the most important reason for the steep rise in oil prices since 2005. It is highly likely that world oil exports have passed their all-time peak because domestic consumption of oil is on a rising trend in most oil-exporting countries, driven by growing populations and/or rising incomes. The rate of decline of world oil exports is likely to steepen once global oil production begins its terminal decline, and could be further accelerated if exporters withhold oil for economic or political motives (Hirsch 2008).

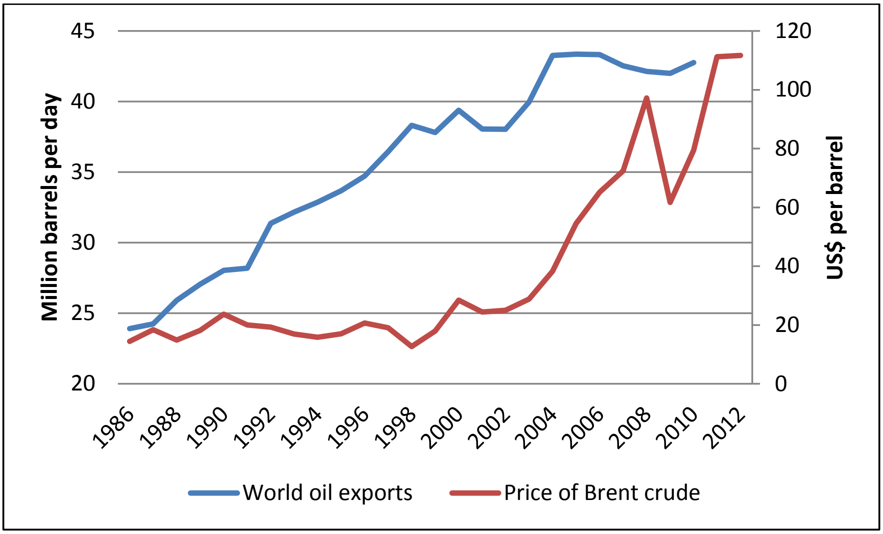

Figure 1: World oil exports and crude oil price (Source: BP [2013] and EIA [(2014a])

Growing oil scarcity has potentially stark implications for the global economy. Two recent International Monetary Fund (IMF) research papers that modelled the interactions of rising demand and geological oil supply constraints warned that the price of oil could rise to at least $200 per barrel (measured in 2012 dollars) by 2020 with potentially devastating economic effects (Benes et al. 2012; Kumhof and Muir 2012). Indeed, the historical record shows that international oil price spikes and temporary supply shortages have had serious negative economic impacts in many oil importing nations, resulting *inter alia* in higher rates of price inflation, slower economic growth, deepening poverty and food insecurity, debt crises, and in some cases civil unrest (see Wakeford 2012, for a review of literature on the economic and social implications of peak oil). In the light of these risks, the next section examines South Africa's oil vulnerabilities.

The international literature contains a diversity of recommended responses to peak oil, often in combination with responses to other environmental and social challenges. One strand urges societies to adapt to 'the end of growth' (Heinberg 2011), or to pursue 'prosperity without growth' (Jackson 2009) or even 'de-growth' (Kallis et al. 2012). Another strand of the literature focuses on the 'transition town' movement, which advocates local, community-led initiatives to build resilience to global (oil and other) shocks (Hopkins 2008; 2012). This article takes cognizance of South Africa's status as a developing country in which a substantial portion of the population still lacks access to many basic goods and services, and thus searches for national-scale resilience and green growth opportunities, as discussed later in this article.

South Africa's oil dependencies and likely impact of oil shocks

This section details the ways in which the South African economy and society depend on oil, and highlights the risks of continuing reliance on imported oil by summarising the results of empirical and historical evidence on the economic impacts of oil price shocks.

Petroleum consumption

Oil comprised nearly 15 per cent of South Africa's total primary energy supply (TPES) in 2011, while refined petroleum fuels constituted the largest share (32 per cent) of total final energy consumption (IEA 2014). Some three quarters of petroleum products are burned by the transport sector, which depends on liquid fuels for 98 per cent of its energy requirements (the balance being supplied by electricity). Agriculture is also heavily dependent on petroleum fuels, which satisfy two-thirds of the sector's energy needs. Many poor households rely on paraffin for illumination and to some extent cooking. Total annual sales of petroleum products grew largely in line with the economy in the period 1994 to 2012 (see Figure 2). However, petroleum product consumption fell steeply from 2008 as a result of sharply rising oil prices as well as rising costs of living and higher interest rates. The recession in 2009 significantly dampened demand for diesel, consumption of which fell by 6.6%. After rebounding strongly in 2011, total petroleum product consumption declined slightly in 2012, mainly due to rising fuel prices.

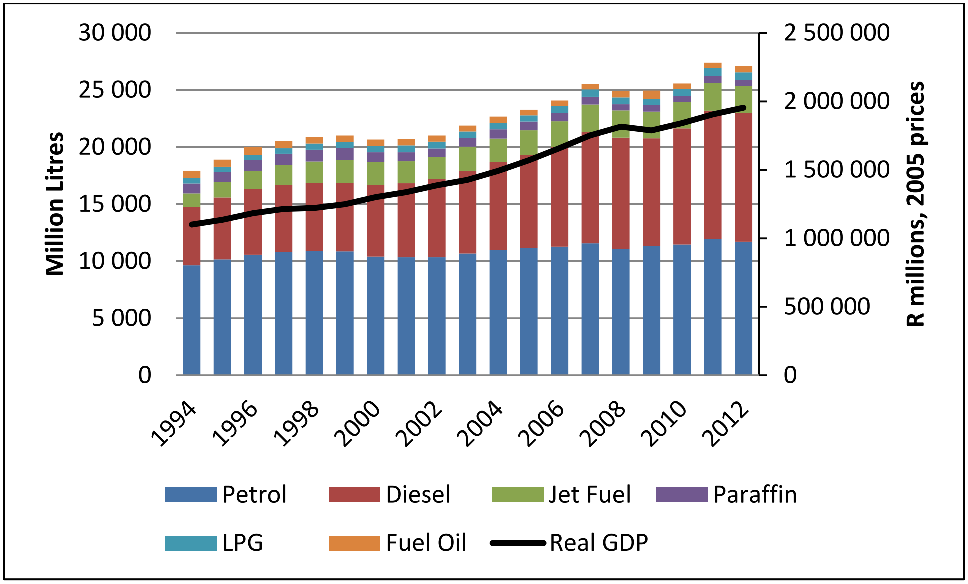

Figure 2: Annual total petroleum product sales and real GDP 1994-2012 (Source: SAPIA [2013] and SARB [2013])

Liquid fuel imports

Imported crude oil and refined products contributed approximately 70% of South Africa's annual consumption of petroleum products in 2013 (EIA 2014b). The remainder was derived from Sasol's coal-to-liquids (CTL) synthetic fuels (26%) and state oil company PetroSA (4%), which produces gas-to-liquid (GTL) synthetic fuels and a very small amount of domestic crude oil. South Africa's crude oil reserves stood at a meagre 15 million barrels as of January 2014 (EIA 2014b), and are likely to be depleted within a few years in the absence of significant new oil field discoveries. Historically South Africa has relied mainly on members of the Organisation of Petroleum Exporting Countries (OPEC), and in 2013 some 90% of South Africa's crude oil imports were supplied by Saudi Arabia, Angola and Nigeria (EIA 2014b).

Impact of oil price shocks on fuel demand and the economy

South Africa is a price taker on the international oil market. Domestically, the downstream liquid fuels industry is subject to extensive government regulation. Prices of petroleum fuels (petrol, diesel, paraffin and LPG) are administered by the Department of Energy, which imposes various levies and taxes and determines retail and wholesale margins, over-and-above a ‘basic fuel price’ (BFP). The BFP is benchmarked on the international spot price of refined oil, and is also influenced by the rand/dollar exchange rate. Sasol and PetroSA’s synthetic liquid fuels are accorded the same status in the domestic market as fuels that are refined from imported crude oil, so domestic fuel production provides no buffer against the impacts of oil price spikes or currency depreciation. If the price of crude oil rose to $200 per barrel and the rand maintained an exchange rate of R10 per dollar, the local price of petrol would rise to approximately R20 per litre (Wakeford 2012).

Wakeford (2012) used econometric models to estimate the price and income responsiveness (elasticity) of the demand for petrol and diesel in South Africa. In the short run (less than a year), petrol and diesel demand is very unresponsive to prices (elasticities close to zero), while the income elasticity of demand for diesel is nearly unity (i.e., a 1% increase in real gross domestic product (GDP) is associated with an approximately 1% increase in demand for diesel, other things being equal). In the long run (i.e., more than one year), the petrol price is moderately responsive to price and income (an elasticity of -0.5), while diesel demand is still price inelastic but is even more responsive to changes in income (GDP) than it is in the short run. Hence a doubling in the price of petrol could reduce demand for this fuel by 50 per cent after a few years, while a substantial contraction of diesel demand would require an economic recession (as occurred in 2009).

On the basis of a review of historical oil price shocks, Wakeford (2012) shows that there are two major transmission channels whereby international oil price hikes impact on South Africa. One is an indirect channel via the slowing down of global economic growth and consequent dampening of foreign demand for South Africa’s exports. This in turn tends to reduce the rate of economic growth and slacken demand for liquid fuels in South Africa. The second transmission channel is the direct impact of higher fuel prices on the economy. Overall, oil price shocks such as that experienced in 2007-2008 tend to result in higher transport costs, rising price inflation, and slowing GDP growth. This pattern can be expected to hold for future oil price shocks as long as the economy proceeds along a business-as-usual path of petroleum dependence. If the quantity of available world oil exports declines in coming years, the world oil price is likely to continue to rise (albeit with heightened volatility). This will in all likelihood slow the global and local rates of economic growth and compound the already high levels of unemployment and poverty.

There are two fundamental strategies for weaning South African society off imported oil. One is to develop domestic sources of liquid fuels to substitute for imported crude oil; however in most cases this would continue dependence on finite fossil fuels. The other strategy, which would form part of a green economy transition, is to embark on a transformation of the transport sector to improve efficiencies and to gradually replace internal combustion engine vehicles with electrified mass transit powered increasingly by renewable energy sources. These two options are discussed in the next two sections, respectively.

Developing domestic liquid fuels to substitute for imported oil

South Africa's state-owned oil company PetroSA currently produces approximately 1,800 barrels per day of crude oil from its Oribi and Oryx oil fields off the southern tip of the country (PetroSA 2014). Although oil exploration is continuing off the western and southern coasts, no new oil discoveries have been announced to date (as of August 2014) and therefore there is no expectation of a notable increase in domestic crude production within the next five to ten years at least. Hence, we consider this below the prospects for expanding domestic production of coal-to-liquids, gas-to-liquids and biofuels.

Coal-to-liquids

Sasol currently supplies approximately 26% of South Africa's annual liquid fuel demand from its coal-to-liquid (CTL) plant at Secunda. The major advantage of CTL is that it is a reliable technology with a proven track record, as evidenced by Sasol's multi-decade history of producing synthetic petroleum fuels (synfuels) including petrol, diesel and jet fuel, which can be used in existing transport infrastructure. Expanding domestic CTL production would therefore reduce South Africa's dependency on oil imports and save foreign exchange.

Sasol has investigated the feasibility of constructing a new CTL plant at the Waterberg coal field in Limpopo Province (Sasol 2010: 20). Named Project Mafutha, the proposed plant would have a capacity of 80,000 barrels of liquid fuels per day, about half of Sasol's current synfuel production volume. Sasol indicated that it would not be the sole investor in such a large scale project, which was estimated to cost in the region of R160 billion, and the company sought financial support from government (Njobeni 2010). In 2008 Sasol signed a Memorandum of Understanding with the Industrial Development Corporation for a planned investment in the project (Sasol 2010), and the company also held investment talks with the departments of Trade and Industry and Minerals and Energy. According to Sasol, Project Mafutha would likely take up to 10 years to complete.

Construction of a new CTL plant faces several risks and would entails costs other than purely financial costs. First, such a project would be viable only if sufficient coal feedstock could be secured for the lifetime of the project. While the Waterberg coal field is relatively underutilised, South Africa's remaining coal reserves are the subject of much contention. The official government figure for reserves was revised downward greatly from over 50 gigatonnes (Gt) to under 30 Gt in 2007 (GCIS 2007). However, recent research casts doubt on even this latter figure. Rutledge (2011) estimates that remaining recoverable coal reserves in Southern Africa (the vast majority of which are in South Africa) may be as low as 15 Gt. Using 'Hubbert curve' modelling, Hartnady (2010) forecasts a peak in domestic coal production at about 284 million tonnes per annum (mtpa) in 2020.

On the other hand, Eskom's demand for coal for electricity generation is set to rise by approximately 30 mtpa (to feed its new Medupi and Kusile power plants) to a peak of around 155 mtpa in 2021, thereafter declining as old power plants are decommissioned (Eberhard 2011). Meanwhile, the coal industry has plans to increase exports from about 65 mt in 2010 to over 90 mt by 2020 (Eberhard 2011). The proposed Mafutha CTL plant would require approximately 25 million tonnes of additional coal per annum. If the conservative coal production forecasts noted above turn out to be accurate, then coal production in the country as a whole will not be able to rise sufficiently to meet projected growth in demand by Eskom, other domestic users, exports and a new CTL plant. Trade-offs amongst these competing uses of coal would have to be made at some point, and domestic coal prices would likely rise considerably. Under these circumstances, it might make more sense for the Waterberg coal to be used to maintain electricity production from existing power plants rather than to feed a costly new CTL plant. Some of this electricity could be used to power transportation such as electric trains and electric vehicles (see the next section).

The second risk to building a new CTL plant is that, even if sufficient feedstock were procured, the energy return on investment (EROI) for CTL is very low and the EROI for coal mining declines over time as the quality of ore grades diminishes, hence raising production costs. Third, expansion of domestic synfuel capacity would come with high environmental costs in the form of water and air pollution, including additional greenhouse gas (GHG) emissions, which contribute to climate change. In view of South Africa's climate mitigation commitments under the Copenhagen Accord of 2009, Sasol may be required to install carbon capture and storage (CCS) technology at a new CTL plant, which would raise its costs considerably. Costs of CTL fuels would also rise as a result of the carbon tax which the National Treasury intends to implement from 2015. A fourth risk is that CTL facilities require large quantities of water, which is an increasingly scarce resource in Southern Africa in general, and in the Waterberg area in particular (Hartnady 2010). Finally, the pollution resulting from coal mining and combustion can also have negative impacts on human health, such as respiratory diseases (Spalding-Fecher and Matibe 2003).

In view of these risks, especially carbon pricing, and because of the present unaffordability of the projected financial costs, Sasol has shelved Project Mafutha. The government has also made no provision for a new CTL plant in its National Infrastructure Plan (PICC 2012). Given the substantial lead times required for new investments of this scale, it is probably safe to assume that no new CTL plant will be built in South Africa for the remainder of this decade at least. In any event, a new CTL facility would take South Africa in the opposite direction from a green economy transition and would seriously militate against environmental sustainability objectives such as reducing GHG emissions.

Gas-to-liquids

PetroSA produces liquid fuels including petrol and diesel using natural gas feedstock at its gas-to-liquids (GTL) refinery at Mossel Bay. Maximum production capacity is

45,000 barrels per day (bpd) of synfuels, although in recent years actual production has been curtailed to about half of this owing to maintenance issues and gas feedstock supply constraints (PetroSA 2013). The existing gas fields in the Bredasdorp basin are rapidly depleting and the company has thus been under considerable pressure to find additional feedstock. In March 2011 the PetroSA Board authorised *Project Ikwhesi*, namely the development of the previously discovered F-O gas field, located 40 kilometres from the existing F-A production platform (PetroSA 2014). The F-O field is expected to extend the life of the GTL plant till at least 2018. PetroSA is also conducting further exploration activities off the country's southern and west coasts, but has not as yet announced any new discoveries.

There are at least three other potential sources of natural gas that could supply feedstock to the Mossel Bay GTL refinery or possibly even a new GTL plant (which could be built by either Sasol or PetroSA): imported gas; shale gas; and underground coal gasification. In recent years there have been very substantial discoveries of conventional natural gas off-shore of Namibia (notably the Kudu gas field just north of the South African border) and especially Mozambique (near its northern maritime border with Tanzania). Theoretically a pipeline could be built to transport gas from either of these countries to South Africa, although the government has not seriously investigated the economic feasibility of such an investment. On the other hand, PetroSA (in collaboration with state-owned electricity utility Eskom) is exploring the feasibility of importing liquefied natural gas (LNG) to sustain its GTL plant beyond 2018 (PetroSA 2014). LNG has to be transported in special tanker ships and then re-gasified before it can be used onshore, which would require costly new infrastructure. Although LNG prices have in the past been quite closely correlated to oil prices, the development of shale gas in North America over the past few years has softened world LNG prices. The major existing markets for LNG are Japan, South Korea and Europe, while new markets are developing in China and India. Thus if South Africa does pursue the LNG option, it will have to compete on the global LNG market, which is expected to expand considerably in the coming decade (IEA 2012).

Another potential source of feedstock for GTL plants, albeit highly contentious, is shale gas. In April 2011 the South African Cabinet placed a moratorium on shale gas exploration and appointed an inter-departmental task team to investigate the economic, social and environmental implications of shale gas development. The Working Group on Hydraulic Fracturing delivered its report in July 2012 (DMR 2012), and the report was subsequently endorsed by the Cabinet. A study commissioned for the U.S. Energy Information Administration (EIA 2011) indicated that South Africa may have potential for shale gas deposits in the Karoo Basin amounting to 485 trillion cubic feet (Tcf) of technically recoverable resources. However, the Working Group stated that 'owing to the limited amount of available data in the area, it is impossible to quantify the resource accurately, other than to say that it is potentially very large'. An updated report from the EIA (2013) downgraded the TRR estimate for South Africa to 390 Tcf, citing geological complexities. Experience from the United States (Berman 2010; Hughes 2011) and other countries suggests that the commercially viable portion of shale gas resources is likely to be much smaller than the technically recoverable resource. Furthermore, serious concerns have been raised about potential negative social and environmental side-effects related to water and air pollution and fugitive emissions of methane, a powerful greenhouse gas (Howarth et al. 2011; Hughes 2011). Of particular concern is the limited availability of and possible contamination of fresh water, which is a very scarce resource in the Karoo area.

In September 2012 the Cabinet endorsed the lifting of the 18-month moratorium on shale gas exploration upon the recommendations of the task team. However, as of this writing the prohibition on hydraulic fracturing has remained in place while an appropriate regulatory framework is being developed. According to the Working Group report (DMR 2012: 29), ‘It may take ten or more years for a successful project to progress from the issuing of an exploration right, through the drilling of a discovery well, the drilling of a number of appraisal wells, the development of an economic feasibility plan, the application for and issuing of a production right, the drilling of production wells and the installation of the pipeline infrastructure before gas is delivered to the end user’. Therefore, the potential of shale gas to contribute to the energy supply in South Africa remains uncertain. It seems unlikely to play a meaningful role this decade, but could potentially have a major impact on domestic energy markets after 2020. If a commercially recoverable resource of say 30-40 Tcf were established, this could sustain PetroSA’s current operations and possibly provide feedstock for new GTL facilities. While there is opposition to shale gas development from some civil society groups that are concerned about various environmental and social impacts, the government has expressed a strong desire to proceed with exploration.

A third source of feedstock for GTL could potentially come from a process called underground coal gasification (UCG), a process whereby coal is ignited *in situ* underground, fed through a borehole by air or oxygen to yield a synthetic gas (syngas). The syngas can in theory be used for electricity generation, for the production of synthetic liquid fuels or for industrial uses (Shafirovich and Varma 2009). UCG is claimed to have several advantages, such as: (1) the utilisation of otherwise uneconomical resources; (2) the avoidance of costs incurred for transporting coal; and (3) the avoidance of health and safety risks associated with traditional mining (Shafirovich and Varma 2009; Eskom, 2010). Nonetheless, there are various disadvantages and risks attached to UCG, such as GHG emissions and concerns about possible underground water contamination and land subsidence (ibid.). Eskom has a small pilot UCG plant in operation at its Majuba power station in Mpumalanga but UCG has yet to be proven on a commercial scale, and thus is a highly uncertain potential contributor to gas supplies in SA. In any event, since the coal fields are located in the northern parts of the country while PetroSA’s GTL refinery is in the southern Cape, costly pipeline infrastructure or a new GTL plant would be required to convert coal gas into liquid fuels.

In conclusion, it is reasonably assured that PetroSA will continue to produce GTL from its Mossel Bay refinery until about 2018 using gas from the southern Cape off-shore fields. Beyond that, there are various possibilities for continuing – and possibly even expanding – GTL production from domestically produced gas (if new conventional fields are discovered or if shale gas is found and developed), or from imported pipeline gas or LNG. However, each of these options would require costly infrastructure investments and could have seriously detrimental environmental side-effects. None of these gas options can truly be considered as part of the green economy since they rely on depleting, non-renewable fossil energy resources that carry multiple environmental risks.

Biofuels

In December 2007 the South African government approved a *Biofuels Industrial Strategy* (DME, 2007). The Strategy excluded maize as a feedstock for ethanol (citing food security concerns), advocating instead grain sorghum, sugar cane and sugar beet. The Strategy also proposed that biodiesel be produced from soya beans, canola and sunflower oil. The target for biofuel penetration was set at 2% of liquid road fuels by 2013, in an initial five-year pilot phase. In August 2012 the Department of Energy gazetted regulations pertaining to the Mandatory Blending of Biofuel with Petrol and Diesel in South Africa; the mandatory implementation date has been set as October 2015. The regulations stipulate that bioethanol must comprise between 2% and 10% of petrol on a volumetric basis, while diesel should have a minimum concentration of 5% of diesel volumes.

Obstacles to the development of biofuels in South Africa thus far have included the following factors: low levels of awareness about the opportunities inherent in biofuels; technical challenges; food insecurity concerns; difficulties accessing financing; human capacity constraints; and an uncertain policy and regulatory environment (Amigun et al. 2008; Chakauya et al. 2009: 174). Although large-scale production of biofuels may now become viable under the new regulations, the constraints imposed by water and land scarcity suggest that it is unlikely that biofuels will make a significant contribution to national liquid fuel supplies beyond what is envisaged in the blending regulations, i.e. approximately 5% of current liquid fuel demand. Moreover, international studies have shown that the energy return on investment (EROI) ratios for biofuels are generally very low (Murphy and Hall 2010).

For the longer term, there may be scope for so-called ‘second-generation’ biofuels, such as cellulosic ethanol, which utilises non-food crops, agricultural waste and wood chips as feedstock (Woodson and Jablonowski 2008), and biodiesel produced from algae (Rhodes, 2009). The problem with cellulosic ethanol is that there is no ecological ‘free lunch’: for arable land to remain fertile, a significant proportion of the nutrients contained in the ‘waste’ must be returned to the soil – the more so when synthetic fertilisers become relatively scarcer and more costly. These second generation technologies are still in the research and development stage and high costs have thus far prohibited their commercialisation, which may take a decade or more.

In summary, it appears as if none of the potential sources of indigenous liquid fuels can adequately substitute for imported oil within the next decade at least. Given the environmental and human health concerns surrounding coal-to-liquids and shale gas, and the uncertainty over reserves of these hydrocarbons, greener alternatives must be sought for reducing oil import dependence. While the biofuel value chain has been identified by the Department of Trade and Industry (2014) as a promising green economy initiative, mainly because of its job creation potential, water and soil constraints plus low EROI ratios are likely to severely limit the amount of net energy delivered by biofuels. The following section accordingly examines the demand side of the oil equation.

Reducing demand for liquid fuels in the transport sector

Rather than investing tens of billions of rands in new infrastructure to produce (mostly fossil fuel) substitutes for imported oil, a much cheaper and quicker alternative is to introduce policies and measures that reduce demand for fuel by encouraging greater energy conservation and efficiency. For long-term sustainability, our liquid fuel based transport system needs to be replaced by one that is powered by renewable electricity. These two strategies for reducing the transport sector's reliance on imported oil are both compatible with the principles of a green economy as they seek to reduce reliance on non-renewable resources and to improve resource (especially energy) efficiency, with the added benefits of reducing environmental impacts such as greenhouse gas emissions and other forms of pollution.

Fuel conservation and efficiency

As transport consumes the lion's share of petroleum fuels, this sector must be targeted for demands for reduction. Fortunately, there is a wide array of measures than can reduce fuel consumption substantially in the short- to medium-term, which do not require substantial outlays for infrastructure (Wakeford 2012). The simplest way to save fuel is through eco-driving techniques, such as use of correct gears, avoiding unnecessary acceleration and braking, appropriate inflating tyres, and adequately maintaining vehicles, which together may yield fuel savings of approximately 5% (IEA 2005). These measures can be encouraged by information campaigns, although individual behaviour is not easy to change unless supported by economic incentives; fortunately, rising fuel prices will assist in this regard. One of the most cost-effective measures for significant fuel savings is car-pooling, which can be fostered by the allocation of dedicated car pool lanes on highways and/or congestion charges in city centres. Traffic management measures – such as reducing road speed limits and imposing selective driving bans in cities – are generally a quick, relatively cheap and effective means of reducing fuel use (IEA 2005). Local governments can partner with companies to encourage telecommuting and compressed work weeks, while the provision of safe cycle lanes can encourage commuters to leaves their cars at home. Similarly, the most cost-effective measures for reducing oil consumption in freight transport are those requiring little new infrastructure and which can be implemented relatively easily in the short to medium term, such as improved vehicle maintenance, optimised routing and scheduling, and intelligent traffic management solutions (Lane 2009).

Another way of reducing fuel consumption over the medium to longer term is to incentivise consumers and businesses to buy more efficient motor vehicles. This can be achieved through the introduction of a 'feebate' system, whereby extra taxes are imposed on larger, 'gas guzzling' vehicles while rebates are provided on purchases of more fuel efficient models. In addition, government can impose fuel efficiency standards on vehicle manufacturers. Even greater reductions in liquid fuel use can be achieved through the replacement of internal combustion engine vehicles (ICEVs) with alternatives like battery electric vehicles, hybrids and plug-in hybrid vehicles. However, replacement of the vehicle fleet will take decades (Wakeford 2012) and require a large capital expenditure on the part of households and firms – money that could be spent more effectively if transport is revolutionised more dramatically.

Electrified mass transport

The quantitatively largest opportunities for reducing oil dependence are presented by modal shifts from private motor vehicles to public transport such as buses, trains and trams in the case of passengers, and from road to rail in the case of freight (Gilbert and Perl 2008). When fully loaded, these mass transport modes are considerably more energy-efficient than private vehicles and airlines (Wakeford 2012). The bus rapid transit systems that are being developed in several cities are a step in the right direction, but need to be accelerated and ideally, electrified. The R123 billion budgeted over the coming 18 years for the upgrade of passenger rail rolling stock is also welcome (Anderson and Allix 2012), but again needs to be accelerated. While this may sound like a large amount of capital investment, it is trivial compared to the roughly R65 billion spent by households on private passenger vehicles each year (SARB 2012). Taxes on vehicles sales and subsidies for public transport can address this imbalance and inefficiency in societal expenditure patterns. However, successfully attracting passengers from cars to public transport will also require improvements in the provision of public transport services, in terms of speed, reliability, regularity, safety and security, convenience, comfort and costs. What South Africa arguably does not need is more investment in airports and airplanes. Triple digit oil prices are already exacting a heavy toll on airline companies, several of which have gone bankrupt in recent years, partly as a result of surging fuel costs. In the case of freight, there is great scope for shifting bulk loads from trucks travelling on the main corridors (e.g., Gauteng-Cape Town and Gauteng-Ethekwini) to railways. Transnet's R300 billion capital expenditure programme is welcome, but much of this is geared towards expanding mineral export lines, rather than general freight. Again, a reallocation of expenditure away from widening highways towards upgrading rail infrastructure would help to reduce the risks of oil dependency.

Certainly, the gradual electrification of both passenger and freight transport will place increasing demand on the national power utility Eskom and independent power producers, which are already struggling to meet the country's power demands. However, electric drive trains are much more energy efficient than internal combustion engines (Kendall, 2008), so there will be net energy savings over the long term, as well as greater transport energy security. Critically, future revisions of the Integrated Resource Plan for electricity generation must take account of growing demand from the transport sector. Much of the additional power generation could come from renewable energy sources like solar and wind, but these suffer from various problems such as intermittency and in some instances low EROI (Hirsch et al. 2010; Murphy and Hall 2010). And yet there are potential synergies to exploit: perhaps the most promising scenario is a marriage of renewable electricity production with integrated smart grids and plug-in hybrid vehicles that act as a storage mechanism for intermittent energy sources (see Rifkin 2011). What seems likely is that transport is set to undergo a fundamental revolution in the coming decades, with grid-connected electric vehicles replacing stand-alone ICEVs (Gilbert and Perl 2008).

Energy and transport transitions typically take decades to unfold (Gilbert and Perl 2008; Fouquet 2010). A scenario for achieving 100% fuel savings in South Africa after 40 years through a range of mitigation measures is illustrated in Figure 3. Each of the 'wedges' represents the percentage of 2010 transport fuels that could be saved through the implementation of groups of fuel saving measures. The various wedges are added vertically to indicate the potential total fuel savings. Some interventions will take longer to implement than others. Savings from eco-driving are assumed to phase out as the current internal combustion engine vehicle fleet is replaced by electric-powered vehicles and mass transit. See Appendix G in Wakeford (2012) for detailed assumptions and data.

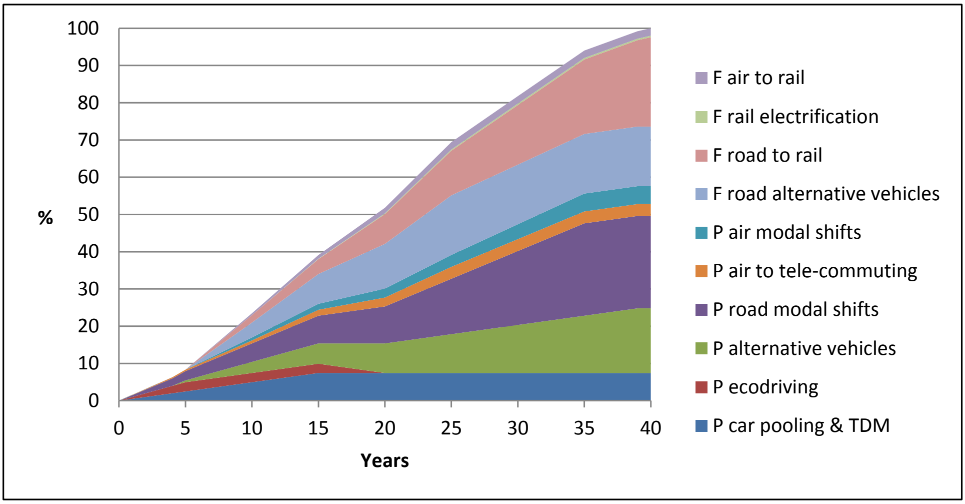

Figure 3: Potential fuel savings in the transport sector (Source: Wakeford [2012])
Note: P= passenger
F= freight
TDM= travel demand management

Conclusions

Over the past several decades South Africa has structured its human settlements and economic systems on the basis of an ever-increasing availability of affordable petroleum fuels. However, the evidence is now clear that the era of cheap and abundant oil is over. The world faces a future of increasing oil scarcity and oil prices are likely to rise further and become increasingly volatile as net world oil exports and the energy return on investment for oil decline in the coming years and decades. Given the critical role played by transport systems in the economy, and the almost total reliance on liquid petroleum fuels for passenger and freight transport, the socioeconomic system is highly vulnerable to the effects of global oil supply disruptions and price shocks. There is an urgent need to chart a new course towards energy independence and more sustainable transport systems. In short, peak oil presents a strong and urgent motivation to pursue green economy policies and practices.

Climate change and other pollution concerns, together with uncertainty over the quantity and quality of remaining coal reserves, demand that the nation eschew additional coal-to-liquid production. Shale gas and its potential to feed gas-to-liquid refineries, looks set to remain a highly contested issue given environmental and health concerns, and in any event will likely do nothing to shield the country from oil shocks within the next decade at least. South Africa may be able to tap into its neighbours' natural gas deposits, but will face stiff international competition for these resources. Biofuels are unlikely to contribute more than a token fraction of liquid fuel demand owing to constraints on arable land and water supplies, which will be increasingly necessary to meet the population's food security needs. Reducing oil import dependence, therefore, requires much greater energy efficiency and conservation in transport systems. This can be achieved in a myriad of ways, the most important being a shift of bulk freight from roads to railways and a massive expansion of public transit in cities. In addition, transport systems should be progressively electrified, bearing in mind that this will require large additional investments in new renewable power generation and upgrading and extending the national electricity grid.

The prospects for a successful green economy transition in the energy-transport nexus will be enhanced by purposive governance by a developmental state which actively manages incentives, regulations and public education in pursuit of sustainability. A South African developmental state must fulfil certain political, institutional, organisational and human resource conditions, and must overcome obstacles such as institutional weakness, the resource curse, corruption, and the need for nation-building in the face of stark inequalities. A key aspect of purposive transition management is support for sustainability-oriented innovations, which can take the form of technological, institutional, organisational and relational innovations (Swilling and Annecke 2011). These innovations mostly occur at a niche level but require support to break the dominance of incumbent socio-technical regimes, such as the coal and petrochemical industries and the broader 'minerals-energy complex' (Fine and Rustomjee 1996). The need for conscious and concerted efforts by social actors and governments is further motivated by historical evidence which shows that past energy and transport transitions or 'revolutions' have taken several decades at least (Fouquet 2010).

Peak oil is just one of a whole suite of resource depletion and environmental degradation challenges that face South African society. These should ideally be tackled in an integrated way by the National Planning Commission, government departments, businesses and civil society. The coming decade is a critical time for South Africa, as the government and its parastatal companies embark on a massive infrastructure roll-out. It is critical that this infrastructure is planned and implemented in a way that reduces South Africa's dependency on imported oil, rather than entrenching it further. The possibly imminent peak and decline of world oil production need not be catastrophic disjuncture, but rather can serve as a catalyst for the greening of the economy and a transformation of South African society toward greater sustainability. In so doing, South Africa could lead the way for other African countries towards green economy transitions, as opposed to attempting to follow the fossil fuel based industrialization pathway which is becoming increasingly unviable both economically and ecologically.

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