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Attention: Mr Tshepo Madingoane  
Director-General of the Department of Energy  
Pretoria

### **Comments on Draft Integrated Resource Plan**

Dear Mr Madingoane

Thank you for the opportunity to comment on the draft Integrated Resource Plan which I have read and duly considered. My overall impression is that the model used is too simplistic and does not consider a number of important factors including:

- the October 2018 report of the IPCC stressing that all countries need to take urgent and appropriate action to limit global warming to below 1.5°C above pre-industrial levels
- only large scale wind and solar projects are considered; there is no mention of batteries or of small scale solar
- the IRP underplays the impact of coal fired generation on health and mortality
- although it is styled an “integrated” resource plan, it does not consider the changing energy needs of the transport industry and the potential impact of the advent of electric vehicles
- the IRP does not consider how low cost renewable energy could help address South Africa’s major socio-economic challenges of poverty, inequality, unemployment and gaining a competitive advantage in the global economy

In the attached document I describe the global trends and South African factors that should be considered in developing the IRP, propose an alternative IRP and list some of the advantages of this alternative IRP compared to your draft IRP. I also attach extracts from my book *Guessing the Future: Signposts to 2050* which is in the process of being published and provides further background to my comments.

Please let me know if you have any comments or questions.

Yours sincerely

Brian Paxton

## Brian Paxton Comments on Draft IRP

### International Trends:

#### **Climate Change**

Climate change, mostly as a direct result of man-made emissions of carbon dioxide and other greenhouse gases, is likely to cause millions of deaths and relocations each year, as well as a degraded lifestyle for many. Experts warn that world temperatures could rise significantly during the 21st century, leading to climate changes everywhere, unless governments, companies and individuals take urgent corrective action soon.

As a direct result of climate change, all the continents and oceans are warming; polar ice caps and glaciers are melting; sea levels are rising and shorelines are eroding; levels of water vapour in the atmosphere have risen; storms are fiercer as a result of warming oceans and once in a thousand year floods have engulfed parts of every continent; ever fiercer forest fires are blamed on global warming; coral reefs are dying; and droughts are lasting longer. There is evidence of natural species starting to migrate uphill or towards the nearest pole and of increased desertification. Extinction is predicted for one sixth of the species on earth.

The 2015 Paris Climate Accord, signed by the leaders of 196 countries, including South Africa, commits each country to take action to hold the average global temperature to well below 2°C above pre-industrial levels. Ideally the temperature increase should be limited to below 1.5°C.

The October 2018 report from the UN Intergovernmental Panel on Climate Change (IPCC) concluded that global CO<sub>2</sub> emissions would have to drop 45 per cent from 2010 levels by 2030 in order to limit global warming to 1.5°C rather than the previously agreed 2°C in order to avoid extreme heat, drought, floods and poverty for hundreds of millions of people. The report highlighted the different impacts of 1.5°C and 2°C across a range of factors with particular emphasis on temperatures, sea levels, biodiversity and precipitation. The authors concluded that the urgent changes required to limit CO<sub>2</sub>, which include investing US\$ 2.4 trillion in clean energy every year through 2035 and cutting the use of coal-fired power to almost nothing by 2050, are affordable.

The Global Commission on the Economy and Climate published its 2018 report *Unlocking the Inclusive Growth Story of the 21<sup>st</sup> Century: Accelerating Climate Action in Urgent Times* concluding that bold action could yield a direct economic gain of at least US\$ 26 trillion and deliver up to 3.7 gigatons per year of CO<sub>2</sub>e savings over the next 15 years, while at the same time limiting dangerous climate change. An AGU report calculated the considerable global economic gains from complying with the Paris Climate Accord for 139 countries; the relative damages from not complying for Sub-Saharan Africa, India, and Southeast Asia are especially severe.

#### **Air Pollution**

According to a paper by the Commission on Pollution and Health, published in the Lancet in October 2017, pollution kills more than nine million people worldwide and costs the equivalent of 6.2 per cent of global economic output every year.

Modern pollution deaths are rising fast while traditional pollution deaths, such as from contaminated water and wood cooking fires, are falling. Air pollution was the biggest killer, leading to heart disease, stroke, lung cancer and other illnesses. Outdoor air pollution causes 4.5 million deaths a year, while indoor air pollution, from wood and dung stoves, only caused 2.9 million

deaths. Nearly 92 per cent of pollution-related deaths occur in low-income and middle-income countries.

The 2018 State of Global Air Report, prepared by the Health Effects Institute and the Institute for Health Metrics and Evaluation, records that 95 per cent of the world's population is exposed to fine particle levels exceeding universal air quality standards. Ambient particulate matter (particulate matter less than or equal to 2.5 micrometers in aerodynamic diameter, or PM2.5) ranked as the 6th-highest risk factor for early death. Worldwide exposure to PM2.5 contributed to 4.1 million deaths from heart disease and stroke, lung cancer, chronic lung disease, and respiratory infections in 2016.

Some 95 per cent of the world's population live in areas of high pollution. Research conducted in China found high pollution levels lead to significant drops in test scores in language and arithmetic, with the average impact equivalent to having lost a year of the person's education. Other studies have found toxic air was linked to "extremely high mortality" in people with mental disorders and earlier work linked it to increased mental illness in children. Another study found those living near busy roads had an increased risk of dementia. Taiwanese researchers have concluded that high levels of air pollution are linked to an increased risk of mouth cancer. Research by doctors in London shows that even exposure to moderate air pollution by expectant mothers can lead to underweight babies. New research from UNICEF shows that exposing young children to air pollution can cause brain damage.

An OECD working paper, *the cost of air pollution in Africa*, calculates that the death toll from air pollution in Africa has increased significantly from 1990 to 2013 in tandem with the uninterrupted growth in the size of the urban population of Africa. Premature deaths from air pollution now exceed those caused by unsafe water and sanitation.

### **Electrical Power:**

Worldwide, improved energy efficiency is leading to a reduction in demand for electric power. What new demand there is will come from electric vehicle charging, the Internet of things and data centres running cloud computing and blockchain applications. In an interview at Davos in January 2018, for instance, IMF CEO Christine Lagarde warned that bitcoin mining alone could end up using more electricity in 2018 than will be consumed in Argentina or Ireland.

The past five years have seen huge technology leaps together with major reductions in the price of wind and solar generation. The capital costs of large scale solar and wind generation and battery storage are dropping fast and are now lower than the equivalent cost of coal, nuclear or even gas generation while the running costs are negligible as the sun and wind are free. Solar PV and wind costs are forecast to decrease by 18 per cent and 16 per cent respectively per the doubling of global capacity. In addition, solar, wind and battery projects can be implemented in a much shorter time period than for a conventional power station.

According to Bloomberg New Energy Finance, the cost of wind and solar energy dropped 18 per cent in 2017. Between 2010 and 2017 the cost of solar has dropped by 77 per cent to a benchmark global average of \$US 70 / MWh, the cost of wind has fallen 38 per cent to a benchmark global average of \$US 55 / MWh and the benchmark price for lithium-ion batteries has fallen nearly 80 per cent to \$US 209 / kWh. Lazard's *Levelized Cost of Energy Analysis* calculated that in much of North America "the full-lifecycle costs of building and operating renewables-based projects have dropped below the operating costs alone of conventional generation technologies such as coal or nuclear." Australia's Origin Energy has concluded that the cost of wind and solar farms there has fallen so far it is now cheaper than the marginal cost of coal generation.

Carbon Tracker predicts that global demand for fossil fuels will peak in 2023 because of expanding renewable energy growth, action on climate change and slowing energy demand. As a result, oil, gas and coal assets, currently worth trillions, could be worthless. Around the world coal fired and nuclear plants are being closed and new build projects cancelled as a result of growing civil society pressure, public alarm at pollution from coal power plants and associated infrastructure and increased aversion to carbon projects by private banks and insurance companies including Standard Chartered Bank and, now, South Africa's Standard Bank. This is leading, amongst other things, to a reduction in coal mining and the coal trade. Coal mining companies are being liquidated leaving taxpayers to foot the bill for environmental remediation. Experts have warned that the price of solar could drop so much that almost all coal mining companies could be out of business by 2025, just eight years from now.

More than half of all coal fired power stations in the EU are already loss-making, rising to 97 per cent by 2030. A complete phase-out of coal by 2030 could stem utility losses by €22 billion. Nineteen countries at the Bonn Climate Change conference signed an agreement to phase out the use of coal. Seven countries have already set a date for ending coal power by 2030 or earlier with the French government announcing plans to close all coal fired power stations by 2021. In September 2018 Japan's Marubeni, a major player in the coal sector, announced plans to halve its ownership of coal-fired power plants by 2030, and withdraw completely from the coal plant building business.

According to BP, the growth rate of renewable energy generation, which includes hydro, has averaged an impressive compound 16 per cent per annum over the past decade. As a result, world solar and wind generation in 2017 was equivalent to 82 per cent of global nuclear energy generation and 53 per cent of hydro energy consumption. Solar energy usage has grown by a compound 50 per cent per year in the past decade, albeit off a small base, while wind power grew at a compound 22 per cent over the same period.

Bloomberg New Energy Finance reported that by the end of June 2018 there was a total of 1,013 GW of wind and solar capacity around the world, 54 per cent wind and 46 per cent solar. Since the year 2000, total installed capacity has grown 65 fold and more than quadrupled since 2010. The level of investment necessary to achieve the next 1,000 GW will cost much less because of the increased level of technological innovation and subsequent declines in cost.

Batteries are also getting both more powerful and much cheaper, allowing electricity to be stored for when the wind doesn't blow and the sun doesn't shine, making electricity networks more reliable and removing the requirement for baseload power. By 2026, it's expected that 2.1 GW of hybrid energy storage, such as a combination of batteries and ultracapacitors, will be deployed globally. In September 2018 the World Bank announced a new \$US1 billion global program to accelerate investments in battery storage for energy systems in developing and middle-income countries such as South Africa.

One criticism of large-scale renewable energy systems has been that they don't provide a baseload supply when the sun isn't shining or the wind isn't blowing. This has been shown to be false. In 2016, Denmark and Germany successfully managed peaks of 140 per cent and 86.3 per cent, respectively, of electricity generation from renewable sources. Spreading wind and solar facilities over wide areas allows access to a wide range of different weather and also helps to smooth out peaks in users' demand. Storage can also help match up energy generation with demand patterns.

Smart networks are collecting power from a range of sources and distributing it to where it is needed at each point in time. Deloitte's September 2018 Report, *Global Renewable Energy Trends*,

concludes that renewable energy sources are rapidly becoming the preferred option for reasons of cost and balancing electrical networks rather simply for environmental reasons.

It's not clear if these numbers quoted above just include the large scale commercial solar power generators or also include small domestic PV and battery installations where equipment costs are also dropping fast and the main cost is now installation manpower related. In Australia, for instance, despite the government's strong bias towards coal, some 30 per cent of homes there now have solar panels installed. California has mandated that all new houses must have solar power. New housing estates in Miami and elsewhere in the USA are now required to be energy neutral with all homes having solar panels.

Research showed only 1 per cent of the US\$ 19.4 billion a year funding provided under the United Nations' Sustainable Energy for All program was being invested in off grid solutions. Just as cell phones allowed tens of millions of Africans to communicate without copper cables, so cheap solar panels could provide people across Asia and Africa with access to electric lighting and smokeless cooking without the need for expensive grid connections.

In the developing world where billions of people still live without access to electricity and clean cooking facilities, small scale, stand alone PV systems with LED lights, phone charger and battery using cell-phone based Pay-As-You-Go micropayments systems are also taking off. Bangladesh, with four million domestic PV units installed, has the world's largest solar home system market, funded mainly using microcredit schemes while India plans to electrify every household by 2019 mostly using small scale PV and battery systems.

This is making the traditional method of extending the grid network obsolete. In 2012, investments in PAYG solar companies amounted to only US\$ 3 million but had increased to US\$ 158 million in 2015 and US\$ 223 million in 2016. This trend started in East Africa, where cell phone payment systems such as M-Pesa are in widespread use, and is quickly spreading to West Africa, as well as to South Asia. The mini-grid market now exceeds US\$ 200 billion annually. Despite this, the International Energy Agency calculates that nearly 620 million Africans, most of them rural, do not have access to electricity and some 730 million still depend on traditional solid biomass for cooking. As a result off-grid solar in Africa is forecast to grow by more than 70 per cent a year, reaching over eight million households by 2020 from nearly one million by 2017. This provides a market opportunity for South African companies.

Both large and small scale renewable energy projects are increasing employment in the wider energy sector. By the end of 2017, 10.3 million people were employed in the renewable energy sector worldwide. According to a report by the International Renewable Energy Agency, more than 500,000 new renewable energy jobs were created in 2017 most of them in China manufacturing solar panels. The transition to a 100 per cent renewable electricity system will require 36 million jobs by 2050 compared to 19 million jobs in the 2015 electricity system.

In addition to generating power, renewable energy reduces carbon emissions. A 2017 report by Dev Millstein, Ryan Wiser, Mark Bolinger and Galen Barbose entitled *The climate and air-quality benefits of wind and solar power in the United States* found cumulative wind and solar air-quality benefits of US\$ 29.7–112.8 billion, mostly from 3,000 to 12,700 avoided premature mortalities, and cumulative climate benefits of US\$ 5.3–106.8 billion. A study in *Nature Climate Change* analysed the health benefits of reduced exposure to particulate matter and other pollution from fossil-fuel plants in 154 of the world's biggest cities. Expediting the shift to clean energy could reduce levels enough to save as many as four million lives in Delhi, India, alone over the coming decades.

A director of the ANU Centre for Sustainable Energy Systems, claims that a 100 per cent renewables electricity grid in Australia supported by pumped hydro energy storage would not only be cheaper than the current coal and gas-based system, but would use less than a quarter of the water currently used to generate electricity. This is an important factor in countries facing water shortages due to climate change.

### **Electric Vehicles**

Renewable energy, powered by the wind and sun, is already cheaper than nuclear, coal and even gas. Batteries are getting both more powerful and much cheaper, allowing electricity to be stored for when the wind doesn't blow and the sun doesn't shine. As a result of both of these, the purchase price and running costs of electric vehicles are dropping sharply. And, since they don't use gasoline or diesel they don't pollute the air – unless, of course, their power comes from a coal or gas fired power station.

Electric vehicles are predicted to achieve cost parity with internal combustion vehicles in 2022 and, by 2033, half of new light vehicle sales globally will be electric. According to Bloomberg New Energy Finance the unsubsidised cost of ownership of an electric vehicle will fall below a petrol driven car by 2022 and electric vehicles will be as cheap as gasoline cars by 2025. Currently batteries make up a third of the cost of an electric car; the cost of lithium ion battery packs has reduced from US\$ 1,000 per kWh in 2010 to US\$ 350 in 2016, falling 35 per cent in 2015 alone. They could drop to US\$ 125 in the near future.

Electric vehicles have another important advantage compared to a conventional vehicle. An electric car is easier to make and maintain than one with an internal combustion engine because it has many fewer parts: for instance, a Tesla 3 has between 6,000 and 7,000 parts, while Goldman Sachs estimates that a traditional vehicle has 30,000 or more. Analysts at UBS Group AG who stripped down a Chevrolet Bolt concluded that it doesn't require any maintenance for the first 150,000 miles it drives, another big plus for electric vehicles.

According to Bloomberg New Energy Finance, cumulative passenger electric vehicle sales, including buses, reached four million vehicles by July 2018. The time needed to reach each consecutive million electric vehicles sold has shrunk from 17 months for the second million to 6 months for the fourth million.

Research from UBS predicts 48V mild-hybrid vehicles will overtake diesel engines within five years and diesel will almost entirely disappear from the global car market within a decade. Analysts predict there could be between nine and twenty million electric cars in operation by 2020 and between forty and seventy million by 2025, based on estimates from automobile manufacturers. Morgan Stanley predicts that electric vehicles will form 90 per cent of the global fleet by 2045. The IEA calculates that in order to limit temperature increases to below 2°C by the end of the century, the number of electric cars on the road will need to reach 600 million by 2040.

The move to electric vehicles is being accelerated through legislative action in addition to economics. The governments of Norway and the Netherlands plan to ban petrol car sales by 2025, India, Israel and Germany by 2030, and France and England by 2040. These targets were all set before the October 2018 report from the IPCC urging more urgent action on climate change.

California mandates that a certain percentage of each automaker's sales must be zero emission vehicles. States including New York and Vermont are increasingly offering tax incentives to consumers who buy electric vehicles. The French government has introduced an incentive scheme to

encourage petrol and diesel car owners to replace their old cars with new electric vehicles which has proved very popular with more than 45,000 applications in the first six months of 2018.

Los Angeles, Seattle, San Francisco and Portland are leading a partnership of over thirty cities to mass-purchase electric vehicles for their public fleets including police cars, street sweepers and garbage trucks.

Elsewhere cities concerned about air quality are also taking action: the mayors of Paris, Madrid, Mexico City and Athens plan to ban diesel vehicles from city centres by 2025. Paris has ruled that any electric car is allowed to re-charge at the re-charge stations of its car-sharing program. Norwegian cities provide bus lane access for electric vehicles, frequent recharging stations, privileged parking, and toll-free travel for electric cars. Amsterdam offers to install charging points on public parking spaces for people who make a request. London waives its congestion charge for electric vehicles. Germany's Supreme Court ruled that cities can ban polluting diesel powered vehicles.

The EU has legislated that as of 2019, every newly built or refurbished house must have a charging station and by 2023 10 per cent of all buildings' parking spaces must have chargers. As a group, BMW, Daimler, Ford, and Volkswagen intend to install thousands of EV fast chargers along European motorways. Tesla is installing a similar chain of Australian charging points stretching from Adelaide to Brisbane. Highways England is testing a system where electric and hybrid cars can be recharged as they drive through a wireless power transfer system. American charging infrastructure company ChargePoint plans to install 2.5 million EV charging spots worldwide before 2025.

There are other outcomes from a world of electric vehicles. The air in cities would once more be breathable and their streets quiet. Electric cars would eliminate the need for service stations with their tanks, pumps and safety regulations to prevent fires or explosions. Instead charging stations could be installed alongside city parking spaces or outside eateries on inter-city routes. Interestingly, research has shown that most existing owners of electric cars tend to charge them in the home garage.

Kia and BMW are among other car makers developing wireless battery chargers. The batteries of electric cars also allow owners to store surplus electrical power generated on their rooftops; already some electric car owners are earning as much as US\$ 1,530 a year just by parking their vehicle and feeding excess power back into the grid at peak times.

Electric vehicles could displace oil demand of 2 million barrels a day as early as 2023. That would create a glut of oil equivalent to what triggered the 2014 oil crisis. Bloomberg New Energy Finance predicts that electric vehicle sales will lead to displacing eight million barrels of oil a day by the time they overtake sales of gasoline powered cars. This seems somewhat on the low side considering current world oil production is some 92 million barrels per day.

The proposed ban on the use of diesel vehicles in some European cities has already started to impact the prices realised for used vehicles. At some point in the near future the economics of buying a new gasoline or diesel powered car that has no residual value will start to dent sales of new non electric cars, further accelerating the move to electric vehicles. While demand for oil and platinum for catalytic converters will disappear, instead there will be demand for the metals used in batteries and charging stations, giving new areas of the world export opportunities for lithium, cobalt, vanadium, copper and other commodities.

Very little press coverage has been given to the fact that electric vehicles will lead to the elimination of taxes on gasoline and diesel which are important income earners for many countries. According to the OECD, the average gasoline tax rate among the 34 advanced economies is US\$ 2.62 per US gallon. ITEP calculates that in the US the gas tax is the single most important source of transportation funding for the federal government with taxes on gasoline and diesel fuel raising over \$US 30 billion per year. The fifteen countries of the former EU together earn Euros 152 billion in fuel taxes. The Australian Government Productivity Commission has highlighted the need for reform in the funding of and investment in roads, which is the single largest item of infrastructure spending for many governments.

## **South Africa**

### **Poverty, Inequality and Unemployment**

Poverty, inequality and unemployment are the biggest challenges facing South Africa. The situation is going to get worse as automation bites further and exports of cars, trucks, coal and platinum dry up as the world phases out coal and moves to electric vehicles.

According to the World Bank, South Africa had a GINI rating of 0.63 in 2015 and some 33 per cent of South Africans live on less than US\$ 1.25 per day. While the overall South African unemployment rate is 36 per cent, it is 58 per cent for under 34's. In the former homelands only 25 per cent are employed so that the median monthly income there of R 2,600 is much lower than the R 4,500 median earned in the cities.

South Africa's Integrated Resource Plan should aim to provide employment, lower the cost of doing business and provide the poor with access to low cost electrical and transport services, even if it can't directly reduce inequality.

### **Climate Change**

*Climate Change – Briefings from South Africa* by Bob Scholes, Mary Scholes and Mike Lucas records that South Africa is warming twice as fast as global averages and temperatures in the interior could rise by 3 to 6°C by 2100. The western interior will experience greater warming than the eastern interior or the coastal regions. As a result South Africa is likely to become drier in the west and wetter in the east with the Western Cape and Mpumalanga, where most of South Africa's coal fired power stations are located, experiencing the largest drops in precipitation. Crop yields are expected to decline on average. More flooding is predicted for the Eastern and Southern Cape. The frequency of flood and hail will increase.

South Africa contributes 1.5 per cent of global greenhouse gas emissions. While per capita emissions are only slightly above global averages, emissions per unit of economic value added are amongst the highest in the world. This is largely due to the reliance on coal-fired power stations, many of them using poor quality coal. As a result, the region east of Johannesburg is one of the most polluted on the planet. Synfuels plants, oil refineries and cement manufacturing are the other major CO<sub>2</sub> emitters, along with the gasoline, jet fuel and diesel fuelled vehicles clogging the country's roads and airspace. Frequent veld fires further increase pollution and greenhouse gases.

South Africa's water resources are almost fully utilised with agriculture consuming 63 per cent of the water and mining and electricity also being significant consumers. Domestic usage is about 12 per cent and municipal consumption a further 14 per cent. Cape Town, Port Elizabeth and other towns are currently suffering chronic water shortages, something Johannesburg and other major cities have also experienced in recent years.



South Africa is one of the countries most at risk from the potential impact of carbon mitigation trade and travel policies implemented by its distant trading partners and tourism sources. In addition South Africa can expect waves of migrants fleeing the increasing heat of equatorial Africa.

The 2015 Paris climate accord commits each signatory country to taking action to hold the average global temperature to well below 2°C above pre-industrial levels. South Africa's main response is a carbon tax that is complex and will only come into force in 2022. It's not clear whether Eskom and companies in the oil industry will be required to pay the tax. To date South Africa's government has not responded to the October 2018 IPCC report urging countries to act more urgently.

Replacement of coal fired power plants with renewable energy sources and the conversion of the transport fleet to electrical power are key to meeting the challenges posed by climate change.

### **Pollution and Ill Health**

The Institute of Health Metrics and Evaluation lists South Africa's four main causes of premature death as HIV/Aids, violence, lower respiratory disease and road injuries. In 2015, 9.6 per cent of deaths were attributable to diseases of the respiratory system. It's not clear whether there is a higher prevalence of diseases of the respiratory system in the polluted areas surrounding Eskom's coal fired power stations.

Closure of coal fired power stations and elimination of petrol and diesel fuelled vehicles will improve air quality and improve the health and life expectancy of those living nearby. This will at the same time take some of the pressure off South Africa's under-resourced and hard-pressed health systems.

### **Manufacturing**

According to OICA, South Africa produced 335,539 cars and 263,465 trucks in 2016. These were all powered by gasoline or diesel. According to AIEC, the automotive industry is South Africa's largest manufacturing sector, accounting for 33 per cent of South Africa's manufacturing output in 2016, while the broader automotive industry's contribution to the GDP was 7.4 per cent in 2016 and also accounted for R171.1 billion, 15.6 per cent, of total South African exports. The South African vehicle manufacturing industry employs 34,000 workers to produce 650,000 vehicles each year.

Many of the countries to which South Africa currently exports cars are those moving to electric vehicles and there are currently no plans to manufacture electric cars locally.

### **Mining**

The *BP Statistical Review of World Energy June 2018* records that in 2017 South Africa produced 252 million tonnes of coal, 3.3 per cent of the world total. According to the Mineral Council South Africa website, in 2016 South Africa produced 253.1Mt of coal of which 181.4Mt were sold internally with a value of R 61.5 billion while 68.9Mt, worth R50.5 billion, were exported. South African coal mines, mostly in Mpumalanga province, employed 77,000 people in 2016. The coal mining industry has lost 10,000 jobs in five years and, according to Meridian Economics, some 35,000 coal mining jobs will disappear as Eskom's older power plants are phased out.

Also according to the Mineral Council South Africa, South Africa produced 275 t of platinum valued at R 94 billion in 2015, some 88 per cent of which is exported. The number of people employed in South Africa's platinum mining industry has dropped from 200,000 in 2008 to 170,000 in 2018, with more job cuts promised. Most platinum production is used in the manufacture of catalyst convertors used in gasoline and diesel powered vehicles.

South Africa's mining sector faces two major threats. In a world of renewable energy and electric cars there will be no market for coal or platinum. Instead South Africa needs to focus on providing the minerals needed in a high-tech, renewable energy economy including vanadium, lithium and copper.

### **Transport**

The *BP Statistical Review of World Energy June 2018* records that in 2017 South Africa consumed 212 million barrels of oil worth US\$ 16 billion or R 200 billion at the current US\$ 80 per barrel. It's not clear whether these numbers include the gasoline, diesel and jet fuel produced by the synfuels plants of Sasol and PetroSA. The South African government earns some R 55 billion a year from taxes on fuel.

With the advent of electric vehicles, South Africa will no longer need to import oil, the country's most expensive import item. At the same time, service stations and oil refineries will become redundant. Fuel taxes will be eliminated and the government will need a new source of funding for transport infrastructure.

### **Electricity**

The bulk of South Africa's electricity is produced from coal with some nuclear and hydro and a small amount of renewables. According to Stats SA, 91 per cent of South African households have electricity, 21.3 per cent use paraffin and 12.2 per cent use gas. From 2003 to 2016, the number of GWh required to produce R one billion of GDP fell 26 per cent from 90 to 67.

According to Eskom sources, South Africa currently has a peak requirement of 38 GW. Total Eskom capacity is 44.1 GW, while Independent Power Producers, mostly renewable, are committed to 5 GW. Eskom's sales of electricity dropped 7 per cent from 2011 to 2017. Analysis of the Eskom annual reports confirms Eskom sells less electricity now than it did in 2007; over the past decade coal costs have tripled; and tariffs and revenues have increased fourfold. From 2003 to 2017 the number of employees increased nearly 50 per cent from 32,000 to 47,000 employees while average annual remuneration increased by 400 per cent from R 200,000 to R 825,000.

The *BP Statistical Review of World Energy June 2018* records that South Africa's 2017 electricity generation was 255 Terawatt-hours, up very slightly on 2016. Of this just 3.7 Terawatt-hours was solar, up 12 per cent on 2016, and wind was 4.6 Terawatt-hours, up 9.6 per cent. Another source recorded that during the highest periods of load-shedding from January to June 2015, collectively wind energy and solar power saved the country R 4 billion. In addition many South African homes, including those of low income earners, are now fitted with solar hot water systems which have further reduced the overall demand for electricity, especially at the peak early evening period.

CSIR researchers have calculated that the cost of building new electricity generating plants in South Africa would be R 0.6 /kWh for either solar photovoltaic or wind; R 1.0 for baseload coal from an independent power producer (IPP); above R 1.1 for Eskom variable coal; and above R 1.2 for nuclear. The running costs of solar and wind systems are negligible whereas coal and uranium are major costs for the non renewables.

Eskom is currently building the Medupi and Kusile coal fired plants which have a capacity of 4.8 GW each. At a possible combined cost of R 420 billion (US\$ 30 billion), the cost per MW is more than R 43 million even before the cost of purchasing coal is considered.

Medupi has been under construction since 2007 and is expected to be completed in 2020 by which time costs will have escalated from the April 2007 budget estimate for the first six units of R 69.1 billion to a cost to completion of R 195 billion. These numbers exclude flue gas desulphurization and plant interest during construction, both significant factors.

Kusile coal-fired power station has been under construction since 2008 and won't be completed until at least 2022 with a possible cost to completion of R 225 billion up from the R 80.6 billion approved in April 2007 by the Eskom board including the flue gas desulphurization plant but excluding interest during construction.

In addition, the proposed 557 MW Thabametsi and 307 MW Khanyisa coal plants are awaiting approval. Thabametsi near Lephalale is largely owned by Japan's Marubeni and South Korea's KEPCO, while Khanyisa near eMalahleni has Saudi-owned ACWA Power as its biggest shareholder.

According to the 2018 draft IRP, about 12,600 MW of electricity from coal generation by Eskom will be decommissioned cumulatively by 2030. That will increase to 34,400 MW by 2050. It is also expected that 1,800MW of nuclear power generation will reach end-of-life between 2045 and 2047.

A number of Eskom power plants including Majuba, Tutuka, Duvha, Matla, Kriel and Grootvlei requires extensive emission abatement retrofits to ensure compliance with the law. Failure to comply is likely to result in these plants becoming unavailable for production, which could lead to the early retirement of some of the units at these plants.

To date South Africa has 55 renewable energy projects, of which 19 are wind farms that are fully operational, adding 2.94 GW to the grid, and thirty one solar PV developments totalling 1.34 GW. South Africa has five solar panel factories but three have closed because local labour costs made them uncompetitive with imports.

Most of these renewable energy projects have been developed by Independent Power Producers (IPPs), who contract to supply power to Eskom at mutually agreed prices. Construction times for these projects average less than two years and the electricity price agreed for the projects has declined 68 per cent within three years.

The 96 MW Jasper solar power plant, the largest utility solar PV plant in Africa, is located near Kimberly and commenced commercial operation in October 2014. The 5 MW array on the Mall of Africa near Johannesburg is the largest of South Africa's nearly 150,000 non-utility solar PV installations. South Africa is a world leader in implementing CPV with the 100 MW KaXu Solar One, 50 MW Bokpoort and Khi Solar One concentrated solar thermal power stations operational and the Ilanga I, Kathu Solar Park, Redstone Solar Thermal Power Plant and Xina Solar One projects in the pipeline.

According to the South African Wind Energy Association, as of mid 2017 South Africa had nineteen wind farms comprising more than 600 wind turbines with a combined capacity of 1.47 GW. Some 3.365 GW of wind energy on 36 separate wind farm developments have been procured through the South African Department of Energy's Renewable Energy Independent Power Producer's Procurement Programme (REIPPPP). Some 98 per cent of those selected have reached commercial operation on time. A total of 14,725 MW of renewable energy have been allocated to the REIPPPP. So far 6,377 MW of that has been procured over 6 bidding rounds and 3,029 MW is operational.

Also according to the South African Wind Energy Association, the price of wind energy in the last round 4 expedited was R 0.62 / kWh, cheaper than Eskom's average cost of supply at R 0.84 / kWh and more than 40 per cent less than forecast prices for Kusile and Medupi. For each kilowatt hour of

wind that displaces fossil fuels in the national grid, 1.2 litres of water will be saved. The entire portfolio of the REIPPPP programme will save 52 million litres of water each year.

The REIPPPP is also stimulating local manufacturing and creating sustainable jobs. Since 2013, the construction and operation of renewable energy projects has created 111,835 job years in South Africa. As of June 2017 the REIPPPP program had created 32,532 new jobs, with more than 100,000 new jobs coming from the next stages of the program. By March 2016 over R 30 billion had been spent on local content and a further R 65.7 billion is expected to be spent by projects that have yet to commence construction. Twelve new industrial facilities have been established as a direct result of the programme. According to a report by the Council for Scientific and Industrial Research, wind energy produced net savings of R 1.8 billion in the first half of 2015 and was also cash positive for Eskom by R 300 million.

The development of new renewable energy projects by IPPs is constrained due to the 2007 determination by the Minister of Energy in terms of Section 34 of the Electricity Regulation Act 4 of 2006, which allows Eskom to be the sole purchaser of electricity. Municipalities, businesses and residential groups are thus precluded from purchasing electricity directly from IPPs or from residents or businesses with solar panels on their buildings producing a surplus to their needs. The City of Cape Town was challenging this interpretation of the act through the courts.

The inevitable result, if there are not significant policy changes, is that those that can afford to install stand alone solar systems will take themselves off the grid leaving the poor with the burden of paying for the expensive power provided by Eskom's coal fired plants.

In August 2018, the government published a draft Integrated Resource Plan for comment. The draft IRP uses an average cost of coal of R 558 per ton even though actual costs vary from R 300 to R 650 per ton or higher.

### **Alternative Integrated Resource Plan**

#### **Large Scale Generation**

Phase out all coal fired generation by 2030 commencing with the most expensive and highest polluting plants.

The government should cancel the Medupi and Kusile projects. They are costly white elephants that simply add more CO<sub>2</sub> to the atmosphere. South Africans cannot afford them and those with the means will simply install their own stand alone solar systems leaving the poor to pay the exorbitant tariffs Eskom will need to charge to cover the capital, finance and running costs of these behemoths.

Accelerate the roll out of large scale renewable energy projects using IPPs to implement the projects and provide the capital investment. Tap the World Bank fund to finance large scale battery facilities to store surplus power and stabilise the network.

Cancel all plans for more coal fired plants as well as plans for using Inga or gas fired plants, both of which are expensive and require ongoing foreign exchange.

#### **Small-scale Renewables**

Change building standards to include LED lighting, small-scale solar PV and hot water systems, batteries and electrical vehicle chargers.

Provide incentives for the installation of domestic solar PV and hot water systems.

Change building regulations to require all building projects of more than R five million to include solar PV and hot water systems.

Provide incentives for the installation of low cost, Pay as you Go solar systems in rural areas without access to the grid with a goal of 100 per cent coverage by 2025.

Set domestic feed-in tariffs for surplus small scale PV generation in line with the feed in tariffs for large scale renewables.

### **Electrical Transport**

Include the power requirements of electrical vehicles in load forecasts.

Exports of gasoline and diesel powered vehicles are going to drop sharply in the years ahead. The government should provide incentives so that the vehicle manufacturers convert their factories and start mass producing and exporting electric cars. To facilitate the process further, the government should stipulate that all government vehicle purchases after 2022 will be electric vehicles manufactured in South Africa.

Mandate that all government purchases and rentals of vehicles from January 2023 should be of locally manufactures electric vehicles.

Provide incentives for individuals to buy electric vehicles and mandate that all sales of new petrol and diesel powered vehicles should cease in 2030 or earlier.

Create standards for the installation of charging stations and provide incentives for the installation of charging stations nationwide.

Encourage cities to ban polluting vehicles.

The redundant Mossgas gas to liquids plant should be closed and plans for a new state refinery and for fracking should be abandoned. At the same time the CEF group of companies should be liquidated, including PetroSA and SFF; they are inefficient, corrupt and have no role in a renewable energy economy.

Each year increase the taxes on gasoline, diesel and jet fuel in order to further discourage the use of internal combustion engines.

Cancel all plans for fracking.

Introduce a comprehensive carbon tax would replace the fuels taxes used to fund road building. The tax would also provide funds for sea walls, desalination plants and other infrastructure needed to cope with climate change.

Electrification of the railway network should be completed and a fast passenger train service should be initiated between the major centres to encourage a move from air to land travel.

Over time taxes on transport diesel should be raised so freight moves to a newly streamlined electric train system. The metros should be given full control of their local train and bus services so they can optimise the transport services they provide.

## **Management**

Use Eskom's transmission and distribution assets to create an independent smart grid company manned and managed by professional electrical engineers.

Create renewable energy and electric vehicle training facilities.

The rump of Eskom should be downsized significantly leaving it with the role of efficiently operating and gradually closing the coal fired power stations and the Koeberg nuclear plant. Professional head office employees could be redeployed to municipalities around the country which lack their valuable administrative skills.

The coal mines should be closed and the retrenched mineworkers redeployed on mine rehabilitation, renewable energy projects and replanting indigenous forests which have been depleted for firewood.

The government will need to explore new means for charging for electrical power.

Dykes and sea walls to cope with rising ocean levels will provide employment for construction companies.

Universities should prioritise researching battery technology and the building of low cost smart high rise homes for the poor which are energy efficient.

## **Benefits**

Renewable electric power provides the country with potentially huge economic and environmental benefits. The time is ripe to use South Africa's unique features to lead the world in low cost renewable energy and gain a competitive economic advantage.

The new higher quality jobs created through this program will more than offset low skilled job losses incurred in coal mining and burning.

Capital costs will be incurred by the private sector and consumers, removing a significant burden from the fiscus and Eskom.

Elimination of crude oil imports will improve South Africa's balance of trade and offset losses incurred by falling exports of vehicles, coal and platinum

South Africa will more than meet its obligations under the Paris Climate Change accord.

The air quality over Gauteng, Limpopo and Mpumalanga will improve leading to improved health and fewer deaths from PM2.5 and respiratory diseases. Water quality and availability will also improve in the areas downstream of the coal mines and power stations.

Electric vehicles will not only result in the elimination of crude oil imports, but also a reduction in pollution and noise levels in cities and lower transport costs for all.

Existing renewable energy manufacturing facilities should be expanded so renewable energy infrastructure can be exported to Africa and beyond. The renewable energy infrastructure will provide South African companies with a competitive advantage in the African renewable energy sector.