29 October 2012

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SUBMISSION TO THE STANDING AND SELECT COMMITTEES ON FINANCE

PROPOSED ENERGY INFRASTRUCTURE INVESTMENTS IN THE MEDIUM TERM BUDGET POLICY STATEMENT 2012

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A. INTRODUCTION

This submission by Earthlife Africa-Jhb to the Select and Standing Committees includes two distinct sections namely, legal and economic. Parliament is requested to consider these submissions as they pertain to aspects within the Medium Term Budget Policy Statement. Each section is self-contained. The legal section includes the following sub-sections: Introduction, outline of submissions, factual background and recommendations. The economic section includes the following sub-sections: summary, introduction, Integrated Resource Planning, Issues with IRP methodology, the policy background, nuclear cost assumptions, the technology options and conclusions.

B. LEGAL

I. INTRODUCTION

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A. **The Committee should recommend to the National Assembly that the Department of Energy complete an accurate cost analysis of proposed procurement of energy from nuclear power that takes account of all relevant information, before the funds related to this program which have been allocated to NECSA are approved.**

(i) *The cost estimates of the nuclear build program by the Department of Energy's are set out in the Integrated Resource Plan 2010-2030 but are inadequate as a basis of decision-making and budgeting because such estimates are incomplete and outdated.*

(ii) *Parliament is required to promote effective financial management by the executive. Given the absence of comprehensive information about the cost of the nuclear program parliament will be unable to discharge this constitutional obligation.*

(iii) *Regardless of the current cost of nuclear energy, procurement of a "fleet" rather than single nuclear reactors violates the requirements of cost-effectiveness and effective financial management.*

B. The Committee should recommend that the Department of Energy act in a more transparent manner, providing adequate information to the public and Parliament as to its intentions and the decisions being taken regarding proposed nuclear energy procurement. Only then can Parliament properly exercise its constitutionally mandated oversight role.

(i) Parliament is obligated to promote and ensure transparency in procurement, and in national, provincial and municipal budgetary processes.

(ii) The Department of Energy's current procurement process for nuclear energy has not been conducted in a transparent manner. Parliament should take steps to make the process transparent, in line with its constitutional obligations outlined above.

(iii) Lessons from the Arms Deal

C. The Committee should recommend that any large-scale procurement be conditional upon greater Parliamentary oversight.

(i) Proposed methods of increasing Parliamentary oversight

I. INTRODUCTION

The Minister of Finance has tabled the Medium Term Budget Policy Statement ("MTBPS") in Parliament on 25th October 2012. The Standing and Select Committees on Finance are now tasked to review and report thereon to the National Assembly with their recommendations regarding the proposed fiscal framework. We request that the Committees include in the report the concerns set out in this submission with respect to the proposed allocation of funds to NECSA which are related to the overall nuclear procurement program.

The MTBPS has confirmed the allocation of R1,7 billion to NECSA over the next three years along with an additional **R14.2 million** in 2013/14 to build a waste processing facility. Over the medium term, NECSA will **focus on developing and demonstrating nuclear fuel cycle capabilities aligned with the IRP and new nuclear build requirements**, expanding research and development programmes in its core activities and innovations, developing nuclear equipment, components and fuel manufacturing capabilities, strengthening and consolidating its position in the supply of medical radioisotopes and developing a diversification strategy of Pelchem (pharmaceutical company). It also states that **in response to expected increase in nuclear electricity production resulting from the IRP, the corporation will work to retain and increase the nuclear skills capacity in the country.**[1]

The above activities of NECSA are preparatory to and are integrally linked to the Department of Energy plan to procure a fleet of new nuclear reactors to provide approximately 9600 MW of electricity. We welcome the Government's proposed significant investment in infrastructure, specifically the investments planned in the energy sector. However the nuclear procurement program has to date not been based on complete costing and the first policy framework for energy planning, the IRP 2010 is now out of date. The allocation of R1, 7 billion is a significant expenditure and will limit the flexibility of the state in making energy choices in the future. It will be difficult for the state to justify not building nuclear reactors even if these are not the best cost option if it has already spent billions of Rands on preparatory aspects of the program. However by

[1] Energy ENE, p. 19.

constraining future energy choices in this way this course of action will in all likelihood have far reaching consequences for the energy configuration and the economy of the country as a whole.

An in depth investigation into the cost of the proposed nuclear energy has been recognized to be of vital importance.[2] It is submitted that an appraisal of the financial risks and benefits of this program must take place prior to its inception. We submit further that this has not taken place to a degree that is sufficient to justify the allocation of funds for this program set out in the 2012 MTBPS. As is submitted herein, research shows that the nuclear expansion program will cost significantly more than has been estimated by the State to date.

The nuclear procurement vision of the Department of Energy proposes a fleet of nuclear power stations will involve a level of investment unprecedented in South Africa, hence the urgency of this concern. Such a program could potentially create an onerous financial burden on the State for many decades to come. There are significant uncertainties which need to be addressed.

Before the nation commits to such a large and expensive project, we respectfully remind Parliament of its constitutional obligations to not only 4crutinize and oversee executive action,[3] but to also ensure that the proposed financial budgets are diligently examined with due regard to the national interest.[4] Moreover, the budget and budgetary processes must "promote transparency, accountability and the effective financial management of the economy, debt and the public sector".[5] Since the funds requested are intended to secure a procurement contract/s, Parliament must exercise its oversight role in a manner which fosters procurement of energy by the State that is "fair, equitable, transparent, competitive and cost-effective". [6]

The Fiscal and Financial Committees of Parliament have the duty to take into account the national interest and the needs and interest of the national government determined by objective criteria when overseeing the budget process.[7] It is submitted that this responsibility arises especially when a large expenditure is contemplated that will be incurred over many decades, and where the nature of procurement contacts inevitably results in the state not being able to withdraw from them without massive costs, if more cost effective options become available.

These constitutional duties cannot be fulfilled if Parliament does not have all the relevant information as to the cost of the proposed nuclear procurement at its disposal. More particularly Parliament cannot discharge these duties and act in compliance with its constitutional mandate without up to date information as to the expenditure that is being planned for the nuclear procurement program.

The failure of Parliament to properly exercise its oversight powers at this early stage would not only be in conflict with its constitutional duties, but could potentially constrain the State irrevocably. The implications are wide-ranging, constraining resources which could be utilized by other sectors and inhibiting the fiscal freedom of future generations.[8] The following submissions will set out these concerns in more detail.

This submission will request the Committees to ask for the following information from the Department of Energy before any approval of funds for NECSA:

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[2] National Planning Commission, *Report 2012,* p. 172; *see also* A. Eberhard, "A Powerful New Strategy To Shape SA's Energy Future", Business Day 21 August 2012.
[3] Constitution Section. 42 (3).
[4] Constitution Section 214 (2) (a).
[5] Constitution Section 215 (1).
[6] Constitution Section 217 (1).
[7] Constitution Section 214(2)(a)
[8] *See also,* Section 8 (5), *Money Bills Amendment Procedure and Related Matters Act* 9 of 2009 which requires Parliament when taking any decision in terms of this Act to consider the "cost of recurrent spending is not deferred to future generations" and the "short, medium and long term implications of the fiscal framework" are considered.

A revision and update of the Integrated Resource Plan ("IRP") so as to address the shortcomings of the IRP 2010 relating to the costing of the nuclear program and which includes:

i. an accurate cost analysis of nuclear energy procurement
ii. all relevant information not included in the IRP 2010
iii. an update of information that has arisen in the two years since the IRP 2010;

II. OUTLINE OF SUBMISSIONS

The Constitution requires the National Assembly of Parliament to oversee and 5crutinize the exercise of national executive authority and to provide mechanisms to ensure that all Executive organs are accountable to Parliament.[9] With respect to the Budget, the National Assembly is required to exercise oversight over the passing of money Bills, and may amend them if necessary.[10] Section 214 (2) of the Constitution requires an appropriations Act of Parliament to provide for the equitable division of revenues to different spheres of government and must take into account, amongst other things, the "***national interest***" and *"**the needs and interests of the national government based on objective criteria***".[11] Moreover, section 215 (1) of the Constitution states that national budgets and budgetary processes must promote transparency, accountability and ***the effective financial management*** of the economy, debt and the public sector. Section 195 of the Constitution also mandates that public administration promote the "***efficient, economic and effective use of resources***".

The *Money Bills Amendment Act*, which elaborates on these constitutional duties, requires Parliament, when considering the Budget, to:

- ensure that there is an appropriate ***balance between revenue, expenditure and borrowing***;
- ensure that the cost of ***recurrent spending is not deferred to future generations***; and
- consider the ***short, medium and long term implications*** of the fiscal framework, division of revenue and national budget on the long-term growth potential of the economy and the development of the country.[12]

The nuclear expansion program is at its inception, but its full costs, risks and benefits for the economy have not been adequately determined. Parliament is not is currently not in possession of a comprehensive costing of the program nuclear program, which therefore does not enable it to discharge the above constitutional obligations for a significant portion of the budget. The current cost analysis for nuclear energy is inaccurate and dramatically underestimates the cost to the State – a fact admitted by the State itself.[13] Without this information Parliament will also not be in a position to promote effective financial management by the executive through the budget process, as required by section 215(1) of the Constitution.

Without having before it all the relevant, up-to-date and accurate information, Parliament cannot fulfill its fundamental constitutional duty set out in section 214(2) (a) and (c) of the Constitution, which is to pass legislation equitably dividing the State's revenues after taking into account the national interest, and the needs and interests of the national government on objective criteria. Similarly, Parliament cannot ensure effective use of resources, balanced revenue, expenditure and borrowing, the short, medium and long term implications of the expenditure and its impact on future generations without having sufficient costing information.

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[9] Constitution section 55
[10] Section 77 (3) of the Constitution; further effected by the *Money Bills Amendment Procedure and Related Matters Act* 2009 ("*Money Bills Amendment Act"*).
[11] Sections 214 (2) (a) and (c) of the Constitution.
[12] Section 8 (5), *Money Bills Amendment Act*.
[13] National Planning Commission, *Report 2012*, p. 172.

To address these concerns, we request that the Committee make the following three recommendations to Parliament, to ensure that Parliament has discharged its constitutional obligations and to avoid a possible future constitutional challenge to any appropriations Acts:

1) **The Department of Energy should complete an accurate cost analysis of proposed future nuclear energy that takes account of all relevant information. Provision for R1.7 billion allocated to NECSA should not be approved until:**
    a. **Integrated Resource Plan ("IRP") has been revised so as to address the shortcomings of the IRP 2010 relating to the costing of the nuclear program and should include:**
        i. **an accurate cost analysis of nuclear energy procurement**
        ii. **all relevant information not included in the IRP 2010**
        iii. **an update of information that has arisen in the two years since the IRP 2010;**

2) **The Department of Energy should be required to act in a more transparent manner, providing adequate information to the public and Parliament as to its intentions and the decisions being taken regarding this proposed procurement;**

3) **Any money budgeted for large-scale energy procurement should be conditional on greater Parliamentary oversight.**

Each of these recommendations is addressed in detail below in subsection IV.

III. FACTUAL BACKGROUND

The proposed expenditure on nuclear new build will impact the national economy over the coming decades, subsequently constraining the State's expenditures in other areas. Indeed, if the project costs more than budgeted for, this project will likely increase the nation's budget deficit and national debt.

In 2011, the Minister of Energy estimated the cost of the purchase of a fleet of nuclear reactors at R1 trillion.[14] This is approximately equal to the cost of the entire 2012/2013 national budget. Dwarfing the arms deal which was worth a mere R70 billion, the program could account for 20% of the world's total nuclear spending over the next two decades. [15] Although the 2012 Budget Review included "only" R300 billion for the project, the Minister of Energy called this figure "the beginning".[16] The ultimate cost is likely to be significantly more than budgeted for. Nuclear power in South Africa has historically proven more expensive than other sources of power and there is no reason to doubt that this trend will continue. As stated in the 1998 White Paper on Energy:[17]

> Nuclear energy is a minor component of the South African energy sector, contributing about 3% during 1997 of the national primary energy supply, and about 5% of the country's electricity, but **despite its small contribution the nuclear industry has been the recipient of a major portion of the Department of Minerals and Energy's budget** […] Whether new nuclear capacity will be an option [after 2007] will depend largely on the environmental and economic merits of other energy sources relative to nuclear and its political and public acceptability, construction lead-times and load characteristics. [Emphasis added.]

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[14] C Reed and Staff Reporter "SA nuclear power could be worth at least R1-trillion" , *Mail and Guardian,* 19 October 2011.

[15] L Faull, "Battle for South Africa's R1 trillion rand Nuclear Contract", *Mail and Guardian* 7th October 2011

[16] Reuters, "SA goes big on nuclear a year on from Fukushima", *SABC News*, 8th March 2012.

[17] Para. 7.2.

Despite the fact that a Nuclear Policy was published in 2008 and the publication of an IRP in 2010,[18] the economic merits of new nuclear capacity has not been comprehensively costed and evaluated to date. As noted in the more recently published report of the National Planning Commission:[19]

> According to the Integrated Resource Plan, more nuclear energy plants will need to be commissioned from 2023/24. Although nuclear power does provide a low carbon base- load alternative, **South Africa needs a thorough investigation of the implication of nuclear energy including its costs, financing options**, institutional arrangements, safety environmental costs and benefits, localization and employment opportunities, and uranium enrichment and fuel fabrication possibilities. [Emphasis added.] While some of these issues were investigated in the IRP, a potential nuclear fleet will involve a level of investment unprecedented in South Africa.

In addition, the National Planning Commission ("NPC") identified a concern that there is inadequate institutional support for the investment plans needed to finance infrastructure on the required scale.[20] By inference this would include the scale of the nuclear fleet program. The NPC states that to realize South Africa's vision for energy its energy system needs to be supported by effective policies, institutions, governance systems, regulation and where appropriate, competitive markets.[21] The failure to ensure such institutional support puts the state at risk of being unable to comply with its duty as set out in section 195 of the Constitution, which mandates the public administration to promote "***efficient, economic and effective use of resources***".

There are also concerns with respect to Eskom's ability to raise the funds for this program and its impact generally on the nation's economy. The utility's debt will peak at R350-billion in the next three years to pay for the Medupi, Kusile and Ingula coal fired power stations. That alone will cost R27-billion a year in interest for at least a decade to pay off.[22] Eskom's credit rating has recently been downgraded by both Standard & Poor and Moody's.[23] Eskom has admitted that this downgrading will affect its ability to "access the cost-effective funding needed to ensure that Eskom and the industry can invest in the electricity infrastructure which South Africa needs".[24] This fact informs Parliament of the very real financial risks involved in any large-scale and long-term investments in energy infrastructure.

Based on media reports of statements by the Department of Energy set out in this submission, it can reasonably be concluded that the nuclear expansion program alone could cost anything between R400-billion and R1-trillion, certainly exceeding R300 billion allocated in the 2012 Budget Review.

We acknowledge that the role of Parliament in the budgeting process is at the intersection of two roles, namely in the law-making process (passing revenue appropriation legislation), whilst simultaneously overseeing Executive action and ensuring effective financial management. Without an accurate, up-to-date and comprehensive understanding of the costs and other associated matters identified by the National Planning Commission[25] in regard to the nuclear program Parliament cannot carry out these roles in a constitutionally compliant manner.

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[18] Nuclear Energy Policy for the Republic of South Africa, June 2008.
[19] National Planning Commission, *Report 2012*, p. 172.
[20] National Planning Commission, *Report 2012*, p. 160.
[21] National Development Plan, *Report 2012*, Chapter 4, p. 163.
[22] L. Donnely, "Eskom's soaring energy costs questioned", *Mail and Guardian*, 21 September 2012.
[23] Independent Online, "S&P downgrades Eskom's credit rating", 17 October 2012, accessed at <http://www.iol.co.za/business/companies/s-p-downgrades-eskom-s-credit-rating-1.1404969#.UH-4aG9Fzpg>.
[24] Independent Online, "S&P downgrades Eskom's credit rating", 17 October 2012, accessed at <http://www.iol.co.za/business/companies/s-p-downgrades-eskom-s-credit-rating-1.1404969#.UH-4aG9Fzpg>.
[25] See footnote 1 above

We submit the following recommendations to assist Parliament to meet its obligations, with the intent that the recommendations will result in the production of a more comprehensive and current understanding of the financial impact of the nuclear expansion program, and from which constitutionally compliant budgetary decisions can then be made.

<u>RECOMMENDATIONS:</u>

1) **The Department of Energy should complete an accurate cost analysis of proposed future nuclear energy that takes account of all relevant information. Provision for R1.7 billion allocated to NECSA should not be approved until:**
    a. **Integrated Resource Plan ("IRP") has been revised so as to address the shortcomings of the IRP 2010 relating to the costing of the nuclear program and should include:**
        i. **an accurate cost analysis of nuclear energy procurement**
        ii. **all relevant information not included in the IRP 2010**
        iii. **an update of information that has arisen in the two years since the IRP 2010;**

(i) The Department of Energy's Integrated Resource Plan 2010-2030 is inadequate as a basis of decision-making because its cost estimate for nuclear power is incomplete and outdated.

The Department of Energy based its decision to procure nuclear energy on recommendations from the IRP 2010.[26] However, the IRP 2010, and so consequently, the Department of Energy's decision, did not take into account the full life cycle costs of nuclear reactors. Further, the 2011 Fukushima nuclear disaster and the State's Integrated Nuclear Infrastructure Review have led to changes in the approach to nuclear safety that increases the cost per reactor to build and maintain. It is not possible for Parliament to take into account the national interest and promote accountability and the effective financial management of the economy in budgetary processes without all relevant cost information pertaining to the proposed nuclear expansion program.[27] At the least, this would require the State to consider the following previously unaccounted for costs:

Full life cycle costs

A full appraisal of all life cycle costs of nuclear power includes waste management, decommissioning, project financing, insurance, and operational costs. The IRP 2010 itself acknowledges that it did not employ sufficient research to appropriately cost nuclear technology, particularly regarding decommissioning and waste management.[28] These costs are necessary to determine the full cost of a reactor over its life cycle. We submit that the fact that a final design for the proposed nuclear power has not been determined yet is also an issue of concern in determining the full costs of the nuclear procurement.

Moreover, these costs are far from trivial. The Nuclear Energy Institute, a trade group for the nuclear power industry, says decommissioning costs are typically $500 million per unit. Decommissioning of the Zion

[26] The IRP 2010 was promulgated 6 May 2011, and is a subset of the Integrated Energy Plan contemplated in Chapter 3 of the *National Energy Act*, No 34 of 2008. See also Address by the Honourable MINISTER OF ENERGY, MS. DIPUO PETERS at the Second IPP Bidders Conference For The Renewable Energy Programme 16 August 2012, Helderfontein Estates, Kyalami, Midrand where it was stated : "In 2010, the Department of Energy published the Integrated Resource Plan, our electricity mix and diversification plan, outlining the required generation capacity for the country over the next 20 years."

[27] Sections 214(2) (a), (c), and 217 (1) of the Constitution

[28] IRP, 7.11

power plant in the United States is expected to cost over US $1 billion; the Haddam Neck plant in the United States cost over $1.2 billion to decommission.[29] In Germany, the decommissioning of the Lubmin plant and the storage of the radioactive waste it produced will cost an estimate of $5.2 billion.[30] With six reactors planned as part of the Department of Energy's expansion, with an average decommissioning cost of R4-8 billion per reactor, there are tens of billions of rand unaccounted for in the project cost.

Nuclear-Related Infrastructure Costs

The dramatic expansion of the nuclear program will also have effects throughout the nuclear regulatory structure and will require expenditure beyond the simple construction costs of the new nuclear reactors. First, the Chief Executive Officer of the National Nuclear Regulator ("NNR") said that the proposed nuclear build would require the regulator to increase technical capacity by 50 percent.[31] He further noted this increase would require a proportional increase in the NNR's budget.[32] However, the Treasury's allocations to the NNR do not indicate any such increase and are currently stable through 2014.[33]

Second, South Africa recently undertook an Integrated Nuclear Infrastructure Review ("INIR"), a readiness assessment scheduled for completion by May 2012.[34] The Department of Energy explained that the "INIR involves a comprehensive evidence based assessment of the country's infrastructure readiness for nuclear power expansion".[35] The INIR will provide information on improvements required to bring the nuclear infrastructure into compliance with international standards. This could include changes in the electrical grid, increased safety measures, and additional environmental protections. The Department of Energy has not released the suggestions of the INIR to the public, even in the face of a *Promotion of Access to Information Act* request. However, any improvements and their associated costs must be included in the pricing of a nuclear program. For perspective, an independent expert estimated that South Africa would need to upgrade its electricity distribution network, to the cost of approximately R250 billion.[36]

Thirdly the cost of providing backup power in the event of power failures needs to be compared for each base load power generation option, and factored into the overall cost of nuclear power. The costs of such backup for nuclear plants may be significantly higher than providing backup for coal fired power stations.

Post-Fukushima Safety Improvements

A further consideration is the Fukushima nuclear disaster which dramatically changed the landscape of nuclear energy. In early March 2011, a massive earthquake and tsunami incapacitated the cooling mechanisms at a nuclear plant in Fukushima, Japan, causing the nuclear fuel to overheat. The subsequent widespread release of radiation from the plant forced the evacuation of over 100,000 nearby residents, many of whom have still not been allowed to return to their homes even a year later.[37] The evacuation zone covered a 12-mile perimeter around Fukushima, most of which still has high levels of radiation contamination.[38]

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[29] L. Song, "Decommissioning a nuclear plant can cost $1 billion and take decades", Reuters, 13 June 2011.
[30] R. Gessat, "Germany needs plan to close down nuclear plants", DW, 21 June 2012.
[31] S. Wild, "Nuclear build 'needs tougher regulator", Business Day, 15 June 2012.
[32] S. Wild, "Nuclear build 'needs tougher regulator", Business Day, 15 June 2012.
[33] S. Wild, "Nuclear build 'needs tougher regulator", Business Day, 15 June 2012; 2012 Estimates of National Expenditure.
[34] Department of Energy, "Role clarification for State Owned Entities in the nuclear build programme", Press Release, 29 March 2012.
[35] Department of Energy, "Role clarification for State Owned Entities in the nuclear build programme", Press Release, 29 March 2012.
[36] L. Faull, "South Africa's nightmare nuclear bill", Mail and Guardian, 23 March 2012.
[37] Associated Press, "Japan reopens parts of Fukushima evacuation zone", The Guardian, 30 March 2012.
[38] Associated Press, "Japan reopens parts of Fukushima evacuation zone", The Guardian, 30 March 2012.

The head of the International Atomic Energy Agency said the events at Fukushima triggered a "nuclear safety renaissance".[39] Many nations around the world decided to phase out nuclear power completely. Those that kept nuclear power undertook new costly safety measures.[40] For example, Electricite de France SA committed to 10 billion euros worth of safety improvements on France's reactors alone.[41] One researcher at the Energy Institute of the Cape Peninsula University of Technology estimated that post-Fukushima safety adjustments increased the cost of nuclear technology by 5 percent.[42] Even using just the "beginning" R300 billion stated in the Budget Review, these safety improvements increase the cost of South Africa's nuclear project by R15 billion, which has not been included in the present figures relied upon by the Department of Energy.

Moreover, in South Africa, as a result of post-Fukushima safety assessments at Koeberg and Safari-1, the NNR recommended a number of improvements to reduce risk and manage accidents.[43] Some hardware modifications at Koeberg are already in the project definition phase.[44] Additional improvement recommendations include measures such as upgrading on- and off- site communications, strengthening key equipment, and building a robust portable equipment storage facility.[45] These improvements will have to be incorporated into the design of any new reactor. The NNR has also adopted requirements that must be met to gain a future nuclear authorization, for example new testing and maintenance provisions.[46]

It is clear the Fukushima experience has changed the accepted safety requirements for nuclear reactors. Because these new safety measures were unaccounted for in the IRP 2010, the IRP 2010 cost estimates do not accurately reflect the cost of a post-Fukushima reactor. Therefore, the IRP 2010 contains insufficient relevant information and necessarily does not provide a complete understanding of the associated costs for a nuclear expansion program. Hence, it cannot be relied upon as the basis for the allocation of funds in the Budget.

Nuclear Disaster

The IRP 2010 also does not factor in the probability of a nuclear disaster. None of the associated potential costs have been included, nor has the cost of creating emergency plans. Studies done after Fukushima demonstrate that catastrophic nuclear reactor meltdowns could happen every ten to twenty years — much more frequently than previously thought.[47] The chances of a nuclear disaster are a relevant factor to consider when weighing the value of nuclear power against its potential costs to determine whether it really is in the national interest to pursue such a program.

Cost overruns

The Minister of Finance has also acknowledged that infrastructure projects have often experienced "significant cost over-runs".[48] History demonstrates that these projects require improved planning, costing, and project management.[49] Globally, these types of overruns have been witnessed specifically in nuclear power projects.

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[39] S. Pfeifer, "Fukushima triggers 'nuclear safety renaissance'", Financial Times, 11 March 2012.
[40] E.g., Reuters, "NRC to finalize nuclear safety guidelines in August", 1 June 2012.
[41] T. Patel, "EDF to complete post-Fukushima nuclear safety measures in 2018", Bloomberg, 8 March 2012.
[42] L. Faull, "South Africa's nightmare nuclear bill", Mail and Guardian, 23 March 2012.
[43] National Nuclear Regulator, "Media briefing on measures taken to strengthen our safety regime and nuclear power plants operations post Fukushima-Daiichi nuclear accident", 14 June 2012.
[44] National Nuclear Regulator, "Media briefing on measures taken to strengthen our safety regime and nuclear power plants operations post Fukushima-Daiichi nuclear accident", 14 June 2012.
[45] National Nuclear Regulator, "Media briefing on measures taken to strengthen our safety regime and nuclear power plants operations post Fukushima-Daiichi nuclear accident", 14 June 2012.
[46] National Nuclear Regulator, "Media briefing on measures taken to strengthen our safety regime and nuclear power plants operations post Fukushima-Daiichi nuclear accident", 14 June 2012.
[47] Jamie McGinnes. "Catastrophic nuclear reactor meltdowns like Chernobyl or Fukushima could happen every ten to 20 years, scientists warn." Daily Mail, 24 May 2012.
[48] Minister of Finance, *2012 Budget Speech*, 22 February 2012 p. 13.
[49] Minister of Finance, *2012 Budget Speech*, 22 February 2012 p. 11.

Generation III nuclear technology, which the IRP 2010 seems to promote,[50] has been beset with cost overruns.[51] Not only does this increase the actual cost, but borrowing money on the open market to fund an overrun will dramatically increase the financing costs.[52] This likelihood should also be accounted for in the costing process.

In total, unaccounted for costs in the nuclear program amount to at minimum R40 billion.[53]

This estimate, which does not include the cost of waste management, likely cost overruns, disaster management, or infrastructure improvements, is more than the entire consolidated State expenditure on defence for 2011/2012[54] and is twice as much as the national departments' expenditure on education for 2011/2012.[55]

(ii) Parliament is required to promote effective financial management by the executive. Given the absence of comprehensive information about the cost of the nuclear program parliament will be unable to discharge this constitutional obligation.

The IRP 2010 was designed to identify the "investments in the electricity sector that allow the country to meet the forecasted demand with the minimum cost to the country".[56] The integrated energy approach seeks to guide the selection of appropriate technology and ensure the adoption of the optimum energy mix.[57]

Parliament is bound to promote effective financial management through the budget.[58] The legislative mandate set out in section 8(5) of the Money Bills Amendment Act requires Parliament, when considering the budget, to balance of expenditure, revenue and borrowing, to ensure that the cost of recurrent spending is not deferred to future generations and to consider the short, medium and long term implications of the fiscal framework, division of revenue and national budget on the long term growth potential of the economy and the development of the country. Given the scale of the proposed future expenditure on energy by the State, these requirements suggest that the choice of the most cost effective energy mix would be most appropriate.

However, it is questionable whether the proposed nuclear expansion program would be the most cost-effective energy mix. As stated in the National Planning Commission report:

> South Africa needs a "plan B" should nuclear energy prove too expensive, sufficient financing be unavailable or if timelines are too tight. All possible alternatives need to be explored, including regional hydropower and greater use of gas.[59]

Because of inadequate cost measurements in the IRP 2010, described in detail above, it is impossible for the IRP 2010 to have accurately judged the most cost-effective options, and likewise impossible for the IRP 2010 to serve as a constitutional basis for the State to make large-scale nuclear and energy procurement decisions. The current information available is insufficient for Parliament to properly appraise which energy mix of

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[50] IRP 2010, Appendix B, para B.10.
[51] Olkiluoto in Finland; Flamanville in France
[52] L. Faull, "South Africa's nightmare nuclear bill", Mail and Guardian, 23 March 2012.
[53] R24 billion (R4 billion per reactor for decommissioning) + R150 million (R15 million per year for ten years to account for a 50% increase in the NNR's capacity) + R15 billion (R300 billion X 5% increase for post-Fukushima improvements). Note that this does not include costs of waste management, of related infrastructure improvements, cost overruns, emergency planning or disaster management.
[54] 2012 Budget Review.
[55] 2012 Budget Review.
[56] Department of Energy website, http://www.energy.gov.za/files/irp_frame.html (accessed 18 June 2012).
[57] Clause 6 (6), National Energy Act, No 34 of 2008; Ms Ramuedzisi, Chief Director for Energy Planning in the Department of Energy, *Energy Planning Colloquim: Overview of the National Energy Planning Process*, 30 March 2012.
[58] Constitution section 215
[59] p. 172.

technologies would be most appropriate to meet the State's needs. Further information is therefore needed for it to be able to carry out its oversight and financial management functions.

The IRP 2010 also did not undertake a modeling of the socio economic impacts of the procurement of one or more nuclear reactors, in order to indicate how energy from nuclear power would impact on the price and availability of electricity in the future as well as its impact on employment and poverty alleviation. This assessment is reasonably required in terms of other policies of the State including the New Growth Path. As stated by President Zuma in his State of the Nation Address in 2009:

> "The creation of decent work will be at the center of our economic policies and will influence our investment attraction and job creation initiatives."

The Framework for a New Growth path recognizes that the State often does not received value for money in service delivery and procurement.[60] In the light of these concerns it is submitted that Parliament should request further studies into the socio economic impacts of the nuclear build program, ie its impact on electricity prices, job creation and poverty alleviation in order to enable it to perform its oversight and financial management function.

(iii) Regardless of the current cost of nuclear energy, procurement of a "fleet" rather than single nuclear reactors violates the requirements of effective financial management.

The IRP 2010 recognised that not only are there uncertainties about the cost of nuclear power,[61] there are uncertainties regarding future demand.[62] The likelihood of cost overruns, potential delays, and changes in future demand are significant factors for consideration in the nuclear build, especially given the build is estimated to extend over 17 years. Because of these uncertainties, the IRP 2010 recommended firm commitments to just 3200 MW of electricity from nuclear power, which would mitigate costs if nuclear power were to be more expensive than expected.[63] The Department of Energy, however, has indicated it wishes to procure 9600 MW of power.[64] A contractual undertaking for 9600 MW of nuclear energy would bind the State for decades. If these contracts are with foreign parties, the penalties for withdrawal could be astronomical due to bilateral investment treaties South Africa has signed with other nations.

Moreover, this long term commitment would preclude a further future consideration of other energy solutions, in respect of that portion of the budget devoted to nuclear energy. It would therefore not be possible for the State to ensure that it has chosen the most efficient, economic, and effective technology to provide the electricity needed, which would most certainly not be in the national interest. In order to preserve future discretion, the State must purchase nuclear reactors incrementally, rather than as a fleet, if at all.

Yet, if a 9600 MW commitment is what the Department of Energy really considers as the most appropriate means to meet the nation's energy demands, Parliament should require the Department of Energy to provide an explanation for its deviation from the IRP 2010 recommendation. This would be in line with Parliament's obligation to effectively oversee and scrutinize Executive action and effectively manage the economy and future debt.

<u>In light of the above, Parliament should recommend a revision of the IRP 2010, and request that it include a cost analysis for nuclear energy that takes into account the costs which have thus far not been ascertained.</u>

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[60] The New Growth Path: The Framework, published by the Ministry of Economic Development 22 October 2010 page 27

[61] IRP 2010, clause 6.9.2

[62] IRP 2010, clause 6.9.1

[63] IRP 2010, clause 6.9.2

[64] *See*, e.g., Mail and Guardian, 19 October 2011; Mail and Guardian 23 February 2010.

A proper cost analysis could be done through the revision of the IRP 2010, which in any case was envisioned to go through a revision process with stakeholder input every two years.[65] This timetable schedules the IRP 2010 for revision at the end of 2012, although the Department of Energy has not released any indication that the revision will take place on time. Further refinements and regular updates of the IRP are also necessary to monitor electricity demand (which could be lower because of energy efficiency gains, sharp price increases and a sluggish economy; or higher if economic growth accelerates) and to assess whether new-generation technologies are delivering timely and affordable power.[66]

There are two main benefits to using the IRP 2010 as the new method of cost analysis. First, it gives effect to the integrated approach to energy planning, and allows the Department to consider the cost of nuclear energy in relation to other technologies. Second, the IRP 2010 revision process allows for stakeholder input, consistent with Parliament's obligations to facilitate public involvement in legislative and other processes.[67]

Further, a revised IRP can take into account the staged approach to energy procurement. The IRP 2010 already advised limited commitments to nuclear energy, with greater commitments to be considered in future versions. The revision process can develop this approach, while also allowing for changes in energy cost and demand.

B. The Committee should recommend that the Department of Energy act in a more transparent manner, providing adequate information to the public and Parliament as to its intentions and the decisions being taken regarding this proposed procurement. Only then can Parliament properly exercise its constitutionally mandated oversight role.

(i) Parliament is obliged to promote and ensure transparency in national, provincial and municipal budgetary processes, and in procurement.

Although the Department of Energy is bound by the Constitution and the PFMA to ensure transparent use of the State's resources[68], it has failed to act in a transparent manner. However, since we are before the Committees of Parliament, we restrict our submissions to the obligations of Parliament. There are two independent sources of obligation for Parliament regarding transparency in the budget and procurement processes. First, Parliament is bound by the provisions of the Constitution that mandate transparency in procurement and the budget.[69] Second, transparency within the Executive is necessary for Parliament to properly exercise its oversight responsibilities.

<u>Oversight over the budgetary process</u>

As mentioned above, the transparent use of the State's resources is constitutionally required by sections 195, 215 and 217 of the Constitution. In particular, section 215 requires transparency in the Budget process. As the institution with ultimate approval over the Budget, Parliament has responsibility to ensure this budgetary transparency. Although the Executive, as the other key player in the budget, has concurrent responsibility to promote transparency, that does not diminish the role of Parliament. The PFMA also explicitly requires departments and public entities to have transparent systems for budgeting and procurement.[70]

<u>Oversight over the Executive</u>

[65] IRP 2010, clause 1.1
[66] A. Eberhard, "A Powerful New Strategy To Shape SA's Energy Future", 21 August 2012.
[67] Sections 59, 72 of the Constitution.
[68] Sections 195, 215 and 217 of the Constitution; sections 38, 51, PFMA.
[69] Sections 215, 217 of the Constitution.
[70] Sections 6, 27, 38 and 51 PFMA

Parliament also has an obligation to exercise oversight specifically over the national executive. One of the National Assembly's primary duties is to ***scrutinize and oversee*** executive action.[71] The *Money Bills Amendment Act* recognizes this role in its Preamble, declaring that "the purpose of amending money Bills is to give effect to resolutions on oversight of the National Assembly and the National Council of Provinces". The Act further directs that all interpretations of the Act give effect to the "constitutional authority of the National Assembly and the National Council of Provinces in [. . .] maintaining oversight of the exercise of national executive authority".[72] In order to properly exercise this oversight role, it is imperative that Parliament ensures the Executive acts in a transparent manner. Only with proper and complete information can Parliament be assured that it is fulfilling its role in our constitutional structure.

Oversight with respect to procurement

As a corollary of Parliament properly carrying out its oversight function with respect to the Budget, Parliament also needs to consider the actual procurement for the nuclear expansion program, given that that is the basis for the allocation of funds. Parliament should bear in mind its future obligation to ensure the procurement contract for the proposed nuclear expansion program is "fair, equitable, transparent, competitive and cost effective".[73] This extends to the future implications discussed above, including the likelihood of cheaper technology developments and project cost overruns.

(ii) The Department of Energy's current procurement process for nuclear energy has not been conducted in a transparent manner. Parliament should take steps to make the process transparent, in line with its constitutional obligations.

Only minimal information has been provided to the public regarding the nuclear expansion program, contrary to the above constitutional obligations. The nuclear program – a multi-billion rand project – was not discussed in the 2011 Medium Term Budget Policy Statement, the Minister of Finance's 2012 Budget Speech or the President's 2012 State of the Nation address.[74] The National Nuclear Energy Executive Co-ordinating Committee, a body created in 2011 to lead and oversee the nuclear expansion, has not yet met.[75] Even State-owned entities such as the NNR,[76] the South African Nuclear Energy Corporation[77] and Eskom[78] have protested the lack of guidance provided by the Department of Energy regarding nuclear procurement. Further, the Department of Energy has specifically excluded nuclear energy from its regulations governing the procurement of new generation capacity.[79] Those regulations set minimum standards for power purchase agreements, provide a framework for the implementation of a procurement program with an independent power producer, and facilitate the planning for new generation capacity through feasibility studies. There has been no promulgation of similar regulations to govern nuclear power, in spite of the fact that the IRP 2010 committed the State to finalise the regulatory framework for the procurement of non-Eskom generated power as well as regulations for the implementation of the IRP 2010.[80]

From this, it is clear that the Department of Energy has not been acting in a transparent manner. However, there are currently no regulations requiring the provision of such information to Parliament. The Executive has

[71] Section 42 (3) of the Constitution.
[72] Section 2, *Money Bills Amendment Act*.
[73] Section 217 of the Constitution.
[74] National Treasury, *2011 Medium Term Budget Policy Statement*, 25 October 2011; Minister of Finance, *2012 Budget Speech*, 22 February 2012; Jacob Zuma, President of the Republic of South Africa, *State of the Nation Address*, 9 February 2012.
[75] T. Creamer, "SA sets up nuclear oversight body, to name participants 'in due course'", Engineering News, 28 November 2011; T. Creamer, "SA's assessment of nuclear readiness to be handed to IAEA for review", Engineering News, 29 May 2012.
[76] "Energy department clarifies roles of Necsa and NNR", Business Live, 29 March 2012.
[77] "Energy department clarifies roles of Necsa and NNR", Business Live, 29 March 2012.
[78] T. Creamer, "Eskom calls for urgent 'guidance' on its role in energy plan", Engineering News Online, 22 May 2012.
[79] GNR 399 of 4 May 2011: Electricity Regulations on New Generation Capacity
[80] IRP 2010, clause B.22 and Appendix E.

almost complete authority – with any checks on discretion of one executive department simply coming from another executive department. For example, when the Department determines whether procurement should be in-house or from an external provider, Treasury regulations require a feasibility study.[81] Without Treasury approval of this study, procurement cannot proceed.[82] However, at no stage do the regulations provide for this study to be approved, let alone even shown to Parliament. Without appropriate information, such as feasibility studies, cost assumptions, and procurement criteria, Parliament does not know enough about specific projects or procurement to judge whether it merits approval. Parliament should require executive departments take all necessary steps to provide more information to Parliament and the public. This would bring the Executive into compliance with its constitutional duties for transparency, and allow Parliament to fulfill its own constitutional duties to promote transparency in the budget, 15crutinize and oversee Executive decisions, and be able to properly adjudge whether procurement is actually "fair, equitable, transparent, competitive and cost effective".

It is also submitted that a special dispensation for oversight of nuclear procurement should be established by Parliament in the light of the fact that it is excluded from the regulations governing the provision of new generation capacity.[83]

(iii) Lessons from the Arms Deal

Of relevance to the above concerns is the report of the Select Committee on Public Accounts (SCOPA) in 2000 reviewing the Arms Deal.[84] In 1999, the State entered into a military procurement contract where the Executive had failed to inform Parliament of certain costing information. It is submitted that steps should be taken to prevent a repeat of this major shortcoming in financial governance.

SCOPA commissioned this report after the Auditor-General raised concerns relating to the Arms Deal. The following issues are relevant to the current submissions regarding nuclear procurement:

4. SCOPA stated that when Cabinet entered into the arms procurement contract it had not fully taken into account all the costs that the contract implicated, such as unfavourable foreign exchange movements, the cost of servicing the loans taken to finance the package and price escalation conditions in the contracts.[85]

2. The contract that was initially meant to cost R30,3 billion had risen to R43,8 billion a year after it was entered into.[86] SCOPA expressed its concern that the overall cost of the package would increase further.[87]

3. It also recommended that this information should have been made available to the public.[88] Cabinet was aware of the risk of the greater costs of the contract, yet did not make the public aware of this.[89]

4. SCOPA expressed doubts as to the suggested positive economic benefits of entry into this contract and suggested that these estimated benefits were not properly verified before being accepted.[90]

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[81] 2005 Treasury Regulations, clause 16.4.1.
[82] 2005 Treasury Regulations, clause 16.4.1.
[83] GNR 399 of 4 May 2011: Electricity Regulations on New Generation Capacity
[84] SCOPA, *The Special Review of Strategic Arms Purchases*, 14th Report, October 2000.
[85] *Id*, p. 1.
[86] *Ibid.*
[87] *Ibid.*
[88] *Ibid.*
[89] *Ibid.*
[90] *Id*, p. 2.

Many of the concerns raised in the SCOPA report are very similar to the concerns we have raised in our submissions here. Moreover, it is not stated explicitly in the report, but it can be reasonably inferred that the decision to enter into arms contract was not made openly and transparently. Furthermore, as this information was kept within the Executive, one can also deduced that it was not made available to Parliament. This failure to provide relevant information to the Parliament and public was not only a failure by the Executive to carry out its functions in accordance with principles of open and democratic governance as established by the Constitution, but also a failure by Parliament to ensure that necessary processes were in place to oversee and scrutinise Executive action and promote transparency. This failure by both parties contributed to the controversy of the Arms Deal and the ill-use of public resources.

With respect to the current proposed nuclear expansion program, these concerns raised by SCOPA should be borne in mind. Parliament should act to ensure that there will not be a repeat of these mistakes in any future procurement process, let alone the current proposed nuclear procurement.

C. The Committee should recommend that any large-scale procurement be conditional upon greater Parliamentary oversight.

In light of the above concerns arising from the Arms Deal, the deficiencies in costing in the IRP 2010, and the scale of proposed future energy procurement, Parliament should require greater oversight before approving expenditure for the nuclear program. More generally, Parliament should exercise greater oversight over procurement which is of such magnitude that it could impact adversely on the economy, poverty alleviation and job creation in future decades.

As discussed above, Parliament must exercise oversight over the Executive as part of its constitutional role. It is appropriate that this oversight take place from its very inception, that is, from the budgeting stage, and throughout the planning and purchase process of large scale procurement. The stakes of multi-billion rand procurement are too high for Parliament to approve expenditure based only upon the request of a Department.

In fact, the Executive itself has recognized that large-scale procurement requires different treatment from lower cost procurement. For procurement costing over R500,000, the National Treasury has promulgated a number of specific regulations that treat large-scale procurement differently. For example, competitive bidding is preferred for this type of large-scale procurement, whereas quotations are acceptable for lower cost procurement.[91] Moreover, there are additional regulations, although currently postponed, that govern procurement over R10 million.[92]

According to the Electricity Regulation Act of 2006, the procurement of new generation capacity must be transparent and competitive. Nuclear energy is however excluded from the provisions of the Electricity Regulations on New Generation Capacity[93] promulgated in terms of this Act. It is only reasonable in these circumstances that nuclear procurement should be treated as a separate category of energy procurement and given the costs of this procurement should be subject to specific parliamentary oversight provisions.

(i) Proposed methods of increasing Parliamentary oversight

[91] 2005 Treasury Regulations, clause 16.6.1 requires that procurement take place within the threshold values determined by the National Treasury. National Treasury Practice Note No 8 of 2007/2008, clause 3.4.1 set the threshold for competitive bidding at R500,000.

[92] National Treasury Instruction Note on enhancing compliance monitoring and improving transparency and accountability in supply chain management, May 2011; sections relevant to procurement over R10 million postponed in the National Treasury's Supply Chain Management Circular, September 2011.

[93] GNR 399 of 4 May 2011: Electricity Regulations on New Generation Capacity

In this regard, there are a number of ways that Parliament could exercise its constitutionally mandated oversight role. First, Parliament could require that the procuring Department provide periodic reports to it or alternatively seek direct approval from Parliament at certain stages of procurement. For example, Parliament could require that the Department of Energy obtain Parliamentary approval of the feasibility study recommending provision of a good or service from an external provider. Parliament could also require approval over the final contract before it is signed.

Second, Parliament could create multi-stakeholder committees to oversee key aspects of the procurement processes, which then report back to Parliament. Such committees could include members of the procuring Department, the National Treasury, affected businesses and civil society. This approach is gaining approval internationally.[94] Indeed, once a procurement contract is entered into, Parliament could also require that such Committees continue reporting to Parliament at critical phases of the contract to review and oversee the actual performance of the contract. This would be done with the view of ensuring that the original objectives of the procurement were being adequately met and achieved within a reasonable timeframe and cost, and where any significant deviations from it were explained and accordingly mitigated by the procuring Department.

[94]For example see: Global Organisation of Parliamentarians against Corruption website on parliamentary oversight accessed at http://www.gopacnetwork.org/programs/parliamentary-oversight/ Parliamentary Oversight (GTF-PO); Derrick V McRoy, "Parliamentary Oversight of the Executive Procurement: Lessons from Contractors-General of Jamaica and Belize." University of the West Indies at Mona, Faculty of Law January 11 2007, accessed at Social Science Network http://papers.ssrn.com/sol3/papers.cfm?abstract_id=958098

C. ECONOMIC[95]

1. **SUMMARY**
2. **INTRODUCTION**
3. **INTEGRATED RESOURCE PLANNING**
4. **ISSUES WITH IRP METHODOLOGY**
5. **THE POLICY BACKGROUND**
6. **NUCLEAR COST ASSUMPTIONS**
7. **THE TECHNOLOGY OPTIONS**
8. **CONCLUSIONS**

Summary
Integrated resource planning is an appropriate tool for planning electricity systems and if applied correctly, should ensure consumers receive a reliable, clean electricity service at the lowest cost. However, the nuclear programme of six reactors of 1600MW commissioned at 18 month intervals from 2022 onwards is not an output of the IRP calculations, it is an input assumption imposed by the government.

The key assumptions for the cost of nuclear power are the construction cost, the cost of capital and the reliability of the plant as measured by the load factor. In all three cases, the assumptions used in the IRP are far too optimistic. For construction cost, the Government had a good indicator of the cost through the 2008 tender. Inexplicably, they chose to ignore this and commissioned consultants, who provided an estimate of about half the level of the 2008 bids. This was used in the first iteration but revised up by 40 per cent for the final version of the IRP. Despite this, the revised estimate ($4300/kW) is still about 60 per cent of more reliable current estimates, for example, from the UK ($7000/kW).

On cost of capital, the Government applied a flat rate of 8 per cent to all options, implying all were equally economically risky. This is blatantly wrong and nuclear, based on its historic record worldwide is by far the most risky option and should attract a much higher cost of capital to reflect the risk that financiers would not be able to recover their loans. A low cost of capital would only be consistent if consumers guaranteed to pay whatever costs were incurred no matter how badly the project went. A rate of at least 12 per cent and perhaps 16 per cent would be most appropriate.

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[95] Section B was researched and written by Professor Stephen Thomas, as a consultant to Earthlife Africa-Jhb. Stephen Thomas is Professor of Energy Policy and Director of Research in the Business School of the University of Greenwich, London, where he has led the energy research since 2001. He has a BSc in Chemistry (Bristol). He has worked as an independent energy policy researcher for 35 years. From 1979-2000, he was a member of the Energy Policy Programme at SPRU, University of Sussex and in 2001, he spent 10 months as a visiting researcher in the Energy Planning Programme at the Federal University of Rio de Janeiro. He was a member of the team appointed by the European Bank for Reconstruction and Development to carry out the official economic due diligence study for the project to replace the Chernobyl nuclear power plant (1997). He was a member of an international panel appointed by the South African Department of Minerals and Energy to carry out a study of the technical and economic viability of a new design of nuclear power plant, the Pebble Bed Modular Reactor (2001-02). He was part of an independent team appointed by Eletronuclear (Brazil) to carry out an assessment of the economics of completing the Angra dos Reis 3 nuclear power plant (2002). He has published extensively on economics and policy on nuclear power.

On reliability, the Government assumes a load factor of 92 per cent, a level almost unprecedented worldwide and far higher than has been achieved at Koeberg where the two reactors there have a life time load factor of less than 70 per cent.

If more central estimates were applied ($6000/kW, 12 per cent cost of capital and 70 per cent load factor), the expected cost of power from the nuclear plants would probably double and, if things did not go as well as planned, a common occurrence with nuclear projects, the cost could triple.

A particular shortcoming is the lack of estimates for decommissioning and waste disposal. In accounting terms, the increase from taking account of these is limited but if the methods for ensuring sufficient funds are available to carry out these tasks when needed are not properly designed, future generations could face huge bills in the order of 10s of billions of Rand.

None of the technologies being discussed is proven in the sense of having operating reactors anywhere in the world. The French EPR was the lowest bid in 2008 and the two reactors in the West under construction have gone badly wrong with costs and times way over budget. There are also unresolved safety issues. The AP1000 (supplied by Toshiba-Westinghouse) has less experience and placed a higher bid than the EPR in 2008. None of the possible Chinese designs is complete enough yet to be ordered and they have not undergone a comprehensive regulatory safety review. The Korean design, AP1400, has plants under construction. The design is acknowledged not to meet Western safety standards and upgrading it will add significant cost. The current Russian design (AES2006) has construction experience in Russia but has not undergone a comprehensive safety review by Western authorities.

The background to this decision is a period of 14 years when the government worked on the assumption that a nuclear programme was desirable and feasible, first with the Pebble Bed programme and then with the failed call for tenders for nuclear capacity in 2008. This resulted in the waste of a large amount of public money, but, more important a period of 14 years when other options that could have delivered were not exploited as fully as they should have been. South Africa can ill-afford another significant period when a non-viable option is pursued.

2. Introduction

This paper examines the South African Integrated Resource Plan 2010 (IRP2010).[96] In particular it examines the contribution of new nuclear power stations to meeting demand in the period 2010-30. In the second part, I examine the history and rationale of IRP; in the third, general issues raised by use of IRP are discussed; in the fourth, the role of nuclear power in the IRP is analysed; in the fifth, the assumptions behind the cost of nuclear power are examined; in the sixth part, the nuclear technology options for South Africa are examined; and in the final part, conclusions are drawn

3. Integrated Resource Planning

Integrated Resource Planning (IRP) and the closely related Least Cost Planning (LCP) methodologies date back about 30 years and were used widely in the USA in the 1980s. The rationale for these techniques was that consumers were largely indifferent to how their energy needs were met provided they met the legal standards for example, for environmental impacts. Their concern was to get a reliable service for the lowest cost. In practice, the two major differences this made to utility planning was that, for the first time, demand side measures were given equal weight to supply side measures on the grounds that consumers cared about the size of their bill not the cost of a kWh. If a consumer used fewer kWh, even if the cost per kWh was more (to finance demand side measures), they would be happy if the overall bill was lower. The other major change was that utilities could not pursue high cost options ahead of lower costs options because of some internal bias

[96] http://www.energy.gov.za/IRP/irp%20files/IRP2010_2030_Final_Report_20110325.pdf

in favour of the high cost option. In the USA, use of IRP revealed that utilities were pursuing nuclear power ahead of cheaper options at considerable cost to consumers.

The use of IRP, which was generally seen as successful, declined after the 1980s as electricity systems were increasingly reformed to run on competitive criteria. Ina competitive system, it is assumed that market forces will achieve the same as IRP because in a fully competitive market, companies that choose expensive options incur high costs, lose market share and, ultimately, go out of business. Whilst this logic was appealing, results with the competitive model were problematic, with spectacular failures in California and Brazil. Even in the UK, the main pioneer of markets and often taken as the model for reforms, the government and the regulator both agreed in 2010 that the competitive market would not give reliability and would not allow the UK to meet its long-term goals for reductions in greenhouse gas emissions. As a result, a process of Electricity Market Reform was started, which, logically, will lead over time to a return to a fully planned electricity system.[97]

South Africa abandoned its attempt some years ago to create competitive electricity markets in favour of retaining a planned system with a strong element of public ownership. In a planned electricity system, IRP methodology remains an appropriate way to plan an electricity system.

4. Issues with IRP methodology

There are a number of issues that can make application of IRP methodology difficult.

4.1 Strategic decisions

Prior to use of IRP methodology, many expensive decisions were justified on strategic grounds, often bogus. IRP methodology does increase transparency for strategic decisions but given that the value of strategic objectives are often difficult to quantify, for example, what is the value of reducing dependence on an unreliable fuel supplier, strategic decisions cannot generally be integrated into the IRP methodology but must be imposed on the options. This is of particular relevance to South Africa's IRP 2010 in which the government has chosen to override cost considerations and force its preferred nuclear programme of adding 9600MW of nuclear capacity by 2030.

The IRP states[98]:

> 'Three policy choice options were identified:
>
> a) Commit to the nuclear fleet as indicated in the RBS;
> b) Delay the decision on the nuclear fleet indefinitely (and allow alternatives to be considered in the interim);
> c) Commit to the construction of one or two nuclear units in 2022-4, but delay a decision on the full nuclear fleet until higher certainty is reached on future cost evolution and risk exposure both for nuclear and renewables.
>
> The Department accepted option 4.3a, committing to a full nuclear fleet of 9600 MW. This should provide acceptable assurance of security of supply in the event of a peak oil-type increase in fuel prices and ensure that sufficient dispatchable base-load capacity is constructed to meet demand in peak hours each year.'

In short, the option to choose to build 9600MW of new nuclear capacity did not emerge from the IRP process, it was imposed upon it. Imposing options is not wrong *per se*, but if a strategic objective is being pursued, it would be logical that checks be made to confirm that the option chosen is indeed the cheapest way to meet that objective. This does not appear to have been done in the case of the decision to impose 9600MW of nuclear capacity on the plan.

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[97] For more details on Electricity Market Reform, see http://www.decc.gov.uk/en/content/cms/meeting_energy/markets/electricity/electricity.aspx

[98] http://www.energy.gov.za/IRP/irp%20files/IRP2010_2030_Final_Report_20110325.pdf p 11.

4.2 Demand projections

IRP methodology is heavily dependent on demand projections. If the forecast is too high, there will be over-investment leading to higher than necessary energy prices and if it is too low, security of supply will be jeopardised. The IRP is based on an assumption that peak demand will grow by about 75 per cent between 2010 and 2030, an annual rate of about 3 per cent.

While it is intuitively sensible to assume that with many South Africans consuming very little electricity, that demand will grow as living standards increase. However, South Africa already consumes a comparable amount of power per capita as Western European countries because of the existence of large amounts of electric intensive industry such as metal manufacture. Whether it is appropriate for South Africa to support electric intensive industry, which may contribute relatively little to GDP, employment and government income is a political decision. However, if some of this industry, which receives very cheap power, was relocated to other countries, the welfare of South Africans, as measured by their electricity consumption could increase in a scenario of low demand growth. More aggressive demand side measures could also achieve the same. The government acknowledges that its demand forecasts are high[99]:

> 'The forecast demand is at the higher end of the anticipated spectrum. The risk is thus that the actual demand turns out to be lower than forecast. In this case, the effect would be limited to over-investment in capacity. Security of supply is not jeopardised because of the conservative assumptions regarding energy efficiency and thus demand reducing measures.'

This paper does not discuss the accuracy of the demand forecast. Nevertheless, it should also be noted that electric utilities have an interest in adopting relatively high forecasts because the consequences of high forecasts is an increase in prices while the consequence of under-forecasting is insecurity of supply. Utilities are also often reluctant to acknowledge the importance of demand side measures because adopting demand side measures reduces their market side. Similarly, decentralised measures also reduce the role of large centralised utilities.

4.3 Data requirements

The basis for IRP is that all options should be considered and this places a huge burden to collect accurate cost data for all the options so they can be evaluated fairly. Inevitably, in some cases and particularly decades into the future, costs are going to be speculative and subject to a wide margin of error, perhaps sufficient to invalidate the results of the exercise. Again, this does not invalidate the exercise but it does mean results dependent on highly uncertain variables must be treated with care. In this paper, I examine in detail the cost assumptions made for nuclear power, including the value chosen and the level of uncertainty associated with these variables.

5. The policy background

The government has chosen to impose a programme of new reactors with a total capacity of 9600MW to be on-line by 2030. It is assumed that there will be six reactors each of 1600MW and the French design, the European Pressurised water Reactor (EPR), which has this capacity, is used for illustration. It appears no decision on technology has been taken yet and it is expected a call for tenders will be opened in the next year.[100] The first reactor is expected on line in 2022 with the next five following at 18 month intervals. This programme is described as follows[101]:

> 'A commitment to the construction of the nuclear fleet is made based on government policy and reduced risk exposure to future fuel and renewable costs.'

There is some ambiguity about when a commitment needs to be made. On p 16, the first two orders are shown as required before the next iteration of the IRP: 'Long lead times for new nuclear power stations require immediate, firm commitment to the first 3,0 GW, but government policy is to pursue the full nuclear fleet.'

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[99] http://www.energy.gov.za/IRP/irp%20files/IRP2010_2030_Final_Report_20110325.pdf p 18

[100] Q2 2012 Areva CI Earnings Conference Call – Final.

[101] http://www.energy.gov.za/IRP/irp%20files/IRP2010_2030_Final_Report_20110325.pdf p 22

Whereas, in discussion of some of the scenarios, it is stated:' Nuclear energy comes in as a base-load option from 2023 – but because this is 13 years away, this decision does not yet have to be made.' It is not clear how these statements can be reconciled. However, progress in the UK suggests that a minimum of 15 years is needed from government commitment to a nuclear programme to first power. The UK government committed to nuclear power in 2006, but by 2012, the UK was still no less than a year away from being able to place an order, so even if the reactor is ordered in 2014 and is on-line in no more than 5 years, it will have been 13 years from commitment to first power.[102]

On costs, there is ambiguity. The new version of the IRP assumes nuclear construction costs are 40 per cent higher than previously assumed, although, the new higher estimate still appears far too low. Yet in the report summary (p 6), it is stated: 'to account for the uncertainties associated with the costs of renewables and fuels, a nuclear fleet of 9.6GW is included in the IRP' and on p 18, it is stated: If the nuclear costs should turn out to be higher than assumed, this could increase the expected price of electricity. This can be mitigated with a firm commitment to 3.0 GW of nuclear.'

It is hard to see the logic in this. If estimated nuclear power costs are so uncertain that they can be increased by 40 per cent in a short period of time, this suggests nuclear power is highly risky and not a sensible choice to reduce risk. There is no evidence that the costs can be fixed by committing to order just two reactors. Most international tenders are for at least two reactors and real costs are continuing to rise not least as lessons from Fukushima are fed into reactor designs, no vendor is going to fix the price for a decade forward at a price that might well not cover its costs.

However, most relevant is the earlier call for tenders of 2008. Thomas wrote[103]:

> By mid-2007, Eskom was targeting construction of 20,000 MW on new nuclear capacity by 2025, although completion of the first unit had slipped to 2014.63 It expected a construction cost of $2,500/kW. In January 2008, Eskom received two bids in reply to its call for tenders from November of the previous year for 3200 to 3400 MW of new nuclear capacity in the near term and up to 20,000 MW by 2025. One bid was from Areva for two EPRs (plus 10 more for the long-term) and the other from Westinghouse for the three AP1000s (plus 17 more in the long term).[104]Both claimed their bids were "turnkey," but whether they were really turnkey in the fixed price sense or whether they were simply for the whole plant is not clear. It was later reported that the bids were for around $6,000/kW – more than double the expected price.[105] It was therefore no surprise when Eskom abandoned the tender in December 2008 on the grounds that the magnitude of the investment was too much for it to handle.[106] This was despite the willingness of Coface, the French government's loan guarantee body, to offer export credit guarantees and despite Areva's claims that it could have arranged 85% of the financing.[107] While Eskom is still claiming it expects to order nuclear plants, it seems unlikely that it will be able to finance these. *Engineering News* reported that the issue was the credit rating of Eskom[108]: 'In fact, ratings agency Standard & Poor's said on Thursday that South Africa's National Treasury needed to extend "unconditional, timely guarantees" across all Eskom's debt stock if it hoped to sustain the utility's current BBB+ investment-grade credit rating. The National Treasury was still to announce the details of the package. The Eskom board had, as a result, decided to

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[102] S Thomas 'Nuclear Europe: a dream unwinding' China Dialogue, June 6, 2012. http://www.chinadialogue.net/article/show/single/en/4956-Nuclear-Europe-a-dream-unwinding

[103] http://www.boell.de/downloads/ecology/Thomas_economics.pdf p 44

[104] Nucleonics Week 'Eskom Gets Bids for Two EPRS, Three AP1000s, Bigger 'Fleet,'' February 7, 2008.

[105] Nucleonics Week 'Big Cost Hikes Make Vendors Wary of Releasing Reactor Cost Estimates' Sep 11, 2008.

[106] Nucleonics Week 'Eskom Cancels Tender for Initial Reactors' December 11, 2008.

[107] The Star 'Nuclear Bid Had Funding – AREVA' January 30, 2009.

[108] Engineering News 'Eskom Terminates Nuclear 1 Procurement Process, but SA Still Committed to Nuclear' December 5, 2008.

terminate the commercial procurement process to select the preferred bidder for the construction of the Nuclear-1 project.'

A number of points emerge from this experience:

- The South African government has a history of unrealistic expectations on nuclear power that predate this experience with the decade wasted trying to commercialise the Pebble Bed Modular Reactor;
- The bids in the previous tender were about 50 per cent higher than the cost assumed in the updated IRP and more than double the level originally assumed in the IRP2010. It is incomprehensible why the South African government went to international consultants to get an estimate of the cost of a nuclear power plant when it had recent experience likely to be a much more reliable estimate of costs, the results of its earlier tender, than a consultant's cost estimate;
- The issue of finance is not considered as an uncertainty in the IRP. Only four years ago in 2008, a programme of two reactors proved to be unfinanceable yet it is not even questioned that a programme of six reactors might not be financeable.

6. Nuclear power cost assumptions

Under conventional cost accounting procedures, the majority of the cost of a kWh of nuclear electricity is accounted for by the fixed costs associated with the construction of the cost. These costs are fixed in the sense that they are incurred regardless of whether the plant is operated. This fixed cost has three main components:

- The 'overnight' cost of construction. This excludes the cost of finance (i.e., as if the plant was built 'overnight' but includes the first fuel charge (a relatively small cost);
- The cost of finance. Typically, any large investment is financed by a mixture of borrowing (debt) and use of own resources or sale of shares to a third party (equity). The interest rates should be expressed net of inflation (i.e., 'real' rates). Debt is typically lower cost than equity but financiers are often unwilling to provide finance unless the borrower is prepared to put up some of their own money. If the real cost of borrowing is 8 per cent and borrowing accounts for 60 per cent of the finance and the rest is made up of equity at a real cost of 12 per cent, the Weighted Average Cost of Capital is 9.6 per cent (8*0.6 + 12*0.4);
- The load factor. The load factor (capacity factor in US parlance) is the output of the plant in kWh, typically over a period of a year or over the life of the plant, expressed as a percentage of the output the plant would have produced had it operated uninterrupted at full power for the entire period. The more output the plant produces, the more thinly the fixed charges can be spread.[109]

Other factors, are either much smaller (not insignificant) for example, the operating costs, including fuel or the way in which conventional accounting deals with them makes their contribution small, for example, waste disposal and decommissioning costs. The operating costs are not dealt with here in much detail but the waste disposal and decommissioning costs are covered.

6.1 Construction cost[110]

The construction cost is central to the cost of power from a reactor. Conventionally, construction cost is quoted as the 'overnight' cost (excluding finance) in dollars per kW of capacity. So, a reactor costing $5000/kW with a capacity of 1500MW would have a total overnight cost of $7.5bn. Clearly there are still a number of problems of comparison: cost estimates from different years may be difficult to compare because of general price inflation; currency exchange rates can fluctuate by up to 20 per cent over quite a short period of time; and site specific costs might differ, for example, the transmission connection cost might differ and the cost of construction will depend on the coolant method and the local geology. Differences in cost of up to 20

[109] For a more detailed account of the economics of nuclear power, see http://www.boell.de/downloads/ecology/Thomas_economics.pdf

[110] For more details, see http://www.boell.de/downloads/ecology/Thomas_economics.pdf

per cent might be accounted for by such factors. Nevertheless, the cost per kW does allow the cost of reactors of different sizes installed in different countries to be compared on a reasonably fair basis.

It is sometimes claimed that costs in developing countries will be significantly lower than in developed countries because of lower labour costs. This is not valid. The labour needed is often highly skilled and specialised and has to be brought in from outside the country and has to be paid internationally competitive rates. For example, for the Olkiluoto plant, the workforce is drawn from about 20 countries and this has led to problems of communication. Finland is a much richer country and has substantially more nuclear experience than South Africa.

When the Nuclear Renaissance was being first discussed a decade or more ago, the nuclear industry confidently predicted Gen III+ reactors could be built for $1000/kW. In retrospect, this claim was never feasible but it did convince governments like those of the USA and UK to start efforts to recommence nuclear ordering. By the time the Olkiluoto bid was placed, the price was about $2300/kW. Estimate costs continued to rise and as US utilities began to plan their new reactors, their cost estimates were around $5000/kW. From 2008 onwards, a number of calls for tender were held, for example, in Canada, South Africa and the UAE and the lowest bids, apart from the Korean bid for UAE were at least $6000/kW.

In the UK, there are plans by EDF to build four new nuclear reactors of the EPR design. The expected cost of these reactors is reported to be £7bn per reactor.[111] Assuming a reactor output of 1600MW and an exchange rate of £1=$1.60, this gives a cost of $7000/kW.

Given that in 2008, South Africa had held a call for tenders, the most reliable estimator of actual costs other than out-turn costs, it is incomprehensible why South Africa asked consultants, EPRI, to provide a construction cost estimate. The estimate from EPRI turned out to be hopelessly unrealistic at about $3000/kW. Even with the 40 per cent added for the final version of the IRP, the cost estimate, $4300/kW, is far below recent experience. The lessons from Fukushima can only add to the costs of construction as new safety features are added. It will be many years before it is understood exactly what happened there and for it to be confidently claimed that a new design includes all the lessons from Fukushima. By comparison with Fukushima and Chernobyl, Three Mile Island was a much less serious accident but it still took five years before it was discovered, to the surprise of those involved, that the core had substantially melted.

Throughout the 60 year life of the nuclear industry, real construction costs have only ever gone up and there is no sign that the cost curve is yet flattening, much less declining as would be expected with any normal technology. So, the IRP estimate of construction cost appears a major underestimate and it might even be that it turns out to be half the real cost.

6.2 Load factor

The nuclear industry consistently assumed that nuclear power plants would be very reliable and would achieve lifetime load factors of 90 per cent or more. Reliability worldwide has improved since around 1980 when the average load factor worldwide was about 60 per cent and now the average is about 80 per cent. However, over the life of the plant, no more than a handful of reactors with more than a couple of years of operation has achieved a lifetime load factor of more than 90 per cent (most of these are in Germany). The two Koeberg reactors both have life time load factors over their 20 year life of 69 per cent.[112] The IRP assumption of 92 per cent appears hopelessly unrealistic.

The impact of poorer reliability goes much beyond the impact on the fixed costs. Poor reliability is likely to result in higher maintenance and repair costs and, perhaps most important, the power that the plant was expected to produce but did not, has to be produced from other sources. Power systems are usually run on 'merit order' basis under which plants are brought into operation or taken off line as demand rises and falls on a daily basis according to their operating costs. So, if a nuclear power plant breaks down, it must be replaced by a plant that would otherwise have been too expensive to operate. These so-called replacement power costs can be huge.

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[111] Daily Telegraph 'EDF Energy puts price cap on Hinkley Point nuclear plant' August 13, 2012, p 29

[112] http://www.iaea.org/PRIS/CountryStatistics/ReactorDetails.aspx?current=836

6.3 Cost of capital

The cost of capital is covered by use of a 'discount' rate. The discount rate is not the same as the cost of capital, but it is clearly related. The main factor determining the cost of capital is the financiers' perception of how risky the project is. The credit rating of the country involved has some impact but, in most cases, mainly it is the riskiness of the project and who that risk falls upon. The record of nuclear power plants seldom if ever being built to time and costs, of operating significantly less reliably than expected and of real cost escalation in all aspects of the product life cycle from construction costs, through operating costs to decommissioning and waste disposal makes nuclear power by far the riskiest commercial generation option. In the past, this riskiness has been of limited relevance because the implicit assumption has been that consumers would pay whatever costs were incurred and if things went wrong, the company owning the plant was not at risk.

In the past two decades this assumption has in many cases been broken with the adoption of competitive markets in some cases and the introduction of independent price regulators in others. In a competitive market, a company whose costs are too high goes bankrupt as was the case with the UK nuclear generation company, British Energy, in 2002. Independent regulators may be unwilling to pass on to consumers costs they consider to be 'imprudently incurred'. These imprudently incurred costs had to come from profits and if the amount was high, the utility could be bankrupted. The increased scrutiny of US regulators in the late 1970s led to the end of nuclear ordering there (the last order not subsequently cancelled was placed in 1974) as banks made it clear that it would not lend money for nuclear projects and pressured utilities to cancel existing orders.

The only orders for nuclear power plants in the past two decades have been placed in centrally planned, generally publicly owned systems, such as China, Russia and Korea or in countries where the utility has a dominant market share (for example, EDF in France, or is offering a 'cost-plus' contract to purchase the power (for example, TVO in Finland).

In South Africa, there is now an independent regulatory body and of that body has any rationale, it will be unwilling to pass on large cost overruns for a nuclear project to South African consumers. A nuclear power plant in South Africa must therefore be regarded as a risky investment as was made clear by the views of Standard & Poor's, the credit rating agency, which was asking for unconditional state-backed guarantees on *all* Eskom's debt if it was not to reduce Eskom's credit rating. Reducing Eskom's credit rating would have increased their cost of borrowing for all its debts and would have increased its overall costs (and the price of electricity) substantially.

There are two options other than guaranteed cost pass-through that would reduce the risk on banks. A 'turn-key' (fixed price) contract would place the risk of cost escalation on the vendor. Such contracts have been extremely rare for nuclear power plants because the vendors do not have the financial resources to take that risk. A turn-key contract was signed for the Olkiluoto plant but when costs began to escalate, Areva, the vendor refused to honour the contract blaming the utility and the case about who pays the extra costs (now more than €3bn) will be settled in the Stockholm Court of Arbitration. For these purposes, it is irrelevant who is to blame, the consequence is that a fully fixed price contract to supply a nuclear power plant is highly unlikely to be offered and even if it is, financiers are likely to assume it is not worth the paper it is written on.

The other option is for state guarantees to cover the loans, for example, offered by the government of the country of the vendor. Under this, if the utility went bankrupt and could not repay the bank, the taxpayers of the country offering the guarantee would repay the banks. This would mean the bank was, essentially, lending to a national government and the interest rate would be commensurately low. This has attractions, but there are serious problems: First, if the costs do overrun, the utility will have to go to the market to borrow money to finance a project going badly wrong; second, this will be extremely expensive. If the utility does fail, the banks will be repaid but consumers and or taxpayers will be faced with large costs to bail out the utility or make alternative provisions; third, in today's economic climate government Treasury's are going to be reluctant to take on large potential liabilities and will be unwilling to offer loan guarantees; and finally, under OECD guidelines, loan guarantees should attract an fee that reflects the riskiness of the project. This fee should be an economic one and if it truly reflects the risk, this fee might well counterbalance the advantages of the lower interest rate.

For the IRP, a standard real discount rate of 8 per cent for all options is used. In practice, and unless an explicit risk analysis is done, this implicitly assumes all options are equally risky. The problems with this assumption are alluded to on p 22 where it states: 'The possibility of different discount rates for technology to factor in

different risk profiles for the technologies should also be investigated.' This has not been done. It is difficult to know what an appropriate cost of capital for a nuclear power plant exposed to risk would be. It could well be double the assumed rate.

6.4 Impact of changes to the fixed costs on the cost of power

To measure the impact of alternative assumptions on construction cost, load factor and cost of capital would require a full re-running of the IRP but some idea of the impact can be gained by making some very simple assumptions. Let us assume, purely for illustration, that with IRP assumptions, the cost of power from a nuclear power plant was ZAR100/MWh and that was made up of two thirds fixed costs associated with construction 1812

and one third running costs. Let us assume that the construction cost is 50 per cent higher than assumed, bringing it into line with most current estimates. This would increase the cost of power to ZAR133/MWh. If the cost of capital was 12 per cent rather than 8 per cent, this would also increase the cost of power to ZAR133/MWh. If we assume the load factor was 70 per cent instead of the 92 per cent assumed, this would increase the cost of power to ZAR121/MWh. A lower load factor would lead to other increases in cost, such as replacement power costs and higher maintenance and repair costs. These extra costs are not estimated here.

If all three alternative assumptions were applied, the cost of power would increase to ZAR230/MWh.

These alternative assumptions are far from worst cases. For the construction cost, the alternative assumption only brings it into line with international estimated and the cost of capital could easily be double the assumed level and the cost of capital could also be double the assumed level. This would mean the cost of power from a nuclear reactor would be about three times the expected level. If more realistic assumptions were applied to running costs and the cost of decommissioning and waste disposal were properly factored in, the costs would be even higher.

6.5 Decommissioning and waste disposal

In absolute terms, the cost of waste disposal and decommissioning are of the same order as the cost of construction. For example, in the 2007/08 annual report and accounts of British Energy, the British nuclear power generator, it was estimated the cost of decommissioning its eight plants was £9.4bn and the cost of disposal of the spent fuel was £5.5bn.[113]

However, these liabilities fall due far into the future. For example, in the UK, the most difficult stage of decommissioning, cutting up and disposing of the contaminated equipment and cleaning the site so it can be released for unrestricted use is not expected to take place until about 60-80 years after plant closure. So, if it is assumed that a nuclear plant operates for 40-60 years, on the day of its commissioning, it will 100-140 years before most decommissioning funds are needed. Current UK government plans foresee that a disposal site for spent fuel will not be available until 2125.

Worldwide, there is no experience of siting a high-level waste disposal site, much less actually building and operating one, so the costs must be seen as extremely speculative and, unless experience here is completely different to experience so far with nuclear power, the actual cost is likely to be substantially higher than current forecasts. Similarly, there is very little experience of the most challenging part of decommissioning, cutting up and disposing of the reactor vessel. In the UK, the first reactor (retired more than 20 years ago) is not expected to start this process before 2070. Worldwide, no more than a handful of commercial nuclear reactors have been fully decommissioned and this experience is of limited value. Some of these plants are very small, some use different technologies to those considered here and most have had a short operating life so are much less contaminated than a reactor that had operated for, say 40 years or more. So, as with high-level waste disposal, there is huge uncertainty about what the costs will be and a strong likelihood that the actual costs will turn out to be much higher than currently estimated.

Under conventional accounting procedure, liabilities that must be met in the future should be 'discounted'. Effectively this means that a sum of money (or assets of that value) is set aside now and it is assumed that

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[113] http://www.british-energy.com/documents/Annual_report_2007_2008.pdf Note, more up to date data is not available because the company was taken over by Electricite de France and no longer publishes this data.

money will earn interest and grow to meet the liability. So if a liability of $105 falls due in a year and an interest rate of 5 per cent can be earned, the 'discounted' value of the liability is $100 because in one year, it will grow sufficiently to meet the liability.

In the short term this sounds a sensible procedure, but over longer periods, the operation of compound interest rates mean that sums of money can grow remarkably. For example, a sum invested for 100 years earning an interest rate (net of inflation) of only 3 per cent, will grow 19 fold. So even if the cost of decommissioning a nuclear plant is, say a quarter the cost of building it, in the accounts, the liability will show as, perhaps, 1.3 per cent of the construction cost, in short, a trivial amount. However, if things go wrong, a future generation of taxpayers will have to meet the full cost of decommissioning a facility that they have derived no direct benefit from.

This is not just a theoretical possibility. In the UK, consumers paid money for decommissioning from 1979 onwards only to find that, by 2002, none of that money was available. It had been lost for example, by the Treasury using it for general government expenditure and investment in assets that proved worthless (a nuclear power plant). As a result, future UK taxpayers will have to meet a liability over the next century or more of more than £100bn.

UK experience is worse than most but as a result of issues such as these, best practice has evolved and now, typically, a decommissioning fund has the following characteristics:

- Consumers pay into the fund through their electricity charges;
- The company owning the plant has no access to the fund so if it goes bankrupt, the fund is not lost;
- It is invested in low risk investments (earning a commensurately low rate of return);
- The cost estimates are frequently updated so contributions can be increased to meet this cost escalation.

This represents a substantial improvement on past practice but it is still far from sufficient to provide a high degree of certainty that no financial burden (there is no way to avoid them having to carry out the hazardous task) will fall on future generations to clean up our mess.

To reduce the risk further, all major risks must be taken into account. These include the risk that:

- The fund will be lost or invested in assets that earn a lesser rate of interest than expected. After the current financial crisis, it is clear that few if any investments can be regarded as 'safe' in the long-term and that the assumption of a positive real rate of interest is hard to justify. Real interest rates are negative and decommissioning funds are losing value currently;
- The plant operates for less time than expected. This would mean that less money could be collected from consumers and the time for the fund to grow would be less;
- The cost estimate proves too low. Especially if this discovery comes late in the life of the plant or after it has closed, it will be too late to make up the shortfall through larger contributions. In the UK, the estimated cost of decommissioning has increased about 6 fold in only 20 years;
- The company owning the plant goes bankrupt. In the UK, British Energy, the UK nuclear company, went bankrupt in 2002 and as part of the rescue package, future taxpayers took over the financial burden of paying for decommissioning.

These risks can probably be dealt with by means of financial instruments, effectively insurance policies to cover these contingencies, but the cost will not be low if the current generation is to meet its ethical obligation to provide a very high degree of certainty that the 'polluter will pay'.

7. The technology options

When the programme of 9600MW of new nuclear capacity was announced, there was a great deal of speculation about potential suppliers in addition to the two companies Areva with the EPR and Toshiba/Westinghouse with the AP1000 that participated in the 2008 call for tenders. These included suppliers from China, Russia and Korea. It seemed that the conclusion of the government and Eskom was that the reason the bids were so high was that the tender had been done wrongly so that the bids were higher than they

should have been and that other suppliers, not included in that process would offer much cheaper prices. This attitude was quickly shown to be naïve.

It seems that South Africa is interested only in Pressurised Water Reactors (PWRs) not their close relative, the Boiling Water Reactor (BWR). The two reactors at Koeberg are PWRs so this has some logic. If BWRs were included, one or two more options would emerge but there is no evidence the costs would be lower. There was also speculation that earlier generation designs, so-called Generation II, that would not meet current Western safety requirements, assumed to be cheaper, would also be considered. This option now appears to have been discounted and South Africa is only interested in Generation III or III+ designs.

The designation of design generation is not precise but, broadly, Gen I includes demonstration and early commercial plants. Gen II includes most of the approximately 450 commercial reactors in operation in the world, including Koeberg. Theses reactors were designed in the late 1960s and the 1970s but pre-date the Three Mile Island accident of 1978. Gen III designs take account of Three Mile Island but do not take full account of the Chernobyl disaster, while Gen III+ are the latest designs. Few reactors of Generation III design are in service yet and no reactors of Gen III+ are in service yet. Only two Gen III+ designs have received orders. The EPR has four orders, two for China, one for Finland and one for France. The AP1000 has eight orders, four for China and four for the USA, although main construction work on the four US units has yet to start.

So if South Africa wants proven technology, that is, a design with significant operating experience, it will need to go back to designs made 30 or more years ago.

Amongst the PWR suppliers there five options worth considering: the Areva EPR, the Toshiba-Westinghouse AP1000, the Korean AP1400, the Russian AES-2006 and Chinese designs.

7.1 Areva EPR[114]

This option was the lowest bidder for the 2008 tender albeit far too high to be financeable. It was the first Gen III+ design to receive an order, with construction starting on a reactor in Finland (Olkiluoto) in May 2005 followed by an order for France (Flamanville) on which construction was started in December 2007. Two EPRs are under construction in China (Taishan), starting in 2009. The Olkiluoto project has gone disastrously wrong and the plant which was expected to take four years to build and cost €3bn is now going to take at least 10 years and cost more than double the estimate. Things have gone no better at Flamanville, which is also now four years late and 100% over-budget. There is no clear cause for these delays, a large number of design issues, construction errors etc. seem the main culprits

Reports from China claim the Taishan plants are on schedule but it is hard to get independent verification of this.

One of the issues with the Olkiluoto and Flamanville plants was that the design had not been fully reviewed by the safety authorities before construction started, as was normal practice up to then. In the USA and the UK, full 'generic' design reviews are now required before construction can start to avoid the sort of problems encountered at Olkiluoto and Flamanville. This process is not expected to be complete in the UK till 2013 or later and in the USA by 2014 or later. There is still a major issue to be resolved in the Instrumentation and Control system (the 'brain' of the reactor). This was flagged up by regulators in 2009, but the solution to the issue is still some way from being established.

This means the EPR design is not yet finalised – the designs for Olkiluoto, Flamanville and Taishan will all differ from this final design. Areva and EDF are now reviewing the design again to reduce the cost and this means the design that is approved in the UK and the USA may be changed again before orders for South Africa could be placed. China seems unlikely to pursue the EPR option, although it is possible that China could partner an EPR bid for South Africa.

7.2 AP1000

The AP1000 has orders for China and the USA but independent information on the progress of the Chinese sites is hard to establish. It appears construction is running up to a year late.[115] Construction work is expected

[114] For more details on this design, see S Thomas (2010) 'The EPR in crisis', PSIRU, University of Greenwich http://gala.gre.ac.uk/4699/3/%28ITEM_4699%29_THOMAS_2010-11-E-EPR.pdf

to start in 2013 for the four US reactors. The generic review of the AP1000 has been completed in the USA but the process has been suspended, incomplete, in the UK until Toshiba-Westinghouse has a UK customer.
The AP1000 was expected to take over as the main choice for China but concerns over its high price have put this in doubt. It is not clear whether the AP1000 would be bid again in South Africa. It is possible that China could partner Toshiba for a bid for South Africa.

7.3 Korea

Korea has been building reactors for decades with increasing local content, although the designs it has built have all been under license to US vendors. Its latest design, the AP1400, was licensed from the US company, Combustion Engineering, now part of Toshiba-Westinghouse. Toshiba Westinghouse does allow it to offer the design for export. It received generic design approval in the USA in 1997, but that approval expired in 2012. Construction work in Korea on the first two units of this design (Shin-Kori 3 & 4) started in 2009 with a third (Shin-Ulchin) starting construction in 2012. Korea emerged as a potentially significant exporter of nuclear technology with its winning of a competitive tender in UAE in 2009.
In December 2009, the UAE ordered four nuclear reactors from Korea using AP1400 technology beating opposition from consortia led by EDF with the EPR and GE-Hitachi (ABWR).[116] The contract is with Korean Electric to build and operate the plants, the first coming on line in 2017 and the last by 2020. KEPCO will provide design, construction and maintenance for the nuclear reactor and will subcontract some of the work to equipment suppliers such as Hyundai, Doosan and Samsung. The terms of the deal and what is included are not clear although the contract is reported to be worth $20.4bn. The Korean bid was reported to be $16bn lower than the French bid and the GE-Hitachi bid was reported to be significantly higher.[117] It appears not to be a whole project 'turnkey' (fixed price) deal. Korean companies will hold an equity stake in a joint venture with UAE public companies, which will operate the plants after their completion. Construction work on the first of these at the Barakh site started in July 2012.
The design being built in Korea and UAE, without a 'core-catcher' and a 'double containment', probably would not be licensable in Europe. Areva was particularly bitter about losing the tender to a design it claimed had much lower safety standards than their EPR. Their then CEO, Anne Lauvergeon likened the APR1400 to "a car without seat belts and airbags".[118] It is unclear whether the AP1400 would meet South Africa's requirement that it order only Gen III designs. In 2010, Korea claimed it would submit the AP1400 to the US NRC for generic design review in 2012.[119] By November 2012, the target date for submission was March 2013. Even if that date was met, the process typically takes at least 6 years so would not be complete by the time the first South African orders were placed

7.4 China

In the period 2008-10, China saw a remarkable spurt of construction with construction work starting on 25 reactors in that period. This compares to only 17 ordered in the 25 years up till then. Since December 2010, no new construction starts have taken place. In part this is due to reviews following the Fukushima disaster with a desire, increased by Fukushima to move away from the old designs that made up most of these orders. None of the reactors ordered from 2008-10 is yet in service. Of these, four were AP1000s and two EPRs. Of the other 19, two were smaller reactors and the other 17 were supplied by Chinese vendors under license to Areva. This design, M310, was built in France in the 1970s and France itself licensed it from Westinghouse around 1970. So while this design has been updated, it is fundamentally a very old design. France is unwilling for China to export it so, even if such an old design was acceptable in South Africa, it is not a feasible

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[115] Nuclear Intelligence Weekly 'CHINA: AP1000s Delayed by 6-12 Months, SNPTC Says' January 17, 2012, p 4
[116] Korea Herald 'Korea wins landmark nuclear deal' December 28, 2009
[117] Right Vision News 'UAE: Middle East leads rally in nuclear plant orders' January 12, 2010
[118] Nucleonics Week 'No core catcher, double containment for UAE reactors, South Koreans say' Apr 22, 2010, p 1
[119] Inside NRC 'Kepco to submit APR1400 design for NRC review in 2012' April 26, 2010

option.[120] Nucleonics Week reported: 'The French nuclear safety authority has said it will not condone French nuclear companies participating in construction of reactors abroad that would not be licensable in France.'[121]
There are a number of Generation III/III+ under development in China: ACPR1000, ACP1000 and CAP1400, the latter in collaboration with Toshiba. However, the designs on all of these are some way from being ready to order. Until China restarts its nuclear programme after the halt called following the Fukushima disaster, it will not be clear which design China will pursue. Even then, the design will not have been reviewed by Western safety authorities so unless South Africa was prepared to rely on the Chinese authorities' assessment, these would not be an option for South Africa.

7.5 Russia

Like China, Russia started ordering nuclear power plants again about 5 years ago. Apart from two export orders for plants to China and India, the Russian nuclear industry had not received an order since the mid-80s prior to the Chernobyl disaster. The Chernobyl technology has been abandoned and Russia now only offers its own version the PWR, the VVER. Its latest design is the AES-2006, a 1200MW design which Russia claims should be seen as Gen III+. Five reactors of this design are under construction in Russia, but not yet in service. Russia has won orders for this design for Turkey and Vietnam but construction has not started yet. There appear to be a couple of variants on this design (V-392M and V-491), although it is not clear how far these differ. Russia has shown some interest in getting into Western reactor markets but it has not bid yet in the West and its new designs have only been reviewed by the Russian authorities. Whether this review is comparable to a US/UK full generic review is not known so it is impossible to say whether the AES-2006 would be licensable in the West.

8. Conclusions

In a centrally planned electricity system, integrated resource planning is an excellent tool to ensure that consumers' pay the lowest price possible, consistent with a reliable and 'clean' electricity supply. However, the outcome that South Africa should install 9600MW of new nuclear plants by 2030 has nothing to do with the use of IRP. It is an assumption imposed by government. The IRP is based on what is acknowledged to be a demand forecast at the high end of the likely outcomes.
The key assumptions determining the cost of a nuclear kWh are the construction cost, the cost of capital and the load factor. An earlier iteration of the IRP was based on a hopelessly unrealistic forecast of construction costs, about half the level actually bid in 2008 when South Africa carried out an ill-fated call for tenders for nuclear capacity. For the final iteration, this estimate was increased by 40 per cent but this still leaves the estimate about 70 per cent lower than most current estimates.
The cost of capital used, 8 per cent, is the same for all options, implying that all are equally economically risky. This is blatantly not the case and, based purely on its past record worldwide, nuclear power is by far the most risky option. If this was reflected in the cost of capital, the cost might double and is unlikely to be less than 50 per cent higher than assumed. The load factor assumed, 92 per cent, is almost unprecedented worldwide for the lifetime of a reactor and is far higher than the two Koeberg reactors have achieved, less than 70 per cent. Poorer load factors than assumed would also lead to other significant extra cost in terms of repair and maintenance and replacement power costs not here estimated.
If more realistic assumptions on construction cost (50 per cent higher), cost of capital (50 per cent higher) and load factor (reliability similar to reactors at Koeberg) were applied, this would double the expected cost of power and if things did not go smoothly, for example, construction cost and cost of capital double the expected level, the cost of power from a new reactor could be two and a half times that expected.
The IRP acknowledges that decommissioning and waste disposal costs are not properly estimated. If provisions were made that properly embodied our moral obligation not to impose financial costs to clean up our environmental damage on a future generation, this would add significantly to the cost, although no estimate of these extra costs is made here. Other assumptions, for example on reactor life-time are also

[120] Nucleonics Week 'EDF executive seeks joint ventures in China' October 14, 2010
[121] Nucleonics Week 'Chinese companies look to become nuclear export force with own designs' Dec 2, 2010

optimistic. Using more realistic assumptions throughout and accounting properly for decommissioning and waste disposal could easily lead to a cost per kWh about three times the level expected.

The government imposed the nuclear programme on the IRP on grounds of its assumed positive impact on security of supply. It is hard to understand how such a blatantly risky option can be seen as a positive contributor to security of supply. Equally, it is hard to believe that with more realistic cost estimates, building nuclear power plants would be the cheapest way to achieve that desired improvement in security of supply.

There has been a lot of ill-informed discussion of the technology options available to South Africa since the failed tenders of 2008. It seemed that the conclusion of the government and Eskom was that the reason the bids were so high was that the tender had been done wrongly so that the bids were higher than they should have been and that other suppliers, not included in that process would offer much cheaper prices. Five options have been mooted: Areva's EPR; Toshiba-Westinghouse's AP1000; a Korean design AP1400; Chinese-supplied reactors; and Russian-supplied reactors.

None of these options is proven in the sense of having operating reactors in service yet.

The EPR is the design with the most experience but most of this is appallingly bad. Reactors in Finland and France are running 4-6 years late and at least double the expected cost. There are still major unresolved regulatory issues with the design that were identified at least three years ago.

The AP1000, which has never underbid the EPR in a tender has less experience of construction with no experience outside China, but does have regulatory approval in the USA. Like the EPR, in the previous tender, it proved unfinanceable and it is highly unlikely the price bid in a new tender will be anything other than higher than in 2008.

China is seen as an attractive assumption on the basis of the large number of reactors ordered there in recent years and on the tacit assumption, with no evidence to support it, that because it is Chinese, a reactor would be cheap and of good quality. In practice, the reactors that made up most of the recent burst of orders could not be exported because of license restrictions and would probably be of too early a design generation to meet current safety standards. It has advanced reactor designs under development but these are still some way from being orderable and they have not undergone a comprehensive safety review so are not a realistic option.

Russia has also emerged on the reactor market in the past five years with orders for its home market using a new design that it claims meets current Western standards. These claims have not been tested and no Western regulatory body has undertaken a thorough review of the design.

Overall, there is a risk that South Africa will commit itself to order a large number of reactors that will impose huge additional costs on consumers. However, the more likely risk is that, as in 2008, the nuclear programme will prove impossible. Since 1998, when the Pebble Bed Modular Reactor programme was launched, the South African government has operated on the assumption that nuclear power plants would make up a significant proportion of generation. The result has been that other options, that could have met South Africa's electricity demand needs reliably and cost effectively have been neglected – South Africa, like any other country, has limited resources and cannot pursue all options. If the nuclear programme is not abandoned now, the risk is that efforts to make it happen will continue for several more years, wasting government time and money and leading to more neglect of alternatives, before the government again, as it did with the PBMR and the failed tender of 2008, has to admit defeat.

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