



UNITED NATIONS
UNIVERSITY
UNU-WIDER

WIDER Working Paper 2016/19

The social shaping of nuclear energy technology in South Africa

Britta Rennkamp¹ and Radhika Bhuyan²

April 2016

In partnership with



Abstract: This paper analyses the question why the South African government intends to procure nuclear energy technology, despite affordable and accessible fossil and renewable energy alternatives. We analyse the social shaping of nuclear energy technology based on the statements of political actors in the public media. We combine a discourse network analysis with qualitative analysis to establish the coalitions in support and opposition of the programme. The central arguments in the debate are cost, safety, job creation, the appropriateness of nuclear energy, emissions reductions, transparency, risks for corruption, and geopolitical influences. The analysis concludes that the nuclear programme is not primarily about generating electricity, as it creates tangible benefits for the coalition of supporters.

Keywords: nuclear energy, energy policy, science and technology policy, discourse network analysis, South Africa

JEL classification: O14, Q48, O33, O55

Acknowledgements: The authors would like to thank all colleagues, unknown reviewers, and interviewees who supported our work on this paper. Thanks to the interviewees for the trust of sharing your insights. Thanks to the reviewers and colleagues for the helpful comments on previous versions of this paper and constructive comments during two seminars at the Universities of the Witwatersrand and Cape Town. Thanks to UNU-WIDER and the Volkswagen Foundation, Compagnia di San Paolo, as well as Riksbankens Jubileumsfond under the project, ‘Climate Change Mitigation and Poverty Reduction’ for support.

¹ Energy Research Centre and African Climate and Development Initiative, University of Cape Town, South Africa, corresponding author: britta.rennkamp@uct.ac.za; ² Mapungubwe Institute for Strategic Reflection, Johannesburg, South Africa.

This study has been prepared within the UNU-WIDER project on ‘[The Political Economy of Clean Energy Transitions](#)’.

Copyright © UNU-WIDER 2016

Information and requests: publications@wider.unu.edu

ISSN 1798-7237 ISBN 978-92-9256-062-1

Typescript prepared by Leslie O’Brien.

The United Nations University World Institute for Development Economics Research provides economic analysis and policy advice with the aim of promoting sustainable and equitable development. The Institute began operations in 1985 in Helsinki, Finland, as the first research and training centre of the United Nations University. Today it is a unique blend of think tank, research institute, and UN agency—providing a range of services from policy advice to governments as well as freely available original research.

The Institute is funded through income from an endowment fund with additional contributions to its work programme from Denmark, Finland, Sweden, and the United Kingdom.

Katajanokanlaituri 6 B, 00160 Helsinki, Finland

The views expressed in this paper are those of the author(s), and do not necessarily reflect the views of the Institute or the United Nations University, nor the programme/project donors.

1 Introduction

Why is the South African government pursuing a nuclear energy programme, despite abundant and accessible fossil and renewable energy resources? The South African electricity sector has historically been mainly coal-fuelled. One nuclear power plant has contributed five per cent of electricity since the 1980s. A renewable energy programme contributes another five per cent.¹

We argue that the government has chosen to procure an additional 9.6 GW of nuclear capacity, because of a significant coalition of nuclear energy supporters. The role of coalitions in shaping policy outcomes has long been established. The constructivist literature on science and technology policy explains why decision-makers sometimes choose less practical and less cost-efficient technologies over others. The concept of social shaping of technology suggests that the interplay of social, political, economic, and cultural factors in a society shape the design and implementation of a technology. The literature identifies political factors leading to the prioritizing of nuclear technologies over other alternatives. We apply this theoretical perspective to the recent nuclear programme in South Africa. A discourse network analysis helps to establish the political arena of nuclear energy and to identify the coalitions supporting and opposing the nuclear energy programme, as well as the arguments that motivate their positioning (Leifeld 2012). The analysis uses data from 350 media articles, relevant policy documents, and background interviews. In this paper, we link discourse network analysis and the science and technology literature to analyse ‘social shaping’ of nuclear technologies in South Africa.

2 Social shaping of nuclear energy technologies and the role of discourse coalitions

Existing research from the sociology, political science, and nuclear scholarship identifies various motivations for governments to pursue nuclear programmes, despite other options. Sociologists framed theories of social shaping of technology (SST), social construction of technology (SCOT), and actor network theory (ANT) in the 1980s and 1990s. These approaches dismiss the idea of ‘technological determinism’, which assumes technological choices are purely economically or technically determined. Constructivist theories suggest that organizational, political, economic, and cultural factors ‘pattern the design and implementation of technology’ (Williams and Edge 1996). The reasons for acceptance or rejection of a technology emerge from the societies themselves (Bijker 1992, 1995; MacKenzie 1993, 1998). ‘Relevant social groups’ shape technological trajectories according to their interests and interpretations (Bijker 1995: 269; Mort 2002).

Constructivists argue that choices are inherent to a technology trajectory. The logic of choice between technological trajectories makes technology a negotiable matter. Choices may be irreversible and lead towards long-term ‘lock-in’ situations (Bijker 1995; Williams and Edge 1996). The concept of choice relates directly to the politics that emerge from prioritizing one technology over another. Technologies are never neutral. Choices trigger controversy among their supporters and opponents (Williams and Edge 1996; Latour 2005). Complex social, political, and cultural dynamics are inherent to technological knowledge production and technology choices (Bijker 1995; Williams and Edge 1996; Latour 2005).

Scholars have identified factors that explain the choice of energy technologies, which may not be economically or technically advantageous. The analysis of the social construction of large

¹ 2.2 GW has been installed in 2016 of a total of 13.2 GW to be installed by 2025.

technological systems demonstrates how technology choices correspond to the political and economic structure of a nation. The analysis of the United Kingdom (UK) and German electricity sectors suggests that the political system shapes the governance structure of the power sector. Centralized governments produce large centralized electricity systems. Decentralized systems favour smaller distribution and generation infrastructure (Hughes 2011).

Autocratic elements within a political regime were critical in the adoption of large and centralized nuclear energy technologies (Winner 1986, 1999; Temples 1980). Countries that adopted nuclear technology show strong connections between nuclear power and nationhood (Jasanoff and Kim 2009). Nationhood is an idea built through public discourses and debates about national identity and a nation's path of future development.

National public discourses often emerge from energy technology and its politics, as energy counts as a basic building block of industrialization, technological progress, socio-economic development, and consequential economic power. Governments often procure energy technologies because of prestige, rather than economic necessity (Hughes 2011).

A comparative analysis of six nuclear nations identifies six drivers that sustain commercial nuclear power programmes (Sovacool and Valentine 2012: 250):

- (1) National security and secrecy
- (2) Technocratic ideology
- (3) Economic interventionism
- (4) Centrally coordinated energy stakeholder network
- (5) Subordination of opposition to political authority and
- (6) Social peripheralization.

The characteristics of countries that are following a nuclear path include closed political systems that minimize opposition, low transparency, and accountability; economies with a history of central planning and government intervention; as well as strong national commitment to technological progress (Sovacool and Valentine 2010, 2012).

Public discourse reflects the debates about national identity, a nation's path of future development, and its significance on the global arena. The way a nation exploits its energy resources is an essential component of this process (Bouzarovski and Bassin 2011). Nuclear technology programmes are state interventions that create winners and losers, as any other public policy. Distributional conflicts motivate actors to shape coalitions in support or opposition of these policies that represent their beliefs, ideas, and interests (Sabatier 1988; Hajer 1995; Weible et al. 2009).

Discourse coalitions differ from traditional political coalitions or alliances, because there is a linguistic basis for political coordination between various parties. 'Story-lines, not interests, form the basis of the coalition, whereby story-lines potentially change the previous understanding of what the actors' interests are' (Hajer 1995: 66). This paper presents analysis of the discourse coalitions that emerge in support and opposition to the nuclear programme in South Africa.

3 Nuclear power politics in South Africa

South Africa may soon count as both old and new nuclear power. Nuclear power was a substantial commitment of the apartheid government, which ruled the country on behalf of the white minority between 1948 and 1994. Under apartheid rule, engineers built nuclear capacity in

nuclear fuel production, a weapons programme, uranium enrichment, and research since the 1950s. The programme came with a high cost, as large parts of the electricity produced from the reactor went into fuel and uranium production.² The remainders of this programme are Africa's only commercial nuclear plant in Koeberg outside Cape Town, a research reactor in Pelindaba near Pretoria, a state-owned nuclear cooperation, a regulator, and a coalition of nuclear engineers.

The African National Congress (ANC) actively opposed nuclear power in its role of a liberation movement and during its early days as a ruling party (ANC 1994). The ANC's environment desk stated in 1994,

Nuclear power impacts negatively on the environment and is a perpetual threat to human health. [...] Reducing the nuclear industry could be a source of providing finance. The nuclear industry should be phased out in the shortest of possible time. [...] An investigation [should] be made on how best to redeploy the skill of the scientist and technicians involved (ANC 1994: 238).

This position changed gradually, as the scientist and technicians involved in the pro-nuclear coalition continued pushing for a continuation of nuclear energy.

The Pebble Bed Modular Reactor (PBMR) programme was the ANC's first nuclear programme. The programme aimed to commercialize a German licenced small reactor design, which did not succeed in a research and development (R&D) programme in Germany and lost public funding in 1998 (BMU 2006). The main problem with the pebble bed reactor was that it created very high temperatures at its core, which could not safely transform into process heat. The temperatures inside the reactor could only be estimated, as the movement of the pebbles inside the reactor destroyed all measuring devices (Moormann 2008). South African and German scientists convinced the ANC government to fund the technology from 1993 until 2010. The PBMR received more than ZAR10 billion of public funding, accounting for one-third of the Department of Trade and Industry's R&D budget (Creamer 2010; Hogan 2010). One of the main supporters and chief technology officer at the PBMR concluded, 'At the end of the day, the South African nuclear industry was simply too infantile for a first-of-its-kind nuclear project such as this. The nuclear environment was not developed enough to evaluate the safety and engineering needed' (Johan Slabber, quoted in Groenewald 2010).

The PMBR programme originally envisioned producing electricity in smaller reactors than pricy pressurized water reactor (PWR) plants like Koeberg. Yet, it became part of a wider 'nuclear policy' published in 2008, which aimed to revive the manufacturing processes including uranium enrichment and nuclear fuel production. The policy framework aimed to build new PWR plants by 2015 and create more than 10,000 new jobs in the industry (DME 2008).

The release of the nuclear policy coincided with the world's financial crisis and severe shortages in electricity supply. International rating companies evaluated Eskom's³ financial prospects

² De Klerk called the nuclear programme '...yet another major expense, which we would never have undertaken had it not been for our growing isolation and sense of confrontation with the international community' (Marquard 2006: 196).

³ Eskom is South Africa's public utility for electricity generation, transmission, and distribution. Eskom generates about 95 per cent of South Africa's and 45 per cent of Africa's electricity. The government allowed independent power producers to produce renewable energy and later fossil fuels since 2011. Attempts to split the utility failed and Eskom basically continues to operate as a monopolist with a single buyer status.

negatively, which did not correspond with the government's ambition to acquire new nuclear power plants, 'owned and operated' through Eskom (DME 2008; Roelf 2008).

In 2011, the ANC restated its plans for nuclear build programme three days after the accidents in Fukushima. The nuclear build programme suggests building six nuclear plants to add 9.6 GW of capacity to the current national capacity of about 40 GW. The programme refers to the country's electricity plan, the integrated resource plan (IRP) that outlines South Africa's future until 2030. The IRP was the first integrated, participative plan for the future of the electricity sector, which grounds in the energy white paper (DME 1998).⁴ The plan proposed two scenarios with 9.6 GW of nuclear power (DoE 2011). Nuclear power counted as an option to help reduce greenhouse gas emissions along with renewable energy (Winkler 2007). Initially, the plan was set out as a flexible planning instrument, subject to updates every two years as economic and technical parameters may change. The original IRP was grounded in higher assumptions of economic growth than in reality, which translated into a higher supply demand (RSA 2010; DoE 2011). The original IRP stated clearly that growth assumptions have to be revised in the future (DoE 2011). The IRP update report (DoE 2013) revised the lower electricity demand and lower growth assumptions. The report established several scenarios taking alternative electricity generating technologies and prices into account. It recommended delaying or abandoning the nuclear built programme if the electricity demand does not unfold accordingly; solar, hydro, and gas options become available; or the cost of procuring nuclear energy exceeds a certain cost.⁵ The IRP update report did not undergo a public consultation process and the report was not presented for parliamentary approval. Therefore, the original IRP remains the main policy basis for the government's plans to expand nuclear power generation capacity.

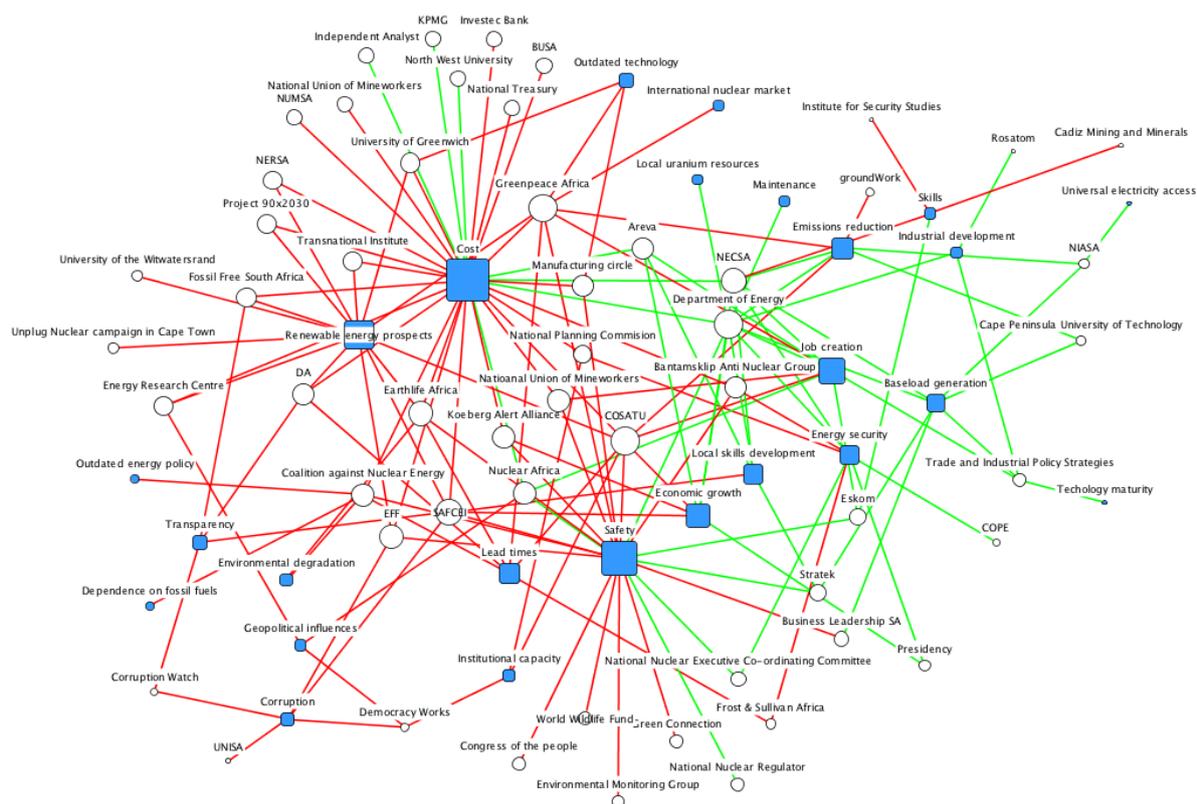
3.1 Discourse coalitions in support and opposition of the nuclear build programme

The government's plans to expand nuclear energy triggered a polarizing public debate between two coalitions in support and opposition of the programme. Fifty-five organizations are publicly involved in the debate on the nuclear programme. Figure 1 shows these actors as white circles. The organizations range from business (including industry, consulting firms, trade unions, and business associations) to governmental departments, state agencies, state-owned enterprises, and civil society organizations, which include non-governmental organizations (NGOs) and academic institutions.

⁴ The Energy White Paper (DME 1998) ruled out that new nuclear capacity should be added before 2007. The paper qualifies that 'Whether new nuclear capacity will be an option at that point or beyond will depend largely on the environmental and economic merits of other energy sources relative to nuclear and its potential and public acceptability, construction lead-times and load characteristics' (p. 58).

⁵ The IRP update report (DoE 2013) suggests delaying the decision to procure nuclear energy if the demand is lower than 270 TWh, if hydropower in the Inga 3 in the Democratic Republic of the Congo, or if rooftop photovoltaic or shale gas options succeed. The programme should be cancelled if the procurement price exceeds US\$6,500 per kWh.

Figure 1: Discourse network on South Africa's nuclear power programme



Source: Authors' compilation.

Actors share a connection if they put forth the same argument to support or oppose the nuclear programme. These arguments appear as blue squares. The coalition in support of nuclear power shares connections in green lines. The actors in the opposing coalition connect through red lines. Arguments that share both green and red lines are the most contested arguments. Actors and arguments that share many connections are more relevant to the discourse. The discourse network emerges from a dataset of 350 articles, which made 64 statements in favour or against the nuclear programme. Arguments and actors were coded and their discursive relationships appear in the network.

The actors put 24 arguments forth in support or opposition of the nuclear energy programme. Cost and safety emerge as the main contested issues in the current nuclear debate. Impacts on emissions reductions, economic growth, job creation, and skills development are also contested in the public debate. The four most frequently used arguments, calculated in Eigenvector centrality,⁶ are cost, safety, renewable energy prospects, and job creation.

3.1.1 The coalition of supporters

The coalition of supporters consists mainly of government departments, agencies, and state-owned enterprises, private business, as well as a few outspoken individuals in universities and consulting companies. The Department of Energy (DoE) is the central actor in this coalition,

⁶ Eigenvector centrality is a network characteristic that measures the influence of a node in a network. Eigenvector centrality assigns relative scores to all nodes in the network based on the assumption that a node's connections to high-scoring nodes contribute more to the score of a specific node than equal connections to lower scoring nodes.

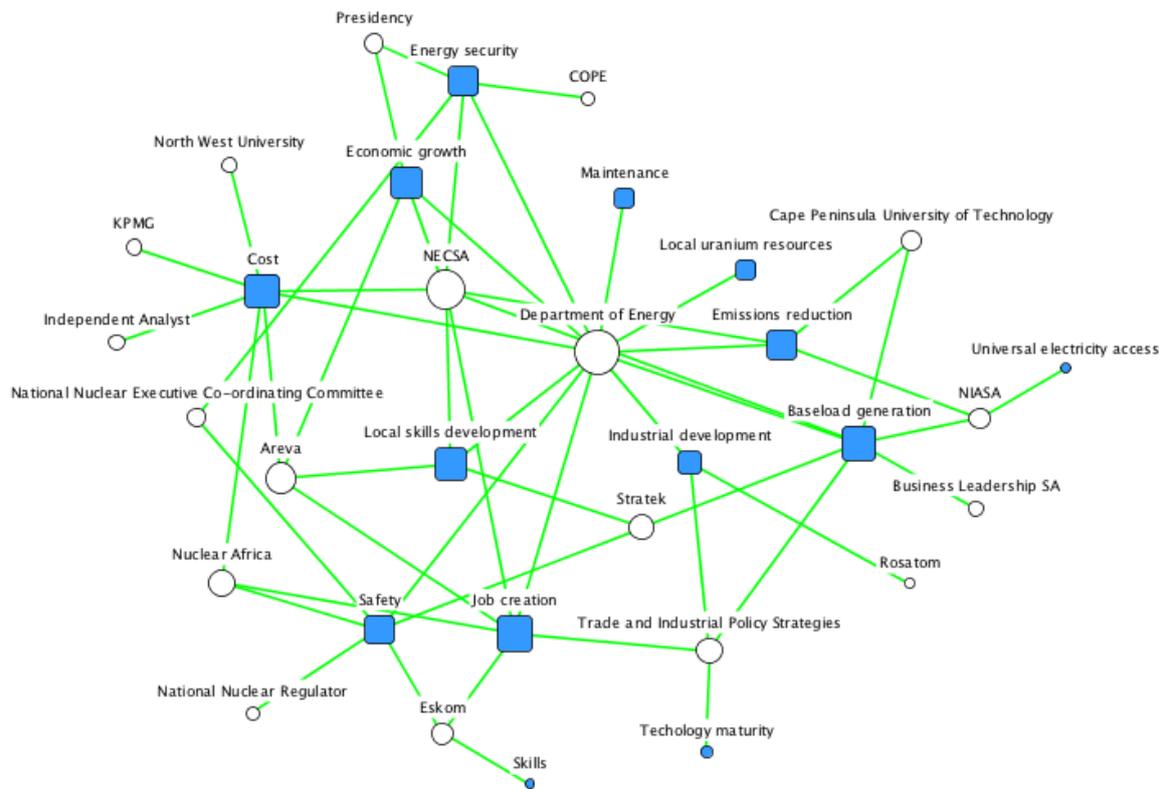
followed by the Nuclear Energy Cooperation South Africa (NECSA). Further state actors in support of the programme are the utility Eskom, the Presidency, the Nuclear Regulator, and the Nuclear Energy Committee (NNEECC). The DoE has become very active in advancing the nuclear programme, especially since the appointment of Minister Tina Joemat-Pettersson. The Department's main arguments for nuclear power include cost, baseload generation, energy security, emissions reductions, job creation, industrial, and skills development.

South Africa's state-owned nuclear cooperation, NECSA, supports the programme arguing for benefits in job creation, industrial development, energy security, and skills development. The organization employs about 100 of the country's nuclear engineers and scientists. NECSA has high stakes in the nuclear debate, as the organization is supposed to play a significant role in the future programme. The ownership of the new fleet is not yet clearly defined, however. Eskom owns and operates Koeberg, but there is uncertainty whether the utility will be in the position to manage the new plants as well or if NECSA will step in. NECSA denied media reporting that the organization is under financial constraints and unable to pay salaries (Joubert 2015). The annual report disclosing finances for 2015 is still outstanding.

The NNEECC was first established in 2008 and headed by the former President Kgalema (Creamer 2012). The committee consisted of a group of ministers supplemented with a committee of technical experts, which were exchanged to political appointments. Motlanthe did major preparations and networking efforts with international vendors to identify financing for the nuclear programme. In 2013, Jacob Zuma took over the committee's leadership (City Press 2013; Donnelly and Faull 2013). This move reflects the president's growing interest in the nuclear programme. His main arguments for nuclear power are economic growth and its contribution to energy security of the country in the long term. Cost has been its only publicly stated constraint to the programme (Zuma 2016).

In 2014, the committee changed its purpose to overview the entire electricity sector. The committee continues supporting the nuclear programme arguing that nuclear energy will contribute to energy security and that the technology is safe. The National Nuclear Regulator echoes safety affirmations.

Figure 2: Overview of the discourse network in the coalition of supporters



Source: Authors' compilation.

Business representation falls into three categories. International vendors, namely Rosatom of Russia and Areva of France are in the first category. Rosatom argues that the main benefit will be industrial development, as the company plans to involve the South African nuclear industry in a 'global value chain' through high rates of locally produced components of nuclear technology. Areva argues for job creation, contributions to economic growth, and skills development. The second category is domestic business representation. The Nuclear Atomic Industry Association (NIASA) and Business Leadership SA share the arguments for local skills development, economic development, and baseload generation. The third category consists of consulting companies and academic institutions. The consulting firms, Stratek and Nuclear Africa, as well as the universities of the North West and the Cape Peninsula are institutional homes to a handful of individuals who are very actively engaged in supporting nuclear energy in the public debate. Their arguments concentrate mainly on the cost of the nuclear programme and its contributions to emissions reductions, job creation, baseload, and economic growth.

Table 1: Summary of actors and arguments in the coalition of supporters

Main actors in the coalitions of supporters	Main arguments for the nuclear build programme
<u>Government</u>	Baseload
DoE	Cost
Eskom	Economic growth
NECSA	Emissions reduction
NNEECC	Energy security
NNR	Industrial development
Presidency	Job creation
<u>Business</u>	Local skills development
Areva	Local uranium resources
NIASA	Maintenance
Business Leadership SA	Safety
KPMG	Skills
Nuclear Africa	Technology maturity
Rosatom	
Stratek	
Trade and Industrial Policy Strategies	
<u>Academia</u>	
University of the North West	
Cape Peninsula University of Technology	

Source: Authors' compilation.

3.1.2 *The coalition of opponents*

The coalition of opponents to the nuclear programme connects some government departments and agencies, business associations and trade unions, political parties, academic institutions, and many NGOs. The opposing coalition is larger in terms of numbers of actors and arguments.

This coalition does not show a central actor pushing against the programme. It is a wide range of 40 actors with a majority of civil society organizations. The main arguments against the nuclear programme are the cost, safety of nuclear technology, and alternative solutions that include an expansion of the renewable energy programme. Numerous local and international NGOs share these views, motivated through environmental conservation concerns or place-based concerns about the prospects of having nuclear power plants built in their proximity.

The main business actors in this coalition are business associations and trade unions. The main mine worker unions (NUM, NUMSA, and COSATU) argue against the programme. The unions express concern about harmful impacts of an expensive nuclear programme on economic growth and job creation (COSATU 2015). The trade unions historically protect labour rights in the mining sectors. COSATU argues that the baseload generation argument for nuclear energy does not hold, as coal-fired plants can provide sufficient baseload to supplement renewable energy. COSATU also expresses its concerns about the possibility of human error and natural disasters, which led to the accidents in Ukraine, the United States (US), and Japan. They highlight the lack of safe waste storage and a policy framework to store waste in a secure manner. Business Unity South Africa (BUSA), South Africa's largest business association, shares the unions' concern about the cost of the programme. The association supports the recommendations of the national planning commission to delay the decision on an 'extremely expensive technology option', as the electricity demand has declined (Paton 2014).

for the programme is too high, the technology is not safe, and emissions reductions can be achieved through expanding the renewable energy programme (Ndlozi 2015).

Table 2: Summary of actors and arguments in the coalition of opponents

Main actors in the coalitions of opponents		Arguments
BUSA	Koeberg Alert Alliance	Corruption
Bantamsklip Anti-Nuclear Group	Manufacturing circle	Cost
Business Leadership SA	NECSA	Dependence on fossil fuels
COSATU	NERSA	Economic growth
Cadiz Mining and Minerals	NUMSA	Emissions reduction
Coalition against Nuclear Energy	National Union of Mineworkers	Energy security
Congress of the people	National Planning Commission	Environmental degradation
Corruption Watch	National Treasury	Geopolitical influences
Democratic Alliance	National Union of Mineworkers	Institutional capacity
Democracy Works	Nuclear Africa	International nuclear market
Economic Freedom Fighters	Project 90x2030	Job creation
Earthlife Africa	SAFCEI	Lead times
Energy Research Centre	Transnational Institute	Local skills development
Environmental Monitoring Group	UNISA	Outdated energy policy
Fossil Free South Africa	University of Greenwich	Outdated technology
Frost & Sullivan Africa	University of the Witwatersrand	Renewable energy prospects
Green Connection	Unplug Nuclear campaign in Cape	Safety
Greenpeace Africa	Town World	Skills
GroundWork	Wildlife for Nature	Transparency
Institute for Security Studies	World Wildlife Fund	
Investec Bank		

Source: Authors' compilation.

3.2 Political discourse shaping South Africa's nuclear technology decision

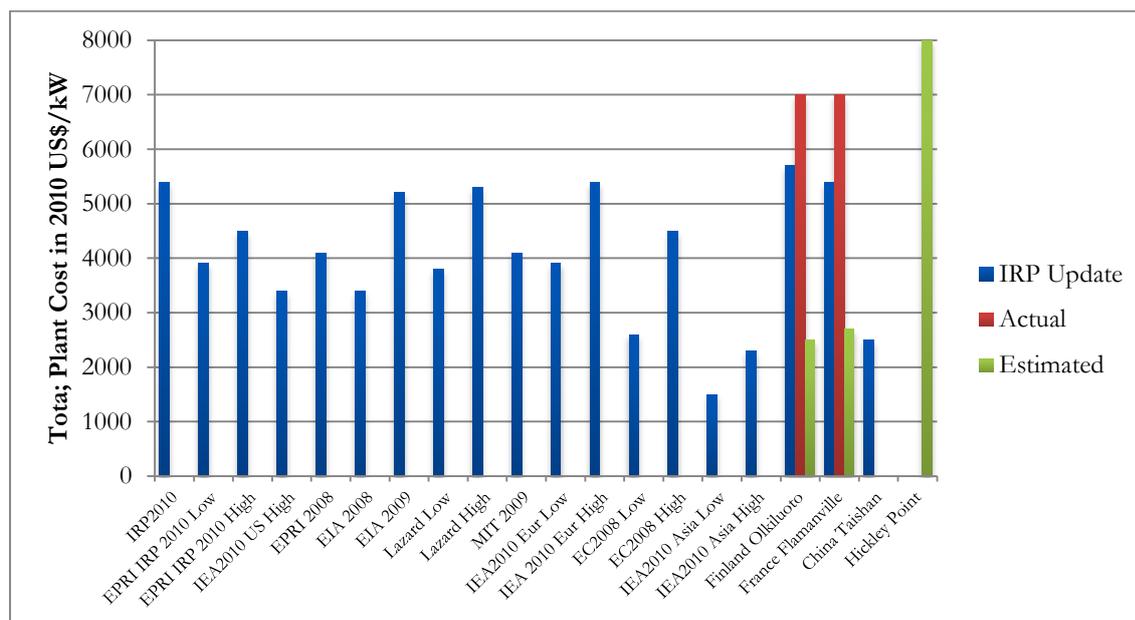
The following section contextualizes the main arguments and actors in the discourse networks within the framework of analysis of political factors that favour nuclear programmes, according to Sovacool and Valentine (2012).

3.2.1 Cost

Cost is the most controversial issue in the current debate on the nuclear build programme. Both coalitions refer to the cost argument. Thirty-nine statements from the opposition question the affordability of the programme, while the supporters affirm the affordability of the programme. The polarizing debate on costs emerges from the variety of cost estimates available publicly and the lack of cost assessment for the South African programme.

The costs per kilowatt of new build nuclear power vary from different sources and high or low cost scenarios between US\$1,500 and US\$8,000. Figure 4 builds on a summary of different costs from the IRP update report (in blue) and adds the estimated and actual cost of the recently built nuclear plants in Finland, France, and the UK. Taking the lowest and the highest price estimates for the nuclear build programme of 9.6 GW, prices range between US\$14.4 billion and US\$76.6 billion. The National Treasury collects annual revenue of roughly ZAR780 billion/US\$46 billion.

Figure 4: Overview of nuclear capital costs in 2010 (US\$/kW)



Source: Thomas (2010); EDF Energy, cited in Caetano and Rennkamp (2013); IRP update report, DoE (2013).

Delayed scenarios that increase the initial cost estimates are likely in nuclear power plant building, because every plant is innovative. Any changes that engineers need to make in the construction require approval from the national regulator to ensure the safety of the plant. These additional bureaucratic processes often cause delays. Recent nuclear plants built in Flamanville, France⁷ and Olkiluoto, Finland⁸ cost more than twice the originally estimated budget and delayed construction times over ten years (WNN 2015). Figure 4 shows the estimated and actual cost in green and red bars for Flamanville, Olkiluoto, and Hinkley Point in the UK.

Large public infrastructure works bear additional risk factors in South Africa. Strikes of highly unionized workers may cause delays. Scarce civil engineering and road infrastructure may cause unforeseen logistical challenges. Both risk factors have caused delays during the construction of the coal-fired plants in Medupi and Kusile.⁹

3.2.2 Opposition to political authority

The contested price tag of the nuclear build programme caused major debates within the government and the energy stakeholder network. Several ANC internal battles emerged from this issue. The controversial dismissal of former Minister of Finance, Nhlanhla Nene, had its roots in his critical eye on the build programme, among other issues (Brummer 2015; Paton 2015). Old and new Minister of Finance, Pravin Gordhan, committed to funding only projects that fall within the budget (England 2015). Jacob Zuma stated in his state of the nation speech in February 2016, ‘we will only procure nuclear on a scale and pace that our country can afford’

⁷ The pressurized water reactor in Flamanville was estimated at a total cost of €3.3 billion to be finalized in 2007. The EDF corrected cost estimates to €10.5 billion and expects construction to finish in 2018 (EDF 2015)

⁸ The Areva Siemens Consortium also updated its plans to finalize the Olkiluoto plant, which changed from 2009 to 2018 (WNN 2015)

⁹ Medupi and Kusile experienced delays due to strikes and lack of civil engineering infrastructure. Cost doubled from ZAR69.1 billion to 154.2 billion in the case of Medupi; and ZAR80.6 billion to 172.2 billion between 2007 estimates and 2015, according to media sources (SAPA 2015; Steyn 2015a).

(Zuma 2016). The Minister of Energy stated repeatedly that nuclear energy ‘will be affordable’ and that it had calculated the cost of the build programme, but cannot release any of the cost estimates (Gqirana 2015).

The National Planning Commission commissioned a study on the cost implication of a nuclear programme, which revised the assumption of the integrated power plan (IRP) that was put together in 2013 (ERC 2013). The update of the IRP in 2013 reported similar dynamics and suggested that the nuclear decision:

Can possibly be delayed. The revised demand projections suggest that no new nuclear base-load capacity is required until after 2025 (and for lower demand not until at earliest 2035) and that there are alternative options, such as regional hydro, that can fulfil the requirement and allow further exploration of the shale gas potential before prematurely committing to a technology that may be redundant if the electricity demand expectations do not materialize (DoE 2013: 8).

The update process of the IRP suggests that there are controversies within the department, as department internal analysts suggested delaying the nuclear decision. These controversies have not been reflected in the public discourse.

The debates on the cost of the programme closely relate to the power battles internal to the ANC and the opposition to political authority, as Sovacool and Valentine (2012) put it. In a single party system with nearly two-thirds majority of the vote, internal opposition creates substantial checks and balances. Traditional opposition work from alternative political parties is compromised, as they are unlikely to win a national election and threaten the power position of the ruling elite.

3.2.3 Economic interventionism

The debate on cost also relates to the concept of ‘economic interventionism’. The nuclear programme would be South Africa’s largest public expenditure in the history of the country. The public procurement process will have to correspond to the constitutional rules. These require that public expenditure correspond to five principles: 1) value for money; 2) open and effective competition; 3) ethics and fair dealing; 4) accountability and reporting; and 5) equity. Public procurement procedures in principle need to correspond to each of these pillars (RSA 1996, n.d.). The rules correspond to the government’s attempts for Black Economic Empowerment (BEE), which targets (previously) disadvantaged groups of individuals, small businesses, and local producers to benefit from economic development. Inequalities in ownership of South Africa’s asset base continue to be a major structural problem, which these rules aim to correct. The procurement rules specify more details on the relationship between price and social development criteria (localization, community development) in specific programmes. A ‘public protector’ oversees these processes (RSA 2014). A government gazette supports the procurement of the nuclear programme (DoE 2015a), which caused confusion in the public as it was published just before Christmas in 2015, but signed by the previous minister Ben Martin in 2013.

Another typical characteristic of economic interventionism is the attempt to advance job creation and industrial development through large publicly procured infrastructure projects. The analysis of discourse coalitions showed that the supporting coalition argues for industrial development and job creation as positive outcomes of the nuclear programme. ‘Localization’ is a very specific objective in South African economic policy-making. The idea of introducing local content requirements into public procurement rules is common in developing countries. The aim is to

minimize the amount of imported technology and to produce as many components as possible locally. South Africa's Department of Science and Technology developed a 'Localization strategy' that aims to mainstream the approach of localizing technological components across the economy (DST 2008). Localization always comes with the trade-off between potential job creation locally, a higher technology price, and delays caused through technological learning.

Nuclear energy technology also falls under the localization strategy (DST 2008). The DoE aims to achieve the following objectives through localization, based on its nuclear energy policy: 1) lead the supply of nuclear products and services; 2) create jobs; 3) become self-sufficient in all aspects of the nuclear fuel cycle; and 4) contribute to energy security and economic growth (DOE 2013). Uranium enrichment can be mined as a by-product of gold and copper mining. A small industry of three companies contributes to 1 per cent of the world's uranium supply. This is a relatively small share, given that South Africa's accessible uranium reserves add up to 4.8 per cent of the world's known resources (Van Wyk 2013).

The representatives of the Russian nuclear industry nurtured the South African government's aspiration to revive nuclear manufacturing processes locally and to create jobs in the sector. Rosatom spokesperson, Segey Novikov, sees potential for 60 per cent localization of the nuclear plants in South Africa through Rosatom (SABC 2013). Former Energy Minister, Ben Martins, pointed out that localization, job creation, and skills development were the main 'tenets' to 'create a better life for our people' (Campbell 2013). The dreams of reactivating the nuclear value chain with a local enrichment and nuclear fuel programme are 'unrealistic' with outdated technologies and no access to an enrichment plant, according to a representative of the Nuclear Energy Industry Association. 'The Russians have offered a black box at Pelindaba to ensure security of supply not actual localization' (Interview, South African Nuclear Industry Association 2013). Localization of the construction increases the cost of the programme, but the actual numbers are unknown.¹⁰

Areva criticized the South African localization plans as being unrealistic, as only 10 per cent of local companies were qualified to contribute local content, which makes 50–80 per cent targets difficult to implement (Steyn 2015b).

3.2.4 Job creation and skills

Job creation is the third contested impact of the nuclear build programme. The coalition of supporters uses this argument frequently in support of the programme. In light of a national unemployment crisis with unemployment as high as 25 per cent and youth unemployment at 50 per cent, the national government's discourse centres on prioritizing job creation (RSA 2010). The programme is sure to create similar employment to the Koeberg fleet in each of the new power plants, which add up to roughly 10,000 permanent jobs in the operation of the fleet. Job creation in construction, design, and manufacturing are uncertain.

The debate on job creation questions who the beneficiaries of the jobs created in this programme would actually be. Former Energy Minister, Dipuo Peters, saw job creation potential along the value chain including the uranium-mining sector. The controversial Gupta family acquired a uranium mine, but required additional funding to operate it (Shamase 2011; Gosam 2016). Greenpeace argues that job creation in the nuclear programme is unlikely to make a difference, as the technology is highly specialized and import-driven. COSATU argues along similar lines, nuclear programme will have minimal effects on South Africa's unemployment

¹⁰ Interview, South African Nuclear Industry Association 2013.

crisis. Most likely, this will benefit specialists in the nuclear establishment and foreigners. The estimates for job creation vary from 27,000 (Eskom) to 70,000 (DoE) on up to 400,000 (Areva) (Biyase 2010; Felix 2013).

The debate on skills and their development intertwines with the debate on job creation. NECSA appears in the opposing coalition once, because of the statement that there are not enough skills in the nuclear sector, despite their training efforts. Cadiz Mining and Minerals and the Institute of Security Studies doubt whether the skills development in the past still suffices to manage a large scale build programme in the future (Wild 2013). Southern African Faith Communities' Environment Institute (SAFCEI) argues that the country lacks the nuclear engineers to operate the fleet safely (Abbas 2015). Eskom denies any skills shortages, while Areva and Nuclear Africa support the argument that there are sufficient local skills available (Wild 2013).

3.2.5 Safety

Safety concerns are the second main contested argument in the discourse network. The coalition of opponents mainly uses this argument along three lines. The first argument refers to the risks of nuclear accidents, which can be caused by human error or natural disasters and make the technology inherently unsafe. Greenpeace argues that there is a lack of regulatory capacity to deal with nuclear accidents at the scale of Fukushima (Macleod 2011; Donnelly 2015). The bulk of the NGOs, political opposition parties, and trade unions share this general concern. The second argument refers to the risk from radiation under normal operation. The third argument refers to waste and its storage. Nuclear waste can never be stored safely and can jeopardize the health of the generations to come according to Earthlife and the Coalition against Nuclear Energy in South Africa (Bega 2011).

The main argument of the nuclear supporters is that Koeberg has been operated safely for 30 years. Eskom, Nuclear Africa, Kgalema Motlanthe, the DoE, and the National Nuclear Regulator share this point. Regarding the risk of accidents, 'the impact of the nuclear accident in Japan on the loss of lives seems to be insignificant in comparison to lives lost as a result of the devastating effects of flooding' according to the Regulator (Bega 2011).

Safety and environmental concerns of the nuclear programme motivated numerous local and international NGOs to engage publicly in the discourse on nuclear energy. Earthlife and Greenpeace produced studies to inform the debate (Earthlife 2007, 2011; Adam et al. 2011). Almost half of the actors in the opposing coalition are environmentally concerned, faith, or development driven NGOs.

There are a number of local organizations, including the Koeberg Alliance and the Bantamsklip that tackle the immediate consequences of nuclear power plants near major urban spaces. Yet, civil society engagement remains largely at the small scale of individual research, publications, and media interviews. There is no national awareness campaign that brings the possible implications of the nuclear programme regarding cost and safety into the wider public domain.

The factor of 'social peripheralization' implies that NGOs are only marginally influential in the political discourse (Sovacool and Valentine 2012). The South African NGOs are a substantial component of the coalition of opponents and civil society organizations are actively involved in the public discourse on the nuclear programme. Overall, 16 active NGOs represent a population of 55 million people and their focus is mainly on knowledge production, media outreach, and local initiatives, but there are no visible nationwide campaigns.

3.2.6 Energy security, renewable energy and 'baseload'

A third debate centres on energy security and the feasibility of nuclear technologies over other alternatives. The third most frequent argument in the opposing coalition relates to the feasibility of nuclear versus renewable and other technologies. The coalition members argue that the prospects of renewable energy technologies make the nuclear energy programme unnecessary. Actors in the coalition of opponents argue that renewable energy technologies are quicker to install. Their short construction lead times can help solve the current shortages in the electricity supply systems. Further arguments relate to higher cost effectiveness and safety, as well as the fact that South Africa has abundant solar and wind resources that have not been exploited yet.

The coalition of supporters counters arguments for renewable energy with the need for 'baseload generation' (Pressly 2013). This argument refers to baseload power needed to address the intermittency of solar and wind technologies during the night and in case of no wind. The actors supporting nuclear energy argue mainly that nuclear power provides basepower, which renewable energy does not. NIASA, NECSA, CPUT, and the DoE continue this line of argument that the country needs to reduce emissions. Nuclear energy will provide baseload power to achieve both emissions reductions and energy security at the same time at a low cost. Minister Joemat-Pettersson summed up the viewpoint of the supporting coalition asking the question, 'How are we going to reduce our carbon footprint and increase our baseload if we are not going to do nuclear energy?' (Gqirana 2015).

The argument for baseload power is not inclusive of South Africa, but has been established as a common argument against renewable energy in the Australian power sector (Diesendorf 2007). The research literature reflects a debate on baseload power and renewable energy, which has not been reflected in the public discourse in depth.¹¹

The debate on energy security centres mainly on the timing of the nuclear fleet to provide electricity. Recent power shortages put the electricity sector into the centre of the public debate, as the rolling power cuts or 'loadshedding' affected almost every citizen in the country. The supporters of the nuclear programme argue that the nuclear fleet will contribute to energy security in the long term. The opposition argues that the programme will not be able to contribute to the current crisis, because of several years of construction for nuclear plants, which are also likely to be delayed. The critics of the programme also point out that there is a risk of overbuilding generation capacity, with a knock-on effect on cost.

The main debates on the technical issues on energy security, as well as baseload and alternative technologies for electricity supply reflect the structure of the power sector and the energy network. Increasing the influx of renewable energy would favour independent power producer and change the current structure of the power sector towards decentralization. A power sector reform towards decentralization would create power losses in the current beneficiaries of the sector, which are mainly the state-owned companies operating coal and nuclear plants, Eskom, and to some extent NECSA. Attempts to restructure Eskom have failed as the process of the

¹¹ Baseload power refers to baseload power plants, which provide electricity constantly. Solar and wind technologies are weather dependent. The intermittency is bridged with baseload power to ensure constant power supply. Gas, coal, and nuclear power provide baseload power. They do not necessarily generate baseload 24 hours a day, because of scheduled maintenance or unexpected technical problems. Renewable energy from hydro and biogas also count as baseload technologies (Matek and Gawell 2015). Experiences with roll out of wind technologies have shown that the demand for baseload power declines, the more renewable energy is installed, as the likelihood of intermittencies declines. Gas and coal plants tend to react quicker to intermittency in renewable energy than coal and nuclear plants (Ueckerdt and Kempener 2015).

Independent System Markets Operator (ISMO) illustrate. The ISMO bill suggested splitting Eskom's operations into two entities, but the proposal was dropped after five years of consultation.

In sum, the debate on baseload versus renewable energy technology reflects the polarizing positions on the current and future structure of the power system and its stakeholder network.

3.2.7 Secrecy, transparency, and corruption

The political opposition parties, DA and the EFF, as well as NGOs, argue against the nuclear programme, because of the lack of transparency in the policy process and risk for corruption. Secrecy surrounding the relationship with Russia, the cost of the programme, and the appointment of Tina Joemat-Pettersson as the Minister of Energy fuelled these arguments. The Public Protector, Thuli Madonsela, found that Tina Joemat-Pettersson awarded a tender improperly in her capacity as Minister of Agriculture, Forestry and Fisheries. The WWF argues that the nuclear programme can be compared to the arms deal in the way the cabinet runs the process secretly ignoring the Promotion of Access to Information Act (PAIA) (Fakir and Pienaar 2016). The NNEECC's 'proceedings and documents are classified under the Minimum Information Security Standard Act (MISS Act) as TOP SECRET'. The Committee reports to the cabinet. No agenda or minutes can be shared with the public (Zuma 2015).

The DoE has denied any allegations of secrecy arguing that the documents need to be kept classified in order not to compromise the integrity of the process or confuse the public (DoE 2015b; Gqirana 2015; Zulu 2015; Le Cordeur 2016).

The arguments about corruption and lack of transparency from the opposition to the nuclear programme emerge from the unknown cost of the programme, the lack of transparency in the procurement process, and the agreements for international cooperation with specific countries.

Reports on cost cited in the media from the CSIR, Stellenbosch, and North West University have not been published. The requests from an opposition party in parliament to gain access to technical reports on feasibility of the nuclear programme remained unanswered (DoE 2015b; Gqirana 2015). The details of the procurement programme are unclear. Plans to move the procurement of nuclear energy to the IPP office that procures renewable energy will also ensure that costs remain undisclosed.

3.2.8 International prestige and geopolitical dimensions

The veil of secrecy on cost and procurement reaches into the geopolitical dimensions of the nuclear energy programme. The nuclear technologies will require technology transfer from international vendor companies. These companies are typically closely linked to their national governments and make presidential diplomacy an essential component of international nuclear procurement. The South African government entertains close relationships to the world's old and new nuclear powers. Old nuclear powers include the US, France, Japan, Russia, Ukraine, Canada, Germany, and the UK. These eight nations built significant commercial nuclear plants between the 1950s and the 1970s. Most of the world's installed nuclear capacity sits in the US, France, Japan, and Russia.¹² New nuclear powers, India, China, and South Korea, embraced

¹² The US has the world's largest nuclear capacity with 99 reactors and 98.6 GW. France runs 58 reactors, which produces three-quarters of the country's supply. Japan is still recovering from the accident in Fukushima, which led the government to close down all plants for maintenance. According to the IAEA, its capacity went up to 4.2 GW produced from 48 nuclear plants. Russia runs 34 reactors that add up to 24.6 GW of capacity (IAEA 2015).

nuclear energy before the Cold War ended. An invitation to join the BRICS economics club catalysed the government's attempts to expand relations with other emerging economies. In this group of emerging economies, Russia has been the country that the South African government has least established relations with. The nuclear programme offered an opportunity to fill the gap along with the annual BRICS summits. The BRICS are one of the few clubs that mostly favour nuclear power.¹³ Russia has been revitalizing its nuclear programmes under Putin's rule. Zuma had made the nuclear programme his presidential priority. He used the engagement with the BRICS nations to explore partnerships for implementation. According to media reports, Putin and Zuma negotiated the terms of the nuclear cooperation during the BRICS summits and several bilateral visits between 2010 and 2015 (Hunter and Faull 2014; Gosam 2016).

The DoE worked towards signing Memorandi of Understanding (MoU) with several countries, which are eligible to supply nuclear technology to South Africa. These MoU were very different in nature, length, and detail with the MoU with Russia the most lengthy and detailed (DoE 2015b). The opposition to nuclear power suspected that Russian suppliers had already been chosen as preferred partners without following public procurement rules. The DoE kept the MoU with Russia secret and did not reveal the details until the *Mail and Guardian* published a translation from the Russian version of the same MoU. Russia's nuclear provider, Rosatom, had published it on its website (RSA/RF 2014).

The DoE organized highly secret 'vendor parades' with different original equipment manufacturers in the mountains of KwaZulu-Natal. These gave the manufacturers the opportunity to present their proposals to the government and selected experts. CEO of Nuclear Africa and NECSA recommended the proposed Rosatom and Toshiba/Westinghouse reactors to the government (Wendell 2015). Three actors publicly criticized the geopolitical dimensions of the nuclear build programme, including Nuclear Africa, which is generally in support of the programme. The geopolitical aspects strongly relate to the concerns about cost and transparency in the procurement of the programme.

4 Conclusion

The analysis has shown the main controversies and coalitions in favour of and in opposition to the South African nuclear build programme. The structure of the coalitions and the main arguments in the debate can explain why the South African government chose to procure nuclear power over other alternative options. The nuclear build programme shapes two polarized coalitions. The opposing coalition is larger and consists mainly of civil society organizations concerned with environmental issues and good governance. The most powerful actor is the National Treasury, which is the main political counterweight to supporters in the DoE, NECSA, and the Presidency. The coalition of supporters is much smaller and consists mainly of government actors, business, and a few experts in academia and consulting firms. The supporting coalition may be smaller, but has higher stakes in the programme, as well as immediate financial and employment benefits in case of success.

The arguments in the discourse network relate to the six political conditions that help to explain why they should favour nuclear programmes. First, the debate on the cost of the nuclear programme reveals the main political battles within the ANC. The subordination of opposition to political authority is particularly striking in the single party system. Most checks and balances occur within the ruling party, while the formal opposition poses no immediate electoral threat.

¹³ Brazil has nuclear power plants near Rio, but plans for their expansion are currently on hold.

The National Treasury is therefore the main political counterweight to the nuclear programme. Both ministers, Nhlanhla Nene and Pravin Gordhan, have been facing pressure to move the programme forward. Second, the debate on cost also relates to the favouring factor of economic interventionism, as the state plays a strong role in picking winners through public procurement and setting rules for localization and job creation for relatively specialized nuclear workers who have very different profiles from the millions of unemployed in South Africa. Third, the debate on safety reflects an active civil society engagement in knowledge production, but without major political awareness campaigns and public outreach to ANC voters. Civil society engagement is not peripheral, but it has not mobilized those who can make a difference with their votes. Fourth, the debate on energy security, baseload, renewables, and emissions reductions reflects the clashes in the energy stakeholder network in a centrally organized political system between those who want to preserve the status quo and those who argue for reform. The defenders of the status quo aim to preserve existing privileges, while supporters argue for decentralization and uptake of new technology options. Fifth, security concerns are secondary in today's nuclear debate. International prestige mattered more in the past than today. Secrecy is a major characteristic of the current nuclear governance style and the ANC has preserved the culture of secrecy of the past in managing the nuclear build programme. The lack of transparency in the procurement, classification of documentation on any environmental and cost assessments, and hidden details on the nature of international relations fuel doubts on the legitimacy of the programme. Sixth, geopolitical influences play a significant role in the implementation of the programme. Secrecy conferred on the agreements with Russian agencies and institutional counterparts has fuelled suspicions of corruption. The ANC's political culture of secrecy reflects elements of an autocratic rather than a democratic, open, and transparent regime.

The analysis revealed how the political conditions that favour nuclear programme play out in South Africa. Economic factors such as cost, job creation, the health of the financial sector, and state-owned entities turned out to be significant, which the original framework did not account for. Security concerns become insignificant, as the economic factors turn out to be the main determinant of success or failure of the programme. Benefits of job creation, financial prospects for constrained public entities, and uranium mining prospects for government-related businesses are tangible gains for the coalition of supporters, which suggests that South Africa's nuclear programme is not primarily about generating electricity.

References

- Abbas, G. (2015). 'Interfaith group says no to nuclear energy deals'. *Cape Argus*, 2 July.
- Adam, F., D. Fig, D. Gilbert, M. Kantey, F. Musana, N. Schulz et al. (2011). *The True Cost of Nuclear Power in South Africa*. Johannesburg: Greenpeace Africa. Available at: <http://www.greenpeace.org/africa/global/africa/publications/the%20true%20cost%20of%20nuclear%20power%20in%20sa-screen.pdf> (accessed on 20 March 2016).
- ANC (1994). 'The nuclear debate: Proceedings of the conference on nuclear policy for a democratic South Africa'. 11–13 February 1994. Cape Town: Environmental Monitoring Group and ANC Science and Technology Group.
- Bega, S. (2011). 'Cabinet's approval of nuclear plans ignores tragedy'. *The Star*, 19 March.
- Bijker, W.E. (1992). 'The social construction of fluorescent lighting, or how an artifact was invented in its diffusion stage'. In W.E. Bijker and J. Law (eds), *Shaping Technology/building Society: Studies in Sociotechnical Change*. Cambridge, MA: MIT Press, 75–102.
- Bijker, W.E. (1995). *Of Bicycles, Bakelites and Bulbs. Towards a Theory of Socio-technical Change*. Cambridge, MA: MIT Press.
- Biyase, L. (2010). 'Areva predicts a new nuclear plant'. *The Star*, 19 February. Available at: <https://www.highbeam.com/doc/1G1-219377683.html> (accessed on 22 November 2015).
- BMU (2006). 'Gemeinsames Übereinkommen über die Sicherheit der Behandlung abgebrannter Brennelemente und über die Sicherheit der Behandlung radioaktiver Abfälle, Bericht der Bundesrepublik Deutschland für die zweite Überprüfstagung.' Berlin: BMU. Available at: http://www.bmub.bund.de/fileadmin/bmu-import/files/pdfs/allgemein/application/pdf/2nationaler_bericht_atomenergie.pdf (accessed on 25 February 2016).
- Bouzarovski, S., and M. Bassin (2011). 'Energy and identity: Imagining Russia as a hydrocarbon superpower'. *Annals of the Association of American Geographers*, 101(4): 783–94.
- Brummer, S. (2015). 'Nuclear price tag set Nene against Jacob Zuma'. *Mail & Guardian*, 18 December. Available at: <http://mg.co.za/article/2015-12-17-nuclear-price-tag-set-nene-against-jacob-zuma> (accessed on 1 March 2016).
- Caetano, T., and B. Rennkamp (2014). 'Nuclear power: Structural change, lock-ins and trade-offs'. ERC Research Paper prepared for the IAEA. Vienna: IAEA.
- Campbell, K. (2013). 'SA government wants country to be global nuclear competitor'. *Engineering News*, 25 November. Available at: <http://www.engineeringnews.co.za/article/sa-government-wants-country-to-be-global-nuclear-competitor-2013-11-25> (accessed on 8 March 2016).
- City Press (2013). 'Government denies sidelining Motlanthe'. *news24*, 26 July. Available at: <http://www.news24.com/Archives/City-Press/Government-denies-sidelining-Motlanthe-20150429> (accessed on 7 March 2016).
- COSATU (2015). 'COSATU statement on the introduction of nuclear energy'. 31 July 2015. Available at: <http://www.cosatu.org.za/show.php?ID=10744> (accessed on 4 March 2016).
- Creamer, T. (2010). 'PBMR pullback a "painful" decision, Hogan admits'. *Engineering News*, 15 April. Available at: <http://www.engineeringnews.co.za/article/pbmr-pullback-a-painful-decision-hogan-admits-2010-04-15> (accessed on 8 March 2016).

- Creamer, T. (2012). 'Motlanthe-led nuclear committee meets'. *Engineering News*, 6 August. Available at: <http://www.engineeringnews.co.za/article/motlanthe-led-nuclear-committee-meets-2012-08-06> (accessed on 4 March 2016).
- Diesendorf, M. (2007). 'The base-load fallacy'. ANZSEE Solar 2007 Conference, Alice Springs. Available at: <http://www.ceem.unsw.edu.au/sites/default/files/uploads/publications/MarkBaseloadFallacyANZSEE.pdf> (accessed on 1 March 2016).
- DME (1998). 'White paper on the energy policy of the Republic of South Africa'. Pretoria: Department of Minerals and Energy. Available at: http://www.energy.gov.za/files/policies/whitepaper_energypolicy_1998.pdf (accessed on 4 March 2016).
- DME (2008). 'Nuclear energy policy for the Republic of South Africa'. Pretoria: Department of Minerals and Energy. Available at: http://www.energy.gov.za/files/policies/policy_nuclear_energy_2008.pdf (accessed on 4 March 2016).
- DoE (2011). 'Integrated resource plan for electricity'. *Government Gazette*. Tshwane: Department of Energy.
- DoE (2013). 'Integrated resource plan for electricity (IRP) 2010–2030'. Update report. Tshwane: Department of Energy. Available at: http://www.energy.gov.za/IRP/irp_files/IRP2010_2030_Final_Report_20110325.pdf (accessed on 4 March 2016).
- DoE (2015a). 'Nuclear programme: Determination under section 31(1) of the electricity regulation act 4 of 2006'. *Government Gazette*, 606. Pretoria: Department of Energy.
- DoE (2015b). 'Presentation of International Cooperation Agreements to the Portfolio Committee on Energy'. 1 September 2015. Cape Town: Department of Energy.
- Donnelly, L. (2015). 'SA's nuclear safety is reassessed'. *Mail & Guardian*, 1 August. Available at: <http://mg.co.za/article/2011-08-01-sas-nuclear-safety-is-reassessed> (accessed on 1 March 2016).
- Donnelly, L., and L. Faull (2013). 'Zuma slips into nuclear driver's seat'. *Mail & Guardian*, 26 July. Available at: <http://mg.co.za/article/2013-07-26-00-zuma-slips-into-nuclear-drivers-seat> (accessed on 1 March 2016).
- DST (2008). 'Technology localisation plan: A framework for engagement in national technology localisation actions'. Tshwane: Department of Science and Technology. Available at: http://www.saoga.org.za/sites/default/files/attachments/eventrecord/DST%20Tech%20Localisation%20Plan%20June_2010.pdf (accessed on 12 January 2016).
- Earthlife (2007). 'The following submission provides ten reasons that Earthlife Africa Cape Town is opposed to nuclear energy'. Cape Town: Earthlife Africa.
- Earthlife (2011). 'Submission on the revised draft environmental impact report ("Revised DEIR")'. Cape Town: Earthlife Africa.
- EDF (2015). 'Flamanville EPR: optimised project management and a new timetable'. Available at: <https://www.edf.fr/en/the-edf-group/dedicated-sections/press/all-press-releases/flamanville-epr-optimised-project-management-and-a-new-timetable> (accessed on 8 March 2016).

- England, A. (2015). 'Pravin Gordhan pledges to keep a grip on South Africa's spending'. *Financial Times*, 20 December. Available at: <http://www.ft.com/intl/cms/s/0/df241314-a561-11e5-a91e-162b86790c58.html#axzz42ISHnuSH> (accessed on 8 March 2016).
- ERC (2013). 'Towards a new power plan'. Research Report prepared for the National Planning Commission. Cape Town: Energy Research Center.
- Fakir, S., and G. Pienaar (2016). 'Government's nuclear plans—will it be the Arms Deal 2.0?'. *Daily Maverick*, 21 January. Available at: <http://www.dailymaverick.co.za/article/2016-01-21-op-ed-governments-nuclear-plans-will-it-be-the-arms-deal-2.0/#.VuK3lFLLKLE> (accessed on 2 March 2016).
- Felix, J. (2013). 'Nuclear plants “still |a top priority” for SA'. *The Mercury*, 26 June. Available at: <https://www.highbeam.com/doc/1G1-348147843.html> (accessed on 21 January 2016).
- Gosam, L. (2016). 'Zuma, the Gupta's and the Russians'. *Rand Daily Mail*, 19 February. Available at: http://www.rdm.co.za/politics/2016/02/02/zuma-the-guptas-and-the-russians--the-inside-story#_ftn4 (accessed on 23 February 2016).
- Gqirana, T. (2015). 'Nuclear build will be affordable'. *Mail & Guardian*, 1 September. Available at: <http://mg.co.za/article/2015-09-01-nuclear-build-will-be-affordable> (accessed on 3 March 2016).
- Groenewald, Y. (2010). 'Money rows over PBMR'. *Mail & Guardian*, 23 April. Available at: <http://mg.co.za/article/2010-04-23-money-rows-over-pbmr> (accessed on 3 March 2016).
- Hajer, M.A. (1995). 'The politics of environmental discourse: ecological modernization and the policy process'. *Journal of Chemical Information and Modeling*. Oxford: Oxford University Press.
- Hogan, B. (2010). 'Address by the minister of public enterprises, Barbara Hogan, to the national assembly, on the pebble bed modular reactor'. Available at: <http://www.dpe.gov.za/newsroom/Pages/ADDRESS-BY-THE-MINISTER?E-NATIONAL-ASSEMBLY,-ON-THE-PEBBLE-BED-MODULAR-REACTOR.aspx> (accessed on 22 February 2016).
- Hughes, T. (2011). 'The evolution of large technological systems'. In W.E. Bijker, T.P. Hughes, and T. Pinch (eds), *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge, MA: MIT Press.
- Hunter, Q., and L. Faull (2014). 'Jacob Zuma's secret nuke “stitch-up”'. *Mail & Guardian*, 26 September. Available at: <http://mg.co.za/article/2014-09-25-jzs-secrete-nyke-stich-up> (accessed on 21 March 2016).
- IAEA (2015). *Nuclear Power Reactors in the World*. Vienna: IAEA. Available at: <http://www-pub.iaea.org/books/IAEABooks/10903/Nuclear-Power-Reactors-in-the-World-2015-Edition> (accessed on 1 March 2016).
- Jasanoff, S., and S.H. Kim (2009). 'Containing the atom: sociotechnical imaginaries and nuclear power in the United States and South Korea'. *Minerva*, 47(2): 119–46.
- Joubert, J.J. (2015). 'Nuclear body faces financial meltdown'. *Sunday Times News*, 8 March. Available at: <http://www.timeslive.co.za/sundaytimes/stnews/2015/03/08/nuclear-body-faces-financial-meltdown> (accessed on 7 March 2016).
- Latour, B. (2005). *Reassembling the Social. An Introduction into Actor-Network Theory*. Oxford: Oxford University Press.
- Le Cordeur, M. (2016). 'Joemat-Pettersson wants nuclear under IPP office', *Fin24*, 23 February. Available at: <http://www.fin24.com/Economy/joemat-pettersson-wants-nuclear-under-ipp-office-20160223> (accessed on 3 March 2016).

- Leifeld, P. (2012). 'Discourse network analyzer'. Dübendorf: Eawag. Available at: <http://www.philipleifeld.com/software/discourse-network-analyzer/discourse-network-analyzer.html> (accessed on 20 August 2015).
- MacKenzie, D. (1993). *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance*. Cambridge, MA: MIT Press.
- MacKenzie, D. (1998). *Knowing Machines: Essays on Technical Change*. Cambridge, MA: MIT Press.
- Macleod, F. (2011). 'Avoid disaster on our shores'. *Mail & Guardian*, 18 March. Available at: <http://mg.co.za/article/2011-03-18-avoid-disaster-on-our-shores/> (accessed on 24 February 2016).
- Marquard, A. (2006). 'The origins and development of energy policy in South Africa'. PhD thesis. Cape Town: University of Cape Town. Available at: http://www.erc.uct.ac.za/sites/default/files/image_tool/images/119/Papers-2006/06Marquard-PhD_Thesis.pdf (accessed on 8 March 2016).
- Matek, B., and K. Gawell (2015). 'The benefits of baseload renewables: a misunderstood energy technology'. *Electricity Journal*, 28(2).
- Moormann, R. (2008). 'Safety re-evaluation of the AVR pebble bed reactor operation and its consequences for future HTR concepts'. Available at: www.iaea.org/.../39099096.pdf (accessed on 3 March 2016).
- Mort, M. (2002). *Building the Trident Network: A Study of the Enrollment of People, Knowledge, and Machines*. Cambridge, MA: MIT Press.
- Ndlozi, M.Q. (2015). 'EFF urges the South African government to strongly consider Germany's advice on nuclear energy'. Johannesburg: Economic Freedom Fighters. Available at: <http://efffighters.org.za/eff-urges-the-south-african-government-to-strongly-consider-germanys-advice-on-nuclear-energy/> (accessed on 1 March 2016).
- NPC (2011). 'National Development Plan –2030'. Pretoria: National Planning Commission.
- Paton, C. (2014). 'Nuclear is not power priority, says business'. *Business Day LIVE*, 12 November. Available at: <http://www.bdlive.co.za/business/energy/2014/11/12/nuclear-is-not-power-priority-says-business> (accessed on 21 March 2016).
- Paton, C. (2015). 'Nuclear must be affordable, says Nene'. *Business Day LIVE*, 24 August. Available at: <http://www.bdlive.co.za/business/energy/2015/08/24/nuclear-must-be-affordable-says-nene> (accessed on 3 March 2016).
- Pressly, D. (2013). 'Full steam ahead for nuclear expansion'. *IOL Business News*, 15 May. Available at: <http://www.iol.co.za/business/news/full-steam-ahead-for-nuclear-expansion-1515871> (accessed on 3 March 2016).
- Roelf, W. (2008). 'Mail & Guardian Account Login'. *Mail & Guardian*, 2 September. Available at: <http://mg.co.za/article/2008-09-02-erwin-moodys-eskom-downgrade-cause-for-concern> (accessed on 3 March 2016).
- RSA (1996). 'Constitution of the Republic of South Africa, No. 108 of 1996'. Pretoria: Republic of South Africa. Available at: <http://www.gov.za/sites/www.gov.za/files/images/a108-96.pdf> (accessed on 3 March 2016).
- RSA (2010). 'The new growth path: the framework'. Pretoria: Republic of South Africa, Department of Economic Development.

- RSA (2014). ‘Public Protector Thuli Madonsela on public procurement system’. Pretoria: Republic of South Africa. Available at: <http://www.gov.za/subject-public-procurement-system-needs-attention-public-protector> (accessed on 3 March 2016).
- RSA (n.d.) ‘Guidelines for public procurement. Pretoria: The National Treasury. Available at: <http://www.treasury.gov.za/legislation/pfma/supplychain/General%20Procurement%20Guidelines.pdf> (accessed on 14 January 2016).
- RSA/RF (2014) ‘Agreement between the Government of the Russian Federation and the Government of the Republic of South Africa on strategic partnership and cooperation in the fields of nuclear power and industry’. English translation available at: <http://www.ee.co.za/wp-content/uploads/2015/02/amaBhungane-English-translation-of-Russian-nuclear-cooperation-agreement.pdf> (accessed on 20 November 2015).
- Sabatier, P.A. (1988). ‘An advocacy coalition framework of policy change and the role of policy-oriented learning therein’. *Policy Sciences*, 21: 129–68.
- SABC (2013). Interview with Sergey Novikov, Rosatom Spokesperson. Available at: www.youtube.com/watch?v=3agXfl2sXi8 (accessed on 20 March 2016).
- SAPA (2015). ‘Eskom contractors fire more than 1 000 workers’. *Mail & Guardian*, 27 March. Available at: <http://mg.co.za/article/2015-03-27-eskom-fires-1-000-workers> (accessed on 3 March 2016).
- Shamase, N. (2011). ‘Row over “unpaid” bills at Gupta family’s mine’. *Mail & Guardian*, 9 September. Available at: <http://mg.co.za/article/2011-09-09-row-over-unpaid-gupta-mine-bills> (accessed on 3 March 2016).
- Sovacool, B.K., and S.V. Valentine (2010). ‘The socio-political economy of nuclear energy in China and India’. *Energy*, 35: 3803–13.
- Sovacool, B.K., and S.V. Valentine (2012). *The National Politics of Nuclear Power: Economics, Security, and Governance*. New York: Taylor & Francis.
- Steyn, L. (2015a). ‘Sinking into Eskom’s black hole’. *Mail & Guardian*, 2 May. Available at: <http://mg.co.za/article/2015-02-05-sinking-into-eskoms-black-hole> (accessed on 02 March 2016).
- Steyn, L. (2015b). ‘SA’s nuclear deal with Russia is far from done’. *Mail & Guardian*, 19 February. Available at: <http://mg.co.za/article/2015-02-19-sas-nuclear-deal-with-russia-is-far-from-done> (accessed on 3 March 2016).
- Temples, J.R. (1980). ‘The politics of nuclear power: a subgovernment in transition’. *Political Science Quarterly*, 95(2): 239–60.
- Thomas, S. (2010). *The Economics of Nuclear Power: An Update*. Heinrich Berlin: Boell Stiftung. Available at: http://www.boell.de/downloads/ecology/Thomas_economics.pdf (accessed on 13 December 2013).
- Ueckerdt, F., and R. Kempener (2015). ‘From baseload to peak: renewables provide a reliable solution’. Working Paper. Abu Dhabi: IRENA. Available at: http://www.irena.org/documentdownloads/publications/irena_baseload_to_peak_2015.pdf (accessed on 21 February 2016).
- Van Wyk, J. (2013). ‘South Africa’s nuclear future’. Working Paper. Johannesburg: South African Institute of International Affairs. Available at: http://www.saiia.org.za/doc_download/337-south-africa-s-nuclear-future (accessed on 7 March 2016).
- Weible, C.M., P.A. Sabatier, and K. McQueen (2009). ‘Themes and variations: Taking stock of the advocacy coalition framework’. *Policy Studies Journal*, 37(1): 121–40.

- Wendell, R. (2015) 'Experts eye Rosatom, Westinghouse reactors for South Africa nuclear power'. Available at: <http://af.reuters.com/article/investingNews/idAFKBN0OZ10D20150619> (accessed on 2 March 2016).
- Wild, S. (2013). 'SA need skilled nuclear scientists'. *Mail & Guardian*, 18 October. Available at: <http://mg.co.za/article/2013-10-17-sa-needs-skilled-nuclear-scientists> (accessed on 4 March 2016).
- Williams, R., and D. Edge (1996). 'The social shaping of technology'. *Research Policy*, 25: 865–99.
- Winkler, H. (ed.) (2007). 'Long term mitigation scenarios: technical report'. Pretoria: Department of Environment Affairs and Tourism.
- Winner, L. (1986) *The Whale and the Reactor. A Search for Limits in an Age of High Technology*. 1st Edition. Chicago: Chicago University Press.
- Winner, L. (1999). 'Do artifacts have politics?'. In D. MacKenzie and J. Wajcman (eds), *The Social Shaping of Technology*. Philadelphia: Open University Press.
- WNN (2015). 'Claims updated in Olkiluoto 3 delay arbitration'. *World Nuclear News*, 3 August. Available at: <http://www.world-nuclear-news.org/C-Claims-updated-in-Olkiluoto-3-delay-arbitration-0308154.html> (accessed on 8 March 2016)
- Zulu, T. (2015). Press statement by the Director-General of the Department of Energy, Mr Thabane Zulu. 'Progress with the nuclear new build programme'. Available at: <http://cdn.bdlive.co.za/images/pdf/nuclear.pdf> (accessed on 7 March 2016).
- Zuma, J. (2015). 'President Jacob Zuma's Written Reply to Questions in the National Assembly'. Available at: <http://www.thepresidency.gov.za/pebble.asp?relid=19365&t=79> (accessed on 1 March 2016).
- Zuma, J. (2016). 'State of the Nation Address 2016'. Available at: <http://www.thepresidency.gov.za/pebble.asp?relid=21584> (accessed on 1 March 2016).