INDEPENDENT DESIGN ASSESSMENT OF THE ENERGY RESEARCH DEVELOPMENT AND INNOVATION (ERD&I) STRATEGY

Authors: Brett Cohen, Brent Cloete and Rachael Glaser

The Green House
Ubunye House
70 Rosmead Avenue
Kenilworth
7708
t: + 27 (0) 21 671 1410
f: + 27 (0) 86 638 3692
e: brett@tgh.co.za

Project: 11045

2 July 2012

Disclaimer

EXECUTIVE SUMMARY

The Energy Grand Challenge is one of the five grand challenges identified as part of the Ten Year Innovation Plan (TYIP), which aims to support the transformation of South Africa towards "…a knowledge-based economy, in which the production and dissemination of knowledge leads to economic benefits and enriches all fields of human endeavour." This report was commissioned by the Department of Science and Technology and presents an independent design assessment of its draft energy research, development and innovation (ERD&I) strategy and the associated Implementation Plan. The design assessment seeks to determine the suitability of the current design of the ERD&I strategy document to guide the implementation of the DST's interventions in the area of energy RD&I.

Prior to development of the assessment framework against which the ERD&I strategy was assessed, a literature review was conducted. The first part of the literature review explored the role of evaluations in the South African context – including how these relate to the outcomes based framework to collectively achieve the strategic imperatives of government. It also discussed the various sources of guidance on developing monitoring and evaluations frameworks within the South African public sector, as well as the different types of evaluations that are conducted at different stages of the policy development and implementation process.

The second component of the literature review started off by exploring the role of the DST in the energy RD&I space, and identified, albeit based on limited baseline information, that there are many areas where South Africa performs poorly in various general and energy-specific RD&I indicators. The work then proceeded to explore the EGC within the broader DST policy arena, and sought to determine the extent of alignment between the EGC and the ERD&I strategy. Consideration was also given here to the Ten Year Innovation Plan (TYIP), recognising that the TYIP was in turn informed by the White Paper on Science and Technology and the National Research and Development Strategy (NRDS). The alignment was considered from two perspectives, the first being the key drivers of a knowledge economy as articulated in the TYIP, and the second being the research thrusts or focus areas identified in the two documents.

The outcome of this review indicated limited alignment between the strategy and the TYIP from both of these perspectives. Firstly, the key drivers of the knowledge economy from the TYIP are poorly articulated in the ERD&I strategy. Secondly the EGC in the TYIP identifies four research thrusts, whereas the strategy identifies nine. It was established through the interviews that the strategy and its research themes are based on a document which precedes the TYIP which could explain the misalignment. The strategies R&D themes were identified through a stakeholder process run sometime between 2003 and 2005.

Finally, a selection of international case studies was presented to identify any learnings that could be gained from international experience.

An Assessment Framework was developed based primarily on the National Evaluation Policy Framework (The Presidency, 2011), but also informed by the Draft Departmental Evaluation Framework for the Department of Science and Technology (DST, 2011) and the Performance Information Handbook (National Treasury, 2011). The framework also incorporated elements of international best-practice taken from the OECD and other sources. The assessment framework was used to evaluate the ERD&I strategy based on six key elements.

- **Relevance:** Is the rationale for the strategy clearly defined? Is the need identified supported by baseline data?

- **Clarity:** Does the strategy have a clearly defined set of objectives? Are the objectives SMART? Is baseline data provided?
- **Context:** Has the local context been sufficiently addressed? Is the strategy workable given the local context?
- **Effectiveness:** Is the logic model clearly defined? Is the logic model analytically sound
- **Efficiency:** Is the strategy consistent with international best-practice?
- **Monitoring and evaluation:** Does the strategy include a monitoring framework? Are the indicators included in the monitoring framework of good quality? Is the monitoring framework cost-effective and practically feasible? Does the strategy include an evaluation plan? Is the level of detail provided in the evaluation plan sufficient?

Measuring the ERD&I strategy against the assessment framework, it was found that the current draft version of the document did not adhere to best practice. Consequently, it seems unlikely that the version of the strategy reviewed will be able to effectively guide the implementation of the DST's future activities in the area of energy research, development and innovation. This conclusion is based on the following:

In terms of **relevance,** a high-level rationale for the existence for the ERD&I strategy is provided. The desired outcome of the strategy, however, is not clear. There is no clear indication of the 'problem' or 'blockage' within the energy RD&I system that the strategy must try and address. The lack of baseline data (which is restricted to the outputs of basic and applied research), makes it difficult to identify how widespread potential issues within the energy RD&I system is that prevents or delays the commercial implementation of new energy supply and energy efficiency options. As such, it is difficult to identify the practical actions that need to be taken to ensure that the ERD&I strategy has the desired impacts listed previously.

There is limited **clarity** as to the objectives of the ERD&I strategy. In particular, there is uncertainty as to how the 'energy system goals', 'key national growth and development drivers' and 'national R&D themes' mentioned in the strategy interact in terms of objectives. Limited baseline data is also provided, and as such none of the three possible set of objectives are defined in sufficient detail to meet best practice in terms of objective definition.

In terms of **context**, it was found that although the ERD&I strategy is not in opposition to other legislation and policy both within DST and in other government departments, the clear definition of roles and responsibilities of DST is lacking, which has the potential to hinder implementation of the strategy.

The **effectiveness** relates to the logic model, which was found not to be clearly defined. The lack of a detailed overview of the mechanics of the energy RD&I and the identification of the factors that are stopping the energy RD&I mechanism from functioning optimally, combined with uncertainty regarding both the objectives of the ERD&I strategy and responsibilities of meeting them, effectively means that a logic model for the strategy has not been described in sufficient detailed to enable an assessment of its analytical soundness.

Efficiency was assessed by comparing the ERD&I to international case study examples, including the International Energy Agency (IEA) good practice recommendations for Energy R&D, and the National Energy R&D strategies for Denmark and Ireland, being the only two countries identified that have produced National Energy R&D strategies. The ERD&I strategy was found to fall short on the recommendations of the IEA. The two country strategies were found to be quite different, responding to the particular context within which each country

finds itself. Denmark's focus is on retaining market competiveness through innovation in the renewable energy sector, while that of Ireland is on energy research for energy security and environmental sustainability. Both strategies, however, are strong on institutional collaboration in energy research and recommend a criteria- based system to determine research foci. Both these features are lacking in the current design of the ERD&I strategy, and provide clear areas where the efficiency of the current strategy can be improved. The lack of broad-based strategies in the area of energy RD&I internationally, however, raise questions as to the scope and ambition of the ERD&I strategy locally. The ideal strategy design, however, will depend on the local context. This again emphasises the importance of providing a clear picture of the local energy RD&I system in order to assess the appropriateness of the resulting strategy.

Finally, the ERD&I strategy lacks a **monitoring and evaluation** framework, along with the associated baseline data and clearly defined logic model which would be required to allow for effective M&E. The process of generating the detailed baseline information necessary to describe how the energy RD&I system in South Africa works, and thus to define the logic model, should also provide the basic information necessary to create an effective M&E framework.

During the inception phase of the project, it was identified that the Draft Implementation Framework (DIF) for the ERD&I strategy would be reviewed against the above assessment framework if appropriate. Based on the desktop review, as well as discussions with key informants, it was identified that the DIF as it stands does not represent a suitable implementation framework for the ERD&I strategy. Apart from the fact that the ERD&I strategy in its current form is not detailed enough to enable the development of an effective implementation framework, the content of the DIF strongly suggests that it was developed in isolation of the ERD&I strategy. The DIF introduces a number of new concepts and addresses a number of topic areas which would more appropriately be located within the ERD&I strategy, does not show explicitly how it is aligned with the ERD&I strategy, and does not provide any clear guidelines for implementation. There is reference to the need for an M&E strategy, but no design for such a strategy is provided. As such, there was not considered to be any merit in further analysis of the DIF.

In conclusion, therefore, there are a number of limitations of the ERD&I strategy, and the strategy is suggested not to be clear enough to help guide implementation of DST energy RD&I related activities. It is therefore suggested that the ERD&I strategy be substantially reworked. Various recommendations have been provided as to how this could be done. The strategy development process should start with a detailed analysis of the energy RD&I system, coupled with a stakeholder process, to map out the roles and responsibilities of different stakeholders and also the interrelatedness of different components of the system. An analysis of the barriers or blockages that are preventing the system from functioning optimally need to be undertaken to identify the areas where the strategy can have a real impact in increasing the outputs of the energy RD&I system that will lead to the desired energy sector impacts. An analysis of the possible types of interventions (at a high level) and the stakeholders that are responsible for these interventions is then required, supported by suitable interdepartmental collaboration.

Detailed baseline information is required to ensure that the identified blockages are real and will enable policymakers and implementers to ascertain whether the barriers are becoming less or more significant over time. At the very least, the ERD&I strategy needs to include as complete a set of baseline data as is feasible initially, and include actions that will be taken to ensure that more detailed and timely baseline data is available in future.

Finally, it is not clear how the ERD&I strategy aims to interact with themes that have existing strategies (such as

Hydrogen and Fuel Cells). This should be addressed.

Once the ERD&I strategy has been reworked into a format which addresses the concerns presented above, a new implementation framework should be developed from scratch, to produce a document which would support implementation of the Strategy.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

DST	Department of Science and Technology
DEA	Department of Environmental Affairs
DoE	Department of Energy
DHE&T	Department of Higher Education and Training
EGC	Energy Grand Challenge
EDD	Economic Development Department
ERD&I	Energy Research Development and Innovation
HCD	Human Capital Development
NRDS	National Research and Development Strategy
R&D	Research and Development
RD&I	Research, Development and Innovation
TYIP	Ten Year Innovation Plan

1 INTRODUCTION

The Energy Grand Challenge is one of the five grand challenges identified as part of the Ten Year Innovation Plan (TYIP), which aims to support the transformation of South Africa towards "…a knowledge-based economy, in which the production and dissemination of knowledge leads to economic benefits and enriches all fields of human endeavour." Four critical elements which are required to support the transition are identified, being:

- Human capital development
- Knowledge generation and exploitation (R&D)
- Knowledge infrastructure
- Enablers to address the "innovation chasm" between research results and socioeconomic outcomes

The Energy Grand Challenge (EGC) specifically encapsulates the trade-offs which need to be made between meeting the need for a safe, clean, affordable and reliable energy supply, while supporting the development of more environmentally preferred energy options in the long term.

This document provides the results of a design assessment commissioned by the Department of Science and Technology (DST). As outlined in the National Evaluation Policy Framework (NEPF) (The Presidency, 2011), a design assessment is an ex ante evaluation that seeks to evaluate mechanisms, inner logic and consistency of the theory of change/logic model that forms the basis of a policy or strategy. The assessment aims to determine whether an intervention is designed to effectively and efficiently meet its stated objectives. The current design assessment thus aims to assess the suitability of the current design of the ERD&I strategy document to guide the implementation of the DST's interventions in the area of energy RD&I, including the realisation of the Energy Grand Challenge. The assessment was to be achieved through the development of an evaluation framework against which the strategy was to be assessed. The framework was also to be used to assess the Draft Implementation Plan of the ERD&I strategy, if deemed appropriate. In order to contextualise the analysis, a background literature review was to be included. Finally, the study was to provide recommendations on moving forward with the ERD&I.

The report is structured as follows:

- The context for evaluations in South Africa is presented to provide an understanding of how evaluations help to inform government activities, and the types of evaluations that are available;
- A literature review is presented which highlights the role that DST has to play in the energy space, discusses the EGC within the broader DST policy context and looks at some best practice examples in ERD&I strategy;
- An overview of the study approach is then presented;
- The components of the assessment framework against which the assessment was conducted are described;

- The outcomes of the assessment are discussed in detail; and
- A summary of the results is presented, followed by recommendations on this strategy moving forward.

2 EVALUATIONS IN A SOUTH AFRICAN CONTEXT

2.1 Background

The policy framework for monitoring and evaluation is derived from the constitutional principles governing public administration. Chapter 10 of the Constitution places an obligation on government to ensure the efficient, economic and effective use of resources in the delivery of public services. In addition, the Constitution as well as the subsequent Promotion of Access to Information Act (2000) calls for government to provide the public with timely, accessible and accurate information.

The enactment of the Public Finance Management Act (1999) and Municipal Finance Management Act (2004) gives effect to the constitutional principles of efficiency, economy and effectiveness. Collectively, these three principles guide all key aspects of revenue and expenditure management within the public sector. More importantly, these acts create an accountability framework which governs the use of public funds by ensuring that the roles and responsibilities of the accounting officer within national, provincial and local government are clearly defined and legally enforceable.

Achieving efficiency, economy and effectiveness in the management of public policies and programmes is a difficult task. Unlike the private sector, where profits create a system of incentives that promote efficiency and economy to maximise shareholder value, the public sector is development orientated. Hence, a system of incentives as well as regulations must be established and enforced to ensure efficiency and economy.

Monitoring and evaluation systems can be used as a powerful form of incentive and enforcement within the public sector. Traditionally, public monitoring and evaluation systems have focused on expenditure management and have been punitive – penalising departments for over and under expenditure. However, recent public finance management reforms which place emphasis on results and performance, have led to the emergence of results-based monitoring and evaluation. This new paradigm focuses on developmental outcomes and overall allocative efficiency by ensuring that scarce public funds are allocated towards the priorities of the electorate.

In 2005, the Government of South Africa recognised the need to strengthen government-wide monitoring and evaluation to improve decision making and resource allocation. The Policy Framework for the Government-wide Monitoring and Evaluation System (GWM&ES) approved by Cabinet in 2005 provides the overarching framework for monitoring and evaluation in South Africa. The implementation of the GWM&ES was done through the Programme of Action – an objective orientated system of monitoring and reporting. Under the initial iteration of the Programme of Action (POA), national departments and public entities were responsible for coordinating the delivery of a particular strategic objective.

One of the main shortcomings of the POA was its focus on activities rather than outcomes. This meant that the long list of activities delivered by government did not necessarily translate into meaningful and relevant outcomes for the citizens of the country. In 2010, Cabinet approved the development of an outcomes based framework to collectively achieve the strategic imperatives of government. This framework articulated twelve key outcomes for the entire country towards which the majority of government funds and efforts would be directed. These twelve outcomes are:

1. Improved quality of basic education.
2. A long and healthy life for all South Africans.
3. All people in South Africa are and feel safe.
4. Decent employment through inclusive economic growth.
5. A skilled and capable workforce to support an inclusive growth path.
6. An efficient, competitive and responsive economic infrastructure network.
7. Vibrant, equitable and sustainable rural communities with food security for all.
8. Sustainable human settlements and improved quality of household life.
9. A responsive, accountable, effective and efficient local government system.
10. Environmental assets and natural resources that are well protected and continually enhanced.
11. Creation of a better South Africa and contribution to a better and safer Africa and World.
12. An efficient, effective and development oriented public service and an empowered, fair and inclusive citizenship.

This outcomes based framework was informed by international and generally accepted experience in developing logical frameworks.

The results based management pyramid is illustrated in Figure 1. In terms of this framework, each outcome can be broken down into outputs and activities. Delivery agreements identifying these outcomes and their concomitant outputs were signed between the President and Ministers, strengthening the system of executive accountability in government. Since 2011, all national departments have been required to link their budgets directly to outcomes, thus establishing linkages between inputs and outcomes.

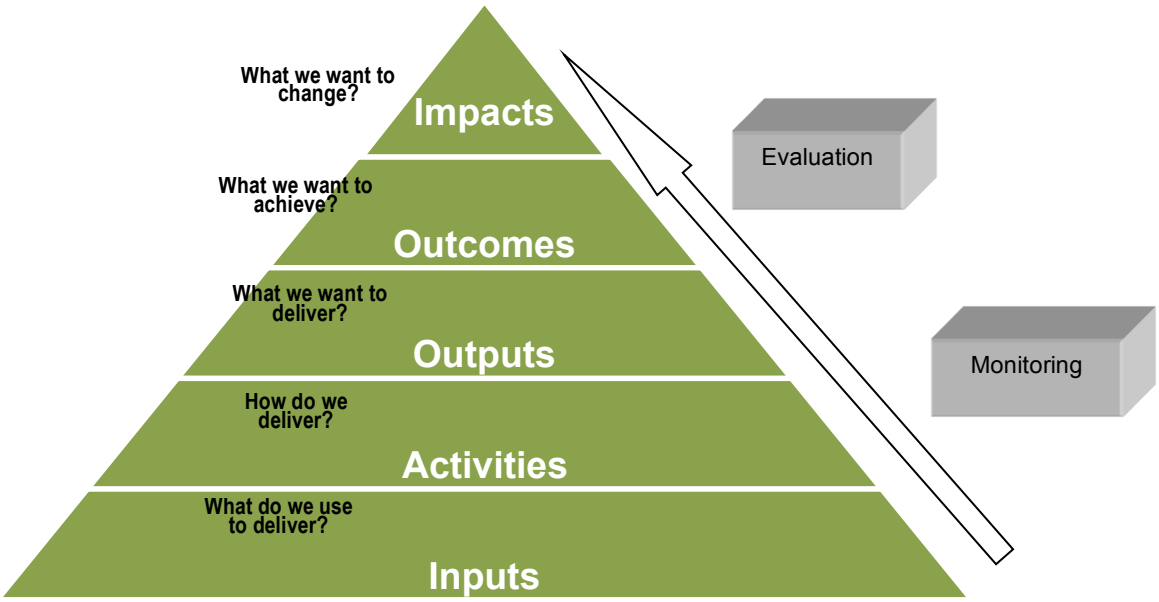

FIGURE 1: RESULTS BASED MANAGEMENT PYRAMID

Source: Adapted from National Treasury (2007)

Further guidance on developing monitoring and evaluations frameworks within the South African public sector are provided through:

- South African Statistical Quality Assessment Framework (Stats SA)
- The Role of Premiers' Offices in Government-wide Monitoring and Evaluation: A Good Practice Guide (The Presidency)
- The Green Paper on Improving Government Performance (The Presidency)
- Management Performance Assessment Tool (The Presidency)
- Citizen-based Service Delivery Monitoring: research into current practices (The Presidency)

Whereas the GWM&ES and the Framework for Managing Performance Information emphasised regular monitoring and reporting activities, the National Evaluation Policy Framework published in 2011 institutionalises the use of evaluations within government. It also creates a strong conceptual framework for evaluations in government and strengthens the relationships between the planning, budgeting, implementation and evaluation cycle.

In addition to these national policies, the DST has compiled its own departmental evaluation framework. This framework is still in draft form, and its aim is to ensure that DST evaluations provide a comprehensive and reliable base of evaluation evidence to support programme reporting and decision-making (DST, 2011).

2.2 Types of evaluations

There are numerous types of evaluations that can be carried out (Table 1). The type of evaluation used is largely dependent on the research questions that need to be answered as well as the type of policy, programme or project under consideration. The timing of evaluations is also a critical factor that needs to be taken into account:

- Formative evaluations generally occur during projects or interventions and help to assess compliance with predetermined objectives.
- Summative evaluations tend to occur at the end of the project or programme and are useful in assessing impact.
- Midterm reviews are increasingly used to monitor the implementation of government wide strategies and policies and are used to refine projects or interventions.

Projects and policies can be evaluated at all stages. Whereas ex ante evaluations (diagnostic evaluations and design assessments) are undertaken during policy-making and/or the programme design phases that precede implementation, most other types of evaluations (implementation, economic and impact) can either be carried out during the implementation or upon completion of projects. Impact evaluations, specifically, are generally carried out after sufficient time has passed for impacts to be observable and measurable.

The design assessment of the ERD&I strategy is an ex ante evaluation. Ex ante evaluations provide a wealth of information that can be used in policy-making and programme design. These evaluations can help optimise the allocation of resources and are used to inform more efficient policy-making processes (EU, 2007). Recommendations are made in each of the step of the ex-ante evaluation with the aim of improving the effectiveness of policies or programmes. In general, ex ante evaluations are undertaken by experts in the project field, who come with the requisite sector knowledge and experience.

Ex ante evaluations, and particularly design assessments, are quite rare in South Africa. The project team was not able to identify any publicly available local design assessments or strategies, policies, programmes or projects. Since these types of evaluations are explicitly identified in the National Evaluation Policy Framework, it is expected that this will change in the near future.

TABLE 1: TYPES OF EVALUATIONS

No	Type of evaluation	Description	Timing
1	Diagnostic evaluation	The diagnostic evaluation sets out the current situation prior to an intervention and aims to inform the intervention design. It includes both an assessment of the need for an intervention, and collects the baseline information that will be used to evaluate the success of the intervention. It summarises the current state of knowledge regarding the problems and/or opportunities to be addressed, causes and consequence of the current state of affairs, what an intervention is likely and unlikely to deliver, and the likely effectiveness of different intervention designs. Based on this information, the theory of change or logic model that forms the heart of any intervention is designed.	At key stages prior to design or planning
2.	Design assessment	A design assessment analyses mechanisms, inner logic and consistency of the theory of change/logic model that forms the basis of an intervention. The assessment aims to determine whether an intervention is designed to make it possible to effectively and efficiently meet its stated objectives. Design assessments should include an assessment of the quality of indicators and assumptions. These assessments are intended to be based on secondary information, but interactions with the developers of an intervention can be used to supplement secondary information if required. Design assessments should be used for all new interventions, but can also be used during implementation to see whether the theory of change appears to be working	After an intervention has been designed, in first year, and possibly later
3	Implementation evaluation	Commonly termed “project evaluations”, it is used to assess whether a project was implemented as planned. This type of evaluation generally reviews the design, implementation and closure phases of discrete projects. It relies extensively on project documentation and assess where implementation occurred in an efficient, effective and economical manner. Rapid appraisals are a subset of implementation evaluations and focus on delivering timely information to management on whether projects are being/or have been implemented as planned. They also provide recommendations on remedial or corrective action requirements	Once or several times during the intervention
4	Impact evaluations	Impact evaluations are data intensive evaluations that measure the impact of a policy, programme or project on a set of beneficiaries. For impact evaluations, extensive primary research and data collection is required to statistically test the changes in outcomes and impacts and how much of the changes can be attributed to the intervention. The purpose is to inform high-level officials whether an intervention should be continued or not, and if any modifications are needed. Impact evaluations are implemented on a case-by-case basis.	Impact checked at key stages e.g. 3/5 years based on baselines implemented early.
5	Economic evaluation	Economic evaluation considers whether an intervention generated a net benefit to society. Types of economic evaluations include: ▪ cost-effectiveness analysis, which compares the costs of implementing and delivering the policy with the outcomes generated, to produce a “cost per unit of outcome”, and ▪ cost-benefit analysis (CBA), which places a monetary value on the changes in outcomes as well to generate the net benefit of an intervention. Economic evaluations build on data collected in implementation and impact evaluations. The net cost/benefit of an intervention is compared to alternative interventions.	At any stage of an intervention.
6	Evaluation synthesis	These types of evaluations generally synthesise the findings of a set of evaluations to develop a broad perspective, identify common findings and good practices. Evaluation synthesis can take the form of a qualitative report or meta analysis where data is collated and analyses to highlight trends across different evaluation studies.	After a number of evaluations.

Sources: CIPPEC (2010, DST (2011), Presidency (2011), World Bank (2004)

3 ENERGY RESEARCH, DEVELOPMENT AND INNOVATION POLICY AND SUPPORT

The Ten-Year Innovation Plan (TYIP) aims to support the transformation of South Africa towards "…a knowledge-based economy, in which the production and dissemination of knowledge leads to economic benefits and enriches all fields of human endeavour." The four key drivers required to support the transition are identified in the TYIP as follows:

- Human capital development
- Knowledge generation and exploitation (R&D)
- Knowledge infrastructure
- Enablers to address the "innovation chasm" between research results and socioeconomic outcomes

The TYIP focuses on five critical "grand challenges" to the country in the transition, of which energy security is one. The Energy Grand Challenge (EGC) encapsulates the trade-offs which need to be made between meeting the need for a safe, clean, affordable and reliable energy supply, while innovating for the long term in clean coal technologies, nuclear energy, renewable energy and the possible emergence of the "hydrogen economy". In addition to having the EGC to shape energy related activities at DST, the Department has developed the Energy Research Development and Innovation (ERD&I) Strategy and its associated Implementation Plan with the aim of providing a high level strategic framework for supporting the activities in this area.

The rest of this section provides an overview of the theoretical argument for DST intervention in the energy sector, the relationship between the EGC and other DST policies, and international best-practice relating to ERD&I strategies.

3.1 The role of the DST in the energy sector

This section provides a detailed overview of the theoretical argument for government intervention in the area of energy RD&I in accordance with the terms of reference for this project. In addition to providing this high-level intervention logic, it attempts to provide an overview of some of the easily accessible sources of baseline data that are currently available. The baseline data provided, however, is intended to be indicative only and is not intended to be exhaustive.

Arrow (1962) was amongst the first economists to highlight the fact that market economies may fail to provide for socially optimal levels of R&D activity. One of his key insights was to characterise knowledge as a non-rival good (i.e. the consumption of the good by one individual does not reduce its use by other individuals) and that the producers of knowledge cannot fully appropriate all of the benefits to be derived from it.

This characterisation of knowledge as a non-rival good implies that the overall economic value to society of an innovation will often exceed the economic benefit accruing to the innovating firm. These *positive externalities* associated with inventive research often *spillover* and accrue to consumers or more established firms, resulting in under-investment in R&D and innovative activities by firms.

Importantly this problem of *appropriability* is often more acute for smaller firms because they are less likely to possess *complementary assets* such as a brand name reputation, a distribution base or the ability to secure the intellectual property for their innovation. Larger firms are generally more adept and better equipped to internalise the spillovers associated with innovative activities (Gans & Stern, 2000).

In addition to these positive externalities, R&D activities are constrained by capital market imperfections which results in markets allocating limited funding to innovative firms and entrepreneurs. Innovation is an inherently volatile endeavour, associated with uncertain and intangible returns - in such cases the entrepreneur will often have private information about their innovative activity and as a result investors find it difficult to adequately evaluate and assess the value of the new product or process being developed. Such *information asymmetries* result in financing constraints with investors being disinclined to finance projects with such inherent uncertainty (Kelm et al, 1995).

Economists have long realised that some activities offer benefits to society at large that do not show up in the rewards earned by the private companies that undertake the activities. As a result, less than the socially optimal amount of these activities will be undertaken. R&D is one such an activity, and for this reason R&D is widely supported by public sector funding internationally.

R&D in energy is particularly important for South Africa for a number of reasons. Energy contributes about 15% of South Africa's GDP, with an economy historically structured on the provision of comparatively cheap energy (and in particular electricity) supply. This has resulted in high energy intensity in South Africa's production economy, and comparatively only 10 other countries have higher industrial energy intensities (Pouris, 2010).

South Africa also has a number of highly developed energy sectors and companies. Eskom is counted as one of the world's 10 biggest electricity generators, generating almost all of South Africa's electricity requirements and exporting energy to other Southern African countries. South Africa also has a well developed synthetic fuels industry, with a number of leading private and public sector companies in this sector (Pouris, 2010).

Despite activity in a number of energy sectors (including coal, nuclear and renewable), South Africa's supply of primary energy resources is limited mainly to coal (and associated products). The global move towards less carbon-intensive energy and greater efficiency in energy use has meant that South Africa has a greater need for research in both supply and demand side energy.

In terms of R&D funding for the energy sector, South Africa appears to be on par with other developing countries, as shown in Figure 2. Estimates by Kempener et al (2010) suggest that both government and non-government funding for energy related R&D averaged just over 0.1% of GDP in South Africa between 2000 and 2008. A comparison of South Africa with five major developing economies suggests that only China has, in GDP percentage terms, provided more funding for energy R&D. South Africa's funding for energy R&D is, however, much lower than when compared to developed countries.

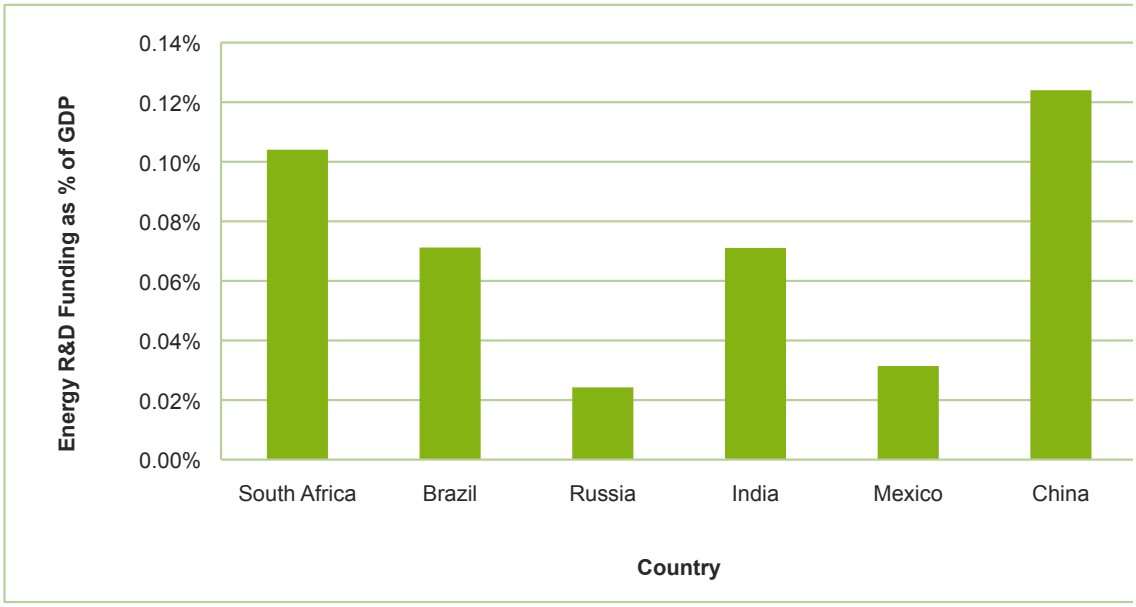

FIGURE 2 ENERGY R&D FUNDING, AVERAGE 2000 – 2008

Source: Based on Kempener et al (2010) and World Bank data.

Pouris (2010) provides an analysis of a number of indicators of South Africa's energy R&D. A summary of these indicators is provided below. The two major indicators are the number of energy-related publications (considered by Pouris (2010) to be one of the most efficient and objective methods of assessing R&D output) and the number of energy-related patents granted to South Africa.

Table 2 shows the number of academic publications by country, in total and energy-related publications, between 2004 and 2008. When comparing the share of energy-related publications to total academic publications, South Africa compares poorly, with energy publications accounting for just over 1% of publications, as opposed to countries such as Egypt, Malaysia, Nigeria and Algeria energy publications making up more than 3% of total publications. Even countries not explicitly well endowed in energy resources, such as South Korea and India, produce a high proportion of energy related research.

TABLE 2: COMPARISON OF COUNTRY ACADEMIC PUBLICATIONS, 2004 - 2008

Country	Number of publications		Energy share in total (%)	Average annual publications per million population	
	Total	Energy		Total	Energy
USA	1,551,846	15,476	1.0%	1,006	10.0
Canada	231,581	3,939	1.7%	1,366	23.2
South Korea	141,640	3,818	2.7%	587	15.8
India	143,687	3,367	2.3%	24	0.6
Australia	149,487	1,558	1.0%	1,353	14.1
Brazil	101,895	1,525	1.5%	106	1.6
Egypt	16,551	593	3.6%	43	1.5
Argentina	27,942	410	1.5%	139	2.0
Malaysia	9,864	373	3.8%	70	2.6
South Africa	27,008	297	1.1%	110	1.2
Nigeria	6,470	207	3.2%	8	0.3
Algeria	4,809	153	3.2%	28	0.9

Source: Adapted from Pouris (2010)

South Africa's energy research output is even poorer if looked at in per capita terms, with South Africa producing just over two energy publications annually for every million people. Developed countries, such as Australia, produce close to 15 times this output per capita, while even developing countries such as Argentina perform better than South Africa.

In terms of patents, South Africa has been granted just 0.15% of energy-related patents granted by the US patents office over a 20-year period between 1988 and 2008, shown in Table 3.

TABLE 3: ENERGY RELATED PATENTS

Energy related patents	Total patents (1988 – 2008)			Total patents (2004 – 2008)		
	World	SA		World	SA	
Demand Technologies						
Waste Heat: Liquid Heaters and Vaporizer/ Industrial/Waste Heat	224	1	0.45%	38	0	0%
Waste Heat: Power Plants/Fluid motor means driven by waste heat or exhaust energy	1,645	0	0%	590	0	0%
Heat Exchange	16,043	7	0.04%	4,597	1	0.02%
Heat Pumps	660	0	0%	175	0	0%
Stirling Engine	517	0	0%	120	0	0%
Total demand technologies	**19,089**	**8**	**0.04%**	**5,520**	**1**	**0.02%**
Supply Technologies						
Coal Liquefaction: Mineral oils: Process and Products/by treatment of solid material	349	1	0.29%	31	0	0%
Coal Liquefaction: Fischer-Tropsch Process	894	31	3.47%	328	19	5.79%
Coal Gasification: Gas; Heating and Illuminating	248	2	0.81%	40	0	0%
Nuclear: reactor techniques	5,579	7	0.13%	716	5	0.70%
Nuclear: radiation acceleration/detection techniques	12,233	17	0.14%	3,471	0	0%
Biomass	810	2	0.25%	73	0	0%
Wind Power	1,161	0	0%	556	0	0%
Solar Power: Materials, Cells and Modules	2,232	0	0%	377	0	0%
Solar Power: Systems	4,569	6	0.13%	1,859	0	0%
Solar Thermal: Collectors	1,588	2	0.13%	272	0	0%
Solar Thermal: Heating	507	0	0.0%	122	0	0%
Hydropower	2,039	3	0.15%	690	0	0%
Geothermal Energy: Systems	258	0	0%	56	0	0%
Geothermal Energy: ground-coupled heat pumps	83	0	0%	44	0	0%
Wave and Tidal Power: Tidal power	342	0	0%	136	0	0%
Wave and Tidal Power: Wave power	421	0	0%	166	0	0%
Hydrogen and fuel cells: Hydrogen production	70	5	7.14%	25	0	0%
Hydrogen and fuel cells: Hydrogen storage	2,632	6	0.23%	766	3	0.39%
Hydrogen and fuel cells: Proton-exchange membrane fuel cells	4,026	2	0.05%	1,969	0	0%
Hydrogen and fuel cells: Solid oxide fuel cells	1,134	1	0.09%	484	0	0%
Hydrogen and fuel cells: Molten carbonate fuel cells	872	0	0%	342	0	0%
Hydrogen and fuel cells: Other types of fuel cells	2,539	0	0%	997	0	0%
Carbon capture and storage	5,988	16	0.27%	1,316	2	0.15%
Waste-to-energy: Refuge-derived fuel	2,764	1	0.04%	390	0	0%
Waste-to-energy: Mass burn	2,819	2	0.07%	359	0	0%
Total supply technologies	**56,157**	**104**	**0.19%**	**15,585**	**29**	**0.19%**
Total	**75,246**	**112**	**0.15%**	**21,105**	**30**	**0.14%**

Source: Adapted from Pouris (2010)

The major sectors in which South Africa appears to be active are primarily the supply-side energy sectors, particularly coal liquefaction, where South Africa has been granted over 5% of patents between 2004 and 2008, nuclear reactor techniques and hydrogen storage. What is apparent is that South Africa research in the energy demand-side is especially poor, and the number of patents granted (as a proportion of total patents grants) in the demand-side has fallen over the 2004 to 2008 period when compared to the previous 15 years.

Academic institutions have produced an average of about 34 post-graduates (at masters and doctorate level) per year between 2000 and 2009, shown in Figure 3. However, since 2005 there has been a declining trend in degrees awarded, with a substantial fall in degrees awarded at both the doctorate and masters level. This is a serious constraint to producing research excellence in the energy sector.

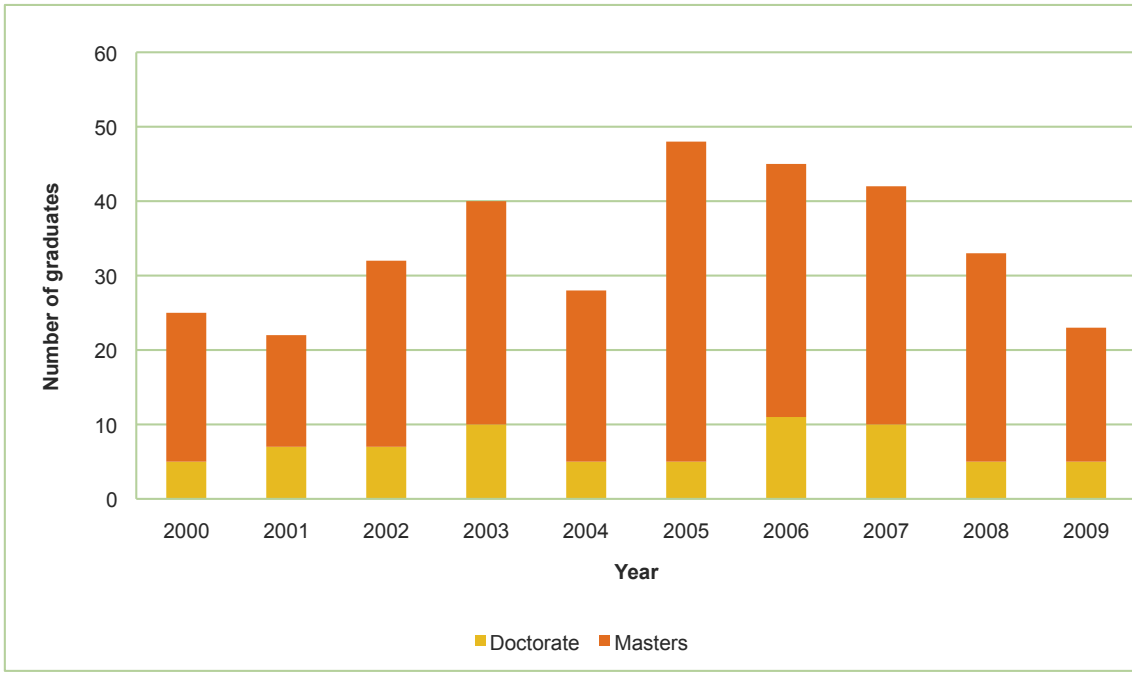

FIGURE 3: NUMBER OF POST-GRADUATE ENERGY DEGREES AWARDED IN SOUTH AFRICA

Source: Adapted from Pouris (2010)

3.2 The EGC within broader DST policy

The previous section focussed on identifying the important role for DST in the energy RD&I space, based on a limited set of baseline data. Consideration is now given to the Energy Grand Challenge (EGC) as outlined in the Ten Year Innovation Plan (TYIP), as well as the Energy, Research, Development and Innovation (ERD&I) strategy, to determine how these relate to other policy instruments which inform DST's work. At the start of the study, the authors of this report were of the understanding that the purpose of the ERD&I strategy was to support realisation of the EGC as articulated in the TYIP.

The four key drivers of the knowledge economy articulated in the TYIP, along with the four R&D thrusts of the ECG will be considered. The key drivers and R&D thrusts are shown in Figure 4.

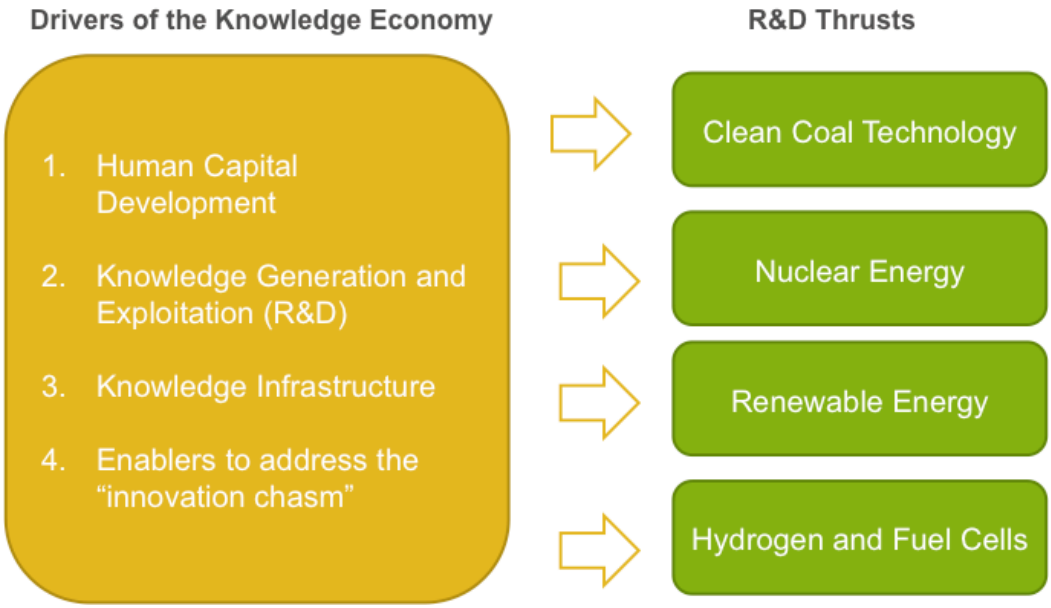

FIGURE 4: THE FOUR KEY DRIVERS OF THE KNOWLEDGE ECONOMY AS THEY RELATE TO THE FOUR R&D THRUSTS OF THE TYIP

To be implemented efficiently the ERD&I strategy should be aligned with other relevant DST policies and priorities. The mandate of the DST is primarily informed by three key policy instruments: The White Paper on Science and Technology; the National Research and Development Strategy (NRDS); and the Ten Year Innovation Plan. These instruments have been developed sequentially and have progressively incorporated concepts and priorities of antecedent instruments. The chronological progress and contributions towards the National System of Innovation are highlighted in Figure 5.

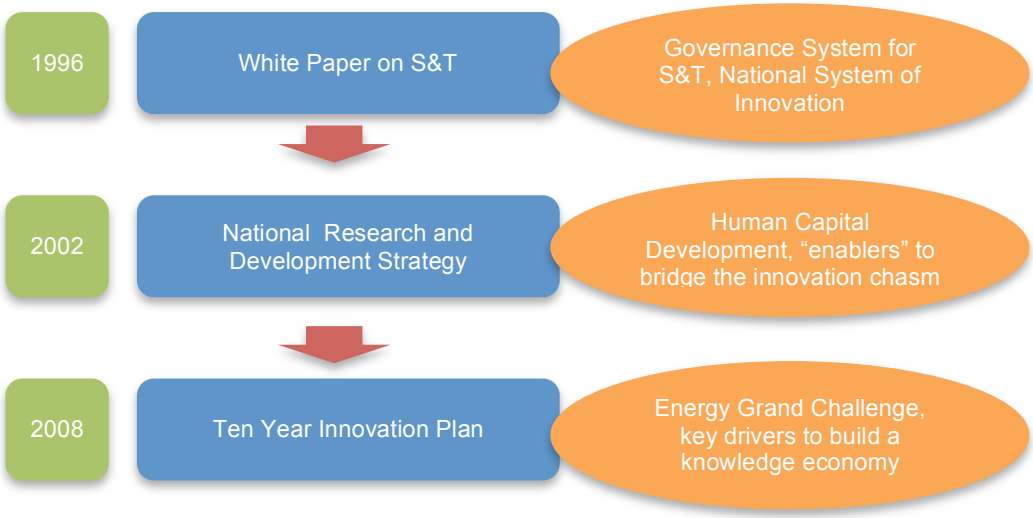

FIGURE 5: POLICY INSTRUMENTS INFORMING THE MANDATE OF THE DST

The most recently developed instrument, the TYIP, draws on its 'parent' instruments, the National Research and Development Strategy (NRDS) and the White Paper on S&T, for its rationale and focus.

These earlier instruments will not be dealt with explicitly here. Rather, the analysis will focus on alignment of the ERD&I strategy with the Energy Grand Challenge as articulated in the TYIP. In particular, the assessment aims to determine whether:

- The strategic focus areas of the TYIP and the ERD&I are aligned.
- The four key drivers of the knowledge economy articulated in the TYIP are addressed in the ERD&I in relation to the R&D thrusts of the EGC.

To answer the first question, Table 4 compares the Energy R&D thrusts of the TYIP and the Energy R&D themes of the ERD&I, highlighting areas of alignment/misalignment.

TABLE 4: ALIGNMENT OF THE R&D THEMES OF THE EGC WITH THOSE OF THE ERD&I

R&D Themes of the EGC (TYIP)	Alignment	R&D themes of the ERD&I
Clean coal technologies	Partly aligned	Cleaner fossil fuel development, including clean coal technologies
Nuclear Energy	Aligned	Nuclear Energy
Renewable Energy	Aligned	Renewable energy
Hydrogen and fuel cells	Aligned	Hydrogen and Fuel cells
	Not aligned	Energy Infrastructure Optimisation
	Not aligned	Energy Efficiency and Demand Side Management
	Not aligned	Understanding the impact of energy use on the environment
	Not aligned	The role of energy in socio-economic development
	Not aligned	Energy Planning and modelling
	Not aligned	Energy policy research

What is clear from the table is that, whereas the TYIP only has four strategic areas, the ERD&I strategy identifies nine focus areas. Therefore, strategic foci of the ECG are only partly aligned with those of the ERD&I strategy. Interviewees reported the reason for this misalignment - that the draft EDR&I strategy (which has now been substantially modified) was developed prior to the publication of the TYIP. These additional foci were reportedly identified through an extensive stakeholder engagement process in about 2005.

To answer the second question posed above, that related to key drivers of the knowledge economy, it is noted that the ERD&I strategy makes some limited suggestions for development of these drivers:

- **Human Capital Development** -Section 3.6 deals with Human Capital for innovation, briefly mentioning that a targeted human capital development programme, targeting women and black South Africans, is needed;
- **Knowledge Generation and Exploitation**- R&D themes relating to energy forms such as cleaner fossil fuel development and renewable energy are suggested (pg 34);
- **Knowledge Infrastructure** - no direction is given for this driver;

- **Enablers to address the innovation chasm**- Section 4.3 briefly makes recommendations as to the commercialisation of R&D.

There is no further clear articulation of these drivers in the ERD&I strategy. Apart from research themes suggested for cleaner fossil fuel and renewable energy, the ERD&I strategy does not provide clear direction of how the other drivers can be developed to support the relevant R&D thrusts. For example, the section on "Cleaner Fossil Fuel Development" and "Renewable Energy" provides no focus on how to develop human capital, knowledge infrastructure or what enablers are relevant to bridge the innovation chasm in these areas. With respect to "Nuclear Energy" (pg 37), there is no reference to any of the drivers.

Significantly, the ERD&I strategy does not deal with these drivers in a framework that is consistent with the priority given to them in the TYIP, whereas the TYIP provides a delineated framework for action, the ERD&I strategy presents a related collection of ideas and suggestions that are not aligned to the TYIP in their organisation or logic.

It can therefore be concluded that there is limited alignment between the ERD&I strategy and the TYIP, with respect to both the research thrusts and articulation of the drivers of the knowledge economy. As such, the remainder of the document focuses primarily on the ERD&I strategy without considering its relationship to the TYIP.

3.3 International best practice in ERD&I strategy

This section summarises the International Energy Agency (IEA) good practice recommendations for Energy R&D. It also provides an overview of National Energy R&D strategies for Denmark and Ireland, being the only two countries identified that have produced National Energy R&D strategies.

Since the aims, purposes and local context of strategies differ between countries, this section is not intended to provide a definitive answer as to whether implementation of the ERD&I strategy will be the most efficient way to meet its desired outcomes. Instead the review aims to identify salient features of international strategies (and good practice) that will provide an indication of whether the design of the ERD&I strategy can be improved to increase its expected efficiency. Potential improvements, and issues to consider, will be highlighted in the summary at the end of this section.

3.3.1 International Energy Agency Good Practice Guidelines for Energy R&D

The International Energy Agency (IEA) Secretariat has produced a Good Practice Policy Framework for Energy R&D.[1] According to the IEA, Governments must set ambitious technological challenges to inspire the private sector to pursue R&D. A shared vision between Government and Industry should form the basis of a fruitful public-private dialogue. Achieving this vision requires a comprehensive strategy that integrates a portfolio of policy tools adapted to both national systems and individual

[1] International Energy Agency, 2009, Good Practice Policy Framework for Energy R&D, Online: http://www.iea.org/papers/2011/good_practice_policy.pdf

technologies. The policy framework recommended by the IEA contains six elements as shown in the table below.

TABLE 5: IEA GOOD PRACTICE POLICY FRAMEWORK FOR ENERGY R&D

Element	Key messages
1. Coherent Energy R&D Strategy and Priorities	▪ Energy strategy should support national policy priorities. ▪ Strategy should be based on a portfolio approach encompassing technologies at different stages of development and with large-scale potential. ▪ Priorities and quantifiable objectives should be established for the short, medium and long term. ▪ Strategy should be developed in collaboration with major stakeholders in the public and private sectors. ▪ Strong links should be formed with relevant government departments. ▪ The whole innovation chain should be considered in the development of the strategy. ▪ Technology roadmapping, foresight exercises and technology assessment and evaluation should be used to determine priorities. ▪ Public funding should focus on investments that the private sector would not normally take, particularly high-risk activities with social benefits.
2. Adequate and stable R&D funding and policy support	▪ Fragmentation in the budget over too many priorities should be avoided. ▪ Stable funding over a number of years is preferable to annual changes in the budget. ▪ Funding for R&D will have to be aligned with other initiatives that affect RD&I indirectly by allowing innovation to thrive (e.g. tax, competition, public acceptance, education).
3. Coordinated energy R&D governance	▪ Programmes should be coordinated throughout the entire innovation process, as well as across topic areas (e.g. energy and environment) and ministries.
4. Collaboration with Industry through Public-Private Partnerships	▪ Effort should be made to involve companies early and keep them involved throughout. ▪ R&D should be relevant to industry and industry should be involved in priority setting.
5. Effective R&D monitoring and evaluation	▪ Monitoring and evaluation results should provide feedbacks for the next programme cycles and for the setting of new targets to aid the planning of future R&D programmes and policies.
6. Strategic International Collaboration	▪ Partnerships can be bilateral, multilateral and regional. There are a number of international cooperative forums on Energy R&D, e.g. The EU Framework Programme. ▪ Governments should develop a strategy for international cooperation, with priorities.

3.3.2 *Strategy for Energy Research, Technology Development and Demonstration in Denmark*[2]

The Danish strategy, published by the Danish Advisory Committee on Energy Research, provides an overview of energy challenges for Denmark: reliability of supply; global climate change; and growth and industrial development. It also describes the international energy market conditions in which Denmark participates as a competitive player in the field of renewable energy.

The emphasis of the Danish strategy is on developing Danish core strengths in order to remain internationally competitive in the energy technology market. These strengths are identified to be in the areas of renewable energy (including experience in adapting the use of these into existing energy systems); efficient and clean power station technologies; and efficient and flexible exploitation of energy and energy saving.

The strategy provides an overall framework and indicates focused criteria for the setting of priorities which guide all players and programmes. In particular, three elements in the strategy are emphasized:

- That effort to demonstrate newly developed technologies is targeted and given higher priority.
- That focus is placed on research contracts directed towards consortia consisting of companies and research institutions; and towards large-scale projects which include co-funding and a relatively wide framework in terms of content.
- That there is increased focus on potential for growth and industrial development.

6 strategic goals are described:

1. Providing an overall, long-term and robust basis for determining focus areas and evaluation of applications' relevance. The strategy conceptually distinguishes between "development of energy technologies" and "development of energy systems and markets", and suggests assessment criteria for assessing the relevance of applications.
2. Improvement of the interaction between the R&D programmes and the companies in the energy sector as well as financial markets. A list of suggestions is provided to address the innovation chasm.
3. Ensuring a targeted effort to demonstrate newly developed technologies. Here a list of assessment criteria for the selection of demonstration projects is presented.
4. Maintenance of Denmark's position in international R&D programmes and improved interaction regarding the utilisation of international knowledge. Suggestions are offered for maintaining a strong Danish position and expanding Danish core strengths.

[2] Strategy for Energy Research, Technology Development and Demonstration in Denmark, 2006, Advisory Committee on Energy Research, Online: http://193.88.185.141/Graphics/Publikationer/Energiforskning_UK/Strategy_for_energy_research_okt06/pdf/Strategi_engelsk_apr06_a.pdf

5. Development of a basis for current feedback of experience on a continuous basis. A model for evaluation of projects is offered.
6. Active coordination and clearer division of responsibilities between the R&D programmes. A method for delimitation of responsibilities amongst agencies is proposed.

A high level implementation plan outlining areas of activity in the chain of development, players in the public system and measures to be taken is also provided.

The strategy is aligned with the implementation of the Danish energy policy which includes the objective to achieve the highest possible degree of innovation and growth in the energy sector, developing an internationally competitive knowledge environment in the energy field. The strategy further emphasises that energy R&D must support general energy policy goals in Denmark, being fulfilment of goals for CO_2-reduction supply security, energy efficiency and energy system efficiency.

Public sector R&D funding for strategic research in the field of energy comprises four programmes in the following Ministries: Ministry of Transport, Ministry of Science and Technology and Research and Ministry of Energy and Environment. The strategy recommends coordination and collaboration between these departments.

3.3.3 An Energy Research Strategy for Ireland[3]

This strategy, prepared by the Irish Energy Research Council, sets the context by reviewing Irish and international energy challenges and describes the context of energy research in Ireland, Europe and Internationally. Subsequently it maps out the strengths, weaknesses and opportunities for energy research in Ireland.

The vision is presented as:

> "Ireland meeting its energy system requirements in a manner that addresses the challenges of energy security and environmental sustainability informed, underpinned and facilitated by highly motivated and strongly coordinated teams of energy researchers of world class standard operating in a stable, adequately resourced and continuous research environment" (pg 7).

The strategy proposes a framework with a set of selection criteria for prioritizing energy research areas, a set of five major strategic lines of activity and a funding apportionment for the various lines. The major areas of research activity are:

- Energy systems modelling and analysis;
- Fundamental frontier and multi-disciplinary research;
- Energy R&D in a limited number of sector-specific fields;

[3] An Energy Strategy for Ireland, 2008, Irish Energy Research Council, Online: http://www.dcenr.gov.ie/NR/rdonlyres/2DAEBBFF-6162-4D88-8220-654E2E9ED2B1/35288/EnergyResearchStrategyApril2008.pdf

- Research support in identifying and mapping Ireland's energy resources; and
- Maintaining a 'watching brief' for technologies of potential application in Ireland.

The priority sector-specific fields identified for targeted action are Ocean Energy, Grid /Infrastructure, Energy in Buildings, Energy in Transport and Sustainable Bioenergy. The strategy sets out the factors influencing the selection of these areas as well as suggesting some potential research topics which could be pursued.

Key deliverables for this vision, over a period of 5 years, are:

- Increased critical mass in energy research in Ireland;
- Increased number of PhDs and Post Doctoral research in energy;
- Improved research support infrastructure for energy research in Ireland; and
- Comprehensive support for the development of energy and environmental policies for Ireland.

The strategy also presents criteria for developing relevant areas for energy R&D and to guide priorities in allocating resources and integrating policy relevant energy research. Various means of ensuring research excellence are proposed. For example, it is recommended that there should be international peer review for all significant funding proposals; that projects should either be continued or cease according to whether milestones are met; and that there should be a strong emphasis on ex ante and ex post evaluations.

The strategy recommends a twin-track approach to ensure that the policy system can absorb policy-relevant research on both the demand and supply sides. This approach comprises capacity building in the public sector, particularly at policy and advisory level; as well as capacity building in academic institutions, various public sector implementing agencies and research bodies. The use of existing bodies and mechanisms to promote and support energy research is recommended, emphasizing the need for consultation with relevant stakeholders and high-level coordination, monitoring and evaluation. It also recognizes that the cross-sectoral policy perspective requires structured coordination between the relevant government departments and agencies and suggests that a high level cross-departmental/agency forum be established to coordinate and monitor all energy research activities and programmes. It emphasises that Irish research to be fully informed and coordinated with EU and international efforts.

More broadly, the strategy points to the need for coordination between energy and related environmental research and suggests that demonstration projects should be evaluated against established baselines with published results. Energy research budgets are suggested to be sufficiently separated from non-research programmes to provide certainty in the long term. It proposes an indicative spread of public funding across the elements of the strategy.

3.3.4 Summary of international experience

The two country strategies are quite different, responding to the particular context within which each country finds itself. Whereas Denmark's focus is on retaining market competiveness through innovation

in the renewable energy sector, Ireland's focus is on energy research for energy security and environmental sustainability. Both strategies, however, are strong on institutional collaboration in energy research and recommend a criteria-based system to determine research foci.

The lack of broad-based strategies in the area of energy RD&I internationally, however, raise questions as to the scope and ambition of the ERD&I strategy locally. The ideal strategy design, however, will depend on the local context.

4 STUDY APPROACH/METHODOLOGY

As mentioned in Section 2.2, design assessments are relatively new in South Africa, and no publicly available examples were able to assist in the design of the current assessment. Consequently the project team referred to best practice to guide the study design. In particular, the following documents were reviewed:

- The National Treasury (2011): *Performance Information Handbook*
- The Presidency (2011): *National Evaluation Policy Framework (NEPF)*
- Department of Science and Technology (2011): *Departmental Evaluation Framework for the Department of Science and Technology*
- Centre for the Implementation of Public Policies Promoting Equity and Growth (CIPPEC) (2010): *Handbook on Monitoring, Evaluating and Managing Knowledge for Policy Influence*
- Development Assistance Committee (DAC) at the OECD (OECD-DAC) (2010): *Evaluating Development Co-operation: Summary of Key Norms and Standards*
- European Commission (2009): *Impact Assessment Guidelines*
- World Bank (2004): *Ten Steps to a Results Based Monitoring and Evaluation System*

The approaches proposed in all these documents are largely consistent. Consequently it was decided to use the NEPF as the main guiding document. The reasons for this are as follows:

- The NEPF is part of the Policy Framework for Government-Wide Monitoring and Evaluation System approved by Cabinet in 2005, and as such provides the official basis for a minimum system of evaluation across government.
- The Presidency is the national custodian of public sector M&E in South Africa. It is thus important that evaluation frameworks are consistent with the Presidency's approach to ensure that results are comparable across departments and agencies.
- The NEPF conforms to international best-practice in M&E, as is evident in the degree of similarity in exhibits with the other approaches reviewed.
- The NEPF was developed locally and is thus suited to local conditions.

In order to account for the fact that the NEPF provides a high-level framework, and that the current assessment is both ex ante and deals with a broad strategy rather than a more tangible programme of projects, elements from the other approaches reviewed were used to supplement the NEPF approach where appropriate to develop a more detailed assessment framework (as shown in Section 5).

The study was conducted as follows:

- An Assessment Framework was developed based on guidance found in the NEPF and expanded by including elements of other authoritative local and international M&E frameworks;
- The ERD&I strategy was assessed against the Assessment Framework (as detailed below, it was not considered relevant to assess the Implementation Plan against the Assessment Framework) based on:
    - A literature review to provide an understanding of legislation and policy, and roles and responsibilities as they relate to energy Research, Development and Innovation (RD&I) in South Africa;
    - A detailed desktop analysis of the ERD&I strategy and Implementation Plan; and
    - Interviews with key informants in the DST.
- An internal DST workshop was held to sense-check the findings of the study and clarify outstanding issues.
- Conclusions and recommendations were formulated based on the outcomes of the study and the internal DST workshop.

5 DEVELOPMENT OF ASSESSMENT FRAMEWORK

The Assessment Framework was developed to interrogate the ERD&I strategy. It provides a yardstick (based on international best-practice) of the characteristics of 'good' strategy/policy against which to measure the ERD&I strategy.

In developing this Framework, guidelines in the National Evaluation Policy Framework (NEPF) were considered and expanded upon for the reasons highlighted in the previous section. In particular, the NEPF requires that all plans and policies (The Presidency, 2011:4):

- Include a diagnostic analysis;
- Clearly specify their logic models; and
- Identify good quality measurable indicators.

The Assessment Framework therefore includes six aspects which together determine how well the ERD&I meets these requirements of the NEPF:

- Relevance
- Clarity
- Context
- Effectiveness
- Efficiency
- Monitoring and evaluation

These aspects are described in detail in the sections that follow. In defining the aspects, and defining the key questions that need to be answered to complete the assessment (listed in the sections that follow), insights from the other sources mentioned in Section 4 were used to expand on the content of the NEPF.

The assessment framework developed below explicitly recognises that the purpose of the current exercise is a design assessment rather than an evaluation. The ERD&I strategy is still in draft form and has not been implemented. As a result, the framework focuses on factors that are predictors of success, rather than output factors that measure success after the fact. A strong emphasis is placed on the content of the draft ERD&I strategy document.

5.1 Relevance

Strategies are developed because certain outcomes are not expected to occur naturally. In other words, there is some kind of problem that is preventing the desired outcome from occurring, and the problem requires an intervention to be resolved. Relevance speaks to "assessing whether the need as conceptualized in the intervention strategy, actually exists in the population [and] whether it is, in fact, a problem" (DST, 2011: 10).

The problem or need the strategy is trying to address should thus be clearly identified, including the parties affected by the problem, how widespread the problem is, and baseline information highlighting the measurable manifestations of the problem (DST, 2011).

Q: Is the rationale for the strategy clearly defined? Is the need identified supported by baseline data?

5.2 Clarity

Before the success of a proposal in meeting its objectives can be evaluated, there must be clarity on exactly what those objectives are. To help ensure clarity, objectives should be SMART (Specific, Measurable, Achievable, Realistic, Time-dependent) (OECD, 2009:28):

- **Specific**: Objectives should be "precise and concrete" enough to avoid varying interpretations and confusion.
- **Measurable**: Outcomes of a strategy should be measurable. This allows the future verification of whether objectives had been achieved. Objectives can be defined on a

quantitative or qualitative basis, but qualitative criteria need to be specific (e.g. include a combination of description and scoring scales).

- **Achievable**: It is critical that the implementers a strategy should able to achieve its objectives. The actions that are expected to flow from a strategy must thus be able to influence its objectives (OECD, 2010).
- **Realistic**: Objectives and targets should be ambitious, but they should be realistic both in scope and time frame if implementation is to be achieved.
- **Time-dependent**: Clear time frames are necessary to guide implementation Objectives remain vague and open-ended if they are not related to a fixed date or time period.

Q: Does the strategy have a clearly defined set of objectives? Are the objectives SMART? Is baseline data provided?

5.3 Context

For a strategy to be effective, it needs to take into account the environment in which it will be implemented. It is thus important to assess the influence that the broader context (i.e. external policies and institutional arrangements) may have on the likely success of the strategy (OECD-DAC, 2010). For this reason, the NEPF (2011:4) states that a strategy should "include a diagnostic analysis of the current situation and the forces at play, and which are likely to be the main strategic drivers of change". It also mentions that assumptions made about the external environment should be explicitly stated.

In checking for policy alignment, the project team will map out government agencies and departments with similar policies (and programmes) to assess whether the proposed policy is consistent with existing policies. Policy alignment is important to avoid potential unintended consequences that may arise as a result of the implementation of the policy. Also, a lack of policy alignment could cause one or more of the clashing polices to be ineffectual – leading not only to the desired impacts of the policies not materialising, but to a waste of effort and resources.

Important issues in this regard are:

- Is the policy aligned with DST's strategic goals?
- Has the local policy context been sufficiently mapped?
- Will the strategy work with or against existing policies (i.e. is there policy alignment)?
- Has the role of the DST (and its agencies) been sufficiently defined (and if so, can the DST fulfil this role?)

Q: Has the local context been sufficiently addressed? Is the strategy workable given the local context?

5.4 Effectiveness

It is important that the strategy details how its recommended actions will lead to its objectives being achieved. The causal relationship between the actions proposed in a strategy and the desired outcomes

and impacts should thus be clear, or as the NEPF puts it, a strategy should "explain the underlying hypothesis that if we do what we suggest, we will achieve certain objectives and targets" (The Presidency, 2011:4). This link between the likely actions to flow from a strategy and its objectives constitutes its 'logic model', 'theory of change' or 'impact pathway' (DST, 2011; The Presidency, 2011:4).

Whereas the logic model approach (often implemented by the creation of a log frame document that succinctly and clearly sets out the logic model) is well entrenched in donor organisations and international policy making process, it is less popular in South Africa. Developing a logical framework compels policy makers to hypothesise the causality between the inputs, activities, outputs, outcomes and impacts. Therefore, a log frame allows policy makers to articulate the outcomes they would like to achieve and describe the way in which these outcomes will be achieved.

The use of a logical framework in policy making also establishes linkages between the inputs and outputs required which may determine the extent to which the policy is implementable in the given timeframes. The project team will assess whether there is a logical flow from the prescribed inputs and activities to the desired outputs and outcomes.

While the DST DEF (DST, 2011) mentions that the logic model can be implicit, the NEPF calls for it model to be explicitly outlined in the strategy. The project team agrees with the NEPF approach. Unless the logic model, and its components and relationships, are explicitly defined in the strategy, there is no guarantee that there is a common understanding of what a strategy intends to achieve, or how it plans to achieve it. It is possible that similar terms could have different meanings to different individuals, and there may be divergent views on how the energy RD&I system works that may not become clear unless a detailed conceptualisation is provided that stakeholders can agree or disagree with.

Furthermore, even if a common understanding of terms, components, mechanics and interactions exist when a strategy is developed, there is no guarantee that this common understanding will persist while the strategy is implemented. Staff turnover or the internal movement of resources within a department or agency means that the original drafters of a policy or strategy may not always be accessible when an evaluation is undertaken. If this is the case, it may not be possible to verify whether the logic model included in the strategy or policy is sound.

Q: Is the strategy's logic model clearly defined? Is the logic model analytically sound?

5.5 Efficiency

There are often a number of ways to achieve a given policy objective. Ideally the least costly way of achieving a strategy's objectives should be chosen. This typically requires comparing alternative approaches to achieving the same objectives to see whether the chosen process is the most efficient approach has been chosen (OECD-DAC, 2010).

For the current design assessment, a brief review of strategies or approaches used overseas to support energy related R&D projects is used as a benchmark to assess the ERD&I's expected efficiency in meeting its objectives. Included in this review is one international guidance document and two country studies, being those described in Section 3.3.

Q: Is the strategy consistent with international best-practice?

5.6 Monitoring and evaluation

To analyse the success of a strategy, indicators of success should be identified during the strategy development process. An outline of future monitoring and evaluation processes should thus be in existence before the strategy is implemented. NEPF (2011:4) states that a "failure to collect baseline information" on important indicators and "monitor and record changes to the indicators during implementation" complicates the objective evaluation of a strategy. An M&E framework should thus include both indicators and details of how data is to be collected that ensure that the indicators are collected on a regular basis.

Monitoring and evaluation are two distinct activities. Essentially the difference between the two activities can be expressed as: "monitoring asks whether the things we planned are being done right", while evaluation asks "are we doing the right things, are we effective, efficient and providing value for money, and how can we do it better" (NEPF, 2011:3). Monitoring is thus more process orientated, while evaluations are more judgement based (NEPF, 2011). Importantly, the monitoring process needs to support the evaluation process by generating the indicators that will be used to evaluate the effectiveness of the strategy.

Ideally an M&E framework should thus include two distinct but interdependent components:

- A **motoring framework** that includes indicators that are collected and monitored on a regular basis and used to manage progress against the activities set out in strategy.
- An **evaluation plan** that guides the timing and extent of evaluations.

5.6.1 Monitoring framework

For DST and its partners to effectively evaluate the ERD&I strategy, it is important that a logical framework (or impact chain) exists that clearly articulates the ERD&I strategy's logic model. A logical framework maps inputs through specific activities and outputs, and includes the specific expected outcomes and impacts resulting from a strategy. The logical framework ultimately forms the basis of the M&E framework.

To guide monitoring and planning, a logical framework should include good quality indicators to monitor the inputs, activities, outputs, outcomes and impacts of a strategy. Indicators play a critical role within any M&E framework by allowing the extent to which a strategy has been effective in achieving its intended outcomes and impacts to be measured.

National Treasury (2011) outlines a number of important characteristics that influence the quality of indicators. The most important of these, in the experience of the project team, are:

- **Relevance and usefulness**: A clear balance must be struck between the number of indicators, their usefulness and their relevance to the objectives of the study. To be useful, OECD (2010) mentions that indicators should be easy to interpret and transparent (i.e. users

should be able to assess the significance of the values associated with the indicators and their changes over time).

- **Incentives**: Indicators should not incentivise behaviour that is not consistent with the overall logical framework (i.e. lead to an excessive focus on 'easy-to-do' activities like training at the expense of more difficult activities). A good balance between output and outcome indicators tends to lead to a better alignment of incentives with the overall purpose of a strategy.
- **Data quality and reliability**: The credibility of any M&E framework is largely dependent on the reliability and validity of the indicators produced. This refers both to external indicators collected and the quality of internal data collection systems.
- **Frequency, costs and benefits**: Indicators should provide information to managers and decision makers in a timely manner. Trade-offs exist between the benefits of timely collection of data and the costs involved in data collection. Where data collection systems are in their infancy, the costs of collecting data for each indicator may be prohibitive. Where possible, the indicators should be collected from existing data collection systems and avoid duplicating existing performance reporting.

Q: Does the strategy include a monitoring framework? Are the indicators included in the monitoring framework of good quality? Is the monitoring framework cost-effective and practically feasible?

5.6.2 Evaluation plan

Different activities may demand different evaluation methods and techniques. The type of evaluation method used largely depends on the nature of the intervention and the purpose of the evaluation. In general, however, an evaluation plan should include (DST DEF, 2011):

- The types of evaluations required;
- Key research questions based on the logical model;
- The timing and frequency of evaluations; and
- The target audience for evaluations

Q: Does the strategy include an evaluation plan? Is the level of detail provided in the evaluation plan sufficient?

6 ASSESSMENT OF ENERGY RESEARCH DEVELOPMENT AND INNOVATION (ERD&I) STRATEGY

In this section, the Assessment Framework detailed in Section 5 is applied to the ERD&I strategy. Section 3.2 showed that there is limited alignment between the ERD&I strategy and the TYIP. As such, the remainder of the analysis focuses primarily on the ERD&I strategy without considering its relationship to the TYIP.

6.1 Relevance

Q: Is the rationale for the strategy clearly defined? Is the need identified supported by baseline data?

The importance of energy to economic development and improving the socio-economic welfare of South Africans (particularly the poor) is clearly highlighted in the ERD&I strategy. The positive impacts of greater diversity of energy supply are identified, including those of contributing to energy security, balance of payments, economic growth, energy access, air pollution, power supply shortages etc. Furthermore, the case is made that there is a desirable outcome (in this case the development and roll-out of diverse energy sources) that is not occurring naturally.

Based on the understanding of the role of energy more broadly, that of energy diversity, and the fact that the development and roll out of diverse energy sources in not occurring naturally, the desired impact of the strategy is articulated as (DST, 2008:8):

> "(a) to ensure that clean, affordable and sustainable energy is provided to improve the quality of life of as many people as possible; (b) to expand the economy of South Africa; (c) to reduce the impact of energy activities on the climate; and, (d) to reduce dependence of the South African economy on imported fossil fuels."

The link between energy RD&I and these considerations is, however, not clearly articulated. The 'problem' that is preventing these outcomes from occurring, and which requires an intervention to address (which is the justification for the ERD&I strategy and is one of the questions to be asked as it relates to "relevance"), is thus not sufficiently addressed.

Qualitative statements are provided that suggest the existence of problems within the energy RD&I system hindering the development and roll-out of new energy sources (and thus preventing the desired impacts listed above). However little baseline information is provided to back up these statements. The ERD&I strategy states that the "[i]nnovation infrastructure in the field of energy infrastructure is woefully inadequate", but no energy-specific empirical or other evidence is provided to support this assertion, beyond basic research(DST, 2008:6).[4]No further comment is offered on the energy RD&I system, and in fact no indication of what the RD&I system in the energy sector in South Africa looks like is provided.[5]. As such, it is not clear whether the problem lies with basic and applied research, or elsewhere in the energy RD&I system.

The ERD&I strategy mentions that the following weaknesses identified in the 2002 National Research and Development Strategy apply to the energy sector (DST, 2008:12):

- Limited public funding;

[4] The ERD&I strategy quotes research by Pouris (2007) that provides evidence that basic energy research in South Africa is below optimal levels. Sibanda (2007) provides a similar conclusion for applied research (using patents as a proxy for successful applied research), but his conclusions pertain to general RD&I, and energy-specific patents are not addressed separately (although this analysis may be possible, see Section 6.6.1).

[5] Terms like the 'RD&I system in the energy sector', energy sector RD&I model etc will be used interchangeably and describe the portion of the South African national research system/system of innovation that relate to energy sector RD&I activities.

- Strategic competencies are not being maintained;
- Human resources are not being adequately developed, especially black and female scientists;
- Declining R&D in the private sector; and
- Challenges with regard to the management of intellectual property.

No data to back up these assertions is provided. It is further noted that the 2002 National Research and Development Strategy (DST, 2002) refer to any of these issues specifically within the context of the energy sector.

With respect to the first point, that of limited public funding, despite being the main focus of the document, the ERD&I strategy does not attempt to quantify current public interest energy R&D (PIER&D), and simply states that "reliable data on the amount invested in PIER&D is not available" (DST, 2008:14). Furthermore, no attempt is made to quantify the R&D expenditure by private companies or SOEs beyond that of the PBMR Company, Eskom and Sasol.[6] The lack of expenditure data is problematic, since the ERD&I strategy asserts that "the rate of patenting is strongly correlated with investment in R&D", an assertion which cannot be tested or benchmarked (DST, 2008:16).[7]

With respect to strategic competencies and human resource development, the ERD&I strategy states that "[w]hile the shortage of science, engineering and technology (SET) skills in South Africa is acknowledged, it is particularly severe within the energy sector" (DST, 2008:28). While the work of Pouris (2007) and Sibanda (2007) support this assertion at a high level for researchers, no detailed evidence for or breakdown of the shortages are provided. Pouris (2007) also largely focused on researchers working in the public sector (at academic institutions), which further highlights the need for an assessment of private sector energy SET skills. Similarly, the claim that "national research capacity resides primarily in a few specialist areas, most notably in power and synthetic liquid fuels", is not backed up by statistics or other proof (DST, 2008:6). Nor is the implications of this on the wider energy RD&I system further interrogated, in terms of whether it is only a constricting factor or a potential opportunity.

In conclusion, the ERD&I strategy does include a high level rationale for an intervention in the energy sector to support energy RD&I activities. Because a detailed overview of the energy RD&I system in the energy sector was not provided, however, it is difficult to know where the intervention needs to be focused. The 'problem' or 'blockage' that the intervention should address has thus not been sufficiently addressed. The lack of baseline data (which is restricted to the outputs of basic and applied research), makes it difficult to identify how widespread potential issues within the energy RD&I system is that prevents or delays the commercial implementation of new energy supply and energy efficiency options.

[6] An estimate of Gross domestic expenditure on R&D (GERD) is provided, but the portion attributable to energy R&D is not shown.

[7] Patenting is used as a proxy for innovation in various sections of the ERD&I strategy. Given that the correlation is based on information for one country only, it is debatable how much weight should be given to this assertion.

As such, it is difficult to identify the practical actions that need to be taken to ensure that the ERD&I strategy has the desired impacts listed previously.

6.2 Clarity

Q: Does the strategy have a clearly defined set of objectives? Are the objectives SMART? Is baseline data provided?

The overarching goal of the ERD&I strategy is stated as being to "achieve the 2018 vision of a South African energy system that is driven by globally competitive industries, provides modern, affordable and reliable energy services for all, and does so with minimal impact to the environment" (DST, 2008:40). These goals are referred to as the 'energy system goals' contained in the strategy in the remainder of this section.

In addition, the ERD&I strategy proposes a number of high-level "key drivers" (not to be confused with the key drivers of the knowledge economy as articulated in the TYIP) that should be considered in order to support "national growth and development objectives" as follows:

- Building a globally competitive knowledge-based economy;
- Expanding development opportunities;
- The environmental imperative (reducing greenhouse gas emissions);
- The natural energy resource base: constraints and opportunities;
- Regional cooperation and development; and
- Developing human capital and promoting transformation.

How these 'key drivers' and the 'energy system goals' interact in defining the objectives of the ERD&I strategy is not made explicitly in the document. It is not clear how the key drivers and overarching objectives should be used to rank energy RD&I initiatives. The key drivers could either be seen as secondary criteria that can be used to rank energy RD&I initiatives that perform equally well in satisfying the energy system goals or that all energy RD&I objectives must meet the overarching objectives as a first requirement and then be assessed against the key drivers, or they could be seen as competing policy objectives that should be given equal weight in the decision-making process to the energy system goals (cost-effectiveness, reliability and environmental impact).

It could also be argued that the energy system goals and the key drivers could potentially need to be traded off against each other. At present the ERD&I strategy does not include a mechanism to rank or weight these objectives and drivers. This makes it hard for these objectives and drivers to provide practical guidance in the choice between competing energy RD&I initiatives.

As identified in Section 3.2, the ERD&I strategy also suggests a number of "national energy research and development themes" (DST, 2008:29) where public sector energy RD&I support should be focused. These were identified to include:

- Energy infrastructure optimization;

- Energy efficiency and demand side management;
- Understanding the impact of energy use on the environment;
- The role of energy in stimulating socio-economic development;
- Cleaner fossil fuel development, including clean coal technologies;
- Renewable energy;
- Alternative energy (nuclear energy and hydrogen and fuel cells);
- Energy planning and modelling;
- Energy policy research; and
- Commercialising energy R&D.

Consultation with key informants at DST has identified that these themes were identified through a stakeholder process run in around 2004 to 2005.

It is not made explicit how these themes relate to the energy system goals and the key growth and development drivers mentioned earlier. Interviews have suggested that interventions within the broad themes are likely to contribute to the energy system goals and impact positively on key drivers.[8] However no indication is given as to how individual energy RD&I opportunities within and between the different themes are to be ranked according to the overarching objectives and key drivers, or whether the different themes still need to be prioritized based on the ERD&I strategy objectives. If the former is true, then measurable success factors/targets are required for each of the themes. If the latter is true, then success factors need to be defined for a subset of the themes, and one of the measurable objectives of the strategy should be to prioritise interventions in a set number of themes. This could be challenging given the different kinds of interventions DST will make under the different thematic areas.

A further question needs to be asked as to whether the identification of national energy research and development themes should sit within the ERD&I strategy in the first place.

Apart from the conceptual issues raised thus far, at a practical level none of the possible objectives in the ERD&I strategy (be they the energy system goals, growth and development drivers, or investment in theme areas) are SMART (Specific, Measurable, Achievable, Realistic, Time-dependent) (OECD, 2009:28):

- **Specific**: As is clear from the discussion above, objectives are not “precise and concrete” enough to avoid varying interpretations and confusion. The ERD&I strategy thus does not satisfy this criterion.

[8] The issue of the relationship between the goals and the drivers highlighted above remains an issue, since no indication was provided as to whether the interventions in the broad theme areas should prioritise the goals or the drivers. Or how trade-offs between the two need to be dealt with.

- **Measurable**: No quantitative or qualitative targets (e.g. a requirement to rank the attractiveness of the energy RD&I themes) are set in terms of objectives. Also, no *baseline data* is provided for objectives. This means that a qualitative assessment of whether or not objectives have been met (i.e. a certain variable increased even though a specific target was not specified) is not possible. The future verification of whether objectives had been achieved or not is thus not objectively possible, and this criterion is therefore not met.
- **Achievable**: Because of the ambiguity in terms of objectives, it is not clear whether the actions that can be expected to flow from this strategy will influence its objectives. As will be highlighted in section 6.4 below, it is also not clear which of the objectives can be influenced by the DST or its agencies, which adds further complexity to determining if objectives are achievable.
- **Realistic**: Not applicable given that preceding criteria were not met.
- **Time-dependent**: No time frames or end dates are specified in the ERD&I strategy. It does refer to the 2018 vision for the energy sector put forward in the DST Ten Year Innovation Plan. Had measurable objectives been set, this would likely have been the future date at which they would have been assessed.

In summary, therefore, there is limited clarity as to the objectives of the ERD&I strategy. A number of potential sets of objectives are listed, but none of meet the SMART requirements, and limited baseline data is provided to support the objectives.

6.3 Context

Q: Has the local context been sufficiently addressed? Is the strategy workable given the local context?

To answer this question, the EGC as articulated in the TYIP, as well as the ERD&I strategy, are now considered in the context of other the key government departments involved in energy R&D, and the related policies that inform their work (Figure 6).

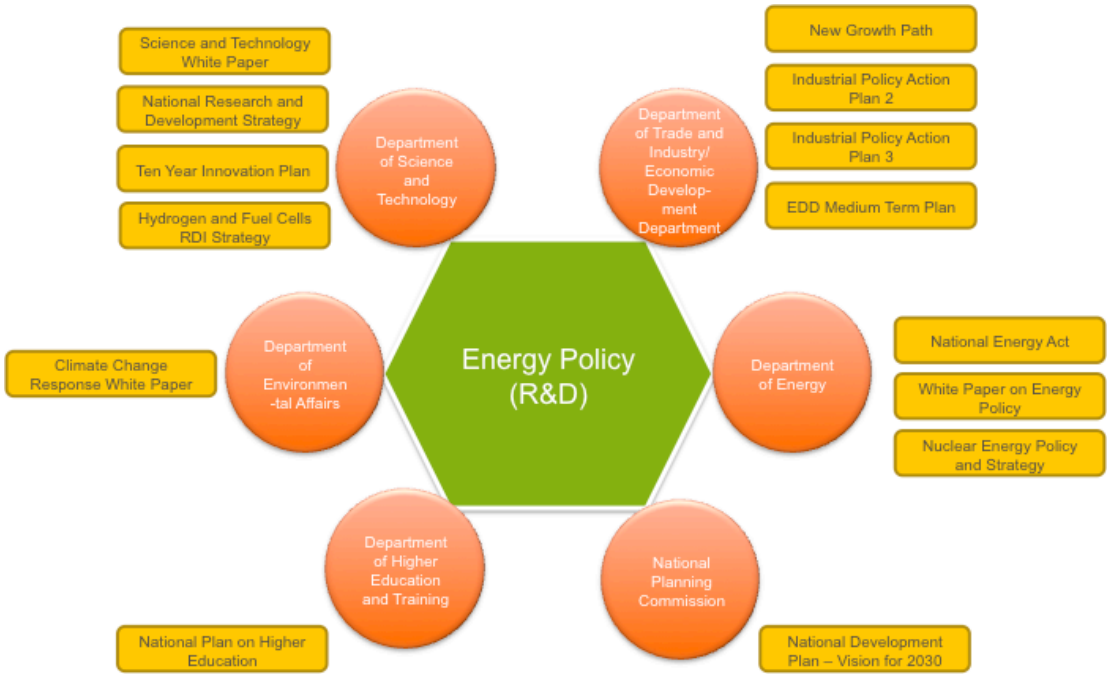

FIGURE 6: GOVERNMENT AGENCIES AND POLICIES DRIVING ENERGY RD&I POLICY

As indicated in Figure 6, the energy RD&I policy environment in South Africa is complex, with a number of government departments directing energy RD&I policy via existing frameworks. The key departments involved are DST, DEA, DoE and DHE&T. The work of these departments in relation to the four energy R&D thrusts and/or the key drivers of the knowledge economy outlined in TYIP as follows: DST participates through its involvement in RD&I (as discussed further below); DEA participates through its climate change mitigation and renewable energy activities; DoE participates through its stated role of ensuring secure and sustainable energy supply for socio-economic development; and DHE&T is responsible for building human capital for the NSI.

As a means of exploring this complex landscape further, details of the policies and their related institutional contexts are mapped out in Table 6. Table 6 also highlights relevant energy RD&I policy content and indicates that which is aligned with TYIP. The analysis sought further to determine whether there are any areas in which the broader RD&I policy context are potentially obstructive or contradictory to the TYIP, and no such areas were found.

In summary, therefore, it is identified that the EGC and the ERD&I strategy are not in any way in conflict with other departments' energy related RD&I agendas. In fact, there is 'general' alignment in the following areas: a focus on research, development and innovation; renewable energies and human capital development for innovation. What is less clearly articulated is where the DST's role ends and that of other departments begin, or alternatively how DST should interface with other departments on meeting their energy-related agenda. The latter is discussed further in the following section.

TABLE 6: POLICY AND INSTITUTIONAL CONTEXT

Government Department/ Agency	Responsibility	Relevant Policy instruments	Policy content alignment with TYIP(by supporting the key drivers of the knowledge economy or the EGC R&D Thrusts in the TYIP)
Department of Science and Technology	Developing the National System of Innovation by developing human resources, research and innovation	White Paper on Science and Technology (1996)	Introduces the National System of Innovation as a guiding framework for science, technology and innovation in South Africa
		National Research and Development Strategy	Focuses on human capital development for innovation and enablers to bridge the innovation chasm
		Ten year Innovation Plan	N/A
Department of Environment	Responsible for facilitating a multi-stakeholder national mitigation and adaptation response to climate change.	Climate Change Response Strategy (2011)	Technology research, development and innovation for low carbon technologies and energy efficient technologies HCD such as Climate Change Centres of Excellence and Research Chairs
Department of Energy	Ensures a secure and sustainable source of energy for socio-economic development	National Energy Act	Establishment of the South African National Energy Research Institute (SANERI) which provides for Energy RD&I, HCD for energy and commercialisation of energy RD&I
		White Paper on Energy Policy	R&D role for government, energy suppliers and private sector; identified need for National Energy Research Strategy and allocation of national research funding. Identifies need for international or bi-national research activities; proposes good database for energy policy process and integrated energy planning
		White Paper on Renewable Energy (2003)	To promote, enhance and develop renewable energy technologies, focus on local manufacture
		Nuclear Energy Policy and Strategy (2007)	Proposes nuclear RD&I and that Government maintain one national organisation for the coordination of nuclear energy RD&I. ie. NECSA
Department of Higher Education and Training	Responsible for developing human resources for the NSI	National Plan for Higher Education	To produce graduates with the skills and competencies to meet the human resource needs of the country; to sustain current research strengths and to promote the kind of research and other knowledge outputs required to meet National Development Needs
National Planning Commission	Responsible for developing a National Development Plan	National Development Plan-Vision 2030	To allocate research and development funding to development and commercialisation of low carbon technologies as a means to increase South Africa's competitiveness; To build a skills and knowledge base for the NSI from preschool to tertiary; to increase participation in higher education to more than 30%, increasing university science and mathematics entrants, increase number of doctoral graduates
Department of Trade and Industry (DTI) and the	Responsible for economic planning and industrial	New Growth Path (NGP)	Common energy themes across the NGP, IPAP 2 and 3 and the EDD medium term plan appear to dovetail somewhat with the DST's EGC and ERD&I focus areas. The
		Industrial Policy Action Plan 2	

Economic Development Department (EDD)	development	(IPAP 2) Industrial Policy Action Plan 3 (IPAP 3) EDD medium term plan	economic and industrial development plans highlight a number of energy-related sectors which are key areas of focus and intervention: • The "green" and energy-saving industries of focus include the production of solar power and wind energy. These areas of intervention relate to directly to plans by relevant departments including the IRP 2 and the Renewable Energy Independent Power Producer Programme • Encouraging growth in the biofuels industry to supplement existing fuel sources, focussing on financing and resolving regulatory hurdles • Ensuring the "localisation" of the proposed nuclear build programme by providing a platform for maximising local procurement to feed into the programme • Refocusing the current beneficiation strategy to move further downstream, towards fabrication and away from current smelting and refining sectors, which are considered comparatively energy and capital intensive The EGC mentions a further two areas of possible intervention not outlined in the economic development plans, being clean coal technologies and hydrogen and fuel cell technologies.

6.4 Effectiveness

Q: Is the strategy's logic model clearly defined? Is the logic model analytically sound?

The ERD&I strategy does not provide a detailed description of the RD&I model prevalent in the energy sector, or the roles and responsibilities of the different stakeholders in this area (see Section 6.3). As a result, a clear picture is not provided in the document of what activities are expected to be carried out directly by the DST or its agencies, what activities the DST can influence through collaborations/interactions with other departments, or what activities are wholly beyond the mandate of the DST. For an issue like energy, where RD&I responsibilities sit with a number of agencies and departments (see Section 6.3 above), this is a serious shortcoming in the strategy in terms of communication and institutional memory. It is noted that this issue is identified in the ERD&I strategy (DST, 2008:6), which states that "there is a critical need for integration, communication and coordination of national [energy] research efforts", but not further guidance is provided on how this need should be addressed.

This is not to say, however, that the DST does not have a clear understanding of what its role is, rather that it is not being communicated here. One of the roles of the DST was stated during the stakeholder workshop (although not reflected in the strategy) to broadly be that of supporting the development of technical capability and know how to drive towards an innovative knowledge based economy. It was also identified that DST plays different roles in different parts of the energy arena – for example driving local content certain areas, human capital development in other areas and technology development in others. It was also recognised that the response is somewhat demand driven, for example DoE pursues activities in Solar Water Heater and nuclear roll-out, DST then supports development of infrastructure to support local content for these activities.[9] This information, however, needs to be explicitly included in the strategy document to ensure that there is broad consensus and a shared vision relating to these issues. In addition to the fact that the objectives of the ERD&I strategy are not clearly defined (see Section 6.2), the factors that are stopping the energy RD&I systems from working effectively have not been sufficiently highlighted in the ERD&I strategy (see Section 6). As a result, it is difficult to determine whether the objectives of the ERD&I strategy, if met, will lead to the desired impacts of the strategy being realised.

The lack of a detailed overview of the mechanics of the energy RD&I and the identification of the factors that are stopping the energy RD&I mechanism from functioning optimally, combined with the uncertainty regarding both the objectives of the ERD&I strategy and the responsibility of meeting them, effectively means that a logic model for the strategy has not been clearly defined. A systemic review of the problem requiring a policy intervention, which also identifies the actions needed to address the problem, has not been carried out. Without such a review, it is not possible to determine the relationship between inputs, activities, outputs, outcomes and impacts that constitutes the logic model of a strategy. Without these linkages being clearly specified, the resultant strategy has a 'black box' nature that does allow its expected effectiveness to be assessed.

At a more practical level, while individual activities are specified for the energy R&D themes, only a superficial treatment of the factors that have retarded RD&I activities within these thematic areas is provided in the ERD&I strategy. For some themes, such as Commercialising of Energy R&D, actions are specified in the complete absence of an analytical justification. No analysis of the factors that complicate commercialising energy R&D

[9] Most of the interviewees, however, emphasised the fact that the DST's role is to think long-term and focus on issues beyond the planning horizons of other departments. How this long-term vision is to be reconciled with short-term needs and responses was not clear.

outputs in South African is presented, nor is the case made that there are factors/blockages that can be effectively addressed by policy interventions.[10] It is thus not immediately evident what the basis for the proposed actions in this area included in the ERD&I strategy is, or whether these actions are likely to lead to positive outcomes and impacts. The effectiveness of these individual actions in leading to positive outcomes is thus unclear.

To assess whether the logic model is sound, it is also important to look at the responsibilities of the implementing agencies listed in the strategy. Two of the implementing agencies specified in the ERD&I strategy (namely NECSA and SANEDI[11]) report to departments other than the DST. The strategy does not discuss the mechanism through which these agencies be induced to play a constructive role in implementing the ERD&I strategy. The agency that reports to the DST, namely the Technology Innovation Agency (TIA), is tasked with commercialising R&D outputs in the ERD&I strategy. This is an area that received very little attention in the ERD&I strategy as mentioned above. Of the three implementing agencies mentioned in the strategy, it is thus unclear from a practical perspective how the actions of two of them will be influenced, while it is not clear how influential or effective the actions of the third (which does report to the DST) will be in meeting the objectives of the ERD&I strategy (which themselves are not clearly defined as yet – see Section 6.2).

In summary, the lack of a detailed overview of the mechanics of the energy RD&I and the identification of the factors that are stopping the energy RD&I mechanism from functioning optimally, combined with the uncertainty regarding both the objectives of the ERD&I strategy and the responsibility of meeting them, effectively means that a logic model for the strategy has not been clearly defined – and hence could not be assessed for analytical soundness.

6.5 Efficiency

Q: Is the strategy consistent with international best-practice?

The two country strategies highlighted in Section 3.3 are quite different as a result of the context in which they were developed. Both strategies, however, are strong on institutional collaboration in energy research and recommend a criteria-based system to determine research foci. Both these features are lacking in the current design of the ERD&I strategy, and provide clear areas where the efficiency of the current strategy can be improved.

The lack of broad-based strategies in the area of energy RD&I internationally, however, raises questions as to the scope and ambition of the ERD&I strategy locally. The ideal strategy design, however, will depend on the local context. This again emphasises the importance of providing a clear picture of the local energy RD&I system in order to assess the appropriateness of the resulting strategy. As mentioned elsewhere, this clear picture of the energy RD&I system is lacking in the current version of the ERD&I strategy.

In terms of the IEA's good practice guidelines for Energy strategy, comparing the guidelines to the ERD&I strategy suggests a number of areas for potential improvement of the latter document:

[10] While the problems with commercialising R&D outputs in South Africa is acknowledged at a general level in other DST documents, no analysis of the situation in the energy sector is provided, nor is it suggested that such an analysis be undertaken.

[11] At the time the strategy was created SANEDI was still SANERI and reported to the DST.

1. The ERD&I strategy does not give clear guidance regarding energy RD&I at various stages of the innovation chain. As mentioned previously, TIA is mentioned only briefly. TIA has a mandate for energy innovation, however its role is not articulated. The mention given at the end of the strategy to commercialisation is very brief.
2. Recommendations for research foci in the ERD&I are general. The strategy does not make its objectives quantifiable for the short, medium and long term.
3. The ERD&I strategy does not explain the cross institutional context in which Energy research and related topics such as higher education exist. Neither does it provide recommendations on how links should be formed with these other institutions in order to streamline implementation.
4. The strategy does not provide clear guidance of how the private sector can be engaged to facilitate innovation

In summary, the existence of these shortcomings in the ERD&I imply that it is not consistent with the good practice recommendations of the IEA.

6.6 Monitoring and evaluation

6.6.1 Monitoring framework

Q: Does the strategy include a monitoring framework? Are the indicators included in the monitoring framework of good quality? Is the monitoring framework cost-effective and practically feasible?

The ERD&I strategy does not explicitly include a monitoring framework. Given that the logic model underlying the strategy is not well defined, it will be very difficult to develop a logical framework that can serve as the basis for an M&E framework at this stage. The lack of clear objectives further increases the difficulty of creating a logical framework or an M&E framework.

Apart from the lack of a well-defined logic model or clear objectives, two further factors complicate the creation of an M&E framework, namely a lack of baseline data and the fact that the ERD&I strategy does not clearly outline the 'next steps' required to move from a strategy to an implementation plan. The only potential baseline data on energy RD&I provided in the ERD&I strategy was obtained from Pouris (2007) and relates to basic research output and capacity (number of energy-related journal publications, number of energy researchers at tertiary institutions, distribution of publications by university etc) as discussed in Section 3.1. The information from Pouris (2007), however, is provided as background information only, and is not structured as baseline data to guide either policy formulation or future M&E systems. It is thus not clear whether the information provided in Pouris (2007) is suited for use as good quality indicators to monitor the inputs, activities, outputs, outcomes and impacts of the strategy.[12] The ERD&I strategy also refers to work by Sibanda (2007) on patenting. Although Sibanda (2007) does not explicitly address energy patents as a stand-alone category, the content of his report seems to indicate that this may be possible (either by focussing on the descriptions and/or categories of patents, or by considering the activities of the firms named in the patent applications). Given that this exercise has not yet been undertaken, the caveat mentioned in relation to the data from Pouris (2007) applies similarly to that of Sibanda (2007) or future attempts to generate baseline data along these lines.

[12] See Section 5.6.1 for a summary of the characteristics that National Treasury (2011) believes influence the quality of indicators.

Given the lack of 'next steps' specified in the ERD&I strategy, even basic monitoring of the process to implement the ERD&I strategy is not possible. While there are individual actions specified for the Energy R&D themes, it is unclear whether these actions are realistic in terms of being doable or under the influence of the implementers of the ERD&I strategy (see Section 6.4). Furthermore, since no ranking of the actions within themes (or of the themes themselves) is provided, it is not certain what proportion of the individual actions for what proportion of the themes need to be implemented for the ERD&I strategy to be judged a success. Given the sheer volume and diversity of individual actions (and the large number of different institutions that will be involved in implementing them), it seems unlikely that all of the actions will be implementable within a realistic time frame.

In summary, no monitoring framework is included in the strategy. With no clear logic model it is premature to create such a framework. The process of generating the detailed baseline information necessary to describe how the energy RD&I system in South Africa works, and thus to define the logic model, should also provide the basic information necessary to create an effective monitoring framework.

6.6.2 Evaluation plan

Q: Does the strategy include an evaluation plan? Is the level of detail provided in the evaluation plan sufficient?

The ERD&I strategy does not explicitly include an evaluation plan. Of the four factors that are typically included in an evaluation plan mentioned in Section 5.6.2, only the "types of evaluations required" will be able to be specified since the sequence is relatively standard. Given the lack of 'next actions' in the ERD&I strategy, however, it is debatable how useful this would be. It is not possible to specify a "research questions based on the logical model" given that the logical model has not been sufficiently defined. The "timing and frequency of evaluations" is unknown since no time dimension is coupled to the objectives of the ERD&I strategy (which themselves are not clearly defined). Even the "target audience of the evaluation" is unclear since the roles and responsibilities for achieving the objectives of the ERD&I strategy have not been defined.

The conclusion is that it is too early for development of an evaluation plan for this draft of the strategy.

6.7 Review of the Draft Implementation Framework (DIF)

During the inception phase of this project, it was identified that the DIF for the ERD&I strategy would be reviewed against the above assessment framework if appropriate. Based on a detailed desktop review of this document, as well as discussions with key informants, it is identified that the DIF as it stands does not represent a suitable implementation framework for the ERD&I strategy.

Apart from the fact that the ERD&I strategy in its current form is not detailed enough to enable the development of an effective implementation framework, the content of the DIF strongly suggests that it was developed in isolation of the ERD&I strategy. This is assertion was confirmed during interviews with DST personnel.

The DIF introduces a number of new concepts and addresses a number of topic areas which would more appropriately be located within the ERD&I strategy, does not show explicitly how it is aligned with the ERD&I strategy, and does not provide any clear guidelines for implementation. There is reference to the need for an M&E strategy, but no design for such a strategy is provided.

As such, there is not considered to be any merit in further analysis of this document. Once the ERD&I strategy has been reworked into a format which addresses the concerns presented above, a new implementation

framework should be developed from scratch, to produce a document which would support implementation of the Strategy. As mentioned above, however, this does not mean that the DIF has no value. It is quite possible that the new ERD&I strategy will draw heavily on the DIF.

7 SUMMARY

This study set out to assess the design of the ERD&I strategy and its associated Implementation Plan. After presenting an understanding of evaluations in the South African context and a literature review to contextualise the ERD&I strategy, the study established an assessment framework against which the documents were to be assessed. The study then conducted the assessment through a detailed review of the strategy and plan, and through interviews with key informants located within DST.

The literature review identified a strong role for DST in improving South Africa's performance with respect to supporting energy-related RD&I. This assertion was based on the analysis of a small amount of data that is available in the open literature that suggests poor performance in this regard. The review also identified limited alignment of the ERD&I strategy with the Energy Grand Challenge as outlined in the TYIP. Finally, the review of international experience found few similar types of strategies globally, with those of Denmark and Ireland being presented, along with the IEA good practice guidelines for energy R&D.

The review and evaluation of the ERD&I strategy against the assessment framework highlighted a number of limitations of the ERD&I strategy, and suggested that it is not clear enough to help guide implementation of DST energy RD&I related activities. Some of the limitations include the following.

Whilst clearly defined by key informants interviewed as part of the process, the role of the DST in the energy space is not defined in the ERD&I strategy. The reasons for this are twofold. Firstly, because the logic model is not clear, there is no guidance as to what the DST is trying to achieve at a practical level, or how it would go about achieving this. Secondly, because the roles and responsibilities in the energy RD&I space are not clearly outlined, it is not clear what mechanisms are open to the DST to try and affect change in this space.

Following from this, one of the challenges identified during the review and interviews is that components of many of the R&D thematic areas identified in the strategy fall under the ambit of different departments, but two of the implementing agencies specified in the ERD&I strategy (namely NECSA and SANEDI[13]) report to departments other than the DST. The agency that does report to the DST, namely the Technology Innovation Agency (TIA), is tasked with commercialising R&D outputs in the ERD&I strategy. This is an area that received very little attention in the ERD&I strategy. It is likely that significant collaboration between departments will be required in order to achieve the objectives of the strategy. Without laying out exactly how this cross-departmental collaboration is to be achieved (the mechanisms for which need to be jointly developed by the relevant parties during the stakeholder engagement process that should be at the heart of developing the strategy), it is unlikely that the ERD&I strategy will be successful in meeting its objectives.

A further observation is that the strategy does not clearly specify the objectives which it is trying to achieve – be they high level objectives as suggested by one of the informants, or to guide implementation of specific activities. There are energy sector goals, key growth and development drivers, and broad research themes identified, but

[13] At the time the strategy was created SANEDI was still SANERI and reported to the DST.

these are not presented in a way conducive to serving as the practical objectives of a strategy . Furthermore, a list of R&D focus areas is presented, but no details of what component of these the strategy is trying to address is presented. The objectives need to be the result of a systematic process to identify the blockages or barriers that prevent the energy RD&I system from functioning optimally and which forms the basis of the strategy's logic model. It is not clear that this is the case in the current draft of the ERD&I strategy. Thus, while the current draft clearly includes a lot of useful information and suggestions, it does not have the internal consistency and coherence that would come from a systematic approach starting from a detailed problem analysis.

The lack of a clearly specified logic model, and a clear overview of the energy RD&I system in South Africa that would underlie this, is particularly problematic. The logic model does not need to be over prescriptive at the strategy level, but it should provide a clear indication of how the strategy aims to meet its objectives. At the very least, it needs to describe specific blockages or issues that warrant interventions, and then the mechanisms to be used to facilitate these interventions (be they agencies, instruments, forums, sub-sector strategies etc).

The ERD&I strategy is prescriptive in terms of areas to focus research. Furthermore, it specifies the likely interventions to undertake. This leaves little room for responding to new opportunities or situations that change. The focus should rather be on specifying criteria to guide interventions, while leaving the areas in which to focus the interventions relatively open. Ideally a process will be specified of how to scan, assess and put in place the necessary mechanisms to implement interventions via an implementation plan. An implementation plan for the strategy may include activities like drafting individual strategies (which may lead to implementation plans) or more focussed action plans. This will allow the DST to take a long-term view and focus on the kind of long-term research that other departments are often not in a position to undertake given the immediate challenges they face.

With respect to the draft Implementation Framework (DIF), a comprehensive analysis was not undertaken for three reasons, the first of these is that the ERD&I strategy is not appropriately structured so as to develop an implementation plan, the second is that the DIF and ERD&I strategy are not well aligned and the third is that the existing DIF does not resemble an Implementation Plan, providing information that should rather sit in a strategy, and providing little guidance for actual implementation and the monitoring and evaluation thereof. As such, the DIF requires a substantial restructuring prior to there being value in its assessment.

Based on the outcomes of the study, the DST may well consider redeveloping the ERD&I strategy, and its associated Implementation Framework, from first principles. The following section provides some recommendations that should be taken into account in this regard.

8 RECOMMENDATIONS

8.1 Recommendations: ERD&I strategy

The strategy development process should start with a detailed analysis of the energy RD&I system. This should map out the roles and responsibilities of different stakeholders and also the interrelatedness of different components of the system. The analysis should include an intensive stakeholder engagement process to ensure that there is no ambiguity regarding the roles and responsibilities of stakeholders. Once this has been done, an analysis of the barriers or blockages that are preventing the system from functioning optimally need to be undertaken. This will identify the areas where the strategy can have a real impact in increasing the outputs of the

energy RD&I system that will lead to the desired energy sector impacts. Once the areas where interventions are called for has been identified, an analysis of the possible types of interventions (at a high level) and the stakeholders that are responsible for these interventions are required. Given the cross-cutting nature of energy RD&I, it is likely that extensive collaboration between departments, agencies and organisations will be required. The on-going stakeholder engagement process should then be used to ensure that the necessary mechanisms, structures and institutional arrangements are in place to support these collaborations.

As part of the analysis of the energy RD&I system and the identification of barriers to its optimal functioning, it is important that detailed baseline information is gathered that deals with all the components of the system. This will ensure that the identified blockages are real and will enable policymakers and implementers to ascertain whether the barriers are becoming less or more significant over time. This call for detailed baseline data is supported by Pouris (2007a) who mentions that national science and technology indicators dealing with energy was not included in the TYIP. Pouris (2007a) calls for the development of a set of "South African Energy Science and Technology Indicators" to monitor all aspects of the energy RD&I system. While the actual indicators to be monitored will depend on the exact nature of the local energy RD&I space, common indicators include research publications, patents, number of PHDs, expenditure on R&D etc (Pouris, 2007a).

While it is acknowledged that there is currently a lack of baseline information relating to energy RD&I activities in South Africa, and that it may be a time-consuming and costly exercise to put the processes and mechanism in place to generate more detailed baseline data, that is not an argument for proceeding without baseline data. Without baseline data it will be impossible to properly measure the success of the ERD&I strategy, and consequently to refine and improve the strategy in future. At the very least, the ERD&I strategy needs to include as complete a set of baseline data as is feasible initially, and include actions that will be taken to ensure that more detailed and timely baseline data is available in future.

Some of the themes in the ERD&I strategy have existing strategies (like Hydrogen and Fuel Cells). It is not clear how the ERD&I strategy aims to interact with these strategies. At the very least it should refer to existing strategies in order to avoid duplication of effort.

8.2 Recommendations: Implementation plan

Once the ERD&I strategy has been developed, an Implementation Framework can be developed through a process of interaction with stakeholders. The Implementation Framework needs to provide clear guidance on what needs to be done technically to achieve the requirements of the strategy. A decision needs to be reached as to whether a single Implementation Framework is used for all DST energy related activities, or whether there is an overarching framework with individual implementation frameworks for specific thematic areas.

An important component of the Implementation Plan is a detailed monitoring and evaluation framework which follows the guidelines of that described in Section 5.6 of this report.

9 REFERENCES

Arrow KJ (1962) *Economic Welfare and the Allocation of Resources for Invention,* The Rate and Direction of Inventive Activity, Princeton University Press, Princeton, US.

Chiavari, J. and Tam, C. (2011) *Good Practice Policy Framework for Energy Technology Research, Development, and Demonstration*. Information Paper. International Energy Agency Accelerating Energy Innovation Series. Available [online]: http://www.iea.org/papers/2011/good_practice_policy.pdf

Center for the Implementation of Public Policies Promoting Equity and Growth (CIPPEC) (2010) *Learners, Practitioners and Teachers Handbook on Monitoring, Evaluating and Managing Knowledge for Policy Influence*. Available [online]: http://www.thepresidency.gov.za/MediaLib/Downloads/Home/Publications/PolicyCoordinationandAdvisoryServicesPolicyUnitPCASpublicationsanddocuments/MonitoringandEvaluation/Usefuldocuments/MandE%20and%20KM%20Handbook.pdf

Department of Science and Technology (DST) (2011) *Draft Departmental Evaluation Framework for the Department of Science and Technology*. Draft: September 2011.

Department of Science and Technology (DST) (2008) *South African Energy Research, Development and Innovation Strategy*. Draft Strategy Jointly Prepared with the Department of Minerals and Energy. DRAFT v1.0 July 2008.

Department of Science and Technology (DST) (2002). *South Africa's National Research and Development Strategy*. Pretoria: Government Printer.

Development Assistance Committee (DAC) at the OECD (OECD-DAC) (2010) *Evaluating Development Co-operation: Summary of Key Norms and standards*. Second Edition. Paris: OECD. Available [online]: http://www.oecd.org/dataoecd/12/56/41612905.pdf

European Commission (EC) (2009) *Impact Assessment Guidelines*. SEC(2009) 92. Available [online]: http://ec.europa.eu/governance/impact/commission_guidelines/docs/iag_2009_en.pdf

European Union (2007) *Ex-Ante Evaluation of the ERDF Programme for Northern Ireland*. Available [online]: http://www.detini.gov.uk/ex-ante_evaluation_of_the_european_sustainable_competitiveness_programme_for_ni_2007-2013.pdf

Gans, J.S. and Stern S. (2000) *When Does Funding Research by Smaller Firms Bear Fruit? Evidence from the SBIR Program,* NBER Working Paper 7877, September 2000.

Kempener, R., Anadon, L.D. and Condor, J. (2010) *Governmental Energy Innovation Investments, Policies, and Institutions in the Major Emerging Economies: Brazil, Russia, India, Mexico, China, and South Africa*. Energy Technology Innovation Policy Discussion Paper Series, Discussion Paper #2010-16, Harvard Kennedy School

Kelm, K., Narayanan, V. & Pinches, G. (1995) The response of capital markets to the R&D process. *Technological Forecasting and Social Change,* 49, 75-88.

National Treasury (2007) *Framework for Managing Programme Performance Information*. Pretoria: Government

Printer. Available [online]: http://www.treasury.gov.za/publications/guidelines/FMPI.pdf

National Treasury (2011) *Performance Information Handbook*. Pretoria: Government Printer. Available [online]: http://www.treasury.gov.za/publications/other/performance/Performance%20Information%20Handbook%20-%20web.pdf

OECD (2010) *Green Growth Strategy Interim Report: Implementing Our Commitment for a Sustainable Future*. Meeting of the OECD Council at Ministerial Level, 27-28 May 2010. C/MIN(2010)5. Available [online]: http://www.oecd.org/dataoecd/42/46/45312720.pdf

Pegels, A. and Stamm, A. (2010) *Decarbonising South Africa? Prospects and Barriers to the Energy Transition*. Paper presented at Dynamics of Institutions and Markets in Europe (DIME) workshop "Globalization and Environmental Innovation in Newly Industrializing Countries", 5-7 May, Fraunhofer ISI, Karlsruhe. Available [online]: http://www.dime-eu.org/files/active/0/Pegels_DIME2010_Ettlingen.pdf

Pouris, A. (2007) *Energy and Fuels Research in South Africa: A Comparative Assessment and Mapping* .Contract report to the South African National Energy Research Institute (SANERI). Business Enterprises at the University of Pretoria.

Pouris, A. (2007a) R&D Capacity at Tertiary Education Institutions. *Energy Management News*, 13 (4):3-6.

Pouris, A. (2010)*The State of Energy Research in South Africa – 2009*. SANEDI Energy Efficiency Research Report Number 16. Available [online]: http://www.sanedi.org.za/wp-content/uploads/2012/02/ee/The%20State%20of%20Energy%20Research%20in%20South%20Africa%20-%202010%20-%20A%20Pour.doc

Sibanda, M. (2007) *The State of Patenting in South Africa*. Special Report. Innovation Fund.

The Presidency of the Republic of South Africa(The Presidency) (2011) *National Evaluation Policy Framework (NEPF)*. Pretoria: Government Printer.

The Presidency of the Republic of South Africa (The Presidency) 2010. *Guide to the Outcomes Approach*. Pretoria: Government Printer. Available [online]: http://www.thepresidency.gov.za/dpme/docs/guideline.pdf

World Bank (2004) *Ten Steps to a Results Based Monitoring and Evaluation System*. Washington: World Bank. Available [online]: http://www.oecd.org/dataoecd/23/27/35281194.pdf

APPENDIX A: PERSONS INTERVIEWED

The following persons or "key informants" were interviewed to inform this study:

- Dr Valanathan Munsami - DDG of Programme 2: (Research, Development and Innovation)
- Dr Thomas Auf der Heyde - DDG of Programme 4: (Human Capital and Knowledge Systems)
- Mr Somila Xosa – Director of the Renewable and Transport sub-programme
- Dr Cordellia Sita – Director of the Alternative Energy sub-programme
- Ms Anza Murovhi - Director of the Nuclear and Energy Efficiency sub-programme
- Ms Nosipho Ntuli
- Ms Mandy Mtyelwa