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# Drivers of Effective Renewable Energy Policies

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*Sustainability and green issues are becoming an integral part of business and management. Large gird connected renewable energy (RE) facilities form a subset of sustainability and the clean technology sector. From a business perspective, it is important to understand what policies are available and what factors (drivers) play a key role. This study identifies five main RE policy mechanisms (Feed-In Tariffs (FITs); Tradable Green Certificates; Renewable Portfolio Standards; Bidding/Tendering and Fiscal) of which the FIT has experienced the most success in establishing a RE sector. Using Fuzzy Cognitive Mapping (FCM), the study relates the policies to the drivers to identify which drivers are most effective within a RE sector. The development and analysis of the model is based on an iterative process, where the draft FCM was adapted to fit a representative model and then further validated by applying country specific examples. Results indicate that all simulations reached an equilibrium state in the FCM model. The four drivers, observed as the most influential drivers, as set out in the propositions are: big players (category: local conditions), non-RE sector (category: economics), cost competitiveness (category: financial) and risk (category: financial). These four drivers seem to play the most influential part of a RE sector when a FIT policy mechanism is deployed. It is proposed that these four drivers are best suited to model a FIT system. This study is one of the first to empirically examine how various drivers emerge and how they need to be managed when designing a RE policy mechanism. Managing the four key drivers – as identified in this study - is pivotal in establishing a sustainable RE sector.*

Keywords: *environmental impact assessment, renewable energy, policy drivers, feed-in-tariffs, independent power producers, developing economy, fuzzy cognitive mapping.*

## Introduction

Energy and going green is a topical item on the world's agenda (Makiela & Misztur, 2012). With traditional sources of electricity being generated from fossil fuels (non-renewable), resource depletion and increased levels of greenhouse gases emissions (GHG) are major concerns (Martinot & Sawin, 2010; Pernick & Wilder, 2008). This leads to climate change issues (increasing temperature levels on the planet) and a risk to the security of future energy requirements. Various world initiatives have been established to tackle these issues. The most popular one has been the Kyoto Protocol, which is a commitment by 141 countries to reduce GHG emissions to 5 % of the 1990 levels by 2012 (UN 1998). Similarly, the European Council has implemented an integrated climate change and energy policy for the European Union (EU), with specific targets (20 % by 2020 compared to 1990) aimed at reducing greenhouse gas emissions, EU's energy consumption, and to achieve a binding target of 20 % share of renewable energies in the overall EU energy consumption by 2020 (Eurostat, 2009).

Recognising the importance of energy and environmental policies, where energy efficiency and renewable energy are considered as the main pillars to cope with climate change (Urban & Govender, 2012; Uzsilaityte & Martinaitis, 2010), the focus of this paper is on marketable energy, specifically grid-connected electricity in the renewable energy segment. Electricity can be generated from many sources, such as liquids, nuclear, renewables, natural gas and coal (EIA, 2010a). Renewable energy (RE) is defined as "energy resources that are naturally replenishing but flow-limited. These energy sources are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. RE resources include biomass, hydro, geothermal, solar, wind, ocean, thermal, wave action, and tidal action" (EIA, 2010b, pp. 6). For the purpose of this article, only renewable sources that are used to produce electricity will be investigated.

Governments around the world have recognised that in order to establish a RE sector, which is desirable from a societal point of view, policy support is required (Grace *et al.*, 2007). Various financing mechanisms exist for RE venture creation, like carbon credits, government grants and incentives (tax breaks) and climate change funds, however, these all require high level support. For this reason various government support policies and regulations need to be established to develop the RE sector. Traditionally there have been three high level instruments that have been used in countries which have an established RE sector and these include feed-in-tariffs (FIT), bidding systems and tradable green certificates (TGC). These can be broadly categorised into price driven (FIT, bidding/tendering systems) and quantity driven (quotas on TGC) (Faber *et al.*, 2007). All of these instruments have varying degrees of application and in certain cases a hybrid system can be used (Kelly, 2007).

Traditionally, the renewable energy feed in tariff (REFIT) has demonstrated the fastest growth rate in this sector, which is due to the long term stability of the agreed prices (price certainty) (Martinot & Sawin, 2010).

The purpose of this study is to provide empirical evidence on the efficacy of RE policies and to compare developing and developed economies in this regard. Moreover the paper will identify the key factors (drivers) that influence growth in the RE sector, and will aim to illustrate plausible future scenarios for the South African RE sector. South Africa (SA) is classified as a developing country and hence is excused from the commitments of the Kyoto Protocol. By virtue of it being a developing country, it is classified as a non-annexed country and hence has no obligations to reduce its GHG emissions (Christie *et al.*, 2009). However, SA has adopted various strategies that attempt to align with international targets, one being the establishment of a Renewable Energy Policy White Paper, in 2003 (Eskom 2009; NCP 2011; SARi 2011).

Fuzzy Cognitive Mapping (FCM) has been selected as a data analytic technique as it allows for causal links to be analysed between various polices and drivers (Lashgari *et al.*, 2012). FCM is a qualitative method alternative to dynamic system analysis, where the main advantage is that the whole system can be observed quickly and holistically (Aguilar, 2005; Razavi *et al.*, 2012). This technique has the advantage of rendering subjective and implicit decision making more objectively and accommodates both quantitative and qualitative data (Turskis *et al.*, 2012).

This study is important in generating understanding of how policy affects the business of RE, where the major premise of this paper is that if managed properly, the growth of the RE sector will see GHG emission reductions, increased employment and more security established around electricity supply (Volochovic *et al.*, 2012). The study has both academic and practical implications where researchers, investors and policy makers can make more informed decisions about the RE sector by understanding the efficacy of high-level policies and how this sector can evolve and maintain a solid growth trajectory and overall sustainability. The long term benefactors of this study will be investors, society (present and future), and multiple stakeholders in the RE sector.

The rest of the article is structured as follows. First relevant theoretical foundations are accessed to provide a basis for the propositions. Next the research approach is delineated in terms of the sample and measuring instruments. This is followed by highlighting a testable model best suited for this study. Results and implications are then discussed in an emerging and developing market context, and the study's limitations are addressed with future research suggested.

## Renewable Energy; Policies and Drivers

RE forms a subset of the clean technology sector, which is made up of energy, transportation, water and materials (Pernick & Wilder, 2008). The growth of the RE sector is based on a range of reasons which include security of energy supply, job creation, and the reduction of GHGs (Daniels *et al.*, 2003). Various policies to support the RE sector have been developed over the past three decades (Martinot & Sawin, 2010; SARi, 2011). In the early 1980's only a handful of countries had a policy in place where now there are over a 100 countries with some sort of policy to spur growth across all RE generation methods (heat, electricity and fuel) (Busch *et al.*, 2007). These policies have been enacted at various levels, namely national, regional, provincial and even at city level. The number of such constituencies with a deployed RE policy have almost doubled from 2005 to 2010, where the deployment of RE policy(s) has influenced investment, industry and market developments in relation to the RE sector (Faber *et al.*, 2007; Finon & Perez 2007; Martinot & Sawin, 2010).

In order to promote RE generation, targets had to be set, which are generally set at national level, and define what portion of the energy (primary or final supply) needs to come from renewable sources. Most countries have set targets for the 2010–2012 years, with longer time frames set to 2030. Once targets are set and agreed, a policy instrument or combination thereof is deployed to promote RE electricity generation (Daniels *et al.*, 2003; Martinot & Sawin, 2010).

Leading developed countries have been engaged in high level policy formulation to achieve agreed targets for reducing GHG emissions. RE is seen as a key component in achieving these targets and reducing the reliance on traditional methods of electricity generation (Faber *et al.*, 2007). As with any new industry, the barriers to entry are numerous and therefore the need for high level support to gain critical mass and become cost-competitive is critical. For this reason various support mechanisms have been developed (Busch *et al.*, 2007). At present, 83 countries have developed/adopted some sort of policy to spur their RE power generation (electricity) (Daniels *et al.*, 2003). Of the 83 countries, 41 are developed countries and the balance is from the developing world. These countries have adopted a single or a combination of the following ten main policy instruments that are delineated, in terms of their drivers, in Table 1.

Table 1

**Available policies and their categorisation**

| No. | Policy | Price / Quota Driven |
|---|---|---|
| 1 | Feed-In Tariffs (FITs) | Price |
| 2 | Renewable energy portfolio standards (RPS) | Quota |
| 3 | Capital subsidies or grants | Price (Fiscal) |
| 4 | Investment tax credits | Price (Fiscal) |
| 5 | Sales tax or VAT exemptions | Price (Fiscal) |
| 6 | Tradable Green Certificates (TGC) | Quota |
| 7 | Direct energy production payments or tax credits | Price (Fiscal) |
| 8 | Net metering | Price |
| 9 | Direct public investments or financing | Price |
| 10 | Public competitive bidding | Quota |

*Source: Renewables, 2010; Global Status Report (Martinot & Sawin, 2010)*

Despite the proliferation of these various policies and support mechanisms varying degrees of success have been noted where not all are equally effective or efficient (Martinot & Sawin, 2010). Moreover, it has been reported that a combination of policies has produced better results particularly as a need has arisen to evolve policies as a country's RE sector matures (Pegels, 2010). The incentives and/or policies that are offered to ignite the RE sector of a country are not deemed to always be sustainable in the long run. These mechanisms tend to place financial strain on the economy and end user, and they need to evolve as the sector matures (Finon *et al.,* 2001). Experience from the EU shows that RE policy has evolved as the sector has matured and/or government targets have been met. For example, in the UK, up until 2002, a bidding/tender instrument was employed due to government targets not being met (Faber *et al.,* 2007; Kelly, 2007). This indicates that once a country has chosen a RE policy, it can change and must be adjusted to reflect developments in this sector.

In addition, there are various ways of designing a selected policy instrument. For example FIT designs can vary from country to country, tailored to meet regional conditions. The level of support through the tariffs may differ across regions and indeed the choice of technology can differ depending on the most abundantly available RE resource. In the EU, 20 of the 27 member states have deployed a FIT policy (Busch *et al.,* 2007). Of these, Spain, Denmark, Estonia, Czech Republic, The Netherlands and Slovenia pay a premium tariff for the electricity produced. Denmark, however, only applies the premium tariff, to onshore wind (Busch *et al.,* 2007). This serves to illustrate how a commonly deployed high level policy may vary in its regional applicability.

As gleaned from this brief literature review, it is apparent that a number of policy instruments exist to help a RE sector grow. To consolidate these various policy instruments from the literature, the most popular and successful policies together with how these instruments inform policy nodes (aligned to this study's FCM model) are delineated in Table 2.

Table 2

**Policy Nodes for FCM***

| Policy | Node/ instru-ment | Reason/Notes |
|---|---|---|
| 1 | FITs | This has been the most successful in creating growth in a RE sector. |
| 2 | TGC | Green Pricing will form part of this instrument as they follow similar principals. |
| 3 | RPS | This mechanism has been largely deployed in The USA and UK. |
| 4 | Bidding /Tender | Uses market forces to drive down the cost to society. |
| 5 | Fiscal | Fiscal and financial incentives are viewed as secondary mechanisms for supporting the RE sector (Daniels *et al.*, 2003). For this reason all the aforementioned fiscal incentives will be grouped together. This will include: capital subsidies, Investment tax credits; sales tax or VAT exemptions; direct energy production payments or tax credits; direct public investments or financing. |

**Note that net metering has been excluded. This research is concerned with large grid-connected schemes and net metering does not meet this delimitation.*

Recognising these various policies in terms of policy nodes, specific policy designs vary and evolve, from region to region. Evolution depends on the level of sector maturity, technological cost-competitiveness and the attainment of set capacities (Faber *et al.,* 2007).

Various technologies exist for generating electricity from RE sources. Each technology is at a different level of maturity and cost-competitiveness. For instance, hydro power is the most mature and hence most comparable in relation to the cost of fossil fuel generation methods, followed by wind and solar. Wind power generation differs from conventional thermal generation due to the stochastic nature of wind. Thus wind power forecasting plays a key role in dealing with the challenges of balancing supply and demand in any electricity system, given the uncertainty associated with the wind farm power output (Foley *et al.*, 2012).

The worldwide demand for RE is increasing rapidly because of climate issues. Wind energy appears as a clean and good solution to cope with a great part of this energy demand. In Denmark for example, 20 % of the electricity is produced from wind, and plans are towards reaching 50%. As space is becoming scarce for the installation of onshore wind turbines, offshore wind energy, when possible, seems as a good alternative (Breton & Moe, 2009). A key component of RE policy is how it encourages the development and learning curve in innovation, aimed at driving these expensive technologies down to a cost-competitive plain. For the purposes of this research report, only the technologies of wind and solar are considered as these areas have seen the most deployment and technological advances (Busch *et al.,* 2007). The need to improve technology to drive costs down not only drives innovation investment, but also encourages the establishment of manufacturing sector for these technologies. Hence technology improvements have far reaching consequences that can spur economic development and secondary industries. Secondary industries relating to technology and manufacturing can include local skills and engineering training, maintenance needs and material inputs to make the value chain.

Based on the evolving research and literature it is proposed that different policies affect the growth of the RE sector and where specific factors need to be considered when selecting a policy instrument.

***Proposition 1:*** The renewable energy sector has demonstrated the largest growth in terms of sustainable energy as a result of effective policy interventions. Under this proposition, various scenarios are interrogated in terms of policy type. In this instance all driver nodes are left in the inactive start-up position, and the focus is on policy choice where the following scenarios are investigated:

Scenario 1: To determine the influence on the renewable energy sector if there is an absence of high-level policy for a country or region.

Scenario 2: To determine the influence on the renewable energy sector if only a FIT instrument is deployed.

Scenario 3: To determine the influence on the renewable energy sector is if only a TGC system is deployed.

Scenario 4: To determine the influence on the renewable energy sector if only a bidding/tendering instrument is deployed.

Scenario 5: To determine the influence on the renewable energy sector if only a RPS instrument is deployed.

Scenario 6: To determine the influence on the renewable energy sector if only fiscal instruments are deployed.

Scenario 7: To determine the influence on the renewable energy sector if a combination of policies are deployed. Combinations are configured as follows: FIT with TGC, FIT with TGC and Bidding Tendering, FIT with TGC, Bidding/Tendering and RPS.

***Proposition 2:*** Policy choice relies on various country specific conditions and drivers to ensure their effectiveness. The following scenarios have been formulated to test this proposition:

Scenario 1: To determine the influence on the renewable energy sector if only the local energy constraints drivers are activated with a FIT policy.

Scenario 2: To determine the influence on the renewable energy sector if only the RE industry drivers are activated with a FIT policy.

Scenario 3: To determine the influence on the renewable energy sector if only the local condition drivers are activated with a FIT policy.

Scenario 4: To determine the influence on the renewable energy sector if only the economic drivers are activated with a FIT policy.

Scenario 5: To determine the influence on the renewable energy sector if only the financial drivers are activated with a FIT policy.

Scenario 6: To determine the influence on the renewable energy sector if only the technical drivers are activated with a FIT policy.

The effectiveness and influence of the various drivers, as identified in the literature and tested through these propositions are incorporated into a model to analyse the effect on an RE sector when deployed within a FIT policy mechanism. The blueprint of this model is discussed in the following section.

## Research Methodology

Since the objective of this study is to determine the efficacy of various policies and drivers on the RE sector, Fuzzy Cognitive Mapping (FCM) was selected as a data analytic technique as it allows for causal links to be analysed between the polices and drivers. For this study, FCM was run iteratively to determine what states are produced by activating the various policy nodes. FCM is not without precedent in scholarly research and has been employed to model electrical circuits, organisational behaviour, job satisfaction, virtual worlds of dolphins, sharks and fish, as well as economics and demographics of the world (Ozesmi & Ozesmi, 2004). Analysis of FCM can be done either though geometric or numerical avenues. Simpler FCMs with fever nodes can be analysed by following paths as depicted in a diagram, however as the number of nodes increase, a mathematical model using vectors and matrices to represent nodes and edges respectively is often used (Aguilar, 2005).

For the purposes of this paper a FCM was developed which relies on mathematical principles to deal with the qualitative data (Kosko, 1993). Initially a model was designed based on past research and empirical evidence as determined by the literature review, where this model was then employed to test the series of scenarios as proposed in terms of the RE sector. Country specific examples, were used to validate the model, selected on the basis of the extensive reference to the notable growth in the RE sectors in these respective countries. The development and analysis of the model followed an iterative process, where the draft FCM was adapted to fit a representative model and then further validated by applying country specific examples. Once the model had been validated, the propositions were analysed and predictions could be made in terms of which high level policy drivers lead to a sustainable RE sector in a specific country.

## Model Development

The model was predicted to produce one of the following three states: equilibrium state, limit cycle state or a chaotic state (Calais, 2008; Kosko, 1993). As determined by the literature review, ten different policy mechanisms were identified, and these were condensed into five main policies, which form the policy nodes in the FCM. Nodes can be divided into two distinct categories: Policy nodes and non-policy nodes. Policy nodes are nodes with no incoming links and represent the nodes that are controlled by the researcher. Non-policy nodes are the opposite of the policy nodes and have established links.

As with the policy nodes, causal links can be extracted for each of the thirty six identified drivers. The three possible states that can exist are:

1. A positive causal link indicated by a **Green "+",**
2. A negative causal link indicated by a **Red "-",** or
3. No causal link indicated by a **"0"**. This has been omitted for simplicity.

Adopting this approach in this study allowed for each non-policy node (driver) to be tested against all other drivers, excluding the originating driver. Each causal link that was established was in the context of the affect it had on a RE sector and its deployment, i.e. what affect does driver X have on driver Y in terms of deploying a RE sector, see Table 3 for an example of the causal links between non-policy nodes on local energy constraints.

Table 3

**Example of revised Casual links between non-policy nodes**

A. Local Energy Constraints

By increasing the energy mix by deploying more RE generation capacity, what affect does it have on the 23 other drivers?

| 1. Diversification | | | |
|---|---|---|---|
| **Driver No:** | **Driver** | **Effect** | **Comment** |
| 2 | RE Target Capacity | + | A move away from fossil fuels. |
| 3 | Energy Cost | + | Greater use of expensive RE is initially at a higher cost. |
| 4 | FDI / Investment | + | Attracts investment in new projects. |
| 5 | Common Good Elements | + | Reduced GHG emissions leads to less negative impact on the environment, health and weather. |
| 6 | Energy Security | + | Less reliance on imported energy. |
| 7 | Market Liberalisation | + | RE induced Independent Power Producers and can dilute previously monopolistic markets. |

| Driver No: | Driver | Effect | Comment |
|---|---|---|---|
| 8 | Resistance | 0 | |
| 9 | Big Players | - | New generation methods reduce market share of existing power producers. |
| 10 | Administration / Bureaucracy | + | Increased power generation pool requires greater administration and hence bureaucracy. |
| 11 | Climate Politics | + | Increased lobbying for and against RE generation will be experienced. |
| 12 | Climate Change Initiatives | + | Reducing reliance on fossil fuels is seen in a positive light as it reduces the tragedy of the commons phenomenon. |
| 13 | Employment | + | New generation methods provide employment opportunities throughout the project life cycle, from development to decommissioning. |
| 14 | Socio-Economic Development | + | Greater dependability on energy resource and increased employment opportunities corresponds with increases in socio-economic development. |
| 15 | Skills Enhancement | + | Through a new industry, a new skill set is required and this will drive skills training and development. |
| 16 | Industry Development | + | A new industry requires the value chain to be established, depending on the local capacity. Generally, opportunities exist to grow primary industry involved with manufacturing and deployment of RE technology. However, support services are also required and hence also benefit. |
| 17 | Non-RE Sector | - | Increasing diversification can lead to traditional generators losing market share. |
| 18 | Cost of Capital | 0 | |
| 19 | Cost Competitiveness | - / + | Initially, RE technology is not always cost competitive with traditional generation methods, and consequently a positive or negative effect may result. |
| 20 | Reliable Profits | 0 | |
| 21 | Risk | - | A new industry / sector is at times uncertainty and therefore has greater risk. |
| 22 | Technology Innovation | + | New generation methods need to mature and there is scope to improve and refine them. Hence new technological developments are spurred by diversification. |
| 23 | Existing Infrastructure | + | Connecting new RE generation facilities to the grid will require existing and new infrastructure to be built/adapted. |
| 24 | Deployment Time | 0 | |

Based on this procedure, which was conducted on all identified drivers, the FCM model was subsequently revised to reflect the simplification of the model from 36 drivers to 24 drivers.

## Results

### Model Validation

Two methods were employed to validate the FCM model. The first was to test scenarios from countries with established RE sectors and to see if the model could predict how the specific RE sector did react in reality to these drivers. The second was to approach experts in this field and present the model to them for expert review and comment. Each of these methods is briefly delineated.

Method country specific examples: Countries with relatively well established RE sectors and where published literature was available were selected to facilitate this type of validation. The analysis also included how the particular RE sector evolved in that country which serves as a reference point allowing to determine if the model does indeed predict how the evolving RE sector leads to growth and development. Two countries were examined for specific time-periods at various stages of their RE sector development, representing various policy instruments, and ranked accordingly.

Expert input: In order to reduce the risk of researcher bias, and in addition to the country specific validation analysis, the FCM model was presented to external experts for further validation. Experts from a range of backgrounds were approached for further validation. These responses included both foreign and local industry experts with experience (5–20 years) in the RE sector relating to financing and lobbying.

### FCM Model and Testing

Once the FCM model was validated through both the country specific case studies and expert input, and as no inherent flaws were identified during the validation process, no major changes were made to the model. Consequently the propositions as set-out earlier were modelled and analysed accordingly:

***Proposition 1***: The renewable energy sector has demonstrated the largest growth in terms of sustainable energy as a result of effective policy interventions.

The various scenarios predicted for the model were calculated (not shown due to space limitations) and the results were interpreted as follows.

The simulation of proposition 1 reached an equilibrium state on the FCM model and shows an interesting result. The results suggest that regardless of a ‘no policy choice’ or deployment of a single policy type to ignite a RE sector, (in light of no other drivers), four drivers are present in the equilibrium state. These drivers include: big players, non-RE sector, cost competitiveness and risk. All four drivers were inactive in the start-up position, yet are activated under all of the six scenarios. This can be further interrupted by recognising that of all the existing generators, big players are the first to react to any intention to deploy an RE sector. In addition, risk levels increase and cost-competition is the driving factors as the industry takes shape.

***Proposition 2***: Policy choice relies on various country specific conditions and drivers to ensure their effectiveness.

To test this proposition the effectiveness and influence of the various drivers identified in the literature were simulated according to the FCM model.

Based on the various scenarios five categories were activated in isolation to identify which set is most effective in driving a RE sector. As not all scenarios could be modelled, the drivers were used under the high level policy deployment of a FIT system. For instance, the set of local energy constraints were all activated with the FIT system and the results interrupted accordingly.

Interpretation of Scenarios 1 to 6: All the above simulations reached equilibrium in the FCM model. It is noteworthy that for the first time, the FCM model takes zero cycles to reach the equilibrium state. The four drivers, observed as the most influential drivers in proposition 1since they are ever present in the equilibrium state, were: big players (category: local conditions), non-RE sector (category: economics), cost competitiveness (category: financial) and risk (category: financial). These four drivers seem to play the most influential part of a RE sector when a FIT policy mechanism is deployed. It is proposed that these four drivers are best suited to model a FIT system.

These findings are generally in line with the literature review, where the driver - big players as represented by large firms have the largest balance sheets to enter into the RE generation field and can act as barriers to entry for IPPs. Hence their presence in the start-up and equilibrium state is warranted. The non-RE sector driver is forced to react as any significant capacity awarded to IPPs will reduce their market share and hence this driver's presence is in line with FIT policy literature. It is also noted that the price certainty offered by FITs are usually at a significant higher rate than traditional generation sources, and indicates that the issue of cost is ever present. While tariffs do decline in various procurement rounds, the previous tariffs need to be absorbed by the consumer can lead to resistance. So reducing cost, to maintain profit margins for producers and keep electricity affordable for the final users is high on the policy agenda. Subsequently, this leads to technology development as a means to reduce costs with the aim of achieving cost parity. Therefore in conclusion the ubiquitous driver - cost competitiveness is deemed to be a key factor in FIT policy deployment.

Finally, the risk driver is also ubiquitous, as suggested within the FIT literature, where various risks are associated with FITs, most notable being the potential for authorities to remove or digress tariffs faster than agreed in PPAs. PPAs on average run for 20 years and if removed prematurely can lead to a halt in new capacity deployment and IPPs having to absorb the losses. For instance, Spain as recently as 2008 experienced such a manoeuvre, which had originated from the economic recession (Eurostat 2009). So the presence of risk under the FIT policy seems to be an acceptable driver.

To further elucidate and provide a practical example of the role of the four drivers in the RE sector when a FIT policy mechanism is deployed, the FCM model was applied to investigate if South Africa's choice of a policy support mechanism will lead to a sustainable RE sector. The initial choice to deploy a FIT was compared with the current choice of a hybrid system of a capped FIT with a competitive bidding system. South Africa (SA) has a non-liberalised electricity market, with over 90 % of the electricity being generated through coal resources where RE support policies are extremely new, with no track record (DoE, 2011). The SA authorities had initially used the fiscal measure of the REFSO, which was superseded by a FIT policy and recently been replaced with a hybrid support mechanism of a capped FIT and competitive bidding system, locally termed, "REBID". Developments lately have also seen the formulation of funds and initiatives to support the new RE sector through blended financial tools, multilateral agreements and high level government strategy to protect and mature the local RE sector (NERSA, 2009; SARi, 2011). Four systems within the context of the local drivers were analysed:

1) REFSO System – model using just a fiscal policy driver, within the context of local drivers;

2) REFIT System -model using the FIT system policy driver, within the context of the local drivers

3) REBID System – Model using the capped FIT in conjunction with the competitive bidding system, within the context of the local drivers

4) REBID (as above), but coupled with the funding mechanisms of SARi and thus a fiscal policy mechanism, within the context of the local drivers.

Table 4

**SA REBID Start-Up Position**

| | | **Situation** | **Start-Up** |
|---|---|---|---|
| REFIT | | Capped FIT. | 1 |
| TGCs | | N/A | 0 |
| Bidding/Tender | | Competitive bidding | 1 |
| RPS | | N/A | 0 |
| Fiscal | | N/A | 0 |
| 1 | Diversification | Seen as a move to diversify the SA energy mix. | 1 |
| 2 | RE Target Capacity | Clear targets, medium and long term set through the IRP. | 1 |
| 3 | Energy Cost | Energy cost seen as a major driver and hence the move away from a standalone FIT system. | 1 |
| 4 | FDI / Investment | The RFP outlined conditions for foreign investment. | 1 |
| 5 | Common Good Elements | Part of the COP17 agenda and now a major driver locally. | 1 |
| 6 | Energy Security | Becoming a major driver and part of the future energy mix for SA. | 1 |
| 7 | Market Liberalisation | The DoE RFP geared towards IPPs and hence market liberalization. | 1 |
| 8 | Resistance | Resistance from developers for changing the FIT to REBID. | 1 |
| 9 | Big Players | Continue to be a driver, but grid access and PPA conditions seen as way of managing these players. | 1 |

| | | Situation | Start-Up |
|---|---|---|---|
| 10 | Administration/ Bureaucracy | Clear guidelines set out in the RFP, but too early to gauge level. However, RFP set out to make the process as clear and transparent as possible in the hope of streamlining. Therefore not a driver. | 0 |
| 11 | Climate Politics | Not a major driver. | 0 |
| 12 | Climate Change Initiatives | SA does not need to ratify the Kyoto Protocol, but has aligned strategies to international goals, through the SA Renewable Energy Policy in 2004. | 1 |
| 13 | Employment | RFP has set clear targets and criteria for job creation that aligns with other national strategies and plans (NPC, Green Economy Accord etc.). | 1 |
| 14 | Socio-Economic Development | Clear targets for Socio-Economic Development and Enterprise development in the RFP. | 1 |
| 15 | Skills Enhancement | Again a driver and follows on from the above two. The DoE wants to develop local skills so SA does not become reliant on imported skills and thus creates local value. | 1 |
| 16 | Industry Development | The DoE RFP geared towards local content and manufacturing facilities being established. | 1 |
| 17 | Non-RE Sector | Not a major driver. | 0 |
| 18 | Cost of Capital | Seen as a driver. The thoroughness and transparency of the RFP seen as a way of reducing risk and hence the potential higher costs of capital. | 1 |
| 19 | Cost Competitiveness | Energy cost seen as a major driver and hence the move to the REBID system. | 1 |
| 20 | Reliable Profits | FIT profits seen to be too high for IPPs and hence another reason for going to the REBID system. | 1 |
| 21 | Risk | Major driver. RFP and clear guidelines seen as a way of driving risk out of the process. Yet, risk remains high. | 1 |
| 22 | Technology Innovation | RFP still calls for reduction in costs and technology remains a major area to focus on. | 1 |
| 23 | Existing Infrastructure | Seen as a major driver and hence national grid access guaranteed. | 1 |
| 24 | Deployment Time | Deployment times specified in RFP and seen as a major driver. | 1 |

For each of the above systems, the 24 country specific drivers were analysed within each different system, to show the start-up position for a specific policy and country. Table 5 shows the existing drivers during the deployment of the REBID policy. The FCM model for these drivers and policy was affected and the results were interrupted accordingly.

Interpreting Table 4 shows that this FCM model also reaches a state of equilibrium. The first observation is that the REBID drivers are almost identical to the REFIT drivers. But on closer inspection it can be noted that the equilibrium state of the FIT has activated drivers in the REBID scenario and most of these drivers remain active in the REBID equilibrium state. For example the following drivers remain active: common good elements, resistance, and deployment time. It is feasible that these three drivers remain common and would be so for any policy system. Environmental sustainability and quick deployment are essential in any RE market. Similarly with resistance, any change to an accepted environment of operation will be met with resistance from various parties. So the presence of resistance seems justifiable. Of interest in this FCM model is the ever present driver of energy cost. The evolution of the FIT to REBID was based on the fact that the FITs would become too costly to the consumer and were not aligned to national policies of societal equality and development. Since the energy cost driver is still active in the equilibrium state, this suggests that REBID may not be able to reduce the final energy cost and will remain an issue as the RE industry in SA evolves. On the other hand the cost competiveness driver is no longer active in the final equilibrium state. This is interesting since under the REBID system, RE should become more competitive with fossil fuel based electricity. This is a fundamental goal of any RE sector and policy environment, especially under REBID. One final observation from the above FCM is the cost of capital driver. It is present in both the start-up and equilibrium states, suggesting that financing these RE facilities will remain an issue. Indeed with a developing economy like SA and the associated risks, it is anticipated that the cost of financing these projects will be high to cater for local risks.

To conclude, the REBID system bares much resemblance to the REFIT system. No major step changes have been introduced through this hybrid system. The only significant differences seem to be in the cost and finance drivers sections, which are of interest as REBID has replaced REFIT on costing grounds.

## Conclusions

1. This study builds in the direction of research where understanding of how policy affects the business of RE has been recognised as important for both developed and developing economies. The major premise of this paper was that various drivers influence different policies in the RE sector, where the FIT system is the most successful in growing this sector. To this end a model was developed to test the two propositions addressing the research purpose under various scenarios.

2. The empirical evidence emanating from this study indicates that when a RE support policy is selected, the twenty four drivers as delineated in this study need to be considered concomitantly. Choosing only a policy type without considering which drivers are needed, has the same effect as not choosing a policy type at all. In all modelled

cases under proposition 1, the same four drivers were activated in the final output of the model - these were labelled as big players, non-RE sector, cost-competitiveness and risk.

3. The results flowing from proposition 2, where it was estimated that a policy choice relies on the specific local drivers, the FIT was cited as the most successful policy mechanism, where all model scenarios were run by activating them under this policy system. Various categories of drivers were identified which included, local energy constraints, encouraging RE, local conditions, economics, finance and technology. While variations in drivers did exist in the model a trend emerged, where of the six different modelling scenarios, four drivers were always present. These drivers were the big players (big industry, mining, manufacturing etc.), the non-RE sector (traditional electricity generators), cost-competitiveness and risk.

4. In line with literature the risk and cost-competitiveness drivers were categorised into a financial set of drivers, while big players and the non-RE sector were categorised into the local conditions and economics set of drivers respectively. These categorisations proved to be useful as the financial set of drivers remain at the core of an effective RE sector. Long-term financial attributes of a RE policy revolve around FIT levels and digression levels, economic spin-offs, country risk, TGC pricing, market forces and how they are instrumental in shaping RE prices. Additionally, as the RE sector competes with the traditional energy generation sector, cost comparison, both direct and indirect inform the basis of many climate and clean energy research work. Energy is needed to power industry, especially in industry and manufacturing based economies and hence energy cost is a major determinant of these financial drivers.

5. Furthermore, the risk associated with policy mechanisms failing or not being designed and supported properly point to the issue of cost-competitiveness, which resonates with this study's findings in terms of its importance as a key factor in RE policy (NERSA 2009).

6. The other influential drivers identified in shaping RE policy were big players and the non-RE sector. It is recommended that policy makers ring fence these active drivers in an economy so as to protect IPPs. These big players have the strongest balance sheets and established markets to form large barriers to IPPs. Policy needs to be formulated to include these players (e.g. mandate them to connect IPPs to grid, help legislate the purchase of green electricity, and exclude them from participating in the RE generation procurement process).

7. This study is not without limitations. For instance it does not analyse the myriad of design options for each policy type. Secondly, as FCMs cannot cater for policy nodes accepting incoming causal links, the model does not facilitate policy evolution scenarios. Moreover this study does not discuss the regulatory and legislative aspects of the various policies, which would lead to a more enriched discussion. Finally, the objective nature of some of the casual links in the FCM model may have affected the models validity. In future research, weighted links may be needed to smooth out absolute inclusion or exclusion of certain drivers.

8. Future research could also investigate timeframes in deploying RE capacity in developing economies to measure the rates of growth against set targets and objectives. Furthermore analysing technology maturation rates could possibly assist in understanding which policy is best suited to establish a sustainable RE sector.

9. In conclusion this study is one of the first to empirically examine how various drivers emerge and how they need to be managed when designing a RE policy mechanism. Managing the four key drivers – as identified in this study – is pivotal in establishing a sustainable RE sector.

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