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# Exploring the Role of Regime Actors in Shaping the Directionality of Sustainability Transitions in South Africa

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## Abstract

This study explored the influence of regime actors to shape the directionality of sustainability transitions. Sustainability transitions are not only limited to system design and development but an interaction of incumbent actors and path-dependent mechanisms. Policymakers may develop a strategy to steer the application of sociotechnical innovation but are faced with directionality challenges if they are explicitly focused on linear transitions. We conducted face-to-face interviews with 26 policy and technical experts to explore this concept. We base the analysis of this study on the actor's perspective, vested values, and interest to provide a basis to inform the future of sustainability transitions in South Africa. The results of the study presented divergent transition patterns across the dominant actors, creating choices for alternative pathways. The study also found considerable ambivalence about shale gas development bordering on the suitability of shale energy to facilitate the South African energy transition. This study improved our understanding of how varied interests and values of actors can present significant challenges to sustainability transitions and shapes the prospect of sociotechnical innovations.

Keywords: Directionality, Sustainability Transitions, Regime Actors, Sociotechnical Innovation, Shale Gas Development.

#### **1.0 Introduction**

The concept of sustainability transition is widely held as a defining characteristic in today's world [1, 2]. More specifically, debates about sustainability transitions have been elusive involving a broad range of concerns that differ widely in their urgency, spatial and temporal dimensions, consequences, and uncertainties [3, 4, 5]. The debates extend to the direct or indirect potential to improve the quality and well-being of humans and the environment. This paper argues that sustainability transitions should be consistent with the values, interests, beliefs, aesthetic preferences, and regime dynamics of the society [3, 6]. This characterization should be used to appraise policy choices to avoid hindering sustainability transitions. Nevertheless, to the extent that sustainability transitions foster a long-term perspective, the concept should be used to facilitate divergent viewpoints or perspectives which appear to be at variance with the conventional norm.

The way normative position and values of actors shape sustainability transition are often ignored or left out in transition discourse [6], yet we find that values and specific characteristics of regime actors vary across contexts and can evolve in different ways, driving sustainability transitions in a specific direction [7, 8, 1, 2]. Although the role and function of actors may change in a regime, actors are understood to be vital components in sustainability transitions [6]. This study defines "regime actors as a group of actors sharing a set of rules that are unique to that regime" [1].

We found compelling evidence in the literature that the specific values, roles, functions, and interests of actors are mostly embedded in incumbent institutions and dependencies with the potential condition to influence the directionality of sustainable transitions [9, 10, 11]. There are questions about the extent to which different directionality or alternative pathways in sustainability transitions may arise as a result of contested values and interests of regime actors and the extent to which it should require policy interventions [6, 11].

This study provides the empirical basis for the different trajectories and models of sustainable transitions. The study described the concept of sustainability transitions as impacting disciplinary fields and policy practice. More specifically, this study argues for a greater focus on the attributes of contested values and the interest of regime actors in driving sustainability transitions. Our contribution provides a stronger theoretical and empirical basis for

understanding sustainability transition pathways. The study aims to address the following research objectives:

- 1. Provide insight on how policymakers and technical experts respond and drive systemic change towards long-term sustainability objectives.
- 2. Provide a robust understanding of South Africa's systemic challenges and the need for sustainable transitions.
- 3. Design a framework regarding the interaction of policymakers and technical experts in shaping the specific outcome of sustainability transitions.

## 2.0 The Directionality of Sustainability Transitions

Development in transition studies attempts to uncover policy feedback, path dependence, and transition actors to distill policies and programs that may aid in addressing sustainability issues [7, 12, 13, 2]. However, pertinent quarries regarding 'who drives the transition', '' the speed'', 'the scope'' and ''scale'' of the transitions are often neglected or missing in transitions discourses [7] including the challenge to describe how contested values and interest (norms) disrupt pathways (i.e. departs from the present (conventional) state of sustainability transitions [12]. While the level of destabilization builds on current trends and conceptualizations of transition pathways [14, 15], sustainability transitions add elements of contestable values and interests of regime actors [16, 13]; direction and speed of change may be divergent. Therefore fixation on a particular pathway can 'lock in' or 'lock out' alternative values and viable pathways impeding sustainability transitions. Therefore, this study suggests the concept of directionality as a defining characteristic in 'sustainability transitions'. Contextual factors in this study refer to the nexus of social, environmental, and economic factors and the range of themes discussed in the results section (see section 7).

The framework that allowed us to assess whether the directionality of sustainability transitions is viable or not, is governed by a myriad of self-reinforcing and interlinked incumbents including actors' values, interests, and institutional dynamics [9, 11, 17]. Forging more sustainable transition trajectories involves the consideration of both the regimes and complex panoply of values, and interests in the energy sphere [18, 19]. Therefore the trajectories of sustainability transitions will vary across contexts and unfold according to specific characteristics (contested values and interests) in the regime. The choice of directionality in a multi-dimensional space may arise from conditions of path dependency, actor's perspective,

and technological possibilities. Therefore, sustainability transitions may develop along different pathways at the national, regional, or global scale [20, 2].

Therefore this study contributes to conceptualizing the dynamics, speed and directions in which sustainability transitions can develop. We provide empirical examples involving technical experts and policymakers to illustrate our conceptual contribution where the directionality of sustainability systems resulted in the emergence of fast and slow transition (see the section in this study on the discussion on the sense of directionality of sustainability transitions).

Combined with this insight, the outcome presented in the study supports policymakers interested in promoting and exploring the directionality of shale gas development in South Africa with an understanding of the technical, environmental, social, and economic merits of developing the shale resource as a 'bridge fuel' and implications to the energy transition in South Africa.

#### 3.0 The Energy Landscape of South Africa

South Africa's power sector is facing significant challenges [21, 22, 23]. Access to reliable, affordable, and sustainable electricity is required to transform the development of the country [24]. As the country grapples with these urgent challenges, natural gas could offer a new baseload to address the country's CO<sub>2</sub> emissions in the short term, energy shortage, and enable the penetration of renewables [25, 26, 27]. Beyond this, the switching of coal to shale gas presents an opportunity to retire the country's aging coal power fleets ensuring a sustainable pathway that will stimulate economic growth, create job prospects, and spur industrialization of the country [28, 22].

While there is no universal strategy and approach for transitioning from coal-to-gas power, references exist in countries like China, Viet Nam, India, Indonesia, and Mongolia demonstrating the socioeconomic effects of shifting to low-carbon energy [30]. Coal accounts for more than 86% of the South African energy mix and presents a significant risk to the country's decarbonization efforts [31, 32]. Addressing South Africa's energy demand and CO<sub>2</sub> emissions are the key drivers for the changing energy landscape [33, 34, 23]. The country revised Integrated Resource Plan (IRP) aims to decommission 11 GW of coal-generated electricity by 2030 with a mix of renewables [34, 29]. However, South Africa cannot depend solely on green energy to mitigate both the challenges of climate change and economic drive industrialization [35]. South Africa will need to grow variable levels of natural gas and

renewables in the energy mix even as coal continues to play a dominant role in generating electricity (Figure 1).

Studies have demonstrated that gas-fired electricity plants generate lower  $CO_2$  emissions (<320g /kwhr) than coal and other fossil fuels (ca 1000g /kwhr) showing it as an alternative energy low carbon source [37, 38]. Gas-fired plants are operationally flexible at scale and easily deployed to accelerate the decarbonization of the energy grid [39].



Figure 1: South Africa's Electricity Generation by Energy Source. Source: [36].

South Africa could draw lessons from energy policy reforms in China to accelerate coal fire electricity to the gas energy transition, accompanied by the use of carbon capture sequestration (CCS) and hydrogen technologies [40]. The deployment of these technologies incorporating gas-generated electricity presents a cost-effective strategy and optimal bridge fuel to support South Africa's decarbonization agenda.

Recent offshore gas (Brulpadda gas condensate and Luipend-1X well) discoveries in South Africa and reserves of shale gas resources in the Karoo Basin [41] (Figure 2) could be a 'game changer' and a baseload for gas-generated electricity in the country [42, 29]. Nonetheless, the commercialization of these assets is far from development due to operational, infrastructural, and political uncertainties in the country [43]. South Africa needs 4–6 GW of electricity in the short term to mitigate current load shedding [29]. Thus, financing for the country's lower

carbon fossil fuel gas power projects is critical to increasing reliable electricity supply and transforming into a low carbon resilient economy.



Figure 2: Gas reserves in South Africa Source: [43].

Policy decision on Shale gas development is an emerging field of interest, focusing on the concerns that have prevented the shale gas industry from been widely accepted as a sustainable energy resource [41, 44, 45]. Issues related to the potential long term social, health, and environmental impacts of shale gas development [46, 47] and the appropriate system of risk governance continued to shape negative perception of the shale technology [48, 49].

South Africa is undergoing a transition from a coal-based economy to renewables [50, 51]. The energy transition policy of South Africa explores how shale gas can be deployed as a 'bridge fuel' in the decarbonization pathway [42, 47, 29]. The need for urgent climate change mitigation and access to both reliable and affordable electricity requires greening the power generation mix with available energy sources. The South African Climate Change Bill and Nationally Determined Contribution (NDC) specify a significant commitment to meeting these objectives [52]. This is a step in the right direction given that South Africa is the 12<sup>th</sup>-largest emitter (per capita) of global greenhouse gas (GHG) emissions intensity and the highest in Africa [52]. In this context, a structural and criteria framework approach is designed to reduce

17 % of  $CO_2$  emissions by 2025 and 32 % by 2030, representing 398 to 614 MtCO<sub>2</sub>e million tonnes of  $CO_2$  equivalent in 2025 and 2030 [53. 52] Fig. 1.

The role of shale gas in the energy transition has raised concerns from energy experts and policymakers [54, 55, 47]. Studies have indicated that shale gas if properly managed, has low carbon footprint than the other fossil fuels [56]. The development of carbon capture storage systems (CCS) plays an increasing role in mitigating carbon emissions in hard-to-abate sectors and large point sources [57, 58, 59, 60].

#### 4.0 The Influence of Regime Actors on Sustainability Transitions

[61] highlights three mechanisms by which regime actors influence the direction of sustainability transitions; maintain the existing regime, disrupt/ destabilize the regime or create new niches for the emergent technology [62, 63]. This implies that sociotechnical systems may take different shapes and directions [64, 65]. Studies suggest that transitions are non-unidirectional or linear processes but develop from both the influence and interaction of multiple actors and institutional systems [66, 67, 68]. These interactions reflect a range of varied configurations and spatial geographies of nested values, and interests embedded within the incumbent regimes. The 'actor-based approach' becomes an appropriate tool to analyze the directionality of sustainability transitions because it shifts the emphasis from a 'technology fix' to a fundamental change in systems designed to achieve societal needs [69, 70, 71, 72, 73]. The 'actor-based approach' focuses on the local manifestation in addressing sustainability challenges through meaningful interaction in the local context offering alternative ideas to advance sustainability transitions [74]. Based on a focused literature review on the directionality of sustainability transitions, this study explores how policymakers and technical experts shape their perspectives of sustainability transition in South Africa [62, 66, 68, 74].

#### **5.0 Theoretical Framework**

Transition frameworks are important tools for framing the way transition unfolds and are valuable in planning the pathways of sustainability transition [75]. They are an important tool for improving our understanding of the dynamics of transitions including managing uncertainties in sustainability transitions [76, 75]. In all, transition frameworks are useful models in identifying and theorizing the interaction of relevant actors, institutional systems, and path-dependent mechanisms (such as 'lock-ins'), this allows us to find out if the interaction leads to a very specific outcome or produces an emergent pathway [14,77, 78].

In the context of the sustainability transition in South Africa, we focus on understanding the interaction of the dominant actors and processes and how that becomes sufficiently significant to destabilize the prevailing regime to create new pathways. We define a regime' in this study as the aggregation of shared norms, rules, and practices influencing the adaptation of actors [79]. Building upon this, the theoretical framework used in this study (Fig. 3) captures the complexity and multi-dimensionality of sustainability transitions with a particular focus on regime actors (policymakers and technical experts). The framework also presents divergent transition patterns across the dominant actors, creating choices for alternative pathways. Figure 3 depicts the dynamics of transition processes arising from the interplay of developments at three analytical levels: actor, 'lockin' mechanism, and directionality.



Figure 3: Theoretical Framework

#### 6.0 Methodological Approach, Collection, and Analysis

Unlike most sustainability transition studies that are systematic in design [80, 81, 82], the methodological approach employed in this study is planned to be more descriptive, exploratory, and interpretative than systematic. This paper is based on original empirical work on sustainability transitions using qualitative methodology to explore the interrelated influences shaping the responses of incumbent actors to the sustainability challenges in South Africa, detailing the salient themes and experiences of the actors. The participants for this study were purposively selected as existing actors in the energy industry (Table 1). This study applied the definition of incumbent actors to select the participants as influential and established

individuals responsible for leading sustainability change and niche innovations in the energy industry in South Africa [83, 84].

Semi-structured interviews comprising 13 policymakers and 13 technical experts were conducted face-to-face with each interview lasting about an hour (Table 1). Semi structure interviews have the benefit of investigating both salient and unobservable factors [85]. The interviews were conducted in English, audio recorded, and transcribed in Nvivo version 12 software. The study examined the role and perspective of the actors including the institutional work they engage in to shape the directionality of the energy transition. A list of interviewees is provided in Table 2.

The demographic characteristics of the study sample are presented in Table 2.

Participants Interviewed	Description of Participant	Number of Participants (n 26)	Sample Share (n 26) %
Technical Expert	Senior staff from the oil and gas industry, technical, engineers, geologists, and consultancies, focused on oil and gas exploration and development.	13	50
Policy Expert	Regulators and advisers are involved in energy issues, climate change policies, and strategies. South Africa Government agencies, focused on climate and energy- related issues. Framing concerns of sustainability and the formation of local and national policies.	13	50

Tabla	1.	Classification	of Participants
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Variable	Number of Actors	Percentage (%)
Age /years		
29-35	5	19
36-40	5	19
41-50	9	36
51-60	7	26
Total	26	100
Gender		
Male	18	69
Female	8	31
Total	26	100
Professional Status		
Geologist	5	19
Reservoir Engineer	5	19
Drilling Engineer	3	12
Policymaker	13	50
Total	26	100
Experience Level		
5-10	12	46
11-15	7	27
16-20	4	15
21-30	3	12
Total	26	100

Table 2: Demographic Characteristics of the Qualitative Sample ( $\eta$ 26)

Table 3 shows a summary of the interview questions. The study analysis is built on quotations and illustrations derived from the interview sessions.

Table :	3: Interview Questions
S/N	Interview Questions

<b>5/</b> 1N	Interview Questions
1	Please describe your professional background and area of your expertise.
2	What factors constitute the most critical impact assessment of shale gas development in South Africa
	and how do these impact South Africa's decarbonization target?
3	What is your sense of a solution to climate change?
4	What is the level of uncertainty regarding the current level of knowledge of each factor?
5	What is your concept of 'bridge fuel'? Do you consider shale gas as the optimal transition energy?
6	Can these uncertainties be mitigated? How can decision-makers operationalize these mitigations?
7	How can decision-makers build an effective and fit-for-purpose framework to guide the energy
	transition?
8	What explains your sense of directionality of sustainable transition in South Africa?

## **6.1Thematic and Content Analysis**

The interviews were transcribed and inputted into Nvivo software for thematic and content analysis. The study adopted a coding strategy and generated a balanced code tree that captures the underlying factors shaping the viewpoints of the participants.

The transcripts were coded manually to pinpoint emerging themes arising from the interviews and to examine if the themes reflected the dominant views of the actors – technical experts and policymakers. The codes were reviewed severally to produce a balanced perspective of dominant themes. The coding process involved categorizing and reviewing participants' responses to each of the questions to extract the final set of descriptive and final themes to reflect the perspectives of the - technical experts and policymakers. The final themes are represented in Figure 4. Some literal and relevant quotations from the participants are presented in the study.



Figure 4: Responses to Dominant Themes

## 7.0 Results of the Study

## 7.1 Thematic Inductive and Process of Analysis

This paper provides the groundwork for further qualitative study in sustainability transitions in South Africa and similar sociocultural contexts. We recognized that human behavior is shaped by the interaction of social structures/ conditions, risk perception, and protective human behavior [85, 86]. It was important to strengthen the quality of the analysis by improving the logical flow and rigor of the coding process in order to compare codes, identify patterns of emerging themes in the data.

We mapped clusters of keywords and common themes that reflected the novelty of factors among the network of actors influencing the directionality of the energy transition in South Africa. The key themes received equal amounts of consideration allowing us to build a theoretical foundation and thematic prediction model for this study. The evolutionary pathway cited in Figs. 5 and 6 allowed us to define the thematic boundaries, and visualize the dynamic development, characteristics, and semantic relationships among the key themes. This development allowed us the opportunity to avoid subjective judgments and potential randomness commonly found in most qualitative studies [87, 88, 89, 90. Based on the aforementioned common themes identified, the study combined references of quotes from interviewees. The response from the qualitative interviews indicates divergent positions about sustainability energy transitions with contending perceptions regarding the risks and benefits of developing the shale resource in the Karoo Basin (Figures 5 & 6).

The emerging themes were categorized under six themes: Geology, Technology, Environment, Social, Economics, Sustainability, and Energy Security illustrating an overview of what the participants collectively considered as dominant themes. The dominant themes to emerge from the interview are: Sustainability and Energy Security, Geology and Resource Estimates, and Environmental related issues were used to explore the competing themes and context for the study.



#### Figure 5: Thematic Map Showing Perception of Risks

The arrows demonstrate networks between the key themes. The path of the arrows suggests whether a theme facilitates another theme.



#### Figure 6: Perception of Benefits

The arrows demonstrate networks between the key themes. The path of the arrows suggests whether a theme facilitates a subtheme.

## 7.2 Economic Factors

Economic growth, job creation and affordable energy access were highlighted by the policymakers as key benefits of shale gas development and critical metrics of sustainable development. The policymakers noted that shale gas development will facilitate the broader social agenda to improve the well-being and living standards of people in the Karoo. The technical experts' highlighted significant uncertainties in scaling the development of shale gas sustainability in the long term noting that most shale wells deplete very quickly. There was a consensus to integrate the proceeds from shale gas development as sovereign funds and investment and develop the local socio-economic programs such as the farming and manufacturing sector. The Technical experts also highlighted the geological and structural constraints of encountering commercial volume of gas in the Karoo basin to encourage significant investment in shale gas development.

"The government has conducted several feasibilities and scientific studies that suggest a favorable economic and energy security outcome of developing the Karoo shale reserves". Male, Policy Experts, 41 years. 'Shale gas development could be a game changer for South Africa should commercial quantities of shale gas found in the Karoo Basin". Male, Technical Expert, 50 years.

## 7.3 Social Factors

The technical experts highlighted the social license to operate as a key consideration and implication for shale gas development. They also noted that greater transparency, consulting with the locals, and incorporating stakeholder views are needed to make progress and there has not been sufficiently demonstrated. The technical experts pointed out that public acceptance of shale gas development can only be achieved if energy policy is aligned with the social agenda of the various ethnic groups in the Karoo. The technical experts highlighted the impact shale gas development could have on South Africa's fragile social fabric if not properly managed. The policymakers highlighted that the social and governance-specific components of shale gas development in South Africa are aligned with the social and economic well-being of the people.

"The national outlook for shale gas development is positive, however, relevant legislation and laws need to be established to improve stakeholder participation and broader community benefit". Female, Technical Expert, 43 years.

"I believe that the institutions in the country are built on a high level of fairness, and integrity and have been consistent in delivering equitable service. The institutions are accountable, resilient, and strong predictors of public trust ".

Female, Policy Expert, 34 years.

"The legitimacy of the institutions is strong and able to enforce compliance and best practices ".

Male, Policy Experts, 41 years.

## 7.5 Technological Uncertainty

New and unfamiliar technologies such as shale gas development provoke a sense of deep uncertainties among technical experts. However, the expert view was mixed regarding the risks and role shale gas development could play in the decarbonization agenda of South Africa. The technical experts advocated the precautionary strategy as a means of mitigating the uncertainties of shale gas development given that the shale technology is nascent in South Africa. However, the policy experts noted that potential delays in deploying the shale gas technology could be costly in establishing South Africa on the energy map and deprive the country of huge economic gains given the favorable energy market. The experts expressed challenges in restructuring historic coal power infrastructure with gas pipelines and facilities.

> "The success of shale gas development in the United States cannot be replicated in South Africa based on conditions that are unique to the US, conditions such as favorable geological features, strong regulatory and institutional framework, established infrastructural and market conditions, and advanced technological capabilities. South Africa does not have the conditions to replicate the benefits of shale gas development as America does. The Karoo shale resource may only be optimal for domestic use". Male, Technical Expert, 56 years.

South Africa can adopt a similar US-led methodology to the regulation of the shale extraction industry, this approach will impose higher regulatory oversight on operators to comply with safety standards. This position is likely to replicate the US shale boom in South Africa. Female, Policy Expert, 40 years.

"Exploration and development of shale gas in South Africa are urgently needed to establish South Africa on the map as a gas hub. The abundance of the shale resource in the Karoo is an answer to the issues of an energy shortage, CO<sub>2</sub> emissions, and economic growth. The exploitation of the shale resource will reduce dependence on foreign supplies".

# 7.6 Geological Factors

The strength in agreement (81% agreed) in support of shale gas development was in part a result of enormous policy and legislative responses to the decarbonization of the economy, a boost for economic growth, job creation, and a feedstock for electricity generation in the country. This includes the 2010 Integrated Resource Plan of having an electricity mix that incorporates gas as a backup to the renewable energy roll-out plan [91]. Successive circles of fiscal projections have continued to give a sense of the potential of shale gas development of a similar magnitude to the American shale revolution [92, 47]. Despite the consensus and support for shale gas development among the experts (mainly policymakers), 19% of participants disagreed with lifting the moratorium based on potential environmental risks, and underlying structural and geological uncertainties in the basin highlighting the difficulty to replicate the American shale revolution elsewhere.

The technical experts noted that the scale of geological risks regarding the Karoo resource potential presents significant uncertainties to shale gas development. The technical experts noted that the knowledge gap in Karoo geology also presents a limiting factor for effective decision-making regarding the commercial potential of the basin. The technical experts noted more stringent science-based policy-making on actual drilling activities and comprehensive technical investigations to de-risk the Karoo Basin. The absence of good geological information will inform poor planning, long term environmental and economic consequences. The policy experts maintained that the benefits outweigh the potential risks, and studies suggest an upside potential of significant economic recovery and robust policy decisions. There was consensus among the participants regarding lifting the moratorium, the technical experts noted that lifting the moratorium offers the opportunity to obtain actual geological data to appraise the geological basin. The policymakers noted that lifting the moratorium is good to accelerate energy development.

"It makes sense to lift the moratorium in order to fast-track energy development. The country risks natural asset straddling which could set South Africa behind in terms of industrialization and economic growth. Male, Policy Maker, 45 years. "While uncertainties exist in the Karoo shale resources, the moratorium over exploration of shale gas assets should be lifted. Lifting the moratorium will allow us to access the full potential of the basin". Male, Technical Expert, 42 years.

## 7.7 Environmental and Sustainability Factors

The broad range of benefits and challenges of transitioning to a sustainable energy future using shale gas development was a key aspect of the interview. Concerns were raised about the potential social, economic, environmental, and health consequences of developing the shale gas industry and whether the development of the shale gas industry would be compatible with South Africa's climate change mitigation plan. The policymakers pointed to the potential benefits of shale gas development – for the South African economy, energy security, and driving investment in a wide range of social and environmental benefits.

The majority of the policy experts noted that shale gas is an innovative solution to mitigate climate change and energy challenges and improve access to affordable energy. The policy experts noted that shale gas development is a potential component of sustainable development bringing job creation and economic growth.

The technical experts described sustainability as an evidence-based innovation in contrast to the policymakers who defined sustainability as an adapted practice incorporating local perspectives. The technical experts noted that shale gas is a finite energy resource and only sustainable development brings job creation and economic growth requiring a cautious and evidence-led approach to exploring the potential risks, benefits, and challenges of exploring the Karoo Basin, as it considers the opportunity of developing the shale gas industry in South Africa.

"Sustainability encompasses the capacity to deliver natural resources over time with minimal risks or harm to the environment".

Male, Technical Expert, 50 years

"Sustainability is adapting innovation or natural resource to the local environment in the short or long term".

#### Male, Policymaker, 45 years

"Decline of peak production of shale gas is likely to be dramatic over a short life cycle making it one of the least sustainable options for economic and energy development."

Female, Technical Expert, 36 years.

"Scenarios exist where shale gas was developed sustainably bringing in huge economic, social and environmental benefits and helping to fulfill the energy need of society".

Female, Policy Expert, 40 years.

## 7.8 The Framing of Risk Perception by the Experts

Risk perception is a subjective psychological concept that defines the probability and severity of a risk and varies between individuals and social groups [93, 86, 94]. The cognitive assessment involved in risk perception depends on several factors such as exposure to the risk, quality of information, trust, awareness, and familiarity with the risk [95,96,97]. Risk perception is also influenced by sociocultural factors and values [98, 99]. The participant's perception of risk was influenced by a shared awareness of sustainability transitions and spanned several domains and contextual factors, including protective behaviors, and environmental, economic, social, and technical considerations. Even though the participants have no direct experience with shale gas development, however, the perception of the participants seems to be influenced by the quality of information concerning the range of uncertainties and benefits related to shale gas development. The perceptions of shale gas development are expressed as a complex interplay of the potential benefits and risks associated with shale gas development. The finding of this study further suggested that participants in support of developing the shale industry see potential value in the industry to address the energy and economic challenges of South Africa. The study also discovered that perceptions about the

shale industry are related to the participant's wider behavior toward the long-term effects of shale gas development on the environment and regulatory framework in managing the industry.

The participants expressed a strong distinction in their perception and analysis using a clear language of scientific uncertainty as a feature of shale gas development. The difference in perception between the technical experts and policymakers aligns with previous studies concerning how scientific uncertainty is used to frame the values and interests of incumbent actors [100,101,102]. It does take into consideration alternative framings of concerns.

The technical experts expressed reservations in different aspects of shale resource development in contrast to the Policymakers who noted scientific certainties within the context of sustainability transitions. However, the critical view held by the experts on decarbonization was unanimous. The quotes highlight the notion of climate change as an environmental concern. We noted that the characterization of sustainability transitions adopted by the Policymakers and Technical experts has implications for policy and decision-making.

*'I see significant value in developing the shale industry – notably in mitigating climate change and energy insecurity – I believe that the potential long-term risks are generic and do not apply to the South African context".* 

Male, Policy Maker, 42 years.

"There is no doubt that shale gas development offers some short-term economic benefits, however, drawing from the US experience suggests that the potential benefits are accompanied by long-term economic, social, and environmental risks".

Male, Technical expert, 46 years.

## 7.9 Perceptions of Shale Gas Development

Shale gas development is an intense and complex engineering technology [94]. Despite the potential benefits of shale gas development as a move toward sustainable energy development [103]. Studies argued that the process induces severe environmental, economic, and social risks

[104,47]. This study showed that risk perception played an important factor in shaping expert behavior concerning shale gas technology. The experts conceptualized risk as the likelihood of undesirable consequences of shale technology. The participants noted multiple undesired consequences and different levels of severity for any given condition in contrast to general impacts provided by extant studies.

The policy experts noted that the potential benefits of shale gas development outweigh the perceived risk and therefore demonstrated significant support (81%) of the shale technology, while 19 % of the participants opposed shale technology. The policymakers noted that shale gas presents many advantages over coal as the cleanest burning fuel of all fossil resources. The opinion of the technical experts about the risks and benefits of shale gas in South Africa was divergent from the policy experts. The technical experts noted that shale gas development is still at the nascent phase of exploration, hence risks and benefits tend to be difficult to understand. The technical experts cautioned that South Africa was very different (geologically and in regulatory context) from the US, rendering the lessons not entirely useful, while the policy experts seemed to see the US as a useful example. This discussion seems to present a divergence in opinion regarding a transition path for shale gas.

"The success of shale gas development in the US is due to a combination of factors such as favorable geological and regulatory environment compared to the Karoo Basin which has many structural and geological risks. While lessons from the US are good but they cannot be replicated in the South African context. Shale gas development in South Africa presents much higher risks than benefits.

Male, Technical expert, 40 years.

South Africa has the unique advantage of developing its shale industry from lessons learned from shale gas development in the US. *Female, Policy Maker, 30 years.* 

# 7.10 Perceptions and Attitudes towards Moratorium

The majority of the participants (mainly Policymakers) agreed that the moratorium on shale gas development should be lifted. These findings support those who support the development of shale gas in South Africa. The findings of this study found that the potential risks associated with shale gas development as the most important factor influencing the perception of policymakers in support of the continuous moratorium on developing the shale industry. Furthermore, the participants believed that evidence-based data were required to lift the moratorium due to the presence of geological and structural uncertainties in the Karoo Basin. Other participants (mainly Technical Experts) noted that the lack of evidence data about the potential risks and structural uncertainties does not indicate an over-cautious assessment of shale gas development in South Africa. The participants believed that the lessons learned about the success of shale gas development in the US are instructive for lifting the moratorium on shale gas development in South Africa.

We should be prioritizing shale gas development in our energy transition plan, not only would shale gas meet our clean energy demand but also create economic opportunities for the local people".

Male, Policy Expert, 45 years.

"Exploration and development of shale gas in South Africa is a complex venture. The benefits of shale gas development are significant for South Africa, however, it is important to pursue the development of the shale resource cautiously".

Male, Technical Expert, 50 years.

## 8.0 Lessons from Sustainability Transitions in South Africa

The study explored how policymakers and technical experts shape their perspectives on sustainability transitions in South Africa. The study demonstrated that the scope and geographical applications of sustainability transitions have broadened to provide a comprehensive understanding of the challenges related to sustainability transitions and societal challenges such as climate change and natural resource management. These challenges cannot

be solved linearly or by technological fixes but by radical shifts in socio-technical systems and the broadening of alternative perspectives [80, 81]. The study conceptualized how alternative directionality can unfold in a low-carbon energy source such as shale gas development. We argue that policymaking plays a critical role in framing the directionality of sustainability transitions through dynamic processes [11]. Supporters of the fast transition pointed out that sustainability policy will need to take advantage of technological innovations to mitigate climate change. They noted that shale gas development provides the opportunity to drive sustainable policies without imposing significant costs on society. Despite the urgent need to take lecarbonize the economy, supporters of the slow transition noted that the transition must proceed at a variable speed, equitable, and specific in addressing the challenges of transforming South Africa's energy mix (Fig. 7).

"We need to adopt a transition that fits South Africa's energy, socioeconomic, and environmental context. Leapfrogging the transition will undermine South Africa's economic development". Male, Technical Expert, 49 years.

"The energy transition is a crucial enabler of sustainable development and climate resilience. An opportunity for South Africa to fast track economic and social development". Male, Policymaker, 40 years.



Figure 7: Directionality and sense of shared direction in guarding the energy transition.

## 9.0 Discussions and Implications of the Findings

Empirical work on what constitutes the directionality of sustainability transitions in South Africa is still unclear and unmapped. Directionality is important as it shapes the alignment of mission-oriented innovation systems and steers transformation in a specific direction [105, 106]. Without a clear and systematic analysis of directionality (actors who influence "current system mechanisms", solutions to sustainability and development challenges such as climate change may not be facilitated [105, 106].

This study explores the role of policymakers and technical experts in shaping the directionality of sustainability transitions in South Africa, revealing its core features, dynamics, and implications. The paper also provided a facet of emerging themes and critical junctures for paving the way to sustainability transitions in South Africa. This study captures the pace, patterns, and dynamics of sustainability transitions and provides a good understanding of how the energy transition can be governed in the face of emergent factors and incumbent actors. Policy support must acknowledge the way transitions unfold, both in terms of speed and direction, taking into account the vested interests and values of incumbent actors.

The study demonstrated that regime actors implement varied perspectives of sustainable transition. For example, the technical experts supported a precautionary position in the diffusion of shale gas development in contrast to policy experts who demonstrated a significant posture of certainty and legitimacy in developing shale gas to advance a fast transition (Figure 7). These differences in perspective and interactions contrast with the conventional understanding in sustainable transition studies where actors are thought to sustain the prevailing institutional and sociotechnical regime [107, 63]. Moreover, all the actors actively share their perspectives and positive associations of increasing the share of renewables in the energy mix as the long-term sustainability focus.

This study provides important insights into the critical uncertainties bordering on the suitability of shale energy to facilitate the South African energy transition. We found considerable ambivalence about shale gas development, but also greater awareness of potential benefits than risks. 81% of the participants (mainly policy experts) maintained the support of shale gas development while 19% opposed the development of shale resources. This is logical given that unconventional energy technologies are complex and contested by differing experts. However, policymakers can glean from this to develop an adaptive framework to support strategic policymaking and responses to the challenges of shale gas as a 'bridge fuel' in the transition pathway.

Participants' emphasis on the lack of clear empirical evidence about the long-term risks associated with shale gas development shows an over-cautious view of developing the shale industry. Others suggested that policymakers and regulators need to learn from the US shale experience in order to understand the trade-offs involved in realizing the benefits of shale gas development.

## 10.0 Limitations of the Study

A key limitation of the semi-structured interview is the tendency of the participants to exercise their perceptions and experiences in a more positive context without consideration of alternative perspectives enforcing the assumption that experts are likely to present a parochial and narrow-minded perspective of a complex situation. These seemingly contradictory assumptions were resolved by presenting the same questions in order to achieve objective responses and aggregating the opinions of the experts.

## **11.0 Summary and Conclusion**

The energy transition focuses on the urgent need to address climate change and accelerate a shift to renewables. While the sustainability transition is underway in the Global North, however, the energy transition is challenged in countries that are heavily dependent on fossil fuels. More evidence is emerging regarding the multifaceted challenges and structural barriers impeding sustainable transition in developing economies such as South Africa.

The challenges faced by South Africa are multi-faceted and linked in complex ways to prevailing energy, environmental, social, economic, and infrastructural systems, making it rigid to achieve rapid fundamental transitions. Against this backdrop, this study concludes that South Africa must adopt incremental transformations involving transitions in dominant institutions, practices, policies, and technologies while safeguarding a long-term sustainability agenda [108]. This is consistent with historical case studies which support a 'punctuated equilibrium' pathway, entailing extended periods of incremental sociotechnical transformation interspersed with fairly short phases of disruption in transitions [109, 110, 111].

Whilst there are substantial potential benefits associated with shale gas development, however, there are concerns about the potential risks of developing the shale industry over the long term. Policymakers face the challenge of balancing these potential risks and benefits. Therefore, this study is imperative as it provides questions about whether current South African policy frameworks are suitable to manage the shale industry.

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