

Renewable Energy and Its Implications in the African Context

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Abstract: The environmental implications of energy systems in developing countries have significant impacts on the daily and long-term life quality of the population. These implications include mitigating impacts of climate change, deforestation, improving food security and the multidimensional energy security concerns. Increasing accessibility of reliable and cost-effective renewable energy streams, creating sustainable and profitable businesses that improve living standards and create economic opportunities, which co-create social and environmental values are necessary and essential markers for transitions towards a flourishing society. Energy is essential to sustain modern life. Here, security implies the economic, social, and environmental impacts of energy on the wellbeing of a society. The energy regime that a country chooses has wider implications on its national security strategy and foreign relations. It affects the economic and technological pathways it takes and impinges on overall developments, which include industry, education, environment, and the way of life. Selecting the optimal innovation strategy that includes appropriate renewable energy technologies which meet the needs and harness the available energy resources is one of the primary variables that impact the performance renewable energy projects. Cost, reliability, maintenance, and cultural orientation need to be considered for innovation & technology selection. In the African context, our research indicates addressing the environmental implications of energy systems necessitates whole system wide change that is underpinned by transitions from utilizing conventional energy sources to renewable energy streams. Furthermore, it requires re-configuration of research & development to applied research, re-constitution & focus on incubating enterprises & entrepreneurs, re-configuration of education from abstract education to education that enables solutions development to address local challenges, development in the energy & other sectors to address climate change, health impacts, job creation, energy & food security in concert with developing synergistic and symbiotic shared vision and paradigm shift towards a flourishing future. Our research findings inform us that the meaning and application of energy affordability has a significant difference from what is in the current literature. Energy affordability is defined as the financial capability of a household to pay for basic energy services. In other words, it could be expressed as the monthly energy expenditure of a household divided by its monthly income. Expenditure substitution, digital/electronic payments for energy services, which are configured as “pay-as-you-go” have changed the affordability landscape. While affordability is an important factor, its meaning and application is more nuanced from what is reported in extant literatures.

Keywords: Environmental Implications, Distributed Renewable Energy, Co-creation, Paradigm Shift Flourishing, Complexity

1. Introduction

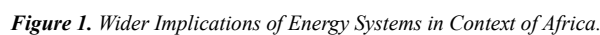
The availability of sustainable and affordable energy regimes has been identified as key to economic and social developments [1]. Furthermore, the strong correlation between the availability of cost-effective energy and

economic development has been evident from the early history of people as hunters and gatherers through the development of the modern-day industrial economy [2]. Most developing countries in general, and Africa in

There are considerable publications on renewable energy in developing economies; however, there is little to no

2. Wider Implications of Energy Systems

The environmental implications of using customary biomass fuels are compounded in the context of developing economies. It negatively impinges on economical, ecological, social, and security spheres of societies at the local, regional, and global level [3]. Wider utilization of such fuels accelerates the rate of deforestation, which results in the loss of topsoil and freshwater retentions, which in-turn results in poor agricultural and farming yields. Poor agricultural and farming yields are forcing functions for food and economic insecurity that lead towards political and social instability, which may be accompanied by mass dislocations a society with significant local and regional consequences [4]. Furthermore, the increased utilization of conventional biomass fuels as a primary source of energy exposes large sector of the population more specifically women and children to indoor air pollution with substantial health impacts and associated economic and social implications. Figure 1 illustrates the complex and multi-level implications of energy systems and Figure 2 illustrates the system dynamic view of RE business benefits.



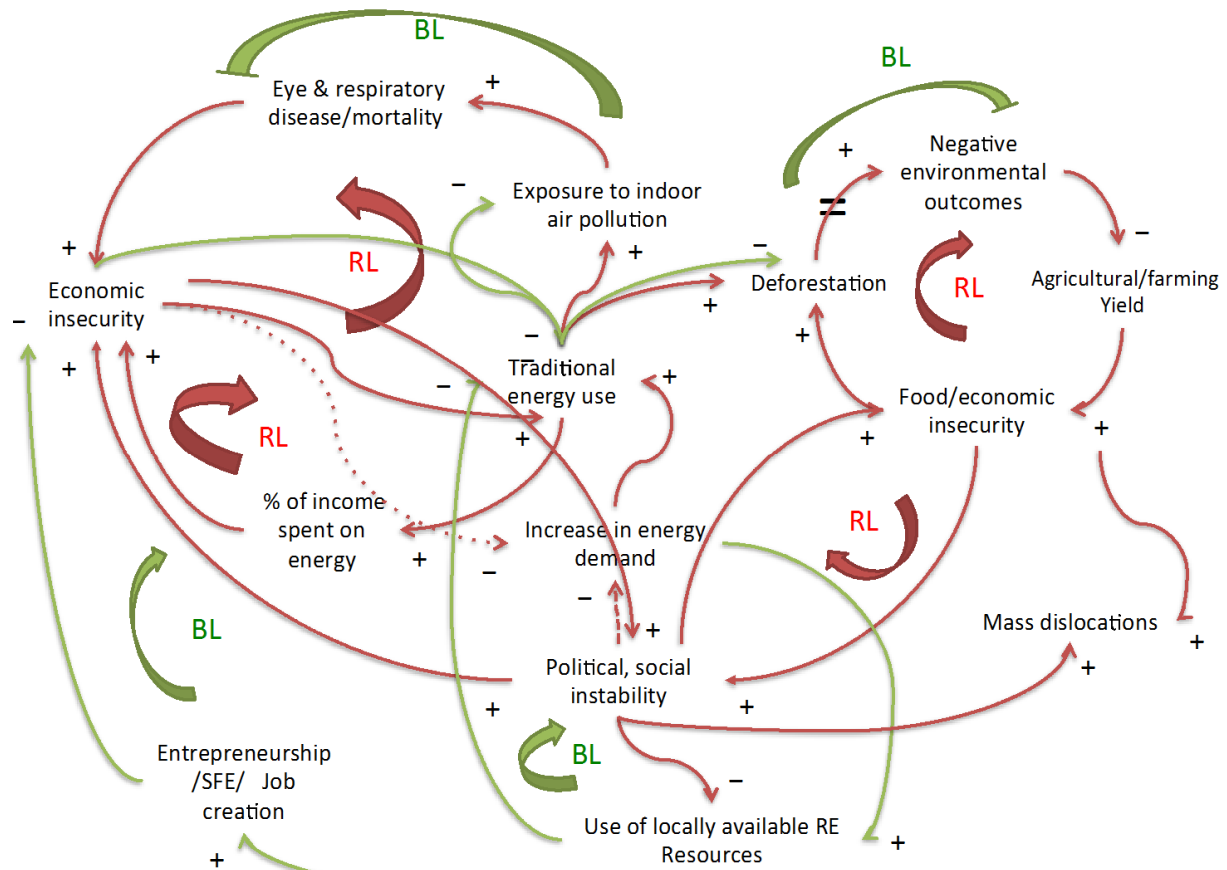


Figure 2. Integrated Benefits of RE Businesses/Projects.

2.1. Research Questions and Situational Map

Energy is one of the key enablers for civilizations. This research strives to answer the following important questions: What influences or explains the performance of renewable energy business (research focus) in Africa? How and to what

extent does innovation, business strategy, policy and regulatory framework, job creation, cost, security (economic & political), culture, climate change, health impacts, deforestation, customer value of service, and capacity development affect the performance of renewable energy businesses in Africa? The situational map is presented in Figure 3.

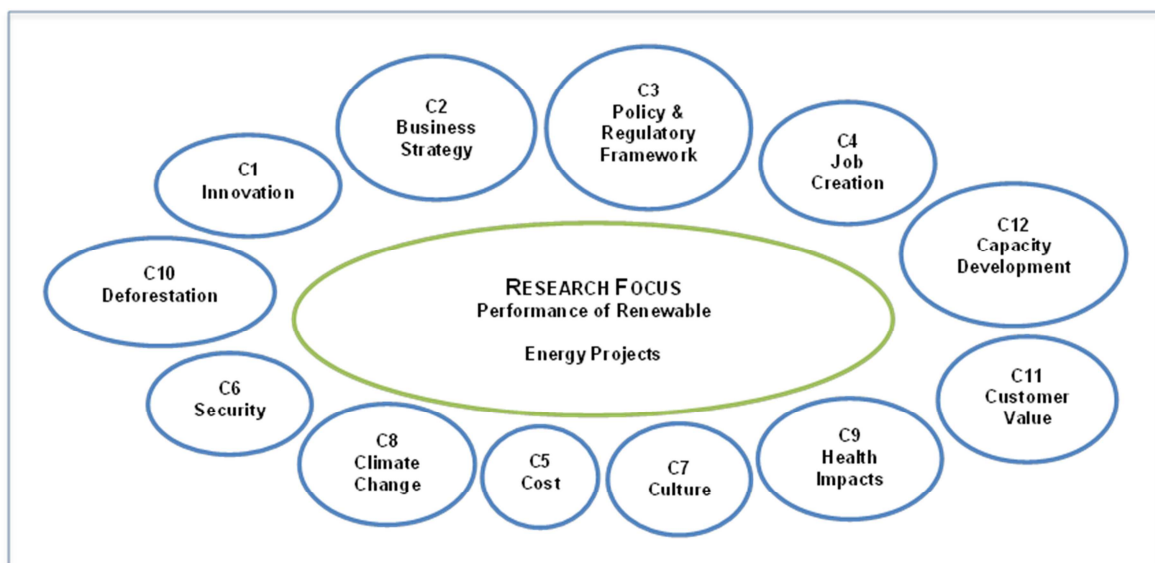


Figure 3. Situational Map of RE Businesses in Africa.

2.2. Key Variables of Research Focus

The outcome of renewable energy business for our purpose is defined as the sustainability attributes that measure the integrated economic and environmental impacts on society on short and long-term basis both from local and global perspectives. The research focus includes meeting target revenue for continued and proper operations of the business/project, improving the quality of life and social conditions of the people, reduction in CO₂ and other greenhouse gases, and improving economic, social, and cultural dimensions of the host community of the business [9], [10]. In this context, the performance of renewable energy projects includes increasing accessibility to reliable and cost-effective electricity, creating sustainable and profitable businesses, improving the living standards, economic opportunities, social, environmental, and cultural developments, increasing energy security, and decreasing energy poverty [11].

3. Literature Review

In this section, foundational and evolving theories of the situational map and the research concepts will be discussed. These include theory of innovation, ecological modernization, and complexity theories.

3.1. Theory of Innovation

The theory of innovation is defined as the process of inventing new elements or ideas and the origin of innovation theory goes back to Joseph Schumpeter. Innovation is asserted to be the prime mover for economic development, according to Schumpeter, entrepreneurs are the forces that innovate and bring new products and services to the market. In his later work, Schumpeter emphasized innovation a collective process, which signifies the link between innovations in the context of institutions, cultures and its implications [14]. The innovation process occurs at the micro and macro levels and national innovation policies have significant impacts on innovations [15]. Hence, innovation theory helps us to assess the outcome of RE business from wider perspectives.

3.2. Ecological Modernization Theory

Ecological modernization theory states that the best way to mitigate ecological degradation is by continued industrial development. The foundational thesis of ecological modernization theory (EMT) is investigating and gaining a better understanding of ecological challenges and the way it is mitigated in the industrial age [16].

York and Rosa capture the concepts of EMT as a process, which internalizes the environmental impacts late-modernization. As such this theory can be instrumental in gaining better understanding on the environmental implications of RE business [17].

3.3. Complexity Theory

Mitchell defines a complex system “as a system that exhibits nontrivial emergent and self-organizing behaviors” [18]. Renewable energy development businesses seem to be complex because of their nested complexity relationships with the economy, ecology, and governance. Renewable energy developments with emerging technologies, alliances, policy frameworks, and economic configurations are dynamic and at the cusp of change which may be termed as chaotic [19].

The management of renewable energy businesses will benefit from complexity theory to formulate an effective strategy of directing a system that needs to be optimized at its current state, while at the same time taking into consideration its future behavior [20].

4. Methodology

In this section the research methodology is described.

Qualitative, grounded theory formulated by Glaser and Strauss was used to conduct this research. Grounded theory is an integrative methodology with the goal of discovering “theory from data” as opposed to developing hypotheses from existing theories [21]. This methodology was chosen because of its fidelity to address research topics concerned with people’s lived experiences and events that unfold during the initiation, development, and implementation of the projects.

Maxwell details five areas of interest that are “especially suited” for qualitative studies. Each of these five areas, have pertinent impact on the measurable and perceived performance of renewable energy businesses [22].

4.1. Research Participants

Twenty-five practitioners engaged in twenty-five different renewable energy businesses were interviewed to elicit rich lived experiences. They were key decision makers on the overall scope of the business and as such they were entrepreneurs, owners, founders, CEO, general managers/managing directors, and project managers of renewable energy businesses.

Background information of the research participants is presented in Table 1.

Table 1. Research Participants Demographics.

Responsibility of Research Participants		
CEO/COO/Founder/Owner	6 out of 25	24%
Consultant	2 out of 25	8%
Director/Managing Director	10 out of 25	40%
Educator/Center Director	1 out of 25	4%
Investment Banker	1 out of 25	4%
Program Manger	4 out of 25	16%
Senior Advisor	1 out of 25	4%

4.2. Data Collection

Interviews were conducted in person, via telephone, and

Skype, adhering to proper protocol. The selected research interviewees were contacted by phone or email and invited to be part of the research. Once their willingness to participate in the research was established, the selected candidates were advised of the established protocols to ensure their privacy and protect their identities. The confidential, semi-structured interviews on average lasted 50 minutes.

During the interview, participants were asked open ended questions about their lived experiences, their assessment about the businesses being successful or less successful, and their experiences were captured through their narratives [23].

4.3. Data Analyses

Data analyzed after the interviews were transcribed and continued throughout the research process. During the

interview process I took significant research notes that were effectively used during data analysis. The coding process was dynamic and iterative, starting with open coding, theoretical framework reviews, and then axial coding [24]. I listened to the interviews, while reading the transcript and research notes during coding. Further reviews of interview transcripts, research notes, memos, and re-listening to the audio recording of the interviews, identified nested codes that were collapsed to primary codes yielding 33 final codes that have significant implication on the outcome of RE businesses. These codes are presented in Table 2.

5. Findings

After conducting open and axial coding, 24 major thematic findings are identified as shown in Table 2.

Table 2. Summary of Coding Results.

		Number of Participants	%	(n) = 25
1	Affordability	13	53%	
2	Aggregation	14	56%	
3	CBO (Community-Based Organization) Engagement	17	68%	
4	Connectedness	17	68%	
5	Climate Change Impacts	16	64%	
6	Culture	18	72%	
7	Corruption	11	44%	
8	Ecocommunal Management	15	60%	
9	Family	17	68%	
10	Localization	16	64%	
11	Governance	13	52%	
12	Security	9	36%	
13	Socially Constructed Helplessness	10	40%	
14	Transition Engagement	16	64%	
15	Financial Model	13	52%	
16	ICT-Initiated Leap Frogging	14	56%	
17	Availability	19	76%	
18	Job Creation	20	80%	
19	Modular System Configuration	19	76%	
20	Survivalism	14	56%	
21	Health Impacts	17	68%	
22	Synthesized/ Contextualized Innovation	22	88%	
23	Infrastructure	18	72%	
24	Maximization	17	68%	

5.1. Implications of Lived Experience on RE Business Outcome

Twenty four out of twenty-five participants reported having had both successful and less successful lived experiences working on renewable energy businesses, while one surmised that all the businesses the respondent has been engaged in and have successful RE business experiences. Eight primary tier findings are identified and discussed in sections 5.1.1 through 5.1.8.

5.1.1. Finding #1

22 out of 25 respondents reported wanting to make a difference and imagining better alternatives as a key source of their motivation. These participants elucidated that their motivation was underpinned by their value reference and connectedness to the community. They

stated they want to make a difference in a multi-dimensional way for the benefit of the host community, environment, and society at large by doing good business and changing the status quo.

5.1.2. Finding #2

17 out of 25 respondents reported Community Based Organization (CBO) engagement to be key enabler for the success of RE businesses. A CBO is self-organizing/emergent community-based organizations that engages in societal endeavors [25].

Our findings indicate that emergent community-based organizations tend to increase access to market and finance by aggregating resources, increasing awareness and mobilizing the community. On the other hand, the lack of CBO engagements seems to be associated with less successful RE business and project experiences.

5.1.3. Finding #3

17 out of 25 respondents reported connectedness as a very important factor for the success of RE business.

Connectedness is defined as building a large tent, rich and complex capacity of blending personal and work life, living and relating with plenty and meager material resources, differentiated technologies, tradition and non-traditional values, peace and chaos simultaneously. Here, its definition is similar to Raskin's [26] and to what Schultz calls inclusion [27]. Research participants reported experiences of affinity and connected with key business stakeholders while they were engaged in RE project.

Furthermore, our research indicates more research participants who had successful renewable energy business and project lived experiences tend to be more connected with the stakeholders of the business/project, the host community, the locality, and the environment of the project than those who had less successful project experiences. This connectedness is expressed in multi-dimensional attributes of identification, understanding, communications, and contextualized symbiotic relationships.

5.1.4. Finding #4

16 out of 25 respondents reported transition engagement to be an important factor in RE business or projects.

Transition engagement is defined as engagement in hastening and effecting transformational [28]. Our research suggests that there is emergent and dynamic transformational engagement in renewable energy development that is contextualized to the local needs, capabilities, and is creating and re-constituting business practices, technology appropriations, education, and customer behavior. Research participants have reported correlation of these engagements and successful renewable energy lived experiences.

5.1.5. Finding #5

16 out of 25 respondents reported that localization is an important factor in RE businesses/projects.

Localization is defined as translation of technologies, knowledge, and instruments to that which are more consistent with the local culture, resources, and capabilities [29]. Our research indicates an emergent shift of emphasis on harnessing and applying local resources, knowing, capabilities and adaptation of appropriate technologies to meet local needs in the context of the local culture. This phenomenon is expressed in-terms of adaptation of efficient cook stoves that is flexible to cook the varied cultural foods, the utilization of corn cobs as a fuel to power bioenergy power generation that supply power to a local agricultural cooperative, reconfiguration of education and training to standards that promote sustainable living, and requirements of increasing local content to imported technologies.

5.1.6. Finding #6

19 out of 25 respondents reported modular system configuration as having a major impact on the performance of RE businesses.

Modular system configuration is a systems design practice

that employs the concept of loosely coupled systems to minimize disturbances/degradation across interfaces, while allowing robust scaling-up or down [30]. As such our research indicate emergent modular & distributed systems configurations are correlated with successful RE engagement experiences. It is observed in emergent power plant and distribution architectures, financial models, flexible small enterprises, and stakeholders' engagements.

5.1.7. Finding #7

20 out of 25 respondents reported stretching [discovery] as a major impetus for their work in RE.

Stretching (discovery) is defined as intentional effort that takes oneself outside ones current or past boundaries to new vistas [31].

Our research findings indicate that key decision makers who are engaged in stretching and discovery are more associated with successful renewable energy development engagements. Furthermore, our research indicates that those who reported that their passion was making a difference in their RE businesses, their community, and society at large have more propensity to be engaged in stretching and discovery endeavors. This group seems to have a strong passion about what they are doing and seem to enjoy the challenge and the reward associated with their work, and life.

5.1.8. Finding #8

In our literature review we found affordability as one of the most important concepts that affect the performance of renewable energy business. However, in our research only 13 out of 25 respondents reported affordability as an important factor in regard to RE businesses and it suggest its importance is contested.

Affordability here is defined as the financial capability of a household to pay for basic energy services. In other words, it is expressed as the monthly energy expenditure of a household divided by its monthly income [32].

Our findings inform us that the meaning and application of affordability has significant difference as it pertains to successful and less successful business and project experiences. Successful projects have utilized total energy cost, and expenditure substitution, "pay as you go, as much as you want at a time", and payment using bit coins [digital money] to make energy access affordable to their customers.

5.2. Secondary Tier Findings

Three are secondary tier findings as a result of importance ranking by research participants that are lower than the primary tier findings, which are not included in this paper. These findings include maximization, and standard development financial model.

6. Discussion

We started the research by investigating and laying out

concepts that impinge on the performance of renewable energy business directly and in-directly and its multi-level implications on environmental, economic, and social spheres. As the research progressed, the concepts that were selected through literature review were validated with varying degrees and new perspectives that are wider in scope have emerged. Furthermore, the environmental implications of energy systems in the context of developing economies are complex and interconnected with economic, social, developmental, and security spheres.

Based on data from the research, the performance of renewable energy business/projects is tenuous and fragmented. It seems to be at the cusp of re-definition and reconfiguration due to complex dynamics and interactions and nested complexity [33] within the eco-social systems and external forces. Renewable energy development is subject to the dynamics of the social system it is embedded in and in turn it shapes the attributes of the social system it belongs to [34]. The forward and backward feedback loops nested in the multivariate dynamic relationships seem to necessitate investigating the performance of renewable energy system in tandem with other spheres of the social system [35].

The key decision makers interviewed reported wanting to make a difference and imagining a better alternative. These participants elucidated that their motivation was underpinned by their value reference and connectedness to the community. They stated they want to make a difference in a multi-dimensional way for the benefit of the host community, the environment, and society at large by doing good business and changing the status quo [36]. These sentiments are exemplified by one research participant's comment:

"My strongest motivation and a force that pushes me to do things are really around people. The fact that everything is done for people and trying to get the biggest potential out of each individual is one of the strongest for me."

Underpinning their connectedness and motivation to make a difference is knowledge and memory creation. This knowledge and memory creation aggregates different knowledge systems, socio-ecological, and socio-technical memory creation that have multi-dimensional attributes and configurations in the social system. These engagements by the research participants were manifested in their expressed motivations and reported behaviors in their lived in experiences in renewable energy businesses and projects and overarching adaptive and resilient capacity building [37]. While connectedness and making a difference are not prominent features of extant literatures on businesses that create sustainable values in the context of developing economies, in our research 22 (out of 25) research participants reported it as very important factor.

Our research further found that community based organizations (CBO) to be key enablers as business gateways that create system wide sustainable value [38]. The CBOs reported by the research participant are not traditional charity organization rather these are community based business organizations that are actively engaged in raising awareness, combining resources, formulating policies, building social and

ecological resiliency through adaptive knowledge and memory creations [39].

As it pertains to transitions engagement, the emergent and dynamic transformational engagements in renewable energy developments, and overarching socio-technical-ecological norms that are contextualized to the local needs, and capabilities, creating and re-constituting business practices, technology appropriations, education training, and customer behavior are different from transitions management and systems innovations found in current literatures [40].

Here, the focus is not simply changing the socio-technical landscape, but it is people focused and it embodies the social construction of technology, knowledge & memory creation, cultural meaning, and redefining development and the development paths of society.

Synthesized and contextualized innovations are holistic innovations that yield the most sustainable value to all the stakeholders, including the ecosphere not only as a tool to gain market advantage. It is augmented by modular systems configurations that enable adaptive capacity and resiliency by reducing cross-interface risk transfer and by increasing flexibility [41].

Our research findings further inform us that the meaning and applications of affordability have significant difference from what is in current literatures. Expenditure substitution, digital/electronic payments for energy services that are configured as "pay-as-you-go" have changed the affordability landscape. Hence, the findings in our research contest the importance of affordability as stated in current literatures.

7. Conclusion and Implications

Based on the data from the research, we ascertain the following conclusions and implications for RE businesses and projects in the context of Africa.

7.1. Nested Complexity of RE Business/Project Performance

Our research suggests the performance of renewable energy businesses to be in nested relationships with three major sectors in social system settings and cannot be viewed in isolation from the social system [42]. These three sectors are identified as knowledge and memory creation at the individual and community level, collective vision/paradigms on development (to be specific energy development), and Input Concepts [ICs]. With these embedded complexities, an integrative approach that combines the effects of nested social, economic, political, and ecological concepts (Page, 2010) may yield a robust and systemic way of gaging the performance of renewable energy businesses [43].

7.2. Community-Based Organizations & Intermediary Businesses Practices

Research participants reported that community-based organization serve as gateways for RE projects facilitating key stakeholders' participation, increasing access by pulling

together their resources, enhancing awareness, and encouraging/demanding that relevant regulatory agencies make an important decision on a timely basis. These activities seem to enable companies/businesses to install RE projects and develop new markets and empower the community.

Gaining a better understanding of the genesis and dynamics of these types of community organization business gateways, which involve new approaches to social innovations, collective action, governance/policy formulations, and intermediary business roles will help to make them more effective [44].

7.3. New Ways of Knowing and Memory Creation

Our research indicates four building blocks shaped and constituted the knowledge base and memory creation of the research participants. These building blocks are self-identification spiritual/value references, and imagining. As it pertains to values, these are values that are both constitutive and contextual [45]. These building blocks interacting with cultural, socio-economic, political, and environmental spheres constituted knowledge and memory creation of the individual and the community. Self-knowledge in the indigenous peoples social and intellectual traditions, which include living in harmony with nature and the larger community/continent are of paramount importance in rediscovering ancient and sustainable African knowledge and memory creation. Natural psychology framework is best suited for these kinds of knowledge and memory creations, which encompass multilevel relational, spiritual, and affective dimensions free from intellectual oppression, colonized mind anti self-disorder [13].

7.4. Continental Transition Discourse

Research participants have reported lived experiences that re-orient educational training, research & development in a new way. Initial experiences from this engagement indicate positive correlation with successful project experiences. Specific transition engagements reported by research participants include:

7.4.1. Energy Resource Transition

Companies that assign its employees to help its customer's transition from utilizing conventional energy sources to renewable energy sources for a period that extends a year to two years.

7.4.2. Education & Training Transition

Re-configuration of educational institution from abstract education to education that enables solutions development to address local challenges.

7.4.3. Research & Development Transition

Re-configuration of research and development to applied research and development in the energy and other sectors to address challenges.

7.4.4. Entrepreneur & Enterprise Incubation Transition

Re-constitution and focus from incubating enterprise to entrepreneurs. The emergence of small flexible enterprises that provide integrated/multi-functional platform solutions.

7.5. Alternative Industrial Development

Our research suggests synthesized and contextualized innovations that are locally produced as key enablers for successful renewable energy businesses [46]. These types of innovations that incubate both entrepreneurs and small flexible enterprises take advantage of the prevailing demographics of technology savvy young people in developing economies. We suggest such developments that are primarily locally focused and augmented by networked and distributed renewable energy-based economy could usher the equivalent of socio-technological paradigm shifts.

7.6. New Wave-Financing

Affordability has been identified as a major problem for wider implementation of renewable energy businesses in Africa in particular. Our research findings indicate that the importance of affordability is nuanced as the majority of the people in Africa spend significant amount of their income on energy [47]. Aggregations, expenditure substitution, investment clubs, micro financing, and pay-as-you go payment combined with the utilization of digital money have made significant headways and are redefining affordability. Pay as you go payment method with Cloud based wireless usage metering and bit coin payment has interesting initial behavioral finance data [48].

8. Alternative Development Paradigm

Based on the data, we propose a conceptual model that includes three major sectors, namely knowledge & memory creation at the individual and community level, collective vision/paradigm on development to be specific energy development, and Input Concepts [ICs]. Portion of the ICs identified in our research have been the focus of prior research, however, our research findings suggest the addition of salient ICs [independent variables] that have significant implications on the performance of renewable energy businesses. The conceptual model developed as the outcome of the research is presented in Figure 4 and the Input Concepts are illustrated in detail in Figure 5. The unit of analysis is individual key business (project) decision maker.

We identified nested complex feed-forward/backward relationships of the performance of renewable energy systems. Furthermore, we identified that the performance of renewable energy businesses cannot be viewed or determined in isolation (contextual reduction) from the social system of the host community and its surroundings. To illustrate these findings, we have developed a new conceptual model that is different from models in current literatures.

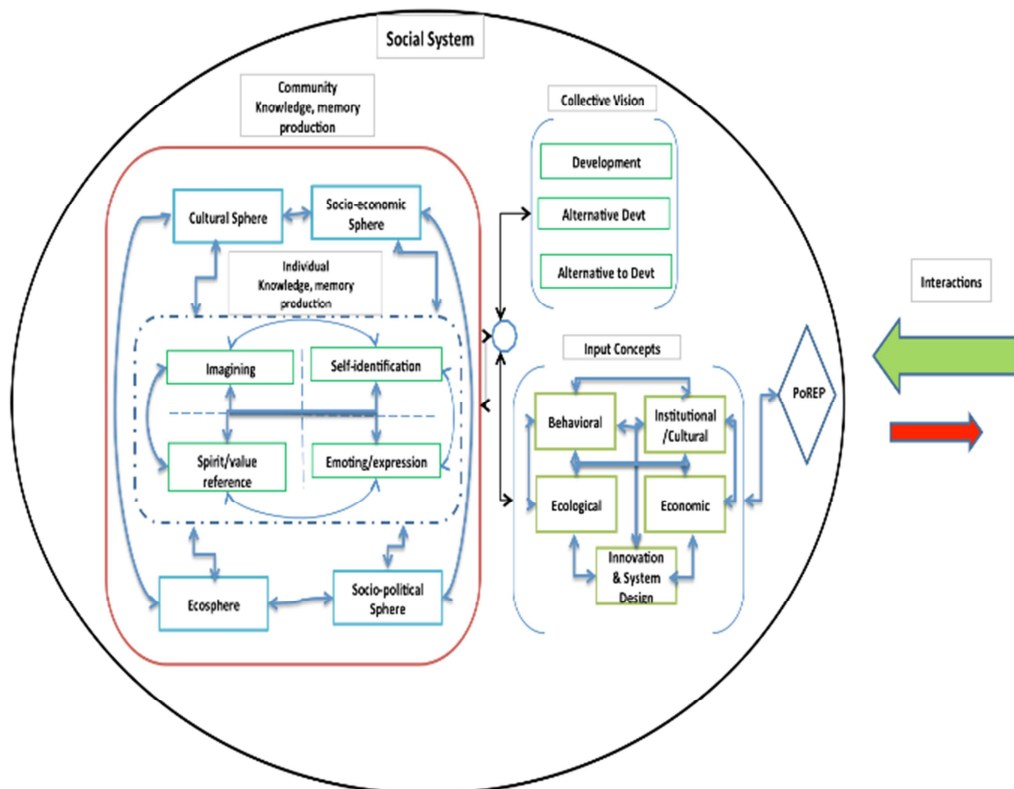


Figure 4. RE Based Development Paradigm.

Legends:

SCP: Socially Constructed Helplessness

CBO: Community Based Organization

TE: Transitions Engagement

PoREP: Performance of Renewable Energy Business/Projects.

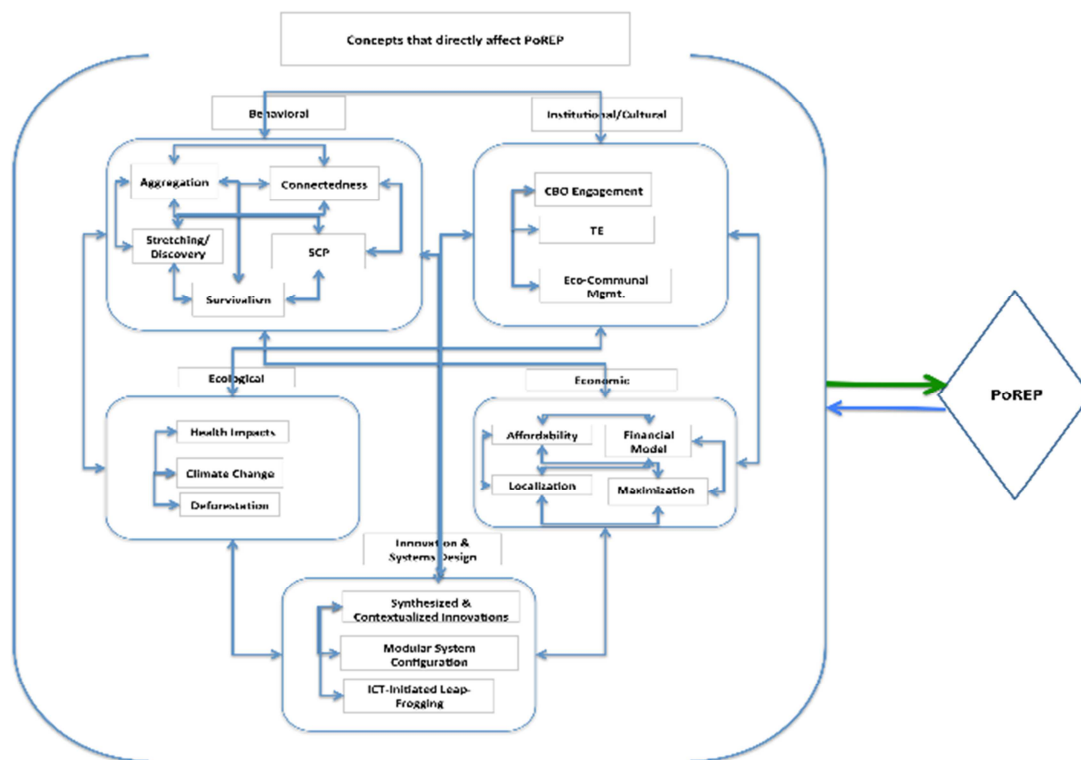


Figure 5. Input Concepts.

We suggest the implication here is that renewable energy businesses possibly could change the socio-technical [34] and social-ecological landscape [39]. Hence, the recommended approach to better understand these dynamics is through an integrative lens, and, more effective results may be achieved with a system wide change.

We have identified several additional elements/concepts (IVs) that were not identified in extant literature review, which have significant implications on the performance of renewable energy businesses/projects. We surmise the integration of the identified independent variables will help to explain the performance of renewable energy businesses better and help practitioners to design and implement more successful renewable energy projects.

We have confirmed the validity of several concepts that were identified in literature reviews, albeit the importance of these variables is nuanced in our findings. We surmise these findings will assist academicians and practitioners to better focus on certain factors that may carry more weight on the outcome of renewable energy businesses/projects.

9. Limitations

Limitations of this research include saturation, which was achieved with sample size of 25 from 17 different African countries. However, it may be considered to be narrowly focused on this region only. It would be an error to claim these findings to be universal. Furthermore, research participants who were interviewed for this research were highly qualified and active in discovery and stretching. As such the data could have been skewed by personality type/interest. Finally, research participants had to recall some incidents that had happened in the past and the fidelity of some of the information is dependent on the accuracy of their memory about the specific situation.

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