Assessment of Public Energy Organizations' Innovation Awareness and Readiness for Climate Action: A Case Study of Icelandic and Kenyan Energy Sectors

Johannes Onjala Ochome

Thesis of 30 ECTS credits

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Abstract

Due to over-reliance on fossil fuels in electricity generation, heating, and transportation, the energy sector is the largest contributor to global GHG emissions, accounting for nearly three-quarters of the 50 billion tons CO_2eq of annual global GHG emissions. Developed and developing economies alike are investing in future energy solutions to meet the ever-increasing energy demand sustainably. The purpose of this study is to determine the understanding and approach to innovation in public energy organizations by investigating the internal drivers of climate action innovation. The study used quantitative research methods, such as structured self-administered, Likert scale-type online questionnaires distributed to public energy organization employees in Iceland and Kenya via QuestionPro Essentials online survey software and was analyzed using IBM SPSS Statistics version 27.

The study's findings revealed that organizational innovation collaboration systems positively predicted the organization's employee innovation awareness. Employee knowledge and skills, on the other hand, were found not to be a predictor of an organization's innovation awareness, despite the fact that theory suggests that education and training equip employees with the knowledge and skills needed to solve difficult tasks, empowering them to innovate and adapt to changing environments and markets. Furthermore, organizational innovation strategy, management structure, and leadership were discovered to be positive predictors of an organization's innovation readiness. Icelandic and Kenyan energy organizations were found to be innovating differently and, as a result, prioritizing climate action projects differently.

Despite the low response rate, this study contributes to innovation research, particularly in the under-researched public sector innovation with a focus on the energy sector. Innovation, being at the heart of climate action, focuses on both technological and policy developments, and is hence key to meeting set climate action goals.

Keywords: *energy security, energy trilemma, public energy sector, public sector innovation, VUCA*

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Október 2022

Útdráttur

Vegna of mikillar þéttni á jarðefnaeldsneyti í raforkuframleiðslu, upphitun og flutningum er orkugeirinn stærsti þátturinn í losun GHG á heimsvísu og er tæplega þrír fjórðu af 50 milljörðum tonna CO_2eq af árlegri losun GHG. Þróað og þróandi hagkerfi fjárfesta í framtíðar orkulausnum til að mæta sívaxandi orkueftirspurn sjálfbærs. Tilgangur þessarar rannsóknar er að ákvarða skilning og nálgun á nýsköpun í opinberum orkusamtökum með því að rannsaka innri drifkraft nýsköpunar loftslagsaðgerða. Rannsóknin notaði megindlegar rannsóknaraðferðir, svo sem skipulögð sjálfstýrð, Likert Scale-gerð spurningalista sem dreift var til starfsmanna opinberra orkusamtaka á Íslandi og Kenýa í gegnum Spurning hugbúnaðar á netinu og var greind með IBM SPSS Statistics útgáfu 27.

Niðurstöður rannsóknarinnar leiddu í ljós að nýsköpunarsamvinnukerfi í skipulagi spáði jákvæðum nýsköpunarvitund starfsmanna. Þekking starfsmanna og færni reyndist aftur á móti ekki vera spá fyrir nýsköpunarvitund stofnunarinnar, þrátt fyrir að kenning bendir til þess að menntun og þjálfun búi starfsmönnum með þá þekkingu og færni sem þarf til að leysa erfið verkefni, sem styrkja þá til nýsköpunar og laga sig að breyttum umhverfi og mörkuðum. Ennfremur kom í ljós að nýsköpunarstefna, stjórnunarskipulag og forysta voru jákvæðir spáir um nýsköpunarviðbúnað stofnunarinnar. Íslensk og Kenísk orkusamtök reyndust vera nýsköpun á annan hátt og þar af leiðandi forgangsraða verkefnum loftslagsaðgerða á annan hátt.

Þrátt fyrir lítið svarhlutfall stuðlar þessi rannsókn að nýsköpunarrannsóknum, sérstaklega í undirrannsakaðri nýsköpun opinberra geira með áherslu á orkugeirann. Nýsköpun, að vera kjarninn í loftslagsaðgerðum, beinist bæði að tækni- og stefnumótun og er því lykillinn að því að uppfylla markmið loftslagsaðgerða.

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Date

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Johannes O. Ochome

Master of Science

Dedication

In memory of my late sister, Everlyne Awuor Ochome

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1 Introduction

1.1 Background

The world is grappling with “wicked problems” [1] such as the Covid-19 pandemic, rising political and social conflicts with growing distrust in governments, energy security concerns with increasing global demand for cleaner, greener, renewable energy solutions, rapid technological advancements with diminishing critical mineral resources, and climate change threatening life on land and in seas [2]–[10]. The situation describes a VUCA world, a world with higher volatility, uncertainty, complexity, and ambiguity, and there is no longer one single way of managing, producing, or delivering goods and services.

Sustainable energy is critical in combating climate change and achieving the UN Sustainable Development Goals (SDGs), particularly SDG 7 on *"Affordable and Clean Energy,"* SDG 9 on *"Energy and Industry, Innovation, and Infrastructure,"* and SDG 13 on *"Climate Action"* [11]. It has the potential to improve land life by raising living standards, creating jobs, and protecting the environment through the development and adoption of renewable energy technologies, as well as increasing energy efficiency and conservation, thereby reducing greenhouse gas emissions [9], [12]. This shall be achieved by the proper management of the competing energy demands, that is, the energy trilemma; 1) energy security, 2) energy affordability, and accessibility, and 3) energy emissions and the environment [13]. The energy sector is the largest contributor to global GHG emissions contributing close to three-quarters of the 50 billion tons CO_2eq of annual global GHG emissions, due to its over-reliance on fossil fuels, especially in electricity generation, heating, and transportation [14]. Energy sector performance impacts, directly and indirectly, the performance of almost all other sectors of the economy including health, education, transport and communication, security, ICT, and the environmental sectors, and thus has a direct correlation with a country’s economy (GDP) [12], [15]. While energy policies’ impact on the economy is predominantly positive, different economies or regions are expected to respond differently to different energy policies [15].

Developed and developing economies alike, are investing in future energy solutions to sustainably meet the ever-increasing energy demand. Global electricity access stands at 90% with nearly half of Africa’s population (570 million) without access and 80% of the connected population suffering frequent supply interruptions [16], [17]. While Iceland’s primary energy source is 90% renewable, geothermal and hydro, for mainly space heating and electricity production with 100% electricity accessibility [18], [19], Kenya’s primary energy source is over 60% biomass with high demand for cooking and heating using wood and charcoal, especially in the rural areas [20] with almost 16 million people not yet connected to electricity [21], [22]. Despite the differences between the Kenyan and Icelandic economies and their varying energy challenges and development priorities, the race toward meeting net-zero emissions targets requires investments in innovation to handle the energy trilemma to sustainably meet the ever-rising global energy demand, especially in emerging economies like Kenya [23]–[25].

Innovation is, therefore, crucial to urgently meet these challenges sustainably and cost-effectively. It shall require public and private sector collaboration in the research and development of innovative, incremental, and disruptive, energy solutions [13]. The Organization for Economic Co-operation and Development (OECD) Oslo Manual 2018 defines innovation as "*a new or improved product or process (or a combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process)*" [26]. The challenge, therefore, is to develop new technologies and policies and/or improve the existing ones to ensure energy security through efficient production from renewable and low-carbon energy sources, improve energy access for all and abate energy GHG emissions.

Limited data and studies on public sector innovation have generally led to a lack of a proper measurement framework of innovation by the public sector [27], [28] with over-reliance on economic theories and private sector innovation experience [29]. Despite this, public sector organizations seem to be at the forefront of innovation, especially relating to policy development and collaborative innovation, albeit they are generally less equipped to respond effectively to nonroutine, nonstandard challenges due to their conservative, bureaucratic structures [1] making them slow-moving and late adopters of innovation [30, p. 5], [31], [32].

This study looks into the sector's innovation awareness, preparedness, and gaps in order to avert the energy-related environmental crisis in Iceland and Kenya and meet set climate action targets of net-zero emissions by 2050. The study attempts to identify innovation opportunities in the public energy sector in response to a call for urgent climate action while enhancing future energy security and recognizing that each country's energy challenges are both unique and complex.

1.2 Significance of the study

Energy is a public good and its development directly affects a country's economic performance. Sharma's (2010) study indicated that Europe's economy is significantly affected by energy, electric and non-electric and that enacting energy or electricity conservation policies would negatively impact its economic growth as it shall reduce energy consumption [15]. The study also concludes that, unlike Europe, the Sub-Saharan African (SSA) region's economic growth is not affected by the enforcement of energy conservation and electricity conservation policies and that non-electric type of energy variables have a greater impact on the economy than electric variables. This study seeks to assess the public energy sectors' differences and convergence in innovation approaches while comparing a developed and developing country's innovation awareness and readiness to deal with a VUCA-world energy challenges.

Several ambitious climate action strategies have been initiated like the net-zero emission strategy to limit anthropogenic GHG emissions by 2050 and keep global warming below 1.5°C above the pre-industrial era global temperatures [5]. The energy sector, public and private, have thus to respond by adopting and developing breakthrough innovative technologies, processes, and policies that would promote the sector's commitment to these strategies especially in managing the energy trilemma to ensure sustainability in energy development and environmental management that will result in economic sustainability.

This study shall contribute to supplementing available studies, literature, and existing theories of public sector innovation with more focus on technical sectors like the energy sector's electricity sub-sector. It also endeavors to assist nations in policy development prioritization based on the energy sector's awareness and readiness levels for innovation and innovation activities.

1.3 Aim and Objectives

With a comparative study of public energy organizations in Kenya and Iceland, this research aims to determine the awareness and approach to innovation in public organizations, by examining the internal drivers of innovation like employee awareness and motivation, organizational and management structures, corporate cultures (strategy and risk), and innovation outcomes. The research shall seek to answer the following questions,

- How do public energy organizations innovate? Are they innovation generators, adopters, or imitators?
- Are the public energy organizations' innovation culture transforming to innovation-as-usual?

- How are public energy organizations handling climate action challenges?

1.3.1 Research hypothesis

This study attempts to develop some theory on public energy sector innovation that will be empirically tested. The following hypotheses relating to organization's internal innovation drivers were suggested for the study.

H1: *An organizations' innovation culture is more positively related to the organizations' innovation management, structure, and leadership.*

Innovation activities require high acceptance of risk, long gestation periods, experimentation with possibility of failure and therefore, huge financial resources to support the risks and costs [33]. Generally, governments are risk averse, and this influences the innovation strategy of the public organization to take on projects that do not have high risk of failure [33]. Organizations generally need sufficient leadership capacity to detect, interpret, and act on ambiguous signals of threats and seize arising opportunities to maximize gains with a long-term plan [34].

H2: *An organizations' innovation readiness is more positively related to the employees' motivation to innovate despite the country of operation.*

Just like customer satisfaction being critical to an organization's going concern concerning its products or services, so is the motivation levels of innovation generators. Conditions at the work like ease of decision making, control of funds, lateral communication, reward schemes inspire the innovators to put more effort into new the organization's innovation activities and remain in the organization [35]. Investing in employee welfare by improving work safety, easing communication, and giving them more decision-making roles, may improve the organization's innovation readiness score.

H3: *Public energy organizations' innovation readiness is more positively related to the employee knowledge, training, and competence.*

Skilled human resources are key to innovation readiness of an organization. The private sector is seen to be most attractive to skilled personnel with the prospects of better pay, more freedom to experiment, higher risk appetite, less bureaucratic organizational structures. Therefore, opportunities for employees to access relevant training on emerging technologies within the organization would translate to better innovation response. Public organizations are posed to remain bureaucratic or create new bureaucracy with changes in the public administration processes [36] implying a less attractive environment for innovative personnel.

H4: *Public energy organizations' innovation awareness is more positively related to the collaborative innovations undertaken by the organization.*

In the era of New Public Management, cross-sector collaboration has been encouraged with the intention of spurring entrepreneurship and innovativeness into public organizations as exchange of knowledge, experiences, information, values, cultures and resources over time, produces innovative outcomes [31], [37], [38]. How best the public organizations explore and exploit these opportunities, determines their pathway in the innovation journey.

H5*: Public sector organizations in Iceland innovate differently from those in Kenya.*

H6: *Climate action projects are more prioritized in Kenya than in Iceland.*

1.4 The Structure of the Thesis

The thesis begins with an introduction in chapter one, which introduces the topic as well as the goals and objectives. Chapter two is a review of recent scientific research studies on innovation, with a focus on public sector innovation versus private sector innovation and the impact of the emerging VUCA world on public energy sector innovation by going through scientific papers, articles, books, reports, and policies on the subject. The techniques or systems for measuring innovation are also examined here. The approach employed in this thesis and how the study was done is detailed in the third chapter. The findings are examined and reported in the fourth chapter. The results are discussed in chapter five. The research limitations and future research opportunities are highlighted in chapter six and the thesis concludes with a summary of the research outcome in chapter seven.

2 Literature review

2.1 Innovation

2.1.1 Definition

It is an organization's mission to remain relevant and ahead of the competition in fulfilling the customers' needs. Governments alike, have had transformative agendas with innovation as their key pillar for economic growth. As customers' needs keep varying, so follows the nature of products and services delivered by the organizations. Organizations have to continuously evolve their products and processes to maintain or grow their market share or maintain their relevance with change as the core factor for their survival [39] and to have a competitive advantage over their competitors. This deliberate, systematic, and continuous approach by organizations to appraise and renew their products, processes, or market presence is a step towards innovation. Innovation is thus a key driver for economic growth and development providing a foundation for new businesses, new jobs, and productivity growth [40].

Before Schumpeter, innovation was known as something unusual [41]. Schumpeter later defined innovation as the process of formation of any or combinations of new products or services, new processes, raw sources of raw materials, new markets, and new forms of organizations [42] revolutionizing the economic structure from within destroying the old one and creating a new one [41]. Schumpeter idealized that innovation had to be radical or revolutionary and now considered disruptive, rendering other existing products and processes irrelevant in the market space. Schumpeter theorized that economic transformation is a function of both innovation and entrepreneurial activities yielding satisfaction and profit as a reward for performance because of market power [39].

Peter Drucker, the founder of modern management, also considered innovation as a specific function of entrepreneurship, as the effort to create purposeful, focused change in an enterprise's economy or social potential to set a standard, and direction for a new technology of new industry, or creating a business that is and remains ahead of others [43]. Drucker concludes that it is through innovation that entrepreneurs create new wealth-producing resources or endow existing resources with enhanced potential for creating wealth and that the practice of systematic innovation is the foundation of entrepreneurship. Drucker's definition introduces the essence of value creation and incremental innovation with entrepreneurial hindsight.

Innovations involve converting ideas and inventions into useful applications for the market or an organization's internal operation [26], [44, p. 13]. It is problem-driven and its purpose is to solve problems with practical or organizational solutions [45]. OECD Manual (2018) defines innovation as a new or improved product or process, significantly different from the previous version, made available for use by an organization or its unit. A product or process may be considered novel to the entire world, a population of similar organizations, or a single organization or its unit [26], [46]. When compared to the state-of-the-art in the sector or industry, or in its market region, newness can be seen as disruptive or radical products or processes, as well as a game-changer. Therefore, an organization can become an innovation developer, adopter, or imitator based on the degree of newness of an innovation [26], [47].

Going by the definitions by Schumpeter, Drucker, and the OECD, organizations need to invest time and effort in systematically studying the market trends and customer response to these trends and react accordingly by either developing products and/or processes to match or supersede the trending ones or adopt new trends [48]. By doing so, the organizations maintain either their lead or market share for the provision of their products and services.

For this research, innovation, as applicable to public energy sectors, is the strategic, systematic, and purposeful development of ideas into new products, processes, or cultures (incremental or radical), or the adoption of new products, processes, or cultures fundamentally different from previous ones, or the creation of entirely new organizations, organization units or markets in response to market and consumer dynamics to generate satisfactory results.

2.1.2 Innovation and entrepreneurship

Bull and Willard (1993) share Schumpeter's understanding of an entrepreneur as the one who exploits innovation or carries out innovation activities, that is, the person who carries out new combinations (untried technological possibilities for producing a new commodity or an old one in a new way, opening up a new source of supply of materials, or a new outlet for products or reorganizing the industry itself), causing discontinuity by revolutionizing the pattern of production [49].

Therefore, according to Schumpeter [39], it is the entrepreneur who creates the innovation and there is no innovation without entrepreneurship. The entrepreneur's primary motivation is independence to work as they would like, ask for or develop novel unusual solutions acting in the venture's long-term best interest [50]. In their research, Herbig et al. (2014) state that "Entrepreneurs themselves do not consciously innovate;

they seek opportunities" those ignored or not undertaken by other larger firms due to their bureaucratic tendencies and therefore does not in itself guarantee innovation. Individual entrepreneurs want to achieve technical contribution, recognition, power, and independence as much as money [51] and therefore require also human resources (technical, marketing, and managerial) to assist in turning their dream ideas into reality [50]. To the entrepreneur, change is a normal and healthy event and so they respond to change to exploit opportunities and shift resources from areas of low productivity and yield to areas of high productivity and yield [50].

Entrepreneurship, according to Schumpeter, is the force that accounts for change and development in a dynamic economy, and its quality determines the speed of capital growth, as well as whether that growth will involve innovation and change resulting in a continuous wave of "creative destruction" of existing ideas, skills, technologies, and equipment [39]. However, all these depend on the rate of diffusion of the innovation through the wide uptake of the innovation throughout the market of potential adopters. The rate of diffusion of innovation shall depend on the innovation's compatibility with values, beliefs, customs, and past experiences of individuals or organizations in the system [39], [52] and the entrepreneur's determination to promote his belief in the innovation despite setbacks and events that threaten its success [30, p. 12].

Entrepreneurship levels thus represent an organization's behavior – structure and culture that is related to and supports the change and innovation [50], [53]. Entrepreneurship and innovation are complementary, dynamic, and holistic processes where entrepreneurship continuously looks for and creates opportunities thereby stimulating the generation of innovation [53].

2.1.3 Innovation in organizations

Damanpour and Wischnevsky's (2006) study on organizational innovation classifies technical organizations as either innovation-generating or innovation-adopting organizations or units of organizations. Innovation generating organizations (IGO) depend on technological knowledge and market capabilities for the commercialization of developed innovation while innovation adopting organizations (IAO) rely on managerial and organizations' abilities to select and assimilate innovation for their operations [47].

The choice of either being an IGO or an IAO is determined by the organization's strategy-structure interplay for innovation and technology management. Christensen's [54] analysis of the strategy-structure relationship in technology-based organizations found that the organization founder(s)' initial strategic inclination, the organization's initial product successes, or the product market prospects had a great impact on the organization's strategy and structure way into the future. Therefore, to understand an organization's innovation, one must study if it is an innovation-generating or innovation-adopting organization [47].

While the assertion "innovate or die", largely attributed to Peter Drucker [55], resonates soundly with organizations, technologies, and enterprises that have fallen due to their lethargy in innovation, there is little evidence of a direct relationship between innovation and organization performance [56], [57]. With adequate capital, appropriate organization infrastructure, and the requisite entrepreneurial environment and capacity, innovation in organizations would thrive [50]. Positive organization structures including an increasing focus on capital formation, changing institutional relationships, supportive government programs, reassessment of intellectual property, and new approaches to innovation are critical to creating a fertile environment for entrepreneurship and innovation. Organizations should, therefore, eliminate any negative influences since the best way to kill off an economy is to eliminate its innovativeness, entrepreneurs, and new ventures [50].

2.1.4 Innovation measurement

Organizations measure innovations' success to get information on their development, monitor and evaluate their performance and control their inputs and processes [29]. Measurement of innovation success (impact and performance) requires an agreement on the definition of innovation in the context of the sector [27], [46]. Due to the limited data and studies on public sector innovation, there is generally a lack of a proper measurement framework of innovation in the public sector compared to the private sector [27], [28] with overreliance on economic theories and private sector experience [29]. However, some studies have been done on public innovation measurement, and metrics developed for public sector innovation including in Nordic countries [58], Australian public sector [27], and OECD countries [29] while Global Innovation Index, Innovation Capacity Index, European Innovation Scoreboard carry out regular global innovation performance measurement [59].

Different approaches have been applied to assess the success of innovation at country, sector, agency, organization or business unit, project team, and individual levels [29], [59] based on the problem and the intended data users; policymakers, organizations, general public or academia and research community [29]. For this research, a survey is used to measures the public organizations' internal environment, to assess the staff awareness on innovation and the organizations' readiness for research and develop and deploy new and/or significantly improved products and services or processes for the market (citizens) especially in response to the global climate action targets including 2050 net-zero targets and the energy trilemma (energy security, equity - access and affordability and the environment) to achieve SDG 7, 9 and 13.

2.2 Energy sector innovation in a VUCA world

There are all indications that we are in a VUCA world today characterized by global challenges including climate change [4], [60], Covid-19 pandemic [6], [7], political intolerance and threats of war [8], food and energy security [4], diminishing natural resources [9], rapid technological changes [7], and industrial revolution 4.0 (4IR) and cyber security and artificial intelligence (AI) [10]. Developed originally at the US War College during the end of World War II, the acronym VUCA stands for volatility, uncertainty, complexity, and ambiguity and is generally applied to describe the forces impacting business environments today [61], [62].

The United Nations Intergovernmental Panel on Climate Change (IPCC) in 2018 recommended that global emissions need to reach net-zero by 2050 to have a 50% chance of capping global warming [63]. By the end of 2020, more than 12 countries and the EU have set a target to realize net-zero emissions by 2050 and China by 2060 [64] to invest in low-carbon sources, renewable energy including renewable hydrogen, scaling up nuclear power while phasing out coal-fired plants [63].

As climate change becomes a reality, nearly all governments, 190 countries, have enacted policies and set targets, nationally determined contributions (NDCs) for climate action under the 2015 Paris Agreement to try to limit the rise of average global temperature to 1.5 °C above the pre-industrial global temperature [64]. The energy sector contributes about two-thirds of the global greenhouse gas (GHG) emissions [14] with direct heat and cooling and transport sub-sectors accounting for one-half and one-third of the total energy consumption [64]. It is, therefore, important that the sector takes all necessary measures to reverse the trend to combat climate change by adopting renewable energy technologies and reducing of reliance and use of fossil-based fuels for industrial, transport, building and electricity sub-sectors, and adapting technologies with increased energy efficiency and conservation to the changing climate and its effects [9]. Further, public-private energy sector collaboration is key in the pursuit of solutions including knowledge sharing, new technologies, and policies development, and coordinated action to avert future crises [65] by discretely examining each element of VUCA, individually or as a combination [66], concerning the sector activities to identify and strategize on the acceleration of adoption of renewable and clean energy, improvement of energy efficiencies, and reduction of emissions from fossil fuels.

2.2.1 Volatility

Oil prices are affected by global events, pandemics, geopolitics, and climate alike as shown by the Covid-19 pandemic in 2020 which led to an unprecedented low price level over summer and a rapid record-high increase in the winter of 2020-2021 due to harsh winter conditions in parts of North-East Asia [67]. The Russian invasion of Ukraine in February 2022 led to an immediate spike in crude oil prices to more than $100 per barrel [68], [69]. Certain changes are relatively unstable, frequent, and sometimes unpredictable causing market volatility. Volatility requires agility to take the opportunity to build their slack resource availability preparing for the challenge ahead [66].

2.2.2 Uncertainty

Uncertainty exists in situations where there is a lack of knowledge or adequate information on the occurrence and significance of a certain event [66] as is the case with disruptive natural disasters which cannot be precisely predicted [70]. Disasters such as wars, pandemics, accidents, and extreme climate events may be preventable and controlled at times, but they are very uncertain and so unpredictable [62].

For example, the Covid-19 pandemic led to a decline in global oil demand in 2020 by 8.4%, coal demand especially in developing countries by 5.7%, natural gas demand declined by 3% of oil equivalent from the pre-Covid forecast, and a delay in renewables energy installations by 3.6% of oil equivalent in 2020 due to changing lifestyles, country lockdowns and reduction in industrial activities and generation [71], [72]. The global coal-fired power plants' future is uncertain, considering the calls to shut them down and redirect funding towards renewables to accelerate energy transition [4], [73] calling for research and investment in alternative, cleaner energy mix to cover the gap in supply and for flexible options like thermal energy storage [74]. What scenarios exist or have been tested for a 100% renewable future? Is it sustainable?

2.2.3 Complexity

The biggest energy sector challenge is meeting the ever-increasing global energy demand, given the need to combat climate change by reducing fossil fuel dependence [5, p. 44]. Energy demand in developing countries, which has tripled since 2000, is predicted to be greater compared to developed countries in the future due to the expected increased access to marketed energy, rapid population growth, and urbanization projections [23], [24].

The energy transition is seen to be inconsistent across jurisdictions, especially in developing countries [24]. Societies must thus be open, have a high-risk appetite for newness, and build cultures that do not restrict knowledge or dictate the path of technological growth [50]. Public sectors' structural reorganization is necessary to strategically handle the complex dynamics in the sector with proposed developments in; e-mobility, energy storage (batteries, pumped storage, green hydrogen), digital technologies and artificial intelligence, smart cities, smart grids, supergrids interconnectivity, net-metering, carbon capture utilization and storage (CCUS), and investment in circular economies among other ideas to drive global technological and cultural change towards achieving net-zero emissions [9], [75]–[77]. The development of these innovative ideas will variably impact future energy demand capacities. To realize the ambitious energy sector proposals, systematic technological, organizational, and policy innovation is required [9] with a perspective of the internal and environmental risks considerations of a VUCA world [75].

2.2.4 Ambiguity

Ambiguity arises due to a lack of knowledge about outcomes of events that are; certain, have occurred already, or are yet to occur [78], cause and effects are understood and there is no precedent for making predictions as to what to expect [66]. Because of the newness of the product, market, technology, or opportunity, there is no historical precedent for determining the outcomes of certain causes or actions [66].

The path toward net-zero emissions will lead to a substantial reduction in oil and gas production to decarbonize the energy sector thereby increasing the focus on energy security [70]. However, the reference to the term "energy security" by scholars, organizations, national governments, and other policymakers has been rather ambiguous with different levels of uncertainty [70]. The understanding of energy security varies in policy development and scholarly works mostly attributing the concept to energy supply, reliability, flexibility, affordability, accessibility, and acceptability concerning geological, environmental, social-economic, and political factors [70], [79]. Therefore, the analysis of the concept of energy security requires a multi-perspective approach looking at energy security strategies towards energy efficiency, energy storage, and diversification of supply and suppliers [79].

Demystifying and managing the ambiguity in the energy transition to renewables towards meeting net-zero GHG emissions targets for assurance of energy security will require policy innovation with focused continuous state interventions [80], and intelligent experimentation [66]. It is, however, unclear when total decarbonization will be achieved given the transnational and multi-institutional approaches with different operating principles and policy frameworks and the technological limitations in efficiency and affordability (economic attractiveness) [74].

2.3 Public sector innovation

2.3.1 Public organizations

The public sector includes all institutions owned and controlled by the government (public administration entities, regulatory agencies, ministries, municipalities, and publicly owned corporations) including public business enterprises [26], [46]. They operate in line with public policy and are often influenced by political forces to provide for their citizens' social needs including; basic goods and services that the private sector may not efficiently provide [26, p. 60], [81]. The public sector's mandate thus remains to improve the citizens' welfare with better quality of life [45] meet their public needs and maintain public order [36]. On the other hand, private sector organizations are privately owned and controlled and engage in profit-making ventures. In some countries, however, both public and private organizations provide basic goods and services like education, health care, transport, energy, and social services [46].

The public sector institutions are either government units or public corporations [26, p. 60]. At the national, regional, and municipal levels, government units are formed through a political process involving legislative, judicial, and executive authorities. These units do not charge prices that are economically significant for their goods and services. Public corporations, on the other hand, are a part of the business enterprise sector, along with private organizations, whose range of products and services, like that of government units, is determined by political and social considerations, but most often offer their products and services to the market at economically significant prices [26, p. 180] but based on political and social considerations and not usually informed by economic objectives [26, p. 60].

2.3.2 Public innovation drivers and barriers

The public sector keeps changing over time due to the evolving social, economic, and environmental challenges, such as climate change, rising energy demand, rising unemployment, homelessness, and the need for economic restructuring. These challenges require institutional collaboration, review of public policies, and strategies to get the requisite knowledge, resources, or cultural insights to tackle them [82]. They thus pose an opportunity to innovate - improve on the goods and services offered and processes or development or adoption of totally new goods, services, and processes - to maintain a competitive advantage. Public sector institutions are, however, seen as bureaucratic, conservative, and slow-moving and only change as a consequence of changes outside them thus adopting innovation, most often, late after development [30, p. 5], [31].

While innovation in the private sector is motivated by competition, profit, market share, and growth in size, public sector innovation is usually hindered by lack of competition, limited financial incentives for improvement, risk aversion, rigid laws and regulations, and large and complex organizational structures [31]. Despite being seen as slow and bureaucratic, the public sector is more dynamic and innovative than perceived and thus plays a crucial role in setting the pace for innovation adoption [31]. Different actors have pushed for public sector innovation like the politicians who take opportunities to shine through the introduction of new ideas and calls for policy changes, managers and employees are quickly adapting to the ever-changing public sector policies to improve services and respond to new problems, strategies and administration, the citizens are getting more involved in the government business giving critical and constructive feedback on policies and services [31].

2.3.3 Public administration and collaborative innovations

Due to the general lack of competition and hence lack of incentive to improve, the future of public sector innovation lies in the links between the public and private sectors in solving ever-changing societal problems to improve their performance and efficiencies and restore trust [31], [37]. The New Public Management (NPM) reform programs in most OECD countries, introduced private sector innovation drivers like strategic management and competition into the public sector to create a more cost-effective, smaller, and efficient public administration for improvement of service delivery, budgetary and human resource efficiency, and effectiveness [83], [84]. Collaborative innovation is still what produces innovation since "*public innovation is a team sport rather than the work of lone wolves*" [85]. The success of the collaborative innovation shall, however, depend on the partners' shared sense of the outcome, the quality of communication and trust, how they manage to reach a consensus despite their conflicts, and the availability of the cost and risk-sharing mechanism [26, p. 134], [86]. Even the failure of a collaborative innovation process brings with it a spin-off in terms of social capital, a new understanding of problems, creative ideas for future innovation of adoption of new values [37], [85].

Developing countries, influenced by policy experiments and organizational practices originating from OECD countries, have slowly and selectively adopted public sector reforms since they require consistent political leadership in policy direction and top officials' and central departments' endorsement [83], [87]. In response to globalization, donor funding constraints, and citizen participation, several developing economies have adopted a hybrid of public administration models that combine components of different public administration models. The demand for a more citizen-centered, collaborative government has given birth to the New Public Service (NPS) model, which is based on the concept of active and engaged citizenship [83]. Multi-sectoral innovation collaboration shall bring together all required public innovation assets (knowledge, capital, and human resources) at any stage of the innovation to create a body of knowledge together with sector partners including, suppliers, enterprises, research institutions, other public organizations, and citizens [31], [37], [88, p. 138], [89].

According to International Energy Agency (IEA) (2021), the private sector's contribution to the global energy sector is significant to meet the world's energy requirement projected to increase by 40% by 2050 with over 40% from renewable energy sources by 2030 [90]. This is due to the need to mitigate GHG emissions by reducing fossil fuels and implementing Net Zero Emissions (NZE) strategies to meet the set limit of 1.5 °C stabilization in rising global temperatures above pre-industrial levels by 2050 with electric vehicles as the major source of demand growth [9], [90] underscoring the need for a strengthened public-private collaborative innovation.

2.3.4 Leadership

VUCA environment calls for organizations to be vigilant and prepared to appropriately respond to challenges and seize opportunities for their competitive advantage despite the risks of taking up new projects which may be more uncertain and challenging [34]. Innovation in a VUCA world thus requires dynamic thinking leaders capable of sensing change, timely seizing opportunities and transforming organizations' ecosystems where possible [34], [91]. Bawany (2018) argues that creating a vision is no longer enough, organizations must focus on career strategies, talent mobility, and organization ecosystem to transform itself and its workforce [92].

Innovation "newness" requires high degree of freedom for experimentation of ideas, adequate fund allocation for prototyping and acceptance of risks for failure without losing focus for the core business and keeping stakeholders satisfied [66], [75], [91]. To do this, the organization leadership must adapt and promote agile behavior pushing for more flexibility and decision-making roles at lower levels of the organization structure [91], [93].

3 Methodology

This chapter describes the study's methodological approach in detail, including the study's purpose and design, data sampling, collection, analysis, and interpretation. This research is being carried out to assess innovation awareness and practices in the public energy sectors of Iceland and Kenya. The findings will be used to build an argument about the level of the sector´s innovation awareness and readiness, as well as the gaps in those levels when compared to known innovation indicators for resolving the energy trilemma toward net-zero emissions national targets.

3.1 Research Approach

The first step was to carry out a review of existing theories, research and literature on public sector innovation followed by a background study of the Icelandic and Kenyan public energy sectors to identify their structure, actors, policies, and opportunities for innovation, as detailed in Appendix A. When deciding on the research methods for the study, it was considered to use analytical tools such as systems dynamics modeling to investigate the impacts of public energy policies relating to the energy trilemma on innovations in the public energy sector, but there was a time constraint to carry out the model design. To engage the public energy sector actors through surveys using interviews and structured questionnaires to compare the Icelandic and Kenyan scenarios, a qualitative study was the next available option.

While the research does not aim to determine who is better at innovation or to measure the performance of individual public sector organizations, it does aim to identify areas for improvement to strengthen the innovation and entrepreneurship culture in public energy sector organizations. With the approval of the organizations' top management, all employees in the public energy sector at all levels were invited to participate in the survey.

3.2 Research Design

When deciding on a research method for the study survey, the use of either qualitative, quantitative, or mixed-method research was considered. While qualitative research can be used to gain in-depth insight into a problem by collecting and analyzing non-numerical data to understand problems and/or obtain opinions, it has a significant challenge in replicability because the researcher decides what is important and relevant in the data analysis, and thus interpretation may vary in the future [94], [95].

Quantitative research, on the other hand, entails the collection and use of numerical data for statistical analysis to discover patterns, and averages, make predictions, generalize results to larger populations, or comprehend a causal relationship [94]. Quantitative research methods include descriptive, correlational, and experimental research design approaches. Descriptive research merely obtains a summary of the study variables, whereas correlational research investigates the relationship between the study variables [94]. The systematic examination of a cause-effect relationship between study variables is the focus of experimental research [94].

Statistics can be used to test research hypotheses or predictions in both correlational and experimental research. Quantitative research findings may be generalized to a larger population based on the sampling technique. While quantitative research is reliable, with results that can be replicated across different cultural settings, periods, or groups, it can suffer from structural bias due to insufficient data, low participant responses, imprecise measurements, or inappropriate sampling methods, which can lead to incorrect conclusions [94].

Gelo et al. (2009), discuss the use of mixed methods research (MMR) which integrates qualitative and quantitative research approaches to overcome their individual limitations [94]. MMR presents an option that maximizes the advantages and minimizes the limitations connected to a single option of either qualitative or quantitative research method leading to increased accuracy and meaningfulness of data interpretation and study conclusions [94]–[96]. MMR approaches are based on either choosing to use a pure mixed-method giving equal status to qualitative and quantitative information or having one approach (qualitative or quantitative) dominating the other [95]. The data collection can be done either concurrently or sequentially, one approach after another to either explain the qualitative findings or explore the quantitative results [94]. MMR approaches, however, generally require a high level of research skills and expertise, more time, effort, and resources [95], and are considered difficult for a single researcher [95], [97].

While MMR is the most preferred research method due to its significant advantage of improved study conclusion accuracy and validity, it requires more time, researchers, and resources to complete. As a result, a quantitative research method, using a structured self-administered questionnaire, was considered the best alternative for this study.

3.3 Sampling

3.3.1 Sampling frame

Since it is impractical to carry out a survey involving all members of the population (the energy sector) due to its large size, a representative sample is chosen to participate.

The energy sector is broad, therefore, for this study, the electricity sub-sector was considered for the survey with representative public organizations in electricity regulation, generation, transmission, and distribution. It is considered that a public organization is that in which the government, national or municipal, has a controlling stake, that is, more than 50% shareholding. The same survey shall be conducted for response in Iceland and Kenya for result analysis. The list of some public energy organizations considered for the participation, as listed in Table 1, was generated based on the organizations ownership and engagement in electricity sub-sector as given by their involvement in the sub-sector (see Figure 11 and Figure 14 in Appendix A).

Table 1: Public Electricity Sub-Sector Organizations Considered for the Survey[1]

Sub-sector	Kenya	Iceland
Regulation	Energy and Petroleum Regulatory Authority (EPRA)	National Energy Authority (NEA) / Orkustofnun, ISOR
Generation	Kenya Electricity Generating Company PLC (KenGen)	Landsvirkjun
	Geothermal Development Company (GDC)	Orka náttúrunnar ohf.
Transmission	Kenya Transmission Company (KETRACO) Kenya Power and Lighting Company PLC (Kenya Power)	Landsnet hf.
Distribution	Kenya Power and Lighting Company PLC (Kenya Power)	Landsnet hf.
	Rural Electrification and Renewable Energy Corporation (REREC)	ON Power ohf. RARIK ohf.

3.3.2 Sampling technique

Quantitative research can use probabilistic sampling, in which every member of the population has the same chance of being included in the sample, or purposive sampling, in which a criterion is used to replace the principle of canceled random error [94], [98]. Simple random sampling, systematic random sampling, stratified random sampling, and cluster sampling are all probabilistic sampling strategies [94], [98]. While qualitative research primarily employs purposive sampling strategies that allow for an in-depth examination of information-rich cases. Purposive sampling techniques include homogeneous case sampling, snowball sampling, extreme/deviant case sampling, and typical case sampling [94].

Findings from the data analysis from a well-selected representative sample should allow for generalization of the results across the total population (public energy sector), with confidence and hence achieve external survey validity. This being quantitative

[1] Extracted from Table 55 in **Error! Reference source not found.**

research, probabilistic sampling will be employed with simple random sampling. A simple random sampling method ensures a random selection of the population members with each member having an equal chance of being included in the sample [99, p. 127].

3.3.3 Sampling size

To avoid sampling error and bias in the survey, a well-designed sample size relative to the complexity of the population must be determined beforehand [26]. A representative sample size shall cater for sampling error, reduce response bias and determine the extent of analysis of subgroups [99, p. 128]. Table 2 gives a choice of sample size based on the researcher's desired accuracy [98] using Cochran's (1997) formula (Equation 1) for calculating sample size for categorical data [99, p. 128] where the population size is unknown, and Equation 2 when the population size is known. Equation 3 calculates the corrected sample size when the calculated sample size is greater than 5% of the population size [100].

Table 2: Sample Size Based on Desired Accuracy [98], [99]

	Variance of the population P=50%					
	Confidence level=95% Margin of error			*Confidence level=99% Margin of error*		
Population Size	5	3	1	5	3	1
50	44	48	50	46	49	50
75	63	70	74	67	72	75
100	79	91	99	87	95	99
150	108	132	148	122	139	149
200	132	168	196	154	180	198
250	151	203	244	181	220	246
300	168	234	291	206	258	295
400	196	291	384	249	328	391
500	217	340	475	285	393	485
600	234	384	565	314	452	579
700	248	423	652	340	507	672
800	260	457	738	362	557	763
1000	278	516	906	398	647	943
1500	306	624	1297	459	825	1375
2000	322	696	1655	497	957	1784
3000	341	787	2286	541	1138	2539
5000	357	879	3288	583	1342	3838
10000	370	964	4899	620	1550	6228
25000	378	1023	6939	643	1709	9944
50000	381	1045	8057	652	1770	12413
100000	383	1056	8762	656	1802	14172
250000	384	1063	9249	659	1821	15489
500000	384	1065	9423	660	1828	15984
1000000	384	1066	9513	660	1831	16244

$$n = \frac{P(1-P)Z^2}{E^2} \qquad (1)$$

$$n = \frac{N(Z^2)}{Z^2 + 4NE^2} \tag{2}$$

$$n1 = \frac{n}{1 + n/N} \tag{3}$$

Where,
n = Maximum sample size
n1 = Corrected sample size (when n > 5%(N))
P = Percentage occurrence of a state or condition
E = Percentage maximum error required
Z = *Z-Value* corresponding to level of confidence required
N = Population size

Barlett et al. (2001) and Gill and Johnson (2010) provide typical values used in determining an adequate sample size. E, the margin of error, in most research cases is taken as 5% a smaller value of E implies a larger sample size. Z-value, a statistical value, corresponding to the confidence level required for similar results in the case of a repeat survey on the same population sample, is typically 95% (0.05: Z = 1.96) or 99% (0.01: Z = 2.57). Therefore, a confidence level of 95% ensures that the samples shall have true population values within the specified margin of error (E). P is suggested to be 50% (0.5) as commonly used by researchers as it maximizes the variance and produces the maximum sample size [99], [100]. Therefore, for P = 0.5, E = 0.05 and Z = 95% (1.96) the maximum sample size is 385 samples.

Using Equation 2, the maximum representative sample size for a population of 11,360 and 1,348 employees in the Kenyan and Icelandic electricity sub-sectors was calculated to be 372 and 299, respectively. It was then distributed pro-rata to individual organizations based on the employee representation of the organization in relation to the total population in the respective countries.

3.4 Data Collection

This is the procedure for collecting research data from reliable sources. Quantitative research data may be obtained directly from experiments that manipulate independent variables to measure their influence on the dependent variable, from subjects in the sample via structured interviews, test or standardized questionnaires with distributed rating scales and closed-ended questions, closed-ended observational protocols, or indirectly from research archives or personal and official documents [94].

This research employed quantitative data collection techniques using standardized self-administered online questionnaires because of its advantages over other techniques including lower cost of administration, faster correspondence between participants and survey administrator, and reduced chances of false negatives [26]. However, it suffers a low response rate given that respondents may not complete or refuse to complete the survey [26].

3.4.1 Questionnaires design

The survey used a 6-point Likert scale questionnaire model containing ratings from 6 ("Strongly Agree / Highly Likely" to 1 ("Strongly Disagree / Highly Unlikely") for an increased measurement precision while avoiding the option of a neutral or middle category which is equivalent to no response or confusion [101]. Likert scale is a psychometric tool for gathering data on respondents' opinions, feelings, or attitudes, on a particular issue or statement [101], [102]. It has the advantage of gathering highly reliable data quickly from many respondents and whose interpretation validity can be established through many ways like combining the use of qualitative data gathering techniques [101], [102]. It however, suffers certain weaknesses including central tendency bias with respondents avoiding extreme options on the scale, acquiescence bias where respondents may respond to please the survey administrator and social desirability bias where the respondents dishonestly portray themselves in a socially favorable manner [102].

The questionnaire design was guided by the OECD Manual 2018 guidelines on questionnaire and questions designs was organized in themes to logically get the participants response and reaction. First, the *participants' demographic data* including age, gender, education level, sub-sector engaged, section in organization, position held, and employment terms, as detailed in Table 3, were collected.

Table 3: Participants' Demographic Data

	Categories
Age	20-29; 30-39; 40-49; 50 Years and above
Gender	Male; Female
Education	Diploma; Bachelors; Masters; PhD; Other
Sub-sector	Regulation; Generation; Transmission; Distribution; Other
Country	Iceland; Kenya
Profession	Engineering & Science; Environment & Natural Resources; Finance & Administration; Human Resources; ICT; Legal; Supply Chain; Other
Position	Top Management; Middle-level management; Consultant; Engineer; Scientist; Technician; Other
Experience	0-4; 5-10; 11-14; 15 Years and above
Employment terms	Permanent and Pensionable; Short-term Contract (Up to 1 Year); Long-term Contract (More than 1 Year)

The second theme had questions on the participants' *innovation awareness* which were drawn to assess their skills and knowledge, workplace environment, motivation levels, and their understanding of innovation.

The third theme assessed the organizations' *innovation readiness* for innovation in two parts. First part were questions on the organizations' innovation management system; leadership and structure, innovation strategy, resource availability for innovation, organization innovation culture and organization collaboration strategy. The second part of innovation readiness survey were question on the energy sector organizations' innovation strategy and commitment towards UN SDGs, 2050 net-zero emissions targets, and innovation activities towards solving the energy trilemma (energy security, equity (access and affordability) and the environment).

The fourth theme or the survey was on *future innovation outlook* of public energy organizations. The section attempts to find out the organizations' long-term (over 5 years) focus and prioritization of innovation, research and development of energy solutions, technology, and policy in areas of electricity generation, energy transition, technology advancements and climate action.

In conclusion, the participants' opinion was sought on their agreement with their *organization's innovation pathway* and finally their *agreement with the adopted definition of innovation* in relation to their public energy organization's mandate.

3.4.2 Pilot survey

The draft questionnaire was sent to a group of twenty-eight public energy sector participants to provide feedback on the survey questionnaire efficacy. This was a pilot survey test with key interest of getting respondents' opinion on the survey length, questions' difficulty and relevance, Likert rating scale appropriateness and overall survey structure.

3.4.3 Conduct of the Research

3.4.3.1 Interviews

It was suggested that interviews be conducted with specific top management of industry innovation activities to discuss specific aspects of the survey. This was to be done after the survey was completed to ensure that it did not interfere with the ongoing process. However, due to time constraints, this was not possible, and thus only survey data was considered for analysis.

3.4.3.2 Research ethics

The research was done among public energy organizations in Iceland and Kenya.

An official letter of recommendation from the Reykjavik University was used to inform the respondents of the research thesis and the researcher details (refer to Appendix C). In Kenya, an approval to conduct the research was sought from the National Commission for Science, Technology, and Innovation (NACOSTI) (refer to Appendix D). A carefully and politely worded email was then sent to respective organizations seeking permission to circulate the survey link to their staff members participation with emphasis on confidentiality and anonymity of the respondents and organizations participating in the research. In analysis, only data obtained from the study were used in the analysis with no manipulation whatsoever to benefit the researcher or participating organization.

3.4.3.3 Distribution and response collection

Because this was an online survey, email communication was required for distribution to potential respondents. The QuestionPro online Survey Software, Essentials version, was used to create the questionnaire. QuestionPro Essentials supports an unlimited number of questions and up to 300 responses per survey. This limitation further reduced the sample size to a total of 300 responses from the initial estimated sample size of 671 responses. The survey was estimated to take 20 minutes to complete, with no option to save entries for later completion due to a limitation of the QuestionPro Essentials version. To distribute to public energy organizations, trust was essential, so third-party sponsors known to the organizations were used to contact and seek organization approvals for employee participation.

3.5 Data Analyzing and Display

The responses were analyzed to find answers to the research question and hypotheses. Data for quantitative research were coded before being entered into a data matrix for statistical analysis with IBM SPSS Statistics version 27 and Microsoft Excel. The collected data was then prepared for analysis to ensure its credibility by ensuring response completeness, dealing with outliers, and that the respondents were engaged during the survey. The significance of missing data was determined using Little's Missing Completely at Random (MCAR) test and corrected accordingly. To replace missing data while keeping the sample size constant, the multiple imputation (MI) technique was used.

The goal of statistical analysis is to determine whether the relationship between observed variables in one or more groups, whether causal or correlational, is statistically significant enough to generalize to the population from which the sample was drawn at a 95% confidence interval. The type of question, the scale used to measure variables (nominal, ordinal, interval, or ratio), and the population distribution (normal or non-normal) all influence the statistical test method (parametric or non-parametric methods). Normally distributed data were analyzed using parametric data analysis methods i.e., linear regression and Pearson's correlation tests while the no-normally distributed data were analyzed using non-parametric data analysis methods i.e., ordinal regression and Spearman rank correlation tests. Summary statements, tables, and/or figures are used to present the analysis results. In this context, data interpretation entails making sense of the gathered evidence to provide meaning to the obtained results in relation to the theory from which the hypotheses were developed.

3.6 Quality of Research

The quality of the survey is assessed based on its criteria and the systematic measurement errors. An assessment of the criteria's reliability, validity, response style and the respondents' preferences and friendliness of the survey [102].

4 Results and data analysis

The methodology for data collection for analysis was the focus of Chapter 3. This chapter summarizes the quantitative research findings based on survey data collected using the methods described in Chapter 3. This Chapter presents descriptive statistics, factor analysis, correlation, and regression analysis results from statistical analysis performed with SPSS and Microsoft Excel.

4.1 Demographic characteristics of respondents

The demographic data submitted by respondents was analyzed in several categories, including age group, gender, education level, electricity sub-sector, country of operation, profession, position in the organization, years of experience, and terms of employment. This information was critical in ensuring the exercise's validity and reliability. Table 4 shows the summary information of the demographic data.

Table 4:Summary of Response on Demographic Data

Category	N		Mode	Category
	Valid	Missing		
Age group	58	0	2	30-39 years
Gender	58	0	2	Male
Education Level	58	0	3	Master’s degree
Electricity Sub-Sector	57	1	2	Generation
Country	58	0	2	Kenya
Profession	57	1	1	Engineering & science
Years of Experience	56	2	2	5-10 years
Position in Organization	58	0	2	Middle-level management
Employment Terms	57	1	1	Permanent & pensionable

4.1.1 Age of respondents

A total of 58 respondents indicated their age group consisting of 2 (3.4%) of age 18-29, 25 (43.1%) of age 30-39, 17 (29.3%) of age 40-49, and 14 (24.1%) of age 50 and above (Table 5).

Table 5: Respondents’ Age Group

Age group	Frequency	Valid Percent
18 – 29 years	2	3.4
30 – 39 years	25	43.1
40 – 49 years	17	29.3
50 years and above	14	24.1

4.1.2 Gender of respondents

A total of 58 respondents indicated their gender consisting of 15 (25.9%) female and 43 (74.1%) males (Table 6).

Table 6: Respondents' Gender

Gender	Frequency	Valid Percent
Female	15	25.9
Male	43	74.1

4.1.3 Respondents' education level

A total of 58 respondents indicated their education level where 20 (34.5%) had bachelor's degrees, 30 (51.7) had master's degrees and 8 (13.8%) had doctorate degrees (Ph.D.) (Table 7).

Table 7: Respondents' Education Level

Education level	Frequency	Valid Percent
Bachelor's Degree	20	34.5
Master's Degree	30	51.7
PhD	8	13.8

4.1.4 Electricity sub-sector

A total of 57 respondents indicated their organization's electricity sub-sector where 1 (1.8%) in regulation, 38 (66.7%) in generation, 1 (1.8%) in transmission, 2 (3.5%) in distribution and 15 (26.3%) who indicated other public electricity sub-sector (Table 8).

Table 8: Organizations' Electricity Sub-Sector

Electricity Sub-sector	Frequency	Valid Percent
Regulation	1	1.8
Generation	38	66.7
Transmission	1	1.8
Distribution	2	3.5
Other	15	26.3

4.1.5 Country the organization is based

A total of 58 respondents indicated the country their organizations operate in, with 12 (20.7%) indicating Iceland and 46 (79.3%) indicating Kenya (Table 9).

Table 9: Organizations' Country of Operation

Country	Frequency	Valid Percent
Iceland	12	20.7
Kenya	46	79.3

4.1.6 Respondents' profession

A total of 57 respondents indicated their profession with 32 (56.1%) belonging to engineering and science, 3 (5.3%) belonging to environment and natural resources, 3 (5.3%) belonging to finance and administration, 2 (3.5%) belonging to health and safety, 4 (7.0%) belonging to human resources, 2 (3.5%) belonging to ICT, 1 (1.8%) belonging to supply chain and 10 (17.5%) belonging to other professional group in the public energy organization (Table 10).

Table 10: Respondents' Profession Group

Profession groups	Frequency	Valid Percent
Engineering & Science	32	56.1
Environment & Natural Resources	3	5.3
Finance & Administration	3	5.3
Health & Safety	2	3.5
Human Resources	4	7.0
ICT	2	3.5
Supply Chain	1	1.8
Other	10	17.5

4.1.7 Respondents' experience

A total of 56 respondents indicated their years of experience in the public energy sector consisting of 4 (7.1%) with 0-4 years' experience, 21 (37.5%) with 5-10 years' experience, 16 (28.6%) with 11-15 years' experience and 15 (26.8%) with over 15 years' experience (Table 11).

Table 11: Respondents' Years of Experience

Experience	Frequency	Valid Percent
0 – 4 years	4	7.1
5 – 10 years	21	37.5
11 – 15 years	16	28.6
Over 15 years	15	26.8

4.1.8 Respondents' position in organization

A total of 58 respondents indicated their position in the organization where 5 (8.6%) were top management, 20 (34.5%) were middle-level management, 1 (1.7%) was a consultant, 13 (22.4%) were engineers, 12 (20.7%) were scientists, 2 (3.4%) were technicians and 5 (8.6%) indicated they held other positions in their organizations (Table 12).

Table 12: Respondents' Position in Organization

Position	Frequency	Valid Percent
Top Management	5	8.6
Middle-level Management	20	34.5
Consultant	1	1.7

Position	Frequency	Valid Percent
Engineer	13	22.4
Scientist	12	20.7
Technician	2	3.4
Other	5	8.6

4.1.9 Respondents' employment terms

A total of 57 respondents indicated their employment terms with 50 (87.7%) being permanent and pensionable staff, 1 (1.8%) having a short-term contract and 6 (10.6%) having long-term contract in their organizations (Table 13).

Table 13: Respondents' Employment Terms

Employment terms	Frequency	Valid Percent
Permanent and Pensionable	50	87.7
Short-term Contract (≤ 1 Year)	1	1.8
Long-term Contract (> 1 Year)	6	10.5

4.2 Reliability and validity analysis

After a survey period, between July 5 and September 2, 2022, a total of 59 responses were received by the study's conclusion (63 days). After a visual inspection revealed a high likelihood of not being engaged during the survey, one response was removed from the survey. Eight (8) negatively worded items were reversed and recoded to correspond with the Likert scale.

4.2.1 Test of normality

Following an assumption that the values from the survey were taken from a normally distributed population, it is therefore, necessary that the data be subject to a test for normality to draw accurate and reliable conclusions [103]. Testing the data for normality was done by analyzing the frequency distribution graphs, Q-Q plots and boxplots. Using statistical testing approaches for normality, like the Shapiro-Wilk test of normality, the P-value (α) was examined to determine if the values were sampled from a normally distributed population (P>0.05) thereby, fail to reject the null hypothesis and reject the alternative hypothesis. Else, if P≤0.05, accept the alternative hypothesis and reject the null hypothesis. Since our sample size was considered small-to-moderate (i.e., $50 \leq n < 300$), Shapiro-Wilk test was considered in the statistical test for normality to check the significance of grouped data from the survey [103]. Table 14 gives the results of normality test carried out on the original collected data for eleven (11) variables. The other Likert items were not grouped hence are not analyzed for normality.

Table 14: Skewness, Kurtosis, and Normality Tests Results

Variable	Skewness			Kurtosis			Shapiro-Wilk test
	Value	Std. Error	$Z_{skewness}$	Value	Std. Error	$Z_{kurtosis}$	
Q04	0.090	0.330	0.273	-1.099	0.650	-1.691	0.068
Q05	0.009	0.330	0.026	-0.664	0.650	-1.022	0.581
Q06	-0.635	0.330	-1.922	0.756	0.650	1.162	0.188
Q07	0.500	0.330	1.513	1.150	0.650	1.769	0.046
Q09	-1.253	0.330	***-3.791***	1.277	0.650	***1.965***	<0.001
Q10	-0.819	0.330	***-2.479***	0.068	0.650	0.104	0.008
Q11	-0.412	0.330	-1.247	-0.382	0.650	-0.587	0.028
Q12	-0.643	0.330	-1.945	-0.313	0.650	-0.482	0.004
Q13	-0.611	0.330	-1.849	1.158	0.650	1.781	0.054
Q16	-0.524	0.330	-1.587	0.103	0.650	0.159	0.022
Q17	-1.255	0.330	***-3.832***	2.274	0.650	***3.529***	<0.001

By observing the plots (histograms and boxplots) of the variables in Table 56 in Appendix F, the variables, generally look normally distributed with slight skewness in most of the variables except for Q04 and Q05. It is recommended that distribution is considered normal when the value of the *Z*-score for skewness and kurtosis lies between $-1.96 < Z < 1.96$, for 95% confidence interval of *Z*, for small-to-moderate samples to accept the null hypothesis implying $P>0.05$ [103]. Variables Q09 (Organization innovation Strategy), Q10 (Organization innovation management: leadership and structure) and Q17 (Organization commitment toward energy trilemma) exhibited a non-normal distribution based on their skewness and kurtosis *Z*-scores being out of the recommended range. Q09 and Q17 had *Z*-scores outside the range for skewness and kurtosis and variable Q10 had *Z*-score for skewness less than -1.96.

Based on Shapiro-Wilk test results, only variables Q04 (Employee Skills & Knowledge), Q05 (Employee Workplace Environment), Q06 (Employee Motivation to Innovate) and Q13 (Organization Innovation Collaboration Systems), exhibit a normal distribution with $P>0.05$ while all the rest of the variables are non-normally distributed with $P<0.05$ and hence parametric statistical tests shall be used in their analysis.

Log transformation of variables Q07, Q09, Q10, Q11, Q12, Q16 and Q17 was done to further confirm non-normality. Conducting the test of normality on these log transforms, Shapiro-Wilk test results informed that only log-transformed variable Q07 was normally distributed with $P=0.300$ with a confidence interval of 95% hence not rejecting the null hypothesis that the data is not significantly different from a normally distributed data thus linear regression analysis shall be used to analyze the variable. Log-transformed variables Q09, Q10, Q11, Q12, Q16 and Q17 were determined non-normal with $P<0.05$ showing that they are significantly different from a normally distributed data thus non-parametric statistical tests were used in analysis.

4.2.2 Missing values

During the data preparation, Little's Missing Complete at Random (MCAR) test was performed on all nine categorical items and the eighty-nine (89) variable item (Chi-Square = 80.30, *df* = 1327, Sig. = 1.000). The Little's MCAR test established that the missing data was not statistically significant (Sig. > 0.05) to reject the null hypothesis implying that the data are missing completely at random [104]. Using Multiple Imputation to analyze the missing values, it was established that 31% of the cases had some missing values in 67% of the variable items, translating to 1.8% of the total values as shown in Figure 1.

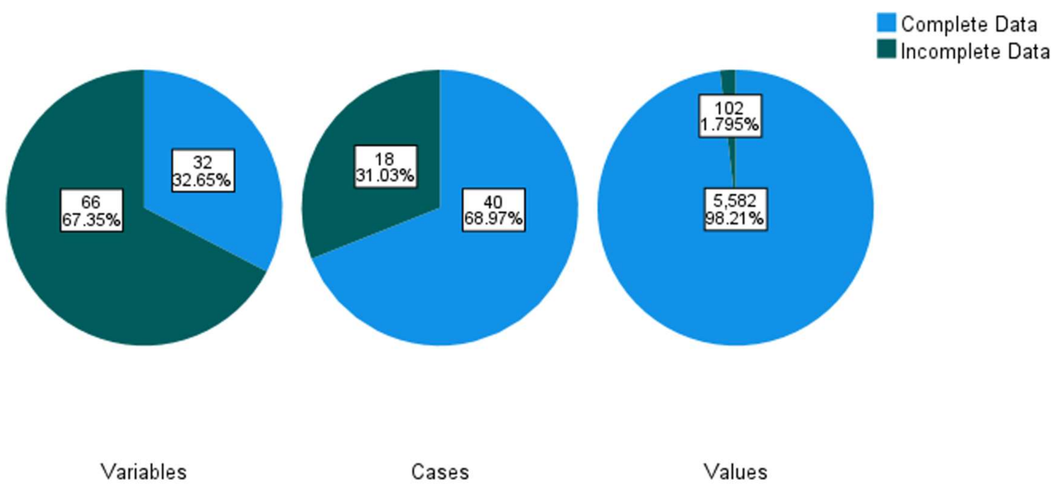

Figure 1: Overall summary of missing values

The chart in Figure 2 shows that the values are missing at random and thus not systematic, confirming Little's MCAR test results that the missing data occurred completely at random and minimizing the possibility of bias in the missing values.

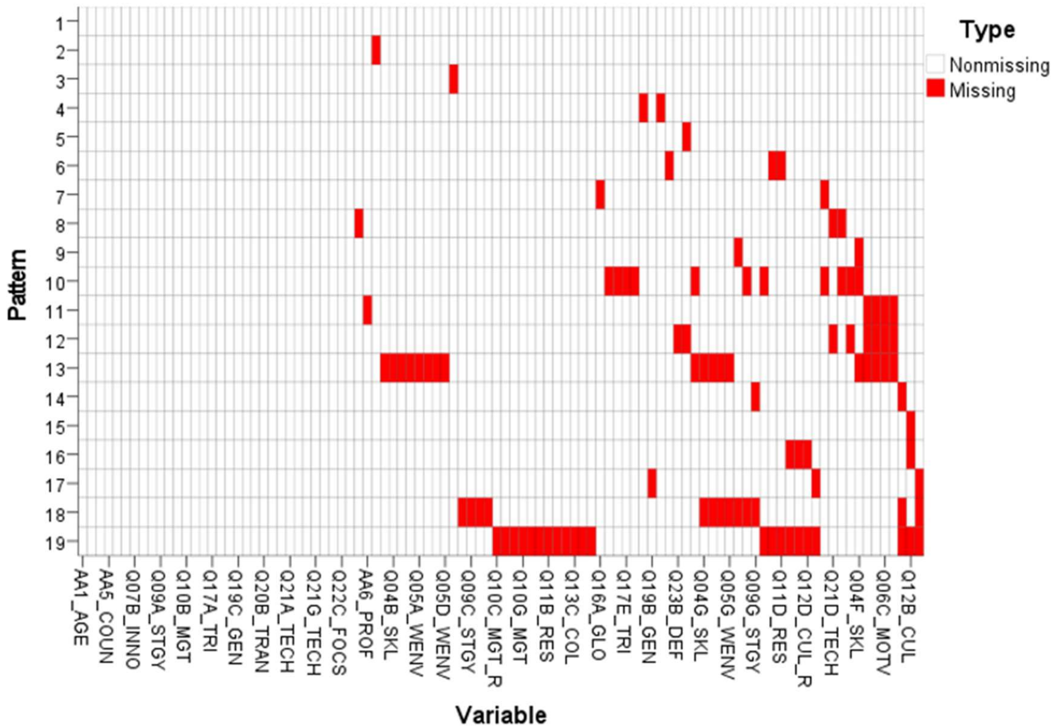

Figure 2: Missing values pattern

Multiple imputation (MI) technique was used to replace the missing data so as to maintain the sample size [105], [106].

4.2.3 Outliers

The data was inspected for existence of extreme values (outliers) that may be out of range or biased for trimming. An analysis of the scale items revealed that item Q04D_SKL (Knowledge of country's energy policies) had extreme cases of outliers whose trimming would result into a bias, and it was therefore, deleted from the dataset.

4.2.4 Recoding of categories

To better analyze the relationship between the ordinal categorical data and the construct latent variable, the categorical data were regrouped and recoded to combine those that related. This improved the counts in categories that had too few responses for better analysis (Table 15).

Table 15: Regrouped Categories

Categories	
Age group	18-39; 40-49; 50 years and above
Gender	Male; Female
Education	Undergraduate; Graduate and above
Electricity Sub-sector	Generation; Other
Country	Iceland; Kenya

Categories	
Profession	Technical; Non-technical
Position in organization	Top Management; Middle-level management; Other
Experience	10 and below; Over 10 years
Employment terms	Permanent; Contract

4.2.5 Descriptive statistics

The mean and standard deviation of the collected data was then analyzed to determine how best they represent the data on the 58 samples. Table 16 shows a summary of the mean (*M*) and standard deviation (*SD*) of the collected data after replacement of missing values. All variables had a mean (*M*) and standard deviation (*SD*) of all items ranging $3.480 < M < 5.086$ and $0.504 < SD < 1.451$ respectively, indicating fair distribution of data representing the respondents' views.

Table 16: Summary of Mean and Standard Deviation

	Variable	Mean	Std. Deviation
Q04	Employee skills and knowledge	4.8444	0.53134
Q05	Employee workplace environment	4.7638	0.60418
Q06	Employee motivation to innovate	4.0873	0.99624
Q07	Employee understanding of innovation concepts	4.1997	0.50396
Q09	Organization innovation strategy	4.4262	0.87700
Q10	Organization innovation management: leadership and structure	4.4219	1.00438
Q11	Organization innovation resources availability	3.9831	1.20241
Q12	Organization innovation culture	4.3427	1.03454
Q13	Organization innovation collaboration systems	4.2297	1.00214
Q16	Organization response to global climate action	4.8260	0.73343
Q17	Organization commitment toward energy trilemma	4.8117	0.85758

To assess the reliability, that is, the data stability or consistency, Cronbach's alpha was performed on the data's measurement scale items to check on their internal correlation. Cronbach's alpha is the most common indicator of internal consistency of grouped items where, $\alpha \geq 0.7$ with mean inter-item correlation range being between 0.2 – 0.4 generally depicting acceptable internal consistency hence reliable with the sample [107, p. 85], [108]. Table 17 shows the results of Cronbach's alpha reliability analysis performed on pooled data.

Table 17: Cronbach's Alpha Reliability of The Grouped Items

Latent Construct	Variable	Indicators	Cronbach's α coefficient (Pooled data from 5 imputation)					
			0*	1	2	3	4	5
Organization innovation awareness	Q04	Q04A - Q04G	0.628	0.608	0.619	0.597	0.627	0.618
	Q05	Q05A - Q05G	0.788	0.787	0.782	0.783	0.784	0.784
	Q06	Q06A - Q06D	0.722	0.712	0.708	0.706	0.708	0.714
	Q07	Q07A - Q07G	0.038	0.006	0.025	0.012	-0.001	0.022
Organization innovation readiness	Q09	Q09A - Q09G	0.827	0.835	0.844	0.838	0.835	0.844
	Q10	Q10A - Q10I	0.860	0.871	0.864	0.872	0.871	0.868
	Q11	Q11A - Q11D	0.910	0.903	0.898	0.905	0.909	0.908
	Q12	Q12A - Q12D	0.769	0.757	0.771	0.757	0.772	0.774
	Q13	Q13A - Q13D	0.865	0.865	0.865	0.858	0.862	0.867
Organization response to climate action	Q16	Q16A - Q16D	0.593	0.571	0.576	0.574	0.574	0.568
	Q17	Q17A - Q17G	0.850	0.846	0.848	0.849	0.844	0.847

*** Original data**

Variables Q04, Q07, and Q16 reported Cronbach alpha coefficients α < 0.7 and mean inter-item correlation of 4.8, 4.19 and 4.8 respectively. To improve the Cronbach's alpha coefficient, weak scale items seen not fitting and having low α values were excluded from the scale. Scale items Q04F_SKL (Participation in organization's research activities), Q04G_SKL (Skill in change management) and Q16D_GLO (Climate action is prioritized in innovation strategy) were excluded from their scales.

From the results, variable scale Q07, despite having an acceptable mean inter-item correlation value, it reported an unacceptable Cronbach's alpha coefficient for original and imputed data that could not be better improved to a value of α > 0.5 even by deletion of scale items and was therefore, not considered for further analysis [108].

4.2.6 Sample adequacy

To determine validity, exploratory factor analysis (EFA) using principal component analysis (PCA) was conducted. While several studies recommend EFA to be performed for large sample sizes above 150 [107, p. 154], other studies show that it is possible to get reliable solutions even with sample sizes well below 50 [109] and hence the use of EFA for this research.

Therefore, PCA tests, Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were performed to evaluate the relationships between scale items [107, p. 154]. Scale items that had unacceptable Cronbach's alpha coefficients and exhibited strong cross-loadings onto the wrong component were considered for exclusion from further tests. The KMO measure of sampling adequacy obtained was 0.765 where a value of 0.6 and above are required for a good FA [107], [110, p. 620]. Bartlett's test of sphericity was significant with $P < 0.001$, $X^2 = 1779.38$ and $df = 666$ (Table 18) implying the factors that form the variables are satisfactory and the dataset is good for conducting FA for the variables.

Table 18: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.765
Bartlett's Test of Sphericity	Approx. Chi-Square	1779.377
	df	666
	Sig.	<0.001

The PCA was performed to extract factors/components and examine the inter-item relations used Oblimin with Kaiser Normalization to maximize the loadings across factors. A total of thirty seven (37) components were extracted with eight (8) factors having eigenvalues ≥ 1 [107, p. 161] as shown in Table 19. The eight (8) extracted components had cumulative variance of 75.40% indicating a satisfactory exploratory power of the factors.

Table 19: Total Variance Explained

Component	**Initial Eigenvalues**			**Rotation Sums of Squared Loadings**			**Rotation Sums of Squared Loadings[a]**
	Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**	**Total**
1	14.317	38.696	38.696	14.317	38.696	38.696	12.093
2	3.092	8.357	47.052	3.092	8.357	47.052	5.853
3	2.547	6.885	53.937	2.547	6.885	53.937	4.663
4	1.943	5.250	59.187	1.943	5.250	59.187	2.139
5	1.889	5.107	64.294	1.889	5.107	64.294	2.759
6	1.598	4.320	68.614	1.598	4.320	68.614	3.628
7	1.293	3.496	72.110	1.293	3.496	72.110	6.608
8	1.217	3.289	75.399	1.217	3.289	75.399	2.193
9	0.953	2.576	77.975				
10	0.873	2.358	80.333				
11	0.788	2.129	82.463				
12	0.765	2.068	84.531				
13	0.688	1.860	86.391				
14	0.554	1.497	87.887				
15	0.521	1.407	89.295				
16	0.466	1.260	90.555				
17	0.418	1.129	91.684				
18	0.394	1.065	92.749				
19	0.318	0.859	93.608				
20	0.306	0.826	94.435				

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
21	0.283	0.764	95.199				
22	0.234	0.633	95.831				
23	0.228	0.615	96.446				
24	0.197	0.533	96.980				
25	0.180	0.486	97.466				
26	0.153	0.413	97.879				
27	0.144	0.388	98.268				
28	0.124	0.336	98.603				
29	0.113	0.305	98.909				
30	0.093	0.251	99.160				
31	0.065	0.175	99.336				
32	0.063	0.169	99.505				
33	0.058	0.157	99.662				
34	0.042	0.115	99.777				
35	0.033	0.090	99.867				
36	0.029	0.077	99.944				
37	0.021	0.056	100.000				

Extraction Method: Principal Component Analysis.

These findings indicate a unique correlation with scale items for scales Q09, Q10, Q11, and Q12, with fifteen (15) items strongly loading into component 1 and explaining 38.70% of the variance of the scale items. Components 2, 3, 4, 5, 6, 7 and 8 explained less than 10% of their respective variances. Scale item Q16A has a weak correlation with its scale Q06 but performs better as an independent scale in component 8. As shown in Table 20, all observed communalities were greater than the recommended threshold of 0.3, ranging from 0.449 to 0.862 [33], [110, p. 654].

Table 20: Rotated Component Matrix

Scale	Scale item	Component							
		1	2	3	4	5	6	7	8
Q09, Q10, Q11, Q12	Innovation funds are allocated in organization's budget	0.936							
	Innovation as a regular organization's operation	0.847							
	Innovation ideas are ranked and prioritized	0.780							
	Innovation ideas are systematically collected	0.771							
	Innovation is incorporated in organization's values and mission	0.766							

Scale	Scale item	Component							
		1	2	3	4	5	6	7	8
	Innovation management office is available	0.737							
	Innovation product development system is effective	0.736							
	Organization structure supports innovation	0.724							
	Innovation performance is regularly communication	0.708							
	Innovation idea-generators are involved in implementation	0.689							
	Formal innovation strategy is available	0.673							
	Innovation strategy is supported by top management	0.656							
	Innovation strategy is communicated in organization	0.642							
	Organization policies and procedures easen product development	0.629							
	Innovation strategy is in line with government policies	0.503				-0.441			
Q13	Structured collaboration with academic research institutions		0.813						
	Structured collaboration with private-sector organizations		0.804						
	Structured collaboration between organization's departments		0.658						
	Structured collaboration with other public organizations		0.635						
Q05	Supervisor's timely feedback on tasks			0.828					
	Consulted for Innovation ideas			0.803					
	Organization's tolerance to experimentation	0.318		0.723					
	Contribution of innovation to individual's performance measurement			0.656				0.364	
	Promotion of teamwork in innovation			0.548					0.380
Q04	Adequate training to deliver tasks				-0.763				
	Adequate resources to deliver tasks		0.373		-0.735				
Q16	Achieving of universal electricity access by 2030					-0.866			
	Organization being carbon-neutral by 2030					-0.670			

Scale	Scale item	Component 1	2	3	4	5	6	7	8
Q06	Motivated by personal reasons to innovate						0.837		
	Motivated by financial rewards to innovate						0.805		0.315
	Motivated by recognition to innovate						0.705		
Q17	Energy efficiency innovation							0.737	
	Infrastructure Technologies							0.736	
	Grid Strengthening							0.704	
	Energy transition innovation							0.688	
	Electricity Affordability		0.352					0.452	
	Energy efficiency innovation							0.737	
Q16A	Achieving 55% electricity GHG emissions reduction by 2030					-0.417			0.709

Note: **Extraction Method:** Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 34 iterations.
b. Only loadings above 0.3 were displayed

Component 1 items relate to the organization's innovation strategy, innovation management, innovation resources, and innovation culture (Q09, Q10, Q11, Q12). These variables were renamed "organization innovation readiness." Component 2 explains the organization's collaboration systems (Q13). Components 3 and 6 of latent constructs Q05 and Q04, respectively, explain the “organization's innovation awareness”. Component 4 explains employee motivation to innovate (Q06). While component 8 (Q16A) had a weak cross-loading (-0.417) onto Q16 items of component 5, it is grouped into component 5 under the label "organization's response to climate action". Finally, component 7 was labeled “organization commitment toward energy trilemma”. The number of latent constructs therefore, increased from three (3) to six (6) because of this reorganization.

4.3 Statistical test results

T-tests were used to compare the dependent latent variables between the public energy organization's countries of operation (Iceland and Kenya) in this study. T-tests are a type of analysis of variance used to determine whether there are any significant differences between groups or conditions [107, p. 177]. The normally distributed continuous variables organization innovation awareness (Q04A, Q04B, Q05C, Q05D, Q05E, Q05F, Q05G), employee motivation to innovate (Q06A, Q06B, Q06C), and organization collaboration systems (Q13A, Q13B, Q13C, Q13D) were subjected to a parametric test, the independent samples t-test. For non-normally distributed continuous variables organization innovation readiness (Q09A, Q09B, Q09C, Q09D, Q10A, Q10B, Q10G, Q10H, Q10I, Q11A, Q11B, Q11D, Q12A, Q12B, Q12C, Q12D), organization response to climate action (Q16A, Q16B, Q16C), and organization commitment toward energy trilemma (Q17B, Q17C, Q17D, Q17E, Q17F), a non-parametric test, independent samples Mann-Whitney's U-test, was conducted

4.3.1 Independent samples t-test

For the normally distributed ordinal or continuous variables, organization innovation awareness, employee motivation to innovate and organization collaboration systems, an independent-samples t-test was conducted to compare the public energy organizations' awareness levels on innovation, employee motivation to innovate and collaboration systems in Iceland and Kenya. Kenyan public energy organizations had higher mean scores than those of Iceland for the three dependent variables as shown in Table 21.

Table 21: Group Statistics

	Country	N	Mean	Std. Deviation	Std. Error Mean
Organization innovation awareness	Iceland	12	4.3626	.62588	.18067
	Kenya	46	4.6978	.51495	.07592
Employee motivation to innovate	Iceland	12	3.5684	1.14632	.33091
	Kenya	46	4.1812	1.07226	.15810
Organization innovation collaboration systems	Iceland	12	3.8750	1.24088	.35821
	Kenya	46	4.3222	.92380	.13621

The samples met the assumption of homogeneity for all the three variables. Levene's test for equality of variance was not statistically significant (Sig. column was greater than 0.05) (Table 22) hence equal variance was assumed for the variables. For organization innovation awareness, the independent-samples t-test, there was not a significant difference in the scores for Iceland (M = 4.36, SD = 0.63) and Kenya (M = 4.70, SD = 0.51) groups; $t(56) = -1.92$, $P = 0.060$ with a small effective size ($d = -0.623$). For employee motivation to innovate the independent-samples t-test, there was not a statistically significant difference in the scores for Iceland (M = 3.57, SD = 1.15) and Kenya (M = 4.18, SD = 1.07) conditions; $t(56) = -1.74$, $P = 0.088$ with a medium effective size ($d = -0.564$). While for organization innovation collaboration systems independent-samples t-test, there was no statistically significant difference in the scores for Iceland (M = 3.87, SD = 1.24) and Kenya (M = 4.32, SD = 0.92) groups; $t(56) = -1.39$, P=0.171 with a small effective size ($d = -0.450$).

Table 22: Independent Samples Test

	Levene's Test for Equality of Variances		t-test for Equality of Means					
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence interval	
							Lower	Upper
Organization innovation awareness	1.288	0.261	-1.921	56	0.060	-0.335	-0.685	0.014
Employee motivation to innovate	0.431	0.514	-1.739	56	0.088	-0.613	-1.319	0.093
Organization innovation collaboration systems	1.049	0.310	-1.388	56	0.171	-0.447	-1.093	0.198

These results suggest that the country of operation of a public organization does not influence the organization's employee innovation awareness and motivation levels to innovate or on the organizations innovation collaboration systems. The magnitude of the differences in the variables' means was small to medium as shown by Cohen's d values in Table 23 [111, p. 40].

Table 23: Independent Samples Effect Sizes (Cohen's d)

	Standardizer[a]	Point Estimate	95% Confidence Interval	
			Lower	Upper
Organization innovation awareness	.539	-.623	-1.266	.026
Employee motivation to innovate	1.087	-.564	-1.205	.083
Organization Innovation collaboration systems	.994	-.450	-1.089	.193

Note: a. The denominator used in estimating the effect sizes.
Cohen's d uses the pooled standard deviation.

4.3.2 Independent samples Mann-Whitney's U Test

The non-normally distributed ordinal or continuous variables, organization innovation readiness, organization response to climate action and organization commitment toward energy trilemma were subjected to the independent samples Mann-Whitney's U-test. Table 24 shows the summary results of the test.

Table 24: Hypothesis Test Summary

	Null Hypothesis	Sig.[a,b]	Decision
1	The distribution of organization innovation readiness is the same across categories of Country.	<.001	Reject the null hypothesis.
2	The distribution of organization response to global climate action is the same across categories of Country.	.310	Retain the null hypothesis.
3	The distribution of organization commitment toward energy trilemma is the same across categories of Country.	.062	Retain the null hypothesis.

Note: a. The significance level is .050.
b. Asymptotic significance is displayed.

Median scores in organization innovation readiness, organization response to global climate action, organization commitment toward energy trilemma were *Mdn* = 4.80, *Mdn* = 5.00 and *Mdn* = 5.00 respectively; the distributions in organization innovation readiness in Iceland (N = 12) and Kenya (N = 46) differed significantly (Mann-Whitney U = 463.50, $P < 0.01$ two-sided) hence rejecting the null hypothesis that distribution across the two countries is the same since $P < 0.05$. This suggested that the country of operation had influence on the organizations' readiness for innovation.

Variables, organization response to global climate action (Mann-Whitney U = 328.00, $P = 0.310$ two-sided) and organization commitment toward energy trilemma (Mann-Whitney U = 372.50, $P = 0.062$ two-sided), however, had the same distribution across Iceland (N = 12) and Kenya (N = 46) hence not rejecting the null hypothesis that the distribution of organization response to global climate action and the organization commitment toward energy trilemma is the same across the two countries. This implied that the two variables were not influenced by the organizations' country of operation.

4.3.3 Hypothesis testing

To test the set hypotheses, regression analysis, a qualitative data analysis technique, was performed. Hypothesis testing helps confirm the observation about the population based on the sample data.

4.3.3.1 Hypothesis 1

H1: An organizations' innovation culture is more positively related to the organizations' innovation management, structure, and leadership.

Since the dependent and the independent variable being investigated by this hypothesis were non-normally distributed, non-parametric statistical tests (ordinal regression and Spearman rank correlation tests) were conducted to determine their relationship.

4.3.3.1.1 H1 Ordinal regression

Ordinal regression was conducted with innovation culture as the dependent variable and organization innovation strategy and organization innovation management: leadership and structure as the independent variables. First the model was tested using maximum likelihood estimation to determine if it fits the data. The model fitting information indicated that it was statistically significant with $P<0.001$ (Table 25) showing that the model fits the dataset well.

Table 25: H1 Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	264.845			
Final	220.447	44.398	2	.000

Note: Link function: Logit

The Deviance and Pearson chi-square goodness-of-fit test was performed to determine if the model fits the dataset well. The Pearson ($\chi^2(642) = 698.368$, $P = .061$) and Deviance chi-square test ($\chi^2(642) = 206.009$, $P = 1.000$) were not significant ($P>0.05$) as shown in Table 26. suggesting a good model fit.

Table 26: H1 Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	698.368	642	.061
Deviance	206.009	642	1.000

Note: Link function: Logit.

The pseudo r-square results for Nagelkerke (Table 27) indicated that 53.9% of the change in in the dependent variable, organization innovation culture is because of the independent variables organization innovation strategy and organization innovation management structure and leadership.

Table 27: H1 Pseudo R-Square

Cox and Snell	.535
Nagelkerke	.539
McFadden	.158

Note: Link function: Logit.

From the parameter estimates table (Table 28), it is deduced that,

a. Organization innovation strategy was a significant positive predictor of the organization innovation culture having a coefficient $P = 0.009$ ($P<0.05$). Thus, for every unit increase in the organization innovation strategy, there is a predicted increase of $\beta = 1.123$ in log odds of being at a higher level of innovation culture.

b. The organization innovation management structure and leadership was also found to be a positive predictor of the organization innovation culture with a coefficient $P = 0.005$ ($P<0.05$). Therefore, for every unit increase in the organization's innovation management structure and leadership, there is a predicted increase of $\beta = 0.810$ in log odds of being at a higher level of innovation culture.

Table 28: H1 Parameter Estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Location	organization innovation strategy	1.123	.428	6.881	1	.009	.284	1.962
	organization innovation management structure and leadership	.810	.289	7.883	1	.005	.245	1.376

Note: Link function: Logit.

The test of parallel lines tests for the violation of the assumption of proportional odds. It was found statistically significant, P<0.001 (Table 29), implying that the assumptions were violated.

Table 29: H1 Test of Parallel Lines[a]

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	220.447			
General	89.480[b]	130.967[c]	26	.000

Note: The null hypothesis states that the location parameters (slope coefficients) are the same across response categories.

a. Link function: Logit.

b. The log-likelihood value cannot be further increased after maximum number of step-halving.

c. The Chi-Square statistic is computed based on the log-likelihood value of the last iteration of the general model. Validity of the test is uncertain.

4.3.3.1.2 H1 Spearman's rank correlation test

Spearman's rank correlation was performed on the dataset to determine the strength and direction of correlation between the three variables organization innovation strategy (Q09), organization innovation management leadership and structure (Q10) and organization innovation culture (Q12). The Spearman's correlation coefficients were as presented in Table 30.

Table 30: H1 Spearman's Rank Correlation

		Q09	Q10	Q12
Q09	Correlation Coefficient	1.000		
	Sig. (2-tailed)	.		
	N	58		
Q10	Correlation Coefficient	.732**	1.000	
	Sig. (2-tailed)	.000	.	
	N	58	58	
Q12	Correlation Coefficient	.567**	.649**	1.000
	Sig. (2-tailed)	.000	.000	.
	N	58	58	58

Note: **. Correlation is significant at the 0.01 level (2-tailed).

There was a significant and strong positive correlation between variables Q09 and Q10, $r(56) = .732$, $P = .000$. The variables Q09 and Q12 also exhibited a significant and strong positive correlation, $r(56) = .567$, $P < .001$. Similarly the correlation between variables Q10 and Q12 was also significant, strong and positive, $r(56) = .649$, $P < .001$ [112].

4.3.3.2 Hypothesis 2

H2: An organizations' innovation readiness is more positively related to the employees' motivation to innovate despite the country of operation.

H2 proposes that the independent variable employee motivation to innovate (Q06) has a positive influence on the organization's innovation readiness (Q09 – Q12). Latent construct variable organization innovation readiness is the transformed mean of the variable Q09, Q10, Q11 and Q12. Since the variable organization innovation readiness had a non-normal distribution, and employee motivation to innovate had a normal distribution, non-parametric statistical test ordinal logistic regression (OLR) and Spearman's rank correlation were performed to test the hypothesis H2.

4.3.3.2.1 H2 Ordinal regression

Pearson and Deviance chi-square goodness-of-fit test was conducted to determine if the model fits the dataset well. The Pearson ($\chi^2(611) = 798.391$, $P = 1.307$) and Deviance chi-square test ($\chi^2(611) = 237.060$, $P = .388$) were not significant ($P>0.05$) as shown in Table 31 suggesting a good model fit.

Table 31: H2 OLR Goodness of Fit[a]

	Value	df	Value/df
Deviance	237.060	611	.388
Scaled Deviance	237.060	611	
Pearson Chi-Square	798.391	611	1.307
Scaled Pearson Chi-Square	798.391	611	
Log Likelihood[b]	-149.919		
Akaike's Information Criterion (AIC)	373.839		
Finite Sample Corrected AIC (AICC)	514.439		
Bayesian Information Criterion (BIC)	450.075		
Consistent AIC (CAIC)	487.075		

Note: Dependent Variable: Organization innovation readiness

Model: (Threshold), Employee motivation to Innovate

a. Information criteria are in smaller-is-better form.
b. The full log likelihood function is displayed and used in computing information criteria.

The omnibus test results confirms too that the model fits the dataset well with a statistically significant chi-square ($\chi^2(1) = 7.994$, $P = .005$) as shown in Table 32 implying that the new model is significantly better.

Table 32: H2 OLR Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
7.994	1	.005

Note: Dependent Variable: Organization innovation readiness

Model: (Threshold), Employee motivation to Innovate

a. Compares the fitted model against the thresholds-only model.

The pseudo r-square results for Nagelkerke (Table 33) indicated that 12.9% of the change in in the dependent variable, organization innovation readiness is because of the independent variables employee motivation to innovate [113].

Table 33: H2 OLR Pseudo R-Square

Cox and Snell	.129
Nagelkerke	.129
McFadden	.020

Note: Link function: Logit.

The test of parallel lines tests for the violation of the assumption of proportional odds. It was found significant. Since the coefficient was statistically significant P<0.001

(Table 34), the assumptions were violated.

Table 34: H2 OLR Test of Parallel Lines[a]

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	299.839			
General	.000[b]	299.839	35	.000

Note: The null hypothesis states that the location parameters (slope coefficients) are the same across response categories.

a. Link function: Logit.

b. The log-likelihood value is practically zero. There may be a complete separation in the data. The maximum likelihood estimates do not exist.

4.3.3.2.2 H2 Multinomial logistic regression (MLR)

Due to the violation of the test of parallel lines assumptions, a multinomial logistic regression (MLR) was conducted to predict the influence of employee motivation to innovate on Icelandic and Kenyan public energy organizations' innovation readiness. Table 35 shows the model fitting information indicating that the final model is significant improvement in fit over the null model square ($\chi^2(2) = 16.973$, $P < .001$).

Table 35: H2 MLR Model Fitting Information

	Model Fitting Criteria			Likelihood Ratio Tests		
Model	AIC	BIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	61.139	63.199	59.139			
Final	48.166	54.347	42.166	16.973	2	.000

The goodness-of-fit table The Deviance and Pearson chi-square goodness-of-fit test was performed to determine if the model fits the dataset well. The Pearson ($\chi^2(53) = 53.799$, $P = .444$) and Deviance chi-square test ($\chi^2(53) = 42.166$, $P = .857$) were not significant ($P>0.05$) as shown (Table 36) suggesting a good model fit.

Table 36: H2 MLR Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	53.799	53	.444
Deviance	42.166	53	.857

From the likelihood ration test results (Table 37), the employee motivation to innovate was not a significant predictor in the model ($\chi^2(1) = .030$, P = .862).

Table 37: H2 MLR Likelihood Ration Test

Effect	Model Fitting Criteria			Likelihood Ratio Tests		
	AIC of Reduced Model	BIC of Reduced Model	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	52.852	56.973	48.852	6.686	1	.010
Employee motivation to Innovate	46.196	50.317	42.196	.030	1	.862
Organization innovation readiness	60.276	64.397	56.276	14.111	1	.000

Note: The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0 (zero).

From the parameter estimates in Table 38, organizations which scored higher on organization innovation readiness were more likely to be in Kenya than in Iceland being the only predictor that was statistically significant (β = 1.400, SE = .436, P = .001). Employee motivation to innovate was therefore not a statistically significant predictor with β = -0.065, *SE* = .374, P = .862. The odds ratio *(exp(β))* of 4.055 indicated that for every one unit increase in organization innovation readiness the odds of a public energy organization being in Kenya changed by a factor of 4.055.

Table 38: H2 MLR Parameter Estimates

Country[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% CI for Exp(B)	
								Lower Bound	Upper Bound
Kenya	Intercept	-4.113	1.704	5.829	1	.016			
	Employee motivation to Innovate	-.065	.374	.030	1	.862	.937	.450	1.951
	Organization innovation readiness for innovation	1.400	.436	10.327	1	.001	4.055	1.726	9.523

Note: a. The reference category is: Iceland.

As a classification table (Table 39) shows which group membership were best predicted by the model. The Icelandic public energy organizations were predicted correctly by the model 50.0% of the time compared to the Kenyan public energy organizations which were correctly predicted by the model, nearly twice better, 95.7% of the time.

Table 39: H2 MLR Classification

Observed	Predicted		
	Iceland	Kenya	Percent Correct
Iceland	6	6	50.0%
Kenya	2	44	95.7%
Overall Percentage	13.8%	86.2%	86.2%

4.3.3.2.3 H2 Spearman's rank correlation test

Spearman's rank correlation was performed on the dataset to determine the strength and direction of correlation between the two variables organization innovation readiness (Q09-Q12) and employee motivation to innovate (Q06). The Spearman's correlation coefficients were as presented in Table 40.

Table 40: H2 Spearman's Rank Correlation

		Q09-Q12	Q06
Q09-Q12	Correlation Coefficient	1.000	
	Sig. (2-tailed)	.	
	N	58	
Q06	Correlation Coefficient	.320*	1.000
	Sig. (2-tailed)	.014	.
	N	58	58

Note: * Correlation is significant at the 0.05 level (2-tailed).

There was a statistically significant but weak positive correlation between variables Q09-Q12 and Q06, $r(56) = .320$, $P = .014$ [112].

4.3.3.3 Hypothesis 3

H3: Public energy organizations' innovation readiness is more positively related to the employee knowledge, training, and competence.

4.3.3.3.1 H3 Ordinal regression

Pearson and Deviance chi-square goodness-of-fit test was conducted to determine if the model fits the dataset well. The Pearson ($\chi^2(179) = 188.299$, $P = 1.052$) and Deviance chi-square test ($\chi^2(179) = 135.654$, $P = .758$) were not significant ($P>0.05$) as shown in Table 41 suggesting a good model fit.

Table 41: H3 OLR Goodness-of-Fit[a]

	Value	df	Value/df
Deviance	135.654	179	.758

Scaled Deviance	135.654	179	
Pearson Chi-Square	188.299	179	1.052
Scaled Pearson Chi-Square	188.299	179	
Log Likelihood[b]	-108.062		
Akaike's Information Criterion (AIC)	290.124		
Finite Sample Corrected AIC (AICC)	430.724		
Bayesian Information Criterion (BIC)	366.360		
Consistent AIC (CAIC)	403.360		

Note: Dependent Variable: Organization innovation readiness

Model: (Threshold), Employee motivation to Innovate

a. Information criteria are in smaller-is-better form.

b. The full log likelihood function is displayed and used in computing information criteria.

The omnibus test results confirms too that the model fits the dataset well with a statistically significant chi-square ($\chi^2(1) = 2.464$, $P = .117$) as shown in Table 42 implying that the new model is not significantly better hence does not fit the dataset well.

Table 42: H3 OLR Omnibus Test[a]

Likelihood Ratio Chi-Square	df	Sig.
2.464	1	.117

Note: Dependent Variable: Organization innovation readiness

Model: (Threshold), Employee motivation to Innovate

a. Compares the fitted model against the thresholds-only model.

The test of parallel lines tests for the violation of the assumption of proportional odds. It was found statistically significant $P = 0.008$ (Table 43), violating the assumptions of proportional odd.

Table 43: H3 OLR Test of Parallel Lines[a]

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	216.124			
General	158.054[b]	58.070[c]	35	.008

Note: The null hypothesis states that the location parameters (slope coefficients) are the same across response categories.

a. Link function: Logit.

b. The log-likelihood value cannot be further increased after maximum number of step-halving.

c. The Chi-Square statistic is computed based on the log-likelihood value of the last iteration of the general model. Validity of the test is uncertain.

The violation of the assumption of proportional odds meant that the model was not suitable in predicting the effect of employee motivation on the organization's innovation readiness. Therefore, a spearman's correlation analysis was carried out to determine the strength and direction of influence employee motivation to innovate on the organization's innovation readiness.

4.3.3.3.2 H3 Spearman's rank correlation

Spearman's rank correlation was performed on the dataset to determine the strength and direction of correlation between the two variables organization innovation readiness (Q09-Q12) and employee skills and knowledge (Q04). The Spearman's correlation coefficients were as presented in Table 44.

Table 44: H3 Spearman's Rank Correlation

		Organization innovation readiness	Employee skills and knowledge
Organization innovation readiness	Correlation Coefficient	1.000	
	Sig. (2-tailed)	.	
	N	58	
Employee skills and knowledge	Correlation Coefficient	.232	1.000
	Sig. (2-tailed)	.080	.
	N	58	58

Note: *. Correlation is significant at the 0.05 level (2-tailed).

The correlation between variables Q09-Q12 and Q04, was found to be statistically not significant, $r(56) = .232$, $P = .080$ ($P>0.05$).

4.3.3.4 Hypothesis 4

H4: Public energy organizations' innovation awareness is more positively related to the collaborative innovations undertaken by the organization.

Since the dependent and the independent variable being investigated by this hypothesis were both normally distributed, parametric statistical tests (linear regression and Pearson correlation tests) were conducted to determine the suitability of the dataset for a model in predicting the outcome in organization innovation awareness and to assess their strengths and direction of correlation.

4.3.3.4.1 H4 Linear regression

Linear regression was conducted to test if the organization innovation collaboration systems significantly predicted the employee innovation awareness. The Pearson correlation coefficient, $r = 0.421$ showed that there was a positive correlation between the two variables. The R-value describes the strength and direction of a linear relationship between two or more variables. The R-squared value of 0.177 shows that about 17.7% of changes in the organization's employee innovation awareness in explained by the organization's innovation collaboration systems. While a greater part of about 82.3% is captured by an error term showing that the model has a poor fit.

The adjusted R-squared value of 0.162 shows that about 16.2% of changes in the organization innovation awareness is explained by the organization's innovation collaboration systems while about 83.8% is captured by the error term, further showing that the model has a poor fit. The Durbin-Watson measure evidence of autocorrelation in the residual with an acceptable range of no autocorrelation being 1.5 to 2.5 [114]. The DW value was 1.963 which is within the acceptable range of no autocorrelation, thus the observations are independent.

Table 45: H4 LR Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.421[a]	.177	.162	.50442	1.963

Note: a. Predictors: (Constant), Organization Innovation collaboration systems
b. Dependent Variable: Organization employee innovation awareness

The analysis of variance (ANOVA) measured the overall significance of the model. The results confirmed that the overall regression model was significant for the data based on the ANOVA (F-statistic) value, F = 12.036 and its associated probability value of P = 0.001 ($F(1,56)$=12.036, P<0.001) that was found to be statistically significant at 5% level as shown in Table 46 showing that the regression model was a good fit for the data.

Table 46: H4 LR ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3.063	1	3.063	12.036	.001[b]
	Residual	14.249	56	.254		
	Total	17.311	57			

Note a. Dependent Variable: Organization employee innovation awareness
b. Predictors: (Constant), Organization Innovation collaboration systems

From the coefficients table (Table 47) the organization's innovation collaboration system B coefficient value was found to be B = 0.231 shows that a unit increase in organization innovation collaboration system on the average increased the organization innovation awareness by 0.231. The calculated t-value for the relationship between organization innovation collaboration system and the organization employee innovation awareness is given as $t = 3.469$ with an associated p-value of $P = 0.01$ ($P<0.05$) showing conclusively that the organization innovation collaboration system has a positive and significant impact on the organization employee innovation awareness. The tolerance value for the independent value, organization innovation collaboration system, is 1.000 which is not less than 0.10, therefore not violating the multicollinearity assumption which is supported by the VIF value of 1.000 which is well below the cut-off value of 10 meaning that the model is free from multicollinearity.

Table 47: H4 LR Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	3.650	.290		12.601	.000		
	Organization Innovation collaboration systems	.231	.067	.421	3.469	.001	1.000	1.000

Note: a. Dependent Variable: Organization employee innovation awareness

4.3.3.4.2 H4 Pearson correlation

Pearson correlation analysis was carried out to determine the direction and strength of the linear relationship between organization innovation collaboration systems and the employee innovation awareness. From the Pearson correlation table (Table 48), the correlation between employee innovation awareness and the innovation collaboration system was found to be moderate and positive, $r = 0.421$ and statistically significant at $P = 0.01$ [112].

Table 48: H4 Pearson Correlation

		Employee innovation awareness	Innovation collaboration systems
Employee innovation awareness	Pearson Correlation	1	
	Sig. (2-tailed)		
	N	58	
Innovation collaboration systems	Pearson Correlation	.421**	1
	Sig. (2-tailed)	.001	
	N	58	58

Note: **. Correlation is significant at the 0.01 level (2-tailed).

4.3.3.5 Hypothesis 5

H5: Public sector organizations in Iceland innovate differently from those in Kenya.

The respondents were asked how they would classify their organizations' innovation. Variable Q14 highlights three types of innovation organizations. Q14A (*The organization develops new products, or services with its own internal resources*) described an organization that is an innovation generator, utilizing its own internal resources to develop new products and services for its market environment. Q14 B (*The organization adopts new products or services developed by other organization*) described an organization that is an innovation adopter. These organizations procure or implement new products or services developed by other organizations but not yet available in their market environment. While Q14C (*The organization replicates new products or services developed by other organization*) describes an organization that is an innovation imitator. These organizations, develop or re-engineer products and services developed by other organization with significant improvement for their market environments.

4.3.3.5.1 H5 Correlation analysis

To assess the relationship between the three classes of organizations, Pearson correlation was conducted. From the results in Table 49, there is a significant weak positive correlation between an organization that is an innovation generator and an organization that is an innovation adopter $r = 0.267$, $P = 0.043$. Similarly, there is a not significant correlation between an organization that is an innovation generator and an organization which is an innovation imitator $r = 0.070$, $P = 0.602$. However, there is a strong positive correlation between and organization that is an innovation adopter and an organization that is an innovation imitator $r = 0.503$, $P < 0.001$.

Table 49: H5 Pearson Correlation

		Organization is an innovation generator	Organization is an innovation adopter	Organization is an innovation imitator
Organization is an innovation generator	Pearson Correlation	1		
	Sig. (2-tailed)			
	N	58		
Organization is an innovation adopter	Pearson Correlation	.267*	1	
	Sig. (2-tailed)	.043		
	N	58	58	
Organization is an innovation imitator	Pearson Correlation	.070	.503**	1
	Sig. (2-tailed)	.602	.000	
	N	58	58	58

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

4.3.3.5.2 H5 Descriptive statistics

Table 50 highlight the descriptive statistics of the variables. It is noted that most respondents identified their organizations as innovation generators (*N* = 58, *M* = 4.474, *SD* = 1.179). Fewer respondents identified their organization as innovation imitators (*N* = 58, *M* = 4.231, *SD* = 1.186).

Table 50: H5 Descriptive Statistics Summary

	Mean	Std. Deviation	N
Organization is an innovation generator	4.474	1.179	58
Organization is an innovation adopter	4.231	1.186	58
Organization is an innovation imitator	3.480	1.451	58

Table 51 details the classification of the organization further by country. Icelandic public energy organizations were identified generally as either innovation adopters (*N* = 58, *M* = 4.683, *Mdn* = 5 (*Agree*)) or innovation imitators (*N* = 58, *M* = 4.167, *Mdn* = 5 (*Agree*)) with slight agreement that they are innovation generators *(N* = 58, *M* = 4.000, *Mdn* = 4 (*Slightly Agree*)). The Kenyan organizations were identified mainly as innovator generators (*N* = 58, *M* = 4.597, M*dn* = 5 (*Agree*)) with slight agreement that they are innovation adopters (*N* = 58, *M* = 4.114, *Mdn* = 4 (*Slightly Agree*)) and slight disagreement innovation imitators (*N* = 58, M = 3.300, *Mdn* = 5 (*Slightly Disagree*)).

Table 51: H5 Descriptive Statistics by Country

		M	Mdn		SD	95% CI for Mean Lower Bound	95% CI for Mean Upper Bound
Organization is an innovation generator	Iceland	4.000	4	Slightly Agree	1.044	3.336	4.664
	Kenya	4.597	5	Agree	1.191	4.243	4.951
Organization is an innovation adopter	Iceland	4.683	5	Agree	0.955	4.076	5.290
	Kenya	4.114	4	Slightly Agree	1.221	3.752	4.477
Organization is an innovation imitator	Iceland	4.167	5	Agree	1.467	3.235	5.099
	Kenya	3.300	3	Disagree	1.408	2.882	3.718

Figure 3, Figure 4, and Figure 5 show the boxplots of the respondents' identification of their organizations' nature of innovation.

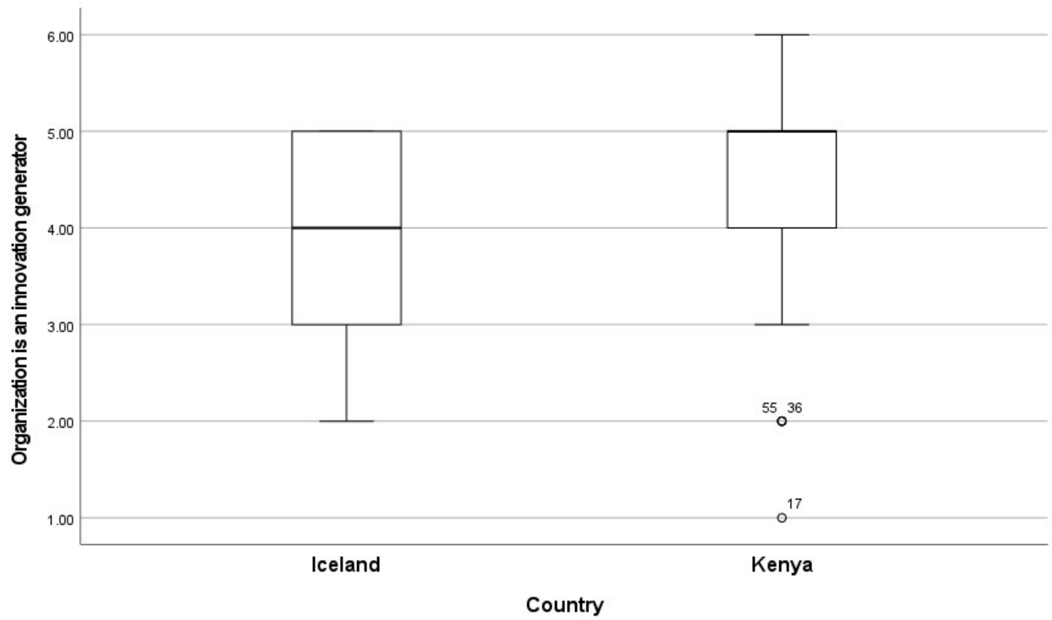

Figure 3: H5 Organization as an innovation generator boxplot

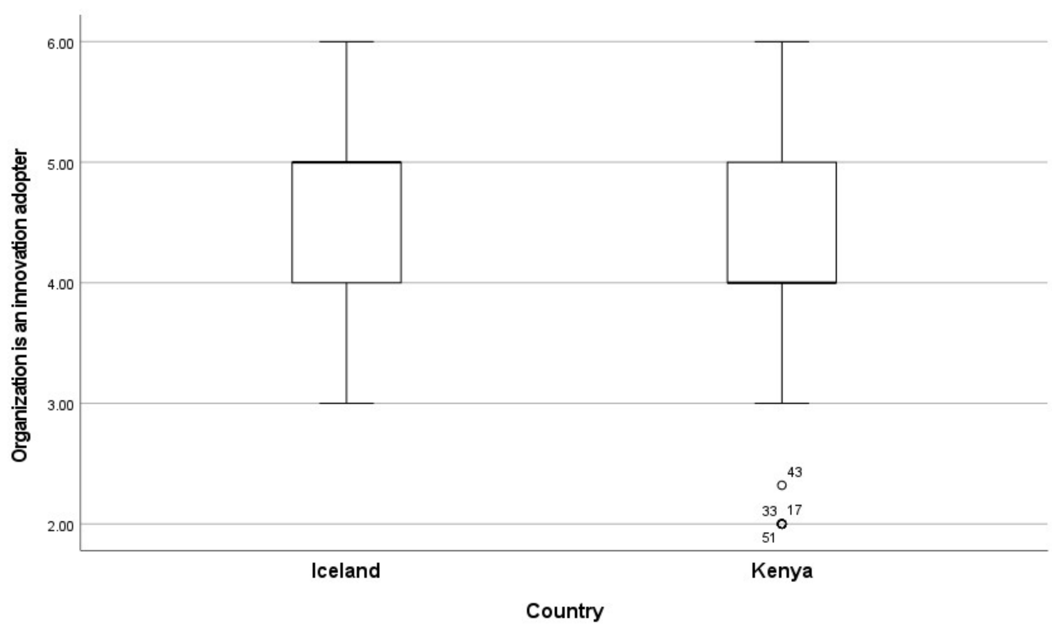

Figure 4: H5 Organization as an innovation adopter boxplot

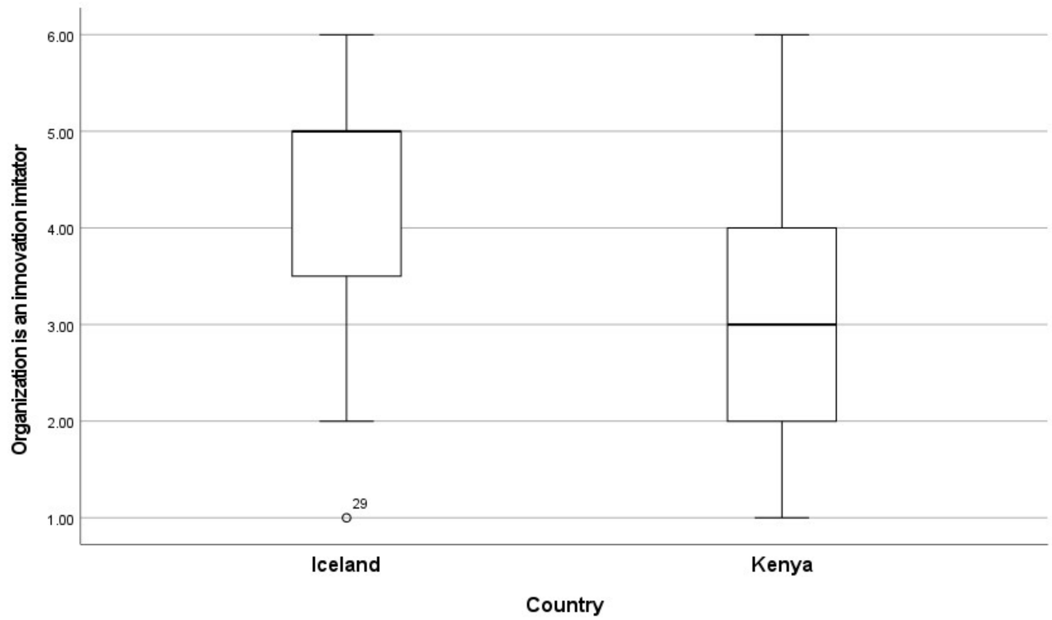

Figure 5: H5 Organization as an innovation imitator boxplot

4.3.3.6 Hypothesis 6

H6: Climate action projects are more prioritized in Kenya than in Iceland.

This hypothesis implied that public energy organizations in Iceland and Kenya had prioritized climate action differently, with the belief that Kenya had given climate action projects a higher priority. The strength and direction of the relationship (strength and direction) between three variables, Q16 (organization response to global climate action), Q17 (organization commitment toward energy trilemma), and Q23A (Respondent agreement with organization innovation pathway), was first determined using a correlation analysis.

4.3.3.6.1 H6 Correlation analysis

Spearman's correlation analysis was carried out to determine the strength of the relationships between three non-normally distributed variables looking into the organization's response to climate action and prioritization.

From the results in Table 52, there is a significant moderate positive correlation between an Q16 and Q17 ($r = 0.403$, $P = 0.02$). Similarly, there is a significant weak positive correlation between Q16 Q23A ($r = 0.363$, $P = 0.005$). However, there is a strong positive correlation between Q17 and Q23A and an organization that is an innovation imitator $r = 0.503$, $P < 0.001$.

Table 52: H6 Spearman's Correlation

		Q16	Q17	Q23A
Q16	Correlation Coefficient	1.000		
	Sig. (2-tailed)	.		
	N	58		
Q17	Correlation Coefficient	.403**	1.000	
	Sig. (2-tailed)	.002	.	
	N	58	58	
Q23A	Correlation Coefficient	.363**	.503**	1.000
	Sig. (2-tailed)	.005	.000	.
	N	58	58	58

**. Correlation is significant at the 0.01 level (2-tailed).

4.3.3.6.2 H6 Descriptive analysis

Table 53 highlights the descriptive statistics of the variables Q16, Q17, and Q23A. It is noted that most respondents identified their organizations' response to climate action as agreeable (N = 58, M = 4.837, SD = 0.852). The organizations' commitment toward energy trilemma was also seen as agreeable (N = 58, M = 4.812, SD = 0.857). The respondents also agreed with their organizations' innovation pathway (N = 58, M = 5.086, SD = 0. 884).

Table 53: H6 Descriptive Statistics

	Mean	Std. Deviation	N
Organization response to global climate action	4.837	.852	58
Organization commitment toward energy trilemma	4.812	.857	58
Respondent agreement with organization innovation pathway	5.086	.884	58

Analyzing further, Table 54 details the respondents' response further by country. Kenyan public energy organizations' respondents agreed with their organizations' response to climate action (N = 58, M = 4.906, Mdn = 5.0 (*Agree*)), organization commitment toward energy trilemma (N = 58, M = 4.975, Mdn = 5.0 (*Agree*)) and the organization innovation pathway (N = 58, M = 5.196, Mdn = 5.0 (*Agree*)). The Icelandic public energy organizations' respondents also agreed, though averagely lower than the Kenyan respondents, with their organizations' response to climate action (N = 58, M = 4.573, Mdn = 4.8 (*Agree*)), organization commitment toward energy trilemma (N = 58, M = 4.185, Mdn = 4.5 (*Agree*)) and the organization innovation pathway (N = 58, M = 4.667, Mdn = 5.0 (*Agree*)).

Table 54: H6 Descriptive Statistics by Country

		M	Mdn		SD	95% CI for Mean Lower Bound	95% CI for Mean Upper Bound
Organization response to global climate action	Iceland	4.573	4.8	Agree	0.960	3.963	5.183
	Kenya	4.906	5.0	Agree	0.818	4.663	5.149
Organization commitment toward energy trilemma	Iceland	4.185	4.5	Agree	1.262	3.383	4.987
	Kenya	4.975	5.0	Agree	0.641	4.785	5.165
Respondent agreement with organization innovation pathway	Iceland	4.667	5.0	Agree	1.155	3.933	5.400
	Kenya	5.196	5.0	Agree	0.778	4.965	5.427

Figure 6, Figure 7 and Figure 8 show the boxplots of the respondents' scoring of their organizations' commitment to climate action with the Kenyan energy organizations' respondents indicating higher prioritization of climate action projects compared to the Icelandic energy respondents.

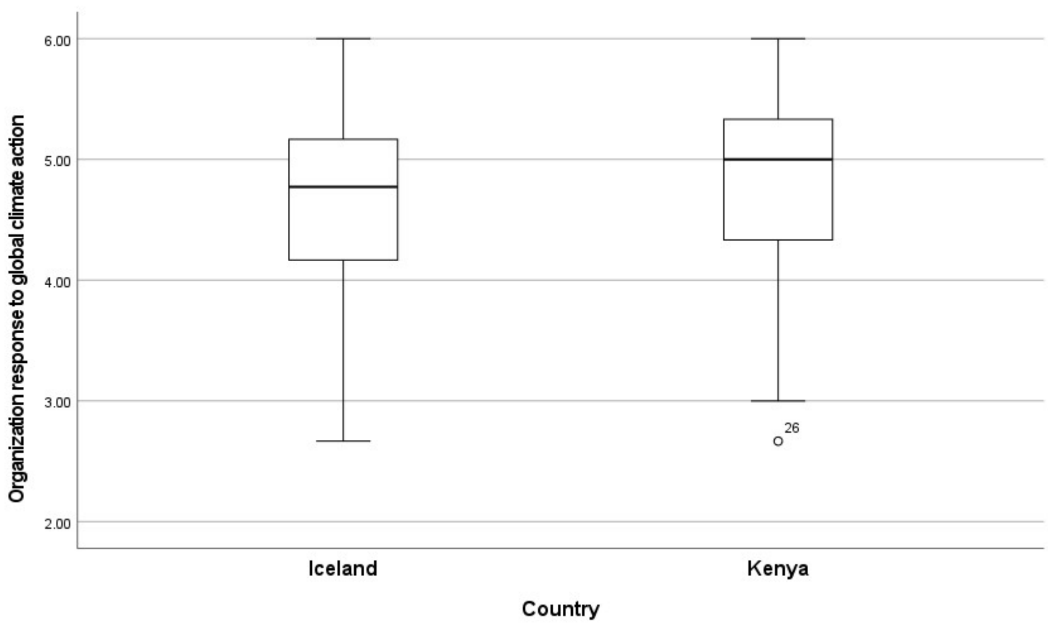

Figure 6: H6 Organization response to climate action boxplot by country

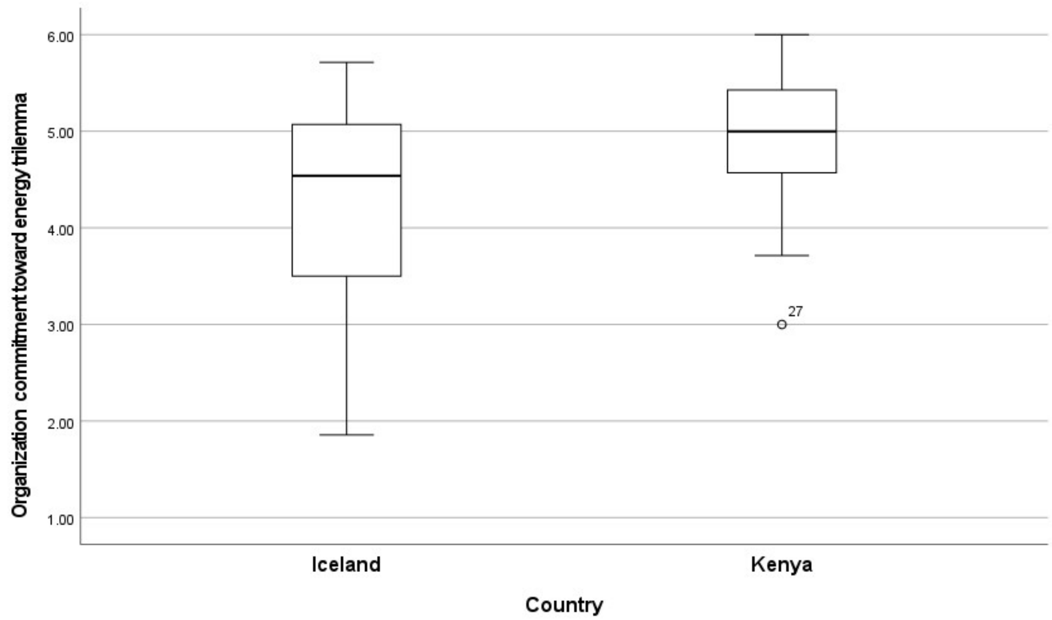

Figure 7: H6 Organization commitment to energy trilemma boxplot by country

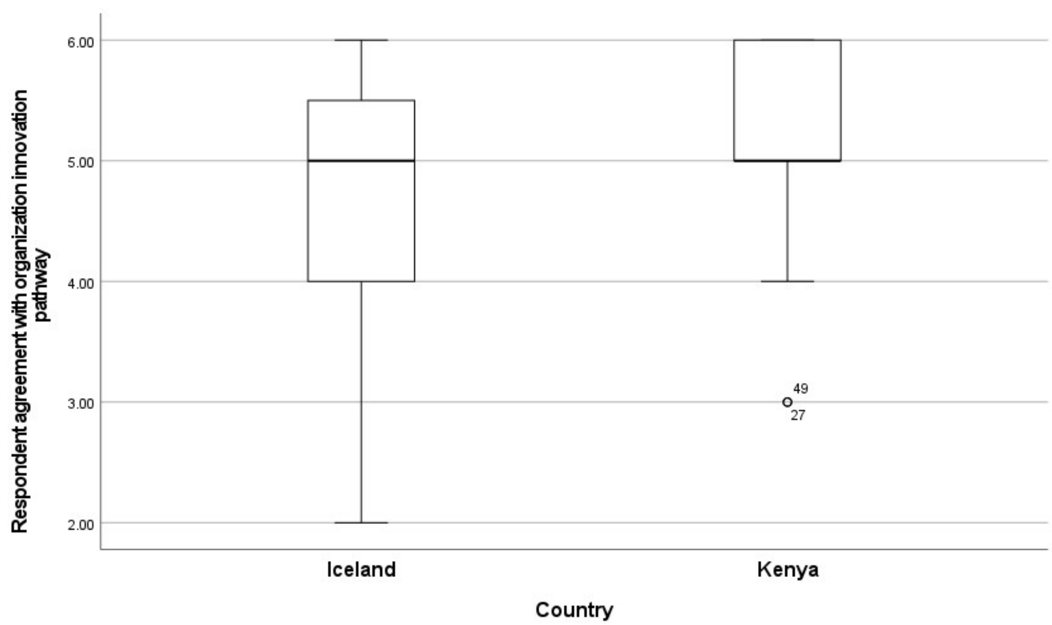

Figure 8: H6 Agreement with organization's innovation pathway boxplot by country

Table 57 to Table 67 in Appendix H and Appendix I show response summary statistics for all scale items used in the final analysis based on the country of operation.

5 Discussions

5.1 Research objectives revisited

This study sought to ascertain the state of innovation awareness and readiness within public energy organizations, particularly regarding climate action. This chapter discusses the research findings by answering the research questions based on the results of the hypotheses tests. The following 3 research questions and respective 6 hypotheses were formulated to carry out the study.

1. How do public energy organizations innovate? Are they innovation generators, adopters, or imitators?
    a. H4: Public energy organizations' innovation awareness is more positively related to the collaborative innovations undertaken by the organization.
    b. H5: Public sector organizations in Iceland innovate differently from those in Kenya.
2. Are the public energy organizations' innovation culture transforming to innovation-as-usual?
    a. H1: An organizations' innovation culture is more positively related to the organizations' innovation management, structure, and leadership.
    b. H2: An organizations' innovation readiness is more positively related to the employees' motivation to innovate despite the country of operation.
    c. H3: Public energy organizations' innovation readiness is more positively related to the employee knowledge, training, and competence.
3. How are public energy organizations handling climate action challenges?
    a. H6: Climate action projects are more prioritized in Kenya than in Iceland.

By the end of the survey, 59 respondents from the public energy sector in Iceland and Kenya had completed a voluntary online self-administered questionnaire. The questionnaire was designed to be completed using a Likert scale, with a scale of 6 for *"Strongly Agree / Highly Likely"* to 1 for *"Strongly Disagree / Highly Unlikely"*. Hypotheses testing results

To test the hypotheses, the data was prepared for analysis to ensure it was reliable and hence representative to the population. To this end, responses/cases were analyzed for missing data and engagement. 31% of the cases had missing data representing less than

2% of the values. One case was deleted from the analysis after determining low level of engagement in the survey. For the missing data, SPSS multiple imputation (MI) technique was used to analyze and replace the missing values after it was established that the data was missing completely at random. The extreme values were then examined to ensure they did not have an undue influence on the analysis. Only one extreme value was found. One case was deleted for further analysis for not being engaged in the survey, reducing the number of responses for analysis to 58 cases where 20.7% of the cases from Iceland and 79.3% from Kenya.

Overall, the majority of respondents were, male (74.1%), aged 30-39 years (43.1%), in engineering and science (56.1%) profession, with over 5 years of experience in the energy sector (92.9%), well learned with a master's degree (51.7%), and working in the electricity generation sub-sector (66.7%). 34.5% of them are middle-level managers with long-term contracts (87.7%) in their respective organizations. A categorical data analysis was performed, which resulted in the recoding of certain categories such as age group, highest education attained, electricity sub-sector, profession, years of experience in public energy sector, position in organization, and employment terms. To optimize categorical data analysis with fewer missing data, some categories were merged during the recoding process.

Statistically, the data was now determined suitable for analysis. With this, eleven (11) key variables were set for analysis. Their mean (*M*) and standard deviation (*SD*) range was fairly distributed $3.480 < M < 5.086$ and $0.504 < SD < 1.451$. The original plan was to analyze the data using a thematic response to innovation awareness, innovation readiness, future innovation focus, and agreement to the organization's innovation pathway and the adopted definition of innovation. Following the completion of a factor analysis, six (6) key factors/constructs were identified: employee innovation awareness, employee motivation to innovate, organizational innovation readiness, organizational innovation collaboration systems, organizational response to climate action, and organizational commitment to the energy trilemma.

5.1.1 How do the public energy sector organizations innovate?

To try to answer this question, the fourth and fifth hypotheses were evaluated. These hypotheses are related to the levels of innovation awareness in public energy organizations, their innovation collaboration systems, and the types of innovations they undertake.

The fourth hypothesis, *H4: Public energy organizations' innovation awareness is* *more positively related to the collaborative innovations undertaken by the organization* was tested to establish the relationship between an organization's innovation collaboration systems and its employees' innovation awareness. The findings revealed that the organizations' collaboration systems were a positive predictor of employee innovation awareness, with a moderate statistically significant positive correlation between the two variables. Energy organizations in both countries determined that collaboration with private enterprises was likely.

Surviving in a VUCA world requires a quick response to ever-changing policies, political commitments, and citizen pressure. Organizations must have an agile structure in place to manage the urgency of response. Climate action policies have declared short-term and long-term plans that necessitate immediate action to avoid a potentially disastrous future. Organizations must train their employees to quickly identify opportunities for innovation to respond to these changes. Experimentation necessitates a capital pool of technical experts as well as adequate funding depending on how familiar of unfamiliar the technology and/or the market is to the organization [44, p. 24]. A collaborative approach will ensure that a diverse pool of entrepreneurs, researchers and innovators from other public organization units, private enterprises, research, and academic institutions are available to safely navigate the VUCA territories in the energy sector. This requires public organizations to seek collaboration with other public and private organizations in order to collect relevant data, implement relevant policies, and coordinate decisively in order to implement appropriate innovative techniques to avert a climate crisis [65].

The fifth hypothesis, *H5: Public sector organizations in Iceland innovate differently from those in Kenya* was tested to establish how the public energy organizations in Iceland and Kenya innovate. Pearson's correlation analysis determined that organizations identified as innovation generators had a positive weak significant correlation with organizations identified as innovation adopters, but not with organizations identified as innovation imitators. The analysis also revealed that the Kenyan public energy organizations strongly identified themselves as innovation generators and innovators, whereas those in Iceland identified themselves more as innovators and imitators. This supports the hypothesis that Icelandic and Kenyan public energy organizations innovate differently and answers the research question on how public energy organizations innovate.

Cirera and Maloney (2017) [115] report indicates that innovation has mostly been viewed as a "first-world" activity with little information on innovation in developing countries. It is thus clear that innovation in Iceland and Kenya would differ. The report further indicates an interesting phenomenon where firms in developing countries including Kenya, reported substantial innovation higher than many OECD countries, with more nontechnological innovations [115]. Further, the report notes that innovation in low- and middle-income countries is mostly imitated or adopted contradictory to the current study results. Given that over 90% of the respondents agreed with the adopted definition of innovation in the current study Table 67, it is expected that classification of the nature of innovations in the respective organizations to be compliant. However, to understand better how the innovation is done in the two countries, analysis of the quality or novelty of reported or recorded innovations would be needed. Therefore, being an innovation generator, adopter or imitator would require measure of newness of product, service, market, region, or specification.

5.1.2 Is the innovation culture changing for the better?

The first, second, and third hypotheses are concerned with the organization's innovation culture and, as a result, its ability to innovate. The quote "culture eats strategy for breakfast" by Peter Drucker resonates quite well with public organizations characterized as bureaucratic, with hierarchical structure and rigid leadership. While an innovation strategy is meant to guide a ready, flexible, and agile workforce with responsive, flexible, and agile leadership, such strategies remain on paper in organizations that have not embraced changes in their structures and management to be aggressively flexible and agile. Actionable innovation strategies require a healthy innovation culture characterized by teamwork, freedom to experimentation, appropriate reward mechanisms, tolerance for diversity, respect, and integrity [44, Ch. 4]. While it is difficult to measure motivation, a motivated and qualified workforce manifest in the organizations' outcomes or performance through improved productivity and customer satisfaction [116].

The first hypothesis, *H1- An organizations' innovation culture is more positively related to the organizations' innovation management, structure, and leadership* was tested to find out whether the organizations' innovation strategy, innovation management and leadership had a statistically positive relationship with the organizations' innovation culture. According to the findings, there was a moderate statistically significant, positive correlation between the variables, with organizations' management leadership and structure having a stronger positive influence on the organizations' innovation culture than the organizations' innovation strategy. Theory agrees that organizational culture and structure supports change and innovation in the organization [50], [53]. Agolla (2015) study on innovation in Kenya's public found that only organizational leadership significantly predicted innovation [33].

The second hypothesis, *H2: An organizations' innovation readiness is more positively related to the employees' motivation to innovate despite the country of operation* was tested to determine how employees' motivation to innovate influence the organizations' innovation readiness based on the country of operation. Employee motivation was found to have a weak positive correlation to organizational innovation readiness, even though it was not a statistically significant predictor of an organization's innovation readiness. Furthermore, Kenyan energy organizations demonstrated greater readiness for innovation than Icelandic organizations. Table 58 displays the findings of a study conducted by country on what motivates employees to innovate. These findings indicate that most employees are motivated by personal reasons and recognitions rather than financial rewards, which aligns with entrepreneurs' expectations for motivation and success to be driven by passion rather than monetary payoffs [117, pp. 4–6].

The third hypothesis, *H3: Public energy organizations' innovation readiness is more positively related to the employee knowledge, training, and competence* was tested to determine the influence employees' skill and knowledge influenced the organizations' innovation readiness. According to the findings, employee skill and knowledge were not a good predictor of public energy organizations' innovation readiness and did not have a statistically significant correlation to public energy organizations' innovation readiness, as hypothesized. The hypothesis, therefore, did not hold true and was thus rejected based on the empirical analysis results. While the hypothesis did not get empirical support, education and training equip employees with requisite knowledge and skills in solving challenging tasks hence empowering them to innovate and adapt to changing environments and markets [33].

5.1.3 What is the impact energy sector innovation on climate action?

Climate action as an outcome of innovation, was tested by testing the sixth hypothesis, *H6: Climate action projects are more prioritized in Kenya than in Iceland*. The organizations' response to climate action, commitment to the energy trilemma, and respondents' agreement with their organizations' innovation pathway were all tested. According to the findings, the organizations' response to climate action had a moderately positive statistically significant correlation with their commitment to the energy trilemma, as well as a statistically significant weak positive correlation with their innovation pathway. The organization's commitment to the energy trilemma, on the other hand, had a moderately positive statistically significant correlation with the organization's innovation pathway. Kenyan energy organizations were found to have prioritized climate action more than Icelandic energy organizations, with a higher mean and lower standard deviation, as hypothesized.

To further analyze climate action outcomes and focus, items Q19 (electricity generation projects), Q20 (energy transition projects), Q21 (energy technological focus) and Q22 (GHG emissions reduction SDG projects) descriptive statistics were evaluated as shown in Table 63, Table 64, Table 65, and Table 66 respectively.

According to these findings on future electricity generation projects, Icelandic and Kenyan energy organizations show similar focus on more geothermal energy being for future electricity generation possibly due to their rich geothermal energy resource development being ranked among the top 10 geothermal countries in 2021 [118]. Given Kenya's diverse energy mix, hydroelectric, solar, and wind power projects stood a good chance of being built. Iceland's investigation into the potential use of wind power for electricity generation was also found to be likely. Finally, despite Kenya's discovery of coal deposits, coal-fired power plant projects are highly unlikely for future electricity generation in both countries. These findings indicate that the public energy organizations in both countries are focused on implementing low-carbon energy sources for future electricity generation in line with the global climate action strategies [119].

Icelandic and Kenyan public energy organizations are more likely to be looking into green hydrogen as an alternative energy transitioning from fossil-based fuels on energy transition projects. In the effort for energy transition for electricity generation, nuclear, natural gas, and biomass power plants showed low likelihood choices, with Icelandic organizations scoring higher on the unlikelihood of electricity generation using the three technologies than Kenyan organizations. While emphasis is placed globally on “cleaner”, “greener” low-carbon energy generation sources by phasing out of coal-fired power plants and increasing electrification of vehicular fleet, investment is also being pushed towards scaling up of nuclear power plants and use of natural gas as an alternative in reaching the net-zero emissions 2050 targets [63]. Kenya has an active Directorate looking into coal and nuclear activities and an agency NuPEA (Nuclear Power and Energy Agency) [120] showing the interest investment in these technologies. Kenyan energy planners, project to use coal in electricity production in case of a deficit [22], [120] bringing to question the country’s commitment to GHG emissions reduction.

Solving the energy trilemma requires the development and adoption of energy-efficient technologies, as well as collaboration with private enterprises to find the most efficient energy solutions for electricity generation, transmission, distribution, monitoring, and storage systems. Energy storage solutions reduce waste during electricity generation and allows for later consumption. According to the findings, Icelandic energy organizations are evenly split when it comes to grid interconnection, electricity market expansion, energy storage, e-mobility infrastructure, net metering, and smart grid solutions. Following the shelving of electrical interconnectivity projects between Iceland and neighboring countries [77], [121], there sems to be uncertainty in expansion of electricity markets and grid strengthening projects, going by the results of this study. Kenyan organizations, on the other hand, indicated a higher likelihood in undertaking these projects. This is probably due to the availability of grid interconnectivity across national borders, expansion and upgrading of existing electricity networks and the focused exploitation of geothermal resources and other renewable energy solutions [122].

6 Limitations and future research

Through an empirical assessment of innovation in developed (Iceland) and developing (Kenya) economies, this study has contributed to the body of knowledge on public energy sector innovation. The study did, however, have several limitations.

- First and foremost, the study only looked at the public electricity sub-sector, which included regulation, generation, transmission, and distribution organizations where the government had a controlling stake of more than 50%, without considering other energy-related industries such as transportation, manufacturing, building, and construction.
- Second, the study only considered the internal environment (drivers) of innovation of public energy organizations, taking note of the fact that the contribution of external variables is equally important.
- Third, the time constraints prevented the use of additional data collection and analytical tools such as one-on-one interviews, workshops, and focus group discussions, as well as the use of system dynamics or modeling to verify or validate the study's findings.
- Fourth, the electricity generation sub-sector received the most responses. The low response rate to the survey in both countries, as well as the low response from other electricity sub-sectors, impacted the statistical analysis's generalizability. However, it was discovered to be fairly representative in terms of population representation between Iceland and Kenya.
- Fifth, questionnaires were only administered online due to time and cost constraints, this could have contributed to the low response rate.
- Finally, the timing of the questionnaire administration added another twist to the study, particularly in Iceland, where most energy sector employees were on vacation during the survey period, lowering the response rate.

Despite these limitations, the study contributed to innovation research, particularly in the under-researched public sector innovation with a focus on the energy sector. Climate action is dependent on key sectors' contributions to innovative approaches to reducing GHG emissions, developing policy frameworks, and developing strategic collaboration systems, the majority of which are covered by this study. It is hoped that this study will contribute to future research on public sector innovation and the energy sector contribution to climate action.

7 Conclusion

The energy sector, as the largest contributor of greenhouse gas emissions, must make a concerted effort to avoid an environmental disaster. This shall be accomplished through public-private partnerships and cross-sector collaboration in research and development, policy formulation, and implementation. Innovation is therefore, at the heart of climate action requirements, with a focus on both technological and policy developments and a key deliverable in the UN Sustainable Development Goals, SDG 9 calling for development of resilient infrastructure, sustainable industrialization and fostering of innovation. Public energy organizations must play a critical role in environmental protection by directly engaging in climate action, funding research and development of innovative technologies, policies and processes that demonstrate and promote good environmental performance.

The study findings show that for organizations to be ready for innovation, their management structure and leadership must be flexible and agile to promote constructive innovation culture characterized by employee creativity, cross-sector, and public-private collaborations. Even though it was not empirically proven, it is critical for organizations to prepare their workforce for innovation through education and training programs and the provision of a conducive and motivating working environment.

While it is unimportant how an organization innovates, it is critical that the innovation novelty be considered in solving the arising energy challenges i.e., energy security, affordability, and emissions to protect the environment. Innovation "newness" is thus an important feature of innovation made available to customers, i.e., process users and product markets. Icelandic and Kenyan public energy organization are shown to be making concerted efforts to develop, adopt, and imitate new technologies, policies, and processes to combat climate change with most respondents agreeing with their organizations' innovation pathway for clean, green, and efficient energy alternatives and solutions.

Continuous evaluation of energy organizations' innovation performance, particularly in relation to environmental performance, will ensure a positive path to climate recovery of keeping global warming below 1.5°C above pre-industrial era temperatures by achieving set climate action goals such as the UN Sustainable Development Goals, net-zero emissions 2050 targets, and the countries' Nationally Determined Contributions (NDCs) under the 2015 Paris Agreement.

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Appendix A

1 Background to the research

This chapter gives an overview of the public energy sectors in Iceland and Kenya, describing the energy sector actors' (regulators, generators, transmitters, and distributors) structure, mandate, and strategy. While the two countries are quite different in their economic performance, energy challenges seem to crosscut especially with regards to the world "wicked" problems while interacting with the environment that is, energy security, accessibility and cost and emissions.

1.1 Icelandic Energy Sector

Iceland is a European island country, 103,000 square kilometers in size, with high life expectancy and low mortality rate, and currently ranked the fourth happiest country after Finland, Denmark, and Switzerland with the highest feeling of social support [123] with 100%[2] access to electricity and clean cooking. Over 50% of its current population of 376,248[3] inhabitants live within the capital city and greater Reykjavík area. Iceland is a close partner to the European Union (EU) through its membership in the European Economic Area (EEA), European Free Trade Association (EFTA), and other bilateral agreements and therefore aligns itself with the EU on foreign policy issues including the environment, enterprise, education and research, competition policy, state aid, social policy, consumer protection, tourism and culture, and energy [124]. Iceland is located at a strategic hot spot on the Mid-Atlantic Edge with volcanic activities, and adequate precipitation for harnessing geothermal and hydropower energies [125].

Since its major energy transition from coal and oil in the seventies, Iceland's primary energy sources are 90% renewable with 68.79% from hydro, 31.16% from geothermal and 0.03% from wind energy sources primarily for electricity generation and district space heating using mainly using geothermal energy [18], [19]. Fossil fuel accounting for 0.02% [18] is used for electricity production in the off-grid islands of Flatey and Grimsey and mobility in the transportation (aviation, road, and marine) sector [126]. Iceland is the largest electricity producer per capita with approximately 55,000 kWh per person [127]. Figure 9 shows Iceland's 2020 installed electrical capacity and electricity production. Its grid-connected electricity is from 100% renewable hydro, geothermal, and wind energy sources, 80% of which is used in the heavy industry sector

[2] Source: https://trackingsdg7.esmap.org/country/iceland
[3] Source: https://www.statice.is/statistics/population/inhabitants/overview

with the aluminum smelters consuming 82.5% of electricity produced [128], as shown in Figure 10, and the rest sold off to the public utility companies and the Icelandic Transmission System Operator (TSO) [127], [129]. Geothermal electricity generation is done in high-temperature geothermal fields within the volcanic zone with fluid temperatures of 200°C or higher at 1000 m depth.

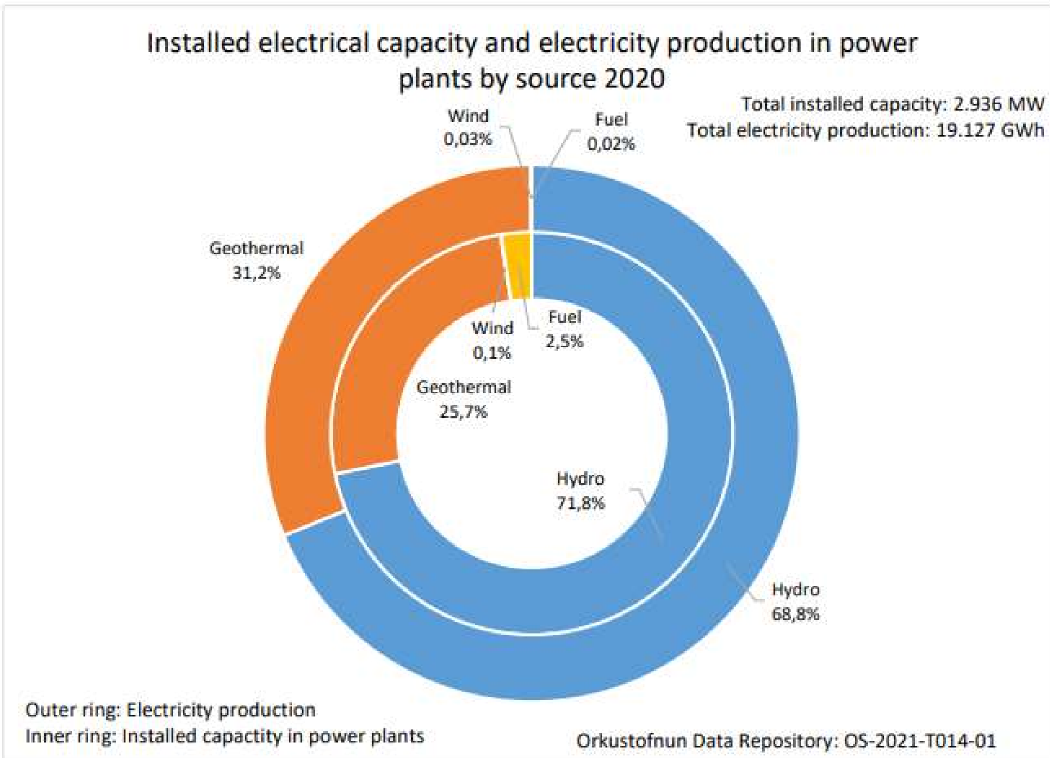


Figure 9: Iceland’s energy mix for electricity sub-sector

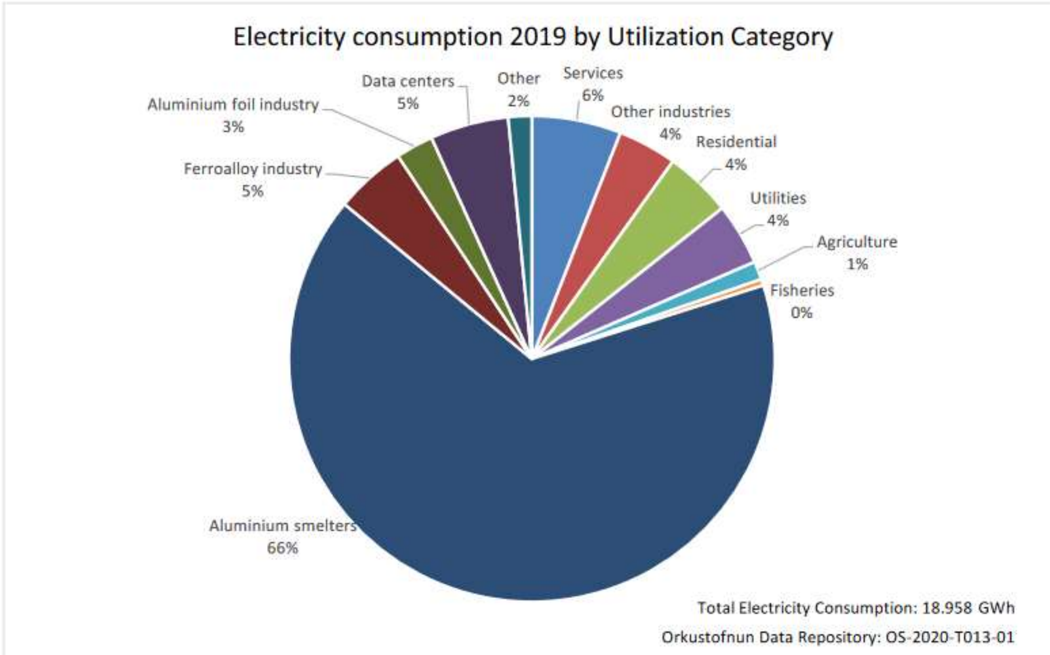


Figure 10: Iceland's electricity consumption per sector

1.1.1 Electricity sub-sector

Iceland's energy sector is managed under its Ministry of the Environment, Energy, and Climate which formulates and enforces Icelandic government policies. The National Energy Authority (NEA), Orkustofnun, is a government agency under the Ministry of the Environment, Energy, and Climate whose responsibility is to promote compliance with the Electricity Act 65/2003 [130]. The Electricity Act, based on the EU Directives 96/92 and 54/2003, introduced competition in the Icelandic energy sector, especially in the production and sale of electricity [130]. The Act further promotes effectiveness and efficiency in electricity transmission and distribution, thereby guaranteeing the security of the electricity supply system and customer protection while conserving the environment using renewable energy sources. NEA, therefore, offers advice to the government of Iceland on energy matters, licenses and monitors the development and exploitation of energy and mineral resources, regulates the operation of electrical transmission and distribution systems, and promotes energy research. The Electricity Act, Article 24 nominated NEA as the national regulatory authority for electricity [129]–[131].

In Iceland, state or municipality-owned enterprises dominate electricity production, transmission, and distribution activities. All power plants with a generation capacity of 7MW or more must connect to the transmission system [130]. Figure 11 shows the composition of the Icelandic electricity sub-sector [129].

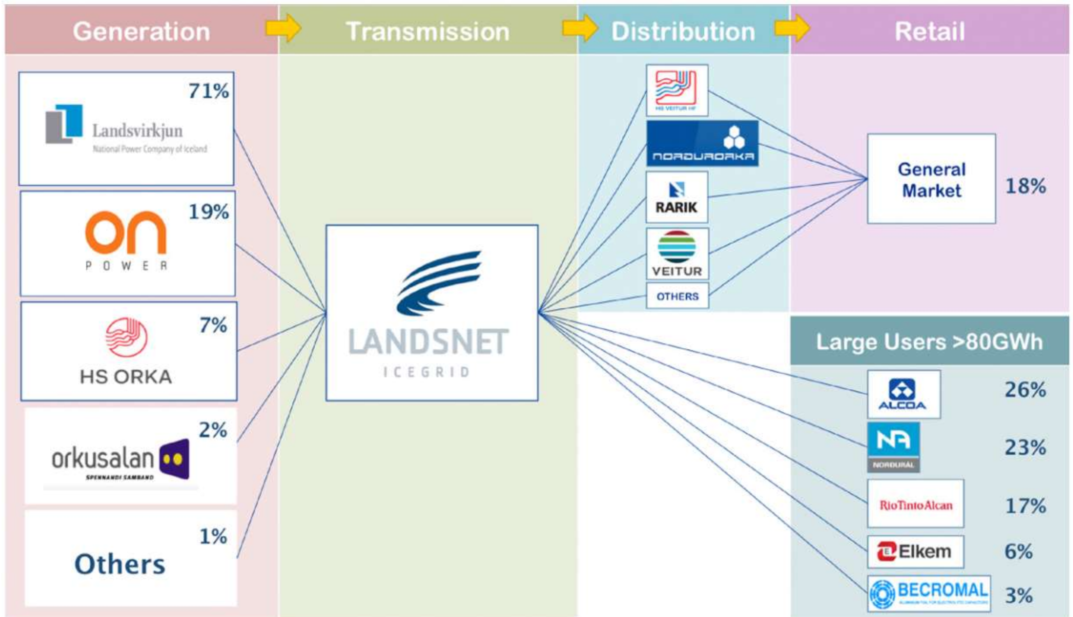


Figure 11: Schematic diagram of the Icelandic electricity sub-sector *[129]*

Landsvirkjun, a state-owned company providing approximately 75% of electricity produced in Iceland, is the main electricity generator with more than 96% stake in Iceland's hydropower plants, 11% of its geothermal power plants, and the sole wind power generator with 1.8MW wind power capacity [18], [127]. Orkuveita Reykjavíkur / Orka Náttúrunnar (ON Power) is a public utility company mainly for the greater Reykjavik area. ON Power generates its electricity from two geothermal power plants and two smaller hydropower plants [127]. The third producer, HS Orka, operating two geothermal power plants, was privatized in 2007 with a Canadian firm (Alterra Power) owning the majority shares. Other electricity producers, Orkusalan ehf. in Reykjavik and Fallorka fully owned by Norðurorka in Akureyri, are privately owned hydropower companies. Other power utility companies HS Veitur, Norðurorka, Orkubú Vestfjarda, Orkuveita Húsavíkur, and RARIK are owned by the Icelandic state and/or municipalities with a minority share of HS Veitur sold to private investors. Other small private power companies also share in the generation and distribution of electricity to consumers [127], [129].

Large energy users, consuming 80 GWh or more annually, have an option to make contracts directly with the single TSO (Landsnet hf. established in 2004, 65% owned by Landsvirkjun) saving on related distribution and service costs [129], [130]. All other consumers make a contract with the electricity distribution retail companies. NEA regulates the transmission and distribution prices.

1.1.2 District space heating

Iceland is generally a cold country with an annual average temperature range of -

3°C – 15°C [132], [133] and is therefore in need of a sustained space heating source. The establishment of NEA in 1967 kick-started further research into the better utilization of geothermal resources for the national economy through collaborative research with the Icelandic Universities, ÍSOR (Icelandic Geosurvey), GRÓ GTP (formerly UNU-GTP) among others [134]. Other than production of electricity, Iceland utilizes its abundant geothermal resource for space heating (residential and commercial buildings) and other cascaded uses like heating recreational pools, horticultural greenhouses, heated garden conservatories, industrial process heating, aquaculture, soil warming, and snow melting in parking spaces and driveways eliminating the use of coal by the 1960s and over time, the use of oil for heating [125], [134]–[137] as shown in Figure 12. Space heating in Iceland is mainly by extraction of hot water from low-temperature geothermal fields (<150°C) using ground-source heat pumps and from geothermal Combined Heat and Power (CHP) plants after the separation of the hot geothermal water from the steam. Space heating using geothermal hot water accounts for about 90% of the total heating requirements with a few houses in isolated areas, outside geothermal regions, using electricity and oil [125], [131], [138].

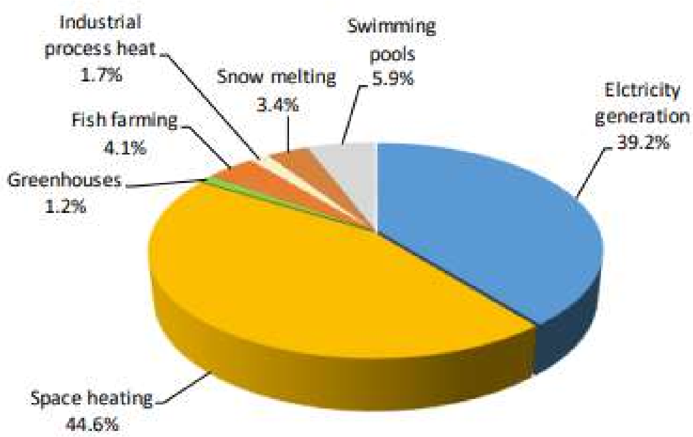


Figure 12: Utilization of geothermal energy, 2018 *[125]*

About 30 separate geothermal district heating systems are in operation in the town and villages and about 200 smaller systems in the rural areas. The main district heating utility operators, who also produce and/or distribute electricity and manage other utilities, are Reykjavík Energy (Orkuveita Reykjavíkur) operating in Reykjavik with a total installed capacity of 1,200 MW_{th}, HS Orka, and HS Veitur operating in Svartsengi and Reykjanes with a capacity of 190 MW_{th} and Nordurorka operating in Akureyri with an installed capacity of 100 MW_{th} [125]. The government provides subsidies to those who must use oil where no other means of heating is available to reduce the heating cost. While recognizing that two spaces may not have the same characteristics in terms of construction and age, the price of heating is not solely determined by the price of the energy [134].

1.1.3 Fossil fuels

With Iceland's abundant low-cost renewable energy, its demand for fossil fuel for heating, industrial and electrification is very low and mostly used in isolated location with no access to grid connectivity and geothermal resources. Iceland imports oil, coal, and gas to be used by various sectors. Oil forms the largest share of fuel imports and almost 95% is mainly used in the fishing and transportation sectors that is, road, sea, and air transport. The ferrosilicon industries, like Elkem Iceland at Grundartangi, import coal as a raw material to be used in the production process and not as a primary source of energy [19].

Energy transition is thus, a key agenda for Iceland especially in the fisheries and transportation sectors. The Act on renewable fuels in on-land transportation, 40/2013 transposing the EU Renewable Energy Directive shows the commitment towards energy transition in the transportation sector reducing the use of fossil fuels and increasing the share of renewables in the sector to 40% in on-land transportation and 10% in the fisheries sector by 2030, in a bid to reduce GHG emissions on-land transportation by 21% and 42% in the fisheries sector by 2030 [139], [140].

1.1.4 Innovation opportunities

Iceland's energy sector has responded continuously by developing and adopting novel technologies and policies [88] to improve energy production, transmission, and utilization of energy while promoting renewable energy and environmental protection. NEA's key policy is to build knowledge in the energy sector in areas of energy production, energy efficiency, and climate issues encouraging innovation as it brands itself a trustworthy, forward-looking, and efficient[4] institution. 2021 OECD economic survey on Iceland however, found that collaboration between research institutions and business sector was weak and limiting knowledge transfer due to the stringent regulatory barriers [141].

i. Energy production

With energy security and security of energy supply being the critical global challenges, Iceland has to look into modern technologies for energy generation at the least costs, disrupting its energy landscape with new electricity production technologies, increasing its resource capacity, and increasing automation and use of AI [142] in its

[4] https://orkustofnun.is/orkustofnun/um-orkustofnun/

distribution systems and fast tracking energy transition from fossil fuels. Proposed electricity interconnection projects including the proposed UK-Iceland 1000 km 700 MW interconnector (Icelink) [77], and the Northern Atlantic Energy Network (NAEN) [121] are a step toward energy security and efficiency of energy production in Iceland. These projects though, add pressure onto the Icelandic energy sector's stretched infrastructure requiring increased production capacities and strengthening of the transmission and distribution systems [143] and on the other hand, provide market opportunities for Iceland's abundant renewable energy resources.

While Iceland's main renewable energy sources, hydropower, and geothermal energy, are in abundance, there is ongoing research on other sustainable renewable energy sources including onshore and offshore wind power [144]–[146] to promote diversification in the energy system and hence the security of the energy supply [139]. Landsvirkjun is researching onshore wind energy with an installed wind power capacity of 1.8 MW[5] into its portfolio with further plans to develop an additional 300 MW from windfarms in Hafið and near Blanda power plant [121].

The Icelandic government has developed policies influencing renewable energy, focused especially on switching fossil fuel-dependent transport sector to renewable energy through electrification of vehicles by prohibiting registration of fossil fuel-driven cars by 2030 [142] and development of a transport system reliant on electricity, hydrogen and synfuels, aviation and marine transport on low-carbon fuels and fisheries switching to hydrogen and synfuels to achieve carbon-neutrality by 2050 [133]. Iceland reported achieving 11.4% renewable energy in their transport sector in 2020 surpassing the EU target of 10% [147], [148]. While energy transition will have a positive effect on climate change, it poses a strain on Iceland's energy-related infrastructure based on the policy timelines demanding increased electricity production, modernized and expanded electricity transmission and distribution system, increased electric vehicle charging stations nationwide, and research on alternative fuels [149]–[151].

ii. Energy efficiency

In the fight against climate change, adaptation of energy efficient technologies and processes is critical in ensuring energy security and reducing GHG emissions from the energy sector. Energy efficiency is a pathway to cleaner production and consumption facilitating the efficient utilization of resources and preventing environmental degradation [152] and in line with the UN SDG7 calling for "affordable, reliable, sustainable and

[5] https://www.landsvirkjun.com/wind

modern energy for all" by 2030 [153]. However, reliance on energy efficiency measures alone in efforts to promote positive environmental performance may immediately reveres or backfire as energy becomes more affordable and production increases, consumption may be on the uprise and thus it requires a system-wide policy review and development with a long term focus [154].

Iceland's opportunities with regard to energy efficiency are in energy production, especially geothermal energy [155] for heating and electricity as it seeks to reduce energy waste by taking advantage of technological innovations like smart metering, development of energy storage solutions, recycling heat where it is desirable, utilization of waste industrial heat in an effort to promote circular economy, development of industrial parks to maximize the value of energy production [139].

iii. Climate action

Rapid climate change is the most critical global challenge at present. Global warming due to anthropogenic GHG emissions is posing unprecedented challenges to governments and institutions to rethink their production and consumption behaviors. Despite the tremendous record of 100% electricity production using renewable energy sources, Iceland ranks highest among EU and EEA member countries in per capita net GHG emissions[6]. The Icelandic government has thus committed to reaching carbon neutrality by 2040 and cut GHG emissions by 55% by 2030 compared to 1990 [156] with the key task being attaining energy transition by completely replacing fossil fuels with renewable energy by 2050 [139].

While contributing 39% of total GHG emissions after industrial processes, 90% of Iceland's energy sector GHG emissions is from mobile sources (vehicle, machinery and fishing vessels excluding international aviation and navigation) and is dominated by CO2 emissions (98.3%) mostly from road transport and fisheries [157]. Iceland has the highest cars per capita among the OECD member countries, most of which are fossil fuel-driven and therefore, the transport sector is key to substantial reduction of CO2 emissions especially through energy transition from fossil fuels [149].

Despite these challenges, there has been progress in management of CO2 emissions in Iceland through direct air capture (DAC) technologies by Climeworks DAC project [158] and carbon capture and storage (CCS) and systems as implemented by Carbfix's CCS for sequestration of CO2 emissions from the geothermal power plants and the DAC

[6] https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20210818-1

facility, both located at Hellisheiði power plant in Hengill, Iceland [159], [160]. Climeworks' DAC project can capture 4,000 tons of CO2 annually from the ambient air for Carbfix sequestration into the basaltic subsurface formation [158] which is now close to 79 kt CO2eq since 2014 [161] against Iceland's energy sector emissions in 2019 was 2,000 kt CO2eq excluding manufacturing plants contribution [157]. Implementation of Iceland's climate action plan 2020 will the reduction of the GHG emission by more than 1,000 kt CO2eq by 2030 compared to 2005 emissions from transport, buildings, agriculture, waste and small industry not included in the EU emission trading system (ETS) [140], [162].

1.2 Kenyan Energy Sector

Kenya is a Sub-Saharan African (SSA) country in the East African region with a population of slightly over 53 million[7] people as of 2020 within an area of 580,367 square kilometers. Ranked 143 in Human Development Index (HDI) [163], Kenya's economic sector is diverse with key sectors being service, agriculture and manufacturing sectors contributing 53%, 30% and 17% to the country's Gross Domestic Product (GDP) respectively[8]. Access to electricity and clean cooking energy remains a challenge in most parts of SSA with an estimated 500,000 premature deaths attributed to use of unclean biomass affecting the forest cover and posing a burden to the productive time, especially of girls and women [16]. The SSA region still remains the least electrified region in the world the past decade, with 570 million people lacking access to electricity in 2019 as shown in Figure 13, despite its electricity access rate growing to 46% from 33% between 2010 and 2019 [22].

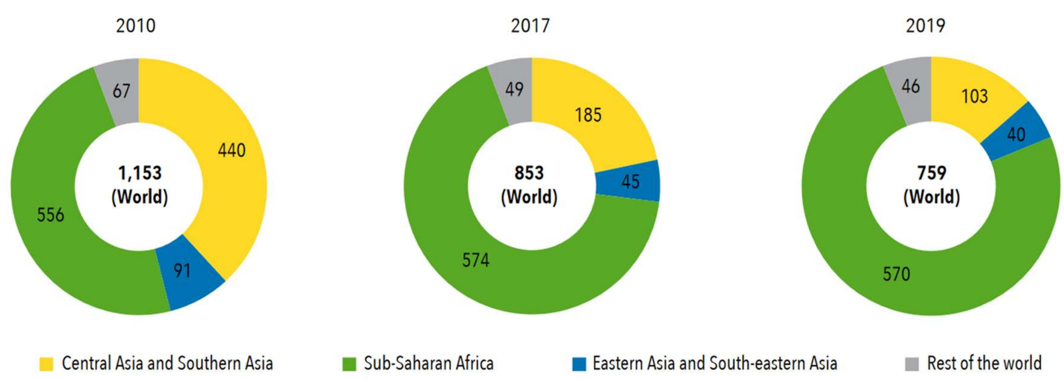


Figure 13: Regional electricity access deficit (millions of people) [22]

Kenya is thus not an exception, its primary energy mix is predominantly biomass

[7] Source: https://data.worldbank.org/indicator/SP.POP.TOTL?locations=KE
[8] Source: https://www.statista.com/statistics/451143/share-of-economic-sectors-in-the-gdp-in-kenya/

68%, in form of wood and charcoal, for cooking and heating and this accounts for two thirds of the final primary energy consumption with electricity accounting for only 4% of the final primary energy consumption [20]. Oil (petroleum and gas) products contributes over 25% of the final primary energy consumption with main users in household, commercial, industrial and transport sectors [20]. Despite the recent rapid expansions in the energy sector, Kenya's electricity access of 75% still remains below the global average electricity access of 90% of the population implying that 16 million people still have no access to electricity [21], [22], electricity supply is unstable and unreliable characterized by fuel and electricity supply interruptions [20], [22, p. 44]. Access to clean cooking energy is extremely low especially in the rural areas due to high dependency on biomass, wood, charcoal and animal dung as fuel leading to an clean energy access deficit of 42 million people, a case worsened by the Covid-19 pandemic [22].

The Ministry of Energy (MoE) oversees Kenya´s energy sector policy development and implementation for the efficient operation and growth of the sector guided by the Energy Act, 2019, the Energy Policy 2018, the Kenya National Energy Efficiency and Conservation Strategy (KNEECS) 2020, Feed-in Tariff Policy 2012, Kenya National Electrification Master Plan 2018, and the Bioenergy Strategy 2020, amongst other policies [120]. The MoE is mandated to provide of energy in all areas and promote of energy investments, especially renewable energy through the Renewable Energy Directorate and the Geo-Exploration Directorate for the exploration and implementation of geothermal energy [120]. Other than renewable energy, the MoE through the Geo-Exploration Directorate is also responsible for coal and nuclear power activities [120].

The Energy Act, 2019 established new energy sector entities including the Energy and Petroleum Regulatory Authority (EPRA) to regulate the energy sector (electricity, renewable energy, petroleum sub-sectors and coal except nuclear power which is under the Nuclear Power and Energy Agency (NuPEA)), collect and maintain energy data and the Energy and the Energy and Petroleum Tribunal (EPT) to hear and determine energy and petroleum disputes and appeals in accordance with the Act or any other law [21], [120]. The Energy Act, 2019 reformed the sector encouraging more private investments and provided new sources of energy while giving the county governments the responsibility to develop the energy sector with the exception of all renewable and geothermal energy resources [120].

1.2.1 Electricity sub-sector

The electricity sub-sector was unbundled in 1997 when Kenya Power and Lighting

Company PLC (Kenya Power) oversaw production, transmission, and distribution systems. The Energy Act, 2019, has further promoted private investment in electricity production by independent power producers (IPPs) in the sector under regulation by EPRA. The electricity sub-sector is dominated by public organization in almost all phases except in electricity generation where independent power producers share in electricity investments. Regional power interconnectivity, especially with Uganda via a 132 kV transmission line, has helped Kenya stabilize its national electricity power supply while also maintaining connections across isolated Tanzanian and Ethiopian border towns [122]. Plans for a wider regional power interconnectivity are underway with ongoing construction of Kenya-Ethiopia electricity highway as a part of the East African Power Pool (EAPP) in a bid to ensure regional energy security with opportunities for energy market for surplus production and access to cheaper renewable energy from member nations. Figure 14 shows Kenya's electricity sub-sector structure.

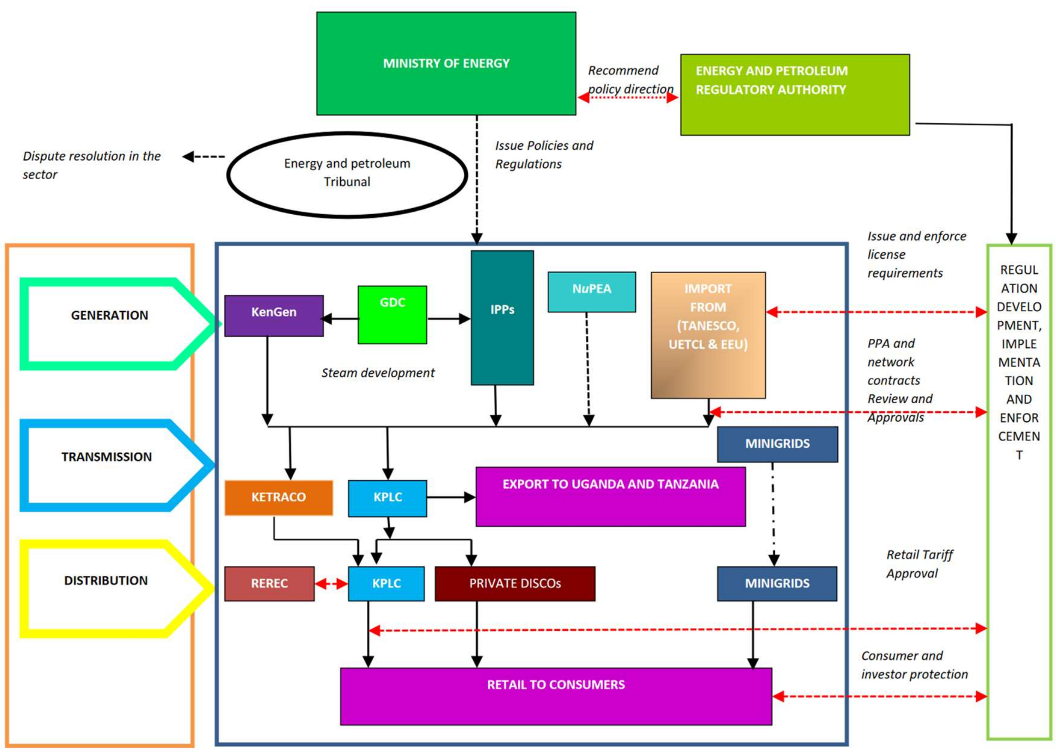


Figure 14: Kenyan electricity sub-sector structure *[122]*

Kenya Electricity Generating Company PLC (KenGen), a government parastatal with 70% government ownership and 30% private shareholders, dominates electricity production providing over 60% of the installed capacity and 75% of electricity sales from 29 power stations with a mix of hydro, geothermal, wind and thermal (oil and gas) energy sources. Kenya has a vast geothermal resource potential of over 10,000 MWe distributed along the Kenyan rift valley which is part of the African rift system that runs from Afar triple junction to Mozambique [21], [164].

The electricity transmission network (400 kV, 220 kV and 132 kV powerlines) are developed and managed by Kenya Transmission Company (KETRACO) and Kenya Power. While KETRACO is fully owned by the government, the government has only a controlling share (50.1%) in Kenya Power. Kenya Power is the only electricity off-taker on the basis of contractual power purchase agreements (PPAs) made with the electricity generators and the only licensed electricity supply in Kenya's power market and is responsible for transmission networks 66 kV and below [120].

It is the continued stepwise exploitation of the geothermal resource that has enabled Kenya's improved renewable energy performance in the electricity sub-sector contributing nearly 50% to total electricity generated as shown in Figure 15 with KenGen producing over 80% (713.128 MW) of the geothermal power [21]. There is a steady growth of renewables in the electricity supply mix and a general decline in demand for thermal energy currently contributing 8% of electricity generated in 2020 from the total installed capacity of 2,984 MW by June 2021 [21].

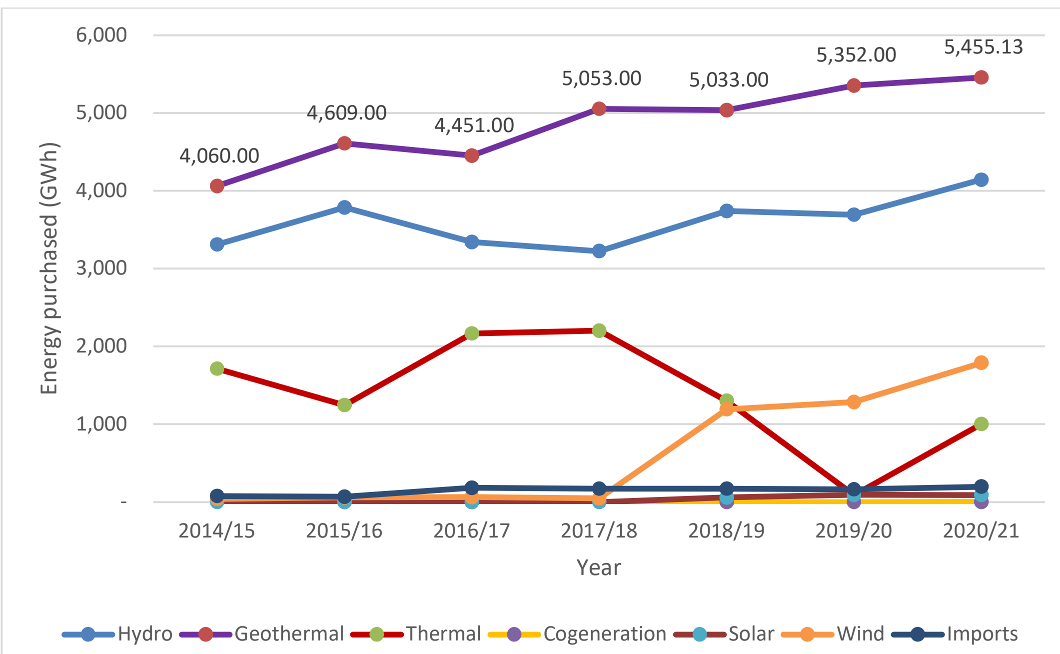


Figure 15: Kenya's electrical energy mix by source 2014 – 2021 [21]

1.2.2 Fossil fuels

Despite Kenya's discovery of oil and gas deposits in its coastal and northern parts, Kenya imports oil for electricity generation, transportation, and industrial use. Rapid expansion of renewable energy including geothermal, wind and solar energy for electricity generation has significantly reduced the reliance on imported heavy fuel oil (HFO) especially in seasons of low rainfall [165]. However, locations that are not connected to the national electricity grid are often connected to isolated electricity mini grids from, mostly, thermal (HFO) power stations [122]. The cost of oil used in electricity generation is regulated by EPRA and passed on to the consumers to minimize the off-takers forex losses due to fluctuating international oil prices [21].

Coal has been fronted by the Ministry of Energy as an alternative energy source for electricity generation with discovery of coal deposits at the Mui Basin, should the geothermal resource not be adequate for the energy demand [122]. Its exploitation for electricity generation, however, has run into headwind owing to environmental concerns [122] and future excess power capacity concerns [165].

1.2.3 Innovation opportunities

i. Energy production

Kenya has fast tracked its electricity production since 2010 improving electricity access from 25% to 75% of the population over the period with an annual electricity access growth rate of over 6% [22]. However, this access does not guarantee industrial or commercial activities. Projects like the last-mile electrification project by Kenya Power that aimed to improve electricity access at affordable cost especially in the rural areas and to stimulate economic developments through extension of the low voltage network to nearly 1.2 million customers, did not achieve the intended energy demand target from productive use energy [22], [166].

Petrik et al. (2020) [120] highlight Kenya's public policy innovation and collaborative innovation that have put a focus on promoting meaningful energy demand from the enactment of the Energy Act, 2019 which made drastic institutional reforms and promotes private investment in the energy sector and the Energy Policy (2018) intention to accelerate economic growth with supply of energy at least cost through exploration and exploitation of geothermal resources while allowing for use of locally available coal to bridge the deficit [22], [120]. Collaboration between EPRA and the energy sector players developed the Least Cost Power Development Plan (LCPDP), a biannual report that provides energy forecasting, long-term network expansion at least cost to the economy and environment. The county governments energy plans facilitate energy demand growth through planning for industrial parks, and other energy consuming activities in line with the LCPDP [120].

The MoE, through policy development, is promoting diversification of renewable energy sources with the introduction of prosumers in the Feed-in Tariff policy (2008) allowing power producers to sell to the off-take for given period of time from wind, small hydro, biomass, geothermal, biogas and solar sources [120], [167] thereby promoting private sector investment and enhancing energy market access. Projects have been done in collaboration with development partners, like Kenya Off-Grid Solar Access Project (KOSAP) by the MoE and the World Bank Group, to improve electricity access and provide clean cooking solutions in areas that are off grid and sparsely populated yet have good energy resource including solar [120]. Further, the Bioenergy Strategy (2020), developed through a multi-stakeholder consultative process, promotes the sustainable development and utilization of biomass is aimed at meeting cooking and heating requirements [120].

ii. Energy efficiency

Electricity supply involves expected energy losses in the system due to various reasons from production to distribution due to technical and commercial factors. the energy sector regulator, EPRA, periodically reviews the allowable system losses to be passed on to the consumers. Kenya Power systems losses have however, exceeded the allowable limits set at 14.9% in June 2020 and 19.9% in June 2021 with reports of 23.46% and 24.08% in June 2020 and June 2021 respectively [21]. Kenya Power attributes its rising system losses to transmission and distribution network expansion, inefficient machinery, and appliances like transformers, metering faults and tampering and electricity pilferages. System losses therefore, cost the economy an estimated US $377 million in the electricity sub-sector in 2020 with the consumers paying 63.5% of the loss through electricity tariff [165], [168].

Kenya plans to reduce the national energy intensity by 2.8% annually among other goals as highlighted in the Kenya National Energy Efficiency and Conservation Strategy (KNEECS) (2020). The KNEECS was developed by MoE in consultation with UNEP DTU partnership as well as local and international organizations and reviewed by World Bank assist Kenya achieved its energy efficiency goals within the set timelines (2020 to 2025) in households, power utilities, transport, buildings, industry and agriculture sectors [120]. The strategy proposes, among other things, reducing electricity transmission and distribution system losses from 23% to 15%, installing a 1 MW energy storage facility, increasing the share of electric vehicles in the transportation sector, improving fleet fuel economy, increasing the number of industrial energy audits performed annually from 1,800 to 4,000 and the implementation of bioenergy strategy for clean cooking [20].

iii. Climate action

Climate action, in the energy sector involves acceleration of renewables, adoption of energy efficiency measures and decarbonization through, energy transition by reduction of fossil fuel in the sector especially coal and through use of low-carbon fuels. Kenya is a signatory to the Paris Agreement 2015 and in 2020 submitted its revamped, ambitious Nationally Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC) with a commitment to abate GHG emissions by 32% to 2030 from 143 MtCO2eq [120].

Despite these agreements, Kenya needs to fulfill its future energy demand and has included coal power in its future generation mix in case geothermal resources are insufficient, sending a mixed message in its decarbonization goal. [21], [120]. It does, however, explore investing in low-carbon nuclear power generation and has established a nuclear energy research, skills and capacity building, and policy development organization within the MoE, NuPEA [120].

Kenya aspires to be Africa's hydrogen production leader, owing to its abundant geothermal resources and other renewable green energy sources. Hydrogen as an energy carrier requires high energy input to produce. In an effort to achieve energy transition and climate action, the MoE conducted a study on the potential for green hydrogen in Kenya's industrial, transportation, and energy sectors in collaboration with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH [169]. Green hydrogen production will necessitate a sustainable surplus of green electricity, the right to and sustainable supply of water, demand for hydrogen and its derivatives, a framework for applications and infrastructure especially in transport and storage technologies, and regulatory frameworks, and adequate funding for research and technological innovations such as electrolyzers. [169].

Annual greenhouse gas (GHG) emissions from combustion of residential cooking fuels are 13.6 MtCO2e split 2:1 between rural and urban populations (estimates from the demand side) [170]. Through development of efficient cooking solutions, Kenya projects GHG emissions abatement of 7.3 Mt C02e by 2030 [170].

Appendix B Kenyan and Icelandic public energy sector organizations

Table 55: Kenyan and Icelandic Public Energy Sector Organizations Considered for Survey

Electricity sub-sector	Kenya	Mandate	State/ municipality ownership	Iceland	Mandate	State/ municipality ownership
Regulation	Energy and Petroleum Regulatory Authority (EPRA)	Regulate the energy sector (electricity, renewable energy, petroleum sub-sectors, and coal). Collect and maintain energy data	100%	National Energy Authority (NEA) / Orkustofnun	Promote compliance with the Electricity Act 65/2003. Regulates the operation of electrical transmission and distribution systems and promotes energy research.	100%
Generation	Kenya Electricity Generating Company PLC (KenGen)	Electricity generation from hydro, geothermal, wind, and thermal energy sources	70%	Landsvirkjun	Electricity generation from hydro, geothermal and wind energy sources	100%
	Geothermal Development Company (GDC)	Geothermal steam capacity development for electricity generation	100%	Orka náttúrunnar ohf.	Electricity generation from geothermal energy sources	100%
Transmission	Kenya Transmission Company (KETRACO)	Electricity transmission via 400kV, 220kV and 132kV powerlines	100%	Landsnet hf.	Sole bulk electricity Transmission service operator (TSO)	100%
	Kenya Power and Lighting Company PLC (Kenya Power)	Electricity transmission via 66kV powerlines and below	50.1%			
Distributor	Kenya Power and Lighting Company PLC (Kenya Power)	Sole bulk electricity off-taker and retailer	50.1%	Landsnet hf.	Distribution to large electricity consumers (>80 GWh annual consumption)	100%
	Rural Electrification and Renewable Energy Corporation (REREC)	Rural electrification projects	100%	ON Power ohf.	Distribution of electricity to general market	100%
				RARIK ohf.	Distribution of electricity to general market	100%

Appendix C Research cover letter

24/06/2022

TO WHOM IT MAY CONCERN

This is to confirm that the bearer is a student at this university and his particulars are as follows:

Name	Mr. Johannes Onjala Ochome
Student ID	1110812209
Course	M.Sc. in Engineering Management
Topic	Assessment of Public Energy Organizations Innovation Awareness and Readiness for Climate Action: A Case Study of Icelandic and Kenyan Energy Sectors

He will be collecting data in fulfillment of his course requirements. Any assistance rendered to him shall be highly appreciated.

Yours Sincerely,

PROGRAMME COORDINATOR

Sóley Davidsdóttir

HÁSKÓLINN Í REYKJAVÍK REYKJAVIK UNIVERSITY

Appendix D Kenyan research permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 878205

Date of Issue: 13/July/2022

RESEARCH LICENSE

This is to Certify that Mr.. Johannes Onjala Ochome of ReykjavÃ-k University, has been licensed to conduct research in Nairobi, Nakuru on the topic: Assessment of public energy organizations' innovation awareness and readiness for climate action: A Case Study of Icelandic and Kenyan Energy Sectors for the period ending : 13/July/2023.

License No: NACOSTI/P/22/18781

878205

Applicant Identification Number

Director General

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

Figure 16: Kenyan research license

Appendix E Innovation Survey

Dear Respondent,

I am currently doing research leading to an M.Sc. (Engineering Management) at Reykjavik University, Iceland. The topic of my research is Assessment of public energy organizations' innovation awareness and readiness for climate action: A case study of Icelandic and Kenyan energy sectors.

You are kindly invited to participate in this M.Sc. project whose purpose is to assess innovation in your organization to meet climate action goals. The survey is voluntary and is estimated to take approximately 20 minutes of your committed time to complete. You reserve the right to withdraw from the survey at any point without providing a reason. However, you are encouraged to participate fully.

There will be no costs or compensation for your participation in the research. We however hope that the information from this research shall help improve your organization's innovation performance and assist in the formulation of innovative policies and processes toward a sustainable energy sector.

All the data and comments submitted are anonymous and confidential and shall not be disclosed or reported.

Thank you in advance for your participation.

Yours Sincerely,
Johannes Ochome
Reykjavik University, Iceland

Respondent's Background Information:

Age
1. 18 - 29 Years
2. 30 - 39 Years
3. 40 - 49 Years
4. 50 Years and above

Gender
1. Female
2. Male

Highest education attained
1. Diploma
2. Barchelors
3. Masters
4. PhD
5. Other

Electricity sub-sector
1. Regulation
2. Generation
3. Transmission
4. Distribution
5. Other

In which country is your organization?
1. Iceland
2. Kenya

Profession
1. Engineering & Science
2. Environment & Natural Resources
3. Finance & Administration
4. Health & Safety
5. Human Resources
6. ICT

7. Legal
8. Supply Chain
9. Other

Years of experience in public energy sector
1. 0 - 4 Years
2. 5 - 10 Years
3. 11 - 15 Years
4. Over 15 Years

Position in organization
1. Top Management
2. Middle-level Management
3. Consultant
4. Engineer
5. Scientist
6. Technician
7. Other

Terms of employment
1. Permanent and Pensionable
2. Short-term Contract (Up to 1 Year)
3. Long-term Contract (More than 1 Year)

Innovation Awareness
This section assesses your skills and knowledge of innovation, your work environment, your motivation levels, and your understanding of the term innovation with regard to your tasks at your organization.

Skills and Knowledge:
On a scale of 1-6, where 6 is "Strongly Agree" and 1 is "Strongly Disagree", to what degree do you agree with the following statements?

	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
I have adequate training to effectively deliver my tasks	❑	❑	❑	❑	❑	❑
I have resources to effectively deliver my tasks	❑	❑	❑	❑	❑	❑
I am aware of the organization's innovation strategy	❑	❑	❑	❑	❑	❑
I am aware on the country's energy policies	❑	❑	❑	❑	❑	❑
I have participated in the organization's innovation processes	❑	❑	❑	❑	❑	❑
I have participated in the organization's research activities	❑	❑	❑	❑	❑	❑
I am a change champion	❑	❑	❑	❑	❑	❑

Workplace Environment:
On a scale of 1-6, where 6 is "Strongly Agree" and 1 is "Strongly Disagree", to what degree do you agree with the following statements?

	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
I am comfortable with my organization's workplace culture	❑	❑	❑	❑	❑	❑
I satisfied with my role in the organization	❑	❑	❑	❑	❑	❑

I am able to experiment with innovative ideas	❑	❑	❑	❑	❑	❑
I am consulted for innovative ideas	❑	❑	❑	❑	❑	❑
My supervisor provides timely feedback on my tasks	❑	❑	❑	❑	❑	❑
My innovation activities contribute to my performance measurement	❑	❑	❑	❑	❑	❑
Teamwork is encouraged during tasks implementation	❑	❑	❑	❑	❑	❑

Motivation:
On a scale of 1-6, where 6 is "Strongly Agree" and 1 is "Strongly Disagree", to what degree do you agree with the following statements?

	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
I am motivated by financial rewards for innovation within the organization	❑	❑	❑	❑	❑	❑
I am motivated by recognition awards for innovation within the organization	❑	❑	❑	❑	❑	❑
I am motivated by personal incentives for innovation within the organization	❑	❑	❑	❑	❑	❑
I am not motivated for innovation within the organization	❑	❑	❑	❑	❑	❑

Innovation Concepts:
On a scale of 1-6, where 6 is "Strongly Agree" and 1 is "Strongly Disagree", to what degree do you agree with the following statements on innovation?

	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
An innovation is something unique	❑	❑	❑	❑	❑	❑
An innovation is a significantly improved existing product	❑	❑	❑	❑	❑	❑
An innovation must be disruptive to succeed	❑	❑	❑	❑	❑	❑
An innovation must have financial returns to succeed	❑	❑	❑	❑	❑	❑
An innovation process requires a structure	❑	❑	❑	❑	❑	❑
Innovations are best achieved by individuals	❑	❑	❑	❑	❑	❑
Innovations are best achieved in teams	❑	❑	❑	❑	❑	❑

Organization Readiness:
This section assesses your organization's readiness for innovation and innovation activities. The phrase “innovation activities” refers to the process while the term “innovation” is limited to outcomes.

Innovation Strategy:
On a scale of 1-6, where 6 is "Strongly Agree" and 1 is "Strongly Disagree", to what degree do you agree with the following statements regarding your organization's innovation strategy?

	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree

The organization has a formal innovation strategy	❑	❑	❑	❑	❑	❑
Innovation strategy is in line with the government policies	❑	❑	❑	❑	❑	❑
Organization's Innovation strategy is widely communicated within the organization	❑	❑	❑	❑	❑	❑
Organization's top-management supports the innovation strategy	❑	❑	❑	❑	❑	❑
Organization's Innovation strategy is regularly updated	❑	❑	❑	❑	❑	❑
High risk innovation ideas are avoided	❑	❑	❑	❑	❑	❑
Incentives for innovation activities are predefined	❑	❑	❑	❑	❑	❑

Innovation Management: Leadership and Organizational Structure: On a scale of 1-6, where 6 is "Strongly Agree" and 1 is "Strongly Disagree", to what degree do you agree with the following statements regarding your organization's innovation management?

	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
Innovation activities are managed by a specific innovation office	❑	❑	❑	❑	❑	❑
Innovation ideas are systematically collected within the organization	❑	❑	❑	❑	❑	❑
Innovation ideas only come from top management of the organization	❑	❑	❑	❑	❑	❑
Innovation ideas come from middle-level and low-level management of the organization	❑	❑	❑	❑	❑	❑
Innovation ideas come from all levels of staff in the organization	❑	❑	❑	❑	❑	❑
Innovation ideas are subjected to customer need analysis	❑	❑	❑	❑	❑	❑
Innovation ideas are systematically ranked and prioritized	❑	❑	❑	❑	❑	❑
Idea generators are incorporated into the innovation implementation teams	❑	❑	❑	❑	❑	❑
Organization's innovation performance is regularly communicated	❑	❑	❑	❑	❑	❑

Innovation Resources:
On a scale of 1-6, where 6 is "Strongly Agree" and 1 is "Strongly Disagree", to what degree do you agree with the following statements regarding your organization's innovation resources?

	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
Innovation funds are included in the annual organization's budget	❑	❑	❑	❑	❑	❑
Organization has an effective product development system	❑	❑	❑	❑	❑	❑
Access to funds for innovation is easy	❑	❑	❑	❑	❑	❑
The organization's policies and procedures make product development easy	❑	❑	❑	❑	❑	❑

Innovation Culture:
On a scale of 1-6, where 6 is "Strongly Agree" and 1 is "Strongly Disagree", to what degree do you agree with the following statements regarding your organization's innovation culture?

	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
Innovation is a part of regular organization's operations	❑	❑	❑	❑	❑	❑
The organizational structure supports innovation development	❑	❑	❑	❑	❑	❑
Innovation is embedded in the organization's values and mission statements	❑	❑	❑	❑	❑	❑
Innovation development is ad-hoc	❑	❑	❑	❑	❑	❑

Innovation Collaborations:
On a scale of 1-6, where 6 is "Strongly Agree" and 1 is "Strongly Disagree", to what degree do you agree with the following statements regarding your organization's collaborations with other units and institutions for innovation activities?

	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
There is a structured collaboration between the organizations' departments	❑	❑	❑	❑	❑	❑
There is a structured collaboration with academic research institutions	❑	❑	❑	❑	❑	❑
There is a structured collaboration with other public organizations	❑	❑	❑	❑	❑	❑
There is a structured collaboration with private sector organizations	❑	❑	❑	❑	❑	❑

Characteristics of innovation:
On a scale of 1-6, where 6 is "Strongly Agree" and 1 is "Strongly Disagree", to what degree do you agree with the following statements regarding your organization's innovation processes?

	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
The organization develops new products, or services with its own internal resources	❑	❑	❑	❑	❑	❑
The organization adopts new products or services developed by other organization	❑	❑	❑	❑	❑	❑
The organization replicates new products or services developed by other organization	❑	❑	❑	❑	❑	❑

This sub-section seeks to rate your organization's efforts and commitment toward achieving the United Nation's Sustainable Development Goals (SDGs) and the 2050 net-zero emissions targets while taking actions to solve the energy trilemma challenges of energy security, energy equity (accessibility and affordability), and energy emissions, and the environment.

The term “Net-zero” refers to a situation in which greenhouse gas emissions are balanced by their removal from the atmosphere, causing global warming to grind to a close.

Global Energy Challenges:
On a scale of 1-6, where 6 is "Strongly Agree" and 1 is "Strongly Disagree", to what degree do you agree with the following statements based on your organization's innovation efforts?

	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
The country is capable of achieving a 55% electricity emissions reduction by 2030	❑	❑	❑	❑	❑	❑
The country is capable of achieving universal access to affordable, reliable, and modern	❑	❑	❑	❑	❑	❑

electricity services by 2030						
Organization can achieve carbon neutrality in its operations by 2030	❏	❏	❏	❏	❏	❏
Climate action projects are a priority in the organization's innovation strategy	❏	❏	❏	❏	❏	❏

Energy Trilemma:
To what extent, in a rating of 1-6 where, 6 is "Strongly Agree" and 1 is "Strongly Disagree", is your organization pursuing the following?

	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
Electricity access projects	❏	❏	❏	❏	❏	❏
Electricity cost reduction projects	❏	❏	❏	❏	❏	❏
Electricity infrastructure resilience technologies	❏	❏	❏	❏	❏	❏
Electricity grid strengthening technologies	❏	❏	❏	❏	❏	❏
Energy transition innovations	❏	❏	❏	❏	❏	❏
Energy efficiency innovations	❏	❏	❏	❏	❏	❏
Greenhouse gas emissions reduction innovations	❏	❏	❏	❏	❏	❏

Future Energy Projects
This section seeks to highlight your organization's long-term (5-10 years) energy innovation projects pathways in the areas of electricity generation, energy transition from fossil-based fuels, innovative energy technologies, and climate action.

Generation:
On a scale of 1-6, where 6 is "Highly Likely" and 1 is "Highly Unlikely", which of the following innovation projects do you foresee your organization focusing on in the next 5-10 years?

	Highly unlikely	Unlikely	Slightly unlikely	Slightly likely	Likely	Highly likely
Hydropower energy generation	❏	❏	❏	❏	❏	❏
Geothermal energy generation	❏	❏	❏	❏	❏	❏
Solar energy generation	❏	❏	❏	❏	❏	❏
Wind energy generation	❏	❏	❏	❏	❏	❏
Coal-fired power generation	❏	❏	❏	❏	❏	❏

Energy Transition:
On a scale of 1-6, where 6 is "Highly Likely" and 1 is "Highly Unlikely", which of the following innovation projects do you foresee your organization focusing on in the next 5-10 years?

	Highly unlikely	Unlikely	Slightly unlikely	Slightly likely	Likely	Highly likely
Green hydrogen	❏	❏	❏	❏	❏	❏

Nuclear energy	☐	☐	☐	☐	☐	☐
Natural gas	☐	☐	☐	☐	☐	☐
Biomass	☐	☐	☐	☐	☐	☐

Energy Technologies:
On a scale of 1-6, where 6 is "Highly Likely" and 1 is "Highly Unlikely", which of the following innovation projects do you foresee your organization focusing on in the next 5-10 years?

	Highly unlikely	Unlikely	Slightly unlikely	Slightly likely	Likely	Highly likely
Regional electricity grid interconnectivity	☐	☐	☐	☐	☐	☐
Electricity market	☐	☐	☐	☐	☐	☐
E-mobility infrastructure	☐	☐	☐	☐	☐	☐
Net-metering technologies	☐	☐	☐	☐	☐	☐
Smartgrid technologies	☐	☐	☐	☐	☐	☐
Energy storage technologies (Batteries)	☐	☐	☐	☐	☐	☐
Energy storage technologies (Pumped storage)	☐	☐	☐	☐	☐	☐
Public-Private collaborations for innovation	☐	☐	☐	☐	☐	☐

Climate Action:
On a scale of 1-6, where 6 is "Highly Likely" and 1 is "Highly Unlikely", which of the following innovation projects do you foresee your organization focusing on in the next 5-10 years?

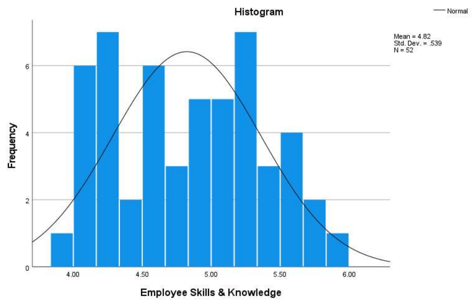
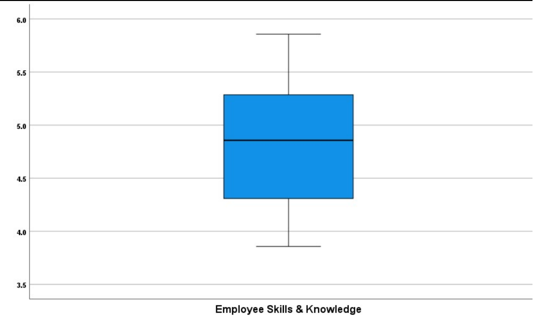
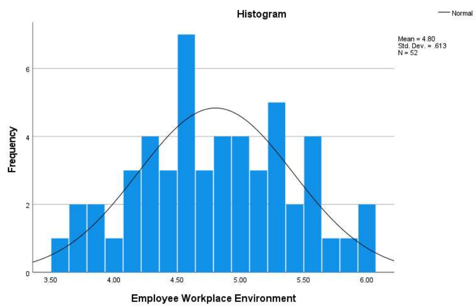
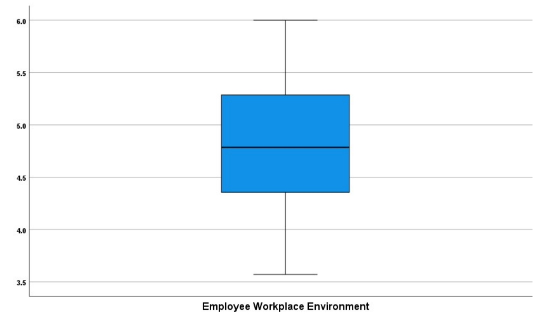
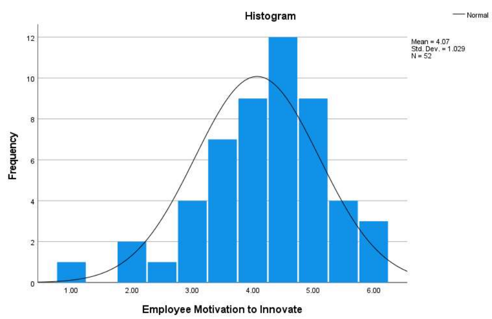
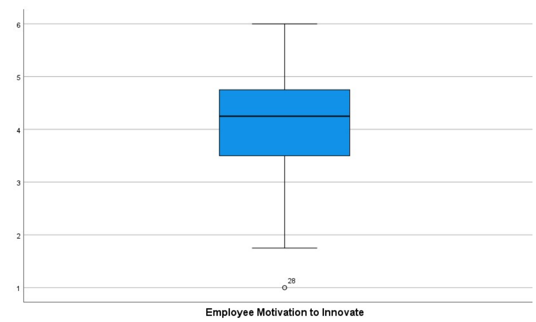
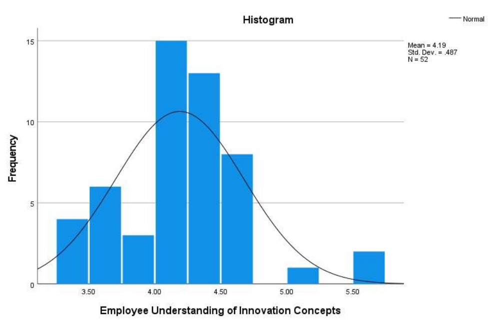
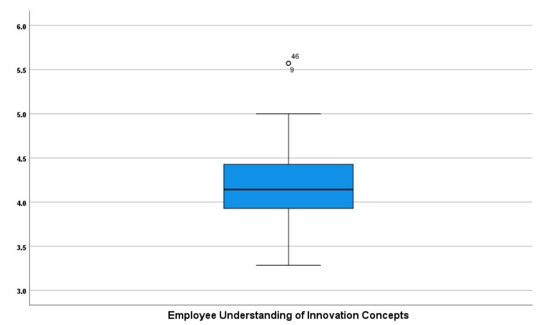
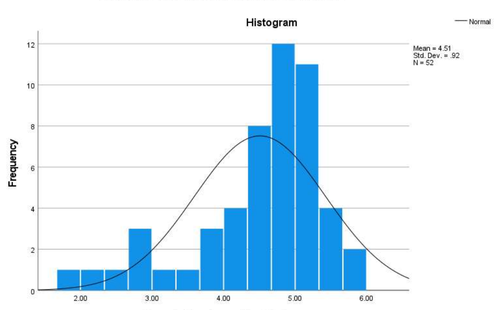
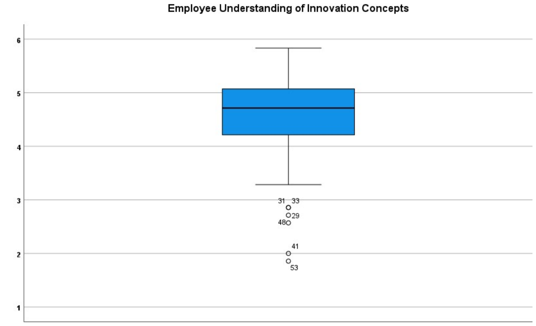
	Highly unlikely	Unlikely	Slightly unlikely	Slightly likely	Likely	Highly likely
Carbon capture, utilization, and storage	☐	☐	☐	☐	☐	☐
Access to clean cooking energy	☐	☐	☐	☐	☐	☐
Energy efficiency	☐	☐	☐	☐	☐	☐

For this Survey, Innovation is defined as, "the strategic, systematic, and purposeful development of ideas into new products, processes, or cultures (incremental or radical), or the adoption of new products, processes, or cultures fundamentally different from previous ones, or the creation of entirely new organizations, organization units or markets in response to market and consumer dynamics to generate satisfactory results. On a scale of 1-6, where 6 is "Strongly Agree" and 1 is "Strongly Disagree"

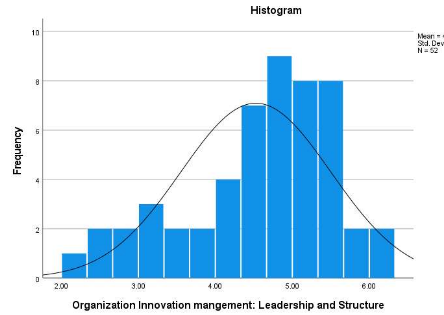
	Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
To what extent do you agree with your organization's innovation pathway towards solving energy challenges?	☐	☐	☐	☐	☐	☐
To what extent do you agree with the definition of innovation in relation to your organization's mandate in the public energy sector?	☐	☐	☐	☐	☐	☐

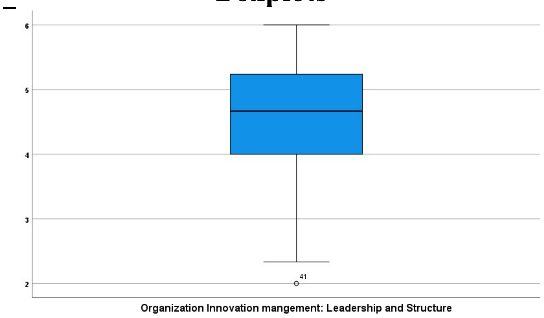
Appendix F Assessment of normality

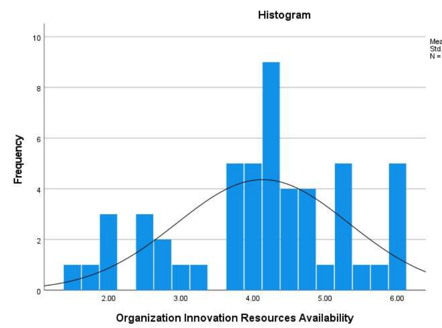
Table 56: Plots of grouped variable to assess normality

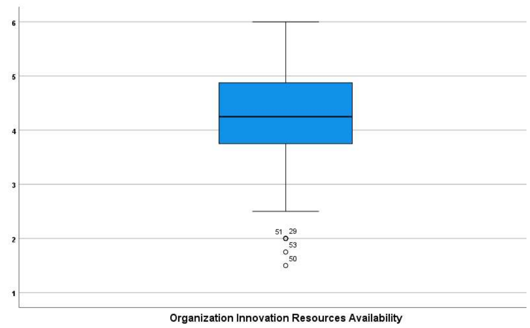
Histogram	Boxplots
	
	
	
	
	

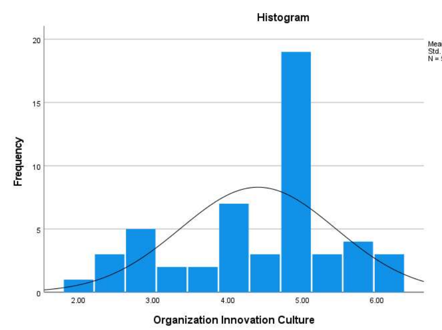
Histogram	Boxplots

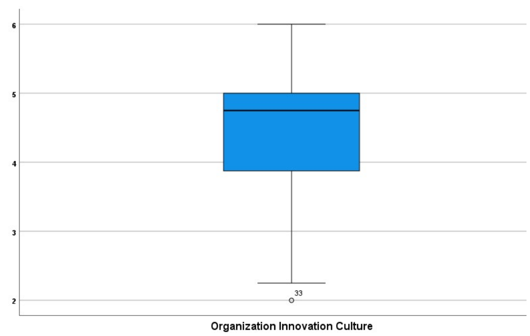


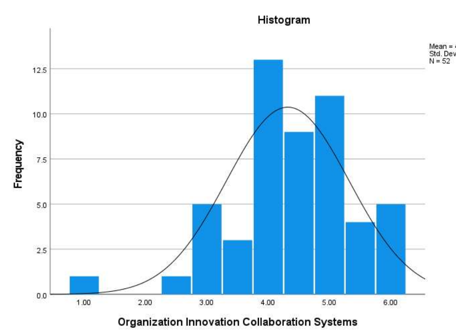


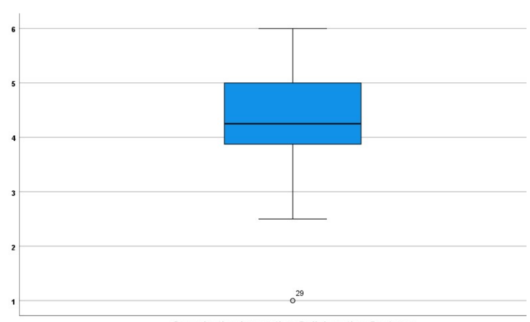


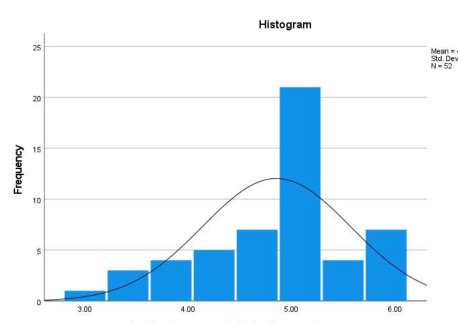


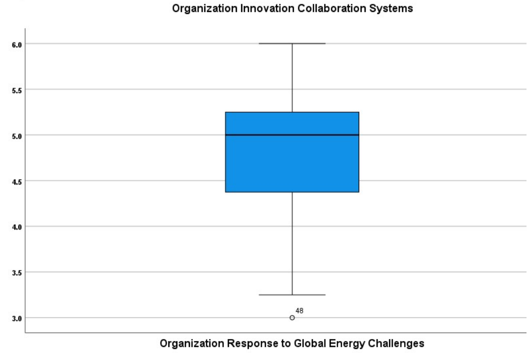


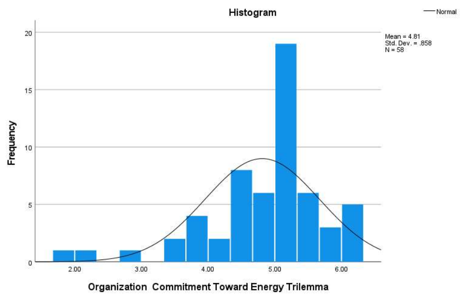
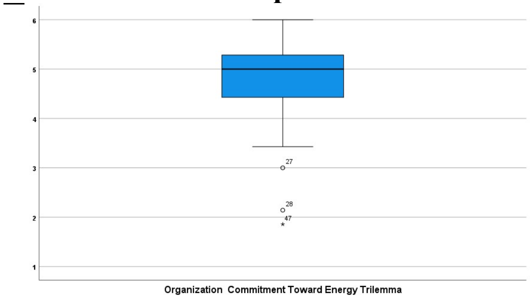










Histogram	Boxplots
	

Appendix G Principal component analysis (PCA)

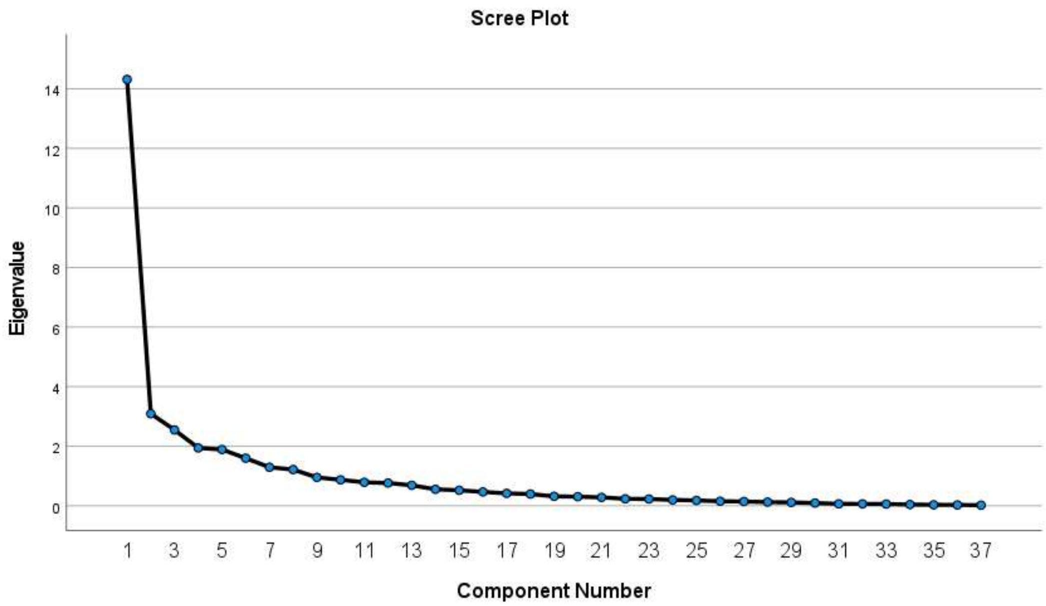


Figure 17: Scree plots

Appendix H Summary response statistics

Table 57: Organization Employee Awareness Statistics

		Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
		%	%	%	%	%	%
1. Adequate training to deliver tasks	Iceland	0.0	0.0	0.0	0.0	50.0	50.0
	Kenya	0.0	0.0	0.0	6.5	50.0	43.5
	Total	0.0	0.0	0.0	5.2	50.0	44.8
2. Adequate resources to deliver tasks	Iceland	0.0	0.0	0.0	25.0	41.7	33.3
	Kenya	0.0	0.0	2.2	23.9	58.7	15.2
	Total	0.0	0.0	1.7	24.1	55.2	19.0
10. Organization's tolerance to experimentation	Iceland	0.0	0.0	8.3	33.3	50.0	8.3
	Kenya	0.0	0.0	10.9	23.9	45.7	19.6
	Total	0.0	0.0	10.3	25.9	46.6	17.2
11. Consulted for Innovation ideas	Iceland	0.0	8.3	0.0	41.7	41.7	8.3
	Kenya	0.0	6.5	8.7	28.3	41.3	15.2
	Total	0.0	6.9	6.9	31.0	41.4	13.8
12. Supervisor's timely feedback on tasks	Iceland	0.0	0.0	0.0	66.7	25.0	8.3
	Kenya	0.0	2.2	8.7	15.2	52.2	21.7
	Total	0.0	1.7	6.9	25.9	46.6	19.0
13. Contribution of innovation to individual's performance measurement	Iceland	0.0	0.0	25.0	41.7	33.3	0.0
	Kenya	0.0	2.2	4.3	19.6	52.2	21.7
	Total	0.0	1.7	8.6	24.1	48.3	17.2
14. Promotion of teamwork in innovation	Iceland	0.0	8.3	0.0	25.0	41.7	25.0
	Kenya	0.0	0.0	2.2	13.0	41.3	43.5
	Total	0.0	1.7	1.7	15.5	41.4	39.7

Table 58: Organization Employee Motivation to Innovate

		Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
		%	%	%	%	%	%
15. Motivated by financial rewards to innovate	Iceland	33.3	16.7	0.0	33.3	8.3	8.3
	Kenya	4.3	15.2	10.9	28.3	30.4	10.9
	Total	10.3	15.5	8.6	29.3	25.9	10.3
16. Motivated by recognition to innovate	Iceland	25.0	0.0	8.3	41.7	25.0	0.0
	Kenya	4.3	4.3	10.9	26.1	43.5	10.9
	Total	8.6	3.4	10.3	29.3	39.7	8.6

		Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
		%	%	%	%	%	%
17. Motivated by personal reasons to innovate	Iceland	0.0	0.0	25.0	16.7	58.3	0.0
	Kenya	4.3	6.5	6.5	32.6	43.5	6.5
	Total	3.4	5.2	10.3	29.3	46.6	5.2

Table 59: Organization Innovation Readiness Statistics

		Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
		%	%	%	%	%	%
26. Formal innovation strategy is available	Iceland	0.0	33.3	16.7	16.7	25.0	8.3
	Kenya	0.0	0.0	2.2	6.5	43.5	47.8
	Total	0.0	6.9	5.2	8.6	39.7	39.7
27. Innovation strategy is in line with government policies	Iceland	0.0	0.0	25.0	25.0	25.0	25.0
	Kenya	0.0	0.0	0.0	21.7	50.0	28.3
	Total	0.0	0.0	5.2	22.4	44.8	27.6
28. Innovation strategy is communicated in organization	Iceland	16.7	16.7	16.7	16.7	25.0	8.3
	Kenya	0.0	4.3	6.5	10.9	41.3	37.0
	Total	3.4	6.9	8.6	12.1	37.9	31.0
29. Innovation strategy is supported by top management	Iceland	0.0	8.3	8.3	33.3	41.7	8.3
	Kenya	0.0	2.2	2.2	17.4	43.5	34.8
	Total	0.0	3.4	3.4	20.7	43.1	29.3
33. Innovation management office is available	Iceland	50.0	8.3	8.3	25.0	0.0	8.3
	Kenya	4.3	4.3	0.0	4.3	34.8	52.2
	Total	13.8	5.2	1.7	8.6	27.6	43.1
34. Innovation ideas are systematically collected	Iceland	16.7	41.7	0.0	25.0	8.3	8.3
	Kenya	2.2	6.5	0.0	10.9	34.8	45.7
	Total	5.2	13.8	0.0	13.8	29.3	37.9
39. Innovation ideas are ranked and prioritized	Iceland	16.7	25.0	16.7	33.3	8.3	0.0
	Kenya	4.3	8.7	6.5	15.2	34.8	30.4
	Total	6.9	12.1	8.6	19.0	29.3	24.1
40. Innovation idea-generators are involved in implementation	Iceland	25.0	25.0	8.3	33.3	8.3	0.0
	Kenya	2.2	4.3	13.0	17.4	37.0	26.1
	Total	6.9	8.6	12.1	20.7	31.0	20.7
41. Innovation performance is regularly communication	Iceland	25.0	25.0	8.3	25.0	16.7	0.0
	Kenya	0.0	17.4	6.5	21.7	39.1	15.2
	Total	5.2	19.0	6.9	22.4	34.5	12.1

		Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
		%	%	%	%	%	%
42. Innovation funds are allocated in organization's budget	Iceland	0.0	25.0	8.3	41.7	16.7	8.3
	Kenya	6.5	4.3	6.5	10.9	39.1	32.6
	Total	5.2	8.6	6.9	17.2	34.5	27.6
43. Innovation product development system is effective	Iceland	16.7	25.0	25.0	16.7	8.3	8.3
	Kenya	2.2	6.5	17.4	30.4	32.6	10.9
	Total	5.2	10.3	19.0	27.6	27.6	10.3
45. Organization policies and procedures ease product development	Iceland	8.3	33.3	16.7	25.0	16.7	0.0
	Kenya	4.3	2.2	19.6	32.6	30.4	10.9
	Total	5.2	8.6	19.0	31.0	27.6	8.6
46. Innovation as a regular organization's operation	Iceland	8.3	33.3	8.3	33.3	16.7	0.0
	Kenya	0.0	6.5	10.9	15.2	37.0	30.4
	Total	1.7	12.1	10.3	19.0	32.8	24.1
47. Organization structure supports innovation	Iceland	0.0	16.7	33.3	33.3	16.7	0.0
	Kenya	0.0	4.3	6.5	8.7	52.2	28.3
	Total	0.0	6.9	12.1	13.8	44.8	22.4
48. Innovation is incorporated in organization's values and mission	Iceland	0.0	16.7	33.3	0.0	50.0	0.0
	Kenya	0.0	4.3	13.0	17.4	39.1	26.1
	Total	0.0	6.9	17.2	13.8	41.4	20.7

Table 60: Organization Innovation Collaboration Systems Statistics

		Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
		%	%	%	%	%	%
50. Structured collaboration between organization's departments	Iceland	8.3	16.7	8.3	33.3	25.0	8.3
	Kenya	0.0	4.3	10.9	32.6	32.6	19.6
	Total	1.7	6.9	10.3	32.8	31.0	17.2
51. Structured collaboration with academic research institutions	Iceland	16.7	0.0	8.3	41.7	25.0	8.3
	Kenya	0.0	8.7	6.5	41.3	23.9	19.6
	Total	3.4	6.9	6.9	41.4	24.1	17.2
52. Structured collaboration with other public organizations	Iceland	8.3	0.0	8.3	50.0	33.3	0.0
	Kenya	0.0	4.3	10.9	41.3	28.3	15.2
	Total	1.7	3.4	10.3	43.1	29.3	12.1
53. Structured collaboration with private-sector organizations	Iceland	8.3	0.0	33.3	16.7	33.3	8.3
	Kenya	2.2	8.7	19.6	39.1	17.4	13.0
	Total	3.4	6.9	22.4	34.5	20.7	12.1

Table 61: Organization Innovation Type Statistics

		Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
		%	%	%	%	%	%
54. Organization is an innovation generator	Iceland	0.0	8.3	25.0	25.0	41.7	0.0
	Kenya	2.2	6.5	6.5	19.6	45.7	19.6
	Total	1.7	6.9	10.3	20.7	44.8	15.5
55. Organization is an innovation adopter	Iceland	0.0	0.0	16.7	16.7	50.0	16.7
	Kenya	0.0	17.4	6.5	34.8	30.4	10.9
	Total	0.0	13.8	8.6	31.0	34.5	12.1
56. Organization is an innovation imitator	Iceland	8.3	8.3	8.3	16.7	50.0	8.3
	Kenya	6.5	30.4	17.4	26.1	10.9	8.7
	Total	6.9	25.9	15.5	24.1	19.0	8.6

Table 62: Organization Response to Climate Action and Energy Trilemma

		Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
		%	%	%	%	%	%
57. Achieving 55% electricity GHG emissions reduction by 2030	Iceland	8.3	0.0	25.0	25.0	25.0	16.7
	Kenya	0.0	2.2	6.5	10.9	43.5	37.0
	Total	1.7	1.7	10.3	13.8	39.7	32.8
58. Achieving of universal electricity access by 2030	Iceland	0.0	8.3	0.0	8.3	33.3	50.0
	Kenya	0.0	6.5	2.2	10.9	45.7	34.8
	Total	0.0	6.9	1.7	10.3	43.1	37.9
59. Organization being carbon-neutral by 2030	Iceland	0.0	25.0	0.0	16.7	25.0	33.3
	Kenya	0.0	2.2	6.5	37.0	32.6	21.7
	Total	0.0	6.9	5.2	32.8	31.0	24.1
61. Electricity Accessibility	Iceland	16.7	8.3	0.0	16.7	33.3	25.0
	Kenya	0.0	6.5	4.3	15.2	37.0	37.0
	Total	3.4	6.9	3.4	15.5	36.2	34.5
62. Electricity Affordability	Iceland	16.7	0.0	16.7	8.3	41.7	16.7
	Kenya	0.0	0.0	6.5	8.7	41.3	43.5
	Total	3.4	0.0	8.6	8.6	41.4	37.9
63. Infrastructure Technologies	Iceland	16.7	8.3	0.0	25.0	33.3	16.7
	Kenya	0.0	2.2	6.5	23.9	41.3	26.1
	Total	3.4	3.4	5.2	24.1	39.7	24.1
64. Grid Strengthening	Iceland	33.3	8.3	8.3	25.0	8.3	16.7
	Kenya	0.0	4.3	6.5	17.4	47.8	23.9
	Total	6.9	5.2	6.9	19.0	39.7	22.4

		Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
		%	%	%	%	%	%
65. Energy transition innovation	Iceland	25.0	0.0	0.0	16.7	25.0	33.3
	Kenya	0.0	0.0	6.5	21.7	41.3	30.4
	Total	5.2	0.0	5.2	20.7	37.9	31.0
66. Energy efficiency innovation	Iceland	8.3	0.0	0.0	41.7	33.3	16.7
	Kenya	0.0	0.0	4.3	17.4	41.3	37.0
	Total	1.7	0.0	3.4	22.4	39.7	32.8

Appendix I Response statistics - Response to climate action and energy trilemma

Table 63: Electricity Generation Focus

		Highly unlikely	Unlikely	Slightly unlikely	Slightly likely	Likely	Highly likely
		%	%	%	%	%	%
Hydro Power	Iceland	25	0.0	33.3	16.7	0	25
	Kenya	21.7	15.2	6.5	28.3	17.4	10.9
	Total	**22.4**	**12.1**	**12.1**	**25.9**	**13.8**	**13.8**
Geothermal Energy	Iceland	8.3	0.0	0.0	0.0	0.0	91.7
	Kenya	4.3	0.0	0.0	2.2	6.5	87
	Total	**5.2**	**0.0**	**0.0**	**1.7**	**5.2**	**87.9**
Solar Energy	Iceland	16.7	16.7	25	25	8.3	8.3
	Kenya	13	2.2	4.3	6.5	23.9	50
	Total	**13.8**	**5.2**	**8.6**	**10.3**	**20.7**	**41.4**
Wind Energy	Iceland	16.7	0	8.3	33.3	16.7	25
	Kenya	13	4.3	0	6.5	30.4	45.7
	Total	**13.8**	**3.4**	**1.7**	**12.1**	**27.6**	**41.4**
Coal-fired Power (R)	Iceland	91.7	0.0	0.0	8.3	0.0	0.0
	Kenya	54.3	21.7	2.2	8.7	8.7	4.3
	Total	**62.1**	**17.2**	**1.7**	**8.6**	**6.9**	**3.**

Table 64: Energy Transition Projects

		Highly unlikely	Unlikely	Slightly unlikely	Slightly likely	Likely	Highly likely
		%	%	%	%	%	%
Green Hydrogen	Iceland	33.3	8.3	0.0	16.7	25.0	16.7
	Kenya	13.0	17.4	4.3	17.4	19.6	28.3
	Total	**17.2**	**15.5**	**3.4**	**17.2**	**20.7**	**25.9**
Nuclear Energy	Iceland	91.7	0.0	8.3	0.0	0.0	0.0
	Kenya	47.8	21.7	4.3	8.7	13.0	4.3
	Total	**56.9**	**17.2**	**5.2**	**6.9**	**10.3**	**3.4**
Natural Gas	Iceland	75.0	8.3	0.0	8.3	8.3	0.0
	Kenya	28.3	23.9	8.7	10.9	17.4	10.9
	Total	**37.9**	**20.7**	**6.9**	**10.3**	**15.5**	**8.6**

		Highly unlikely	Unlikely	Slightly unlikely	Slightly likely	Likely	Highly likely
		%	%	%	%	%	%
Biomass	Iceland	50.0	16.7	8.3	16.7	0.0	8.3
	Kenya	28.3	21.7	4.3	6.5	32.6	6.5
	Total	**32.8**	**20.7**	**5.2**	**8.6**	**25.9**	**6.9**

Table 65: Energy Technologies Focus

		Highly unlikely	Unlikely	Slightly unlikely	Slightly likely	Likely	Highly likely
		%	%	%	%	%	%
Grid Interconnectivity	Iceland	41.7	0.0	8.3	25.0	16.7	8.3
	Kenya	6.5	4.3	8.7	10.9	43.5	26.1
	Total	**13.8**	**3.4**	**8.6**	**13.8**	**37.9**	**22.4**
Electricity market expansion	Iceland	33.3	0.0	16.7	0.0	50.0	0.0
	Kenya	4.3	0.0	4.3	10.9	41.3	39.1
	Total	**10.3**	**0.0**	**6.9**	**8.6**	**43.1**	**31.0**
E-Mobility infrastructure	Iceland	41.7	8.3	0.0	25.0	25.0	0.0
	Kenya	4.3	2.2	6.5	26.1	34.8	26.1
	Total	**12.1**	**3.4**	**5.2**	**25.9**	**32.8**	**20.7**
Net-metering	Iceland	41.7	0.0	0.0	25.0	16.7	16.7
	Kenya	6.5	4.3	10.9	21.7	39.1	17.4
	Total	**13.8**	**3.4**	**8.6**	**22.4**	**34.5**	**17.2**
Smartgrids	Iceland	41.7	0.0	0.0	33.3	16.7	8.3
	Kenya	6.5	0.0	10.9	21.7	39.1	21.7
	Total	**13.8**	**0.0**	**8.6**	**24.1**	**34.5**	**19.0**
Energy storage (Batteries)	Iceland	41.7	16.7	8.3	16.7	16.7	0.0
	Kenya	2.2	4.3	6.5	26.1	34.8	26.1
	Total	**10.3**	**6.9**	**6.9**	**24.1**	**31.0**	**20.7**
Energy storage (Pumped storage)	Iceland	33.3	16.7	8.3	16.7	16.7	8.3
	Kenya	4.3	6.5	13.0	17.4	45.7	13.0
	Total	**10.3**	**8.6**	**12.1**	**17.2**	**39.7**	**12.1**
Public-private collaborations	Iceland	16.7	16.7	0.0	16.7	41.7	8.3
	Kenya	2.2	0.0	0.0	2.2	39.1	56.5
	Total	**5.2**	**3.4**	**0.0**	**5.2**	**39.7**	**46.6**

Table 66: GHG Emission Reduction SDG Projects

		Highly unlikely	Unlikely	Slightly unlikely	Slightly likely	Likely	Highly likely
		%	%	%	%	%	%
Carbon capture, utilization, and storage	Iceland	0.0	0.0	16.7	16.7	25.0	41.7
	Kenya	8.7	4.3	15.2	19.6	23.9	28.3
	Total	**6.9**	**3.4**	**15.5**	**19.0**	**24.1**	**31.0**
Clean cooking	Iceland	8.3	0.0	25.0	16.7	50.0	0.0
	Kenya	4.3	13.0	10.9	13.0	26.1	32.6
	Total	**5.2**	**10.3**	**13.8**	**13.8**	**31.0**	**25.9**
Energy efficiency	Iceland	0.0	8.3	16.7	25.0	33.3	16.7
	Kenya	0.0	0.0	4.3	4.3	37.0	54.3
	Total	**0.0**	**1.7**	**6.9**	**8.6**	**36.2**	**46.6**

Table 67: Agreement with Organization Innovation Pathway and Definition of Innovation

		Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree
		%	%	%	%	%	%
Agreement with organization's innovation pathway	Iceland	0.0	8.3	0.0	33.3	33.3	25.0
	Kenya	0.0	0.0	4.3	8.7	50.0	37.0
	Total	**0.0**	**1.7**	**3.4**	**13.8**	**46.6**	**34.5**
Agreement with innovation definition	Iceland	0.0	8.3	16.7	25.0	33.3	16.7
	Kenya	0.0	0.0	2.2	23.9	39.1	34.8
	Total	**0.0**	**1.7**	**5.2**	**24.1**	**37.9**	**31.0**