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ON THE TREATMENT OF UNCERTAINTY IN INNOVATION PROJECTS WITH FOCUS ON ENERGY TRANSITION

By

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On the treatment of uncertainty in innovation projects with focus on energy transition.

ABSTRACT

Innovation is the key to growth however, the process of innovation is full of uncertainties. Organizations and project management teams that are open-minded and aware of the uncertainties, can tackle them more cleverly and efficiently. Identification of uncertainty type is the foremost step in this procedure. It is critical as it directly relates to the methods used to deal with them. There are a lot of different approaches used to tackle uncertainty, ranging from statistical analysis to a robust knowledge database to efficient managing systems.

In this research, classification of uncertainties is described and three approaches for treating uncertainties in the process of innovation are discussed. These approaches deal with uncertainty through knowledge, influential factors or a clever management. For the detailed analysis of this study, example of the energy transition is taken as an innovation. Moreover, some examples of failures in the energy transition process are discussed like how lack of society's interest is proving as a major setback in this whole process or uncertainties in the technology being used is also full of uncertain consequences. A comprehensive study is conducted on the causes of these failures, the types of the uncertainties encountered and their treatment. This study includes implications of most effective approaches for different situations and type of uncertainties.

Each failure of energy transition is dissected towards its response to the three approaches discussed. An argument is carried out about the fruitfulness of each of the three approaches for every case of energy transition failure. Many experts are of the view that uncertainties can be handled through one strategy. However, treatment successful in one case can be regarded as completely obsolete in another. For example, lack of knowledge in technical or technological issues cannot be tackled through statistical analysis or effective management, Therefore, a better background of knowledge and expertise in different uncertainty handling domains must be used to avoid chaotic situations. Focus through any innovation process must be on types of uncertainties expected or encountered, and then the planning of its treatment accordingly, for instance, a technical default needs more data and information to get corrected whereas distress within human resource can be solved through administration. Sufficient knowledge and clever strategies can enhance the effectiveness of dealing with uncertain situations.

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1. INTRODUCTION

Exploring the unknown requires tolerating uncertainty (Brian Greene) [10].

Innovation is required for progress. It is a proposition that comes with uncertainty as the entity innovating does not know what they are stepping into or what the future holds.

Innovation is change-centralized because it represents a discontinuity from the past. It is not a linear process where just a replacement has taken place from old to new, rather new products or results are added continuously. Dealing with new outcomes implies uncertain conditions and decisions in an innovation process are mostly taken under such circumstances. Innovation is a trial and error method, where failures are of lessons with failing innovators considering them just as important as successes [1].

Uncertainty is necessary for the human desire for betterment and the development of new technologies. Novel projects create uncertainty for each party involved. The earlier the uncertainty is recognized, and the quicker a plan is devised, the more robust the innovation process becomes [10].

Uncertainty is often considered as risks, but risk and uncertainty are exclusive events and are not synonyms to each other. In project management literature, both these terms are not clearly distinguished and in fact overlap in many different works [2]. *Jalonen,* however, differentiates between the two on the base of assigning probability. He quotes *Knight* (1921) who defines ‘‘risk’ as a measurable unknown to which probabilities can be assigned, and ‘uncertainty’, for which such probabilities are very difficult (or cannot) to be assigned’ [1]. Risk is taken as a threat as it only has a negative impact on the project whereas uncertainty is considered both a threat and an opportunity. Moreover, both positive and negative, impacts can be expected [2].

Due to this level of complexity and high number of uncertainties, planning novel projects is not always easy. The possibility of occurrence of unknown unknowns is more which makes innovative projects more complex during their course. As a result, classical project risk management techniques such as risk identification, analysis, probability and assessment are not possible. These techniques correspond well with risks and cannot be confused for dealing with uncertainties. Therefore, these may not be best suited for planning innovative projects [9]. However, uncertainty and complexity should not pose as a hindrance to organizations that want to innovate.

1.1 ROLE OF UNCERTAINTIES IN INNOVATION PROCESS

Innovation is termed as both, the cause and an effect of uncertainty [3]. Sometimes uncertain problems lead to innovation, while sometimes an innovative project is full of uncertainties. In the process of innovation, uncertainties carry both damaging and constructing effects. Despite the knowledge of the negative consequences of uncertainties in novel projects, innovators take the risk. Uncertainty and entrepreneurship are linked with each other and tolerating uncertainty is considered a necessary condition for innovation [1].

Although the risks are present, and results may vary from expectation, the attempt of innovation can give companies an upper hand in influencing the future and purposefully reducing uncertainties. Organizations manage uncertainty through innovation by experimentation and introduction of new policies. In this way, the organization’s very own attempts at innovation reduce uncertainty about the future and results as beneficial to the company. This approach to an innovation strategy helps businesses and organizations to plan their activities strategically. Instead of aiming for abstract horizons, companies focus on the objectives of uncertainty reduction through the process of innovation by creating new products that help to create the future that the company desires [3]

This approach is also supported by *Jalonen* [1]. He discusses that innovation is an activity which processes information for uncertainty reduction and improves decision making.
Societies which accept uncertainties openly are more innovative. Innovation is accompanied by conflicting beliefs, errors and mistakes, all of which are very important because each can be corrected or replaced by a better alternative [1].

However, when the uncertainty is unknown and there is no knowledge about it, actors must act within unfamiliar conditions, resulting in negative consequences. Uncertainties prevailing in the market are inversely proportional to the degree of stability. These uncertainties result in increasing the probability of failure. Assessment of risks and opportunities involved, and understanding the uncertainties are vital for a strong foundation of new ventures. Identification of uncertainties related to an opportunity is a key part of all innovation processes [13]. The treatment of uncertainties is also devised depending upon the fact if uncertainty is the cause or the consequence [3].

1.2 BACKGROUND

Uncertainties in innovation processes are unavoidable. However, entities carrying out innovative processes can equip themselves with enough knowledge about what to expect. Innovators need to understand the process and identify the problems or difficulties they may encounter, beforehand. Only then they can make informed decisions. Sometimes, innovators come across unknown uncertainties. In that case some irrational decisions are made. This lack of knowledge, in many cases, can result in shutting down the entire innovation process.

Extensive research has been done about uncertainties, their types and how to be best prepare for them. These are classified in many ways depending upon their sources. This classification, however, plays a significant role when tackling them.

As more knowledge is available, there can be more than one way to tackle uncertainty. Uncertainty can now be looked at and evaluated in a variety of ways. The traditional approach to deal with uncertainties is through estimating probabilities. Probability modelling forms the basis of statistical analysis and plays an important role in estimating uncertainties. These models update the probabilities of an event occurring [11]. However, with uncertainty, it can be challenging to do this accurately. This is because one can acquire information and get better equipped to decrease the level of uncertainty, but in no way can they influence the probability of the occurrence of an uncertain event. Probability is trusting that whatever the person believes, who oversees judgement, might be the case. Statistics and data back it up but there is also a possibility of bad experience, lack of information and probability modelling skills. As a result, it is safe to say that true probabilities do not exist [12]. The reason behind this is the contribution of one or more of these key factors which act effectively in probability estimation and therefore, influencing the result.

Probabilities and statistical analysis do not work well in the process of innovation. As innovative projects are primarily new, background data is scarce and much of the problems that occur are novel. Modern projects have modern problems and they require modern solutions. For this research, an ongoing novel process of the energy transition is made into a case study. New technologies in this wake are developing, and policies are shaping up around them. As this process is full of new ventures and experimentation, it is also packed with uncertain situations. These situations are occurring in every aspect related to the energy transition. Since problems of each aspect are different from one another, ways of treating them are indecisive. Dealing with these uncertainties tactfully is the ultimate need of the day.

There are numerous approaches used for tackling uncertainty and they all work in different domains. Treatment of uncertainty cannot be generalized with just one or two methods. This treatment can now be tackled long before the execution of an innovation project, starting from gaining knowledge about managing it tactfully, all while influencing the prevailing mentality of the project team in a healthy way. These different approaches are discussed in detail in the third chapter of this research thesis.

1.3 PROBLEM

Availability of a variety of approaches for tackling uncertainties sometimes result into ambiguous situations and decision making becomes difficult. The final decision about adapting a method needs extensive knowledge about the uncertainties, clever and informed verdicts. For the research on most efficient approaches to tackle uncertainties in innovation projects, the innovation of energy transition is taken as a case study. Some problems in this particular innovation are studied. Energy transition is and will be a very long process spanning over decades, with the goal of switching completely from non-renewables to renewable resources. The world has always faced energy additions in the past. Humankind initially depended on biomass only, slowly coal was added as an energy resource and almost 80 years ago, oil, gas and nuclear energy integrated into society's energy resources. A few decades ago, renewable energy also made an impact in the energy market.

The energy transition is completely different from addition of energy in the existing resources, that has been taking place since forever. Energy transition is a process that humankind has never experienced before where one type of energy resources (non-renewable) must be reduced and replaced by another resource (renewable), for example, Germany has shut down their nuclear power plants altogether [31]. Although it has not been fruitful so far, but this step was taken by the German government for making a progression towards decreasing its use of non-renewable resources.

This switching of energy resources is an innovation that has never happened before. Therefore, this process is full of uncertainties. There are no role models and when problems occur, there is no data available for tackling them. Everything must be interpreted and inferred from scratch. Since the whole process is diverse, the uncertainties are present in every step and cannot be handled uniformly. For example, a problem of management cannot be dealt with experiments in the lab. Similarly, tackling uncertainty needs different approaches relative to the cause and the domain in which they occur. One or two methods are not enough.

Many projects in this process of energy transition have failed to achieve their goals. Some of them have similar reasons of failure. A few of stalled energy transition projects are listed in the third chapter of this research. Details are discussed as to what the objectives of those projects, the uncertainties they encountered, the approaches they adapted, the uncertainties they managed and their reasons for failure.

1.4 RESEARCH OBJECTIVES

After studying energy transition as an example of innovation, some key problems are identified. The setbacks have multiple reasons for failure but one of the common observations among these is the non-classification of uncertainty types. For example, no such thoughts are given to differentiate society from market and their respective uncertain behaviour. The classification of uncertainties is very important because managing uncertainty is directly influenced by its source. It is important to consider if they are within an organization or an external factor. Since the energy transition is a global issue almost all uncertainties are internal. The first half of the second chapter of this thesis deals with different classification of uncertainties, mainly in innovation processes and particularly how these classifications fit into the energy transition process.

Once uncertainties are identified, the next step is adapting a tactful approach to deal with them Apart from the traditional probability estimation approach, such approaches range from influential powers of the involved factors to the mental well-being of individuals involved. An overview of some of these approaches is described in the second half of chapter two.

The research aims to analyse uncertainties encountered during the energy transition process and classify them into different categories as discussed in chapter two. Then an argument is conducted about the approaches that could have resulted in better results had they been adopted. Since the approaches used were not fruitful and caused delay and failure, some other methods and tactics are discussed leading to better results. Three different approaches are researched, and their fruitfulness is argued in each case of energy transition failure. Another objective of this research is to justify that there is not one way of dealing with a problem. Instead, there are many, but choosing the most effective one is the key to success. Since energy transition is a wide phenomenon covering almost every aspect of society and industry, it provides a comprehensive outlook for innovation projects.

2. CLASSIFICATION OF UNCERTAINTY AND DIFFERENT APPROACHES TO MANAGE UNCERTAINTY

Jalonen relates uncertainty with amount of information one possesses. He quotes *Galbraith* who defines uncertainty as *'the gap between the amount of information required to perform the task and the amount of information already possessed by the organization'.*

Uncertainties of all types create an atmosphere of displeasure within organizations because the participants feel clueless about taking the next step. But uncertainty is an integral part of implementing an innovation.

Jalonen further differentiates uncertainties into 'known' and 'unknown' uncertainty. This classification involves probability. In known uncertainty, one is aware of the probabilities of different outcomes and variables involved but the accurate values are not clear. Probability analysis play a fundamental role in dealing with known uncertainties. Whereas in unknown uncertainties, there is no room for calculations. Most variables come in as a surprise, cause-effect relationship lacks clarity and the major unknown uncertainty arises when all the involved parties disagree and hold their stance firmly. These are the situations where consequences of events are unpredictable and there is lack of knowledge about the events which will change future [1].

Success and failure of an innovator depends on his dealing with uncertainties before he/she indulges in an opportunity because uncertainties intrude throughout the process of innovation. Creating technological start-ups implies dealing with uncertainties. Therefore, it is very important for the entrepreneurs and innovators to have good knowledge about the relation between uncertainties and innovative intentions [13].

2.1 CLASSIFICATION OF UNCERTAINTY SOURCES INTO BROADER CATEGORIES

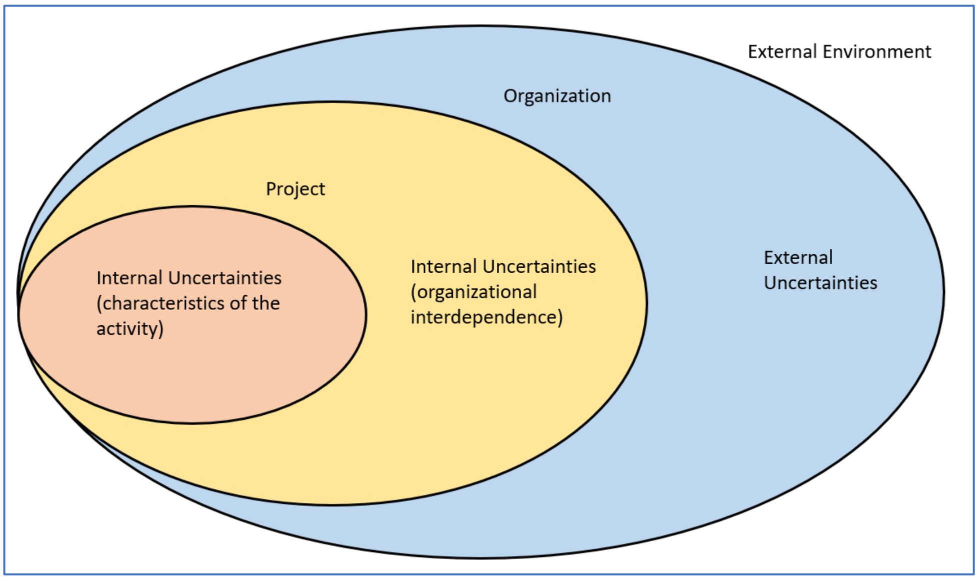

Figure 3 *Broader categorization of uncertainties (courtesy [2]).*

The sources of uncertainty can be classified in a variety of ways into broader categories such as external and internal uncertainty as shown in figure 1. Whereas internal uncertainties are further divided into organizational interdependence and characteristics of activity [2]. *Sicotte* and *Bougault* introduced a third uncertainty called task characteristics in this broader classification [7].

Tomy and *Pardede* also described uncertainties broadly into external and internal orientations. Uncertainties related to market were classified into external domain while learning capabilities of the organization itself was included in internal domain [13].

2.1.1 External Uncertainties

External uncertainties arise because of lack of information about the external factors contributing in the performance of any project. These factors befall in a wide variety for example, technical, technological, policy related, local culture and infrastructure and so on. External uncertainties are further classified into 3 types:

- Uncertainties of state where there is no understanding about the changing components of the environment.
- Uncertainties of effect are those which lack enough knowledge for making a prediction about the effects on environment by a state in future.
- Uncertainties of response take place when there is not enough knowledge about available options as a response to uncertainty. The cost of the response is also unknown [2].

2.1.2 Example in Energy Transition

As mentioned before, energy transition is a global issue so almost all the uncertainties are internal. However, the pandemic of COVID-19 was a huge external uncertainty. It was a black swan event which set back the progress of energy transition.

The world was definitely not prepared for it and it fulfilled all the three types of external uncertainties discussed above. There was no understanding of how the virus was spreading so fast and the fatality of its effects on human life. The virus was new of its kind so there was no knowledge about how to respond to it and stop the spread. The whole world stopped for a few months. Everything on earth related to human life was affected and so was the process of energy transition.

Norway's national oil company, Equinor intended to reach the goal of net zero carbon emission by 2050. During the pandemic, its statistics changed and now they propose that the target might be achieved by 2070.

2.1.3 Internal Uncertainties

Internal uncertainties are caused within the organization or system. These are the research and development tasks which are not part of the routine. And the interdependence for executing them between technical and organizational regimes is very high [7].

2.1.4 Example in Energy Transition

All the other types of uncertainties are taken under this category, be it technical, market, consumer, technological, political or societal. These are explained in detail in the next section.

2.2 DETAILED CLASSIFICATION OF UNCERTAINTY SOURCES

Sources of uncertainties have a direct influential relation with innovator's decision making skills. These factors contribute significantly in directing the kind of action taken in an opportunity [13].

Jalonen first classified uncertainties on the base of their source after reviewing lots of articles. These sources of uncertainties made a long list based on the type of innovation, the matter of their subject, theoretical framework and methods used to tackle them. The list is shown in figure 2 [1].

Technological Uncertainty	Technical Uncertainty	Market Uncertainty
Commercial Uncertainty	Competitive Uncertainty	Consumer Uncertainty
Environmental Uncertainty	Regulatory Uncertainty	Legal Uncertainty
Societal Uncertainty	Political Uncertainty	Economic Uncertainty
Organizational Uncertainty	Resource Uncertainty	Decision-making Uncertainty
Acceptance Uncertainty	Task Uncertainty	Behavioural Uncertainty

Figure 4 *Various sources of uncertainty (courtesy [1]).*

Jalonen further narrowed them down to eight types. The two most important as described by him are technological uncertainty and market uncertainty. Rest of the uncertainties are regulatory or institutional uncertainty, managerial uncertainty, timing uncertainty, and consequence uncertainty, social and political uncertainty and lastly, acceptance or legitimacy uncertainty [1].

Tomy and *Pardede* also had a similar classification encompassing into political, technological, market reputation, resource and competitor uncertainties [13].

The uncertainties based on their resources are described in detail; both in general context and their contribution in energy transition.

2.2.1 Technological Uncertainty

Technology and innovation are so close in nature that sometimes they are used as synonyms. Technology comprises broadly of technical tools and the skills and knowledge required to work with those tools. Both are considered as uncertainty sources [1]. Technology itself roots for the technological uncertainties [13]. Innovators encounter uncertainties in the technological systems, tools used in the process, process itself and availability of technological solutions [1] [13].

Complexity of a technology is directly proportional to the encountered uncertainty. This uncertainty encompasses the availability of an infrastructure for execution, and the flexibility needed to adapt to the prevailing technologies and introducing improved technologies [13].

Product specifications used in technological innovation are almost unknown when it comes to usefulness and functionality and it entirely depends on the novelty of the technology. If the innovation is unique, the uncertainty is categorized into four levels: low, medium, high and super-high. Technology brings new solutions along with new problems to tackle. Lack of knowledge is the main cause in technological uncertainty [1].

Technological Uncertainty in Energy Transition

Technology development and its application for producing, dispensing and utilizing energy resources pose a great uncertainty. The availability of these resources in future is also still in questionable phase. Technological uncertainty is present in many different aspects such as developments in energy transforming technologies, regulations to keep a check on technological development, decentralization of the energy system and the future storage of carbon [17].

A major technological uncertainty in the course of energy transition is the commercial availability of low carbon technologies which are innovative in nature, yet vital for decarbonising the energy system [14]. Exploiting new technologies like deep geothermal energy or fuel cell power and their future accessibility is still uncertain [17]. Future of CCS (Carbon Capture and Storage) availability is full of uncertainty. Lack of policy support, questionable long-term storage of liquid CO2 and a lack of progress on international front for commercial placement of CCS are some of the main factors contributing to this uncertainty [14].

Technological uncertainty also encompasses the decarbonisation of heat. Many countries prefer gas heating and there are no low carbon alternatives to gas broiler heating [14]. Alternative technological options are considered less important by the consumers [18].

2.2.2 Market Uncertainty

Any innovation has no value if there is no market for it. Condition of future market is filled with uncertainty of strong and vocal customers, a change in product life cycles, instability in geopolitical conditions, emerging new technologies and globalization of market. Innovation is basically done to meet the requirements of the market comprising of customers, competitors and the service prices. Market uncertainty is further divided into three types described in the last sentence [1].

> **a) Customer Uncertainty:** The main source of uncertainty in market-based uncertainties are due to customers. It is very challenging to predict the customer behaviour and his needs in the future [1]. Lack of knowledge about customer's expectations and acceptance of a new product makes things very uncertain [13].
> Fragmentation of markets is growing rapidly because of changing values, expectations and attitudes of customer [1]. It is very important to understand who the customer is and what is important for him [13].
> A divided opinion about environment is also a major uncertainty because innovators don't know if their environmentally friendly innovations will be welcomed by the customers on large scale or not [1].
>
> **b) Competitive Uncertainty:** Unawareness about the competitor's actions and behaviour forms the basis of competitive uncertainty [13]. Globalization and liberalization of markets plays a great role in this uncertainty [1]. The inability to recognize the entrants and their services and their competing strategies aids in this type [13].

Market Uncertainty in Energy Transition

As energy transition involve lots of different actors, their way of perception is different from one another. Getting everyone on one board is a challenge.

Technology developers are convinced with the emergence of new energy market and believe that it is a matter of time only until zero carbon emission is achieved. Consumer preferences are not given much importance by most of the technology developers. They are of the view that consumer uncertainties can be reduced by pilot projects. However, this type of uncertainty directly effects the emergence and magnitude of the emerging new market [18].

Political and Technological uncertainties are first to be tackled in the energy transition process, but consumer play an equally important role because without their interest, there is no execution.

2.2.3 Regulatory or Institutional Uncertainty

Innovators need facilitations and arrangements from institutions to carry out their innovative efforts. These arrangements also help in reducing uncertainty in innovation. But at the same time these institutions and their regulations are also taken as an uncertainty. The more complex the institution is and the more unstable a government is, weaker the innovative process is.

Institutes made regulations to keep a check and balance on innovative processes. Also, to make sure that these activities are not harmful for citizens. They are typically related to health and environment. Although these intentions are good, still they pose unfavourable side effects for innovative processes.

Government face challenges in promoting innovation because they have less understanding of an emerging industry. So, instead of imposing constructive regulations, they enforce such restrictions that facilitate pre-existing businesses. A lack of knowledge about the consequences of a regulation results in complexity and uncertainty. [13].

Institutional Uncertainty in Energy Transition

Reliability of governments are always challenged because there is lack of faith in government's continuous changing policies. Governments argue that the energy market should digest the fact that uncertainties due to policy changes is unavoidable, so the market entities should not put the blame on government's reliability rather prepare themselves for such uncertainties. Such arguments make it evident that there is tension between governments and market parties that who should be leading the energy transition towards sustainability [18].

Changes in government affects any ongoing process including climate policy. This directly affects the investors, making it challenging for them to invest in large infrastructure. Multiple changes in government policies makes it is difficult for strategic decisions. Also, with re-elections looming near, governments focus on keeping cost down for consumers and providing leniency to industrial conflicts which is not fruitful for long term policies [14].

Societal conditions also make it harder for governments to enforce climate targets because society is becoming polarised [14].

2.2.4 Managerial Uncertainty

Uncertainties are created in managing innovation due to the risk involved and failure possibility. Lack of knowledge about how effective the management process in risky situations would be, arises uncertainty. Managing routine tasks is completely different from managing uncertainty. Routine tasks are standardized and stable while innovation in unpredictable, autonomous and risky.

Managerial uncertainty is compelled by managing and co-operating with the rest of the organization and partners, change in required resources, project management team and skills. Management is in charge in the face of uncertainty but never in control [1].

Managerial Uncertainty in Energy Transition

Managerial uncertainty can be termed as global uncertainty in the context of energy transition because the issue prevails globally and must be managed likewise. It is the second largest type after technological uncertainty. Tens of developing countries are dealing with their own issues of large magnitudes for example, poverty, famine, war, internal conflicts, scarcity of water etc. to get these countries on board is a huge and time-consuming process. They must be taken on board through proper channelling of global awareness carried out by countries with resources.

A country's pace towards energy transition can be affected by actions of other countries. Therefore, management and co-operation of all the countries of the world is necessary. Every country is required to manage its goals, targets and actions within itself and may ask for assistance from fellow nations. There is no single entity looking over or managing the progress of each country, so it poses a huge uncertain situation globally. Each country has to work on its own, for its own self and its own pace.

2.2.5 Economic (Resource) Uncertainty

Economic growth an economic status of an organization is an important uncertainty [14]. It depends profoundly on resources. Resources comprises of availability of raw material, skilled humans and finances. The uncertainty related to resource is when forecasts of the resources and investment for the process of innovation is difficult [13]. Struggling economies may have resources but no proper infrastructure to execute projects or they might not have resources altogether.

Due to constant change in external and internal conditions, resources become less valuable or completely useless. A constant evaluation is required to manage resources.

Allocation of investments in acquiring the right kind of educational and training skills and also making the right choice for investing is very difficult for projects which are very innovative. This also influence the performance of project and cost [13].

Economic Uncertainty in Energy Transition

Economic uncertainty lies in the approach of different governments whether they would like to maintain their economic growth or switch to a low growth rate just for the sake of accomplishing the transition targets. Incompatibility can be observed in the economic growth where climate policies are being achieved [14].

The costs and benefits related to the transition and market development of both supply and demand are the basis of economic uncertainty. Technology and market both are developing for supply and demand in the process of energy transition. Uncertainties lies in the dynamics of competitors, policies and energy demand [18].

The type of economy also determines the progress. An expanding, growing economy has the leverage of making large investments in different segments because of the availability of big budgets and strong societal influences whereas a contracting, reducing economy will act as a contrary.

2.2.6 Consequence Uncertainty

Consequences of innovation are not possible to be forecasted. Therefore, although innovations are useful, they are not always reinforced because of unpredictability of processes and outcomes. A relationship between inputs and outputs cannot be established.

Three contrasts prevail in consequence of innovation:

> **Direct vs indirect consequences:** Direct consequences induce immediate response towards an innovation whereas indirect consequences are their second order results.
>
> **Desirable vs undesirable consequences:** Functional effects are desirable while dysfunctional effects of an innovation are undesirable.
>
> **Anticipated vs unanticipated consequences:** Intended and recognized effects of an innovation are anticipated, and unintended and unrecognized effects are unanticipated consequences [1].

Consequential Uncertainty in Energy Transition

Consequences of energy transition are beneficial for the environment at macro level, with lesser carbon emission, cleaner energy resources and less pollution. But if it is to be broken down to micro details, renewable energy infrastructure poses a great threat to wildlife, humans and sea life.

Wind turbines is a big hazard for birds and the noise they generate is also harmful for human beings. Offshore wind power plants aid in destruction of sea creatures. All these consequences fall into undesirable and unanticipated consequences.

2.2.7 Social Uncertainty

Innovation is not a solitary process. It involves multiple stakeholders and a healthy interaction about development of activities between these stakeholders is very important. This interaction itself is a big source of uncertainty because it clarifies the goals and interests of different parties involved. It becomes highly complex when involved parties portrays different interests. This brings complicated changes in the relationship between producers, sellers and customers making the social environment uncertain [1].

Societal Uncertainty in Energy Transition

Transition of the society is a very broad challenge [14]. Attitudes and participations of individual and collective actors are the core of societal uncertainty. This uncertainty is present in almost all the entities connected to energy transition. Public protests and acceptances regarding sustainable energy transitions and infrastructure are the limelight of this uncertainty. But under the main cover, it extends to all the actors participating, from governing to implementing. The way interests and practices are developed by these individuals contribute directly to societal uncertainty. It is not possible to assume about the values and lifestyles which will shape up the future and how the society will develop in the terms of consumption patterns [17].

There is a gap in society's understanding of climate change. They are not willing to own the responsibility of contributing towards the achievement of this challenge of energy transition. Getting out of their comfort zones and welcoming new technology has not been easy by the consumers. High uncertainty lies in the future of consumer's response i.e., if they will be willing to adopt low carbon technologies and share the accountability of bringing climate change [14].

2.2.8 Political Uncertainty

Political decisions directly or indirectly influence the innovations and businesses in general for example, laws of employment and consumer protection, reforms and restrictions in trade, taxes, sales and operation stability. Government's behaviour and policies result in political uncertainty. Government's role as organizer, sponsor and controller for businesses plays a critical role in innovation. Uncertainties in policies, distribution contracts, inconsistency between local and national government regulations have serious impacts on innovative processes [13].

Political Uncertainty in Energy Transition

Political uncertainties are generated by political institutions and organizations at competition. But in global issue like energy transition, these institutions become less important and less reliable as compared to a bigger political agenda [17]. Political decision-making greatly influences the progress towards the decarbonisation of energy system [14]. Political uncertainties associated with energy transition impacts the general dissertations and policy making, which then influences the companies or consumer decision. Decision-makers strive for certain policy frameworks in order to evaluate the uncertainties, risks and prospects of investing in new technologies [17].

Political will, political cycles, commitment and vested interests are some of the important factors aiding up to political uncertainty enforced by many Non-Government Organisation (NGO) and Academia (ACA) groups. Strong opponents in the energy sector makes the process of energy transition difficult. Some specific lobbies have disproportionate influence which also intensifies the uncertainty [14].

Uncertainty about subsidies, energy saving norms, energy taxes and legal admissions of individual organisations to the energy market can have fatal consequences to the emerging entities [18].

2.3 DIFFERENT APPROACHES TO MANAGE UNCERTAINTY

Traditionally there is one common approach to uncertainty. That is by estimating the probability of a certain uncertainty based on the data we already have. But if dig deeper, there are multiple but uncommon ways to tackle uncertainties and each has proven to be fruitful in its own way.

By the development of technical resources and skills to predict and estimate, uncertainties can be tackled and reduced successfully. The ability of an innovator to make an evaluation of the environment and assessment of expected changes, uncertainties can be recognised efficiently [13]. In this chapter, we will discuss multiple approaches for tackling uncertainties.

2.3.1 KNOWLEDGE BASED APPROACH TO UNCERTAINTY

An organization has a typical environment where it deals with its competitors, customers, external agencies and different institutions. Uncertainty is always a part of this environment and organizations are recognized by the way they tackle uncertainties and the measures they adopt to tolerate or lessen them [4]. Uncertainty can be reduced by increasing the amount of information where it is lacking [1].

This knowledge-based approach to uncertainty portrays that a firm should have a sufficient capacity for information processing and communicating efficiently in the face of complexity and uncertainty. This information processing ability comes together with creating, applying and integrating knowledge. In critical situations, this approach helps the organization in finding solutions rather than questioning that why this is happening. It also helps in understanding the problem and forming better questions for tackling problem, with the knowledge already acquired.

Context-specific knowledge is not easy to create or transfer through markets. When organizations generate their own tacit knowledge, it helps them in having a competitive advantage in the market since they create a balance between the requirements and capabilities of processing knowledge. Such organizations are presented as a solution for managing and processing context-specific knowledge.

When any organization is categorized in the terms of information required for dealing with challenges, four attributes contribute to that organization's knowledge-processing requirements. These are complexity, uncertainty, ambiguity and equivocality also known as 'knowledge problems.' Each attribute is a unique challenge on its own that requires a particular knowledge-processing capability. These four works in harmony in identifying an organization's knowledge processing requirements and influencing its behaviour in the same aspect.

Uncertainty is not independent of these attributes rather it portrays a fuller picture of challenges ahead when these four are taken together [4]. Complexity and ambiguity of any situation makes people insecure about the knowledge they possess, and uncertainty rises [1]. The four knowledge problems pose a processing load on organization but if they have developed capabilities to deal with each of these individually, it enhances organization's performance and effectiveness [4].

According to Zack, uncertainty, ambiguity, complexity and equivocality are inevitable in any project. Rather than dealing with them as surprise factors, firms should prepare themselves about these attributes and deal with them head-on. This results in being at a better position during uninvited chaos. Once organizations are equipped with good knowledge about dealing with these problems, the approach leads to a steady state of organization, better execution of strategies and much better management of uncertainty, equivocality, complexity and ambiguity. He explains each problem in a unique context and perceive them as challenges that can be manageable by increasing knowledge [4].

A) Complexity

Complexity of a situation is multiple parts playing their role in a multifaceted way. It shows the variety of different factors involved in a situation such as problems, competitors, methods, variables, stakeholders and the complex relation they have with one another. Complexity is not always unpredictable but sometimes, the number of elements involved are too many and the procedures are too lengthy. Many factors and steps make the conditions complex [4].
The response to complex situation is what defines an organization's capabilities. It should gain superior knowledge about all the factors and methods involved and then work up to process the complexity. The richer the knowledge is, the greater ability an organization possess to deal with complexity. It results in greater management and competitive advantages. If a firm can deal with very complex situations, it increases its competitiveness because it is not understandable or imitable to its rivals [4].
Knowledge can be stored within the organization by running procedural routines which are prompted by familiar events and the employees practice solving complex processes. Knowledge gained through experiments always help in solving intricate problems. So, expertise to deal with a complicated situation and an appropriate amount of knowledge helps in decreasing complexity and brings out better outputs [4].

B) Uncertainty

Uncertainty is perceived in two different contexts. One is through decision theory where it is taken as the probability of outcomes and methods to achieve them. The other is through information theory which takes uncertainty as lack of information to decide, perform a task or to choose from a set of possible outcomes [4].
Uncertainties can range from known to partially known to completely unknown. In all situations, they must not bring lack of understanding of situation. Dealing with uncertainty is what defines a productive strategic planning. Taking the information theory in practice, companies should get well equipped with the variety of right options for the future and when the time comes, these opportunities can be narrowed down to a concise number with more certainty. This facilitates the investors and stakeholders to make quick decisions [4].
Just like complexity, uncertainty can also be managed through better and sufficient knowledge within the organization. Acquiring additional knowledge and developing or improving the abilities to estimate and predict can help in reducing uncertainties. Once encountered, uncertainties can be managed by responding quickly to unexpected events by using existing knowledge to infer and estimate values of lacking information. The organizations must invest in developing their intellectual resources and enhance their capabilities for inferring, learning and estimating. Importance must also be given to communication networks for responding effectively and communicating consistently in the time of uncertainty [4].

C) Equivocality

Individuals within an organization hold unique values and knowledge. They have different set of experiences which make their interpretation of things dissimilar to each other. This is known as equivocality when multiple meanings are generated for the same thing. Sometimes all interpretations are correct, but they conflict with each other. Sometimes individuals agree on description of an issue, but they disagree on the boundaries defining the issue or implementation of action for the same matter [4].

For converging on one meaning and agreeing on a single output, negotiations, face-to-face interpretation and interactive decisions are suggested. Some situations can work with coordinated action if multiple meanings are satisfied. Therefore, strict measures, precise policies, hard and fast rules for coordination may end up in misperception and misunderstanding [4].

A better management is required for dealing with equivocality. In some situations, similar thinking and meanings develop but they tend to diverge if not supervised. Multiple interpretations and unclear communication also result in ambiguity so efficient communication through management must be practiced [4].

D) Ambiguity

Unclear situations raise uncertainty and complexity. Organizations lacking the ability to make sense of an unexpected situation always face an underlying ambiguity. Ambiguity can be on surface or deeply rooted. Surface ambiguity means possession of knowledge but inability to use it cleverly, making incorrect interpretations. Deep ambiguity is an insufficient knowledge. Situations are taken as a surprise, resulting in chaotic conditions because the organizations have no idea about which action would be fruitful or how the situation must be tackled professionally [4].

To overcome this problem, situations are reframed by gaining knowledge through learning or experience or utilizing interpretations from external bodies. Ambiguous situations are reformed into meaningful situations. This works well for surface ambiguities but for deep ambiguities, gaining external contextual knowledge is not enough. To get out of deep ambiguous situations, interpretations and explanation are repeatedly done, hypotheses are generated and a hunt for new knowledge begins for testing the hypothesis. This is done as many times as required until some meaningful explanation emerges, and a familiar context is created according to which further actions are planned [4].

Ambiguity within an organization can be reduced by developing the resources for having face-to-face interactions between various set of individuals. British petroleum has set a good example by breaking up its organization into 90 units and communication is enhanced within units and cross-units. This has proven to be beneficial in development of expert views and advisories which can be used when needed [4].

2.3.1.1 Interrelation Between These Four Knowledge-Based Problems

These four problems are interrelated and are differentiated based on how they are tackled i.e., if existing knowledge is concise for further interpretation or if more knowledge is required. This is called restrictive or acquisitive processing. Complexity and equivocality fall in restrictive processing because information and viewpoints are needed to be limited and imposed for structured meaning. While uncertainty and ambiguity are acquisitive in nature.

Uncertainty needs acquiring information based on facts whereas ambiguity tends to gain more interpretive knowledge [4].
In the context of solution-driven aspect, complexity and uncertainty have traits like convergent problems. These are studied more and are subjected to one simplified solution. Facts are analysed, manipulated and communicated after a meaningful knowledge context is agreed on [4].
Whereas ambiguity and equivocality have divergent problem characteristics. These are not easily agreed on one solution. They require creating, interpreting and negotiating different meanings. The more these problems are studied, the more they diverge from a single solution [4].
These problems although different from each other, they show a pattern or sequence. In the face of uncertainty and complexity, meaningful solutions are discussed, and efficient strategic actions are established. In some cases, it might lead to ambiguity, which is then resolved but it has a potential of creating equivocality as a range of interpretations take place. Dissolving this aspect of equivocality in the organization creates a better environment for dealing with uncertainty and complexity [4].

It is very advantageous for innovators to adapt this approach for tackling uncertainty. Organizations which have developed capabilities in fulfilling the requirements for a competitive environment sustain their performance effectively. They reach a level of inimitability where the competitors do not have knowledge about the resources a company has used to develop capabilities., the procedures are hard to understand and factors involved have intricate relations.

2.3.2 INFLUENTIAL-BASED APPROACH TO UNCERTAINTY

Uncertainties are either related to the cause; unpredictability or they are related to the consequences; uncontrollability. It is very much possible that both cause and consequences of uncertainty can be controlled.

Uncertainty is taken as a contingency because it is an inevitable part of innovation. Theory of contingency forms the basis of this approach. This theory states that an organization's effectiveness relates to its fitness with the environment. A project's or innovation's success is directly proportional to the organization of the project in ongoing circumstances because different conditions have their own sets of management requirements [2]. This forms the base of the figure 3 shown below:

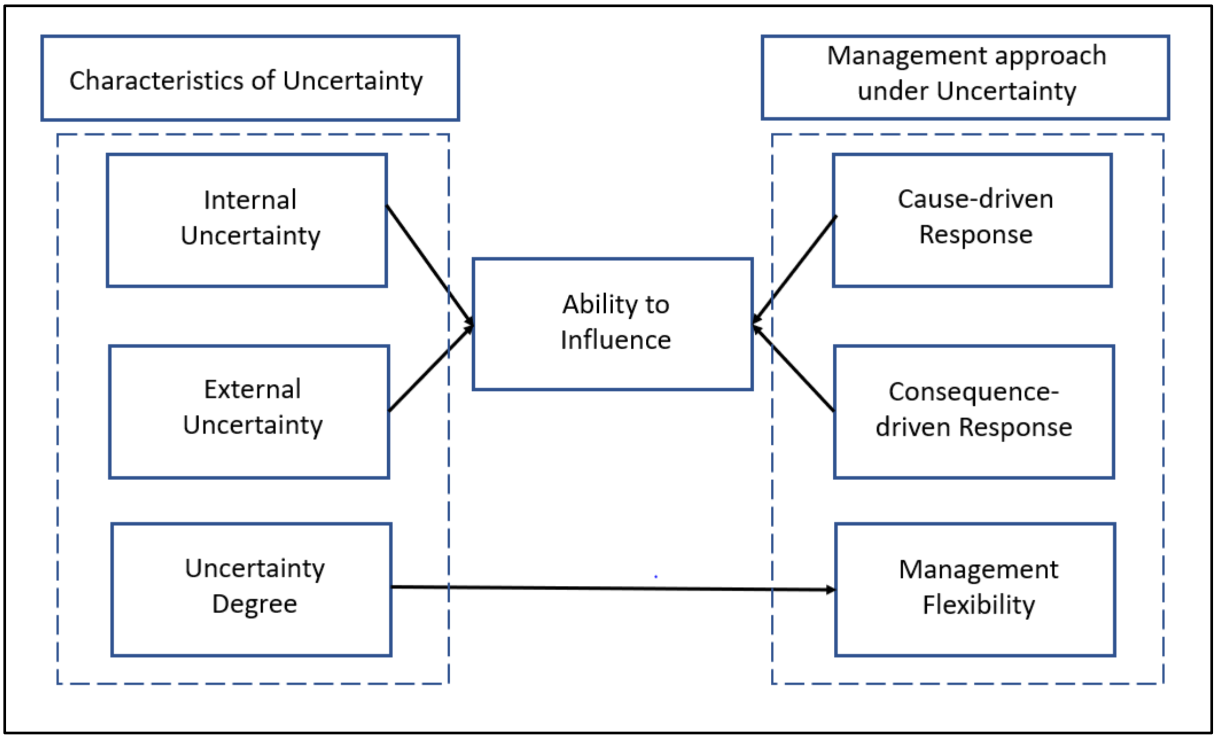

Figure 3 *Relationship between uncertainty type and management with ability to influence (courtesy [2]).*

Actions related to cause of uncertainty are a common practice in risk management. Techniques involving root-cause analysis are utilized to identify risk in quality control area. But if these causes are complex and individual actions are not sufficient for eliminating them than the ability to influence the cause of uncertainty is very low. In this case, management of causes does not have much effect on the uncertainty effects. So, actions are modified for minimizing these effects.

With respect to the source of uncertainty, following observations have been made:

• The ability to influence the source of uncertainty becomes greater when the uncertainties are more internal.

• The ability to influence the source of uncertainty becomes smaller when the uncertainties are more external.

Following observations were made regarding the response of uncertainty:

• The actions are more intensely oriented to the cause of uncertainty when the ability to influence the source of uncertainty is greater.

• The actions are more intensely oriented to the consequence of uncertainty when the ability to influence the source of uncertainty is smaller.

The ability to influence the source of uncertainty is categorized into high, moderate or low degree. These are further explained by involvement of stakeholders. In situations where there is no involvement of stakeholders and effective actions are applied internally, the influential ability is high. When senior management is involved in a situation, the ability becomes moderate. And it is the lowest when various external stakeholders get involved [2]. Following figure 4 depicts the relation between involvement of stakeholders and the ability to influence.

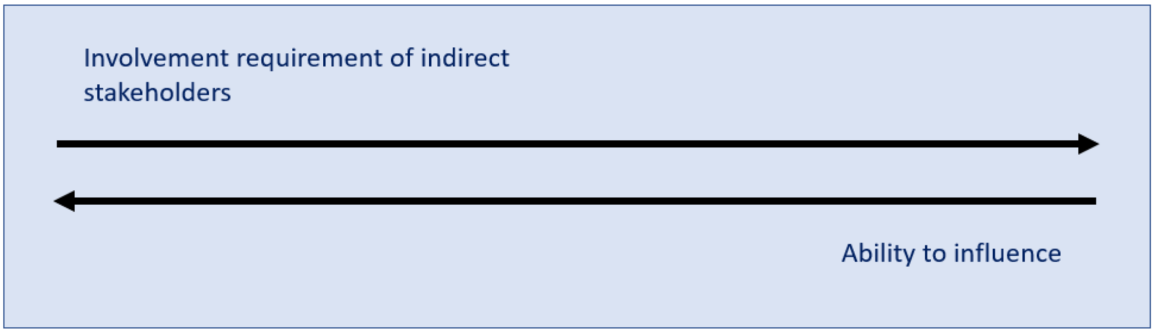

Figure 4 *Relationship between stakeholders and ability to influence (courtesy [2]).*

As mentioned before, uncertainty classification based on predictability is considered here.

Variability or statistical uncertainty has multiple small influences affecting it, so controlling and monitoring them individually is not an easy task. A range of values for any activity is generated. The nature and objectives of the activities, their sequence of occurring, everything is made clear, but the cost and timing varies from the predefined data. It is hard to control these small influences separately but the variations resulting from these influences can be controlled.

Influences which can be identified and understood completely are called predictable uncertainties. The problem with these influences is a lack of knowledge about their occurrence. These influences can be controlled and monitored by devising several alternative plans. These plans or scenarios helps in understanding the system or the forces at work and their behaviour in future without the information about their possibility and timeline of occurrence.

The influences which cannot be preidentified are called unpredictable uncertainties. It is impossible to develop plans or scenarios for them because the mechanisms and functions of a system are not known. However, these can still be categorized into reducible and irreducible unfamiliarity. Reducible unfamiliarity can be reduced by conducting deep surveys, but irreducible unfamiliarity has no solution.

A situation of chaos cannot be influenced because the planning team have no clue about the hidden facts or things which are not even known [2].

2.3.3 MANAGEMENT BASED APPROCAH FOR TACKLING UNCERTAINTY

In innovation, the certainty level in an organization is not high. The environment is complex and the whole process is vague for any project team to comprehend. Managing techniques are therefore, established to incorporate certainty in the organization [9]. This approach deals with uncertainty through management. Encounter and implication of foreseen or unforeseen uncertainty is done through planning of projects, establishing managerial systems, defining a manager’s role and a system to manage tasks in the face of uncertainty planning [8].

These managing techniques are run by different managerial systems which use diverse techniques to manage a variety of uncertainties if encountered. These systems are a vital part of any organization. They either guide actions formally or informally; actually, motivating and enforcing the employees to act right. It is strongly evident from past researches that when organizations expect their employees to solve issues only when problems show up and to have no prior knowledge of problems ahead, they are putting too much pressure and being unfair to their teams. The project teams can only deal with uncertainty successfully, if they have a strong foundation of procedures, routines and a success criterion [9].

When organizations decide to approach uncertainties through management systems, they tend to build an infrastructure consisting of following managerial subsystems:

A) Planning Systems

Planning systems identify tasks and targets along with expected complications and risks. Responsibilities and work structure are defined by this system. This system lays a general overall plan which defines the steps for getting the desired result and, also prevents project getting in conflict if there are more than one project running. This system also determines the type and number of projects to be run.

These systems fail in the face of unknown unknowns. Even than a rough plan can be devised comprising of major steps to be achieved.

B) Monitoring Systems

These systems keep a check on the timeline of activities, whether an activity is accomplished by the set date or the ongoing activities are functioning at the desired progress rate. Monitoring of progress also includes a basic homework for the tools involved and the time they require to execute a certain activity. These also include changing parameters of the tools and knowledge gaps. If parallel projects are running, they keep a check on contributions of all subprojects.

In the face of unforeseeable uncertainty, these systems face catastrophic deviations in the tools performing activities due to accumulation of problems.

C) Coordination Systems

Coordination systems defines the rules for design and timelines that makes sure that all subprojects have certain limits and they are being executed in coordination. A fair process is kept in check from the beginning for subprojects running parallelly. Rules of the game is set for all teams and it is constantly reminded to the teams that the ultimate goal is to achieve the outcome of the bigger goal. And when one subproject is finalized, it is the coordination team's duty to ensure that it brings no negative impact on the other project teams.

Coordination gets redefined throughout the project course.

D) Information Systems

Information systems communicates with the involved parties and keep them updated about the activities and results, changing parameters and deviations in tools. Regular project reviews are also this system's responsibility. Progress of the main project and that of subprojects is also communicated. It is necessary that all the team members have information about the project and not only the subproject they are working on.

These systems work more frequently because the complexity of project demands so. Also, they communicate through multiple information channels; formal and informal both.

E) Evaluation and Incentive Systems

These systems execute evaluation of performance and theses evaluations influences incentives; potential promotions, bonuses or getting laid off. These evaluations are done after considering a correspondence between authority and responsibility. For instance, the design of the job should define measurement of performance.

Strong incentives should not be put in place for people performing risky and uncertain tasks. Because these can cloud the employee's effort and he cannot prioritize between easily measured and difficult-to-measure tasks. Project performance than, should be based on the output, efforts of the employees or the quality of the process [9].

The above discussed approaches work well in the process of innovation. Their fruitfulness is discussed later in chapter 4.

3 INNOVATION OF ENERGY TRANSITION AND THE UNCERTAINTIES INVOLVED.

For analysing and investigating uncertainties in the process of innovation, energy transition is made into the case study. The uncertainties encountered and their treatment are thoroughly examined through various examples and a better solution is proposed according to the three approaches discussed in the previous section.

Paris climate agreement in December 2015 established a goal towards zero carbon emission before 22nd century. The major uncertainty involved in this process is the inclusion of all countries across the globe. The different routes adapted by countries involved, also the magnitude and speed of energy transition is still uncertain [14].

Policies adopted for transitioning national energy systems to fulfil the criteria of decarbonisation is filled with numerous uncertainties. The complex nature of the process itself, the time span it requires, consequences of decision taken, and different approaches used to tackle the risks and uncertainties are some major challenges of this global issue [15].

Energy transition is considered as a long-term risk because its impacts will not be observed for many decades. But it is important to note that however, the transition is a long process but the effects it will have on energy market will be observed in short timescale [16]. Energy market across the globe is facing many challenges. One of the major challenges is that the existing energy systems are not effective for sustainable energy development and needs reformation. The governance of sustainable energy transitions is dealing with many uncertainties in the face of technology, economy, society and politics [17]. The uncertainties accompanying energy transition have already started impacting the decision-making preferences of investors [16].

3.1 SUSTAINABILITY

Sustainability encompasses the study of living in harmony with the nature around us. How different systems function and products while keeping in balance with the environment and keeping it away from damage. Sustainable development is the drive behind energy transition. Human needs are outgrowing technologically and economically but it is extremely important to keep them in check in order to protect our society and environment [19].

Late in the 20th century, greenhouse effect and ozone layer destruction problems made it evident that most non-renewable resources were not infinite. A switch to renewables was proposed. This gave birth to the movement behind Paris agreement.

Sustainability in our future is still unpredictable, but improvements have been made in older fuel sources. New and cleaner technology is being developed to meet our energy demands and encourage good environment practices [19].

3.2 UNCERTAINTIES IN ENERGY TRANSITION

The energy transition is a global matter and energy policymakers face considerable challenges regarding an array of uncertain conditions. Uncertainties are deeply rooted in the energy policies of decarbonisation because of the large scale of this transition, multiple stake holders involved and a long timescale for actions and their consequences [14]. Some of the critical uncertainties are finances, cost of technology, changes in behaviour, infrastructure changes and economic growth. These uncertainties are essential because the investments are enormous, and all the related decisions have long term consequences [15].

Climate policy and energy transition are inseminated with complex problems and deep uncertainties overlap in these processes. *Li et., al* categorized the condition of deep uncertainty into three factors depending on the disagreement between the entities involved in:

i. Models describing relationships between driving forces
ii. How much different outcomes are valuables or desirable?
iii. How uncertainty is distributed probably across different variables and constraints.

These deep uncertainties in multifaceted systems have potent immobilizing effects on the decision-making authorities because prediction is impossible, and stakeholders do not welcome assumptions. Nevertheless, the decarbonisation of the energy systems cannot afford the paralysis of policymakers [14].

Transition is a process involving many actors, each playing their own part in the process. However, the more the actors, the more uncertain the process can be because they do not have knowledge about the effect of their involved decisions. Classification of uncertainties involved depending on different sources [18] are discussed in chapter 2.

3.3 FAILURES IN ENERGY TRANSITION

The goal of the Paris agreement is full of uncertainties. It was signed in 2015, and since then, numerous initiatives have taken place towards the fulfilment of energy transition. Nevertheless, many of these initiatives have been impacted by such uncertainties that have destructive effects and these projects have failed in their course or have not been proven fruitful.

In the following section, the overall performance and operations of some of these start-ups are addressed. The uncertainties encountered, how they were tackled and challenges that limited their effectiveness are discussed to deduce what is not being done rightly and how it can be improved. These improvements are discussed in section 4.

3.3.1 Setbacks in Market of European Energy Transition

EU has expanded and increased its environmental policies integrating both energy and climate policies and has become a global leader in the energy transition. These new policies for decarbonization have, several aspects. Competitive and secure energy markets are one of those main aspects and their integration and friendly bonding with both, the society and the government will lead to progression. However, decarbonization is a long process encompassing many decades and it is very complex. Despite EU's appreciable motives, their proceedings are filled with shortcomings and uncertainties. While the ambitions are high, actions to fulfil the ambition of a secure energy market are inconsistent and full of challenges [21].

— Energy transition is a process that must be incorporated into daily life of consumers. Integrating it at a local level is a very critical factor. Europe has set big targets for achieving energy transition at a municipal level, and municipalities across Europe are also very ambitious in setting and achieving those targets. Still there is an evident lack of supportive infrastructure and policies driven by marketisation laws at both local, national and European levels.

- EU policies have been very enthusiastic for integrating public and locals, but these policies also strongly commit to market solutions in the face of socio-economic problems. As a result, much focus is given to individuals who want to participate in energy markets with their interests. Less interest is given to find collective solutions for enhancing the transition locally. Hence, this approach has clearly not been fruitful [21].
- Apart from that, there is an underlying issue of paying less attention to public ownership. More prominent investors are not ready to plunge their money in expensive low carbon initiatives and they rather choose profitable investments. Germany and Denmark have set examples by combining local ownerships with greater state support for shifting towards decarbonization. And the support has been enforced through non-market-based strategies [22].
- Another market failure that is not given much importance is the lack of price incentives for long-term investment in electricity generation capacity. More and more renewables are being acknowledged and the wholesale market is on a volatile edge. But it is quite evident that in the future significant investments will be required to expand low-carbon (electricity) resources [21].
- The main hurdle in Europe's energy targets is the mismatched speed of the member states. The pace with which each member is progressing varies despite the declarations of achieving a common ambition by a set time. The concern lies in the political commitment and will of each state. Taking an example of the UK and Germany; the two largest states in Europe, UK is ahead in transitioning towards renewable energy whereas Germany lags in its implementation despite its commitment [23].

3.3.2 Resistance from Traditional Oil Export Countries

Major oil exporting countries hold a vulnerable position in the whole process of decarbonization. Loss of government revenues accompanied by shaping their extensive oil and gas reserves are enormous challenges [25]. Countries like Algeria, Iraq, and Nigeria are the first ones to face political instability during the energy transition. Chad, Angola, Azerbaijan are next in a suit because such countries have failed to go beyond the horizon of hydrocarbon export. Moreover, their already weaker political institutions will not stand much chance when the transition will work in full force and they will not be able to face the social displeasure [26]. The political instability of these countries may lead to damaging consequences in the future with shrinkage of hydrocarbon revenues and failure to recover outdated non-oil sectors [24].

Getting these countries on board for energy transition has not been impactful so far. Internal factors of economy, politics, legal and social aspects and corruption have hindered their energy reforms [26]. These countries are at high risk of falling behind from rest of the world in energy transition progression because of governance challenges, higher political instability and lack of diversity [24].

Middle east is in a much better position but despite their energy visions of depending less on oil exports, their reliability ratio, has increased in the past few years. Lack of investment in new projects is one main reason [26]. Their failure to diversify has also put them on a back paddle. This diversification is possible only with infrastructure, legal and economic institutions so a major capital in investing for innovation is required [24].

Norway holds the most favourable position because the national oil producing company, Equinor has been working relentlessly to achieve its zero-carbon emission vision. As a result, their reliance on oil has been reduced [26].

Resolving their internal conflicts and becoming successful in diversifying should be the main focus of these oil exporter countries. There are multiple scenarios that can be faced as a result. For example, these oil exporters may indulge in rigorous monetizing of their reserves resulting in lower oil prices and higher prices of other renewables and can slow down the transition process. Contrary, if they are not successful in shifting their economic reliability from hydrocarbon, oil price may increase abruptly. Consequently, the energy transition process may get faster to achieve less dependence on oil. Such uncertain scenarios make this issue far more complex than it sounds [25].

3.3.3 Socially Rejected Energy Strategies

Social aspects are equally as critical as techno-economic aspects in the complex process of energy transitions. Unfortunately, they are given very little importance leading to the risk of social uncertainty. Due to the ignorance of local inclusion, the placement of wind and solar farms has faced much resistance [27].

For deep decarbonization, existing regulations, investment strategies, the behaviour of users, and prevailing business entities all required a change for a better socio-economic transition. Still these issues are overlooked, and more preference is given to techno-economic issues. Hence there is much complexity in the acceptance of renewable energy schemes by society at large. Furthermore, this lack of acceptance has resulted in, cost related consequences and non-economic barriers [28].

Social and behavioural energy aspects should be dealt with separately from technical research, but they are primarily introduced later, resulting in acceptance challenges from society. These challenges mainly lie in social and behavioural values and attitudes towards policies & strategies, systems & structures of organizations, and services provided through existing energy systems [29].

Wind power and power transmission are the top-most substitutes of the non-renewable source of energy in the wake of decarbonization. The wind power projects however, have met much disapproval from the locals wherever such a project has been proposed. Although each case has its specific reason, certain common factors dominate these rejections. Environmental impacts and visual impact, noise pollution and effects on birds and wildlife have been concern for the society [28].

As discussed in the previous section, the lack of local ownership affects energy transition negatively. Similarly, planning of wind energy projects face hurdles. Benefits and burdens get unequally distributed because of ownership problems. It is emphasized that local communities should be engaged early in the process, rather than a formal inclusion in the final phases. Also, there is intense competition for space between wind power projects and other societal sectors such as transport, farming, defence and tourism.

The construction of high voltage grids is also opposed locally. Locals do not want transmission lines passing through their vicinity as they pose a risk. A counter solution of spreading these lines on the seabed is proposed which faced less criticism, but the fishing industry is reluctant to accept this proposal. These lines emit electromagnetic fields, which are a health concern. All these non- economic aka societal concerns have greatly affected the wind power projects and future is uncertain for the complete success of this renewable energy resource [28].

3.3.4 Market Failure of UK's Smart Meter Adoption

Governments and innovators are investing in different initiatives for facilitating a sustainable energy transition. Societies are encouraged to adapt smart technologies and upgrade their contribution towards climate change. However, this has not been successful in many fronts. One such example is one of UK's massive and expensive innovation of smart meters. It failed to achieve its ambitious goals because of rejection from society.

The smart meter is an internet-based two-way device of communication which measure location-specific energy consumption in real time. It allows the users to save both energy and money, having positive impacts on energy transition. While its benefits have been quite clear for the producers, they had been a bit vague for the customers leading to less societal acceptance. Although the smart meter provides a clear picture of energy usage, there was no estimation of how much the user will connect to the smart meter. Moreover, consumers show a tendency towards paying fixed bills for the sake of simplicity, a variation in bills according to the usage may disrupt their planned budgets. Also, users have their routines and they often struggle to adopt to a shift, in this case, towards usage upon energy demand [30].

Installation of smart meters faced hindrance from the consumers. It was projected that 48 million smart meters would be installed by 2020 but only 16.3 million meters were installed by the end of 2019. Many factors were listed for this behaviour, for example, hidden and financial costs, privacy, consumer vulnerability, distrust in their utility of energy and data security. Privacy and data security were major factors because tenants refused the installation in rented premises. Adding to these issues, smart meter installation provided no clarity of the purpose and benefits it intends to provide to the users. Most benefits were future-based I, e., individuals increasing their own smart energy-friendly choices, investing in money-saving technologies and provision of reduced costs [30].

UK government had big ambitions towards this step taken for the energy transition. Huge investments were made, and integration of high levels was estimated. However, the behaviour of society and a communication gap between government and community dominated the difficulty in implementation efforts.

3.3.5 Obstacles in Germany's 'Energiewende'

Germany's energy transition project, Energiewende, aims to make a conversion from non-renewables to renewables [33]. The success of Energiewende so far is questionable. The goal was to make Germany independent of non-renewable resources but not much progress has been achieved towards it [32].

It was projected that a society with low-carbon emissions would have cheaper electricity bills, but the bills have almost doubled in the past two decades [33]. Carbon dioxide emissions have increased instead of going down because of the rise in coal usage. There are multiple reasons stated for this rise: nuclear reactors shutting down in 2011 [31], insufficient advancements in heating/cooling or transport industries [32] and inefficiency for effectively launching wind and solar energy [33]. The government blames this rise of CO_2 emission on transportation demands and harsh winters instead of the government's return to coal [31].

Wind and solar energies work well on good, sunny days. Although, there is no substitute during wet or dry weather and darkness, since wind and solar energy storage is still in the initial stages, and there are no such energy storage capacities [33]. Germany's latest and most efficient power plant, Goldisthal, has a storage capacity of 8GWh, whereas the average electricity requirement in Germany is 1650 GWh; 200 times more than the storage capacity. A 100% replacement of wind energy generation should always be available in case of no wind. The unavailability of wind is the biggest drawback in relying solely on this renewable source [32].

Also, the distances between offshore wind energy generators and the consumer entities are enormous [33]. The power is generated in the north and the industry is in the south whereas the existing power grid is built on the east-west axis [31].] The establishment of an intelligible power grid is necessary for combining the power generated by random individual generators [32].

Expansion for renewable energies consumes land and results in a disaster for biodiversity. Habitats are destructed, deforestation is happening, and direct killing of birds are some of the most threatening consequences. According to an estimate, 250,000 bats are killed every year in Germany because of wind turbines. Offshore wind turbines hold a better position as they kill sea animals which get deposited on sea-beds. Biomass power plants have drastic effects on plants and insects. Germany faces legal conflicts for contradicting European law [32].

Noise pollution, and an inaudible element of wind turbine sound energy poses a great risk to living beings. Infrasound is a vibration that can be felt and increase brain waves & stress hormone cortisol, dizziness, anxiety, sleep and concentration disorders. Prolong exposure to noise results in hearing damage. The inhabitants near wind turbines are also disturbed by moving shadows and flashing lights at night. The rotors of wind turbines are also subjected to throwing ice several hundred meters away in cold weather conditions. Furthermore, the carbon fibre-reinforced plastics used in wind turbines are impossible to extinguish once they catch fire. They must be burned down in a controlled manner. Their ashes contain carcinogens, harmful to human respiratory systems if inhaled continuously. Catastrophic failures will always be a liability regarding wind turbines and their blades [33].

Energiewende has been facing major setbacks in the face of the economy as well. The state must pay billions of euros to companies generating nuclear power after they were forced to shut down [31]. The electricity produced through wind and solar energy is costly. It increases with instalment of each wind, solar and biomass plants. The producers of these plants are guaranteed with a price for the next 20 years. This price is very high as compare to the market value. For compensation, the consumer is paying the difference which is making electricity prices very high. The decrease in non-renewable power houses and slow development of green energy projects, causes significant unemployment [32].

Germany is currently operating on both energy systems running in parallel. Trying to advance further in using renewable sources, it is heavily dependent on non-renewables for bridging the gap between supply and demand [33]. However, it is almost impossible to rely solely on wind and solar energy with lowering the supply of fossil fuels and diminishing nuclear power plants [34].

3.3.6 Financial Losses at Danish Wind Farm Operator 'Orsted'

In offshore wind farms, projects are facing setbacks in terms of finances as repairing of wind turbines is required which is costly and there is loss of production due to downtime [36]. The establishment of power plants amidst oceans has always been full of reservations. A network of turbines is connected to shore and power grid through cables [37]. This whole setup from turbines to cables and to storage facility, is full of uncertainties and subjected to failures.

Danish wind farm giant, Orsted A/S is the world's largest offshore wind farms developers [37]. In their Interim Financial Report of 2021, it is revealed that almost 10 of Orsted's European and UK wind farms are facing damage in their cables connecting turbines to onshore facilities [35]. These 10 projects were built on the same design, so remediation is required for all of them. A rough estimation of 3 billion Danish kroner is required for all repairment [37], and it will take place over a period from 2021 to 2023 [35].

Wind turbines are mostly surrounded by larger rocks in order to prevent seabed erosion plus the weakening of foundations of turbines [35]. There are systems in place for the protection of cables, but they have been scraping against those rocks causing the failure in cables [37]. It is predicted that may be all cables will fail but Orsted is taking proactive measures with a two-stage approach for limiting production downtime [39]. One of Orsted's wind farms in the UK is going through a complete renovation of its 324 blades on 108 turbines because it suffers from leading edge erosion [36].

This drawback in 10 installations has a massive impact on suppliers, partners and insurers and it is being evaluated [39]. It is highly likely that the problems faced by Orsted are also present among other offshore wind farms [35].

4 APPROACHES FOR TACKLING UNCERTAINTIES IN ENERGY TRANSITION (Discussion)

The energy transition is a vast issue encompassing all aspects of life. As it is a progression covering multiple fields, it is full of a variety of complex and intricate problems. Energy switch is also taking place for the first time in the history of humankind, so uncertainty is deeply rooted in every project initiated and every step taken towards achieving the goal. To solve these problems, different methods have been used, out of which some have been fruitful, and some have failed to deal with uncertainties. In this session, effectiveness of approaches discussed in section 2 are argued with focus towards energy transition examples.

4.1 IMPORTANCE OF CLASSIFYING UNCERTAINTIES

Section 2 discuss in detail the way uncertainties are classified. Classification is critical as it gives insight into the factors involved. Also, classification directs toward a meaningful approach when the uncertainty occurs because a specific group of experts has prior knowledge of uncertainties of their domain and the response can be well-structured.

In a broader spectrum of classification, one gives less attention to external uncertainties because there is no control and no data on those. Preparing for the unknown is close to impossible. More focus is provided to internal uncertainties and measures are taken to reduce them once encountered.

However, in this research, all uncertainties related to energy transition based on sources are considered internal because it is a worldwide issue. Anything related to market, authority, politics, technology or society comes from within the world and the human race. Internal uncertainties are classified in a wide range. The more classified the division of uncertainties into different types is, the more it is easy to identify and tackle the problem from within. When innovation is happening globally, external uncertainties can be regarded as a meteoritic impact, a viral outbreak, a tsunami or a volcanic eruption. In the present case of the energy transition, this external uncertainty is a pandemic.

4.2 PROFITABILITY OF KNOWLEDGE-BASED APPROACH

Organizations adopting knowledge-based views are more proficient in learning and knowledge-processing capabilities. They tend to endure effective performance. With enhanced knowledge about the potential problems, they have a significant advantage over their competitors. In the process of innovation, the knowledge-based approach bear fruits in relative stability. A good database of knowledge about the uncertainties and complexities ahead, makes a stronger ground for the entities involved and compels them to ask the right questions. This also develop confidence for communicating new approaches, reforms and experimentation. Therefore, learning ability and communication level, both get strong and interpreting & sharing of results become easier.

This approach encourages in widening the horizon of information database and tackling problems like complexity and uncertainty through knowledge. If enough information is acquired about the process, customers, competitors and products, a firm can effectively manage difficulties of uncertain times. Too much knowledge has never been an issue and if it is considered so, it can be tackled through well management [4].

In the process of energy transition, this approach can work well in uncertainties related to technology and society. Processes, products and systems related to technology can be made better by acquiring more knowledge and eliminating mistakes. Behaviour of society, its mindset and its reaction to new products and new strategies should be studied in detail and the society should be tackled through productive means.

4.3 EFFECTIVENESS OF INFLUENCE-BASED APPROACH

In different processes of innovation, some factors are always influential. If this characteristic of those factors is used in an informed manner, it can change the course of uncertainty handling. Sources of uncertainties play an important role in this approach as well and directly contribute towards the degree of influence.

In the process of energy transition, influence is generally present within authority figures, corporate strategies and leadership. Government's can influence the market and market, in return can influence the general public. Therefore, societal and market uncertainties can be reduced. Major organizations, oil companies and oil exporter countries can also have impact on each other. However, this approach has not been used efficiently so far.

4.4 EFFECTIVENESS OF MANAGEMENT-BASED APPROACH

Chaos in a company or disorderly situation in employees, leadership or organisational structure can never result in productivity. A better management can reduce the unwanted situations by a considerable amount. Uncertainties can be managed even before they occur. This can be done by forming a very organized management system and a division within this system. Each division responsible for different tasks. Once a company decides to delve into an innovative process, it is fruitful to gain enough knowledge about the process and uncertainties. Then a system can be placed which devise procedures which can keep uncertain situations from happening. These procedures should be checked on regularly. This management-based approach also encourages effective communication between different departments or entities involved in the whole process.

An effective management can help in uncertainties encountered in the process of energy transition. This management is required at a global level as well as this is a global, long term issue. The management system can keep a check on the progress made towards net zero carbon emission goal. Also, issues within countries and companies can be tackled through devoting a management system only towards this aim.

4.5 COMPLICATIONS WITH PROBABILISTIC APPROACH

The energy transition is a complex process with large uncertainties and a probabilistic approach for tackling uncertainties is critiqued for its narrow sightedness. It is very difficult to quantify a connection between agents and effects [39]. *Nassim Taleb* considers probabilistic models obsolete and encourages decision making in unpredictable situations. His principle of *antifragility* argues that it is very convenient to embrace the fragility and uncertainty of a situation and works towards robustness and resilience of the system rather than making assumptions or predictions about the occurrence of a harmful event [39]. The resources should be invested in research and development of making the system antifragile and be better prepared for uncertain events.

Strachan et. al., also enlisted three problems with adopting a deterministic approach while dealing with uncertain conditions in a multidimensional and complex area of study

i. Impossibility of quantifying probabilities for any input
ii. No knowledge about the cost of uncertainty
iii. Difficulty in determining policy insights because of dissimilar scenarios [15].

These situations are constantly changing and predicting an estimation for policies to be adapted and cause-effect relationship of uncertainties is almost impossible. Measuring probabilities for complex situations is considered useless by many experts. The potential of probability prediction of uncertain events occurring is already questionable. There is not much background knowledge about energy innovation and the correct estimation of probabilities cannot be determined. Entities have minimal knowledge of what they will encounter. Therefore, the probabilistic approach is considered unsuitable for tackling uncertainties in the process of the energy transition.

A few alternatives are enlisted below that can be used instead of probability approach

1. Replace the probability approach with other quantitative approaches
2. Balance probabilistic approach with robust approaches which work well in uncertain and unforeseen situations. Robust approaches are designed for flexibility and they work on the principles of antifragility and resilience engineering.
3. Reject the probabilistic approach wholly and altogether depend on robust approaches [39].

These robust approaches and their effectiveness are discussed in this section.

4.6 APPROACH FOR DEALING WITH EXTERNAL UNCERTAINTIES (BLACK SWAN)

Catastrophic events related to COVID-19 can be regarded as a black swan. Nobody was prepared for a pandemic and has thought about the criticality of this external uncertainty. *Aven* termed such uncertainty as the black swan of the unknown unknown type where completely new events occur and are unknown for the existing scientific environment. He specifically enlisted *swine flu* as an example of a disease caused by a virus [39]. An outbreak of a viral infection, like the swine flu of 2009 happened in 2020 but a scale large enough to cover the whole world.

To deal with black swans of unknown unknowns, it is challenging to be prepared. In the case of COVID-19, it changed the economic, financial and managing strategies of many governments worldwide. The outbreak of the virus was sudden, severe and catastrophic. The response of governments and the strategies they adapted immediately as a response, greatly influenced the economies. The decisions taken at that time will affect a great deal in future years [40].

Black swans are usually a surprise for which very minimal or almost no risk, or probability analysis is performed. Upon its occurrence, authorities must make difficult decisions with limited time pressure, so the effectiveness of decisive measures is not guaranteed [39].

For handling COVID-19, the knowledge base was weak, and emergency response was not well designed. A well-resourced approach to such a crisis could have helped minimize the ambiguous nature of this disaster to some extent. Many countries around the world faced major setbacks in their economies. The pandemic also altered the course of energy transitions. COVID-19 has significantly weakened developing countries in Asia and Africa, and they are economically restrained for several coming years and are unable to endorse energy transition. The primary goal for now is to manage a health crisis.

The knowledge-based approach can be effectively used for handling black swans. For example, an outbreak of the virus is not a first-time event, a catastrophic natural disaster like volcanic eruption or an earthquake has happened many times in the past. The knowledge database should be increased through improving risk assessment methods and analysing such past events. The fruitful approaches and the measures which were proven to have gone in vain should all be assessed for any such future events. Experiences and learning should be documented as such knowledge is not possessed by the analysis team responsible in such situations. This will help in breaking down the complexity and ambiguity of the situation [39].

Taleb's principle of antifragility is also fruitful for dealing with black swans. This concept portrays that being positive towards the uncertainties and errors makes us better prepared and protects from harmful effects. However, it is not entirely accurate in real-life situations. This open mindedness needs to be dealt with a strong system of robustness, antifragility and resilience. This system can be achieved by improving the background knowledge, identifying failure scenarios and evaluating measures to deal with those errors. In case of black swans, understanding of risks, mindfulness, and understanding of operations and their consequences are very important [39]. The robustness and resilience require a robust knowledge database.

4.7 SETBACKS IN MARKET OF EUROPEAN ENERGY TRANSITION, FAILURE OF UK's SMART METER ADOPTION and SOCIALLY REJECTED ENERGY STRATEGIES

It is reasonable to combine these three examples of setbacks in energy transition because, more or less, they address similar issues and require similar approaches to deal with them. Society, its behaviour, response, and level of acceptance is the core of these problems. One of the main reasons is that society has been overlooked as a potential stakeholder in this whole process. Governments have failed to develop a sense of responsibility in people for their contribution to bringing energy change. Mainly across the world, authoritative bodies have more significant motives and targeted aims to achieve a transition in energy. However, they have failed to integrate the general public into their mission. People do not have clear ideas of this mission, and they are primarily acting indifferent from the attempts to bring this profound change.

Another reason for the society's detachment or disinterest is the authority's lack of acknowledgement that society is a separate entity and cannot be categorized into technological and market perspectives. Society must be taken as an individual source of uncertainty. This is another reason why the classification of uncertainties is utterly important. Once classified, a whole system can be devised just to deal with it. According to the research conducted, society's acceptance can be regarded as the most considerable uncertainty in the energy transition process. Technological advancement in the laboratories is a convenient job compared to convincing rewiring human brain and shaping it up in one direction.

Estimating probabilities have no scope in dealing with societal or market uncertainties in the energy transition process because the aim of switching from non-renewable to renewable sources is already decided. So, electrification and planting of wind and solar farms are vital. They cannot be disregarded on the probability of society accepting or not accepting the change. The change is bound to happen, and the focus should be on facilitating it and making it comfortable for the people. The probability of unacceptance is there but the authorities can change or influence it and make society more welcoming and appreciative of this transition.

Uncertainties related to society are internal uncertainties. It is easier to influence internal uncertainties and rigorous actions can be taken when the ability to influence is greater. These uncertainties can be tackled through influence and management-based approaches. Governments can be the biggest influencers in this case. They can dedicate a whole system to this perspective by formulating some easily adaptable laws and ensuring consumer protection. Governments need to show support and more interest in their plans for small businesses and new business entries in the market. Steps should be devised for facilitating growth as this could encourage more and more people to think and invest in this particular direction.

For larger businesses, incentive systems should be launched by the governments. They should be given top priority since bigger investors are very reluctant to invest in renewable technologies because of the uncertainties involved. More substantial rewards like more authority in a government funded project or transfer of more power can greatly influence the decision-making of huge investments. Norway sets an excellent example in the electrification of transport system. The road tax and toll system are expensive in Norway, but the government took the initiative and made it minimal for electric cars. Taxes on electric cars were also reduced as compared to non-electric vehicles. This encouraged people throughout the country, and they started buying more and more electric automobiles. More investments in this sector started taking place and now half of the vehicles in the country are electric.

For locals of potential wind or solar farm locations, partial local ownership can be integrated into the system. Since these locations are remote and communities living there do not have modern-day technology, authorities can convince them by working for them. For example, advanced technologies and facilities can be provided or set up in those locations. Steps can be taken to preserve the tourism and wildlife of the area. This may lead to opening up of the conservative local communities when they see the government giving them some authority and working for their benefits.

An efficient management system is also significant for this influencing strategy. Decisions taken behind the authority’s closed doors need strong and effective implementation. So, devising a management approach to deal tactfully with society can also help in reducing these uncertainties. Starting from the planning phase, the consumer’s needs and concerns should be identified, and then a relationship can be established between authority, consumer and the product. This relationship can be enhanced and maintained through proper communication. Consumers just always are satisfied through constant evaluation and improvement of the system involved. These steps in managerial system set by the governments may also result in productivity and lowering uncertainties.

Governments can also lead by examples. For example, in the case of smart meters, the unappreciative response of the people could have been managed through devising a system responsible only for integration. Smart meters could have been turned into an influential product. UK government must have developed influential strategies and public figures like prominent politicians, celebrities and mayors of municipalities could have set up smart meters in their own homes and then share their experience to the public. This might have resulted in confidence building of the society in government's initiative.

Influential and management-based approaches for tackling uncertainties can work best in societal issues.

4.8 RESISTANCE FROM TRADITIONAL OIL EXPORT COUNTRIES

The contribution of war-conflict, oil-producing countries with corrupt administration is a critical issue in the course of the energy transition. The goal to attain zero carbon emission needs the efforts and determination of the entire world. However, some major oil exporting countries have massive internal conflicts and working towards greener energy is not one of their main concerns.

This issue of getting all countries aboard the energy transition journey is the most complex one among all other issues because it involves many different factors and numerous authoritative figures. Getting them all on one page requires tons of effort and planning on a mega scale because ultimately each country has to make advancement towards the betterment of the environment. Active participation is the need of the hour and there is no question about the probability of how many will be involved.

This process will take lots of years, may be decades, even if the initiative is taken now. The countries in question needs to get influenced from stronger companions. The issues within these countries can be addressed through external forces, pressure, and help. Once country's internal situation stabilizes, it will be easier to channelize its goals.

This issue can be tackled through a management approach for the countries with stable economy and political situation like middle eastern counties. An organization globally or smaller organizations setup in different regions of the world should be developed for devising regulations, tackling, and monitoring the progress of these countries.

This matter in conflicted countries needs external stimulus from stable entities and an external check and management overall. So, there is no such requirement of an extensive knowledge database because the situations in these countries are straightforward, and better management and foreign influence can put them on track.

4.9 OBSTACLES IN GERMANY's 'ENERGIEWENDE'

Germany's Energiewende has deep-rooted technological complexities which lead to economical, societal, and management uncertainties. All the relevant important actors, companies, and organizations are dealing with substantial challenges.

With complexity at such a high level, the German government needs to break down these issues into smaller domains and tackle them individually. An extraordinarily vast and robust technological knowledge database is the dire need for accomplishing this project. Tackling noise pollution, saving biodiversity, minimizing the adverse effects of wind turbine installation on locals and building colossal energy storage capacities are some of the main technological uncertainties that need utmost attention. These problems are different from each other and strong knowledge is required in each one of them. With enough knowledge, it is possible to be reduce uncertain conditions that halt the processes and be better prepared for developing wind turbines friendly to biodiversity around them.

Once the technological issues are being dealt with separately, the next focus should be on efficient decision-making skills. Decisions should be taken by keeping the long-termism and complexity of this process. Germany's decision to shut down all its nuclear power plants was, although more politically influenced rather than for the sake of producing more green energy, its aftereffects have been adverse, nonetheless. Firstly, the complete switch to renewables still has not taken place. The development of renewable energy source plants is much more straining for the government with its multiple liabilities. Secondly, it has put an extreme negative consequence on the economy. The government now must pay compensation money to the nuclear power plants owners. The money that could have been used in refining the energy transition processes is instead being drained into the compensation of wrong decisions.

Effective management is also required which will only deal with the advancement of the energy transition process. The management approach for dealing with uncertainty must be used for managing problems. A start should be taken through better planning. For example, wind turbines in north and industry in south is a major managerial issue. This could have been avoided by planning well beforehand. The managerial system's monitoring and coordination sectors can play their part in building balance between supply, demand and finances. The problem of high electricity bills as an effect of fixed prices for the investors can be managed through better monitoring. Information systems can fill the communication gap between government, investors and industry and can provide each party with a better explanation of what other's intentions are. Evaluation and incentive systems can work very effectively for encouraging industries to aim for the same goal as the government. As the government claims that the rise in carbon emission is because of transportation industry, a system can be devised which motivates the said industry with reasonable incentives and promotions.

It can be observed clearly that influence based strategy has failed to work here. Although government's motivation and aim are productive and towards everyone's betterment, but it has failed to influence the masses. Society has not been welcoming towards this change, industries are struggling on their own and they have retreated from investing more into government-led initiatives. In fact, the government's try of imposing laws and trying to influence has backfired.

4.10 FINANCIAL LOSSES AT DANISH WIND FARM OPERATER 'ORSTED'

Financial losses at Orsted are a technical uncertainty. Everything was going smoothly until the failure in wind turbine blades took place, and it was evaluated that the same can be expected from 10 more installations. Mostly, for technical uncertainties, improvement of knowledge, stronger understanding of technical aspects and an enhanced evaluation of how to implement the technology result in fruitfulness. This can be achieved by thorough discussions between experts, widening the database area and attempting to cover all existing theories, techniques and methodologies of that particular technicality.

Insufficient knowledge about installing offshore wind turbines, the whole plant consisting of cables and towers and the relation between these and the seabed has caused this failure. The material used in the whole structure and subsea lithology should be studied in more detail for installing the wind energy plant. Many microfeatures should be taken as important as the major ones. Enhanced understanding might help in eliminating some of the problems.

An offshore installation consists of multiple stakeholders like investors, producers, suppliers etc. When such a failure occurs, each party needs to be satisfied or compensated, which can be done through a resourceful management system which can evaluate, monitor and communicate between all the related entities and try avoiding a chaotic situation. It is productive to consider technical uncertainties through increasing knowledge and eliminating ambiguity and complexity through an effective management system.

5. CONCLUSIONS

From the extensive literature review, it is clear that the uncertainties can be classified in various ways, and there are multiple approaches to tackle them. This research talks about uncertainties in innovation, how they are classified and the efficient ways to tackle them. Classifying uncertainties based on their sources is considered fruitful in innovation. This type of classification makes it easier to identify the uncertainty into a particular category and then deal with a relevant, appropriate method. Out of numerous approaches, three important and comprehensive tactics are discussed: knowledge-based, influence-based and management-based strategies.

Energy transition is taken as a case study as it is an innovation process full of uncertainties. Many failures have occurred in this process due to uncertainties. These uncertainties in energy transition are classified on the basis of their sources. A few failures are discussed along with the type of uncertainties that caused them. An argument is provided for using the three discussed approaches for each failure, if all of them can be used to tackle any particular type of uncertainty or if only one could be proven more beneficial and other are regarded useless.

It is concluded that there is no one way that can be used to tackle with these uncertainties. These approaches represent multiple pathways towards a single destination I.e, the solution. No method is wrong but which way should be adopted depends on the type of uncertainty, the environment and circumstances in which it occurs. In our case study, we developed a conclusion that

- The probabilistic approach does not work well in the innovation process. More resilient and robust approaches are required because types of uncertainties in novel projects mostly come as a surprise, so a probability estimation is difficult to conduct.
- For black swans, an enhanced knowledge database can help in some ways. Also, incorporation of *Taleb's* idea of antifragility can help in being prepared for unknown unknowns.
- Technological uncertainties can always be dealt with knowledge-based approach.
- Technical uncertainties need a better management and extensive knowledge database.
- Societal uncertainties can be tackled cleverly with a passive influence-based approach and effective management.
- Regulatory or institutional uncertainties with involvement at mega scale can be tackled best with influence from companions of same or even bigger magnitude.
- Market uncertainties also need efficient management.

Generalizing one or two methods for dealing with uncertainties has never been fruitful and experts of one view must resort to other views in some cases. So, open mindedness, acceptance of different strategies, better understanding of the process and potential uncertain conditions, management of all the stakeholders involved are essential. The knowledge of multiple approaches to tackle uncertainties can prove productive at uncertain times because then one does not have to investigate into the dark if any method fails. An alternative is always ready to be used.

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