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CONSUMER BEHAVIOR AND STRATEGIC FINANCE IN GREEN ENERGY

Arpit LUDHIYANI, Satyadhar JOSHI, Rohit PATHAK

IEEE Member, Indore, MP, India
Business India Institute of Finance, New Delhi, India
E-mail: arpit.ludhiyani@gmail.com, satyadhar_joshi@yahoo.com, rohitpathak@ieee.org

Abstract. In this work we have executed a comprehensive review of green energy consumers to predict the market behavior and discussed some inputs for financial modeling. We have proposed a model based on different input parameters and linked them to form a structure that can be used for financial analysis to forecast future prospectus of green energy. Impact of various scenarios are considered and discussed in detail, and their effects on the market of alternative energy are explained. Demand, sales, decision making, simulations, extreme events are discussed and modeling options are explored. Importance of forming parity, random movements, and equilibriums are scrutinized so that they can be modified for making financial engineering models for green energy.

JEL classification: C600, C680, C790, C890.
Keywords: Green Energy, Finance, Alternative sources of energy, Strategy.
Reikšminiai žodžiai: žalioji energija, alternatyvūs energijos šaltiniai, finansai, strategija.

1. Introduction

Sustainable energy or green energy is the future of energy resources for mankind. As the non-renewable sources of energies such as coal, crude oil, natural gas etc. are depleting at a tremendous pace there remains no other option but to switch to green energy sources for the need of the mankind. Green energy source is the general term for the energy sources which are less pollutant than the non-renewable energy sources. These are the sources of energy which will not deplete unlike the non-renewable sources of energy which are predicted to deplete around the 2050 A.D. timeframe.

Though the current situation demands that we use green energy sources for our present and future needs, there are many constraints associated with green energy sources which make this option difficult to utilize. Some of the constraints associated with the use of green energy sources are as follows:

- ✓ The technology to use the green energy sources cheaply as well as efficiently is still to come.
- ✓ There is a lot of initial investment associated with green energy sources.
- ✓ The uneven distribution of the green energy sources around the world makes them an inappropriate choice to consider.
- ✓ Solar energy can only be effectively tapped around the equatorial regions and not around the Polar Regions; also there is the constraint of weather, as well as night, which limits the use of solar energy.
- ✓ Wind energy can be tapped only in the coastal regions which is another setback.
- ✓ Tidal energy as well as hydroelectric power has a detrimental effect to the nearby population.

Though there are lots of complications in utilizing green energy sources it can be said with certainty the advantages outnumber the disadvantages. Some of the advantages of utilizing green energy sources are as follows:

- ✓ Though the initial cost associated with green energy sources is high; the cost of operating it is minimal with respect to non-renewable sources of energy.
- ✓ These sources of energy will remain nearly forever and there is no panic of their depletion.
- ✓ Solar energy will remain as long as there is life on earth, so there is abundance of this form of energy that can be utilized for the entire needs of mankind.
- ✓ Wind energy is again a source which can never deplete so it can also be utilized efficiently.
- ✓ On the one hand, non-renewable energy sources are the pollutants responsible for green house gases and subsequently Global Warming effects, renewable sources on the other hand are nearly pollution free.
- ✓ Since it can be easily predicted that with time human demand for energy will only rise, green energy sources are the only alternative left to fulfil this rising demand.

Thus it can be understood easily that green energy sources will become a part of our life in the near future. This will not only help us in conquering the depletion of current energy resources but also help in countering the Global Warming phenomenon which has become a threat to the very existence of life on earth. We have thoroughly seen the advantages as well as disadvantages associated with green energy sources; it is now important to see what are the current and future technologies that will help us utilize these sources for our needs. There can be three generations of technologies associated with renewable energy sources as per International Energy Agency which are as follows:

- ✓ ***First generation technologies***: Hydropower, biomass combustion, geothermal power etc. includes the first generation technologies. These were developed in the late 19th century and some of these technologies are still in use.
- ✓ ***Second generation technologies***: Solar heating and cooling, wind power, solar photovoltaic cells are some of the forms of second generation technolo-

gies. These are the technologies steadily developed from the 1970s with a huge amount of investments as well as R &D into it.

- ✓ ***Third generation technologies***: Biomass gasification, concentrating solar, thermal energy, advancements in nanotechnology are some of the third generation technologies under development. The first and second generation technologies are today present in the market but the third generation technologies are still to be efficiently commercialized. Much will depend on the commercialization of the third generation technologies since they hold the future usage of the green energy sources.

It can be seen from investments in the green energy sources that there is a huge shift of the power base and behaviour from developed economies to developing economies. According to the Bloomberg New Energy Finance [30] in 2010 approximately US $243 billion were invested around the world in sources of energy such as solar energy, wind energy etc. This increase is nearly 30% of the investment in 2009. Thus there is no doubt that this investment is bound to increase exponentially with time to come. China is the market leader in the investment made in green technologies with US $51.1 billion worth of projects in 2010. Brazil stood second in the emerging economies. India is another player to be watched in this space since its investment in green technologies is set to increase drastically in the coming decades. Though India stood 10th in the investment chart in 2010 it is predicted that over the next 10 years the rise in investments will be growing nearly by 369% by current levels and this will place India at the 3rd position in the countries investment chart of green energy.

2. Literature Review

This section will explore consumer behaviour on green energy in various literature. It is important to understand the consumers' behaviour, since only they will decide if green energy sources have a credible future or not.

What are the managerial business ethics perceptions in the Japanese consumer market for daily consumption products? This question is answered by the three-level model of moral agency that distinguishes unintentional moral agency, passive intentional moral agency and active intentional moral agency developed by [1]. This study found out that moral agency of Japanese firms are mostly extended up to unintentional and intentional passive moral agency. Green behaviour of consumers is better analyzed by the model developed by [2] using Kohonen's LVQ technique which is used to predict consumers' purchase intention. This analysis provided better results and motivations for management as follows:

- ✓ To build a strong competitive advantage for the product in terms of quality as well as price.
- ✓ To develop and project a profile of green consumers based on demographics.
- ✓ To meet customer expectations by being seen as socially responsible.

A thorough study was conducted on the potential consumers of eco-labelled wood

products in Sweden and Norway by [3]. The study concluded that the consumers with preferences for eco-labelled wood products generally focused less on the product type than consumers that reported a low preference for eco-labelled wood products. Also green consumers were generally women. Gopalkrishnan R. Iyer [4] takes environmental sustainability as a responsibility of stakeholders—governments, consumers and socio-political institutions. The paper points out the challenges in preserving ecology, making it an ethical responsibility.

Various aspects of deliberative democracy are tested [5] in the light of political consumerism and three cases are listed which avoid ethical and environmental impacts from consumer sphere. The extent to which a consumer rates ethical products and the amount of the consumer's interest in buying them are examined to conclude that consumers are concerned about ethical products but have very short memory to remember the features [6]. The paper also discusses consumers to change their decision and rate the ethical product higher, once additional information is provided.

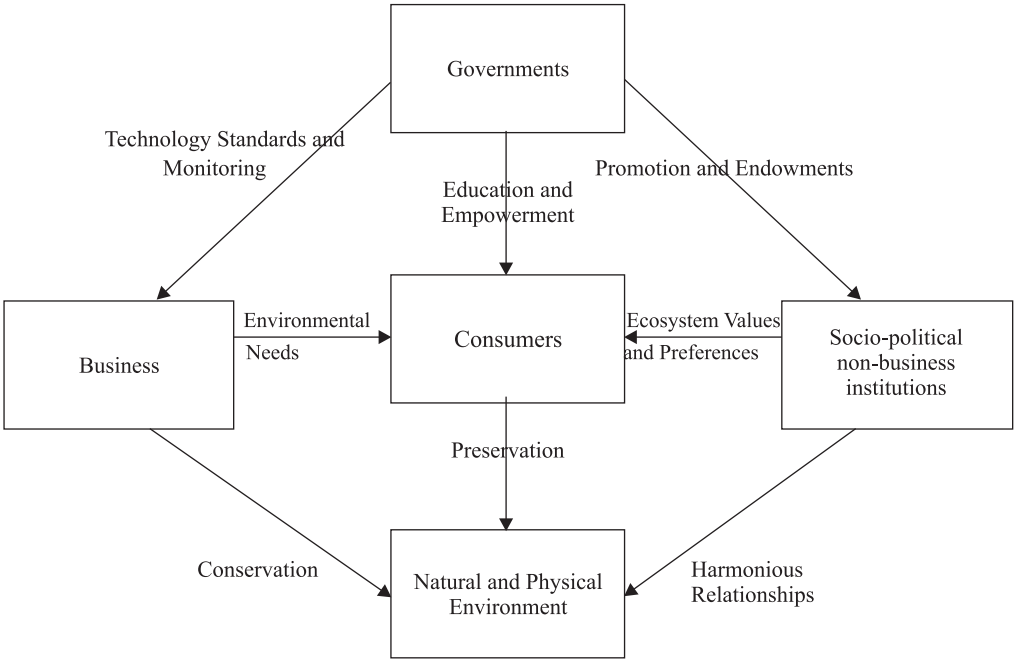

Fig. 1. The balanced vision of multilateral ecocentrism [4]

An investigation is conducted with respect to the driving force behind the environment-oriented management in Slovenia by [7]. This study focuses on the attitude of the managers towards the usage of environment friendly technologies. Also there is a focus on the pressure on the managers to make profit regardless of the usage of green technologies or not. [8] Shows an emergence of cost equipped environmental justice for consumers. The paper deals with cost, taking positive results and negative results as base. In [9] the authors study the model to bring your own bags when visiting a su-

permarket and based on that a hypothesis which derives various aspects in the field of ethics to explain green consumption practices has been presented.

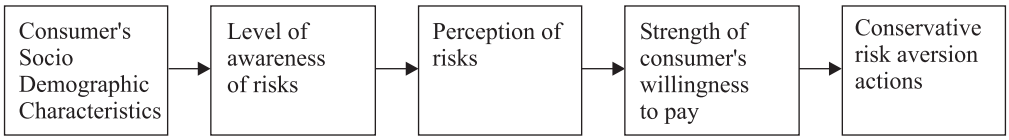

Fig. 2. Process of consumer's willingness to pay for environmental justice associated with green marketing [6]

With the growing concerns over the environmental degradation in the society, a new class of consumers has been generated called the "green consumers." These are those consumers that avoid buying products which are responsible for damaging the environment—from its production to its disposal. A study on this subject has been inevitable; investigation of several variables related with the environmental aspects has been conducted by [10]. This can help to profile this new class of consumers: green consumers. There are certain restrictions on the consumers to change their present lifestyle; these are discussed in [11]. It is so because though consumer policy can empower consumers for changing lifestyles by reducing personal constraints and limitations there are some external constraints that oppose the changes in the present lifestyles to move towards a more sustainable one. This [12] document addresses the issues pertaining to financial institutions and their situation which is resulting as a loss to entities connected with those financial institutions.

Investment in the development of green core competence is very helpful for business enhancement as has been shown by [13]. It raises the green images of the companies as well as strengthens their green innovation performance. Hence a novel construct in green core competence has been proposed. In proposing the model of green core competence there are some hypothesis which have been kept in mind they are as follows:

I. ***Hypothesis 1***—Green core competences of firms are positively associated with their green innovation performance.
   Hypothesis 1a—Green core competences of firms are positively associated with their green product innovation performance.
   Hypothesis 1b—Green core competences of firms are positively associated with their green process innovation performance.

II. ***Hypothesis 2***—Green core competences of firms are positively associated with their green images.

III. ***Hypothesis 3***—Green innovation performance of firms is positively associated with their green images.
   Hypothesis 3a—Green product innovation performance of firms is positively associated with their green images.
   Hypothesis 3b—Green process innovation performance of firms is positively associated with their green images.

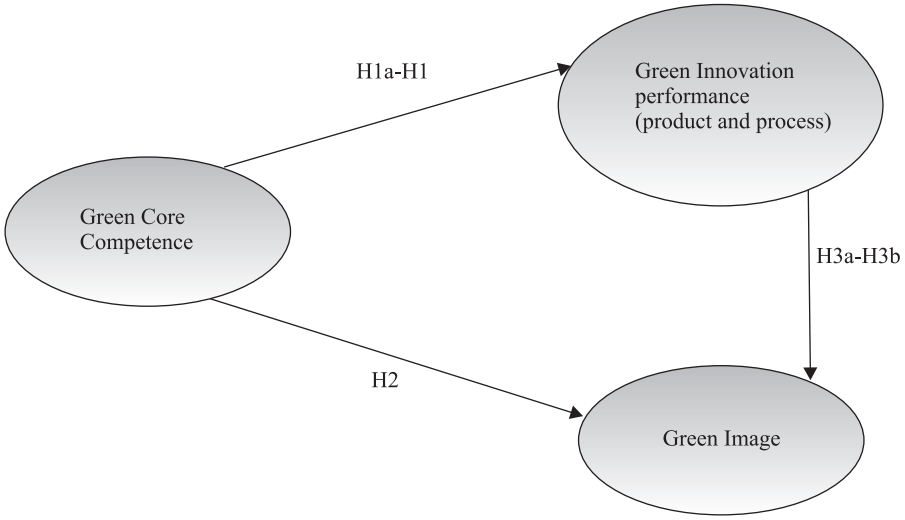

Fig. 3. Research Framework [13]

The research project [14] provides a Green energy plan for Denmark along with focus on employment and foreign exchange in the investments for energy plants. A proper model-based analysis of the introduction of green products has been conducted by [15]. The adaptability of firms with new technology is found to have an important influence on the type of consumers who change their consumption to green products. Though there is strong desirability of green supply yet there is extremely slow rate of implementation of it. These paradoxes have been tried to resolve by [16] with the help of a questionnaire prepared and interviews taken across UK in various firms. The result show that diffusion speeds of green products is a function of various parameters like tax, time in the market, etc. [17] Shows the current inconsistent scenario of green purchasing and examines the effectiveness of green purchasing for an environmental policy tool. In [18] an environmental improvement in life cycle costs of a monitor and an Eco Indicator is shown helping to create an environmental profile of the two and leading to cost savings.

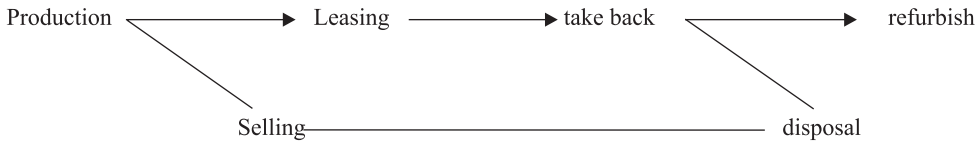

Fig. 4. Chain of action for products, which are sold and leased [15]

With the advent of green technologies and their inevitable usage by a large consumer base; has made green marketing of utmost importance. Systematic research has been completed by [19] for the new ways of developing the strategic management of green marketing. Four aspects have been taken into account—marketing

values and green labels; green product and green prices; distribution channel and international green promotion; innovation of production system and green advanced science and technology. A comparison has been made between the domestic power development of China and that of overseas. With the help of this comparison, [20] discusses the obstacle to green power in China and the impetus to its development. Also a new market mode that is based on green power pricing mechanism is also put forward.

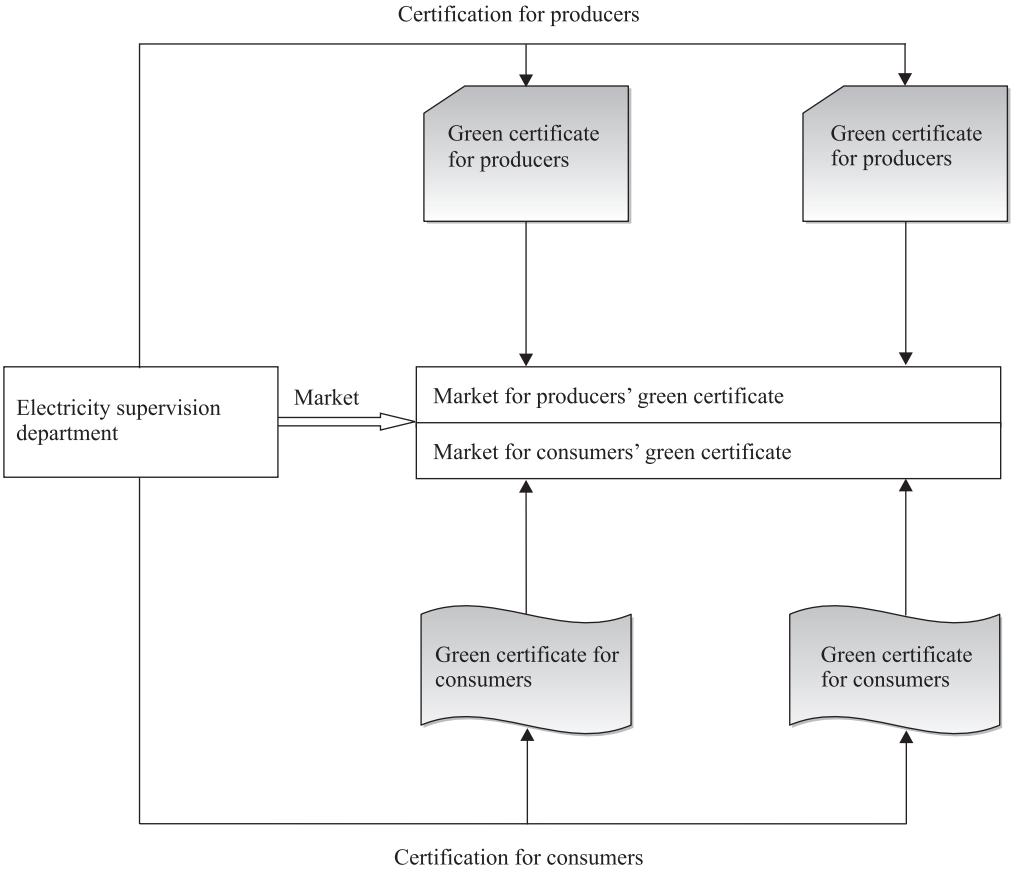

Fig. 5. Green certificate system and trading [20]

The economic crisis of 2008 has posed many questions, since it had a drastic effect on economies around the world it can also be a bane to the green energy sector. An analysis into how the attitudes of Taiwanese consumer and their behaviour towards green products would change due to this crisis is presented by [21]; here 44% of respondents told that they would purchase less of the green products. [22] Address the characteristics of innovation by investigating the existing body of knowledge and investigating empirical aspects and value of customer in terms of green investments. A model for green product which can use its entire assembly more than once and sup-

ports lifecycle nature of a green product showing optimal price solution for all cases has been illustrated by [23].

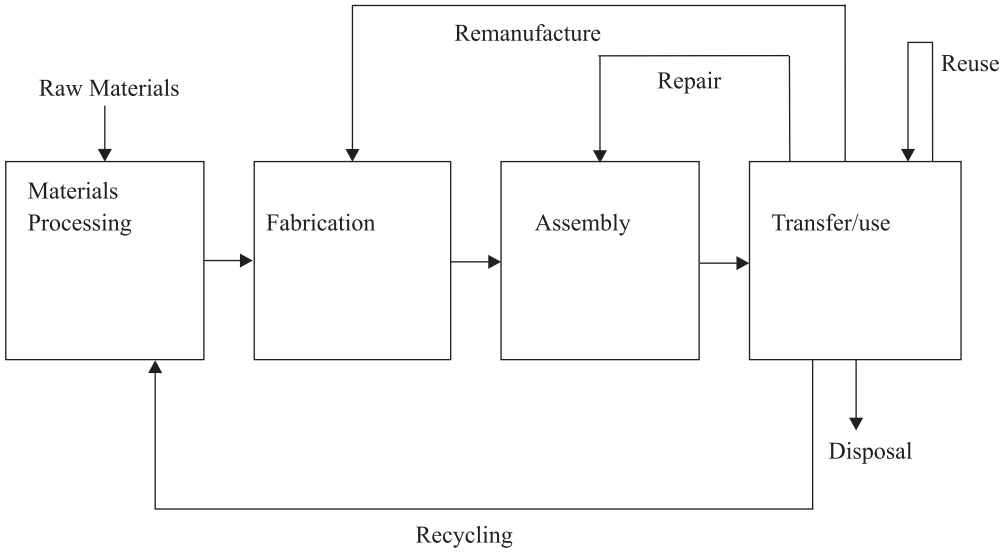

Fig. 6. Green Product Life Cycle [23].

In [24] authors examine practical aspects of "green" dielectric implementation in low I/O land grid array (LGA) based package RF modules. Tulkoff et al [25] describes a study on adaptation of National Instruments on new requirements adopted by world-wide environmental legislation to support new global economy. With the development of green photonics technology it will give many opportunities in the time to come for the design of green, clean and energy efficient lifestyle, which will grow exponentially. An overview by [26] forecasts the optoelectronics expectations for green photonics technology and associated markets over the next decade.

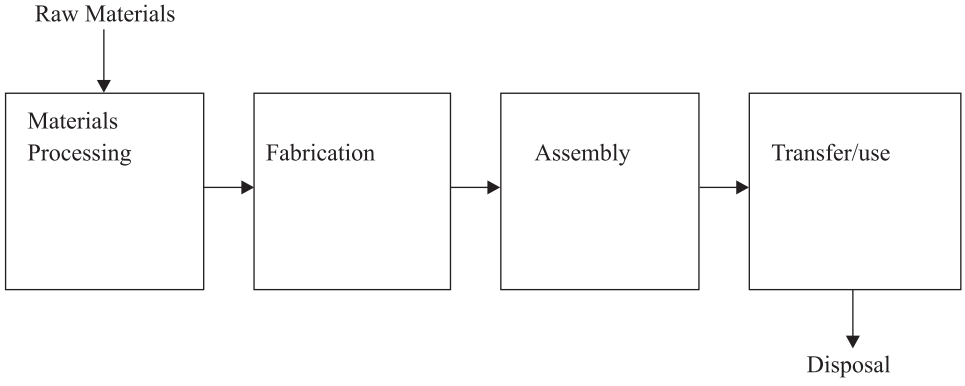

Fig. 7. Standard Product Life Cycle [23]

An intelligent and efficient algorithm, modelling and simulation methodology to estimate new energy planning approach to meet growing energy requirements has been presented by [27]. Upcoming courses and research an institution in the field of green material has been described by [28] it also brings a new field where emphasis is laid on sustainable energy development. These courses will create new brains to work on sustainable sciences in the future which will create competition in green sector. Though the green design of products helps environment sustenance, strictly design based activities alone are likely to be insufficient to achieve the desired goals, this has been argued in [29].

3. Proposed Parameters and Methodologies for Predicting Alternative Energy Prices

Energy made from solar cell and other alternative forms will be in great demand by the consumers in the near future, this has been corroborated in our earlier section of literature review. Study of this behaviour and usage of financial acumen for the current energy options can help us predict usage and pricing of alternative energy. This is because energy derivatives and other inputs can help us to predict the demand of energy as well as the price of energy in future markets. We know that economy plays an important role in the usage pattern of green energy; developing economies show different green energy behaviour than the developed economies and this will have an effect on each of the models that we make in our predictions. Let us take a scenario for better explanation—suppose when the price of oil increases there is shift toward the sales of solar cells or fuel cells or wind turbines where these changes can be modelled empirically. This means that as the price of oil increases the demand for oil decreases and the demand of alternative energy products increases. Accordingly every aspect is linked to each other thus, for making complex models, we need to use carefully the partial differential equations, Black Sholes and Monte Carlo Simulations for Quantitative modelling and do a thorough check of its applicability.

The first step in our model is to focus on sales and demand. Then we will look at Monte Carlo simulation followed by commercialization speed and behaviour of green energy firms. The extreme evens, which are mostly political and will also have an impact on the feasibility, are also listed. Finally the modelling feasibility is discussed with areas of future research.

Overview of seven steps involved in our proposed model:

1. Future sales and Demand
2. Modelling propositions for Monte Carlo Simulation
3. Study of commercialization
4. Study of game theoretical behaviour and predicting Nash Equilibrium for pricing
5. Effect of extreme events
6. Modelling and implementation on available platforms
7. Open research areas

Demand of oil along with crude prices and its effect on alternative energy market like solar cell and fuel cells can be modelled using regression coefficient and appropriate data, though in this work we have not implemented the concept still we have given a proposition. Regression coefficient selection for the Green energy model can be fitted to various factors such as the amount of investment, recent sales and also with the cross sectors like volatility on oil prices and the movement of oil companies. Now let us see the factors, affecting value of overall sector of alternative energies, which are as follows:

- ✓ Looking at Energy Derivatives Market (Crude Oil Prices, Energy, coal, Electricity).
- ✓ Inferring expected price, demands and Macro economic factors (expected inflation and also a look at consumer behaviour).
- ✓ Looking at technology breakthroughs, like reliability, commercialization, technology change, packaging. Linking both to make a model to find out the effects on the demand for alternative energy solutions. This is the most important step. Partial Differential Equation on the intensity of impact of green energy solutions is another thing that we need to take into consideration.
- ✓ Using modified Black Sholes in the model for OTC, call pricing of longer duration, swaps for energy derivatives.
- ✓ Making of decision trees and neural networks, using right distribution probabilities (in Monte Carlo). The drawing of decision tree is the most important step in this regard.
- ✓ Observing financial ratios of current companies and predicting future if required. Looking at Green Consumer and Green marketing coefficients.
- ✓ Currency Risks (more in developing countries).
- ✓ Carbon tax changes/new legislations/cheap debt to green energy.
- ✓ Looking for extreme events (Financial Risk Management) that include wars and financial crisis.
- ✓ Use Game theory to understand competitor behaviour. Estimation and working on complexities of Nash Equilibrium to find out the new points also define game types for better understanding.

Let us look at some of the dependencies in this regard that can help us in building the desired model.

Future Sales is a regression fitted function of:

A. Funding in alternative energy (growing exponentially)
B. Past sales (linear)
C. Oil prices (data available)
D. Risks involved in the future (more than exponential after some time) etc
E. Other growth numbers (assumed linear)

Demand is a Function of:

A. Energy required in the future
B. Consumer behaviour
C. Macro economy of various countries

D. Technological advancement
E. Growth in current companies
F. Extreme events like wars and blockages

Monte Carlo Simulation would require the above steps to get inputs as follows:

a) Selecting all distributions of probabilities of all events.
b) Deciding the motion dependencies like the ones used for the modified Black Sholes.
c) Finding probability of outcomes.

The derivative pricing model for the energy stocks can be modelled after adjustments on the theory of Brownian motion model but it can be used only for short term movements. Linking stochastic calculus for deriving right Black Sholes model where we need to define the dependencies and right partial differential equations in another area which needs to be developed. Though these models are normally used for options, modified versions need to be used just to predict very long termed movements for over the counter deals (OTC).

3.1. Commercialization process

Important research that will affect the green energy commercialization are special type of solar cells, reliability, modelling, manufacturing and making a decision tree on how these things add up to commercialization. These technical areas have been discussed in detail in our previous research on nanotechnology commercialization [34]. ROE, profit loss models, ratios, etc which are the part of any financial analysis can help us decode the growth of alternative energy companies. Next research breakthrough in Nanotechnology is solar energy and its possible impact, on productions can be understood by research allocation and understanding the direction of research.

Example of nanotech enabled solar cells; packaging, etc. are linked to the possibilities of a major breakthrough in nanotechnology. Modelling using HPC [32], multi scale properties, understanding the phenomenon in greater details will be an important aspect. We can also apply our earlier research such as the Time-To-Commercialization model [33] to this effect.

Some breakthrough points in research in solar cells that may trigger the future expected device realization points that one needs to consider in making quant operators are as follows:

1. Research breakthroughs in 3rd generation cell W/USD.
2. Development in Amorphous silicon technologies.
3. Indium Gallium nitride (which covers the entire spectrum of the light).

3.2. Game theoretical models

Game theory for analyzing research and sales of solar and fuel cells is an interesting area that plays very important role in understanding how different companies are harnessing this technology. Game theory helps us realize how to move ahead and strategize

considering various scenarios, because our competitors are working on the same technology. Hence price and sales adjust as new and current players take some steps or make a move in a particular direction. After doing a thorough analysis some of the games can be defined and back tested, for example if we can analyze effects of funding on research and predicting Nash Equilibrium of the games. A part of this has been explained in our earlier game theory models [34]. Two of our earlier models can be integrated on this subject, namely the commercialization model and game theory models.

3.3. Effects of Extreme political events

Effects of extreme events and research implications on solar energy are two things that may change the landscape in a huge way. Extreme events are defined on parameters such as financial, political, environmental, research breakthroughs etc. Not just technology but politics, wars, crude prices, recession, will also affect the scenario which needs to be taken into consideration empirically. Operators for all such events are needed to be included while making a model.

3.3.1. USA, Israel - Iran war—With each step Iran is putting towards its nuclear programme there is an increased risk of a possible US, Israel—Iran war. This possibility of war can make seismic shifts to the world energy markets. Some of the possible effects can be as follows:

- ✓ **The price of oil would skyrocket—Iran is OPEC's second largest producer** With production of about 3.5 million barrels per day, Iran supplies 2.5% of the world's oil**,** 2/3 of its exports are shipped to China, India, Japan and South Korea; 1/5 goes to the European Union. **Any phenomenon damaging its economy and its oil production can have a detrimental effect on the world energy markets. It is being predicted that** oil prices could surge as high as $175 a barrel if the Strait of Hormuz—conduit for 1/5 of the world's oil supply, including all of Iran's exports—is shut [31].
- ✓ **Military spending would escalate for US, Israel and Iran forcing major changes in macroeconomic structure of these nations having a potential to bring major recession in the world.**
- ✓ **Russia would greatly benefit—Any supply disruptions in the Middle East oil export will greatly benefit Russia as Russia is already the highest oil producing nation in the world.**
- ✓ *Massive inflation*—**Oil is used as an energy resource for the supply of essential quantities such as food, thus oil disruptions will mean increased food prices and other commodity prices.**

3.3.2. Euro crisis—Increased tensions in Euro zone can affect the prices of Euro as compared to Dollar which can affect the global international business and thus global energy consumption pattern.

3.3.3. South China sea conflict—Increased assertions by China over South China sea as well as territories such as Taiwan is becoming a major issue for unrest in the Asia-Pacific region which means conflict of two superpowers (US and China) thus affecting the global power balance scenario.

3.3.4. Arab —The revolutions in the Middle-East can have a spill-over effect in the crude oil trade since both the revolutionaries and the administrators are in the battle to control the country's most valued asset—oil, this can result in supply disruptions of oil resulting in higher oil prices.

3.4. Simulation—Proposal on implementing these models on High performance computing HPC has been given in our earlier research [34]; use of multi scale modelling to find abstraction layers of research is an important way to model the behaviour. Building a decision-making tree and taking data to form neural networks using regression models is one way to build a structure that can be used for simulation of the phenomenon. In making decision trees we will make regression models on how to move to various branches using historical data. We have to associate probability distribution to each event in the appropriate manner while moving into new directions. Neural network, inspired from "system and signals engineering" can also be used to model complex trees in various tools like R, SAS, etc. Four types of simulations exist and we need to build hybrid methods, because each method will give a better result in different scenarios.

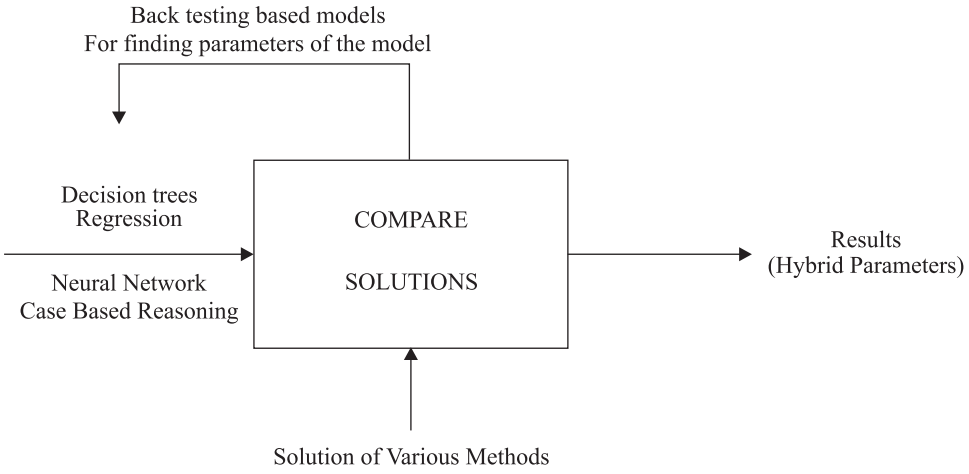

Fig. 8. Methods applied to compare various solutions

The four methods (to be used ad hoc) that are most often used for predictive modelling on various statistical tools which can be also used are:

1. Regressions
2. Neural Networking
3. Decision tree [R]
4. Case based reasoning

Thus using these methods we can link various parameters we have as inputs to predict the movements in various direction.

3.5. Open research domains

Classical Brownian motion equation can be modified to form a new tool for predicting green energy options as follows:

***dS/S* = *μdt* + *σdW* + green partial diff operator** (directional dependencies)

Where *W* is Brownian motion. Here we have *W*, and it's infinitesimal increment *dW*, represents the only source of uncertainty in the price history of the stocks or historic values in a model, μ, the drift rate of *S*, annualized, σ the volatility of the stock's returns[35].

How these equations will function when underlying is an option on green energy? This is something which becomes important in a time frame of longer durations. Stochastic modelling in green energy prices and finding relation between partial differentiation and solving partial differential equations (PDEs) are some issues which come into picture then. Green energy parity relations can also be explored to develop accurate quant models which are based on conservation principles of physics and arbitrage free concepts in finance. Partial differential equation of parities based on demand to make demand constant (which will be met in any case) with possible fluctuations on other parameters. This means that changes in other parameters like currency depreciations will occur but total supply will be equal to demand causing other events. Thus parity equation in energy can be formed based on conservation of different elements and parameters as discussed.

4. Conclusion and Future Scope

This research paper presents a review on consumer behaviour and market scenario for the green energy sector. This research will be helpful in predicting the behaviour and expectation of the consumers and also for modelling an investment strategy for decision making in the area of green energy. Consumer behaviour and government spending are two important factors that will affect the implementation of green energy solutions. Quantitative modelling parameters have been introduced and can be scaled and developed as per requirements with different parameters. Various inputs and open research domains are also introduced and a modelling framework has been proposed. The research forms a strong base to develop and predict future financial prospectus of green energy.

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VARTOTOJŲ ELGSENA IR STRATEGINIS FINANSAVIMAS ŽALIOSIOS ENERGIJOS SRITYJE

Arpit LUDHIYANI, Satyadhar JOSHI, Rohit PATHAK

Santrauka. Šiame darbe pateikiama išsami vartotojų elgsenos analizė žaliosios energijos rinkoje bei aptariamos žaliosios energijos finansų modeliavimo sąnaudos. Pasiūlytas modelis, grįstas įvairiais įvesties parametrais ir struktūromis. Modelis gali būti naudojamas finansinei analizei, taip pat „žaliosios" energijos ateities perspektyvų prognozei.

Arpit Ludhiyani – earned a Bachelor's degree in Engineering from the Shri Vaishnav Institute of Technology and Science (SVITS), India. His research interests include: game theory, utilization of nanotechnology for business, RFID, SMC.

Arpit Ludhiyani – baigė Shri Vaishnav technologijų institutą (Indija). Tarp jo mokslinių interesų paminėtini lošimų teorija, nanotechnologijų panaudojimas verslo sprendimams.

Satyadhar Joshi – earned a Bachelor's degree in Engineering from the Shri Vaishnav Institute of Technology and Science (SVITS), India, and is a co-founder of Tri Nano. He is the author of various papers on nanotechnology and MEMS published in a number of international journals and presented at various conferences. He has also presented his business ideas for the commercialization of nanotechnology for green energy solutions at various business and entrepreneurship events.

Satyadhar Joshi – baigė Shri Vaishnav technologijų institutą (Indija) ir karu su kolegomis įsteigė *Tri Nano India* firmą. Nanotechnologijų klausimus sieja su žaliosios energijos verslo sprendimais.

Rohit Pathak – earned a Bachelor's degree in Engineering in Computer Science and Engineering from the Acropolis Institute of Technology and Research (AITR), India, and is a co-founder of Tri Nano. His papers on HPC and nano modelling have been published in various international journals and presented at various international conferences (including conferences in Malaysia, Thailand as well as India); he is the author of over 40 publications. For a research *Optimization HPC for Nanotechnology* he was awarded a research grant by Microsoft in 2009.

Rohit Pathak – baigė Akropolio kompiuterinių mokslų ir inžinerijų institutą (Indija), yra vienas iš *Tri Nano India* firmos steigėjų. Jo straipsniai publikuoti Malaizijoje, Tailande, Indijoje. 2009 m gavo *Microsoft* leidimą vykdyti didelio našumo skaičiavimų optimizavimo nanotechnologijų srityje tyrimus.