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SUSTAINABLE ENERGY CHALLENGES OF INDIA

Essays of the study course "Future Sustainable Energy Challenges"

FINLAND FUTURES RESEARCH CENTRE
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FOREWORD

Of recent, energy education is acquiring importance in Indian higher education system. As a signatory to many international protocols on reducing carbon emissions, India is obligated to persue alternative sources of energy and awareness building among the masses to meet its global commitments. Once such initiative was undertaken in Solapur University, Maharashtra state, Western India, to introduce a course on "Future Sustainable Energy Challenges", in collaboration with Finland Futures Research Centre (Turku School of Economics in University of Turku, Finland) under the financial assistance from the Finnish National Agency of Education.

The present book is a collection of essays developed by Master students as project work of their course in Energy Education. There are three essays presented in this book which provide glimpses on Renewable Energy Sources and their potential to meet energy needs of India in a sustainable manner. All the three essays are set in 'Futures studies perspective' and have discussed at length the challenges and limitations through specific case studies on wind, solar, biofuel energy, in the context of India's energy sector.

Professor Eranti Ashok Kumar
Solapur University

On the behalf of FFRC I want to thanks Professor Kumar, his staff and of course the students for their effort for the course and this publication. Because of their enthusiasm and eagerness we were able to run through the course as planned. I also thank the Solapur University of its support. As an evidence of the learning curve of the students and the commitment of their teachers we wanted to publish the essays written by the students with help of their teachers.

I hope the publication will be an opening for continuous collaboration of our Universities for sustainable energy production and consumption in India

Director Juha Kaskinen
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DETERMINANTS OF WIND ENERGY FUTURES FOR SOLAPUR DISTRICT: SOME PROBABLE SCENARIOS

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ABSTRACT

The present study is undertaken in the context of India and intends to answer the set of three questions: (i) What is the status of wind energy scenario in the region with respect to policy and technology variants? (ii) What is the interplay between system's components of PESTEC (Political, Economic, social, Technological, Environmental, and Cultural) and the policies & technologies? And (iii) What are the probable scenarios for wind energy futures? Compelled by the questions stated above, the study employed "Two-axis Morphological Matrix" method considering the need for (i) developing alternative strategies to promote wind energy in the region; (ii) analysing the future risks while implementing wind energy projects; (iii) comprehending the means and ends in the process of promoting wind energy; (iv) simplification of complex set of relationships in the course of transition towards wind energy production and distribution. The study infers by developing three sets of strategy scenarios such as idealistic scenarios, realistic scenarios and pessimistic scenarios. Further, the analysis reveals that the policy is more critical driver than the technology. The shortcomings of the existing technologies can be overcome through appropriate policy instruments. The strong policy driver can eliminate the weaknesses of the system components. Thus, the model throws open a number of viable alternatives for planners and developers.

Key words: Wind Energy, Policy, Technology, Drivers, System's Components.

INTRODUCTION

Wind power is a source of clean energy. It evolved over a period of time. At the end of 19th century, the first wind turbine was developed. During 1940s and 50s it underwent a formative stage with simpler technologies to capture wind power. By 1970s, there was a thrust for developing innovative and viable technologies in harnessing wind power due to the oil crises that pervaded the entire globe. At the end of 1990s, wind turbine technologies were developed in different parts of the world. Denmark, Germany and Spain were the leading countries which contributed for the development of wind turbine technologies. In the recent years, wind energy has acquired greater importance and is the fastest growing renewable energy source. The global wind power capacity had increased from 76 GW in1997 to 195.5 GW by 2009 (Zoba and Bansal, 2011). It was estimated that the wind power energy will develop to a scale of 12% of the global electricity supply by 2020 (as quoted in Yao, et al. Global Wind Scenario, Power Line 7 (2003) p. 49–53).

There are various factors affect the wind power as a technology. They are wind statistics for characterizing the variability of wind speed; load factor that is amount of output drawn; and seasonal variations of wind speed. The wind turbine sitting needs a careful considerations such as availability of land, power grid in certain cases, accessibility of site, terrain and soil and frequency of lighting strokes (Yao, et al., p. 8). There are reports available elsewhere that onshore wind energy is emerging as one of the most competitive source of electricity which is now almost within the same cost range that of a fossil fuel and sometimes, even less also. The reasons attributed are the higher hub heights and larger swept areas supported by policy instruments. This indicates that the technologies are improving towards reducing the cost and increasing the efficiency.

India has earned international status in wind energy promotion. Currently, wind power potential in the country is over 302 GW at 100 m height. India is one among the top 4 wind power generating countries in the world. And more interestingly, it is the only country in the world having a separate Ministry for Renewable Energy. India is poised for achieving NAPCC target of 15% from renewable by 2020 and 60 GW wind energy by 2022. However, wind farm establishment needs land acquisition and better Land Reforms and Evacuation Facility for expanding wind energy. As a satisfactory note, India has state-of-the-art technology available and there are18 major companies already engaged in wind energy production with 44 models.

Wind turbines harvest kinetic energy and convert it into usable power which can provide electricity for home, farm, school, or business applications on small (residential), medium (community), or large (utility) scales (Zoba and Bansal, 2011).

Wind power is considered as the largest source of new renewable power capacity. Its role is growing in meeting electricity demand. China is one of the leading countries in wind power generation. The new markets emerged across the countries in Africa, Asia and Latin American continents. Corporations and private companies continued turning to wind energy for reliable and low cost power (REN 21, 2017, p. 11). The major challenge was the lack of transmission infrastructure. Despite the challenges, the annual additions to the wind power global capacity steadily increasing over the decade 2005–2015 (ibid: p. 24). Interestingly, the investment flow in wind power in 2015 increased more in developing countries than the developed countries (ibid: p. 28).

GLOBAL SCENARIO OF WIND ENERGY

There are highly encouraging trends at the global level with regard to renewable energy in general and wind energy in particular. Massive investments are made in solar (China and Japan) and offshore wind in Europe. The axiom "Sun in Asia, Wind in North Sea" is already in vogue in the renewable energy fraternity reflecting the popularity of these energy sources. In between 2014–15, there was nearly 50% plunge in the crude oil prices in the world market. Perhaps as a response to this trend, the year 2014 appears to be a major land mark in promoting renewables especially, wind energy by generating 49 GW which is a record figure (Bloomberg, 2016, p. 12–19). In the top ten countries investing on renewables BRICS countries have made substantial investments. Their investments have swollen substantially. For instance, India invested USD 7.4 billion preceded by Brazil USD 7.6 billion. Regarding costs and challenges, renewable have to face many challenges including unpredictable supportive policies which may hamper investors' motivations (ibid: 2016).

The trends set during the 2014 continued through 2015. There were additional increments in wind and solar energy generation accounting for 118GW which is higher than the previous year (94 GW in 2014). The year 2015 witnessed a higher investment in renewables, double that of the investment made on fossil based sources. The UNCCC conference in Paris held on December, 2015 gave impetus to the policies of various countries to make commitment to invest on renewables and put in place appropriate policy instruments. There was an unprecedented consensus by 195 countries to strive for zero carbon emission in the second part of this century (Bloomberg, 2016, p. 11). The developing world continued to outweigh the investments on renewable than the developed world. China alone invested 102.9 billion dollars which is 36% of the world total (ibid: 2016). The cost of generating renewable energy continued to fall especially in the solar sector and this may have implication on other renewable like wind. However, despite all these encouraging developments, the policy support for renewables remained fickle in many countries including USA. There is high possibility that the prices of coal, oil and gas may fall in the international markets leading to fall back on fossil fuels by several developing countries. There is an emerging thrust on technologies developing storage batteries in the year supported by electric automobiles which is an encouraging trend. Unlike in the past, solar and wind energy sources are no more remained as luxuries and now affordable to the lower economic classes also.

There is a growing competition between fossil fuels and some sources of renewables. Oil competes with renewable power generation in oil producing countries. Gas competes with wind and solar in some European countries. Coal is still competing with renewable, in some parts of the developing world. However, renewables have merit in terms their installation time. For instance, wind farms take on an average 9 months, solar parks 3–6 months whereas coal, gas and nuclear energy sources take several years to install and start functioning (Ibid: 2016, p. 18).

Every year global wind day is observed on June 15 indicating the growing importance of wind energy all over the globe. In 2016 $112.5 billion invested in wind power globally and wind power has crossed the 500 GW mile stone. According to the estimates available 1.2 million people are employed globally in the wind industry. In 2016, un-subsidised new renewable power was cheaper than fossil fuels in over 30 countries which is noteworthy

INDIAN SCENARIO OF WIND ENERGY

Major Initiatives taken by the Ministry

During the year 2015–16, wind power capacity addition of 3.42 GW was made, which is highest ever wind power capacity addition in the country during a single year. The present wind power installed capacity in the country is around 28.28 GW. Now, in terms of wind power installed capacity India is globally placed at 4th position after China, USA and Germany.

India has a strong manufacturing base of wind power equipment in the country. Presently, there are 20 approved manufacturers with 53 models of wind turbines in the country up to a capacity of 3.00 MW single turbines. Wind turbines being manufactured in India are of international quality standards and cost-wise amongst the lowest in the world being exported to Europe, USA and other countries.

The wind power potential of the country has been reassessed by the National Institute for Wind Energy (NIWE), it has been estimated to be 302 GW at 100 meter hub-height. Online wind atlas is available on NIWE website. This will create new dimension to the wind power development in the country.

India has long coastline where there is a good possibility for developing offshore wind power projects. The cabinet has cleared the National Offshore Wind Energy Policy and the same has been notified on 6th October 2015. Certain blocks near Gujarat and Tamil Nadu coast line have been identified. NIWE is in process of doing the wind resource assessment in these coastal areas (MNRE, 2015).

Wind Energy Investment Destination: India

Draft National Offshore Wind Energy Policy, Ministry of New and Renewable Energy, Government of India, highlights the following points of policy support for Wind energy in India:

The entire wind energy industry is governed by solid foundations from the Electricity Act, viable regulatory procedures from CERC and other state regulatory policies.

The paradigm shift from retail market to the IPP market with major investors like Goldman Sachs, Black Stone, IDFC and others is proven demonstration of the interest of the private sector.

Capital cost in India is perhaps one of the lowest in the world and India is emerging as the fastest growing supply chain hub with many industries choosing for in-house manufacture of towers, blades, generators, convertors etc.

The commercial arm of MNRE, IREDA and other financial and banking institutions has backed the industry as a stable market where there is assured off take and no marketing challenges.

The Government of India has announced a laudable Renewable Energy target of 175GW by 2022 out of which 60GW will be coming from wind power.

This will require an addition of more that 5GW per annum. The country would require over 7000 MW per annum of RE to achieve 15% by all renewable by year 2020 under the National Action Plan for Climate Change.

The Government commitment to promotional tariff, incentivizing generation, plans to revitalize the REC market through RPO obligation will certainly make this market vibrant and self-sustaining.

India blessed with coastline of about 7600 KM. United Nations convention on law of the sea gives India an exclusive right over its exclusive economic zone (200 nautical miles from the baseline) to develop offshore wind energy (See: MNRE, 2015; Kiel, 2012; CEI, 2017; Raghab, 2017)

Against the above backdrop, the study intends to address to the following set of three objectives:

Objectives and Methods

1. What is the status of wind energy scenario in the region with respect to policy and technology variants?
2. What is the interplay between system's components of PESTEC (Political, Economic, Social, Technological, Environmental, and Cultural) and the policies & technologies? and
3. What are the probable scenarios for wind energy future?

Compelled by the objectives stated above, the study employed "Two-axis Morphological Matrix" method considering the need for (i) developing alternative strategies to promote wind energy in the region; (ii) analysing the future risks while implementing wind energy projects; (iii) comprehending the means and ends in the process of promoting wind energy; (iv) simplification of complex set of relationships in the course of transition towards wind energy production and distribution; Investigating total set of relationships contained in PESTEC dimensions of wind energy; and creating qualitative (non-quantifiable) inference frameworks.

The methodology involved in identifying PESTEC dimensions in wind energy and assigning a range of relevant values or conditions in the form of standard phrases or abstract labels. For the purpose of operationalization two-axis method is employed where in "Policy" driver is taken on X-axis and "Technology" on the Y-axis. On the X-axis, there is continuum from the most favourable policy to the least favourable policy; and on the Y-axis, the most advanced technology to the status quo that is present technology. Thus, at the point of intersection of the two axes, there are four quadrants such as a) Upper Right (UR); b) Upper Left (UL); c) Lowe Left (LL); and d) Lower Right (LR). When viewed through anti-clockwise direction, each quadrant provides a condition under which various interrelationships between parameter values take place.

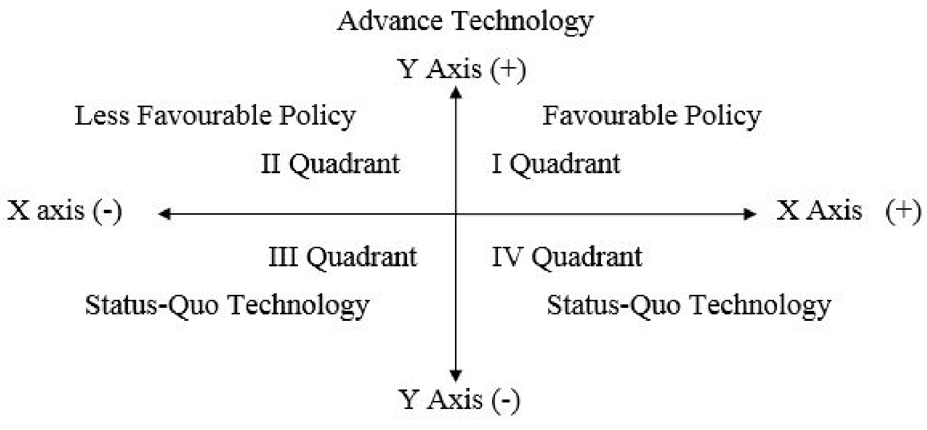
Thus, quadrant UR is a condition comprising of most viable and supportive policy and political system on one hand and most advanced viable technology on the other. The policy/political system and technology are chosen as "scenario placeholders" while the remaining dimensions such as economy, social, environmental and cultural are taken as interactive parameters assuming various values and conditionality. For further deepening our understanding, those parameters and associated values are broken down into strong and weak conditionality. Now, under the quadrant UR the components of analysis are:

- Scenario Place holders: a) Policy/ Political system; b) Technology
- Analytical Parameters: Economic (E), Social (S), Environmental (K), and Cultural (C) under strong and weak conditions.
- Parameter conditions or values: (Explained in the next sections)

Each quadrant will have four scenario configurations since each scenario placeholder takes two sets of parameter matrix, one with strong values/conditions and the other with weak values/conditions. Thus, each quadrant will have four configuration sets. Theoretically, for four quadrants (4*4) 16 configuration sets are available for analysis. However, for the present study, two extreme quadrants, UR and LL are considered for analysis.

All the possible combinations of placeholders and analytical parameters are worked out for arriving at a number of strategies which sum up to 1554 (see the Annexure) from the two quadrants UR and LL. Eight strategy scenarios, 4 from each of the two quadrants (UR and LL) are considered for further interpretation. Since, the placeholders (Prime Drivers) Policy and Technology take 5 values each and assume their corresponding multiples when combined with the 4 analytical parameters, under two conditions, strong and the weak (see the Annexure).Those combinations which produce the highest number of strategies are chosen for strategy interpretation exercise.

(Prime Drivers are Policy and Technology)



2nd Quadrant

Y Axis (+)
Advance Technology

	PESTEC Strength	PESTEC Weaknesses
Less Favorable Policy (FP)	LFP- PESTEC Strengths	LFP- PESTEC Weaknesses
Advance Technology (AT)	AT- PESTEC Strengths	AT- PESTEC Weaknesses

X Axis (-)
Less Favourable Policy

1st Quadrant

Y Axis (+)
Advance Technology

	PESTEC Strength	PESTEC Weaknesses
Favorable Policy (FP)	FP- PESTEC Strengths	FP- PESTEC Weaknesses
Advance Technology (AT)	AT- PESTEC Strengths	AT- PESTEC Weaknesses

X Axis (+)
Favourable Policy

0

X Axis (-)
Less Favourable Policy

	PESTEC Strength	PESTEC Weaknesses
Less Favourable Policy (LF P)	LF P- PESTEC Strengths	LF P- PESTEC Weaknesses
Status-Quo Technology (SQT)	SQ T- PESTEC Strengths	SQ T- PESTEC Weaknesses

Status Quo Technology

Y Axis (-)

3rd Quadrant

X Axis (+)
Favourable Policy

	PESTEC Strength	PESTEC Weaknesses
Favourable Policy (LF P)	F P- PESTEC Strengths	F P- PESTEC Weaknesses
Status-Quo Technology (SQT)	SQ T- PESTEC Strengths	SQ T- PESTEC Weaknesses

Status Quo Technology

Y Axis (-)

4th Quadrant

WIND ENERGY PROMOTION: AN OVERVIEW

Wind power generation differs from conventional energy generation due to the changing nature of wind. Thus, wind power forecasting plays a key role in dealing with the challenges of supply and demand in electricity production system. Accurate wind power forecasting and calibrating production accordingly poses the need for additional balancing energy and reserve power to integrate wind power. There are many more issues associated with the promotion of wind energy in a country like India. Some such issues are generic in nature and applicable to elsewhere on the globe while some are specific to Indian state. For better comprehension and articulation, the literature scanned through, classifies the issues within the broader systemic components, PESTEC (Political, Economic, Social, Technological, Environmental and Cultural/Consumer related).

Political:

Putting appropriate policies in place plays a critical role in bringing any major change in the renewable energy sector. Since these are political decisions, there is a need for strong political will to frame policies that are conducive for renewables. One of the pitfalls in the policy formulation is about lack of integration of economic and technical concerns into policy making. For instance, the credit flow to Private Companies is on high interest rate in the range of 13-18% in the domestic market which is very high. Access to foreign loans though available, can only be used on a project basis according to regulations which curtails freedom (TERI, 2015, p. 14). Lack of coordination among key organizations like revenue department, state pollution control board, grid operators has led to time and cost overruns resulting in high logistical costs. Also, due to the lack of Government's accountability, developers must follow a large amount of paperwork and several levels of bureaucracy before subsidies are approved (Ibid p. 14). There are other inadequacies such as lack of information, publicity and other support programs; lack of financial support for R&D for carrying out studies & resource assessment; Environmental impact assessment; and Oceanographic studies (Ibid p. 1 to 4).

Policy challenges also include supply of reliable and quality power of specified standards in an efficient manner and at reasonable rates (Kazmerski, 2006). Developing skilled manpower to handle the operations and maintenance of the wind energy systems is essential. Training the existing staff and recruiting trained staff may need allocation of budget. Another development difficulty is about the ability to maintain wind projects in rural India. Most of the rural community have modest local resources and require outside training and assistance to maintain their systems. However, such assistance is often expensive and not readily available (Maynard,et al., 2010, p. 33).

There are legislations already in place in India to promote renewable sources of energy. As per National Electricity Act-2003, state regulators are to specify a minimum percentage of power to be purchased from renewable sources. The National Tariff Policy -2005, state regulators provide preferential tariff for renewable power tariff rates offered in the range from Rs.3.40 to Rs.5.30/kwh (7–11 US cents/kwh). This apart, the private companies producing renewable energy are given Income Tax Holiday for 10 year (Nigam, 2014). Other incentives include relaxation in VAT (value Added Tax). In some states there is practice of reduced or no VAT on Renewable Energy components. For instance, Tamil Nadu has reduced VAT From 14.5% to 5% while Karnataka offers 5.5% VAT for all the Renewable energy components. Again in Gujarat, Tamil Nadu and Maharashtra offer 5% VAT for all Renewable components. Capital subsidies are extended by the state governments to private companies. Maharashtra has the provision for capital subsidy to the extent of 11% for wind energy project set up by the cooperative sector. Rajasthan provides soft loan equal to 1/3 of capital cost at low interest rate (MNRE, 2014).

Renewable Purchase Obligation (RPO) is one of the important State Governments' policies and incentives for motivating private sector companies to enter into renewables like Wind.

As mentioned earlier, under the section 86,1 (a) the Electricity Act 2003, state is to purchase a fixed percentage of energy generated from R.E. resources. The RPO percentage varies from 0.5% to 10.25% depending on the local renewable resource and the electricity distribution in the states. RPO obligation can be fulfilled through direct purchase via bilateral contracts and tradable REC (Renewable Energy Certificate) mechanism which can further generate revenue for RE projects (MNRE, 2014).

Under the present circumstances, the status of RE development has many bottlenecks to overcome. The targets set forth by the state have multiple facets leaving stakeholders confused. There are no clearly demarcated performance benchmarks for RE projects posing difficulties for monitoring. Lack of cohesion in policy framework such as technology specific and State specific would create hurdles for smooth transition towards RE. Relaxed enforcement of regulations is not leading the stakeholders anywhere. India is a growing economy and demand for power is increasing. The conventional energy sources are either limited or due to obligations not ideal for use. There is huge untapped wind potential available in India which needs to be harnessed (MNRE, 2014).

Lack of provision of permitting stand-alone systems for rural and remote areas is a policy impediment for expansion of wind energy to the rural areas. In Indian context which is still more rural than urban and access to energy is inadequate. A large majority of the villages reel under energy poverty and the policy shifts in this sector would usher in green development in the country side (Aayog NITI, 2015, p. 7).

Supply of reliable and quality power of specified standards in an efficient manner and at reasonable rates is a policy prerogative. Wind energy appears to be a viable alternative should proper interventions are made (TERI, 2015). Other Policy Initiatives for wind energy include sales tax and excise duty reliefs; concessional import duty on specified parts and components; IREDA and Nationalized Banks provide loan for commercial wind power projects at reasonable rates of interest; Preferential tariff by State Utilities supported by power Generation Based Incentives and many other packages to attract the private entrepreneurs in the renewable energy business. Central Electricity Regulatory Commission (CERC) has already brought out Tariff Regulations as early as in September, 2009 which reflects the commitment by the state. All these measures will have a bearing on tariff framework at state levels in the coming period RPOs have been announced by major states (Nigam, 2014). Renewable Purchase Obligation (RPOs) announced in most states (up to 10%) and penalties were introduced for non-compliance announced by a few states of India. Renewable Energy Certificate (REC) mechanism is in place in many states. As a policy guideline, RECs are to be purchased through bidding process and can be used by companies and Distribution Licensees for meeting their RPOs (I bid).

The state has provided a vast range of incentives for the promotion of wind energy in India. The companies engaged in the production of wind power are exempted from paying Electricity Duty are also given CCD & SAD exemption on specified parts and components used in the installation of wind turbines. Feed-In-Tariff (FiT) and Accelerated Depreciation at 80% or Generation Based Incentive @Rs.0.50/unit are supportive services given by the State Regulators which is implemented with cap of Rs.10million per MW. The repowering policy of the state has paved the way for rejuvenating the non-functioning wind farms commissioned earlier. These facilities have potential to revive and sustain in the context of changing macro level scenario (Ibid).

Wind power generation is characterised by high level of intermittency that is fluctuations in the wind speed. The draft Wind-Solar Hybrid Policy mooted by the Government of India (GoI) in 2016 is a land mark in combining technologies and overcoming the problem of intermittency. The hybridization is a realistic policy initiative since these two sources of power are complementary to one another. The GoI has set an ambitious goal of achieving 10 GW of wind-solar hybrid energy by 2022 and this target seems to be achievable (Ibid).

Wind Policies in India vary across its states. Wind potential states are providing promotional tariff for wind power projects in varying degrees is a welcome move. This apart, states are also providing Concessional Wheeling, Banking, Electricity Duty and Cross Subsidy Surcharges to attract the energy entrepreneurs to engage in wind power production.

Environmental:

Wind farms, even though environmental friendly, are not free from hazards. Most commonly cited one is noise pollution. Wind turbines produce mechanical noise mainly from the gearbox and the generator. Noise occurred from wind turbines affect the residents nearby the wind farms. Due to high frequency sound human life and animal life get disturbed. Old age people and children are the main casualty due to sound occurring from the wind mills (Jaber, 2013). The modern turbines create very little noise (Macintosh & Downie, 2006). However, wind farms never affect the grazing of livestock. The land used for wind farms can still be used for farming and cattle grazing (Ibid: 2013).

Studies show that birds may become dis-oriented in poor weather or foggy night and subsequently, are attracted to light emitted from wind energy plants. Some birds tend to fly lower during heavy overcast weather such as high winds, low clouds, and rain. This increases the bird's potential of flying through the wind turbines leading to fatalities (Ibid: 2013).

With regard to land acquisition and Land use, wind farms are often built on land that has already been impacted by land clearing (Ibid: 2013).

A wind turbine casts a shadow on their vicinity in direct sunlight and poses a problem in sunlight starved countries like those situated in Northern Europe. As the blades keep turning, they may cut through the light beams, causing a flickering effect. Nevertheless, the flickering is annoying when at home and awake and the stakeholder complain about this effect. In some cases like South Dakota, most residents respect their local resources, wildlife, and environment, and have concerns regarding the exploitation and/or degradation of those resources. They endorse the existential and aesthetic values of those natural resources (Jaber, 2013).

Wind energy can bring increased security for electricity supply to non-grid connected locations and it gives protection against electricity price rise. Renewable Obligations Certificates (ROCs) can be received by generating electricity. These can then be sold to electricity generators to allow them to meet their targets to derive a specified proportion of the electricity they supply to their customers from renewable energy sources. Wind power can provide energy while reducing the emission of CO2. According to the World Energy Commission, use of one million kWh due to wind power can save 600 tonnes of CO2 emission. Therefore, massive use of wind power will help mitigate climate change. The use of wind power can also avoid regional environmental problems brought about by burning coal (Jaber, 2013).

The conventional power plants use large amounts of water for the condensation process of the thermodynamic cycle. For coal power plants, water is used to clean and process coal and the amount of water used can be millions of litres per day. Wind energy can save that amount of water used by the coal plants (Saidur et al, 2011).

Environment value of wind energy

The primary environmental value of electricity generated from wind energy systems is that the wind offsets emissions that would have been caused by conventional fossil fuelled power plants. These emissions include sulphur dioxide (SO2), nitrogen oxides (NOx), carbon dioxide (CO2), particulates, slag and ash. The amount of emission saved via the use of wind energy depends on the types of power plant that are replaced by the wind system, and the particular emissions control systems currently installed on the various fossil-fired plants (Saidur et al, 2011).

Vertical shaft turbines are safer and produce twice the energy of prop-style turbine. In addition, their slow turning blades gently generate clean, abundant energy for a revitalized, green Earth. Its design can decrease birds' mortality from collision of the wind turbine (See: Saidur et al, 2011; Kiel, 2012; Wind Energy Facts, 2017).

Social:

Constructing wind turbines and the associated grid creates a multitude of challenging social issues in communities. The primary ones are: adverse health impacts caused by noise; exclusion of women from the decision-making process; degradation of property values; community division and infringement on the rights of citizens to enjoy the residential amenity of their own homes. Wind farms are also socially inequitable as they involve a wealth transfer by levies on energy bills from taxpayers to developers (Maynard, J. E., Lovecraft, A, 2010).

Wind turbines come with eye-catching designs, they impact the natural beauty of the landscape. When a lot more wind turbines are set up, the area becomes unsightly. In many locations, the local community starts resentment against installation of wind turbines, and this can escalate to a conflict (Ibid: 2010).

Another social impact is that citizens' health would increase over time. This means the opportunity cost on health expenditure would reduce due to the substitution of wind energy in place of energy from the fossil fuels. People would not be exposed to as many hazardous wastes and emissions because people would be moving away from burning fossil fuels and using cleaner, greener energy such as wind power (Ibid: 2010).

Wind farm development may be compatible with a variety of other land uses, including agriculture, grazing, open space, and habitat conservation, depending on the site, size, and design of the project. Other land uses, such as hunting/fishing, bird watching, and wildlife photography as well as resource values need to be considered when siting large wind projects in remote areas (Ibid p. 32).

Technology:

Mass scale transition towards renewables is of recent origin and therefore, there is technological mismatch to adopt and replace the conventional energy sources. The prominent ones are lack of high voltage direct current transmission lines, and inadequate grid system for distribution of power. Even though these problems are common to most of the renewables, it appears to be more conspicuous to wind energy. Improving the storage capacity for renewables is another challenging task before the technocrats. Varying sizes of wind turbines are not readily available in the market to suit off-grid requirements like dwelling homes and offices (Ibid p. 35).

In countries like India, the wind power potential has not been utilised to its optimim level. Improved siting of wind farms, may facilitate further expansion of wind energy production. The problem of intermittency is still persisting in wind energy systems (Ibid, 2010).

Incremental improvement in the various systems through the changes in turbine blades is quite possible. Even the advanced composition in the turbine construction, including carbon fibre, and new resins may be developed for better deployment in the field. Another challenge is on the technical front to create monumentally tall towers and light slender blades that can withstand the strong winds (Ibid, 2010).

Currently, there are two kinds of wind turbine technologies (i) vertical-axis wind turbine; and (ii) horizontal-axis wind turbine. The limitations with the vertical axis turbines are associated with, not being self-starting and thus, require generator to run in motor mode at start; lower efficiency (the blades lose energy as they turn out of the wind); and difficulty in controlling blade over-speed. With regard to horizontal axis turbines, generator and gearbox are to be mounted on a tower, which restricts servicing; electricity production depends on- wind speed, location, and season and air temperature which add up to the (Ibid, 2010).

There is a consensus that the wind energy technology is still premature to reach a take-off point. Forward and backward linkages connected with wind energy production are missing in many locations of the world including India. Local technicians and operators who are responsible for technical support are yet to be developed. Due to lack of this grassroots cadre, wastage of productive time is substantial when the turbines were inoperable due to mechanical problems. Lack of adequate wind technology services at a state-wide levels, and more so in rural areas routinely results in inefficient generation or even complete shutdown (Ibid, 2010). Lack of high voltage direct current transmission lines, its impact on grid system for distribution, and costly storage facility further illustrate immaturity of technology and poor grid connection system in case of wind energy (Ibid p. 35–36).

Amongst several technical problems confronting wind energy systems, transmission and grid issues appear to be of importance. From economic point of view, the poor grid stability may cause 10–20% power loss. This pitfall may be the main reason for low actual energy output of wind power generation. The costs increase when the locations for generating wind energy are far distant from the locations of consumption (Zobb and Bansal, 2011).

The connectivity study needs to check if the proposed wind generator can be hosted by the existing power grid in view of stability as well as reliability aspects. Back in India, there is no such connectivity studies carried out systematically before commissioning wind energy projects (Ibid).

The cost of electricity can be reduced by integrating diesel systems with wind power generation, hybrid power system. This system has another advantage of reductions in size of diesel engine and battery storage system, which can save the fuel and reduce pollution. Autonomous hybrid power systems will have a parallel operation of diesel with one or more renewable energy based sources (wind, photovoltaic, micro hydro, biomass, etc.) to meet the electric demand (Ibid, 2010).

Economical:

Capital investment in wind energy is high as compared to other renewables. The policy of Government of India allows Foreign Direct Investment (FDI) in wind energy sector. As per the policy guidelines 100% FDI is allowed in wind power sector and this has helped a great deal in bringing private and foreign investment to India. After the introduction of GBI, FDI has increased in wind sector (MNRE, 2014). There are various economic parameters of wind energy which need to be understood. The prominent ones are (i) *Energy efficiency:* The efficiency of the wind energy conversion system affects the economics of the wind system. (ii) *Investment costs:* Civil work and construction cost include transportation , installation of wind turbine and tower including any cost from the start of the idea until the date of operation which includes land preparation, site, equipment, transport, design, consultancy, project management etc; (iii) High *Capital costs:* The determination of the capital or total investment cost generally involves the cost of wind turbines and its auxiliaries, i.e., tower, wiring, utility interconnection or battery storage equipment, power conditioning unit, etc; Grid connection cost is high including the electric work, electricity line, and the connection point are typically 11% to 14% of the total capital cost; (iv) *Financing costs:* Wind energy projects have intensive amount of money to be invested in the beginning so that the purchase and installation costs are met. For this reason, the developer or purchaser will pay a limited down payment of 10–20% and borrow the rests from the public financial institutions; and (v) *Operation and Maintenance (O & M) costs:* According to the estimations available, O&M costs are very low when the turbines are brand new but increase as the turbine gets old. The O&M costs generally range from 1.5% to 3% of the original turbine cost. Annual operating costs also include battery replacement every 3 to 10 years, depending on the battery type and usage load. O&M costs is include components, insurance, regular maintenance, repair, spare parts, and administration. Except O & M, other costs involved are substantially high (Zobb and Bansal, 2011).

The cost of finance (currently ranging from 12–14%) forms a significant component of the power tariff from. Financing costs depends on the risk perceived by funding institutions and higher the perceived risks result in more stringent financial conditions. The relatively high cost and low availability of credit in India has significantly increased the cost of renewable energy projects which is a major barrier to the expansion of the renewable sector. Higher expenses are associated with equipment, operation, distribution & maintenance of system (Maynard et al, p. 36).

Sophisticated technology such as storage facility, grid system, wind mill components, etc). Grid connection cost is high including the electric work, electricity line, and the connection point are typically 11% to 14% of the total capital cost. Devaluation of rupee against the US dollar is the major barrier for importation of sophisticated technology. Price forecast of energy becomes more and more unpredictable (T E R I, 2015, p. 3–13).

Wind power generation costs have been falling over recent years. It is estimated that wind power in many countries is already competitive with fossil fuel and nuclear power if social/environmental costs are considered. One of the main advantages of generating electricity from the wind system is that the wind is free. The cost of the wind system just occurs once. More over there are efforts to reduce the cost of wind power. Those measures include design improvement, better manufacturing technology, finding new sites for wind systems, development of better control strategies (output and power quality control), development of policy and facilitating instruments, and human resource development (Ibid: 2015).

Cultural:

Unlike in many advanced countries, there are no noticeable conflicts between the communities and the wind farms in India, as of now. Therefore, the issues like lack of community support and acceptance is rare. Similar is the case with aesthetic concerns leading to opposition from the local communities. Not in My Backyard (NIMBY) syndrome, is also not so familiar problem with the Indian conditions. Perhaps, the expansion of wind farms and acquisition of common land for wind farms may lead to dissent from the community. In the context of India, more relevant issues which are culture specific would be lack of public participation in the planning process and deficiency in public awareness. It requires sustained efforts and communication by planners and developers (Maynard et all, 2010 pp-32; MNRE, 2014).

1st Quadrant
Favourable Policy - ESKC Strength

Viable Policy	Economic Condition	Social Condition	Environmental Condition	Cultural Condition
P1-Renewable Purchase Obligation (RPO)	E1- Wind power costs declining.	S1- Public health security and health benefits.	K1- Zero emissions.	C1- Wing energy has religious sanctity
P2-Tax Holiday (10 years) Relief in Tax & Excise Duty	E2- O & M costs are marginal (about 2%)	S2- No alienation of community lands.	K2- Boon for non greed locations	C2- Its usage has long tradition and acceptability
P3-Renewable Energy Certificate (REC)	E3- R & D Initiatives for better viability.	S3- Citizens' right of amenities	K3- Saves water	C3- Mind sets and receptive to clean energy
P4-Appropriate Legislations	E4- Wind power is competitive with other sources.	S4- access to clean energy.	K4- Helps to mitigate climate change	C4- Modern turbines make less noise and acceptable
P5-Institutional Credit	E5- Development of new economic instruments.		K5- Offsets CO2 (1mw=2600 Tones CO2)	
	E6- Foreign Direct Investment (FDI).		K6- Less harmful to flora and fauna compared to fossil fuel.	
	E7- Attracting private investments.			

Favourable Policy – ESKC Weaknesses

Viable Policy	Economic Condition	Social Condition	Environmental Condition	Cultural Condition
P1-Renewable Purchase Obligation (RPO)	E1- Higher Investment capital costs	S1- Lack of communication amongst stakeholders	K1- Noise pollution is hazards	C1- Community support unpredictable
P2-Tax Holiday (10 years) Relief in Tax & Excise Duty	E2- Land transfers are tricky	S2- Lack of public awareness about the land issues	K2- Creates vibrational disturbances	C2- NMBY syndrome
P3-Renewable Energy Certificate (REC)	E3- Costs of finance is high (12% - 14%)	S3- lack of coordination between administration and the community	K3- Shadow flickers are irritating	C3- Lack of community participation in planning
P4-Appropriate Legislations	E4- Wing energy costs unpredictable	S4- Noise pollution and degradation of property value	K4- Affects avian population	C4- lack of right awareness among public
P5-Institutional Credit	E5- Fluctuating foreign exchange affects technology importation costs	S5- Natural and aesthetic beauty of the landscape hampers	K5- Wind farms near wild life sanctuaries/national park disturbs fauna	C5- Diverse perceptions about wind turbine installation
	E6- Greed connection costs is high (11%-14%)	S6- Concentration if wind turbines lead to conflict with administration	K6- Disrupts habitations in some circumstances	C6- Developers and planners have less knowledge about the community
	E7- Civil works are expensive	S7- unequal access to wind energy		
	E8- Wind energy pay back has technology linkages			
	E9- Transmission costs are more due to distance			
	E10- Intermittency implies costs			

Advanced Tech - ESKC Strength

Advanced Tech	Economic Condition	Social Condition	Environmental Condition	Cultural Condition
T1- Carbon Fiber Improved Turbines and Low Intermittency	E1- Reduced wind power generation costs	S1- Ecological security from fossil fuel emissions	K1- Less damage to environment	C1- Wind energy has religious connotation and acceptable
T2- Low Costs Towers	E2- Dismal O & M costs (2%)	S2- Wind form lands are reusable	K2- Vertical shaft turbines are more eco-friendly and efficient	C2- Wind energy use has long tradition in India
T3- Autonomous Hybrid Power System	E3- Expand the scale of wind power production	S3- Community rights to have wind power amenity	K3- Wind farms abate climate change	C3- Favourable attitudes towards clean wind energy
T4- Expanded Siting of Wind Farms	E4- Competitive costs against fossil fuel	S4- Saves water compared to fossil fuel use	K4- Wind energy can offset Co2 Emission (1mw = 2600 tones Co2)	C4- Wind form myths eliminated by new models
T5- Trained Man Power at the Grass Roots	E5- Compatible policy instruments		K5- Wind farms can accommodate other greed posturing activities	C5- Environmental education is changing perceptions
	E6- Tax and duty free incentives, REC & RPO privileges			
	E7- Investments in greed connection having implications on costs			

Advanced Tech - ESKC Weakness

Viable Tech	Economic Condition	Social Condition	Environmental Condition	Cultural Condition
T1- Carbon Fiber Improved Turbines and Low Intermittency	E1- Prohibiting costs of equipment, storage and distribution	S1- Lack of communication and co-ordination among stakeholders	K1- Noise pollution is major pitfall	C1- lack of community acceptance and NIMBY syndrome
T2- Low Costs Towers	E2- unpredictable price for costs for wind energy	S2- lack of awareness about the processes of wind farm installation	K2- small turbines caused vibrational disturbances	C2- lack of public participation in planning
T3- Autonomous Hybrid Power System	E3- High costs of finance	S3- Lack of sensitivity of administration to address the community issues	K3- shadow flickering irritates eyes	C3- lack of public awareness
T4- Expanded Siting of Wind Farms	E4- Fluctuating costs of importing technology due to devaluation of currency	S4- Adverse health impacts and degradation of property value	K4- avian gets affected	C4- inadequate knowledge about rural issues
T5- Trained Man Power at the Grass Roots	E5- Higher costs of greed connection and electric line	S5- Affects natural beauty	K5- intermittent wind energy makes Co2 reduction ineffective	C5- use of common property resources is controversial
	E6- civil works, transportation and installation costs	S6- Overcrowding of wind turbines lead to conflicts with the community	K6- wind energy form dislocate habitat, human and non-human	C6- political interference in commissioning the wind farms
	E7- Uncertainty over energy payback period	S7- Uninterrupted access to wind energy and equity issues		
	E8- Initial investment costs is higher			
	E9- Transmission costs is high due to distance			

3rd Quadrant
Less Favourable Policy – ESKC Strength

Unviable Policy	Economic Condition	Social Condition	Environmental Condition	Cultural Condition
P1- Lack of integration of economic & technological Components	E1- Wind power costs declining.	S1- Public health security and health benefits.	K1- Zero emissions.	C1- Wing energy has religious sanctity
P2- Lack of coordination among the line department	E2- O & M costs are marginal (about 2%)	S2- No alienation of community lands.	K2- Boon for non greed locations	C2- Its usage has long tradition and acceptability
P3- Lack of Govt. accountability/ Fickle Nature of Policy	E3- R & D Initiatives for better viability.	S3- Citizens' right of amenities	K3- Saves water	C3- Mind sets and receptive to clean energy
P4- Lack of Support to R&D	E4- Wind power is competitive with other sources.	S4- access to clean energy.	K4- Helps to mitigate climate change	C4- Modern turbines make less noise and acceptable
P5- Difficulties in Getting Land Clearance	E5- Development of new economic instruments.		K5- Offsets CO2 (1mw=2600 Tones CO2)	
	E6- Foreign Direct Investment (FDI).		K6- Less harmful to flora and fauna compared to fossil fuel.	
	E7- Attracting private investments.			

Status Quo Tech - ESKC Weaknesses

Status Quo Tech	Economic Condition	Social Condition	Environmental Condition	Cultural Condition
P1- Lack of integration of economic & technological Components	E1- Higher Investment capital costs	S1- Lack of communication amongst stakeholders	K1- Noise pollution is hazards	C1- Community support unpredictable
P2- Lack of coordination among the line department	E2- Land transfers are tricky	S2- Lack of public awareness about the land issues	K2- Creates vibrational disturbances	C2- NMBY syndrome
P3- Lack of Govt. accountability/ Fickle Nature of Policy	E3- Costs of finance is high (12% - 14%)	S3- lack of coordination between administration and the community	K3- Shadow flickers are irritating	C3- Lack of community participation in planning
P4- Lack of Support to R&D	E4- Wing energy costs unpredictable	S4- Noise pollution and degradation of property value	K4- Affects avian population	C4- lack of right awareness among public
P5- Difficulties in Getting Land Clearance	E5- Fluctuating foreign exchange affects technology importation costs	S5- Natural and aesthetic beauty of the landscape hampers	K5- Wind farms near wild life sanctuaries/national park disturbs fauna	C5- Diverse perceptions about wind turbine installation
	E6- Greed connection costs is high (11%-14%)	S6- Concentration if wind turbines lead to conflict with administration	K6- Disrupts habitations in some circumstances	C6- Developers and planners have less knowledge about the community
	E7- Civil works are expensive	S7- unequal access to wind energy		
	E8- Wind energy pay back has technology linkages			
	E9- Transmission costs are more due to distance			
	E10- Intermittency implies costs.			

Status Quo Tech - ESKC Strength

Status Quo Tech	Economic Condition	Social Condition	Environmental Condition	Cultural Condition
T1- Immature Technology and intermittency	E1- Reduced wind power generation costs	S1- Ecological security from fossil fuel emissions	K1- Less damage to environment	C1- Wind energy has religious connotation and acceptable
T2- Inadequate wind energy technicians	E2- Dismal O & M costs (2%)	S2- Wind form lands are reusable	K2- Vertical shaft turbines are more eco-friendly and efficient	C2- Wind energy use has long tradition in India
T3- Inefficiency of Greed and Storage Facility	E3- Expand the scale of wind power production	S3- Community rights to have wind power amenity	K3- Wind farms abate climate change	C3- Favourable attitudes towards clean wind energy
T4- Lack of improved wind siting	E4- Competitive costs against fossil fuel	S4- Saves water compared to fossil fuel use	K4- Wind energy can offset Co2 Emission (1mw = 2600 tones Co2)	C4- Wind form myths eliminated by new models
T5- Non-availability of low cost turbines and towers	E5- Compatible policy instruments		K5- Wind farms can accommodate other greed posturing activities	C5- Environmental education is changing perceptions
	E6- Tax and duty free incentives, REC & RPO privileges			
	E7- Investments in greed connection having implications on costs			

Less Favourable Policy - ESKC Weaknesses

Less Favourable Policy	Economic Condition	Social Condition	Environmental Condition	Cultural Condition
T1- Immature Technology and intermittency	E1- Prohibiting costs of equipment, storage and distribution	S1- Lack of communication and co-ordination among stakeholders	K1- Noise pollution is major pitfall	C1- lack of community acceptance and NIMBY syndrome
T2- Inadequate wind energy technicians	E2- unpredictable price for costs for wind energy	S2- lack of awareness about the processes of wind farm installation	K2- small turbines caused vibrational disturbances	C2- lack of public participation in planning
T3- Inefficiency of Greed and Storage Facility	E3- High costs of finance	S3- Lack of sensitivity of administration to address the community issues	K3- shadow flickering irritates eyes	C3- lack of public awareness
T4- Lack of improved wind siting	E4- Fluctuating costs of importing technology due to devaluation of currency	S4- Adverse health impacts and degradation of property value	K4- avian gets affected	C4- inadequate knowledge about rural issues
T5- Non-availability of low cost turbines and towers	E5- Higher costs of greed connection and electric line	S5- Affects natural beauty	K5- intermittent wind energy makes Co2 reduction ineffective	C5- use of common property resources is controversial
	E6- civil works, transportation and installation costs	S6- Overcrowding of wind turbines lead to conflicts with the community	K6- wind energy form dislocate habitat, human and non-human	C6- political interference in commissioning the wind farms
	E7- Uncertainty over energy payback period	S7- Uninterrupted access to wind energy and equity issues		
	E8- Initial investment costs is higher			
	E9- Transmission costs is high due to distance			

Strategy 1: Strong Policy and Strong ESKC

P2 [E4,S4,K4,C3] = Tax Holidays/Reliefs[competition with fossils; access to clean energy; mitigate climate change; receptive to clean energy]

Tax holidays and elated tax relief measures introduced by the state shall certainly attract the investors to enter into wind energy sector. This would attract not only service developers but also those who wish to seek tax reliefs for the income earned through other business ventures. As more number of private investors gets into wind energy business, supported by policy incentives and favourable markets, the present oligopolistic market would move towards perfect competition with the companies producing energy through fossils an also higher priced energy. This would lead to the present price advantage of the fossil fuel (which is low) getting neutralised with the wind energy. Under the present transparency norms of the state where the accountability of the business houses is greater, tax holidays and associated incentives would provide cushion effect to many business groups.

Access to clean energy is a social issue in India. Many parts of the country still reel under energy poverty and inadequate access to even for lighting homes and streets. Supply of electricity is still under the control of the state. Tax rebates would pave way for a large scale private investment into this sector leading to higher production with competitive prices affordable to the weaker sections in the villages. Equity of energy distribution is still a challenge to the state and the present pace of wind energy development would reduce the energy access gap in the society.

Promoting development and mitigating climate change, hand in hand, is a political issue. It needs appropriate linkages in the system. Increase in the renewable energy production, making it accessible to all sections would contribute for reduction in CO2 and climate change. Such situation is only possible when the state introduces attractive policy instruments such as tax holidays and rebates attractive to the investors.

Simultaneously, on the receiving side, the general public need to have appropriate mind sets to use wind energy, a renewable, by paying the price less than or equal to the fossil fuel or even prepared to pay slightly higher price for wind energy. In metropolitan cities of India, the fossil fuel have created havoc and made the environment non-habitable. The health and other related social costs of fossil fuels are becoming enormous. The public are receptive to clean energy options and the conditions are ripe for promoting wind energy.

Strategy 2: Strong Policy and Weak ESKC

P3 [E10, S4, K6, C6]= REC[cost of intermittency; noise pollution and property degradation; disruption of natural habitation; lack of knowledge about the community by developers and planners]

Renewable Energy Certification (REC) is a complementary mechanism to Renewable Purchase Obligation (RPO). It is a market instrument to promote renewable energy which can be traded and exchanged for producing renewable energy. REC as an instrument can overcome some of the weaknesses of economic factors associated with wind energy production. Certain pitfalls of wind energy technology such as "intermittency" which constrain production to reach its economy to the scale would get incentives under REC. REC mechanism is like adding credits to the renewable energy producer for the quantity produced which can be traded or exchanged those incentives associated with the production. In case of wind energy, the producer can earn more REC credits during the favourable season and use it during the slack season.

The noise pollution and the consequent property degradation is another negativity of wind energy. The REC privileges given to the producer may empower for taking risks of investing in improving technologies available in the market that would reduce noise and consequently avoid degradation of the property value.

The disruption of avian and human life is a common drawback with wind turbine technologies. This would discourage many aspiring developers in India from investing in this sector despite being given REC facility. In the Indian context, given vast land space available, new siting for wind farms may be done far away from human habitat to reduce the social cost. Similar may be case with the avian life. The other option would be environmentalists and ornithologists can be invited for suggestions to divert the movement of avian life and their behaviour if possible. The other measures to reduce the disruption and associated social costs would be to keep the motivation levels of the developers intact to continue business and use REC privileges.

Very often, the developers and planners have little knowledge about the communities' perceptions and attitudes towards wind farms which make them to oppose wind farm projects. Such conflicts and oppositions can be managed by educating them about the merits of wind energy and associated benefits. The alarming levels of air pollution in many metropolises of India may be used as an illustration to convince the community about hazards of pollution. This apart, the benefits offered through REC can motivate technology to innovate the system to reduce conflicts by way of understanding community's sentiments, at times with the help of Anthropologists and Ethnographers.

Strategy 3: Strong Technology and Strong ESKC

T4[E4, S1, K3, C1] = Expanded Siting [competitive prices; eco-security from fossil fuels; abate climate change; mass appeal and religious acceptance]

Expanding wind farms sites is an important determinant of wind energy promotion in India. India is ahead of many countries in fine tuning wind energy technologies and expanding new sites to establish wind farms. The expanding siting will certainly pave way for production and storage of wind energy. This can be made available for distribution responding to the demands of the market. The expansion would mean not only the production of energy in MW, also the manufacturing of wind mills and associated accessories. Therefore, the competitive prices refer to the units of energy produced and also the hardware of wind farms, which would become competitive.

Saving the masses of India from the hazards of exposure to the fossil fuels is one of the commitments of the state. Expanding the wind farms siting and making clean energy available for masses is a bold step in the direction of providing ecological security and freedom from air pollution. Providing ecological and environmental security is a human right issue and an indicator of sustainable development.

Obviously, the expansion of wind farm siting and increased production will contribute for climate change in the long term. The expansion of siting presupposes that other linkages will be in place such as storage, grid, transmission lines, market and demand. All these linkages ensure the potential consumers transit towards cleaner energy use. Under the conditions of strong system's components, there are better chances of increasing cleaner energy production and use.

In the Indian cultural context, wind is one amongst the five gods governing the universe (Pancha-Bhuta). Therefore, the energy produced through wind has religious sanctity and acceptable, especially, in rural areas. While promoting wind energy at the community level, this religious dimension of wind energy may be sited in the social marketing strategies. This would reduce the resistance from the community while installing wind farms and motivating them to use wind energy in rural areas.

Strategy 4: Strong Technology and Weak ESKC

T4 [E1, S1, K1, C1] = Expanded Siting [prohibiting costs; weak coordination among the stakeholders; noise pollution; lack of community acceptance (NIMBY)]Wind energy promotion may face challenges and setbacks under the conditions of strong technology and weak system's components. Expansion of wind farm siting adversely get affected if the wind power economics proves to be costly and expensive. This includes hardware of the wind farms and cost per unit of energy produced. Under strong technology, when the costs are prohibitive, expansion of siting may be allowed to proceed for some time until supply side reaches some saturation so that the costs are compelled to go down due to increase in supply. As a short time intervention, state may intervene in the market and incentivise or subsidise the power tariff, for some time to make the costs affordable. This strategy may set the demand and supply equilibrium to be stable in the medium term.

Weak coordination amongst the stakeholders may pose a serious problem for promoting wind energy despite strong technical options available for application. Under such circumstances, the better option would to create some institutional mechanisms to overcome the bottlenecks in coordination.

In a free market condition such institutional mechanisms keep evolving responding to the attractive incentive regimes in place. However, for the initial period, when the stakeholders' constituency is in disarray, the emerging markets may take time to create conditions conducive for the stakeholders to institutionalize themselves to ensure proper coordination. Until such time, state can come forward to create institutions for better governance. In India, Indian Energy Development Agency (IEDA) and Maharashtra Energy Development Agency (MEDA) are good illustrations of state initiated institutions.

It is reported in the literature, that in many advanced countries, noise pollution is considered as hazardous due to wind farms and there are protests by the community. However, in the Indian context, noise, so far, is not taken seriously, even in the urban areas. If that would have been the case, horning vehicles in the middle of the night should have been protested in many Indian cities. Such protests are not in the news. In case of protests against the noise, the developers and the state would think of modern turbines which are available which make less noise.

Similar is the case with NIMBY (Not In My Back Yard) syndrome which is not familiar to Indian communities. Perhaps, it is a long way to go until wind turbines reach back yards of the individuals.

Strategy 5: Weak Policy and Strong ESKC

P3 [E6, S3, K4, C2] = Fickle nature of the policy [FDI; right to amenities; mitigate climate change; tradition of wind energy use]

Under a weak policy regime, which is a prime driver in the whole process would weaken strength points of the system's components such as economy, social, environmental and cultural conditions or may have to exert higher pressure to mend the ways of a weak policy. For instance, in investment starved India, FDI needs to be supported through appropriate policy instruments. If the policy remains weak, feeble and fickle, due to opposing political lobbies, investors from abroad may not show interest to invest in India. Policy needs to be strong and supportive to attract FDI.

Human Rights activists and citizens' fora would demand for clean energy and clean environment as their right. Weak policy regimes may not do much to fulfil the aspirations of these groups. Further, mending of policies would depend on how strong these lobbying groups are? What are their influences on the decision makers? And what is their control over the voters? These questions remain critical in policy advocacy issues. Under the conditions when other system components are congenial, due to weak policy drive, achieving clean energy targets is difficult.

The broader objective of the clean energy mission is to mitigate climate change, policy regime being the important driver in the system is expected to take a major role in moulding other components. In the present case, policy instruments are weak, and may lead to weakening of the other system's components. In the International fora, weak policies of India may become a subject of criticism and may have implications on international trade and commerce, and consequently hamper the economy of the country. India may lose its influence on international politics. This would cost dearly to the Indian nation state and its sphere of influence in domestic and international affairs.

The cultural capital, in the form of values and institutions, congenial for wind energy promotion may go waste under weak policy regime. The human rights lobbies, may make use of this cultural capital to organize and mobilize, public opinion in favour of clean energy and strengthen their lobby to bring out necessary changes in the policy. Such efforts may take medium or long term time period with support of other stakeholders. The weak policies would ruin the spirit of clean energy mission in general and wine energy in particular.

Strategy 6: Weak Policy and Weak ESKC:

P1 [E2, S7, K4, C4] = Lack of Integration [tricky land transfers; unequal access; affect avian life; lack of right awareness]

Lack of integration and coordination among the different line departments is a reflection of weak policy instruments and weak governance. When the prime driver policy is weak and has to work with weak system's components, the results would be disastrous. In the Indian context, the departments of Energy, Forests and Revenue would constitute a good illustration to "lack of integration". For acquiring lands for wind farms all the three line departments have to work in an integrated way as they share a common objective, that is, reducing emissions. Some lands may come under the jurisdiction of Revenue Department while others under the Forests. If they work under isolation, it would be difficult to implement to wind energy projects either under public or private sector. Currently, this issue of inter-departmental integration is an evolving mechanism of governance in India.

Indian society is highly stratified and segmented on the lines of caste, class, power and religion. Therefore, sharing of any resource is likely to percolate down unequally. Lack of integration as a policy instrument would accentuate unequal access to clean energy in already fragmented society and lead to conflicts. Egalitarian energy access could be the goal of this mission.

Wind farms affecting avian life may be a serious issue in India, in the medium term, when the scale of wind farms reaches its optimum level. Until such time the projects can be continued. Diverting the avian life to safer places is another alternative. With the support of ornithologists, appropriate plans may be worked out. Initiatives to protect avian life from wind farms are already in progress in many countries and lessons can be drawn from their experiences.

Lack of right awareness among the masses about the advantages of wind energy would be a major challenge in this mission. The lack of integrated policies may only facilitate spreading the wrong signals to the public when the new sites are commissioned. Under such circumstances, civil society organizations can assume the role of creating right awareness among the masses and the stakeholders. Lack of integration among the line departments is a weak policy driver and may further weaken the other system's components.

Strategy 7: Weak Technology and Strong ESKC

T1 [E1, S3, K2, C4] = Immature Technology/Intermittency [reduced cost; right to amenity; efficient vertical turbines; new turbine designs with less noise]

Immature wind farm technology, with problems of intermittency can move ahead with some progress under the strong and favourable conditions of system's components. The reduced costs of commissioning wind farms, that is, hardware, would still encourage the stakeholders to choose wind energy options. Because, the input cost is free, that is wind. Reduction in cost of the wind energy per unit produced will certainly make the consumers to use this energy irrespective of the fact whether the technology is advanced or not. As a policy issue, if the costs are kept competitive with the fossil fuels, consumers would accept it since they are concerned with energy per se and not the source from which energy is produced.

At the community level, citizens, as rational individuals, always strive for secured clean energy at a reasonable price as a human rights issue. Clean energy availability to the citizens is the obligation of the state. At the given point of time, whatever the technology available in the market, state is expected to make arrangements to ensure access to its citizens. The goal is to reduce emissions with the available technology mediated through the state. Pressure from the citizens' lobby is essential to evolve clean energy alternatives.

Technology option can never be an end in itself since it is an evolving process. The best available technology at the given point of time should be in place. In a global mission like "reduction of emissions" there is a need for transfer of technology without constraints from one corner of the world to another. Such initiatives would reduce emissions on global scale. Vertical turbine wind farms are considered to be more efficient within the available alternatives and may be advocated wherever viable in the Indian context.

Noise and ugly looks and flickers are some of the culture specific pitfalls with the existing wind turbine technology. A number of new designs are now, available in market. These new designs may have better appeal culturally, as compared to the old models. Even though there are technological shortcomings, in terms of intermittency and immaturity in storage, wind farms can be promoted under favourable system's components. Therefore, the shortcomings in present technology may not be a major constraint for promoting wind energy while other components are strong and favourable.

Strategy 8: Weak Technology and Weak ESKC

T4 [E7, S3, K4, C2] = No improved siting [uncertain pay-back period; insensitive administration; ill effects on avian life; no public participation]

Lack of technology initiatives for locating new sites for wind farms may lead to a major setback for expansion of wind energy. Expansion of wind farms is indispensable. In the absence of improved siting methods for augmenting wind energy production and the weak system's components would hinder the promotion of wind energy. The weak technology in the present together with weak system's components would conceptually, lead to downward spiral in the medium term and would lead to elimination of wind energy projects. The available limited siting of wind farms would not be adequate for the private developers to pay back the cost of investment they would make in different sites. For them, the investment would work out economy to the scale when the production levels reach optimum. The private investors should have scope to produce reasonable profit margin out of wind energy business. This would mean, expanding the number of sites where in the aggregate quantity of wind energy would help to reach reasonable profit margin. This would facilitate to overcome the uncertainties associated with the payback period. Unless such arrangements are in place, private sector cannot take-off wind energy production.

Insensitivity of the administration to respond to the needs and aspirations of the citizens for clean energy would further the down spiral trend in wind energy production. Administration is expected to be sensitive to the needs of the society. Under the conditions of administrative laxity state would not be successful in protecting the masses from the ill-effects of emission. State reaches out to the common public through its administrative machinery.

In the Indian context, ill-effects of wind farms on avian life are a minor issue until now. However, this may pose a problem when the wind farm expansion reaches its peak. Perhaps, that would be the time when environmentalists would protest the ill effects of wind farms on avian life and the aesthetics of nature. They may align with the locals to stall the wind farm projects or demand for the compensatory packages which would cost dearly to the state or the corporate.

Citizens' participation would necessary for the success of wind farm projects. Lack of participation may create setback to the wind energy projects. This will have ramifications on other weak components of the system and would adversely affect the program.

CONCLUSION

Out of the eight strategy alternatives discussed in the receding section, strategy-1 and strategy-3 are the critical determinants for the expansion of wind energy farms in the region. These would be idealistic scenarios. These two strategies are supported by strong policy instruments and advanced technology packages as the prime drivers supported by favourable system's components. The policy and the technological conditions chosen for strategizing wind farm expansion appear to be appropriate and determining (eg: tax rebates/incentives and wind farm siting technology). These drivers are supported by strong other system's components. The strategy-5 and strategy-7, despite being weak in policy instruments and technology components, due to strong system's components, due to strong system's components, there are ways to mend drivers suitable for wind farm expansion. These would be realistic scenarios. The strategy-6 and strategy-8 depict both the drivers and the system's components are weak and the combined weaknesses lead to a downward spiral effect on the project. The drivers and the supportive components force the situations vulnerable for stagnation and regression in achieving the goal. These are pessimistic scenarios. Further, the analysis reveals that the policy is more critical driver than the technology. The shortcomings of the existing technologies can be overcome through appropriate policy instruments. The strong policy driver can eliminate the weaknesses of the system components. Thus, the model throws open a number of viable alternatives for planners and developers.

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ANNEXURE

1. Strong Policy and Strong ESEC

a) *P1*

E1	S3	K2	C3
E4	S4	K4	-
E5	-	K5	-
E7	-	-	-

b) *P2*

E1	S3	K1	C3
E2	S4	K2	-
E4	-	K4	-
E6	-	K5	-
E7	-	-	-

c) *P3*

E3	S4	K2	C3
E4	-	K4	-
E6	-	-	-
E7	-	-	-

d) *P4*

E3	S2	K2	C3
E6	S3	K4	-
E7	S4	K5	-

e) *P5*

E1	S3	K2	C4
E3	S4	K4	-
E4	-	-	-
E7	-	-	-

2. Strong Policy Weak ESEC

a) *P1*

E1	S1	K1	C1
E3	S3	K4	C3
E4	-	K5	C6
E8	-	-	-
E10	-	-	-

b) *P2*

E1	S1	K4	C1
E3	S3	K5	C3
E4	-	-	C4
E8	-	-	C5
E9	-	-	-

c) *P3*

E3	S1	K4	C1
E4	S3	K5	C3
E6	S4	K6	C5
E8	-	-	C6
E10	-	-	-

d) *P4*

E1	S1	K4	C1
E2	S2	K5	C3
E4	S3	-	-
E8	S7	-	-
E10	-	-	-

e) *P5*

E1	S3	-	C1
E3	S7	-	C6
E6	-	-	-
E7	-	-	-

3. Strong Technology and Strong ESEC

a) *T1*

E1	*S1*	*K1*	*C3*
E3	*S3*	*K2*	*C4*
E4	-	*K3*	-
E6	-	*K4*	-
E7	-	-	-

b) *T2*

E1	*S2*	*K1*	*C2*
E2	*S3*	*K2*	*C3*
E4	-	*K3*	-
E7	-	*K4*	-

c) *T3*

E3	*S1*	*K1*	*C3*
E5	*S3*	*K2*	*C4*
E7	-	*K3*	*C5*

d) *T4*

E1	*S1*	*K1*	*C1*
E3	*S3*	*K2*	*C3*
E4	*S4*	*K3*	*C3*
E5	-	*K4*	-
E6	-	-	-

e) *T5*

E1	-	*K3*	*C3*
E2	-	*K4*	*C5*
E3	-	-	-

4) Strong Technology and Weak ESEC

a) *T1*

E1	*S1*	*K1*	*C1*
E2	*S2*	*K5*	*C2*
E3	*S3*	-	*C5*
-	*S7*	-	-

b) *T2*

E1	*S2*	*K1*	*C2*
E3	*S6*	*K2*	*C3*
E5	-	-	-

c) *T3*

E2	*S2*	*K1*	*C2*
E4	*S3*	*K5*	*C3*
E7	*S7*	-	*C4*
E9	-	-	-

d) *T4*

E1	*S1*	*K1*	*C2*
E5	*S2*	*K2*	*C3*
E6	*S3*	*K4*	*C4*
E7	*S6*	*K6*	*C5*
E9	*S7*	-	*C6*

e) *T5*

E3	*S3*	-	*C2*
E7	*S7*	-	-
-	-	-	-
-	-	-	-

5) *Weak Policy and Strong ESEC*

a) *P1*

E1	S2	K2	C2
E3	S3	K4	C3
E4	S4	K5	-
E6	-	-	-
E7	-	-	-

b) *P2*

E1	S2	K1	C1
E3	S3	K2	C2
E4	S4	K4	C3
E6	-	K5	-
E7	-	-	-

c) *P3*

E1	S2	K1	C1
E3	S3	K2	C2
E4	S4	K4	C2
E5	-	K5	-
E6	-	-	-
E7	-	-	-

d) *P4*

E1	S3	K1	C1
E4	S4	K2	C2
E5	-	K4	C3
E6	-	K5	-
E7	-	-	-

e) *P5*

E4	S2	K1	C1
E5	S3	K4	C3
E6	S4	E5	-
E7	-	-	-

6) *Weak Policy and Weak ESEC*

a) *P1*

E2	S1	K4	C1
E4	S3	K5	C3
E5	S7	K6	C4
E8	-	-	C5
E10	-	-	-

b) *P2*

E1	S3	K4	C1
E2	S6	K5	C3
E4	S7	-	C5
E5	-	-	-
E8	-	-	-
E10	-	-	-

c) *P3*

E1	S1	K4	C1
E2	S2	K5	C2
E5	S3	K6	C4
E8	S7	-	-

d) *P4*

E1	S3	K1	-
E4	S4	K2	-
E6	-	K3	-
E10	-	-	-

e) *P5*

E1	S1	K4	C3
E2	S3	K5	C4
-	S5	K6	C5
-	S6	-	-

7) Weak Technology and Strong ESEC

a) *T1*

E1	*S1*	*K2*	*C2*
E3	*S3*	*K3*	*C4*
E4	*S4*	*K4*	*C5*
E6	-	-	-

b) *T2*

E2	*S1*	*K2*	*C3*
E3	*S3*	*K3*	*C4*
E4	-	*K4*	-
-	-	-	-

c) *T3*

E1	*S1*	*K1*	*C1*
E3	*S3*	*K3*	*C3*
E4	-	*K4*	-
E7	-	-	-

d) *T4*

E1	*S1*	*K3*	*C3*
E3	*S3*	*K3*	*C5*
E4	-	-	-
E5	-	-	-

e) *T5*

E3	*S1*	*K1*	*C2*
E4	*S3*	*K2*	*C3*
E5	-	*K3*	-
E6	-	*K4*	-

8) Weak Technology and Weak ESEC

a) *T1*

E1	*S2*	*K1*	*C2*
E5	*S3*	*K2*	*C3*
E9	*S7*	*K3*	-
-	-	*K5*	-

b) *T2*

-	*S3*	-	*C2*
-	*S7*	-	*C4*
-	-	-	-
-	-	-	-

c) *T3*

E1	*S2*	*K5*	*C2*
E2	*S3*	-	*C4*
E5	*S7*	-	-
E9	-	-	-

d) ***T4***

E1	*S1*	*K1*	*C2*
E2	*S2*	*K4*	*C3*
E5	*S3*	*K5*	*C6*
E7	*S7*	-	-

e) *T5*

E1	*S7*	*K1*	*C6*
E3	-	*K4*	-
E5	-	*K5*	-
E8	-	-	-

SOLAR ENERGY FUTURES FOR SOLAPUR SMART CITY: A PESTEC APPROACH

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ABSTRACT

This study presents a comprehensive analysis of renewable and especially solar energy through a political, economic, social, technology, environmental, and citizen/consumer (PESTEC) analysis approach and by reviewing the most up to date relevant literature and the field rights available. The study focuses on the Solapur Smart City given the favourable environmental resources for such technologies; the number of solar projects proposed by the local Municipal Government as well as attracting huge amount of the private and public investment in upcoming years. Findings of the analysis identify the challenges and opportunity, and multiple stakeholders involved at all stages of the solar energy projects development from the conceptualization of the design, right through to decommissioning. Many of the stakeholders present benefits through funding, incentives and knowledge sharing to the potential risks in the future of the projects. From this study it can be concluded that several of these challenges can be mitigated early and the opportunity for the future by providing incentives to the stakeholders involved to making Solapur most liveable city with new eco-friendly amenities to the citizens.

Keywords: Solar, Challenges, Smart City, Energy, Future.

INTRODUCTION

Urban areas will occupied around 66% of the world's population by 2050. In India about 32% of population lives in urban areas as of 2014. The rising migration to these developed cities necessitates that our cities be 'smarter'. Realizing this need, the Government has started the 'Smart Cities Mission'. The Smart Cities Mission is an ambitious initiative taken by the Government of India. It seeks to redefine not just urban life but also the Indian economy and our social structure as a whole. It has transformational potential; however, this undertaking necessitates change in the paradigm in the way of managing our cities. The Smart Cities is a thoughtful ideal which brings multiple ideas under it and that involves whole economic sectors in themselves. The Energy is one such idea reflected in the Smart-Cities' architecture and design. The Energy is the primary requirement among the long list of public goods and services that a city provides its inhabitants. The Energy has direct and indirect impacts on the almost every other sector, including critical ones such as water, transport, and industry etc. This makes Energy one of the topmost priorities when addressing the Smart Cities Mission. Before implementation begins, the mission has to develop the definitional framework with well-defined standards and design that are suitably modified only to meet regional and local objectives or constraints. The stakeholders' involvement and participation would act as the preliminary step towards achieving this objective.

Solar energy is a major renewable energy source with the potential to meet huge energy demand. The use of Solar Energy is increasing in popularity because it is versatile use with many benefits to people and the environment. Solar energy is a safe alternative which can replace current fossil fuels like coal and gas for generation of electricity that produce air and water pollution and land degradation. Therefore, solar energy is a clean renewable resource with zero emission, and it has tremendous potential for energy production which can be harnessed using a variety of devices. With recent developments, solar energy systems are easily available for industrial and domestic use with the added advantage of minimum maintenance. Solar energy could be made financially viable with government tax incentives and rebates. Most of the developed countries are switching over to solar energy as one of the prime renewable energy source.

Against this background, the study seeks to be a 'conversation starter' around the idea of Solar Energy integration in to Smart Cities and would kick-start wide consultations with stakeholders that would ultimately inform government policy towards a cogent and cohesive implementation framework for executing the Smart Cities Mission in India.

BACKGROUND

Solapur city has been selected by the Ministry of Urban Development, Government of India (GoI) as one of the top 10 cities for developing as a "Smart City". Accordingly, the Local Government Body (LGB) has been prepared the Smart City Proposal (SCP) a master plan for making Solapur as a Smart city. As per the Smart Cities Mission Guidelines by GoI, It has been mandated that 10% of the smart cities' energy requirement will come from solar energy and at least 80% buildings should be energy efficient and green buildings. In this context, LGB has estimated a number of plans such as installation of solar panels on the area of municipal buildings, stadium, and bus shelters. Furthermore, LGB is projecting energy efficient solar street lighting and installation of solar panels in public space. Solar PV panels on all these facilities will be generating 2.4 MW (i.e. 12% of energy demand in selected area).

The scenarios compiled all expected to help the SMC to find a direction for their experimentation and piloting. In doing so, the study will help to identify challenges and future opportunities before the SMC. The study also brings out the highly unpredictable events which can carry a massive impact on the smart city project. On the other side, the study aims to demonstrate the increasing importance of sharing economy solutions in the quest for sustainability through the solar energy.

POTENTIAL IN THE SOLAPUR CITY FOR SOLAR ENERGY

Solapur city is located in the south-western region of the Indian state of Maharashtra. Solapur is located on major road and rail routes between metro cities like Mumbai and Hyderabad, with a branch line to the cities such as Bijapur and Gadag in the neighbouring state of Karnataka. However, Solapur is classified as a 2 Tier and B-2 class city in India, although it is the 49th most populous city in India and the 43rd largest urban agglomeration (SMC 2017).

As per 2011, census of India, the population of Solapur city in 2011 was 9,51,118. The average literacy rate of Solapur city is 83.88%.Hinduism is the major religion in Solapur city with 75.73% followers (Census of India, 2011). The civic administration of the city is managed by the Solapur Municipal Corporation, which was established on the 1 May 1964. The corporation oversees the engineering works, health, sanitation, water supply, administration and taxation in the Solapur city. The corporation is headed by a mayor who is assisted by municipal commissioner and elected representatives. The Solapur city is divided into 135 wards and 6 zones. The corporation members also known as corporators are elected by the citizens of Solapur after every five years (SMC, 2017).

Solapur City's energy demand of 135 megawatt is completely met by the non-renewable energy sources. However, the Solapur is located in solar intensity zone 1, and there is enough potential for solar energy utilization. In Solapur city has around 250–300 sunny days per year. An annual average solar irradiation value of 5.34 kWh/m2/day makes Solapur a suitable city to tap solar energy and solar power generation (Solar Energy Centre, 2015).

OBJECTIVE

Following are the objectives of the study;

- to comprehend analysis of solar energy issues for Solapur city through a PESTEC analysis approach.
- to study the challenges and opportunities of the solar energy within the Solapur city.
- to identify the high risk the Solapur smart city may vulnerable; and
- to develop the various solar energy scenarios for the Solapur city.

METHODOLOGY

The study employs horizon scanning method using PESTEC analysis. The black swan scenarios are constructed to carry out the unpredictable events which may impact on the solar energy project. Various e-resources used to understand the challenges and debates for the promotion of solar energy in the Solapur smart city. To carry-out this exercise, PESTEC analysis and horizon scanning are together used to identify and each one is considered for developing future opportunities considering the present situation and the bottlenecks. The analysis is presented in the comparative table manner. This exercise is limited to the Solapur smart city context of solar energy.

PESTEC ANALYSIS

This section provides the core part of the study. However, the study considering PESTEC as critical drivers and the analysis has been made to explore the challenges and future opportunities for solar energy sector in Solapur smart city.

Table 1: PESTEC Analysis.

Challenges	PESTEC	Opportunities
• Three-tier Governance • changes in legal and regulatory systems • heterogeneous and complex formalities • Transparency in authorization, certification and licensing. • Absences of solar manufacturing industry.	Political	• Conducive policy & regulatory framework • Promote the investment on solar manufacturing industry • Lobby activity and educate the politicians. • Incentive for citizen and private institutions
• Inadequate financial capability • Low cost substitute conventional energy dominance	Economical	• Public Private Partnership (PPP) model has potential. • Progressive cost reductions • Financial incentives on the solar rooftop installations • saving and earning money by solar
• Misinformation and poor dissemination • Non-involvement of private individuals and institutions • Unavailability of skilled employee	Social	• Paradoxical messages • Public campaign • Collaborative work • incentive schemes • Employment generation • Improves local micro economics • Poverty alleviation • Solapur University as knowledge transfer source
• cost reduction in installed capacity • complexity of manufacturing process • underperformance of cells • dependency on scarce materials • Advanced storage technologies • Integration into the network	Technological	• R & D to develop sustainable technologies using abundant materials. • Adopting advanced storage devices like tesla batteries. • Smart grid connection.

• grid connectivity • Dust accumulation		• Adopt advanced technologies to counter the dust problem
• Solar life-cycle emission • Use of hazardous materials • Workers harmed by exposure to hazardous chemicals. • Recycling of solar panels • adversely affect native vegetation and wildlife	Environmental	• Rare materials like are recycled rather than thrown away.
• Risk of accidental fire • Visual impact	Citizen	• Contribute to sustaining the status in the society. • Economic and social integration benefit to the citizen.

Political

Politics has the potential to have a dramatic effect on the future of solar energy offering many opportunities alongside many risks to existing and future solar developments in Solapur city. The SMC alone does not have complete control as its policies are dictated to an extent by Central and State level politics. Stability of the elected Government varies at Central, State and Local levels. The political framework and the regulatory constraints affect investments in the solar energy sector decisively. Frequent changes in legal, regulatory or tax systems introduced by a government may lead to the absence of a clear coherent solar energy policy and a concise planning. These unstable and unpredictable conditions create uncertainty. Therefore, the state is required to prepare conducive policy & regulatory framework to strengthen the progress.

Another important factor for smart city in solar energy project is the administrative procedural management and the forecast for the result of the policies implemented, which usually turn out to be inefficient. The formalities are often cumbersome and complex as different political parties leads Governments at various levels. The transparency and corresponding rules regarding authorization, certification and licensing are still needed.

Solapur region does not have a solar panel manufacturing industry. Solapur city also has to depend on other regions for the maintenance of the solar panels as well. SMC will need to take political decision to promote the investment on solar manufacturing industry in the Solapur region. They can also prepare some schemes for attracting the investor to manufacturing solar panels locally.

The political issues of solar energy are of great importance in the smart city development project, since the solar industry still is at an early stage and to some extent dependent on subsidies from the government. For SMC, it is important, as a way of achieving their goals, to have political linkages so that the corporation can execute lobby activity and influence the politicians, on the corporations' opinions regarding political issues related to the renewable energy (Paul Breeze 2008).

Economical

The overall economic framework meets more relevant factors as regards strategic concerns: availability of funds, technological competitiveness compared to other forms of energy generation, exchanges rate, inflation in the costs, risks affecting cash flow of investment and investment and absolute or relative energy price changes that undermine the profit margin of the investment.

The Solapur city falls under the second tier city as compared with the income generation. Therefore, SMC has inadequate financial capability for funding the big solar projects in Solapur. However, this problem can be tackled with the public-private-partnership (P-P-P) establishing solar energy projects.

Solar energy efficiency has synergy with economic competitiveness. There are growing number of policies to address them in related to economy targets and regulations. The competitiveness of the solar energy sector compared to other energy generation technologies, depends on the reduction of costs and selling prices of solar energy. In the last

Decade, they had seen a reduction in the range of 50% to 70% of solar panel costs, a major contribution to the exponential growth experienced by the renewable energy sector. Progressive cost reductions will allow achieving the medium-term grid parity so that solar technology would be in a position to compete with both other renewable and conventional energies.

Similarly, low cost substitute conventional sources of energy are already present in the Solapur market in a dominant form. Therefore, the awareness among the society is required to promote the solar energy. Solapur is the city of middle and low income group citizens, in this sense the solar rooftop installations seem to be beneficial for individual households to save money as well as earn money by selling additional energy produced by the solar.

Social

The commitments expressed in the Conference of Parties COP21, Paris encourages the participation of citizen in the renewable energy markets, generating and consuming their own energy source, with consequent saving in electricity bills. Indeed society is increasingly aware of environmental changes and shows greater concern about environment conservation. But they do not receive clear information within the general context of energy. In some countries, misinformation and poor dissemination of the socio-economic benefits of renewable energy sector have caused confusion and rejection by public opinion. Therefore, paradoxical messages must issue stronger measure to curb the effects of climate change and rejection signs against renewable energy. Public campaign helps to increasing awareness to use solar energy as it is a clean and pollution free energy source and can motivate peoples to change traditional mind set. The collaborative work with community can be beneficial to expand the use of solar energy in the city; while it also contributes to reduce world carbon gas emissions and carbon footprints.

Solapur smart city development plan does not include private individuals and institutions to contribute solar energy maturation. Social engagement is essential to share the benefits. For encouraging community, the SMC should chalk-out incentive schemes specifically for citizen and private institutions using solar energy.

Solar energy can create full- and part-time jobs during installation and maintenance process that will help to improve local household economics and drives to poverty alleviation. Along with this, the skilled manpower is required for cleaning and maintenance of solar panels, which is not available in the Solapur city at the movement. SMC have to bring skilled human resources from other areas. All this will result higher operational costs. This problem can be reduced by collaborating with Solapur University encouraging colleges as a knowledge partners. Solapur University's initiative in research and development might help to address the solar energy issues. Along with this, the University can also run the education and training course on the solar energy. This will fulfil the requirement of skilled man power for cleaning and maintenance of solar panels in the Solapur city.

Technological

The energy model systems should tend towards a more decentralized and diversified. This would be more rational and efficient model perfectly fits in the solar energy resources, given its abundance and the benefits of their technology on the issues of modularity and versatility.

There are three relevant issues concerning Solapur smart city context. They are cost, storage and distribution network. The first one is cost reduction in installed capacity including both solar panels and balance of system costs. Regard with to the solar panels, the most advanced and mature technology that led the market is composed of silicon cells (c-Si), but it still has some limitations (MIT2015). Two such limitations are the complexity of manufacturing process and the underperformance of cells. In this respect, this is an opportunity for industry players to further the improvement in efficiency and reduce costs. Another vital limitation is the dependence on scarce materials such as silver, one of the major impediments to large-scale development of the solar panel manufacturing industry. It is an opportunity for research and development sector to develop sustainable technologies using abundant and cheaper materials on the planet (MIT 2015).

The second most important factor is the need to develop new competitive storage technologies, as mass implementation depends on them. The development of these storage mechanisms is bound to the manageability of the facilities connected to the network and will encourage consumption of solar energy.

The third issue related to photovoltaic development is its integration into the network. Transport infrastructure, distribution and management mechanisms are insufficient and in many cases suffer major capacity constraints. So, there is need to improve the quality of the network, to adapt the administration management and coordination between the different agents will allow achieving the objective of stabilization and security of supply, meeting the demand while providing value-added services.

There is a great potential for solar power utilization in the Solapur city by employing solar photovoltaic (PV) modules. But, the dust accumulation on the surface of solar PV modules, mirrors, reflectors and other solar collectors is of great concern due to dust in the Solapur city. Solapur city is one of the most dust prone city in the country. So, the dust issue is major obstruction to the solar projects in the city. The performances of such solar devices are significantly affected by dust accumulation. According to a study indicates that power decrease by as much as 50% can be experienced for solar PV modules that are left unclean for a period of over six months. Solar tracker improves power output and helps reduce dust accumulation effect by 50% at off-peak time (Muhammedet al.2013).

Environmental

Global warming and emissions can be reduced from solar energy, but emissions associated with other stages of the solar life-cycle, including manufacturing, materials, transportation, installation, maintenance, and decommissioning and dismantlement. (IPCC 2011)

Hazard classification of chemicals typically used in solar panel (PV) manufacturing includes a variety of acids or corrosive liquids. These acids or corrosive liquid contains hydrochloric acid, sulphuric acid, nitric acid, and hydrogen fluoride. These chemicals are mainly used for the cleaning of wafers or to remove impurities from raw semiconductor materials. Solvents comprise 1,1,1-trichloroethane and acetone are also used in large quantities in the various cleaning stages conducted during the production processes. Etching compounds such as sodium hydroxide can also be used in large quantities. Therefore, manufacturing of solar cells involves the use of multiple chemicals classified as hazardous, including highly explosive and toxic gases (Roni George et al.2016).

Workers arealso facing risks associated with inhaling silicon dust. Thus, solar panel (PV) manufactures must follow U.S. laws to ensure that workers are not harmed by exposure to these chemicals and that manufacturing waste products are disposed of properly. If these hazardous materials are not handled and disposed of properly, they could pose serious environmental or public health threats (Hand M.M. et al. 2012).

The recycling of solar panels is the big issue, specifically, there aren't enough locations to recycle old solar panels, and there aren't enough non-operational solar panels to make recycling them economically attractive. Recycling of solar panels is vitally necessary due to the materials used to make the panels are rare or precious metals, all of them being composed of silver, tellurium, or indium. Because of the limitability of recycling the panels, those recoverable metals may be going to waste which may result in resource scarcity issues in the future. Moreover, manufacturers have a strong financial incentive to ensure that these highly valuable and often rare materials are recycled rather than thrown away. (IPCC 2011)

The use of large scale rooftop areas for solar panel facilities can adversely affect native vegetation and wildlife in many ways, including loss of habitat; interference with rainfall and drainage; or direct contact causing injury or death. The impacts are exacerbated when the species are classified as sensitive, rare, or threatened and endangered (Handbook of Renewable Energy Technology2011).

Citizen/Customer

Solar panels (PV) may release the hazardous materials which are likely to occur as a result of abnormal plant operations, damaged modules or fire and therefore pose risk to public and occupational health. The increased potential danger of electrocution from the direct current produced by systems and this needs to be taken into account especially by untrained users. (Roni George et al. 2016).

Solapur City's energy demand of 135 megawatt is completely met by the non-renewable energy sources as of date. These resulted in increased pollution in the Solapur city which again bad effect on the health of the citizen. However, the Solapur city has an annual average solar irradiation value of 5.34 kWh/m2/day and this makes a suitable city to tap solar energy and solar power generation. This will also help to reduce pollution and improve the health of the citizens. Thus, SMC can contribute to sustaining the standard of living status in the society through economic and social integration.

With regards to visual impact, one person's beauty is another person's eyesore. For some people, solar panels evoke positive feelings, even when set in a rooftop. For others, the sight of a solar panel invading a pristine desert rooftop beauty. It's largely a matter of opinion.

BLACK SWANS ANALYSIS

The concept of black swan refers to an event that is highly improbable and difficult to anticipate, and which has dramatic impacts if realised. According to Nassim Nicolas Taleb's (2007) definition, black swans are events that cannot be foreseen. Taleb claims, that black swans are an interpretation to almost every significant event in our world. Black swans, wild cards and X events (Casti 2017) are used almost synonymously to refer to sudden, surprising, unanticipated events with broad and radical effects (Heinonen 2013). Black swans are the most debated developmental paths along with weak signals paths within futures studies. However, there may be a lot of information available about the common trends; it is more difficult to foresee the unexpected developments (Steinmüller 2007, 22–23). The study is tries to critically analyse the highly improbable and unpredictable events that would carry massive impacts on the solar energy development in the Solapur city.

Table 2: Black Swan

Political	• China will stop supplying cheaper solar panels and related material. • Government would lose their control and coordination.
Economics	• Cheap non-renewable energy supply by NTPC / import from neighbouring states.
Social	• Boycott solar due misconceptions.
Technological	• Collapse storage system due to dependency on scarce material.
Environmental	• Accidental releases of hazardous gases or vapours
Citizen	• Consumer due to lower cost switching towards the Substitute non-renewable sources

The SMC has been importing solar panels (PV) from China. Most of the Indian companies are only assembling the solar panels components which one manufactured in the China. Therefore, majority of Indian solar panel (PV) industries are depends on the China. There is plausibility or the relations huge scope for the black swan, if the war situation arises between the Indian and Chinese military, or the relation soar. That will also affect the business sector. The supply of new solar panels and related material can completely stop due to conflict. This will create worst situation for Indian solar industry due to its dependency on China.

In case of the governance system in India, it has three tiers Government i.e. Central, State, and Local. Currently, all at the three tiers are headed by one single political party. However, in the future elections the situation may or may not be the same at different levels of governance. There would create black swan. If three tier governance is ruled by different political parties, this situation, would affect smart city project and lose their control over the effective coordination between central, state and local government agencies on various issues related to financing and sharing of best practices and service delivery processes.

National Thermal Power Corporation (NTPC) is setting up coal based power plant with capacity 1320 MW near the Solapur city. The first phase with 660 MW capacities is already constructed and expected to complete the second phase soon. The black swan would fall on the solar energy sector of Solapur city when NTCP starts working with full capacity. Perhaps, there would be drop-in the price of non-renewable energy due to increase in large scale production. Under such situation the solar power price per unit can't complete with the NTPC rate. The average Indian consumers are more price conscious than anywhere else in the world (C. Lakshman 2015). Therefore, there will be the danger of switching of the customer to cheap non-renewable energy source (coal based).

There has been a growing awareness among citizens, of the benefits of sustainable energy products such as solar rooftop. According to a report by Amazon India, demand for solar rooftop and green products online is the highest in urban and semi-urban cities. Perhaps, the society is not getting the complete information about the solar energy or they receive misinformation and poor dissemination that will create confusion and rejection by the public. Condition of this type may destruct whole solar energy development due wide misconceptions.

Solar energy can be powerful instrument to mitigate fossil fuel depletion, but on the other hand scarcity of raw material may pose constraints to enhance deployment of solar power. Securing access to required scarce inorganic mineral raw materials (IRM) at reasonable prices is an upcoming challenge for solar manufacturing industry. Future IRM (e.g. silver) constraints will cause imbalanced demand and supply. In such a case, it may be economically viable to increase production in response to rising demand for certain components or elements. This will cause the complex price patterns and supply risks emerge; while the market tension also occurs in response to unexpected changes in demand. As a result, there will be a risk of collapse of the energy storage system due to dependency on the scarce IRM (IPCC 2011).

Hazardous materials used in the solar panel manufacturing could pose serious environmental or public health threats. Especially, the use of arsine and phosphine in high volumes in current manufacturing technology of PV panels (III-V modules), where relatively high quantities of arsine are used. A facility with a 10 MW/yr production of flat-panel will consume about 23 tons of arsine a year. The quantities required in flat-panel designs could present terrible risks in the future. It is essential to consider that arsine is almost as toxic as methyl isocyanate (MIC) and it release of 40 tons of the latter in Bhopal killed 3,000 people and injured 200,000 more. Perhaps, accidental releases of hazardous gases or vapours can adverse consequences for environment (Vasilis M. F. and Biays Bowerman 2013). The consumer behaviour itself is unpredictable, dynamic and constantly changing (Chandrasekar 2010). The black swan in the form of consumer behaviour may influence to the consumer of solar power to switch towards the substitute non-renewable sources available in the market. This will be displacing the solar power from market.

FUTURE SCENARIOS

Moving from SMC proposed planning of solar implementation to actual use of solar energy requires a long-term perspective. The expected solar energy infrastructure takes time to build up. Government policy shifts often also need many years to take actual effect. On the International scene the transition from fossil fuel to renewable energy will require additional investment and higher supply costs over about twenty years. However, the use of solar energy will have tremendous economic benefits in the long term. Any analysis that seeks to tackle energy and environmental issues that will need to look ahead at least until the mid-century. Scenarios are absolutely necessary to describe possible development paths, to give decision-makers a broad overview and indicate that how they can shape the future energy system (Greenpeace 2015).

There are three scenarios used to show future energy supply in Solapur smart city.

1. Constructive Energy Scenario
2. Discouraging Energy Scenario
3. Revolutionary Energy Scenario

1. Constructive Energy Scenario

The Constructive Energy Scenario is an update of the Energy scenario, which followed the key target set by the Government to reduce carbon dioxide emissions. In this scenario, it is assumed that the Government takes initiatives to implement energy policy.

Politics play an important role to make a constructive energy system in the Solapur city. The ruling party is stable at Central, State and Local level lead by the single political party. Therefore, the energy policy and the regulatory tools affect positively on the investments in the solar energy sector. The Government has engaged a nodal agency to regulate energy policy and planning for the future. Therefore, the transparency in authorization, certification and licensing are encouraging the development of solar energy in the Solapur city.

It is assumed that, Solapur region succeeds to attract solar panel manufacturing industry. SMC's political decision to promote the investment and provide schemes is a call for the solar manufacturing industry to the Solapur region. As a result, the initial cost of solar panel gets reduced. It also fulfils the need for skilled manpower for maintenance of solar panel. Overall effect shows there would be increase the use of solar energy in the Solapur city.

Currently, the solar industry depends on Governments' subsidies. It is assumed that, the Government would continue the subsidy in the future as well as it can provide additional benefits to the household rooftop solar users. This will encourage the people to adopt solar energy.

The installation of roof top Solar PV on all Government buildings as part of Smart City Mission would reduce the electricity cost for SMC by 10% accounting for Rs. 3.6 Crore per annum. This model would receive acceptance by the citizen for using roof top solar PV in the city. As a result, the solar rooftop installations would seem beneficial for individual households to reduce expenditure on the energy bill in every month as well as earn money by selling additional energy produced at the household level.

The financial capability can be expanded by establishing the public-private-partnership (P-P-P) project. The large solar power generation plant can be constructed in Solapur through public-private-partnership (P-P-P). That will supply clean energy to the city and make the Solapur as a Green city.

The community is utmost aware about environmental changes and would show greater concern about environment issues. They receive clear information with the socio-economic benefits of renewable energy sector. Public awareness campaigns assist to spread message of solar energy as it is a clean and pollution free energy source. This would change the traditional mind set of the consumers. The collaboration with community would promote the solar energy in the city and would reduce carbon emissions in Solapur city.

It is expected that, Solapur smart city development plan would include private-public partnership in expansion of solar energy. SMC would introduce new incentive schemes for private partner in solar energy generation. This would positively affect on the energy sector of the Solapur city leading to sustainable development.

Solapur University would work as a knowledge partner for Solapur city. Solapur University could carry out research and development based on the solar energy issues on the one hand and on the other hand, could provide the solar energy capacity building training courses. This will help to generate skilled human resource for maintenance of solar panels in the city. Furthermore, the expansion of solar energy would generate thousands of new employment opportunities in the city while micro economy would grow subsequently.

It is anticipated that the innovative research and development occur in the solar PV technology. It would bring forthcoming improvement in work efficiency and reduce cost of solar PV in the future. Forthcoming sustainable technology would use abundant sunlight and would reduce dependency on the scarce material such as silver for the manufacturing of solar panel.

Furthermore, the new technology is expected to upgrade the storage mechanisms which are capable to store huge energy for longer period. It would increase the durability of the solar PV and would make renewables more reliable and feasible in the future. However, this would easily integrate in to the grid network and enrich the quality of network and prepare towards the fulfilment of consumer demand. The advanced technological improvements in the solar PV would attract the mass of consumers in future and reduce the carbon emission.

Perhaps, the recycling of solar PV panels would not be a major issue in the future. Based on the demand, the state would provide separate parks for recycling purpose. These recycling parks would come up build in remote areas and separate the precious metals used in the solar PV. In addition, manufacturers receive financial incentive from the state to recycle these valuable and rare materials. All these initiatives would go a long way to assist reducing the scarcity for renewable energy in the long run.

As a probability, the accidental risk due solar PV hazardous material can be managed with the safety measures. The trained staff would contribute towards spreading awareness among the citizen. If citizens receive clear information they would more likely to use rooftop solar energy at every household. The final outcome presents Solapur as a pollution free city, more eco-friendly and most liveable city in the country.

2. Discouraging Energy Scenario

This scenario is discouraging pathway which is totally opposite of the previous scenario approach of the constructive Energy. The efforts taken by the Government are adversely implemented; there would a discouraging energy future. Therefore, solar electricity generation decreases significantly in this scenario, assuming solar power sources to be reflected in the future.

Politics has the potential of posing risk on the future solar energy growth in Solapur city. Currently, existing institutions of governance are leads by one political party at Central, State and Local level. However, in the upcoming elections by the year 2019, the situation may not be same as today. If the Governments are headed by the different political parties' coordination among these institutions would pose a major critical problem. Political parties in power may mislead to the policy, planning and coordination. Such development would affect the solar energy progress in the Solapur city.

The absence of manufacturing industry in Solapur region may pose a serious problem in the future. Solapur city is import based and if any disputes arise with the suppliers in the future, would stall the progress of solar energy in Solapur city. The cheaper product may be made available at their door step of the citizens. Apart from this, if the Solapur region would start-up the manufacturing industry in the vicinity would also put the city at risk. There would be always a risk of accident and chances of release of hazardous gases in the environment, which may create seriously health issues in the future. Therefore, there is risk at both side, and the administrators have to take correct decision in the future.

The SMC is presenting the deficit financial budget. It indicates that, SMC is struggling to provide the basic amenities to the citizens. In this situation, the SMC can invest more in the solar power generation. SMC is aware of carbon emissions and their effects on the environment, but the financial limitations restrict them to make high investment in the solar power. Therefore, immediate transition from conventional energy to solar energy is quiet difficult for the SMC. Under such circumstance, the carbon emissions are likely to continue in the Solapur city leading to environmental and health of the citizens.

National Thermal Power Corporation (NTPC), Solapur is setting up coal based power plant with capacity 1320 MW near Solapur city. The first phase with 660 MW capacities is already constructed and is expected to complete second phase soon. The black swan would encounter the energy sector of Solapur city when NTCP starts working with full capacity. Perhaps, there will be a fall in the price of non-renewable energy due to increase in the scale of production. This situation would make solar power price less competitive with the NTPC rate. The common Indian consumers are more price conscious than others. (C. Lakshman. 2015). There will be a risk that customers switching over to cheaper non-renewable energy source.

Coal based power generation plant (NTPC) is expected to produce energy very soon in Solapur city. If the production starts with full capacity, then the cost of solar power is likely to fall than the current prices of solar power produced at roof tops. Low price power availability may be the biggest challenge for the solar energy in Solapur city. Consumer switches towards the cheaper energy source that would adversely affect the solar development in Solapur.

The citizens' awareness is essential for the sustenance of solar energy use. Citizens should in a position to accept and reject coal energy even when there is a price advantage. Without such preparedness marketing solar energy is difficult.

Solar energy development program in Solapur city does not include private stakeholders. Possibly, this would bring out negative impacts on the private stakeholders. They may voluntary exclude from this mission. There is possibility of losing a game changer from the ground. Finally, the progress of solar energy may be hampered in the city.

Till date, the solar energy has not acquired a professional image to offer career for the youth. Therefore, students are not seriously aware about the solar energy as a career prospect. Solapur University can start education and training course related to the solar energy. This lacuna may pose a serious problem related to the skilled manpower development. Inadequate availability of skilled manpower at the local level would increase the operational costs. There are problems for cleaning and maintenance of solar panels in the city. Without skilled manpower, it would be difficult to sustain and maintain the solar power for long run in Solapur city.

There are many unsolved technical issues in the solar energy. The first one is related to the silicon cells (c-Si) used in the solar PV. It is most advanced and mature technology, but still it has some limitations (MIT, 2015). It involves the complexity of manufacturing process and the underperformance of cells on one hand and on the other hand, solar dependencies on scarce materials like silver will be the major problem in the future. The solar energy is not having an advanced storage technologies, as mass production depends on that. This storage technology would be more critical for the implementation of solar energy.

Furthermore, the solar PV has barriers in the energy distribution and management mechanisms. Solar energy is insufficient due to capacity constraints. Apart from this, consumer wants stabilized and security of supply with value-added services. If solar sector cannot fulfil the customers demand, that will impact on the customer loyalty towards the solar energy (World Energy Outlook 2014)

The dust pollution in the city is major obstacle for the solar energy implementation. The solar devices are significantly affected by dust and reduce the performance. Sometimes, the dust accumulation on the surface of solar PV panel, mirrors, reflectors and other solar collectors need to be cleaned with pure drinking water. However, Solapur city is already struggling to supply drinking water to citizens and this situation, will create a big problem for local Government and individual users to arrange water for cleaning. If solar PVs are not cleaned properly then it reduces its output up to 50%. This may lead to resistance from the solar energy users due to the low output.

The increase in the use of solar PVs might lead to the problems regarding recycling. Solapur city doesn't have locations to store and recycle old solar panels. Also; there is no availability of recycling mechanism for non-operational solar PV panels. Due to the absence of recycling mechanism, the recoverability of precious metal like silver, tellurium, or indium used in solar PV is not possible. This valuable metal will go waste and that may result in resource scarcity in the future.

Solar PVs are made up of with hazardous materials and chemicals. If there is any accident occurs or wrong disposed solar panels get damaged or may prove to fire that will create public health issues. Any such incidence is sufficient for creating scarce among the citizens. They may reject the use of solar PV.

3. Revolutionary Energy Scenario

The Revolutionary Energy Scenario is based on the Government's future policies. Its assumption is based on the drastic implementation of large solar power generation plant in Solapur. There are main three major proposals considered under this scenario. This includes, floating solar panels at Ujjani[1] dam generate power, Ministry of New and Renewable Energy (MNRE) support for solar city development and NTCP is contemplating to shift from non-renewable to renewable. These three projects need heavy investment and long time for implementation. However, any one project out of these three succeeds in the future, that will be a revolutionary change and will have massive impact on the Solapur power generation capacity.

The State Government of Maharashtra is working on the mega solar projects in Solapur. The Ujjani Dam is the terminal dam on the river and it is the largest in the valley that intercepts a catchment area of 14,858 km^2. Every year, the dam loses over 1.5 TMC water due to evaporation. Therefore, the State Water Resources Department of Maharashtra and the Department of Energy, New and Renewable Energy have tied up with a private company to set up a solar energy plant. Under this plant, the solar panels will be set up on a water surface of 4,640 acres. The State Government aims to generate 1,000 megawatt (MW) electricity with this project. The Ujjani dam is located in an area where the temperature is high. Thus, the solar panels will generate a lot of power (Vilas Rajput 2017).

If this project is finalized by the State Government, this will be the milestone for the Solapur city. Furthermore, the power generated through the floating solar panels linked with the state power grid owned by the Maharashtra State Electricity Distribution Limited (MSEDCL) will be the great achievement of the project. This project will also generate employment for over 5,000 people. Thus, this floating solar project will fulfill the need for electricity of Solapur city as well as other part of the state. This project will be first-of-its-kind plant in India and one of the largest in the world, if materialized.

Government of India's MNRE has created a Solar City Program. This program supports cities in the development of solar energy. The financial assistance from MNRE is also potentially available for installation of solar energy devices as well as support for other technical activities. Support also is provided to municipal corporations for the preparation and implementation of a master plan, or road map, to develop their cities as Solar Cities. SMC can approach to MNRE to make Solapur as a solar city, because it has potential to become solar city. If MNRE accepts this proposal, then it will be the revolutionary initiative in the resources use for energy generation. In real terms, Solapur city will be the smart city with sustainability.

1 Ujjani is a dam located 100 km from Solapur. A pipeline is laid to supply drinking water facility to Solapur city.

National Thermal Power Corporation (NTPC) is setting up coal based power plant close to the Solapur city. Its total power generation capacity is 1320 MW out of which, first phase with 660 MW capacities already completed and second phase will be finished soon. This energy is purely based on the non-renewable source. According to the current scenario, NTPC is shifting its focus from non-renewable energy to renewable energy. NTPC will go slow on coal-fired generation capacity addition to bring its business plan in line with the Government's priority to fight climate change. On this line, NTCP Solapur also shifts its focus plant from non-renewable to renewable, that will be a great transition for Solapur city as well. The Solapur city gets clean energy without any financial burdens on the SMC, which again may possibly reduce carbon emission from the energy use.

CONCLUSIONS

The Solapur has an abundance of solar energy sources, which have the potential to play a major role in the future of the Solapur power generation. However, the SMC's solar project is still being in its early stages of development. So, there are numerous areas of uncertainty which need to be explored to secure the future of the solar energy. The study carried out a comprehensive PESTEC analysis of solar energy projects within Solapur city. The PESTEC further analysed on the basis of challenges and opportunities for Solapur city. Black Swans analysis is also being carried in the study. This analysis provides improbable and unpredictable future events that would carry drastic changes. However, the black swan events are classified with PESTEC approach. Finally, the study brings the three types of different scenarios. It involves constructive, discouraging and revolutionary energy scenarios. All three scenarios are discussed in detail about their probable impacts on the Solapur city. The study provides few recommendations for the policy makers to avoid the risk associated with solar energy development in Solapur city. Thus, Solapur city prepare for transition towards clean energy. The solar energy will have major role to play in changing the face of modern Solapur city in the coming years.

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FUTURE OF BIOENERGY: A CASE OF BAGASSE COGENERATION SECTOR (BCS)

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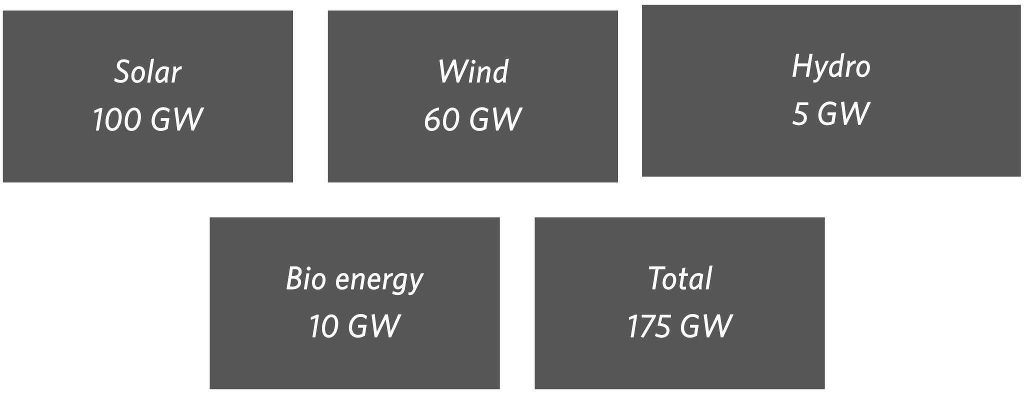
ABSTRACT

The Government of India has taken up one of the progressive steps towards clean and carbon free society in the next twenty years in the context of several crucial international commitments and national responsibility towards sustainable development. The national and state governments have decided their clean energy targets the NITI Aayog (National Institute for Transforming India) a national policy institute of Government of India constituted an Expert Group in June 2015 to assess the requirements and utilization of public finance for achieving 175 GW RE by 2022 through harnessing Solar (100 GW), Wind (60 GW), Hydro (5 GW) and Bio-energy (10 GW). This study executes a case study analysis of one of the Bio renewable sources (BRE's) in India – which is relatively understudied and underutilized – that is bagasse cogeneration sector (BCS). The BCS is an upcoming RE sector and an important organ of India's second biggest trade, Sugar Industry. Based on the futures methodology this study specifically explores the specific hurdles and their key drivers and also offers policy options for future sustainability of BCS. The study locates that if the BCS in India has to come forward as a sound and self-sufficient RE producer, there is a pressing need to make not only structural but several unconventional changes in the entire system as a whole.

Keywords: Bioenergy, Bagasse, Cogeneration, Sugar Factory, PESTEL.

INTRODUCTION AND RATIONALE

The dynamics of electricity supply process in a country like India has always been a challenge in front of various governments since independence. The pace of supplying energy to all has not kept equally along with the growing population, industrialization and urbanization. At present India is dominantly depend upon the energy produced by coal which contributes more than 50% that causes highest amount of pollution and threatens the sustainability of our environment (Tiwari, 2013). Therefore, in the context of 'Paris agreement' and our environmental social responsibility (ESR) perspective one of the growing and upcoming challenges in the near future is providing clean energy to all. However, despite with all complexities the present Modi government has been emerging as a responsible actor towards *'low carbon civilization'* through *'clean energy movement'*. One of India's key advantages at present and going forward is its renewable energy (RE) prospective which is enormous and mostly unused. Current estimation demonstrate that India's solar potential is greater than 750 GW and its announced wind potential is 302 GW (actual could be higher than 1000 GW (NITI Aayog, 2015). India Energy Security Scenarios 2047 show a possibility of achieving a high of 410 GW of wind and 479 GW of solar PV by 2047. The potential of biomass and small hydro is also significant (ESI, 2017). Thus, renewable energy has the potential to anchor the development of India's electricity sector. With this challenge in mind, the NITI Aayog[2] constituted an Expert Group in June 2015 to assess the requirements and utilization of public finance for achieving 175 GW RE by 2022.



India's clean energy policy environment harnessing Renewable Energy (RE) from all available sources including, Bio-fuels (Bagasse cogeneration). Unlike the other popular RE sector such as solar and wind the energy produced by bagasse cogeneration through sugar factories in India has not much explored and even under researched at policy and academia (Halder, 2014; Kumar et al, 2010). However, there is a huge potential to tap clean energy from bagasse cogeneration through sugar factories in India. India's sugar sector is the second largest in the world- could provide approximately 7 GW of power through India's 704 sugar mills (Vivek Patel, 2017: 335).

Thus, taking into consideration of the future potential of bagasse cogeneration sector (henceforth BCS) an inquiry based on futures methodology has been initiated. The report is mainly categorised into five broad sections including the first part introduction and rationale. The second section of the report offers the origin and development of BCS at global and Indian context. Section third discusses a detailed methodology adopted for the present investigation including research questions and there corresponding key futures methods. It also offers important stages of the application of futures meth-

[2] NITI Aayog (National Institute for Transforming India) is a national policy institute of Government of India.

ods. The section fourth of the report which is the core body of the report relied on results and discussion where an attempt has been made to analyse the process according to the four select research questions. The final section fifth of the report is based on overall conclusion of the analysis. The conclusion part is also divided into two distinctive sections, at first instance conclusion is drawn according to four research questions and at the end general conclusion has been made on the entire analysis.

THE ORIGIN AND DEVELOPMENT OF BCS AT INDIAN CONTEXT

Before going to deal with the origin and development of BCS in India it is inevitable to have a brief note on the historical developments in the RE movement in India. The dawn of RE movement in India had been started successfully with the establishment of a Commission for Additional Sources of Energy in the Department of Science and Technology (DST) during 1970s. Later on, a separate department called as (Department of Non-Conventional Energy Sources-MNES) in 1982 which was eventually upgraded as into the Ministry of Non-conventional Energy Sources (MNES) in 1992. To finance RE projects Indian Renewable Energy Development Agency (IREDA) was established in 1987. Meanwhile, to conquer the upcoming challenges in the area of RE the government of India have come up with an exclusive ministry called as Ministry of New and Renewable Energy (MNRE) in October 2006. This is the only such separate ministry in the world at present solely devoted to the promotion of RE sources to make India a carbon free society. MNRE is accountable for the encouragement, management and global collaborations and Research and development for the RE sources such as wind, small hydro, bio-energy and solar energy. RE scenario in India has been growing sustainably at both private and public level as a consequence of sustained initiatives of MNRE. After having a brief genealogy of RE sector in India the coming section discusses the energy produced by bagasse cogeneration in India's sugar industry (See: Bhattacharya and Jana, 2009).

Global sugar dynamics and the dawn of Bagasse Cogeneration at Indian Context

The global sugar industry, similar to the other sectors of commodities, facing critical conditions because of the uncertain and continues decline/ fluctuations in sugar prices and productions. The report published by Food and Agricultural Organization (FAO) 2004, focused on the condition of global agricultural goods market observes that since the mid-1990's the minimum support prices for sugar at global sugar market have been pave way for its decline mainly due to surplus supply and policies adopted on the grounds of Liberalization, Privatization and Globalization(LPG) (FAO,2004). This kind of miserable market condition has deeply affected together to worlds developed sugar-exporting nations for instance: (Australia and the European Union) and developing sugar-exporting nations for instance: (Mauritius and Brazil) therefore realizing the future challenges they have come up with an alternative to diversify sugarcane into allied by-products (Milford, 2003; Filho and Badr, 2004). The policy shift has opened way for few pertinent popular bio-products such as: alcohol, molasses, and black liquor. The energy production through bagasse is also one of the important alternatives that have been widely accepted at worldwide including, India. Diversification of sugar sector has been resulted into several allied socio-economic benefits especially in a highly populous country like India (Ranganathan, 2005). Scholars like Pellegrini and de Oliveira (2011) are of the opinion that it has become inevitable to the Indian sugar industry to diversify, because dependency for revenue generation merely on sugar alone was highly unsustainable. Thus, the global conditions created by the process of LPG and its impact at national level sugar market towards economic sustainability including the rise of global consensus to harness clean energy compelled government of India and the Indian sugar industry to explore alternative strategies like BCS.

BCS in Indian Sugar factories

In the post-Independence era a plan for production of energy through high efficiency cogeneration plants in the sugar factories was mooted during 1980s mainly to cope up with the growing energy demand. In view of the fact that high efficiency bagasse cogeneration plants have become as one of the smart technology options in the context of its duel benefits to make carbon neutral electricity and financial profits for the sugar industry. Considering future policy potential of BCS, several national and international schemes were introduced to expand RE mainly through BCS. Few vital initiatives in this regard are depicted in Table 1.

Table 1: Synopsis of major programmes supported for BCS in India (Source: Haya et al, 2009: 70; Patil, 2017).

Funding agency	Type of support provided
Ministry of Non-Conventional Energy Sources (MNES)	Interest subsidy, capital subsidy, tax benefits, workshops, pilot projects in the cooperative sector and lower customs duty for importing technologies
US Agency for International Development (USAID)	Up to 10% equity contribution for nine demonstration projects, trainings, workshops, newsletter and outreach activities
Indian Renewable Energy Development Agency (IREDA)	Multilateral lines of credit for renewable energy development provided through IREDA from international and bilateral finance institutions. The Asian Development Bank (ADB) provided funds dedicated for bagasse cogeneration
Clean Development Mechanism (CDM)	A project-based carbon off setting programme established under the Kyoto Protocol
Global Environmental Facility (GEF)	Project under preparation to provide creative financing to cooperative mills

The sugar industry has future potential to harness energy from bagasse cogeneration mainly for the following factors: 1) manufacturing sugar through the uninterrupted process which is helpful for continuous power generation; 2) sugar production need only low-pressure steam, creating higher pressure steam accessible for electricity generation; 3) it reduces competence losses due to its favourable nature of decentralized sources of electricity supply; and 4) the cogeneration of bagasse generates zero net energy emission of carbon dioxide, as the carbon freed as CO_2 while bagasse is combusted, was taken out of the atmosphere through photosynthesis(Haya et al,2009).

What is Bagasse Cogeneration?

- Bagasse is the fibrous matter that remains after sugarcane stalks are crushed to extract their juice and is a by product generated in the process of manufacture of sugar[3].
- The concept of cogeneration produces two types of energy from one fuel simultaneously in the forms of heat and the other may be electrical energy. The bagasse produced in a sugar factory is however used for generation of steam which in turn is used as a fuel source and the surplus generation is exported to the power grids of state governments(see: Rosen, Le, and Dincer, 2005).
- The distinctive process of the functioning of bagasse cogeneration in sugar factory is described in the following figure no 1.

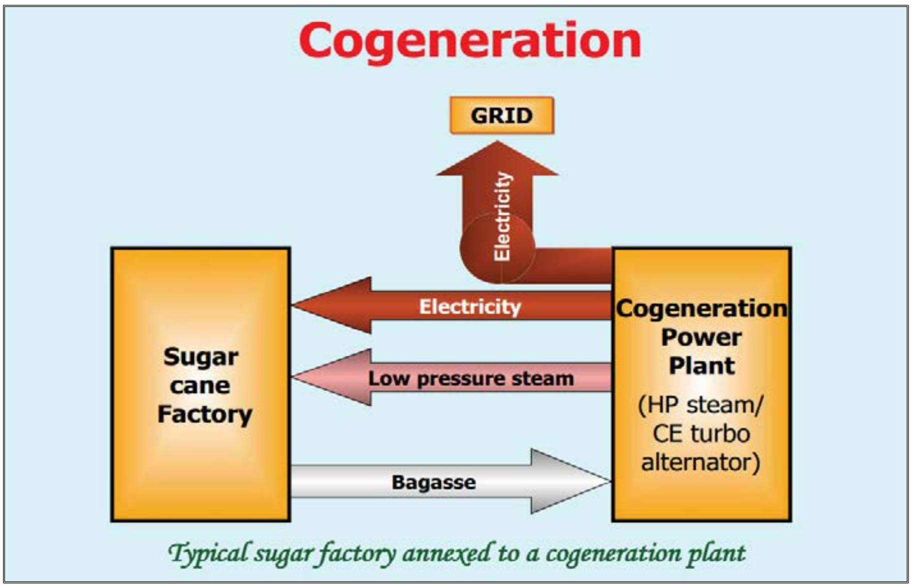


Figure 1: The model of bagasse cogeneration plant at Sugar Factory (Source: http://www.zi-onenggworks.com/images/zion-cogen-process.jpg)

3 http://www.birla-sugar.com/Our-Products/Bagasse-Cogeneration-Renewable-Energy

Generally the electricity produced by the bagasse cogeneration plant (henceforth BCP) mainly during sugar production period is used by the concerned Sugar factory and the surplus energy is being transferred to the grid. This concept provides few vital advantages: no fuel cost, employment to the local population, strengthening sugar factories socio-economic potency, energy security and reduction in transmission and distribution fatalities. The following figure no 2 shows schematic diagram of power generation in a typical sugar factory.

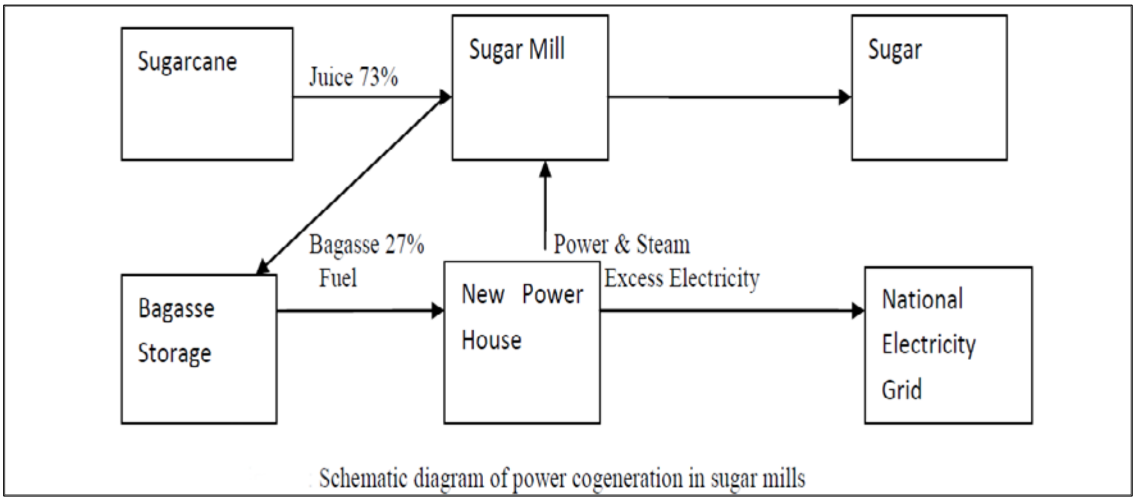


Figure 2: Schematic diagram of power generation in a typical sugar factory. (Source: Kalpana Bisht and Renu, 2016)

Present status of BCS in India

At present nearly 4 million hectares of agricultural land is under sugarcane cultivation including with roughly an average yield of 70 tons per hectare. As of 2016 around 550 sugar factories are operating in India. Sugar industry in India is mainly divided into three sections i) Cooperative ii) public and iii)private in which the highest number of factories are of cooperative in nature. To overcome with growing challenges of the sustainability of industry apart from sugar production industries have started several allied activities. Generating energy through cogeneration is one such futuristic option. During last three-four decades now the concept of bagasse cogeneration has been a well matured sector in India. The following table no 2 shows state wise status of bagasse cogeneration and its potential, installed capacity and utilization in India as on 31-03-2013 (Bishit et al, 2016:561).

Table 2: State-wide scenario of BCS in India, 2013 (Source: Kalpana Bisht and Renu, 2016).

Sr. No	State	Potential (MW)	No of Projects	Installed capacity	% Utilization
1	Andhra	300	22	163.05	54.35
2	Bihar	300	4	43.30	14.43
3	Gujarat	350	0	00.00	00.00
4	Haryana	350	4	31.80	9.09
5	Karanataka	450	32	403.88	89.75
6	Maharashtra	1250	65	580.90	46.47
7	Punjab	300	6	62.00	20.67
8	Tamilnadu	450	26	327.00	72.67
9	Uttarpradesh	1250	53	710.50	56.8
10	Uttarakhand	--	1	10.00	--
	Total	5000	213	2332.43	46.64

It is estimated that bagasse-cogeneration has potential to generate 5000 MW (31.12.2016). Apart from this additional 7000 MW of power could be generated through bagasse based cogeneration if 550 sugar mills will adopt technical and economical optimal levels in process (MNRE, 2016)[4].

Setting of the Study

Maharashtra is one of the leading and industrialized states in India. At present, a highest number that is 196 sugar mills are functioning in Maharashtra – 173 co-operative and 23 Private Mills. As per MNRE Maharashtra has potential to generate 1250 MW of energy from cogeneration process as bagasse is abundantly available after sugar crushing process[5]. For the present study Maharashtra state has been considered as a universe of study and district Solapur is selected purposively as a unit of study. This study presents both macro (National) and micro (Solapur) level insights as a representative case for sugar factories to analyze the intricacies involved in the BCS from futuristic perspective. The rationale behind the selection is multi-fold:

i) Solapur district has highest number of sugar mills not only in Maharashtra State but also at national context.

ii) It has a unique blend of cooperative and private models of sugar factories that gives special advantage to study under systems approach.

iii) It has 47 sugar mills up to 2017 with a capacity of more than 1250 TCD. The capacity of private sugar mills is constantly increasing as to cooperative sugar mills.

4 http://mnre.gov.in/schemes/grid-connected/biomass-powercogen/

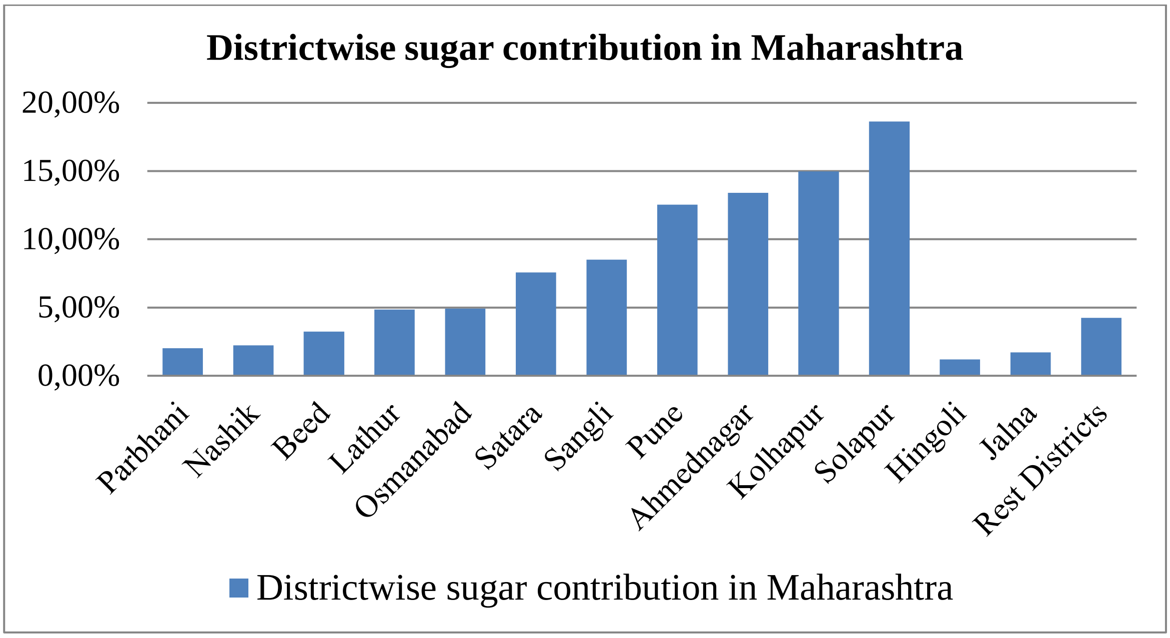
5 https://www.mahaurja.com/meda/grid_connected_power/bagasse

iv) The capacity of sugar mills is 2500-5000 TCD which is now expanding and going even beyond 1000 TCD.

v) The 8% of the total sugar production in India and 17% in state are from Solapur district. The present energy generation capacity is 500 MW and will expand up to 750 MW in next three years[6].

vi) Most of the cogeneration plant in Sholapur District is developed in sugar mills as they have the enough quantity of bagasse.

vii) Solapur is one of the highest contributors of sugar in Maharashtra (see following figure no 3) hence bagasse is also easily available which is used as fuel in order to meet power and steam requirements of production process (See: Solapur District Census, 2011).



Source: *https://www.google.co.in/imgreswww.vsisugar.com%2Fimages%2Fjpg%2Fstatistics%2Fdistrict*

As per above data we can see that more than 18% of sugar contribution in Maharashtra State comes from Solapur District alone.

6 https://en.wikipedia.org/wiki/Solapur_district

Research questions

Thus, taking into consideration of the future potential of this sector an inquiry based on futures perspective has been initiated with following research questions:

GENERAL RESEARCH QUESTION:

What are the critical intricacies, future trends and drivers that determine the future sustainability of Bagasse Cogeneration Sector (BCS) @ (2030)?

SPECIFIC RESEARCH QUESTIONS:

RQ-I

What are the key macro level intricacies that explore influencing factors involved in BCS?

RQ-II

What are the future trends that navigate to recognize early future warnings in (BCS)?

RQ-III

What are the key determining trends (KDT's) for the future sustainability of (BCS)?

RQ-IV

What are the possible key drivers and its corresponding policy suggestions to sustain the future challenges of (BCS)?

METHODS AND ITS OPERATION

In order to operationalize the aforementioned research questions the following corresponding appropriate futures method have been applied:

RQ-I

i) Method: PESTEC: Any structural intricacies of the system consist with multiple dimensions. Therefore, the method of PESTEL analysis was used here to identify the various internal/external (political, economic, social, technological, environmental and cultural) factors that might affect a system as a whole. This exercise helped a lot to assess the contemporary risks and future possible coping strategies for the sustainability of (BCS).

ii) Process: To execute the (PESTEC) method in operation two specific tools have been used i) literature review and ii) brainstorming.

RQ-II

i) Method: Mini-Delphi: Considering the futuristic nature of the second RQ it was decided to have a Delphi method to assess the future trends implicated in (BCS) that could widen at 2030. For the present research we adopted face-to-face meetings with panellists that are called as mini-Delphi. It has benefited to outline three different possible trends (the *uncertain trend; certain trend and static trend*).

ii) Process:

- According to Wendell Bel (1997) Delphi researchers aim to predict and explore alternative future possibilities, their probabilities of occurrence, and their desirability by tapping into the expertise of respondents.
- For this study group of experts from the following three areas were identified:
- Researchers (social sciences, engineering and technology) ii. Managers (from Sugar industry) iii. Policy/Administrators (MEDA, MNRE).
- Altogether 11 experts were selected purposively to discuss on the intended RQ's and to bring their own argued future views into the discussion during June-August, 2017.
- The insights from the above data were used to develop mapping future trends (MFT's).The future trends were grouped in to three spheres (Uncertain trends, UT; Certain trends, CT and Static trends, ST); likewise, to quantify and measure the future trends we applied probability score ranking exercise{1-4(UT); 4-7 (ST); 7-10 (CT)}furthermore, to provide strategic impetus possible future policy impact (FPI) of these trends were also captured on the basis of probability score and future trends. The (FPI) has been measured with the help of the above three fold stratification: {++ and + are positive, = is neutral or unknown, - and - - are negative effects} respectively.
- To analyze the (MFT) exercise four key variables were selected viz: (Technological, Political, Environmental and Economical). See Table no 3.

RQ-III

i) Method: mixed methods: In order to operationalize RQ III we have adopted mixed methods such as (informal interviews, mini Delphi and personal observations). Data was collected from the officials of two sugar factories (Shri Siddeshwar Sugar Factory- Category: Cooperative and Lokmangal Factory-Category: Private).

ii) Process: On the basis of RQ II a clear scenario was emerged towards the possible future trends (PFT's). Later on, based on the MFT exercise four vital key determining trends (KDT's) for the future sustainability of (BCS) in India were identified. See Figure no 4.

RQ-IV

i) Method: mixed methods: To execute the final RQ we have relied exclusively on mixed methods (brainstorming, informal interviews and qualitative observations and diary notes).

ii) Process: The process of exploring answers of RQ-IV was based on futures framework: two steps were developed i) based on the qualitative insights from the preliminary RQ's (I-II and III) specific key drivers (SKD's) for each four key determining trends (KDT's) were selected; ii) finally, policy suggestions to the corresponding four KDT's were proposed with a primary intention to offer remedies or coping strategies to overcome the future challenges possibly affecting the very sustainability of (BCS) in India. See Table no 4.

RESULTS AND DISCUSSION

This section provides analysis based on the four research questions presented in the earlier section. The upcoming segment attempts to explore the answers of the first research question briefly, followed by the remaining questions suitably.

RQ-I

This section has two specific aims with regard to the first RQ. It begins to explore the macro level intricacies involved in the BCS and subsequently also offer key influencing factors responsible for the future sustainability of BCS in India with the help of PESTEL analysis. PESTEL is an acronym that stands for six main categories: political, economic, social and technology, environment and legal (see Table no 3).

Political:

The BC sector in India has been evolved along with multiple rationales. Therefore, it has become more complex to analyse the intricacies implicated in this sector. One of the important common threads that influence the sustainability of BCS is the political factor. BCS is an important subsection of Sugar factory. Hence, any positive/negative changes occur in sugar factory also has similar magnitude towards BCS. The Indian sugar industry is under high political influence similarly, political economy. However, there are contradictions at the national and local level political leadership with regard to RE in general and BCS in particular. At national level presently the Modi government has created a positive environment through enacting favorable policies, plans and programs (e.g Energy for all) and engaged in agreements related to sustainable development at international level to make India a clean and zero carbon country. However, India is a nation with full of paradoxes. One of the vital intricacies at political level is a severe lacking of political leadership at local level who can execute the policies, programs with the same zeal. Historically, majority of sugar factories are headed by political leaders and their families with political interest (See: Baviskar, 1980). Likewise, the Indian political environment especially the opposition show wasted interest that might affect the future growth of this sector. One of the most crucial policy aspects that hinder the present and future augmentation of BCS is the constitutional existence of "Energy" sector as a common subject between federal state and central governments. This kind of dual freedom creates challenges for proper execution of programs. There are incidences where state governments have made special provisions which are contrary to the central governments guidelines for instance under Energy Act 2003 there is a freedom for renewable energy producers to sell the energy to any state across India. However, few federal states law restricts to enjoy the freedom provided by the central government act. In future there will be grave conflicts between the energy producers and federal state agencies that might create unfavourable conditions for the cooperative in general and private sector in particular.

Economic:

The economic sustainability of India's second most popular industry that is sugar sector had been facing both internal-external challenges. Some of the internal challenges are: i) Low level of financial returns ii) Majority of SF's are extremely bankrupt iii) Due to poor financial condition majority of SF's not able to upgrade latest technology for BC in order to produce surplus power for grid iv) Disputes with state/ power agencies with regard to PPA) v) Growing future risk towards financial sustainability vi) lack of goodwill not able to take loan from domestic/international banks.

Thus, considering the financial intricacies at present in the BCS it seems that the sector is going to be affected by serious challenges in the near future. Some of the key future challenges that might affect the economic sustainability of BCS are: i) the impact of climate change and the excessive use of water and pesticide has already disturbing sugar production/ revenue generation at large scale ii) there will be crises to function BC plants due to lack of sufficient bagasse iii) due to surplus production and next generation advancement in other RE like solar and wind it will be difficult for the agencies to purchase energy produced from BC with relatively high purchase rate iv) the high level of professionalism and technological up-gradation by the cogeneration units run by private sector may create monopoly in market becomes threat to the cooperative cogeneration units v) the uncertain global market trends may also affect severely to the SF and similarly to the BCS vi) this kind of trend will not only affects cooperative sector but also creates challenges to government to achieve its required goal.

Table 3: PESTEL analysis: Present status and future challenges

Variables	Present status	Future Challenges @2030
Political	i.Strong leadership to promote RE at central level (MNRE;EA;NEP;IEP;REP) ii.International partnership and agreements(KP, PA etc) iii. Protective acts (Electricity Act-2003)	i.Severe leadership gap to execute RE policies/ programs at federal state level ii.Growing pressure and vested interest by opponent parties and lobbing groups iii.Limitations in EA-2003 for expansion of RE sector and contradictory state laws
Economic	i.Huge amount of readily available bagasse and infrastructure ii. Striking Tariff rates by MNRE iii.Attractive subsidies and startup grants iv.Growing privatization in BCS v. Good credibility for loan/funding	i.Increasing environmental risk and lack of managerial/technical base to utilize total bagasse; age-old and poor infrastructure ii.Lack of uniformity in tariff rates among the different federal states iii. Bureaucratic delays/corruption and lack of competition in domestic market iv.Privatization may create monopoly and threat to cooperative sugar sector v.The BCS may lose trustworthiness to take loan/ fund for further developments
Social	i.Growing awareness among the young entrepreneurs to start new BC plants ii.Provides employment to rural youth iii.Indian sugar industry is under high political pressure iv.Due to LPG Indian sugar sector is reliant on global market forces	i.fragile international exposure and managerial/professional skills ii.Scarcity of trained and skilled human resource iii. Increasing dominance of few dominant political groups may creates serious hurdles, political economy will become serious future threat iv.Unfavourable global market trends may affects the social sustainability
Technical	i.Favourable state funding for technology and R and D innovation ii.Sugar industries adopting next generation technology to harness optimum energy iii. Off grid technology is improving iv.Policy push for technology funding	i.Growing dependency on imported technology and lacks indigenous R&D ii.Old sugar factories face economic and technological challenges to revamp old technology may shut down BC plants iii.Threat of surplus energy production iv.Cost for technology implementation/management will become more than the returns from (BCS)energy
Environmental	i.Favourable climate for sugar cultivation ii. Burning bagasse produces no sulphur dioxide iii.Eco-friendly policies by state	i.Water scarcity, land salinity and climate change impacts may create serious challenges to shut down SF's or changes in its geography ii.Desposal of ash may create future problems iii.Growing insensitivity towards environmental policies and lack of effective monitoring by state agencies
Legal	i.Condusive acts and legal provisions by central government ii.Electricity Act-2003 offers guidelines to all states for functioning of RE projects iii.To protect of the interest of energy producer /end users effective laws have been formed	i. Subjective interpretation of central laws and distractive substitute sub laws by state ii. Coordination and monitoring of laws for RE projects creates a challenge iii. Increasing political interference and misuse of laws by sugar lobbies

Social:

The social sphere of BCS also provides wide-ranging intricacies. At present BCS has opened up few positive avenues such as i) providing employment opportunities to the rural unemployed masses; ii) creating awareness about issues related to clean energy and its direct application/production at village level; iii) it has also been found that there is a growing consciousness among the youths to become green entrepreneurs through establishing private BC projects; iv) it opens up the process of empowering group of people with own green energy production units. Likewise, apart from positive aspects there are few challenges in the social sphere that might affects the social sustainability of BCS such as: i) although there is a cheap labor available for BCS however, the existing labour force lacks professionalism and minimum skills to be applied for the development of the sector at large like Europe and Australia ii) the managerial and leadership level issues at SF's (mainly at cooperative SF's) are indeed worst for instance: delaying in making policy decisions by Board of Management might be due to wasted interest and political economy; lack of international exposure and professional/managerial weakness also hinders the future development of BCS; corruption and tendency of extreme dependency on government relief packages; and poor level of awareness among the primary sugar producers towards the management of sugar leaf during harvesting season; lack of courage for new alternative experiments in BCS. Thus, the social sphere of BCS has shown multiple limitations and linkages with the allied indicators of PESTEL therefore, suitable policy suggestions with the help of specific drivers can be developed to overcome with the existing problems.

Technological:

The BCS has primarily been relied on imported technology since its beginning. Technology has played a crucial role in the establishment and development of cogeneration sector in India. While analyzing the present status and future prospects of the technological sphere of BCS the following intricacies have been emerged. i) It has been observed that government of India through MNRE has providing sustainable financial packages/subsidies for BC plants (see figure no 4) ii) new sugar factories are adopting advanced technology like (CTIG and GTCC) iii) the energy produced by cogeneration does not require storage as is the case with solar iv) adequate technological expertise for maintenance and deployment. In such an optimistic scenario there are some policy and practical gaps that can become future challenges for the BCS. The first and foremost challenge is i)to use 100% energy through BC plants from sugar factories however as of 2013 only 213 sugar mills out of around (35%) have been installed BC plants which comes around merely 35–40% of the total sugar factories ii) due to technological limitations and lack of standardization of cogeneration technologies for high pressure configuration mainly at small sugar mills majority of the small mills are unable to install cogeneration plant iii) majority of SF are established during cooperative revolution having old conventional technology using traditional equipments such as low-pressure boilers and counter-pressure turbo alternators, the level and reliability of electricity production is not sufficient to change the energy balance and attract interest for export to the electric power grid (see: https://www.bioenergyconsult.com/cogeneration-of-bagasse/) iv) there is also discrimination in terms of capital subsidy among private and cooperative and sugar factories according to their presser boiler(See figure no 4) v) Indian BCS sector has poor indigenous R&D mechanism vi)dependency on imported technology creates huge establishment cost. As a result, the expected growth of BCS is being stagnant and its linkages are multifold. Therefore, considering the intricacies involved in the technological sphere there is an urgent need to reframe suitable policies both at local (SF) and at national (MNRE) level.

CAPITAL SUBSIDY

For setting up bagasse plants

Projects by cooperative/ public/joint sector		Private projects
Pressure	Subsidy (per mw)	
40-59 bar	Rs 40 lakh*	Rs 15 lakh** x (capacity in mw)$^{0.646}$ *For eg, a 10 mw plant will get* Rs 66.38 lakh
60-79 bar	Rs 50 lakh	
80 bar & above	Rs 60 lakh (Maximum support can go up to Rs 80 crore per project)	

**In case of back pressure system subsidy will be 50%*
***Rs 18 in Northeast, J&K, Sikkim, Uttarakhand and Himachal Pradesh*
Source: Ministry of New and Renewable Energy

Figure 4: Capital subsidy by MNRE to setup BC plants (Source: http://mnre.gov.in/schemes/grid-connected/biomass-powercogen/)

Environmental:

Similar to various industries, the sugarcane and sugar-bio-product factories are also struggling with issues related to environmental sustainability. Bagasse cogeneration industry also involves intricate concerns with regard to environment. However, as compare to other conventional energy sources the energy produced through BCS has few positive insights with regards to environment: i) BCS produces carbon neutral electricity, the power produced through co-generation substitutes the conventional thermal alternative and reduces greenhouse gas emissions. High-efficiency bagasse cogeneration was perceived as an attractive technology both in terms of its potential to produce carbon neutral electricity[7]. ii) Bagasse-based cogeneration earns carbon credits; burning bagasse produces no sulphur dioxide and very little ash as compared to lignite, the lowest rank of coal. Most coal available in India is of low grade. Bagasse-based cogeneration earns carbon credits since CO_2 absorbed by sugarcane plants while growing is more than the CO_2 produced in burning bagasse[8]. iii) The Indian climatic condition is

7 https://www.indiamart.com/proddetail/bagasse-co-generation-of-renewable-energy-9365954855.html
8 http://www.downtoearth.org.in/coverage/crank-it-up-3445

very much suitable for sugarcane cultivation with large area of cultivable land. On the other hand, signs are emerging at BCS towards its future environmental sustainability some of the future challenges are: i) the study conducted by Sahu et al (2015) article provides the first ever estimation, current status and overview of magnitude of air pollutant emissions from rapidly growing bagasse based cogeneration technology in Indian sugar mills,[9] ii) dawn of multiple impacts of climate change i) due to uneven rainfall and growing temperature severely affecting sugar productivity and recovery; ii) land salinity is increasing due to unscientific surplus use of water for sugarcane farming; iii) lack of sufficient quantity of sugarcane factories are in deep crises towards its functioning (Shrivastava, 2014); iv) sugar production in India set to drop 9% in 2017 as drought hits Maharashtra, Karnataka a forecast made by Indian Sugar Mills Association (ISMA,2017);[10] v) Solapur district, with 32 sugar mills, is the most hit, where the area under sugarcane cultivation has come down by 22,367 hectares. The total reduction of such crop areas in the Mharashtra state alone is 63,457 hectares in 2014-15 (See: ISMA, 2017); vi) ground water depletion, in water-stressed regions like Solapur and Marathwada regions, the increase in area for sugarcane cultivation has resulted in ruthless depletion of the groundwater level, causing acute water crises during summer that creates serious threat for the sustainability of sugar crop. The aforesaid brief analysis of environmental sphere of BCS provides the fact that although the present ecological condition is relatively conducive for its development however, the pace of the development of BCS may offer critical future challenges that needs both micro-macro level policy interventions in near future.

Legal:

India has one of the progressive set of renewable energy laws in the world. At present the electricity sector which includes power generated from RE is covered under Electricity Act (EC)-2003. After almost more than thirteen years of the implementation of EC Act-2003 a few critical issues have been emerging which are threatening the very existence of RE environment in India. Therefore, it needs suitable modifications for its future development. Some of the present intricacies involved in this Act are as follows: i) it lacks push for open access and alternative for supplier for enlarging RE sector ii) as per present law the review process for tariff fixation takes generally after every three year, which is not much conducive from the producers point of view iii) the escalation phase for Tariff for energy produced through bagasse based cogeneration usually not competitive considering the growing maintenances and production cost iv) the laws enacted by several federal states such as Maharashtra Electricity Regulatory Commission (MERC) RE regulations, 2010 adversely affecting BC projects in

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9 The estimated emission from the world's second largest sugar industry in India for particulate matter, NO_X, SO_2, CO and CO_2 is estimated to be 444 ± 225 Gg yr^{-1}, 188 ± 95 Gg yr^{-1}, 43 ± 22 Gg yr^{-1}, 463 ± 240 Gg yr^{-1} and 47.4 ± 9 Tg yr^{-1}, respectively in 2014(Sahu, 2015).

10 http://www.financialexpress.com

terms os problems related to PPA, legal ambiguities and general business environment; [11] v) increasing political interference/wasted political interest from both ruling and opposition parties and misuse of laws by sugar lobbies vi) growing disputes and non-cooperation by line departments during enforcement of legal matters. These are the few representative intricacies' that have emerged out of the primary data collected from the stakeholders. The EA-2003 enacted during the earlier UPA government when the pace and zeal towards the development of RE sources was somewhat sluggish as compared to the present NDA government. However, the present NDA government took an exceptionally significant strike towards the making India a zero carbon nation. During the process of operationalizing the set targets RE producers, suppliers and even national/state government agencies have been realizing the legal lacunas in the present EA-2003. In view of the growing contradictions within the EA-2003 the central government/ MNRE has come up with the draft National Renewable Energy Act (NREA), 2015 (See Annexure-I)[12]. The aforesaid (NREA) is yet to be cleared by the Indian parliament. Since GoI has shown an optimistic stands at an international level during Paris agreement and allied associations towards clean energy movement it has become an inevitable for the government to show its practical implications. Legal hurdles within the present EA-2003 is restricting MNRE to get clearances from different departments and ministries. Therefore, it is important to know about the enforcement of the proposed law. However, politicization and non-cooperation by the opposition may create future challenges in the clearance of (NREA) in general and the development of RE in particular.

Thus, the above PESTEL analysis reflects the answers of the first RQ which basically provides the intricacies affianced within the BCS and helps to recognize the influencing factors that are interlinked within the PESTEL and also have possible future consequences with regard to the sustainability of BCS as a whole. As a result, the first RQ has set the environment to move forward to capture the potential future trends that navigate to recognize early future warnings that are associated with the sustainability of (BCS) as put-forth in the RQ II.

RQ-II

Usually, tools and methods in the direction of analyzing the future do not able to predict the future, even though appraising the probabilities of alternative futures is one of the vital aspects of the methods of future studies. To be more precise, methods of futures studies are normally intended to facilitate public better aware future possibilities in order to formulate better decisions today[13]. In this context in tune with the general RQ of the present study the specific RQ no II attempts to explore future potential trends and their associated early warnings with special reference to the sustainability of BCS @

11 http://www.mercindia.org.in/pdf/Order%2058%2042/Order_46_49_66_of_2012_13_May_2013.pdf
12 For more details see: http://mnre.gov.in/file-manager/UserFiles/draft-rea-2015.pdf
13 For more details see: http://www.crab.rutgers.edu/~goertzel/futuristmethods.htm

2030. In order to employ the futures analysis based on RQ II, the mapping future trends (MFT's) exercise was prepared through applying one of the prominent futures method that is mini-Delphi. For this study an operational definition of future trends has been described as "a common path on the way to future through which something is commencing or changing with special reference to the problem identified for investigation", furthermore, it is an assessment, calculation or forecast of a future state of affairs based on a specific futures method of data of present context that we have".[14] One of the important objectives of (MFT) exercise is to offer future possibilities of trends and warnings towards the sustainability of BCS that will help the stakeholders to make suitable coping strategies in the present context. In order to capture future trends in BCS four variables (Technological, Political, Economical and Environmental) have been identified. Under each four variables three possible future trends (PFT's) have been recognized on the basis of Delphi exercise and afterward it has also been quantified to measure its possibility through probability score rated by the Delphi participants and on the basis of the results of probability score the future policy impact (FPI) of each three possible future trends have been drawn.

Future Trends in Technology

The results of the future trends of the first variable that is technological offer three important future trends for the BCS @ 2030. The most probable certain trend (CT) for the technological variable shows that there will be breakthrough technological innovations at BCS in terms of (Small scale turbine, nano and cost effective hybrid technology) convenient even for small scale sugar factories which also has + + positive Future Policy Impact as a whole. This trend will create two major changes at BCS i)at present only high pressure big sugar factories are able to have BC plants, however due to technological innovations mainly nano and cost effective technology small sugar factories with limited TCD can also become able to start BC unit with increasing amount of power for instance: the advanced technology can generate 6-10% more energy than the old[15]; ii) through this change the industry could be able to use 100% bagasse for energy generation at present only 30–40% sugar factories are only having BC plants iii) likewise, due to unavailability of bagasse during off season majority of SF are not able to start their BC plants however, because of advanced hybrid cogeneration plants in future the BC plants can be able to start their plants even during off season with the help of alternative biomass available at rural areas such as huge amount of sugar leaf is available after sugar cane cutting that can readily be used as an alternative to bagasse along with other available rural bio mass. As far as the static trend is concerned it projects that although there will an advanced technological revolution in BCS due to the increasing cost small sugar factories and overdependence on government funding majority of SF will be out of the

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14 For more details see: https://dictionary.cambridge.org/dictionary/english

15 MNRE Annual Report 2012–2013, New Delhi, India retrieved from http://mnre.gov.in/file-manager/annual-report/2012-2013/EN/chapter3.html on 03-12-2017

BCS. Hence, the same trend will remain without much positive change in the BCS. Therefore, appropriate policy changes have to be initiated according to the future trends captured as above.

Future Trends in Political Sphere

The future trends in political sphere reflect three different trends for BCS. The most uncertain trend shows the drastic political shift at both (Central and State) level which further creates dismal policy environment for RE sector as a whole. However, considering the back casting and present political mapping in India there are very less probabilities to occur this trend in true, however, this can be treated as a black-swan @ 2030. Even though, despite of the drastic shift at the national and state level political affairs it is quite not oblivious that the new government will not continue the RE movement further. Because the recognition which the government of India gained at international level about the environmental stewardship in particularly after the Paris agreement bind the upcoming government to continue the earlier engagements even further. However, the question only remains about its pace of change to implement the RE policies with the same zeal like the NDA government. The remaining trends offer relatively possible computation, the most certain trend proposes + + positive future policy impact which emphasizes further conducive policy and programs for the expansion of RE sector due to the political consistency in leadership, conducive policy environment, operational practical evidences in terms of RE policies and up gradation in present laws and policies according to the conditions[16]. Meanwhile, the static trend suggests that the policy makers should not be over utopian towards RE policies which might create utopian policy environment at RE sector and due to over utopianism the Government may make policy shrink without any drastic changes in coming 10 years.

Future trends in environmental sphere

The existence of sugar cane crop is largely based on water, land and sunlight and therefore has a significant dependency on environmental aspects. The impact of climate change has created serious threats to the sugar industry all over the world. Therefore, to know future trends for the management of environmental risks has become an important chore for the stakeholders associated with sugar industry. The primary insights based on the Delphi propose three alternative future trends with reference to environmental sphere that creates future possible impacts on BCS. The most certain trend which has further positive policy impact + shows a sharp behavioral change among the sugarcane cultivators which includes following few most crucial aspects: changes in the sustainable cropping practices such as use of micro irrigation tools, use of organic seed and fertilizers, advanced farming tools and including forced change in topography of sugar cane crop may appears in the coming years

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[16] The present NDA government has proposed a Draft Renewable Energy Act, 2015 for further policy improvement

@ 2030. The key drivers behind such behavioral changes are manifolds for instance: policy enactment by state governments towards sustainable agriculture (see Box no-I); insecurity and unfavorable conditions to divert to other cash crop; growing awareness about sustainable farming; feminization of agriculture and political economy associated with sugar cane farming.

Maharashtra Government Makes Drip Irrigation Must for Sugarcane Cultivation

Maharashtra is one of the highest sugar cane production states in India. Being a progressive and most industrialized state in India, Maharashtra state has always been ahead in taking contextual future oriented sustainable decisions. In the month of June 2017 the government has taken a significant decision to make drip irrigation compulsory for sugarcane cultivation. There were criticisms by development community towards the huge exploitation of water for sugar cane farming there are critical incidences at rural areas of Maharashtra. As per the cabinet approved scheme the government will provide loan to sugar cane cultivator of up to Rs.85,400 per hectare with financial support at an affordable 2% interest rate. The state government desire to cover nearly 3.05 lakh hecters of land of the total 9.42 lakh hector under sugarcane cultivation under this scheme in coming two years (2017–2019). The positive sign is already there are 2.25 lakh hecters of land covered under drip irrigation[17].

On the other hand, the remaining future trends tend to depict that due to most hostile climate conditions mainly scarcity of water the cultivation of sugar cane crop will fall drastically in near future[18]. If, government and the farming community at large do not make self-assessment towards sustainable farming practices the future of sugar cane farming will be in exiled. Therefore, there is a need to create sufficient and necessary conditions by all stakeholders to cope with future environmental challenges that is going to be affected the sugar cane and ultimately BCS in India.

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[17] The state government has asked NABARD to have a dedicated micro irrigation fund and long term loans will be given to farmers from that fund. The original interest rate for these loans will be at 7.25 % of which 4% will be borne by the state government, 1.25% will have to be borne by the sugar cooperative which buys the sugarcane from the farmer and the remaining 2% will be borne by the farmers himself. Sugarcane is 18-month cash crop, it required nearly 25,000 tmc water for one hectare of the crop and if drip irrigation is introduced the state government aims at saving nearly 7500-12500 tmc of water per hectare, said officials from the state agriculture department. "There was a huge hue and cry over the water requirement of sugarcane during the drought years. Large parts of the drought prone Marathwada grows sugarcane and this scheme will benefit such areas largely," said an official from the agriculture department. Data retrieved from: https://timesofindia.indiatimes.com/city/mumbai/drip-irrigation-a-must-for-maharashtra-sugarcane-cultivation/articleshow/59651898.cms on 03-12-2017.

[18] The satellite images of later part of June 2016 showing the sugarcane acreage across the country was procured by the Indian Sugar Mills Association (ISMA) and after detailed analysis, it was estimated the total sugarcane acreage of the country in the 2016-17 sugar season, which begins from October 2016, would be around 49.91 lakh hectare (hectares), which is about 5.5 percent less than last year. For more details see: http://commoditiescontrol.com/eagritrader/common/newsdetail.php?type=SPR&itemid=8384&comid=,6,&cid1=cid1&varietyid=,25,&varid=

Future trends in economic sphere

The BCS is one of the sub-sectors and solely based on the future of sugar industry for its survival. However, this productive industry is in the midst of turmoil now. The future economic trends illustrate three most crucial trends with varying degree of impact on BCS. If we see the pace of RE sector at large at Indian context it has been growing very much fast than the expectation. Mainly the wind and solar sectors are growing at high rate this trend might create future conflicts within the RE sectors and the relatively under-researched and growing sector like BCS might face problems mainly with regard to its day by day falling tariff charges and policy/legal challenges involved in selling energy to the state and private agencies. The growing maintenance and initial establishment cost of BC plant has become a major challenge in contrast problems are emerging with regard to its grid connectivity, disputes in tariff rates fixed by state agencies and RPO. Thus, considering the issues related to the profit-loss appraisal the sector may face severe risks in near future. The only option remains is to utilize the energy generated by BC plant for the sugar factory itself. This trend creates negative future policy effects. Likewise, the second future trend that show static trend and having = neutral or unknown future policy impact also explores ground level realities. Sugarcane and the sugar industry both are known as a multi-producers, therefore occupies a prominent position on the agro-industrial map of India. However, considering the matters related to the rising financial un-sustainability of BCS in future the sugar industries may think to divert the bagasse to allied sectors like pulp, paper industries and bio-plastic. The most certain trend proposed by the Delphi experts put forward the fact that the future of BCS will be based on small scale, cluster based and private sector. The possible linkages associated with this trend are: i) there will be a paucity of availability of bagasse that might affect big sugar factories ii) the cooperative BCS have multiple economic challenges due to; under heavy debt burden, dominant political economy, corruption, historical mistakes made in setting up sugar factories in close proximity to one another; lack of professional/financial forecasting; lacking of fiscal equity for improvements in competence and towards updating advanced cogeneration equipment. In contrary, private bagasse cogeneration sector will have positive future trend due to their professional and financial strengths in coming future. Likewise, to overcome with the paucity of bagasse during main/off season small/cluster based models can become viable options. Thus, the aforesaid section (RQ-II) based on the analysis of extensive Delphi exercise provides the larger canvas of the possible future trends that might help to recognize possible alternative futures and their corresponding linkages from a systems perspective. This MFT exercise can be employed as a future tool kit for planning strategies and capturing possible key determining trends for the sustainability of BCS in India @ 2030.

Table 4: Mapping future trends for BCS based on Delphi exercise @2030

Variable	Future trend(s)	P S	ToT	F P I
Technological	i) There will be breakthrough technological innovations in terms of (Small scale turbine, nano and cost effective hybrid technology) convenient for small scale sugar factories.	7-10	CT	+ +
	ii) The increasing cost of advanced technology will remain the main technological hurdle for the large number of small scale sugar factories. Hence, the situation will remain constant until next 10 years.	4-7	ST	=
	iii) There will be no breakthrough innovation and cost effective technology in the next ten years.	1-4	UT	-
Political	i) There will be a drastic political shift at both (Central & State) level. Coalition government may take charge. Hence, RE Policy may face negative effect in coming 10 years.	1-4	UT	-
	ii) Further conducive policy environment at RE sector may exist in coming 10 years with an extension of another term for the NDA	7-10	CT	+ +
	iii) There will be a utopian policy environment at RE sector and due to over utopianism the Government may make policy shrink without any drastic changes in coming 10 years.	4-7	ST	=
Environmental	i) Considering the droughts and erratic rain fall, effects of climate change and growing pressure on water (ground and dam) there will be a serious future problem of sugar cane cultivation in next 10 years.	1-4	UT	=
	ii) Due to climate change farmers may change the cropping practices or change topography and also adopts micro irrigation tools/ organic farming to sustain sugar cane farming	7-10	CT	+
	iii) Farmers will not change their traditional attitude to exploit natural resources for sugar cane cultivation and do not stop sugar can cultivation at large scale.	4-7	ST	- -
Economical	i) The bagasse cogeneration industry will not be a much profitable sector due to slowdown in Terrif rates because of surplus energy production in next 10 years.	1-4	UT	-
	ii) Due to increasing demand for bagasse from other growing sectors like pulp and paper industries there will be an enormous increase to purchase bagasse. That might affect the future of cogeneration plants in next 10 years.	4-7	ST	=
	iii) In future only small scale, cluster based and private cogeneration plants can be a viable future option.	7-10	CT	+

Probability Score ***(PS):*** ***1-4(UT);*** ***4-7 (ST);*** ***7-10 (CT)***

Type of Trend(s) ***(ToT):*** *Uncertain Trend* ***(UT);*** *Static Tend* ***(ST);*** *Certain Trend* ***(CT)***

Future Policy Impact ***(FPI):*** *++ and + are positive, = is neutral or unknown, - and - - are negative effects*

RQ-III

The analysis based on the earlier RQ-II sets the ground for further refinement of the futures process that tend to reflect possible key determining trends (KDT's) for the future of BCS @ 2030. In futures methodology, drawing (KDT's) can be seen as a potential tool for developing vigorous, concise futures viewpoint or an outline, which can remove prejudices and unlock minds through exploring and mingling across-the-board developments that may affect the very ecology and surroundings in which the future processes takes place(See: Troutman and Palombo,1983). It is in the context of above futures underpinnings the present sub-section (RQ-III) offers four precise possible (KDT's) with special reference to BCS @ 2030. After MFT's analysis it becomes more imperative to establish what are the most crucial trends which determine the very development and sustainability of BCS? The KDT's depicted in figure no 5 provides a specific trustworthy foundation for assumption/prediction than trust on sheer perception.

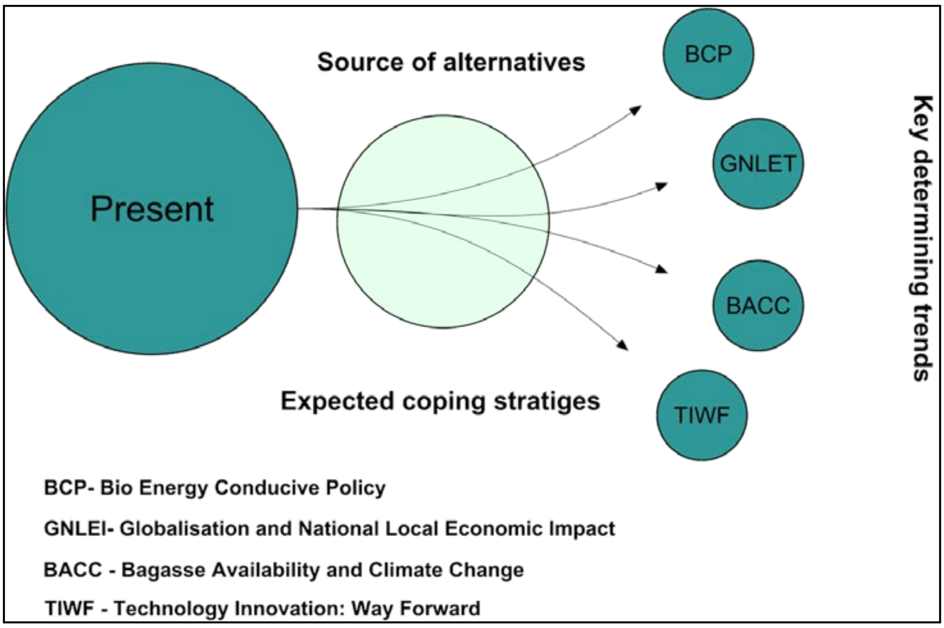

Figure no 5: Key determining trends for BCS @ 2030

KDT-I:

The above KD trend has a significant denotation for the future development and sustainability of BCS in India. The policies/laws related to BCS come broadly under bio- energy which also includes other bio-energy energy sources such as: bio fuel, ethanol, bio gas and bio mass. As a result, it has been observed that the BCS is being neglected at policy level. Considering the holistic and interdependent nature of BCS which is on the one side covered under EA-2003 and on the other hand also depends on the laws applied to the sugar factory. This kind of dual policy playback is being affecting the overall growth and sustainability of BCS. Therefore, there is an urgent need to have BCS specific responsive conducive policies and strategies.

KDT-II:

The second KDT although offer a macro framework of globalization however formulate a variety of consequences at national and local level in relation to sugar industry and their co-industry that is BCS. Considering the world-systems perspective the above KDT's inspect the trajectories of globalization and their corresponding future effects on sugar industry and BCS. In an era of globalization the markets/industries are interconnected hence do have the impact on production, consumption and trade at global/national/local level. India with a large consumption base for sugar has a greater impact at global level, if their sugar supply fluctuates even by a small percentage (Hira, 2011). It has been observed that the Indian SF/BCS have the aforesaid weaknesses: lacks in global sector specific linkages; lacks in global collaborations in R&D, HR up-gradation and intersectional market, financial/funding linkages. These barriers make the industry stagnant and create challenges for the sustainability. In spite being the biggest customer of sugar and the second highest producer of sugar at the global level, sugar industry including bagasse cogeneration sector, more so in the globalization era, has not curved out to be a source of attraction for their stakeholders (Sharma A. K. et al, 2015).

KDT-III:

At worldwide, sugarcane is flattering as one of the sole crops for bio-energy production in general and BCS in particular. The growing problem of greenhouse gas effect and global climatic change results in the rising rate and amount of tremendous weather affairs. Global and National agencies such as (IPCC 2015, FAO 2012, UNDP, 2009) noted that the ill effects of climate change has already been taking place and creating serious consequences for sugarcane production at world, especially in the developing countries like India due to comparatively small adaptive capability, extreme susceptibility to environmental hazards, including fragile weather forecasting and technological/human extenuating policies. Likewise, population growth, changing food consumption pattern both at national/global level and speedily degrading natural resources are also becoming major problems. Consequently, under such hostile geo-ecological conditions at Indian agriculture climate change is an upcoming threat to the very future of sugar cane crop that further have possible pessimistic linkages to its associated subsectors like BCS. One of the crucial future impacts is the scarcity of bagasse which is the primary raw material used to generate cogeneration plants. Thus, trustworthy forecasts of sugarcane response to climate change with specific drivers and concurrent policy suggestions are inevitable for the policy makers to plan coping strategies at the earliest.

KDT-IV:

The optimum production of energy through bagasse cogeneration primarily depends upon two factors: i) the variety of sugarcane crop having added fiber/moisture content/percentage and ii) most significantly, the technology adopted by the sugar industry it includes: the boiler configuration and level of steam pressure (lower/higher) turbines. The technological assessment of the present status of BCS in India shows mixed realities the relatively newely opened sugar factories (mainly after 2000) and preferably private sugar factories having only advanced technology the percentage roughly goes to 30-35 % however, old sugar factories dominantly cooperative/public sector and small sugar factories using traditional technology with low pressure. Studies (Luo et al, 2009; Purohit and Michaelowa, 2007) found that using advanced technology creates 6-10% more energy from BC plants. Therefore, an urgent need is to modernize sugar mills and the existing BC plants for optimum and superfluous energy generation. Furthermore, there are yet 269 sugar mills roughly (60%) of total that are yet to be connected with BC plants and the small mills having (1000 TCD) can also become part of the future energy production through bagasse.

Thus, the above analysis tries to capture four most vital KDT's for enhanced and precise understanding of the composition and extent of intricate backward and forward linkages involved in various connected sectors of the BCS which are not allowing the BCS to tap its full energy potential. Therefore, for the future prospects of BCS suitable policy suggestions based on select drivers has to be developed.

RQ-IV

The preceding section proposed four (KDT's) that impels a range of outlines of the current futures investigation. Therefore, it needs specific drivers to analyze its enormity that unites various trends and concerns raised in the each KDT's. Drivers are the factors resulting in to change and further influencing or shaping the future (FAO, 2014)[19]. In futures studies drivers also assists the futurists to formulate specific policy suggestions to make desirable choices and forecast to avoid future problems to face.

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[19] "Thus, drivers of change are those factors, forces or events […] which may be amenable to changes according to one's strategic choices, investments, R&D activities or foresight knowledge and strategies. They are both presently accessible and future relevant". (Saritas O., Smith J, 2011:295). For more details see: Saritas O., Smith J. (2011) The Big Picture: Trends, drivers, wild cards, discontinuities and weak signals, Futures 43(3): 292–312.

Table 5: Key Determining Trends their Drivers of Change and Policy Concern(s)/Suggestion(s)

KDT-I: Bio-energy Conducive Policy		
Sr.no	Drivers	Policy concern(s) and suggestion(s)
1	Structural reforms in the BCS	2.1. Reforms like Sugar Sector Action Map (SSAM) and Bagasse Industry Efficiency Mission (BIEM) it includes: modernization of cane fields/ production, energy efficiency certificates, incentive/ fund for bagasse storage; creating independent power companies; public-private-co-operative linkages. 2.3. Bagasse Energy Situational Audits(BESA) mandatory for establishing new SF and BC plants 2.4. National level RE segmented data management agency (REDMA) with special reference to all available RE sources and regional specifications.
2	The higher establishment cost and stagnant tariff/ escalation rate	5.1. Bagasse tariff rate/fuel price indexation mechanism formula will be developed every year by the competent agency to overcome with the low tariff rate under (RPO) and including its escalation percentage. 5.2. There must be a state-wise minimum benchmark for fixing tariff rate, centralized or state-level parameters to fix tariffs shall be prepared under a National Electricity Plan and National Tariff Policy by Central Electricity Regulatory Commission (CERC)
3	Sustainable relationships with primary sugarcane growers	3.1. To compensate and encourage growers a good viable plan for sugarcane price could be evolved which is not merely based on sugar content but equally relied on sugar quantity and fiber content. Such future practices will be a panacea for the sustainability of the BCS and SF. 3.2. This kind of crop-incentive would enable them to adopt modern farm practices such as: higher recovery sugar seeds and innovative sugar crop like 'fuel cane' and micro irrigation practices.
KDT-II: Globalization and national/local economic impact		
Sr.no	Drivers	Policy concern(s) and suggestion(s)
1	International funding linkages	1.1. Open up new avenue/ framework for international funding through MNRE and Cogeneration Association of India (CAI) such as independent power producers; small/cluster based BC plants; special bagasse energy economic zones (BEZ).
2	Global reforms in FDI/ industry and future of BCS	2.1. To make the BCS vibrant there must be fair competitive business environment and scope for private international/national actors for investment and expansion 2.2. Since India has secured first time the top 100 rank in the World Bank's ' Ease of Doing Business' ranking there is a huge scope for business reforms in Sugar sector including BCS to attract international investors, partnership and R&D like Brazil, Mauritius and EU countries. 2.3. To sustain Indian sugar industry Indian government endorsed 100 % FDI and creating enabling environment through qualitative reforms and tax exemptions. 2.4. Need to create to favorable environment by MNRE, Sugar federations to get advanced technology, capital investment that brings competition within the local markets, improve managerial skills, innovative ways for energy storage, transfer and additional energy production.
3	Building lobbying and leadership at international level for clean movement	3.1. Already, India has initiated 'International Solar Alliance-ISA", being world's largest sugar producer India has an opportunity to form "International Sugar Energy Industry Alliance-ISEIA" even, initially alliance at BRICS/ASEAN countries can also be a viable option which will help to open new spaces and resources for BCS. 3.2. The alliance of this kind will create future opportunity to: lead global movement in clean energy; fund created through the alliance cane be useful for R&D, training, employment generation and infrastructure; get fund from World Bank and IMF; achieve goal of 175 GW clean energy at 2022; capacity building of Indian research institutes working on clean energy and trap full energy potential through BCS.

KDT-III: Bagasse availability and climate change		
Sr.no	Drivers	Policy concern(s) and suggestion(s)
1	Climate Change and Sustainability of land and water for cane production	1.1. Climate change is emerging as key driver threatening future sugar cane production. An action plan towards sustainable coping strategies on climate change has to be implemented in collaboration with IPCC/ICAR/ISRI. 1.2. Due to one of the vital commercial cash crops land under sugar cane is growing steadily which may create problem of future food security and due to lack of awareness and traditional farming mindset to get more production farmers are using huge water and pesticides for sugar cane farming which results in land salinity and water depletion at higher rate. 1.3. To sustain sugarcane land it is essential to encourage sugarcane grower clubs(SGC) on participatory basis towards agronomic modern ecological land/water management practices such as: incentives for organic sugar farmers associations(OSFA) and special policy/packages for Cooperative/Company based Sugar Farming(CBSF); region wise mapping exercise of future potential zones for sugar cane(FPZS) with the help of Indian Space Research Organization(ISRO) and special sugarcane farming drip irrigation act(SFDIA) for water sustainability.
2	Seasonal availability/ scarcity of bagasse	2.1. Seasonal availability and scarcity of bagasse has been one of the ever greatest barriers affecting energy potential and commercial viability of cogeneration plant which restricts the BC plant only during the crushing term (100 – 180 days). 2.2. The Delphi interviews suggested that to overcome with the seasonality problem an alternative is possible through implementing preservation of bagasse and mixing with off related agro waste such as rice shell, crop scums, region wise seasonal residues/waste materials can be used as fuel for BC plants. This needs a careful seasonal biomass mapping plan (SBMP). 2.3. There are model cases like in Maharashtra state '*Shri Pandurang Sugar Factory'* and in Karnataka state *'Ugar Sugar Factory'* both have successfully established the alternative fuel linkages during off-season by exclusively utilizing sugar cane leaf/garbage available from in and around the command area of sugar factory. 2.4. Although, there is an alternative for bagasse during off-season however, there are critical issues related to the practical application of an alternative biomass such as: the collection of such a huge amount of biomass, packaging, distribution, storage, marketing, pricing, trained human resource and transport/selling.
3	Climate change road map	3.1. It is suggested that considering the future sustainability of BCS the MNRE in collaboration with Ministry of Agriculture(MoA) and Environment(MoE) and National Skill Development Corporation (NCDC) prepare a roadmap for institutionalizing the biomass banks(BMB) through a decentralized approach to financially/technically encouraging private/ rural SHG's/ cooperative institutions/*grampanchayats* to establish strong value chain and linkages for such new avenues which will sustain BCS and also creates enormous employment opportunities in clean energy sector. 3.2. Likewise, MNRE in collaboration with ICAR and Sugarcane Breeding Institute (SBI) instigate special program for developing new varieties of "energy/fuel cane" to overcome with the problem of scarcity and seasonal availability of bagasse.

KDT-IV: Technological Innovation: way forward		
Sr.no	Drivers	Policy concern(s) and suggestion(s)
01	Advancements in plant technologies	1.1.There are two important technological related lacunas that are persistently hampering the development of BCS in India i) Out of total (576) SF's around 156 (27%) small sugar factories with capacity of lower than 2,500 TCD are not eligible to get fund for BC plant and therefore, lacking with standard/advanced technology ii) the rest of SF's around 420 (73 %) are above 2,500 that are eligible for

		funding for BC plant but, out of that only 213(37%) sugar factories installed BC plants, yet 207(36%) SF's are not connected under BC plants as on 2013(PIB, 2013). Yet, in all 363 (63%) SF's can become a part of India's clean energy movement. 1.2.There is an urgent need of technological policy reforms in two ways: i) MNRE could relax the funding norms for small SF's below 2,500 TCD and suggest suitable well tested technology for small SF's; generate policy guidelines for new BC plants(GNBCP) for small SF's ii) there is a discrimination for funding for new BC plants among the cooperative and private SF's it is suggested that MNRE shall give equal funding for even private SF's because they are in more numbers with advanced techno-managerial facilities.
02	Manufacturing capabilities	2.1. To harness maximum amount of energy from BC plants advanced state of art technology with relatively low cost is a need of hour. MNRE shall initiate indigenous manufacturing units under 'Make in India' initiatives to develop generation next cost-effective bagasse technology such as: development of hybrid small scale efficient high pressure technology; bagasse and blended biomass cogeneration technology; special funding for technology updating on the basis of merit and outcome; increase approved manufacturers and suppliers region wise.
03	Non-feasibility of Technology push policy	3.1. It is observed that the so-called technology push policy is not adequate to develop the BCS in India. Instead, 'demand pull policy' on the basis of through market mapping exercise in collaboration with stakeholders demand for technology assessment and economic requirement is in fact needed(See Scherer, 1982).

CONCLUSION

The upcoming developments and rising accountability in the area of RE sources have spurred the prospects of Indian policy makers and allied stakeholders to make future expansion by creating conducive environment for the future RE area like bagasse cogeneration sector (BCS) managed by sugar factories. However, for any growing sector there are always gaps and anxieties about its future role and sustainability. The present study is probably the first attempt to empirically try to fill the aforesaid gap by using futures methodology. In particularly, the study on India's BCS analyses three vital aspects: i)the future prospects for (BCS) by using PESTEL method ii)mapping future trends and their key determining trends(KDT's) and finally offers iii) key drivers and their explicit policy suggestions for future sustainability. The study provides answers to the four specific research questions (RQ's) as above: RQ-I and II: both the RQ's offers two distinctive trends at first instance it concludes with proposing twelve future trends that help to be acquainted with early future warnings and later on finalizes four KDT's. These four dominant KDT's are highly likely to influence the very sustainability of bagasse cogeneration wherein funding, regulatory policies and institutional/ecological features have become more crucial. RQ- III and IV: The final RQ's concludes with drivers of change based on the four KDT's that are causing change and affecting/shaping the future sustainability of bagasse cogeneration and also offers concrete practical policy suggestions. Thus, considering the immediate and foreseeable future that is (2030) for (BCS) it is concluded that, based on the policy suggestions systemic changes in the sector as a whole have to be made.

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