Potential Assessment of Agro-Residues Based Power Generation in Dhule District

A Project Report Submitted
to

Dr. BABASAHEB AMBEDKAR TECHNOLOGICAL UNIVERSITY

LONERE (M.S.), India

In partial fulfillment
for the award of the

Degree of

Bachelor of Technology
in
Electrical

Engineering by

Parth Mahesh Nandre PRN:2254491293032
Mehul Mahaveer Nahar PRN:2254491293031
Vaibhav Shivaji More PRN:2254491293030
Mayur Vijay Jadhav PRN:2254491293021

Under the Guidance of
Dr. Namra Joshi
Assistant Professor

Department of Electrical Engineering
Shri Vile Parle Kelavani Mandal's Institute of Technology Dhule (M S)
Session: 2023 – 2024

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DECLARATION BY THE CANDIDATES

We the undersigned solemnly declare that the report of the project work entitled Potential Assessment of Agro-Residues Based Power Generation In Dhule District is based on the work carried out during our study under the supervision of Dr. Namra Joshi

We assert that the statements made and conclusions drawn are an outcome of the project work. We further declare that to the best of our knowledge and belief, the report does not contain any part of any work that has been submitted for the award of any other degree/diploma/certificate in this University / deemed University of India or any other country. All help received and citations used for the preparation of the project report have been duly acknowledged.

Parth Mahesh Nandre (Signature_____)
Mehul Mahaveer Nahar (Signature_____)
Vaibhav Shivaji More (Signature_____)
Mayur Vijay Jadhav (Signature_____)

CERTIFICATE OF THE GUIDE

This is to certify that the report of the project work entitled Potential Assessment of Agro-Residues Based Power Generation In Dhule District is a record of bonafide work carried out by
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Mehul Mahaveer Nahar (PRN:2254491293031)
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under my guidance and supervision for the award of Degree of Bachelor of Technology in the faculty of Electrical Engineering, of Dr. Babasaheb Ambedkar Technological University, Lonere (M.S.) India.
To the best of my knowledge and belief the project report

- Embodies the work of the candidates him/herself,
- Has duly been completed,
- Fulfils the requirement of the Ordinance relating to the B.Tech. degree of the University and
- Is up to the desired standard both in respect of contents and language for being referred to the examiners.

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Principal

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CERTIFICATE BY THE EXAMINERS

The project report entitled Potential Assessment of Agro-Residues Based Power Generation in Dhule District Submitted by
Parth Mahesh Nandre (PRN:2254491293032)
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has been examined by the undersigned as a part of the examination and is hereby recommended for the award of the degree of Bachelor of Technology in the faculty of Electrical Engineering of Dr. Babasaheb Ambedkar Technological University, Lonere (M.S.) India.

_____	_____
Internal Examiner	External Examiner
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Abstract

This comprehensive report, titled "Potential Assessment of Agro-Residues Based Power Generation in Dhule District," embarks on a nuanced exploration of the district's transition towards sustainable energy, focusing specifically on the untapped potential within agro-residues. The study's objectives are multifaceted, aiming to assess the economic viability, environmental impact, and socio-cultural implications of integrating agro-residues into the energy matrix. The literature review provides a solid foundation, surveying existing research on agro-residue-based power generation and renewable energy in agricultural landscapes, and positioning the study within the broader academic context. Methodologically, a transparent approach is adopted, combining quantitative and qualitative methods, including surveys, interviews, and data modeling. The results and discussions section forms the core of the report, unveiling empirical findings that underscore the energy potential within agro-residues, economic implications for Dhule District, and the environmental benefits of diverting residues from open burning to power generation. The conclusion succinctly synthesizes these key insights, offering a comprehensive resolution to the research questions. Building upon this, actionable recommendations are presented for stakeholders, policymakers, and practitioners, informed by the study's findings. The report concludes with a thoughtful consideration of the scope for further work, acknowledging the dynamic nature of the subject and outlining potential avenues for future research. In appendices, supplementary materials provide transparency and depth to the report, while a comprehensive list of references ensures academic integrity, anchoring the study within the broader body of knowledge on renewable energy and agro-residues. Overall, this report serves as a detailed roadmap for understanding and harnessing the potential of agro-residues in Dhule District's journey towards sustainable power generation.

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List of Abbreviations

Abbreviation	Full form
OLI	Operational Land Imager
STI	Science, Technology, and Innovation
NDVI	Normalized difference vegetation index
NDTI	National Development Team for Inclusion
GWh	Gigawatt hour
CHP	Combined Heat and Power
MW	Megawatt
USD	United States dollar
GHG	Greenhouse Gas

Chapter – 1

Introduction

Chapter 1: Introduction

In an era marked by the imperative for sustainable development, renewable energy has emerged as a beacon of hope, promising a transformative shift away from traditional fossil fuel dependency towards cleaner, more sustainable alternatives. As the global community grapples with the dual challenges of meeting escalating energy demands and mitigating the environmental impact of conventional energy sources, the quest for innovative and eco-friendly solutions has gained unprecedented urgency. At the forefront of this transition stands the exploration of agro-residues an often-overlooked, yet potent, resource that holds the promise of reshaping our energy landscape.

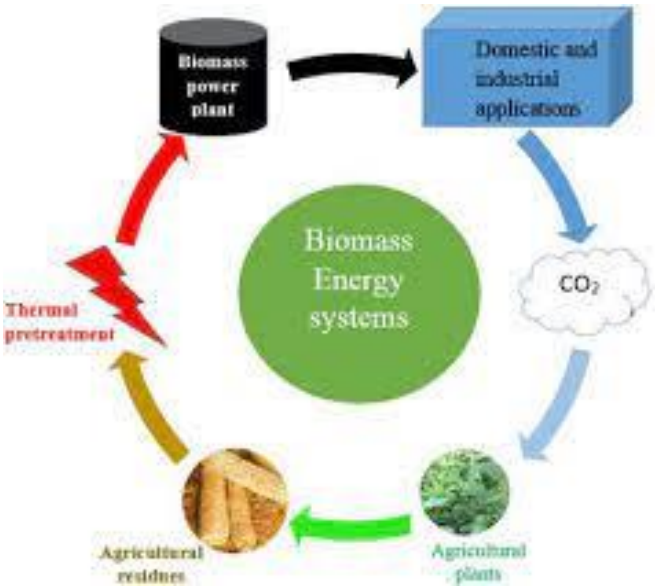

Fig 1.1. Biomass Energy System [28]

The Global Pursuit of Renewable Energy:

The trajectory of global energy discourse has undergone a profound shift, with a growing recognition of the limitations and drawbacks associated with fossil fuel-based energy sources. Climate change, environmental degradation, and geopolitical complexities have underscored the need for a paradigmatic transition towards renewable energy. Technologies harnessing solar, wind, hydropower, and biomass have risen to prominence, offering cleaner and more sustainable alternatives to traditional forms of energy generation.

Renewable energy not only represents a technological evolution but also a fundamental reimagining of our relationship with the environment. The pursuit of renewables aligns with a vision of a future

where energy production is in harmony with ecological systems, mitigating climate change impacts and fostering resilience in the face of global challenges.

Agro-Residues as a Crucible of Renewable Potential:

Within the vast realm of renewable energy sources, agro-residue byproducts of agricultural activities emerge as a compelling frontier that demands exploration. Traditionally considered as waste or discarded material, agro-residues possess intrinsic energy-rich properties that can be harnessed for power generation. This untapped potential presents a dual opportunity: not only can it address the escalating demand for renewable energy but it also provides a sustainable solution for managing agricultural waste.

Agro-residues encompass a diverse range of organic materials, including crop residues, animal manure, and organic waste from processing facilities. Harnessing the energy stored in agro-residues can provide a way to create cleaner energy production while managing agricultural waste. If left to decompose or burned in the open, these residues can cause environmental pollution and the release of greenhouse gases.

The Dhule District Context:

Our concentration on agro-residues resonates with the unique agriculture of Dhule District. This region's fertile plains, diverse crops, and agrarian heritage make it a perfect site for our study. In addition to offering plenty of agro-residues, Dhule's agricultural richness serves as an embodiment of the difficulties and opportunities associated with the integration of such waste materials in the energy mix. Our objectives are varied while engaging on this voyage. To quantify energy potential within agro-residues; evaluate their environmental and economic impacts; identify obstacles to their deployment in electricity generation; and provide meaningful contributions towards wider discourse on renewable energy strategies.

This paper is consequently a journey through renewable energy, particularly focusing on the transformative power that comes with using agro-residues in Dhule District. It is a quest for sustainable solutions, a commitment to innovation, and a recognition of the integral role that renewable energy plays in shaping a resilient and environmentally conscious future.

In the subsequent chapters, we delve into the specifics of our methodology, the agricultural profile of

Dhule, challenges, opportunities, and the roadmap for integrating agro-residues into the energy landscape. Through this journey, we seek not only to contribute to the growing body of knowledge in renewable energy but also to chart a course towards a future where energy production aligns seamlessly with environmental sustainability.

1.1 Importance of the Study for Dhule District:

In the context of Dhule District, the study on the potential assessment of agro-residues-based power generation holds paramount importance, offering a multifaceted array of benefits that extend beyond immediate energy considerations. This section elucidates the significance of the study within the specific socio-economic and environmental context of Dhule.

1.1.1. Economic Diversification and Rural Prosperity:

Dhule's economy, deeply rooted in agriculture, stands to gain substantially from the integration of agro-residues into power generation. By diversifying economic activities, the district can reduce dependency on traditional revenue streams. The establishment of agro-residue-based power generation facilities introduces a new economic avenue, potentially fostering job creation and catalyzing rural prosperity. This economic diversification is crucial for building resilience in the face of fluctuating agricultural markets and changing climatic conditions.

1.1.2. Sustainable Agricultural Practices:

The study's findings can contribute to the adoption of sustainable agricultural practices in Dhule. As residues are diverted from open burning or inefficient disposal methods to energy generation, the agricultural landscape benefits from improved soil health and reduced environmental pollution. This transition aligns with global sustainability goals and positions Dhule as a trailblazer in sustainable agriculture, setting an example for responsible resource management.

1.1.3. Energy Security and Reliability:

Dhule, like many regions, faces challenges related to energy security and reliability. By tapping into the latent energy potential of agro-residues, the district can diversify its energy sources, reducing dependence on external suppliers and conventional power grids. This localized and decentralized

approach enhances energy resilience, ensuring a more reliable and stable energy supply for both rural and urban areas within Dhule.

1.1.4. Mitigation of Environmental Impact:

The study directly addresses environmental concerns associated with the disposal of agro-residues. Open burning of residues contributes to air pollution and greenhouse gas emissions. By converting these residues into a renewable energy resource, the district can significantly mitigate its environmental impact. This shift aligns with global commitments to reduce carbon footprints and enhances Dhule's reputation as a responsible and environmentally conscious community.

1.1.5. Climate Resilience and Adaptation:

Dhule, susceptible to the impacts of climate change, stands to benefit from the study's insights into agro-residue-based power generation. Climate-resilient practices, such as utilizing residues for energy, enhance the district's adaptive capacity. The study contributes to a broader strategy for climate resilience, ensuring that Dhule is better equipped to withstand and adapt to the changing climatic patterns affecting agricultural productivity.

1.1.6. Community Empowerment and Education:

Beyond the tangible economic and environmental benefits, the study empowers local communities by fostering awareness and education. The adoption of agro-residue-based power generation requires community participation and understanding. As residents become stakeholders in sustainable energy initiatives, a culture of environmental stewardship and innovation permeates through the fabric of Dhule, creating a more informed and engaged citizenry.

1.1.7. Showcasing Dhule as a Renewable Energy Pioneer:

Dhule's active engagement in exploring the potential of agro-residues positions the district as a pioneer in renewable energy practices. This study provides an opportunity for Dhule to showcase its commitment to sustainable development on a broader stage. As renewable energy gains global attention, Dhule's efforts contribute to the broader narrative of transitioning towards cleaner and more sustainable energy solutions.

As we stand at the threshold of this exploration into the potential assessment of agro-residues-based power generation in Dhule District, it becomes apparent that this study is not merely an examination of energy sources but a journey towards sustainable innovation. The chapters that follow will delve into the intricate details of our methodology, the agricultural profile of Dhule, challenges, opportunities, and the roadmap for integrating agro-residues into the energy landscape. In doing so, we aim not only to contribute to the growing body of knowledge in renewable energy but also to catalyze a transformation in Dhule a transformation that harmonizes agriculture, innovation, and sustainability. The narrative unfolds, and within these pages, we embark on a collective endeavor to unlock the latent potential within agro-residues, paving the way for a resilient and sustainable future for Dhule District and beyond.

Chapter – 2

Review of Literature

Chapter 2: Review of Literature

2.1 Literature Review

Wenting Cai *et.al.* (2018): This research in Yucheng County, China, utilizes Landsat OLI and Sentinel-2 data to assess winter wheat crop residue cover. Tillage indices, including NDI5, NDI7, STI, NDTI, NDSVI, CRC1, and NDRI, are compared. Thirty 10,000m² fields are studied with nine 1m×1m sub-fields each. Reflectance spectral data (350-2400nm) are measured using Analytical Spectral Devices, and digital photos provide crop residue area ratios.[4] The objective is to pinpoint the most effective tillage indices for estimating crop residue cover through broad-spectral satellite imagery.

Shalini Gnanavel *et.al.* (2019): India, ranking second in global fruit production, produced 90.2 million metric tons in 2018-19, leading in Banana (25.7%), Papaya (43.6%), and Mango (40.4%) production. However, artificial ripening poses health risks due to pesticide residues. With 234 registered pesticides, surpassing permissible levels is a concern.[5] To address this, the paper advocates quality detection through integrated technologies for organic consumption, aligning with the Make in India Scheme to enhance fruit trade.

Linda Ieviņa *et.al.* (2019): Distributed electricity production using biomass-fueled cogeneration units enhances energy efficiency and boosts renewable energy utilization. In Latvia, the rising forest wood stock offers an opportunity for intensified use. To meet growing energy wood demand sustainably, this study explores the increased utilization of low-quality wood for distributed electricity generation. Calculations indicate a potential of 629.72 GWh per year, supporting CHP plants with a total installed power of 73 MW.[6]

E. Tyurina *et.al.* (2020): This study investigates a modular wood biomass plant for combined electricity and methanol production. It employs wood biomass gasification with air-steam as the agent, catalytic methanol synthesis, and a combined cycle. Detailed mathematical models for plant elements were developed, and parameters were optimized.[7] Results highlight technical and economic indices of the optimal plant options, with the most favorable choice featuring a gasifier steam consumption of 0.6 kg/kg biomass.

Ravita D. Prasad *et.al.* (2021): This paper explores biomass use in Pacific Island Countries, focusing on Fiji's potential 10 MW biomass power plant with logging residue. It assesses techno-economics, emphasizing the feedstock cost's impact. With 60,000 tones needed from Viti Levu's western division, the project, based on a USD68.6/ton feedstock cost and USD0.1621/kWh tariff, shows a USD16.1 million net present value, a 5.6-year payback, and a 2.5 benefit-to-cost ratio. Sensitivity analysis highlights key factors. Strategies proposed include using forest residues, policies, stakeholder engagement, and suitable technologies for Fiji's biomass power sector.[8]

Somya Mishra *et.al.* (2021): Fossil fuel burning raises global temperatures, causing ecological imbalance. Biomass gasification is a mature technology with the potential to replace fossil fuels, but improvements are needed. This paper offers a concise overview, discussing key parameters and the production of valuable products like syngas, biofuels, and power. It covers various gasifiers, introducing supercritical water gasification. Future directions are outlined.[9]

Segun E. Ibitoye *et.al.* (2021): Global demand for sustainable energy is increasing due to urbanization and industrialization. Transforming abundant biomass resources, like agro-residues, can address environmental threats and provide job opportunities. Densification processes, including briquette and pelletizing, offer a solution to diversify energy crops, meeting renewable energy demands while mitigating environmental challenges. Various methods produce solid fuels suitable for domestic and industrial use.[10] Biomass densification is crucial for rational and efficient solid fuel utilization, playing a vital role in meeting the growing demand for sustainable energy.

Pradeep Kumar *et.al.* (2021): Power generation from biomass fuels is emerging in India, especially in the wheat and paddy-rich states of North India. Burning waste from these crops is hazardous, contributing to increased carbon emissions. The paper provides an overview of available biomass resources in North India, discussing biomass-based power plants for electricity generation. Alternative crops with higher calorific values than paddy straw are explored, revealing their benefits for power generation. The analysis underscores the economic and environmental advantages of electricity generation through biomass-based hybrid and non-hybrid systems in the region.[11]

Titus O. Ajewole *et.al.* (2022): This study explores converting waste into electricity by blending cocoa and kola nut by-products. Bioethanol, derived from the blend, is mixed with gasoline to fuel a spark ignition engine driving a synchronous machine. The machine performs better with the mixed fuel, showing increased torque and power as ethanol proportion and rotational speed rise. The highest torque and power with pure gasoline were 12.4 Nm and 2574 W, while with a 10%bioethanol fuel mix, it reached 13.1 Nm and 2953 W at 1900 rpm. The driven machine, with 90 Vdc excitation voltage at 1500 rpm synchronous speed, continuously generated electricity.[12] This study demonstrates the potential for steady electric power generation from cocoa and kola nut wastes, suitable for off-grid microgrid electrification in crop-abundant regions.

Sivaraman P *et.al.* (2022): This paper proposes a downdraft biomass gasifier utilizing coconut shells to generate electricity, aiming to reduce carbon emissions in remote regions. The producer gas fuels a combustion engine coupled to a generator. Performance assessment considers reactor temperature, tar content, producer gas, and system mass balance. Results show a 60% decrease in carbon footprint using coconut shells as fuel. Biomass gasifiers can offer efficient power generation in isolated areas where coconut shells are abundant and underutilized commercially.[14]

Samson Nnaemeka Ugwu *et.al.* (2022): This study compares the environmental impacts of enhanced anaerobic digestion for biogas production from okra and pig wastes, considering various enhancement options. Results show that the combined enhancement (co-digestion + PPy/Fe3O4 NPs) has the least global warming potential (0.0053 kg CO2-eq/MJ). Recommendations include adopting the combined enhancement, followed by PPy/Fe3O4 NPs only, for minimizing environmental impacts in electricity generation from biogas.[15] Further suggested analyses involve techno-economic and life cycle cost assessments of the preferred scenario.

Akashdeep Dey *et.al.* (2023): This paper explores the untapped waste-to-biomethane potential in India's sericulture, fisheries, and agro-industrial sectors. Annual biomethane potentials for 2018–19 were 88 million m3, 207 million m3, and 3514 million m3, respectively. The comprehensive review estimates gross thermal energy and electricity generation potentials at 132 PJ and 22 TWh, benefiting 19 to 95 million people. This waste-to-energy approach also aids in removing 5.5 to 9.3 million tons

of chemical oxygen demand from India's surface waters. Cumulative GHG abatements are 11.4 million tones for electricity generation and 6.8 million tones for cooking, supporting India's energy goals and aligning with government policies and six Sustainable Development Goals.[16]

Arashdeep Singh *et.al.* (2023): This study characterizes agro-residue pellets for syngas generation in a downdraft gasifier using oxygen and steam. The high ash content (11.46 wt%) and inorganic elements necessitate temperature control below 900 °C. Optimized char-ash extraction achieves consistent production of hydrogen-rich (42.2 vol%) syngas with a lower heating value of 8.3 MJ/Nm3 and gross cold gas efficiency of 78.9%. A vacuum pressure swing adsorption system with zeolite 13X adsorbent separates pure hydrogen at a pressure ratio of 7.5.[17] The study integrates oxy-steam gasification with low-pressure swing adsorption for practical syngas separation and hydrogen quality assessment.

2.2 Summary of Literature Review

Table No: 2.1. Summary of Literature Review

SR. NO.	YEAR	AUTHOR NAME	TITLE	FINDING
1	2018	Wenting Cai *et.al.*	Comparison of Different Crop Residue Indices for Estimating Crop Residue Cover Using Field Observation Data	• It is happily found that straw burning is almost non-existent in Yucheng Country, which leads to a high crop residue coverage concentrated between 80% and 95%. • The research results confirm what China has done in environmental protection in recent years.
2	2019	Shalini Gnanavel *et.al*	Quality Detection of Fresh Fruits and Vegetables to Improve Horticulture and Agro-industries	• The overall aim of the prototype is to help in finding/detecting the quality of the fruit and to provide organic consumption levels. • This can greatly reduce the occurrence of deadly diseases in children upon consumption of these pesticides.
3	2019	Linda Ieviņa *et.al*	Mapping of Distributed Power Generation Versus Biomass Availability	• Results should be taken into account in the process of planning national energy development. By focusing on the development of distributed generation, as well as sustainably

				harnessing the full potential of forest resources, stabilized power supply, and efficient use of forest resources, as well as contributing to regional economy and employment.
4	2020	E. Tyurina *et.al*	Power and Methanol Co-Generation Based on Wood Biomass	• Studies have shown that MPEM for combined methanol and electricity production is more energy efficient than separate production plants. Methanol obtained at MPEM has a competitive price with the prices of motor and boiler fuels.
5	2021	Ravita D. Prasad *et.al*	Prospects of Sustainable Biomass-Based Power Generation in a Small Island Country	• Island nations are striving to satisfy their international climate change-related commitments while ensuring national development and energy security. For biomass power plants in Fiji and elsewhere, the technical aspects are not much of a problem.
6	2021	Somya Mishra *et.al*	Review on biomass gasification: Gasifiers, gasifying mediums, and operational parameters	• In this manuscript, different gasification technologies are presented, along with an emphasis on SCWG. The primary technologies such as fixed bed, fluidized bed, some advanced gasifiers such as entrained flow, dual fluidized bed, and SCW reactor are also considered.
7	2021	Segun E. Ibitoye *et.al*	Densification of agro-residues for sustainable energy generation: an overview	• An overview of densification technologies (pelletizing, briquette) as an efficient and convenient method for providing energy was presented in this article.
8	2021	Pradeep Kumar *et.al*	Biomass Availability and Biomass-Based Generating Units In North India: A Review	• It will increase the level of underground water because the quantity of underground water used for paddy straw is more in comparison to other crops. • Another advantage is that they will less pollute the environment as air pollution is increased by the burning of paddy straw.
9	2022	Titus O. Ajewole *et.al*	Agro-residues for clean electricity:	• This study demonstrated the possibility of continuous generation of

			in-lab trial of power generation from blended cocoa-kola nut wastes	electric power from cocoa and kola nut wastes. • The result obtained from the laboratory-based trial indicates that at such agricultural regions that are advantaged in the production of the two crops, harvest residues of the crops can be explored as a steady source of biofuel for an off-grid microgrid.
10	2022	Sivaraman P *et.al*	Biomass Gasification Using Coconut Shell for Small-Scale Electricity Generation	• The gas produced by gasifiers is utilized to power the combustion engine. To produce power, a 3kW three-phase synchronous generator is connected to the combustion engine. • The performance of biomass gasifiers using coconut shells as fuel is investigated using various analyses. The system is found to be stable as evidenced by the efficiency of 78%.
11	2022	Samson Nnaemeka Ugwu *et.al*	Comparative life cycle assessment of enhanced anaerobic digestion of agro-industrial waste for biogas production	• Various intensification strategies have been reported as an anaerobic digestion enhancement option for biogas production. • The positive gains associated with increased biogas yield and the associated environmental trade-offs have triggered some concerns between higher clean energy production and environmentally sustainable processes.
12	2023	Akashdeep Dey *et.al*	The biomethane generation potential of wastes and wastewater from the sericulture, fisheries, and agro-industrial sectors in India	• This paper evaluates the annual waste-to-biomethane generation potential from the sericulture, fisheries, and agro-industrial sectors in India (in 2018–19) to be 3,810 million m3, excluding sugarcane bagasse and press mud, which are reported separately.
13	2023	Arashdeep Singh *et.al*	Hydrogen production through agro-residue gasification and	• The current work presents the results of an experimental investigation adopted to generate high-purity hydrogen through downdraft oxysteam gasification of mixed ARP

			adsorptive separation	and subsequent multi-component syngas separation in a low-pressure VPSA system.

2.3 Research Gap:

The research gap in the report "Potential Assessment of Agro-Residue Based Power Generation in Dhule District" is evident in the limited exploration of specific technologies, economic feasibility, and regional variations. To enhance the report's utility, a more in-depth analysis of efficient technologies, economic viability, and regional nuances within Dhule District is crucial. Addressing these gaps not only provides a more comprehensive understanding of agro-residue-based power generation but also offers valuable insights for future planning, enabling informed decision-making, sustainable practices, and potentially unlocking untapped benefits for the district's energy landscape.

Chapter – 3

Problem

Identification

Chapter 3: Problem Identification

Dhule District, despite its agrarian richness, faces a confluence of challenges that underscore the need for a paradigm shift in its approach to energy generation. The traditional reliance on conventional energy sources not only poses a threat to environmental sustainability but also leaves the district vulnerable to economic uncertainties and the impacts of climate change. Open burning and inefficient disposal of agro-residues, once considered mere byproducts of agriculture, contribute to environmental degradation and hinder the realization of a circular and sustainable agricultural economy. Additionally, the absence of a systematic exploration into the energy potential within these residues further exacerbates the district's energy insecurity. The problem at hand, therefore, is the lack of a comprehensive understanding and utilization of agro-residues as a viable and sustainable source for power generation in Dhule. Addressing this gap is paramount to unlocking economic opportunities, mitigating environmental impact, and bolstering the district's resilience in the face of evolving energy and climate challenges.

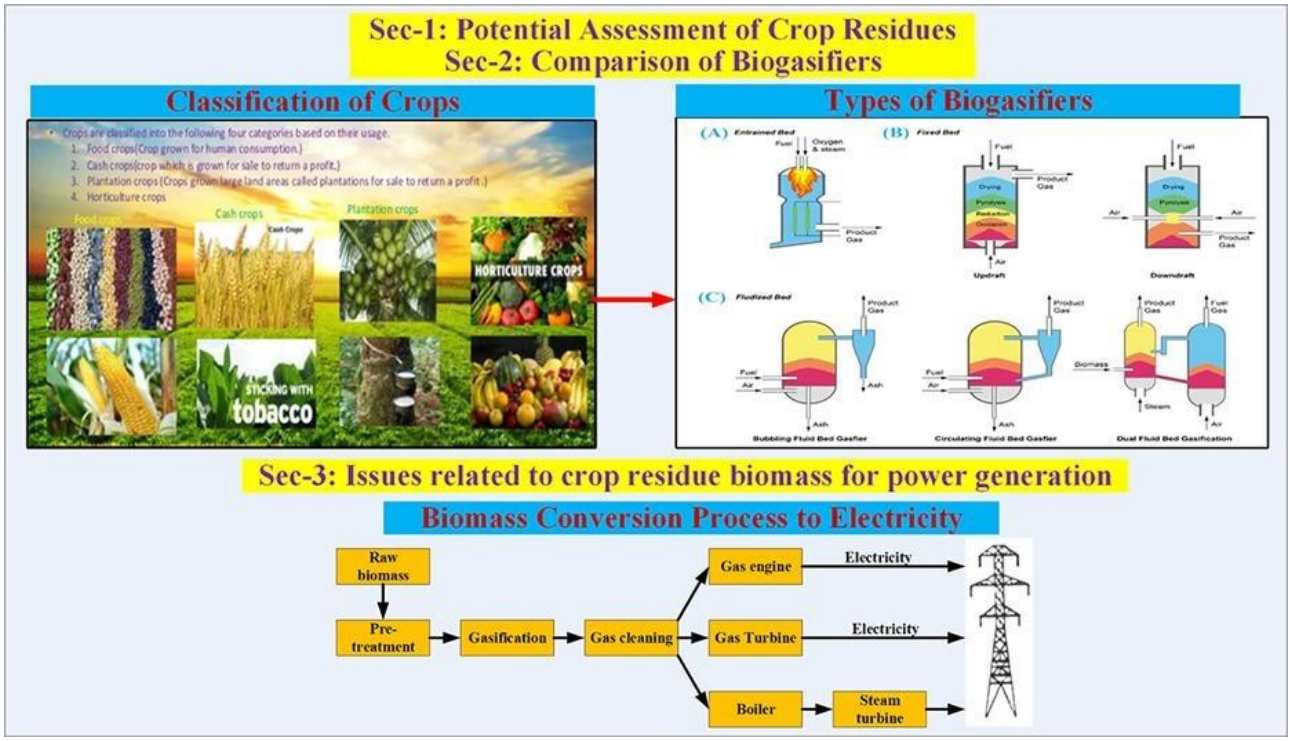

Fig 3.1. Potential Assessment, Comparison & Issues [27]

3.1. Challenges and Issues Related to Agro-Residue Utilization in Dhule District:

3.1.1. Open Burning and Environmental Impact:

Agro-residue open burning is rampant in Dhule District and poses a major challenge. Inexpensive and quick, it is a common practice among farmers for disposal. Significant contributions to air pollution are made through harvesting. Nonetheless, this activity remains notorious for releasing pollution. Environmental footprint? A pressing concern in the district, as greenhouse gases are worsening the situation. It's high time we take action. Traditional agro-residue can hurt the environment, so it's important to find ways to mitigate this impact. Methods of disposing of waste vary. There are many ways to dispose of waste, but not all of them are ideal. Waste management techniques can include incineration, landfills, recycling, and composting. Incineration is not the preferred method because it is not environmentally friendly. Landfills can be a problem if they are not properly designed and managed. Recycling is a good option for waste that can be reused. Composting is an option for organic waste that can be used for soil enrichment. Choosing the right method of disposal for waste depends on the type of waste and the environmental impact.

3.1.2. Lack of Awareness and Education:

There is a noticeable deficiency in knowledge and instruction among farmers and the nearby population concerning substitute applications for agricultural leftovers. The underutilization of leftovers in power generation is mostly attributable to a lack of awareness regarding sustainable practices and the financial advantages of doing so. It is imperative to close this knowledge gap to promote a move toward more economically and ecologically sound disposal techniques.

3.1.3. Technological Constraints:

Affordability and accessibility issues impede the implementation of technology for the use of agricultural residues. It might be difficult for small-scale farmers, who make up a sizable share of Dhule's agricultural population, to acquire or afford the equipment required for processing waste. Targeted interventions are needed to overcome these technological limitations; these might take the form of government programs or partnerships with the commercial sector to increase farmers' access

to these technologies.

3.1.4. Infrastructure for Residue Processing:

Hindering the district's ability to harness renewable resources is a significant obstacle that stems from the absence of dedicated infrastructure for agro-residue processing. Efficient utilization of agro-residues for power generation requires facilities that can collect, process, and convert residues into energy, which is an investment-heavy and planning-intensive task. Without these facilities, the district is unable to effectively harness this renewable resource.

3.1.5. Economic Viability:

Economic viability is crucial when it comes to determining the sustainability of any project. This means that there must be a balance between the costs of a project and the benefits it brings to the company. It is essential to consider all costs such as labor, equipment, materials, and overhead costs when determining the economic viability of a project. To ensure that a project is economically viable, companies must develop a detailed plan that includes accurate cost estimates and revenue projections. Without a thorough economic analysis, companies risk investing in projects that may not provide adequate returns on their investments. Therefore, assessing the economic viability of a project is an essential step in determining its long-term success. Promising as it may be, utilizing agro-residue remains hindered by economic concerns. The sustainability of such ventures lies in the hands of farmers, who already face various financial challenges. Their reluctance towards adopting new practices requires reassurances of benefits that are weightier than just environmental. Therefore, linking clear market incentives, financial aid, and support mechanisms is essential for residue utilization to become widespread.

3.1.6. Policy and Regulatory Framework:

Agro-residue usage is hindered by the lack of a reliable policy and regulatory framework. For farmers and entrepreneurs who want to investigate power generation that's agro-residue-based, there needs to be precise guidelines, incentives, and regulations to follow. The creation of supportive policies will enable easier movement towards agricultural practices that are more sustainable.

3.1.7. Social and Cultural Factors:

Social and cultural factors also play a role in impeding the efficient utilization of agro-residues. Traditional practices and attitudes towards residue disposal may resist change, requiring a nuanced approach that considers the socio-cultural context. Community engagement and awareness programs are vital to address these factors and garner local support for sustainable residue management practices.

3.1.8. Seasonal Variability and Crop Diversity:

Dhule's agricultural landscape is characterized by seasonal variability and diverse crops. Different crops generate various types and quantities of residues, making it challenging to establish standardized approaches for residue utilization. The diversity in residue composition necessitates adaptable technologies and strategies that can accommodate the varying characteristics of agro-residues throughout the agricultural calendar.

3.2. Emphasizing the Significance of Addressing Challenges in Agro-Residue Utilization:

Addressing the aforementioned challenges in agro-residue utilization is pivotal for Dhule District's sustainable development across environmental, economic, and social dimensions

3.2.1. Environmental Sustainability:

Mitigating open burning and adopting sustainable residue management practices significantly contributes to environmental sustainability. The reduction of air pollution and greenhouse gas emissions preserves the ecological balance, fostering a healthier environment for both the agricultural and local ecosystems. This, in turn, safeguards biodiversity and supports the overall resilience of the district's natural resources.

3.2.2. Economic Resilience:

Creating awareness about the economic benefits of agro-residue utilization is paramount for enhancing the economic resilience of Dhule District. By addressing viability concerns and showcasing the potential for additional income streams through renewable energy generation, the

district can empower farmers economically, leading to a more robust and diversified local economy.

3.2.3. Community Well-being:

Improving residue management positively impacts the health and well-being of local communities. Cleaner air resulting from the reduction in open burning contributes to a healthier living environment, reducing respiratory issues and enhancing overall quality of life. Prioritizing community well-being fosters a more vibrant and sustainable social fabric.

3.2.4. Climate Change Mitigation:

Agro-residue utilization aligns with global climate change mitigation efforts. By reducing the release of greenhouse gases, Dhule can actively contribute to broader initiatives addressing climate change. This commitment not only demonstrates environmental stewardship but also positions the district as a proactive participant in global sustainability endeavors.

3.2.5. Resource Optimization:

Efficient utilization of agro-residues optimizes available resources, transforming what was once considered waste into a valuable commodity for power generation. This resource optimization not only reduces dependency on traditional energy sources but also minimizes the ecological footprint associated with agriculture. It fosters a circular economy, promoting a more sustainable and resilient agricultural system.

3.2.6. Rural Empowerment:

Creating awareness and providing support for agro-residue utilization empowers rural communities. By offering innovative and sustainable avenues for economic growth, the district can uplift the economic standing of these communities. This empowerment contributes to social and economic equity within Dhule, fostering a sense of community pride and resilience.

In recognizing the multifaceted challenges surrounding agro-residue utilization in Dhule District, it becomes clear that the current practices not only pose environmental and economic threats but also hinder the district's potential for sustainable growth. As we delve further into this report, our focus

shifts from the identification of these challenges to the exploration of strategic solutions. The subsequent sections will unravel a comprehensive analysis, delving into methodologies, results, and discussions aimed at forging a path toward sustainable agro-residue-based power generation. By understanding the challenges at hand, we lay the groundwork for transformative solutions that will not only mitigate the identified issues but also contribute to the district's journey toward a more resilient and sustainable future

Chapter – 4

Methodology

Chapter 4: Methodology

4.1. Research Design:

Embarking on the research design phase, we delve deeply into the distinctive context of Dhule District, a fundamental initial step before conducting further research investigations. Commencing our approach, we engage in an extensive evaluation of regional publications, governmental protocols, and analytical assessments regarding power generation and agro-residues within Dhule. This thorough exploration of local literature yields pivotal revelations into the complex nuances, exceptional attributes, and obstacles that cultivate Dhule's energy topography.

Our approach stands out because of our consistent and direct collaboration with crucial regional players. This interaction encompasses a range of individuals and groups, such as the district's electrical utility representatives, area farming associations, environmental advocacy organizations at the district level, as well as the Agricultural Department of Dhule. We engage with these stakeholders for two purposes: to guarantee that our research is in line with applicable local requirements and outlooks, and to construct an inter-connected resource network for obtaining data during our study. The involvement of these community experts is vital to achieving the substantial and credible data we gather.

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4.2. Data Collection:

Using a multifaceted approach, we meticulously gather data tailored to Dhule District's unique goals and context, all of which support our research findings.

4.2.1. Local Surveys and Questionnaires:

In our tailored survey and questionnaire design for Dhule District, we intricately address the local characteristics, focusing on the dynamics of agricultural residue production, utilization practices, and community attitudes toward electricity production. What sets our approach apart is the depth of collaboration with local partners, notably agricultural cooperatives, transforming consultation into a strategic alliance that enhances the efficacy of data collection. Precision-crafted survey instruments account for crop diversity, farming techniques, and seasonal variations. Adapted to various residue uses, our surveys yield detailed insights. The engagement with local partners goes beyond distribution; they actively participate in survey administration, fostering trust and community ownership. This collaborative strategy not only maximizes response rates but also ensures the authenticity of data, establishing a foundation for sustainable relationships and allowing the community's perspectives to shape the narrative of their agricultural practices and energy preferences.

4.2.2. Local Interviews:

Augmenting the depth of our research methodology, we conduct extensive in-depth interviews with a diverse array of local stakeholders in the Dhule region. This inclusive approach encompasses conversations with farmers, power plant managers, government officials, and various other pertinent stakeholders. These interviews transcend the confines of quantitative data, providing a qualitative dimension that allows us to delve profoundly into the lived experiences, challenges, and opportunities that intricately shape the region's agricultural residue and power generation landscapes. Through a carefully crafted series of questions, our interviews aim to extract nuanced perspectives, uncovering not only the what but the why behind the dynamics we observe. This qualitative exploration ensures a comprehensive understanding of the intricate interplay between local practices, policies, and socio-economic factors, enriching our research findings with a holistic portrayal of the factors influencing the sustainable development of the agricultural and energy sectors in Dhule**.**

4.2.3. Local Government Data:

Acknowledging the multifaceted nature of our research, we recognize the complementary value of secondary data sources to augment the insights derived from primary data collection. Embarking on our comprehensive exploration of Dhule District's agricultural, environmental, and energy

dynamics, we dive into the vast reservoirs of government records and reports. These archives contain a rich tapestry of historical information, chronicling the evolution of the region. We not only collect quantitative metrics but also extract qualitative contextual details that are hidden within the records. In Dhule, we endeavor to reinforce the veracity and durability of our primary data through an assortment of secondary sources. By cross-referencing and verifying information, we aspire to depict a comprehensive and subtle portrayal of the intricate and intertwined connections between the environment, agriculture, and energy. Our ultimate ambition is to enhance the soundness and integrity of our research findings by drawing upon a multifaceted variety of sources, both primary and secondary.

4.3. Data Analysis:

The data is like putting puzzle- pieces together. It is a critical time during our research when we carefully look into the loads of information collected. We don't just want to plow through the data; our real aim is to uncover important, useful facts. From these facts, we can then provide smart suggestions. We're specifically focusing on agricultural waste and its energy potential in Dhule. By using top-notch math techniques and analysis that dive-s deep into the numbe-rs, we identify repe-at patterns and number relations. In essence, we find the "why" behind the data. This process involves not only quantitative metrics but also a nuanced exploration of qualitative nuances, capturing the essence of local practices, socio-economic factors, and environmental considerations. Through this comprehensive analytical lens, we aim not just to provide a surface-level understanding but to uncover hidden trends and potential leverage points for sustainable interventions. The depth of our analysis is geared towards offering stakeholders a holistic and actionable understanding of the complex interplay between agricultural residue, energy dynamics, and the unique socio-economic context of Dhule.

4.3.1. Quantitative Analysis with Local Context:

The survey data undergoes a rigorous and sophisticated statistical analysis process utilizing specialized software tailored to handle the intricacies of the information collected. What sets this analysis apart is its unwavering emphasis on the unique local context of Dhule. Beyond the conventional crunching of numbers, our approach is characterized by a meticulous interpretation and presentation of statistical results that accentuates their direct relevance to the distinctive conditions

of the Dhule region. These statistical outcomes are not treated as mere numerical outputs; rather, they are scrutinized through the lens of Dhule's specific socio-economic, agricultural, and environmental dynamics. This approach allows us to move beyond the surface, quantifying not only agricultural residue production but also delving into the granular details of local disposal practices. Furthermore, it enables us to estimate community preferences for electricity generation methods, ensuring that the statistical insights are not abstract figures but tangible reflections of the community's unique needs and preferences. In essence, our commitment to contextualized statistical analysis serves as a bridge between raw data and meaningful, region-specific recommendations, contributing to a comprehensive understanding of Dhule's agricultural residue energy landscape.

4.3.2. Economic Modeling Specific to Dhule:

The economic models crafted in our research are not merely generic frameworks; they are bespoke and intricately tailored models that meticulously account for the distinct economic landscape of Dhule. Far beyond conventional one-size-fits-all approaches, these models are designed to be dynamic and responsive, factoring in the nuanced intricacies of Dhule's economic conditions. This includes a thorough consideration of local investment requirements, operational costs intricately tied to the region's specific resources and infrastructure, detailed revenue projections, and potential returns that are expressly calibrated to the district's unique characteristics. The incorporation of Dhule's economic idiosyncrasies in our models is not merely a superficial overlay; it is a foundational element that ensures the generation of insights directly relevant to the economic feasibility of power generation from agro-residues within the district. This in-depth economic modeling serves as a robust decision-support tool, offering stakeholders a nuanced understanding of the financial dynamics involved and facilitating strategic decision-making tailored to the specific economic realities of Dhule.

4.3.2. Qualitative Analysis with Local Insights:

Embedded in the intricate context of Dhule, our qualitative data analysis process represents a deliberate and nuanced exploration, particularly applied to interviews and surveys featuring open-ended responses. This method transcends the constraints of quantitative metrics, aiming to unearth the rich tapestry of unique and regional themes woven into the narratives surrounding agro-residues,

power generation, and local perspectives within Dhule. Far from a cursory examination, the qualitative analysis delves into the intricate layers of responses, identifying emergent themes, subtle variations, and latent patterns that may escape quantitative scrutiny. By employing thematic analysis, we not only capture surface-level observations but also penetrate deeper to reveal the underlying dynamics that shape Dhule's distinctive energy landscape. This approach allows for a more profound comprehension of the interplay between local practices, cultural influences, and socio-economic factors, enriching our understanding and providing stakeholders with nuanced insights crucial for the formulation of context-specific strategies and interventions.

4.3.3. Content Analysis Tailored to Dhule:

Derived from a synthesis of interviews and surveys, our qualitative approach incorporates both thematic and content analysis methodologies, providing a multifaceted examination of textual data. Content analysis, in particular, is a comprehensive and deep investigation that involves a thorough penetration into text nuances revealing Dhule District’s views on agro-residues and power generation. Instead of only identifying themes, this methodology goes beyond to expound on language, context, and subtext at length to establish what is being stated but also why and how it is being said. When examining the narrative fabric, we detected peculiarities, cultural colorations, and underlying moods that have produced its outlooks. Moreover, the content analysis can be used as a tool to dismantle complexities and opportunities embedded within the narrative thereby enhancing insightful understanding of the district’s unique socio-economic and environmental setting. Our understanding of the local environment is thus not only enriched but also refined through an extensive exploration that offers stakeholders a deeper insight into Dhule’s complex energy landscape which enables targeted interventions and strategies specific to the context.

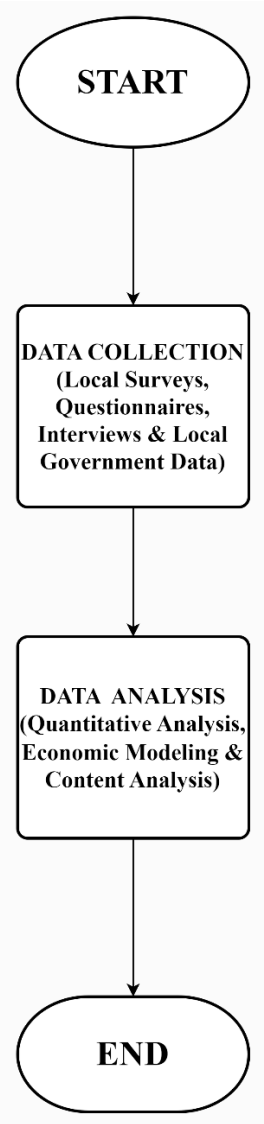

Fig 4.1. Flowchart

4.4. Local Technology Assessment:

Our research endeavors for Dhule District are underpinned by an unwavering commitment to unraveling the intricacies of its requirements and potential. The evaluation of innovative technologies is not a generic exercise but a meticulous scrutiny, anchored in the specific nuances of Dhule's landscape. We delve into the feasibility and environmental ramifications of diverse power generation methods, encompassing biomass power plants, anaerobic digestion, and gasification while remaining attuned to their precise applicability within the district's context. Our analysis transcends the realm of theoretical possibilities; it extends into the practical realm, meticulously examining the local efficiency, emissions, and scalability of these technologies. This multifaceted approach ensures that

our assessment is not confined to theoretical prowess but is rooted in the pragmatic realities of Dhule. By aligning our analysis with the district's energy targets and environmental priorities, our aim is not just to explore possibilities but to pinpoint the technologies that resonate most harmoniously with the unique aspirations and challenges of Dhule District. This depth of inquiry serves as the bedrock for informed decision-making, guiding stakeholders toward sustainable and context-specific energy solutions tailored to Dhule's distinctive needs.

4.5. Regional Environmental and Economic Assessment:

At the core of our research lies a dedicated focus on power generation derived from agro-residues, and our approach is characterized by an exhaustive evaluation aimed at discerning the nuanced environmental and economic impacts within Dhule District. This assessment forms not just a component but a crucial cornerstone of our research methodology. We traverse beyond surface-level analyses, delving deeply into the intricate interplay of environmental sustainability and economic viability inherent in agro-residue-based power generation. Environmental considerations span beyond mere emissions, encompassing land use, water usage, and ecological implications, ensuring a comprehensive understanding of the ecological footprint. Simultaneously, our economic evaluation extends beyond direct costs, accounting for local investment dynamics, employment generation, and overall economic resilience. This in-depth examination is not only pivotal in gauging the immediate effects but also serves as a predictive tool, guiding the formulation of sustainable strategies that align with Dhule's aspirations for economic growth and environmental stewardship. Through this comprehensive approach, we endeavor to not only uncover the impacts but also to pave the way for informed decision-making, steering the district towards a balanced and sustainable energy future.

4.5.1. Dhule-Specific Life Cycle Analysis:

The pivotal aspect of our research lies in conducting a specialized life cycle analysis meticulously tailored for Dhule District, representing a critical juncture in comprehensively assessing the environmental impact of agro-residue-based power generation. Our approach transcends conventional analyses, recognizing and accounting for the distinctive environmental conditions, emissions profiles, and land use patterns specific to the region. This tailored analysis is a paradigm shift from generic methodologies, ensuring that the insights derived are not only accurate but also

precisely aligned with Dhule's unique environmental priorities. We delve into the entire life cycle of the energy production process, encompassing resource extraction, processing, transportation, utilization, and eventual disposal. This thorough examination allows us to uncover the nuances of environmental impacts, including carbon footprints, resource depletion, and ecological consequences, all within the context of Dhule's specific ecosystem. By tailoring our approach to Dhule's distinct context, our life cycle analysis becomes a powerful tool for decision-makers, offering granular insights that enable the district to forge a sustainable path forward, harmonizing environmental conservation with energy needs in a manner that resonates with its specific ecological intricacies.

4.5.2. Cost-Benefit Analysis Tailored to Dhule:

Our exploration of power generation from agro-residue in Dhule District goes beyond a cursory evaluation; it involves a meticulous cost-benefit analysis intricately tuned to the region's unique economic landscape. In this comprehensive assessment, we scrutinize factors such as local capital investments, revenue generation potentials, operational expenses, and prospective environmental benefits, recognizing that these elements are interwoven with the district's distinct economic dynamics. Instead of relying on generic presumptions, our approach pivots on empirical figures and local knowledge, ensuring that estimations are not only accurate but are deeply rooted in the specific economic realities of Dhule. The cost-benefit analysis unfolds as a nuanced exploration, considering not just direct financial implications but also the socio-economic ripple effects within the local economy. By adopting this in-depth approach, our aim is not only to unveil the economic feasibility of agro-residue-based power generation in Dhule but to present stakeholders with a detailed roadmap, aligning economic gains with sustainable practices and fostering an inclusive approach to regional development.

4.6. Challenges and Solutions in Dhule District:

Central to the depth of our research is the meticulous identification, documentation, and analysis of challenges that are inherently unique to Dhule District. These challenges transcend mere categorization and span diverse domains, encompassing technological intricacies, economic considerations, policy landscapes, and social dynamics. What sets our approach apart is not only the comprehensive understanding of these challenges but also our unwavering commitment to proposing

region-specific solutions and recommendations derived directly from our research findings.

The challenges encountered are not perceived in isolation but rather as dynamic opportunities for innovation and transformative change within the district. Each challenge becomes a focal point for detailed analysis, with an emphasis on unveiling its underlying causes and intricate connections to the local context. Importantly, our approach recognizes that challenges are multifaceted, often interlinked, and require nuanced solutions that resonate with Dhule's distinctive circumstances.

Our commitment extends beyond mere problem identification; we navigate these challenges as catalysts for positive change, envisioning tailored solutions that align with the unique characteristics of Dhule. This depth of analysis not only enriches our research but serves as a guide for stakeholders and policymakers, providing actionable insights that go beyond generic recommendations. By addressing challenges as opportunities, our research aims to catalyze a transformative impact on Dhule District, fostering resilience, sustainability, and innovation tailored to its specific needs and aspirations.

4.7. Local Case Studies:

The culmination of our research involves a meticulous investigation and in-depth analysis of case studies intricately tied to successful agro-residue-based power generation projects. The selection of these case studies is a deliberate process, grounded in their direct relevance to the specific context of Dhule District. Beyond serving as illustrative examples, these case studies are scrutinized with a keen focus on deciphering their applicability within the unique landscape of Dhule.

The chosen case studies are not merely sources of best practices; they serve as rich repositories of valuable lessons and insights. Our approach goes beyond a surface-level examination; it involves a nuanced dissection of the factors that contributed to the success of these projects, considering technological, economic, environmental, and social dimensions. Importantly, these lessons learned from successful ventures are not adopted wholesale but are critically adapted and tailored to suit Dhule's specific needs, circumstances, and aspirations.

This in-depth analysis of case studies ensures that our research is not confined to theoretical frameworks but has a practical and actionable dimension. By distilling the essence of successful projects and applying them judiciously to the unique challenges and opportunities in Dhule, our research serves as a blueprint for the district's journey toward sustainable and efficient agro-residue-

based power generation. This depth of analysis, rooted in real-world examples, is intended to guide stakeholders, policymakers, and implementers toward strategies that have a proven track record of success, thereby enhancing the likelihood of positive and impactful outcomes in Dhule District.

In essence, this comprehensive methodology is poised to provide a profound understanding of agro-residues and power generation within Dhule District. It is designed to capture the nuances and intricacies of the local context, empowering policymakers, stakeholders, and researchers with actionable insights that can guide sustainable energy initiatives in this distinctive region.

Chapter – 5

Results & Discussions

Chapter 5: Results & Discussions:

The unprecedented economic growth in Dhule has created a stampede to increase energy demand. Fluctuating fossil fuel costs and increasing demand for more power due to rapid urbanization have compounded the rolling power cuts that affect most cities. The biomass-based power production holds great potential to meet India's growing energy demand, but it is not being entirely utilized. Such factors as resource availability and seasonality, supply chain logistics and infrastructure, technical alterations, weak legal and financial mechanisms/incentives, and policy ambiguities have made investors less interested in investing in biomass power or even closing down some of the existing biomass-driven factories. These are all among current traditional and cultural practices that limit the supply of biomass for energy generation. All in all, this would be unrealistic without working within the context of how people use their biomass for other things socioculturally; this means that using some of it as animal feed is essential in India. Therefore, non-fodder crops (e.g., soybean husks, cotton stalks, and coconut fronds) need to be employed as sources of energy instead. Conversely, modern cooking stoves (improved cooking stoves, subsidized LPG) and government housing programs. Switching from traditional energy use would not only reduce the dependency on biomass but also improve the living standards of poor people. In this pretext, during the Census 2010–2011, less than 50% of urban households and only 6% of rural households used LPG. The remaining 80% of rural Indian households continue to use traditional fuels for cooking due to affordability, access, and awareness limitations. Therefore, the current LPG subsidy mechanism is heavily skewed in favor of higher-income groups and urban areas.

The current biomass sector lacks successful stakeholder models for ensuring the viability of biomass as a source of energy. For example, continuous biomass supply, quality and mix of biomass, water resources, biomass price, power evacuation infrastructure, labor availability, public acceptance, industrial competition, and cooperation among government departments. Any variation in any one factor would have profound effects on plant production. Apart from these factors; however, commercial installations of renewable energy are higher than the financial risks involved in other purchase options such as those of traditional non-renewable power plants. In this direction co-firing biomass in coal-fired power plants or using hybrid energy systems coupled with green certificates (assuming that biomass is carbon neutral) would reduce emissions and create some kind of balance in energy production at least at this stage. The organized supply chain for biomass is crucial to

securing a reliable and stable supply of biomass. An efficient supply chain is needed to make agricultural biomasses bulky and increase their cost competitiveness and energy efficiency. To this extent, appropriate fuel collection methods like bundling (paddy straw, sugarcane tops), and chipping (e.g., eucalyptus,) regarding fuel type should be chosen thereby yielding more amount of biomass to be transported in a single truck. Subsequently, the biomass could be further processed using fuel processing technologies like pelleting or briquetting to increase the energy efficiency of the fuel. In addition to its increased energy value, the fuel handling becomes easier, and then the biomass can be efficiently transported to longer distances. The sustainability of biomass for energy must be evaluated in detail concerning food security, environmental performance, and energy efficiency. Importantly, a country like India cannot afford to have pure energy plantations in agricultural lands which would eventually increase the food competition and food prices. On the other hand, agro-forestry practices (where agriculture and energy crops are cultivated together) could be adapted to meet both the agricultural and biomass needs for various food and non-food uses.

5.1 Methods:

Agro-residue-based power generation involves using leftover agricultural materials such as crop residues, husks, straw, and other organic waste to produce energy. There are several methods for generating power from agro residues.

- **Biomass power plant**: These plants use organic materials to produce electricity or heat. Agro-residues are burned to produce steam that drives turbines connected to generators.
- **Biogas Production:** Agro residue can be used in anaerobic digesters to produce biogas, a mixture of methane and carbon dioxide. Biogas can then be burned to generate electricity or used as fuel for heating.
- **Biofuels:** Through chemical or fermentation procedures, agricultural leftovers can be transformed into biofuels like bioethanol or biodiesel. Both cars and power plants can use these fuels.
- **Pyrolysis and Gasification**: To create syngas, which may be used as fuel or to generate power, agricultural leftovers can be treated through partial combustion processes like gasification or pyrolysis.

- **Renewable Energy sources:** Because agro leftovers come from plants, which may be regenerated every year, they are regarded as renewable energy sources.
- **Reduced Greenhouses Gas Emissions:** By using agricultural wastes for electricity generation instead of burning them in the field or letting them break down, greenhouse gas emissions can be decreased. This is because controlled combustion for electricity production can be more effective and environmentally benign than open burning, which discharges carbon dioxide straight into the atmosphere.
- **Bioenergy and Rural Development:** Agro residue-based power generation can help with rural development by giving farmers another source of income, generating employment, and encouraging environmentally friendly farming methods.
- **Government Policies and incentives:** Government policies and incentives that support and initiatives may influence the success of agro residue-based power generation projects.
- **Energy potential**: If utilized effectively, agro residues possess a great amount of energy capacity that can have a huge effect on the energy supply.
- **Technological advancement:** Improvements in technologies, such as biomass power plants and biogas production units, are crucial for enhancing the efficiency of energy extraction from these residues.
- **Waste Management:** Proper disposal of agricultural residues through energy production addresses waste management issues, preventing environmental degradation.

5.2 Challenges:

- **Logistics:** The logistics of collecting, transporting, and storing these residues can be challenging and costly, affecting the feasibility of large-scale power generation.
- **Technology and Efficiency:** Some technologies may face limitations in effectively converting certain types of residues into energy, impacting overall efficiency.
- **Policy support:** The success of agro residue-based power generation initiatives often relies on supportive policies, incentives, and infrastructure development.[21]

5.3 Sustainability:

- **Balancing agricultural needs:** It's essential to balance the use of residues for energy generation with their role in maintaining soil health and fertility, as leaving residues in the fields contributes to soil organic matters.
- **Biodiversity Conservation:** Ensuring that harvesting residues do not harm ecosystems or biodiversity is a critical consideration for sustainable practices.

Chapter – 6

Conclusion

Chapter 6: Conclusion

As we conclude our exploration into the potential assessment of agro-residue-based power generation in Dhule District, a tapestry of challenges and opportunities unfolds, weaving together environmental sustainability, economic resilience, and community well-being. Challenges, from open burning to technological constraints, highlight the need for a reevaluation of current practices. Yet, this is more than an identification of hurdles; it's a quest for transformative solutions, where technology meets policy, and community engagement intertwines with environmental stewardship. Dhule's sustainable future lies in the convergence of these elements. In traversing our findings, the path forward becomes clear. It's not a solitary journey but a collaborative expedition involving policymakers, resilient farmers, innovative technology providers, and the heartbeat of the local community. It's a shared commitment to a future where agro-residues transcend their conventional role, becoming a cornerstone for sustainable energy and economic growth.

As we conclude, envisioning the metamorphosis of Dhule, we see a future where the integration of agro-residues into the energy matrix is a catalyst for holistic development. The challenges identified are gateways to innovation, and within these complexities lie opportunities for growth, empowerment, and positive transformation. Our recommendations are not mere directives but a roadmap—a compass pointing towards a future where Dhule stands as a model for sustainable agricultural practices. In this spirit of progress, we extend our hope that the insights shared here spark a collective resolve. May they inspire a paradigm shift towards a more resilient, sustainable, and human-centric energy landscape for Dhule District and, by extension, the wider world. As we bid adieu to these pages, let them not mark an end but a commencement—a commencement of a journey where agro-residues, once considered remnants, become the seeds of a greener, more vibrant future.

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List of Publication

[1] Mehul Mahaveer Nahar, Parth Mahesh Nandre, Vaibhav Shivaji More, Mayur Vijay Jadhav, “Potential Assessment of Agro-Residues Based Power Generation In Dhule District”, submitted for presentation & publication in IEEE International Conference on Computer, Communication & Informatics Scheduled on 29-31 Jan 2024. (In Review)

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