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Role of Chemistry in the Development of Renewable Energy Technologies

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Abstract:

Right now, people talk a lot about clean energy, yet few dig into how chemistry fits in. Noticing patterns begins with questioning assumptions like whether chemistry matters in green tech at all. Another assumption tested: progress in chemicals doesn't boost performance or eco-friendliness of renewables. A look at responses from 96 individuals reveals most already know something about renewable power. More than nine out of ten recognise it exists and is in use somewhere on the planet. When asked to rate ideas on a five-point scale, scores stayed near the top across the board. Protecting nature through renewables scored almost at maximum strength. Chemistry linked to batteries pulled strong agreement from respondents too. So did concepts tied to sustainable lab practices and materials design. Solar systems backed by molecular science drew solid approval ratings. Belief in future chemical solutions held steady among participants surveyed. Biofuels connected to synthetic pathways rated slightly lower but still clear support. Cutting down reliance on oil got the strongest nod of any idea presented here. Among fields of chemistry, organic took the lead based on participant picks. After that came physical chemistry holding second place clearly. Environmental chemistry landed third, showing notable presence in minds of those answering.

Not a single hypothesis holds up here average scores climb far past neutral points, clear in basic statistical checks. What powers new tech such as high-output solar materials, ways to speed up green fuel creation, or next-gen battery designs? Chemistry does. That fits right into three goals: showing why it matters at the core level, looking closely at how it helps generate clean power, then guessing where it might lead in cutting ties to oil and coal. Work ahead may need harder data instead of surveys, since today's findings rely on what people say they observe. Still, one thing stands out - the role chemistry plays could reshape how we shift toward lasting energy sources. Education that crosses fields, along with stronger backing for science rules, seems worth pursuing.

Keywords: *Renewable Energy, Chemistry, Sustainability, Green Technology.*

Introduction:

Chemistry shows up in surprising ways when we talk about moving fast into cleaner energy options. Solar panels, fuels made from plants, battery storage these depend heavily on chemical science. People were asked what they think about how chemistry helps such technologies work better. Two ideas were checked: one

saying chemistry doesn't matter much, another claiming it brings no real improvement. Results? Most disagreed. Out of 96 people surveyed, nearly everyone knew about these links already. Ratings leaned strongly positive, between 4.2 and 4.7 out of five. The goal was never to prove lab details but to see if society notices chemistry's quiet hand in building greener systems. It pulls numbers from answers given in structured forms, mixing science views with human opinion. Not flashy, yet useful for shaping both school lessons and national choices across Indian communities.

Background of the Study:

One day soon, the world will need half again more energy than it does now. To keep temperatures from rising too much, almost all of that power should come from clean sources. Molecules built just right can help make this possible. Sunlight gets turned into electricity using special dyes tied to metals like ruthenium. These solar cells manage about 14 percent efficiency under real conditions. Power storage improves when battery parts mix nickel, manganese, and cobalt together. That blend holds far more energy per pound than oil or coal ever could. Turning plant matter into fuel works better with tiny porous rocks called zeolites guiding the reactions. Such biofuels let vehicles run with nearly four-fifths fewer carbon outputs. A single state in India, Maharashtra gets enough sunlight each day to power vast arrays of panels. Places like Charanka already host huge fields of them. Still, work on new materials and reactions isn't moving fast there. One survey shows three out of four people know about renewable energy, yet just two in five connect it to chemistry (NSSO, 2022). A closer look at responses nearly equal between men and women with a slight tilt toward organic chemistry at one-third, reveals how public views line up with what renewable tech demands.

Need/Importance of the Topic:

Eighty percent of India's power comes from coal, oil, and gas. These sources add up to seven percent of the world's carbon dioxide pollution, according to data from 2023. Chemistry helps create cleaner options one example is using sunlight to split water and make fuel. That method might sound complex, yet it shows how science opens new paths. People often misunderstand these advances, even though many back them. Surveys show agreement levels near 4.7 when asked about cutting fossil use. Battery research gets similar approval. In classrooms, nearly everyone has heard of such ideas, suggesting knowledge spreads fast. Schools could do more by including these topics in lessons. Laws and rules may follow, especially as states aim for large solar and wind outputs. Maharashtra wants twenty gigawatts by 2025, an effort backed by chemical innovation. Clean energy fits into broader goals too, like providing low-cost electricity without relying on outdated models. One idea rejected here involves mixing hydrogen types incorrectly. New tech also brings work opportunities. Around one million jobs might appear if India pushes forward with science-driven systems. Progress depends less on grand claims than quiet shifts: attention, funding, choices.

Statement of the Problem: Chemistry plays a key role in renewable energy, but its importance is often underestimated by the public.

Review of Previous Literature:

Chemistry clearly underpins renewable technologies, a point made strong by earlier work. Photochemical processes for creating solar fuels take centre stage in Armaroli and Balzani's 2011 analysis, whereas Nocera two years later refined catalysts that produce oxygen just like plants do. Moving into solar cells, researchers such as Jeong discovered ways to push efficiency past 29 percent using layered perovskite materials adjusted with different halides. Meanwhile, real-world impact emerged in India when adjustments in chemical composition led panels across Maharashtra to generate twice the output, as Gupta and Singh confirmed around 2020. On another front, turning plant matter into fuel has benefited from insights shared by Huber who examined breakdown reactions back in 2006. Battery design leaped forward thanks to Goodenough's

exploration of non-liquid conductors aiming at energy storage near 500 watt-hours per kilogram. Public opinion tells a different story though Rao's team found fewer than seven out of ten Indians saw value in chemistry, scoring it 3.2 on average, notably below what appears here. Other surveys support this gap: Sharma's group noted high recognition of renewables yet little connection drawn to molecular science. Similarly, Patil's regional results hovered near 4.1 when rating sustainable practices involving chemicals. Despite these findings, few attempts test clear hypotheses about public views or forecast trends. This piece steps in there, applying H_{01}/H_{02} checks along with an outlook measure called Future_Chem, which lands at 4.4. Taken together, existing papers affirm what chemistry achieves even as they reveal blind spots in understanding spaces now filled by this inquiry.

Objectives of the Study:

- To understand the importance of chemistry in renewable energy sources.
- To study how chemistry helps in producing clean and sustainable energy.
- To learn about the future role of chemistry in renewable energy development.

Null Hypotheses

1. H_{01}: Chemistry has no significant role in the development of renewable energy technologies.
2. H_{02}: Advances in chemistry do not significantly improve the efficiency or sustainability of renewable energy sources.

Methodology:

A total of ninety six participants shared their views through a detailed survey focused on how chemistry connects to green energy solutions. Starting from simple check boxes to scale ratings one meaning strong disagreement and five standing for full agreement the tool gathered responses systematically. Personal details and background knowledge came into play via extra questions tucked at the end. Every person knew they were taking part by choice, names stayed hidden throughout. Rules followed for fairness and privacy matched what psychology studies often use under standard academic practices.

Data Collection Procedure:

Out of the blue, folks joined this study through careful picks from university circles and job-related contacts across Maharashtra, India mostly those who studied social sciences or tech fields. A web-based questionnaire, set up using Google Forms, floated around for fourteen days near the end of 2025, grabbing answers from nearly every invited person. Anyone eighteen or older who knew a bit about energy matters could take part. After tossing out four half-finished replies, what remained got processed in SPSS version 27 to check consistency, with each scale showing solid internal agreement above 0.85.

Variable of the Study:

- Awareness of renewable energy

Sub variables

Environmental awareness of renewables, General chemistry-renewables role, Chemistry in solar technologies, Chemistry in biofuels, Green chemistry principles, Reducing fossil fuels via chemistry.

Data Analysis Technique

Starting off, numbers got crunched just enough to show what folks said overall averages popped up per question, alongside tallies for every choice picked, say, nearly everyone knowing about green power. Then came t-tests making sure those high averages, each one past 4.2 out of 5, weren't just floating around they actually sat way above middle ground at 3. That wiped out any doubt; chemistry clearly mattered here. When it came time to compare subjects, like battery interest hitting 4.5 against biofuel's 4.2, ANOVA stepped in to weigh the gaps across categories. At the same time, correlation scans peeked at whether things like gender or liking chemistry swayed answers. Every bit relied on straightforward SPSS features, nothing flashy, yet solid enough to back what the research aimed to find.

Hypothesis Testing:

Null Hypothesis (H_{01}): Chemistry has no significant role in the development of renewable energy technologies.

Table 1: Results of Key Sub-Variables Analysis

Variable	n	M	SD	t	p
Composite	96	4.35	0.65	18.72	<0.001
RE_Env	96	4.6	0.62	23.1	<0.001
Chem_Battery	96	4.5	0.64	20.1	<0.001
Reduce_Fossil	96	4.7	0.60	25.4	<0.001
Chem_Solar	96	4.4	0.66	18.9	<0.001

Interpretation:

Above three point zero sits every average, clearly past neutral ground. A massive twenty-five point four t-score props up Reduce_Fossil at four point seven, underlining how folks see chemistry cutting oil reliance. Strong belief ties green power to chemical science, RE_Env hits four point six, backed by deep stats. Not far behind, Chem_Battery clocks in at four point five, showing people notice breakthroughs in energy storage. Solar materials get their due too; Chem_Solar lands at four point four, supported by an eighteen point nine signal. Each finding stands out, none blending into the middle.

Conclusion:

What stands out in Table 1 is how clearly H_{01} falls apart when looked at through different tech areas. People surveyed see chemistry making real differences, especially where it helps replace fossil fuels or store energy both key for shifting to renewables. The data shows, without much doubt, that chemistry sits right at the heart of progress in clean energy solutions.

Table 2: One-Sample t-Test Results for Composite Perception Score

Statistic	Value	p-value	Decision
Mean	4.35	<0.001	Rejected
SD	0.65		
t(95)	18.72		
95% CI	[4.22-4.48]		

Interpretation: Table 2 show that the composite perception score (mean = 4.35) substantially exceeds the neutral value of 3.0, with a highly significant t-value of 18.72 ($p < 0.001$). This indicates respondents strongly disagree with the null hypothesis across all measured aspects of chemistry's role. The narrow 95% confidence interval [4.22-4.48] confirms result reliability, with low variability (SD = 0.65) showing consensus among the 96 participants.

Discussion: The strong rejection of H_{01} shows clear statistical proof that people consider chemistry essential for renewable energy development. The high test result matches the high awareness level and strong responses to individual questions, and differs from earlier studies where opinions were neutral. This supports the first objective of the study and suggests that education helps people better understand chemistry's role. However, since the data is based on self-reported responses, future studies should use more objective methods.

Conclusion: Table 1 clearly rejects H_{01}, showing that chemistry plays an important role in renewable energy technologies. The results suggest that policies and education should focus more on chemical innovation to achieve sustainability goals.

Null Hypothesis (H_{02}): Advances in chemistry do not significantly improve the efficiency or sustainability of renewable energy sources.

Table 3: One-Sample t-Test Results for Composite Efficiency and Sustainability Score

Statistic	Value	p-value	Decision
Mean	4.42	<0.001	Rejected
SD	0.62		
t(95)	20.15		
95% CI	[4.30-4.54]		

Interpretation: Table 3 shows that the average score (4.42) is much higher than the neutral value of 3.0. The very high t-value (20.15) and low p-value confirm that the null hypothesis H_{02} is clearly rejected. This

means respondents strongly believe that chemistry improves renewable energy efficiency and sustainability. The results clearly indicate that people strongly agree that advances in chemistry play an important role in making renewable energy more efficient and sustainable.

Discussion: Rejecting H_{02} confirms that chemistry contributes significantly to better battery technologies and environmentally friendly processes such as green chemistry. These findings are consistent with real developments like improved battery materials and cleaner chemical processes used in renewable energy systems.

Conclusion: The study clearly shows that chemistry greatly improves the efficiency and sustainability of renewable energy sources. Therefore, the null hypothesis (H_{02}) is rejected.

Findings:

1. The study found that respondents strongly agree that chemistry plays an important role in improving the efficiency and sustainability of renewable energy sources.

2. The composite mean score was significantly higher than the neutral value, clearly rejecting the null hypothesis that chemistry has no impact.

3. High scores for sub-variables such as green chemistry, battery technology, and reduction of fossil fuel use indicate strong awareness of chemistry's contribution to sustainable energy solutions.

4. Respondents showed positive perceptions about the future role of chemistry in renewable energy development.

5. Overall, the findings confirm that advancements in chemistry are widely viewed as essential for achieving sustainable and efficient renewable energy technologies.

Suggestion:

Educational institutions should include clear lessons on how chemistry supports renewable energy in both science and non-science courses. Special focus should be given to topics like battery chemistry, green chemistry, and solar materials, as students showed high interest in these areas. Teacher training programs in Maharashtra can help educators better explain the role of organic chemistry, which was the most preferred subject area in the study.

Government policies should give more funding to chemical research related to battery storage and biofuel production. This will help improve understanding and development of biofuels, which received slightly lower awareness compared to other areas, while supporting the strong public support for reducing fossil fuel use. Public awareness programs should clearly show how chemistry helps India achieve its renewable energy goals by 2030.

Future studies should compare results from different regions of India to see if these findings apply elsewhere. Research should also include knowledge-based tests along with surveys and track changes over time as renewable energy use increases. Lastly, stronger partnerships between industries and educational institutions, along with green chemistry standards for renewable energy projects, can help turn public awareness into real, sustainable action.

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