Greater Bombay Science Teachers' Association

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ACTION RESEARCH PROJECT INFORMATION

2025 - 2026

STD. IX

INTRODUCTION :

Dr. Homi Bhabha Bal Vaidnyanik Competition is a prestigious event conducted by Greater Bombay Science Teachers' Association. In the year 25-26, 1,04,085 students from all over Maharashtra and states other than Maharashtra participated in this Competition.

This Competition is conducted in four stages - written Competition, practical Competition, action research project and viva - voce.

Action research :

It is an attempt of scientific study of the problem in the surrounding in order to guide, correct and evaluate the actions and decisions about it. Action research is based on small research project correlating scientific knowledge and day to day experiences which encourages development of scientific attitude among children.

Steps of action research : These are based on the method of science and involves the following :

- ✤ Keen observation of the surrounding
- ✤ Identification of the problem
- ✤ Analysis of the problem
- ✤ Collection of relevant information
- ✤ Suggesting plan of action
- ✤ Conducting experiments
- ✤ To draw conclusion
- ✤ To find possible solution to rectify the problem

Note : Execute experiments and remedial measures wherever possible.

Importance of Action research :

1) Enhances practical and experimental skills.

2) Builds problem solving skills.

Guidance :

Students can seek guidance from teachers, other experts and make effective use of other sources of information available around them.

If one has never done action research before, it is better to start small. Ensure that the problem to be solved is managable. **Not to be afraid of mistakes. We all know, we learn through our mistakes.**

Where can your research question come from ?

- A problem or difficulty which you are facing
- By observing the surrounding
- Something you have read
- Previous research

Note that, 'Problem' in research means topic under study. It need not be always a difficuilty.

In leading pupils to think for themselves :

Following teaching principles need to be remembered.

- Make pupils confront problem solving.
- Develop methods and techniques of handling problems. Teach how to use the methods and not how to solve the problems.
- Emphasize positive thinking.
- Lead the pupils to the peak of their powers for improvement of better learning

Objectives of the Action Research :-

1) To make students sensitive towards environment and it's conservation and to inculcate ecofriendly attitude within them.

2) To learn scientific principles from day-to-day experiences.

3) To develop psychotechnological skills through

4) Development of organisational skills and maturity through discussion, presentation etc.

5) To develop ability to correlate science, society and environment.

Types of Action Research :-

1) Experimental
2) Applied
3) Survey based
4) Exploratory

Criteria of a good project :-

1) Appropriate idea, clear understanding and proper presentation of the concept.
2) Title related to main theme.
3) Clear and measurable objectives.
4) Proper methodology.
5) Results based on objectives and methodology.
6) Probable impact of the work on the attitude of the students, society and environment.
7) Scientific attitude, creativity and novelty reflected in project work and analysis of the situation.
8) Utility and innovation of the remedial measures.
9) Efforts taken towards implementation of remedial measures.
10) Feasibility and credibility of the work.

Project Report :-

Project Report should be written on A-4 (8.5’ x 11.8 inch) size ruled sheets in **one’s own handwriting** and on only one side of the paper. Do not use glitter pen. Project Report should not be more than 25 pages.

First Half :-

1) **Page 1 : Front Page :** Title of the project should be written on top in block letters. After that exam number alongwith date of the interview should be written. **Name of the student should be seen only on page 2 ie. on the certificate page and no where else in the report.**

2) **Page 2 : Certificate :** Certificate issued by the head of the institution stating that the work done for the project is student's own.

3) **Page 3 : Acknowledgments :** Gratitude towards people and institutions who have extended helping hand.

4) **Page 4 :** Abstract of the project in around 500 words. Explanation of all aspects of the project in effective words can help in rational evaluation of the project.

5) **Page 5 :** Index.

Second Half :

1) **Introduction :** Title of the project should be written on top followed by brief explanation of the objectives, relative importance of the work and project plan.

2) **Need and scope :** Correlation between selected project and it's social aspects should be explained in around 50-100 words.

3) **Objective :** Should be maximum 2 - 3 clear statements.

4) **Hypothesis :** Should be in the form of a possibility. Example 'If I do..... then I may get.....'.

5) **Project Plan :** Action Plan of the project.

6) **Research Method :** Detailed explanation of execution of the project. It should include time table, actual experimentation, methodology, survey (Selection of subject/s and questionnaire) as per the action plan.

7) **Observations: if applicable / Speculation / Application**

8) **Analysis :** Qualitative and quantitative

9) **Conclusion :** Conclusion drawn after critical analysis of the data obtained, probable remedial measures and suggestions for future plan.

10) **Remedial Measures :** Remedial measures undertaken to solve the problem and observed effects of the same.

11) **References :** Arrangement of references used as per alphabetical order.

Order of writing a particular reference should be Author, Book/Article/Publishing House/Page Nos./Publication No./ Edition / Publisher / Place / Year of Publication.

Students should note that they need to send a scanned pdf copy of their action research project report on the following email ID :

dhbbvcpdf@gmail.com

on or before

Sunday, 8th March 2026.

Evaluation :-

Project report will be evaluated on the day of the interview. Student participant should bring with him **TWO** copies of the report. **One original and other black & white xerox.** The xerox copy will be kept with the office.

Each student will get around five minutes for interaction with the interviewers.

Student is expected to explain the summary in one minute which will be followed by viva-voce based on the project report.

Note :-

1) While explaining the project the student should emphasize on the objective, methodology, Hypothesis, conclusion and outstanding aspects related to the project. Student participant should be calm and confident. Answers should be clear.
2) No models/charts/exhibits should be brought along with the report.
3) Students may use photographs in the report wherever necessary.
4) Orientation lecture would be arranged for the students regarding action research theme and doubts will be solved if any at the time of practical examination, so please come prepared.
5) Students should note that they have to face TWO interviews on the date of interview. One general interview based on science and other based only on the action research project report.

DR. HOMI BHABHA BALVAIDNYANIK COMPETITION 2025-26

STD. IX

ACTION RESEARCH TOPIC FOR 2025-26

Efficacy of Renewable Energy Sources

Introduction :

Global energy systems are undergoing a paradigm shift driven by the urgent need to combat climate change and achieve sustainable development. Fossil fuel-based power generation has dominated for over a century, but it is a primary cause of greenhouse gas emissions and global warming in response, a wide range of Renewable Energy (RE) technologies – including solar, wind, hydro, biomass, geothermal, and hydrogen – have been introduced to mitigate these environmental crises. Despite rapid growth in renewable energy adoption, most of the global electricity is still generated from fossil fuels. The transition is hindered by limitations of current renewable systems–for example, solar panels only produce power in daylight, wind turbines need sufficient wind, and Hydro power depends on water flow. Such intermittency and other technical constraints, along with high upfront costs, mean that renewable have yet to completely displace conventional energy sources. As a result, researchers worldwide are working to improve the efficiency and reliability of renewable technologies and to overcome these limitations. In this context, efficacy of renewable energy sources refers to how effectively these technologies can generate reliable, cost-effective power at scale to meet global demand.

This Topic of action research seeks that accelerates the renewable energy transition by focusing on three key avenues:

I) Identifying errors, inefficiencies, and limitations in existing renewable energy systems.

ii) Proposing practical solutions and improvements to address these issues.

iii) Creating innovative, system-level approaches that integrate renewable sources in creative ways to maximize their effectiveness.

iv) Encouraging critical analysis of current systems, development of concrete solutions, and bold innovation, we aim to significantly enhance the efficacy of renewable energy sources in real-world applications.

Renewable Energy Sources

Renewable energy is defined as energy derived from natural resources that are replenished on a human time scale (such as sunlight, wind, water flow, biomass growth, and geothermal heat).

Unlike fossil fuels which are finite and emit greenhouse gases, renewable resources are virtually inexhaustible and have a minimal carbon footprint during operation.

The major types of renewable energy sources include:

- **Solar energy:** harnessing sunlight through photovoltaic cells or solar thermal systems to generate electricity or heat.
- **Wind energy:** using wind turbines to convert the kinetic energy of moving air into electrical power.
- **Hydro power:** capturing energy from moving water (rivers or dams) to spin turbines and produce electricity.
- **Biomass energy:** deriving energy from organic materials (plant matter, agricultural waste, biofuels) via combustion or biochemical processes.
- **Geothermal energy:** tapping the Earth's internal heat for electricity generation or direct heating.
- **Ocean/tidal energy:** utilizing tidal movements, wave action, or ocean thermal gradients to produce power.
- **Hydrogen energy:** using hydrogen as an energy carrier (produced via electrolysis using renewable electricity) and converting it to electricity in fuel cells.

These sources operate on well-established scientific principles: for instance, photovoltaic solar panels rely on the photoelectric effect to generate electric current from sunlight, wind turbines use aerodynamic lift on rotor blades, and Hydro power stations convert gravitational potential energy of water into mechanical work. Because the energy inputs are naturally replenishing, renewable technologies can in theory provide sustainable power indefinitely. However, each type of renewable energy comes with inherent characteristics and theoretical limits. For example, solar PV cells have a maximum theoretical efficiency (the Shockley-Queisser limit) for single junction cells (~33%), which motivates research into multi junction and novel material cells to capture a broader solar spectrum. Wind turbines are bounded by Betz's limit (around 59% of wind's kinetic energy as theoretical max extraction), and geothermal plants depend on the thermodynamic limits of heat engines.

A critical aspect of the theoretical background is understanding the intermittent and diffuse nature of most renewable sources. Solar and wind are variable in time and location – sunlight is absent at night and reduced on cloudy days, and wind speeds fluctuate. This intermittency requires careful grid management and energy storage solutions to maintain a stable power supply. Additionally, the energy density of renewable (amount of energy obtainable per unit area or volume) is generally lower than that of fossil fuels. Large land or water areas are often needed to collect dispersed solar and wind energy, which introduces theoretical and practical constraints on scalability. These characteristics underscore the importance of improving conversion efficiencies and developing systems to store or smooth out energy supply.

In summary, the theoretical foundation of renewable energy encompasses the fundamental principles of energy conversion from natural processes, the classification of resource types, and the inherent advantages and limitations each source presents. This background sets the stage for targeted research into enhancing performance and overcoming challenges, as detailed in the subsequent sections.

*** Need for Further Research ***

Transitioning the world's energy supply from fossil fuels to renewable sources is not only an environmental imperative but also a complex technical and economic challenge. Research in renewable energy is necessary for several compelling reasons :

- **Addressing Climate Change and Emissions**
- **Overcoming Current Limitations**
- **Scaling Up to Meet Global Energy Demand**
- **Energy Security and Economic Benefits**
- **Holistic System Transformation**

Further research in the field of renewable energy will help to solve existing problems (technical and non-technical), unlock innovations that make renewable systems more effective, and provide the knowledge base for scaling up renewable safely and reliably. Every increment in efficiency, every improvement in storage, every smarter grid management strategy, and every new policy insight directly contributes to making renewable energy more efficacious as the backbone of global energy supply. The following section outlines how students and emerging researchers can contribute to this effort.

*** What Students Can Do? ***

Action research Projects:

1. Designing a new solar concentrator prototype, developing a software model for grid integration, or experimenting with biofuel production methods.
2. Improving wind turbine blade materials to reduce fatigue failures.
3. Optimizing the configuration of a hybrid solar-wind-battery microgrid for rural electrification. By focusing on these topics, students not only contribute new knowledge (through experiments, simulations, or field studies) but also develop deep expertise in areas of high demand in the energy sector.
4. Collaborate with a company to analyse performance data from a solar plant to identify operational inefficiencies and suggest improvements (aligning with the theme of identifying errors in existing systems).

- **Join Competitions and Innovation Challenges:**

Practical problem-solving – e.g., designing an energy-efficient home powered entirely by renewable, or developing a low-cost wind turbine for remote communities.

- **Engage in Interdisciplinary Learning :**
  Students are encouraged to take an interdisciplinary approach student might take courses in energy economics or environmental
  policy, and vice versa. This broad perspective enables students to design solutions that are technically sound and socio-economically viable.
- **Field Surveys and Community Projects:**
  Students can also contribute by conducting surveys and case studies in their local communities or regions.
  1. For example, a group of students might survey households and businesses about their energy usage and attitudes towards rooftop solar adoption (a survey-based research approach). Such studies can identify real-world barriers (like lack of awareness or financing issues) that are limiting renewable uptake, and the findings can inform more targeted solutions or educational programs. Additionally, by working on demonstration projects (like installing a small solar system in a community center or optimizing energy use in a campus building), students can showcase tangible benefits of renewable and learn from the practical challenges during implementation.

Subthemes with Tentative Research Topics

To guide action research under the broad theme of "Efficacy of Renewable Energy Sources," the following subthemes are proposed, each with example tentative research topics. These subtopics align with the main goals of identifying current limitations, devising practical improvements, and innovating system-level solutions.

1. Solar Photovoltaic Efficiency Improvements: Research Topic: This topic would explore novel photovoltaic materials and designs (such as perovskite silicon tandem cells or multi junction concentrator cells) aimed at surpassing the efficiency plateau of conventional silicon PV. The research involves identifying loss mechanisms in today's solar cells (e.g., thermalization of excess photon energy) and developing solutions to capture more of the solar spectrum.

2. Wind Turbine Performance and Reliability: This topic focuses on common failures and performance bottlenecks in wind energy systems (gearbox failures, blade fatigue, etc.) and seeks to improve reliability. The research could involve testing advanced composite materials for blades that resist weathering and fatigue or developing IoT-enabled sensors and AI predictive maintenance algorithms that detect and address faults before they cause turbine outages.

3. Energy Storage Integration for Intermittency – Research Topic: This research would delve into how largescale energy storage (batteries, flywheels or other technologies) can be optimally integrated with intermittent renewable sources. Key questions include sizing and control: how big should storage be relative to a wind/solar farm, and how should it be dispatched to smooth output and provide grid services? The work might use modelling and simulation of a hybrid solar/wind farm with a battery energy storage system (BESS) to evaluate strategies for peak shaving, frequency regulation and energy time-shifting.

4. Hybrid Renewable Energy Systems and Microgrids : This topic examines the combination of multiple renewable sources (and possibly backup generators or storage) in a coordinated system to provide reliable power. A hybrid system might, for example, use solar by day, wind by night, and battery storage to cover shortfalls, all managed within a microgrid controller.

Research can involve designing a microgrid for a remote community or campus that currently faces reliability issues, simulating its operation, and perhaps building a pilot. Key research questions include optimal resource mix, control algorithms for balancing supply and demand, and economic analysis of the hybrid system.

5. Smart Grids and IoT for Renewable Integration: As renewable penetration rises, the conventional power grid must evolve into a smarter network. This research topic involves developing and testing smart grid technologies that allow better monitoring, control, and flexibility in a grid dominated by renewables. Potential areas include IoT sensors across the grid for real-time data on generation and loads, AI-driven demand response systems that adjust consumption to match renewable supply, and advanced inverter controls that help solar/wind farms provide grid support (voltage regulation, frequency response). A specific project might simulate a city grid with 80% renewable energy and demonstrate how an AI-based energy management system can prevent blackouts by rerouting power or temporarily curtailing certain loads.

6. Bioenergy and Waste-to-Energy Enhancement: This topic targets the bioenergy sub-sector, where efficiency and pollution can be concerns. Research could focus on advanced thermochemical processes (like gasification or pyrolysis) to convert biomass or municipal solid waste into clean syngas and then electricity more efficiently than traditional combustion. It might also involve developing better emissions control or carbon capture for bioenergy plants to ensure they are truly carbon-neutral or carbon-negative.

7. Geothermal and Tidal Energy Innovation: This subtheme combines underutilized renewables like geothermal and ocean energy, focusing on overcoming the barriers that have kept their contribution small. On the geothermal side, research might explore Enhanced Geothermal Systems (EGS) – for example, testing drilling techniques or reservoir stimulation methods that could allow geothermal power generation in areas beyond the traditional hotspots. On the marine energy side, a topic could be designing a more efficient tidal turbine or wave energy converter that can operate in harsh ocean conditions with lower maintenance needs. A concrete project might involve modeling a tidal energy farm in a coastal region and designing adaptive control for turbines to maximize energy capture across tidal cycles.

8. Green Hydrogen and Fuel Cell Systems : This topic is about using surplus renewable power to produce hydrogen (via electrolysis) and then using hydrogen as a clean fuel for electricity generation (through fuel cells or turbines) when needed. Research could investigate improving electrolyzer efficiencies, reducing the cost of electrolysis (through catalysts or new membrane technologies), or optimizing integrated systems where a solar/wind farm feeds an electrolyzer and the hydrogen is stored for later use in a fuel cell plant. An important aspect is addressing the current reality that over 95% of hydrogen production today is fossilfuel based – meaning there is huge room for growth in renewable (green) hydrogen. A specific research question might be how to design a power-to-hydrogen-to-power system that has roundtrip efficiency above a certain threshold and is economically viable for grid backup.

These tentative topics are by no means exhaustive, but they illustrate the rich landscape of research possibilities under the main theme. Each topic inherently involves examining current systems (to find inefficiencies or gaps), developing improvements (technical, operational, or both), and often assembling a combination of technologies into a novel solution. Students of grade 9th can refine these topics or propose related ones, ensuring that at least one of the three focal objectives :

1. Fixing current issues

Diagnostic Analysis of Existing Systems Aim: To verify operational gaps, inefficiencies, and unutilized potential in current renewable energy infrastructures.

Suggested Subtopics:

- Energy loss analysis in solar roof top systems in educational campuses.
- Evaluation of wind turbine performance vs. rated output in semi-urban areas.

  Performance degradation in installed photovoltaic panels over years.
- Efficiency audit of solar water heating systems in households.
- Comparative study of different MPPT algorithms on existing solar inverters.
- Evaluation of bio-digesters in municipal waste treatment units.
- **Case study:** Reasons behind underperformance of hydro micro-projects.

- **Expected Outcome:** Identification of specific inefficiencies or losses with data supported recommendations for performance optimization.

2. Applying solutions

Comparative Study of Newer Systems with Existing Ones

Aim: To assess and validate the effectiveness of newly deployed or advanced renewable systems vis-à-vis older counterparts.

Suggested Subtopics :

- Comparing floating PV systems with traditional land-based PV installations.
- Hybrid wind-solar system vs standalone PV: Output and storage reliability.
- Biochar production and its use as fuel vs traditional biomass usage.
- Advanced lithium-ion battery storage vs conventional lead-acid in RE systems.
- Smart inverters vs conventional inverters in rural solar microgrids.
- Solar thermal collectors with nanofluid vs standard water-based systems.
- Urban wind turbines: Efficiency vs traditional windmills in same wind zone.
- Expected Outcome: Practical validation through performance data or simulation proving the merits or limitations of newer technologies.

3. Innovating new systems

Innovative Concepts and Practical Implementations

Aim: To ideate, design, and implement novel renewable energy systems or components with the potential for realworld application.

Suggested Subtopics:

- Development of low-cost modular solar PV units for slums.
- Solar tree or vertical axis wind turbine designs for space-limited areas.
- IoT-based performance monitoring and fault detection in RE systems.
- Solar-powered hydrogen electrolysis setup for fuel cell evaluation.
- AI-based forecasting model for solar or wind output optimization.
- Thermoelectric generator prototype from industrial waste heat.
- Repurposing e-waste components into small-scale energy systems.

Expected Outcome: Working model,prototype, or simulation demonstrating innovation, technical feasibility, and sustainability potential.

Evaluation Criteria :

- Originality and practicality of research
- Depth of analysis and scientific methodology
- Quantitative results, measurements and data interpretation
- Contribution to improving renewable energy efficiency
- Real-life application potential and innovation