# EcoHusk Project Report

## 1. Project Background

The idea of our project *EcoHusk* started during my bachelor's study when I participated in a competition at my university. It was organized by a Chinese electricity production company, and we were asked to write a report about the electricity production scenario of our home country. While researching, I found something very surprising about Bangladesh: even though more than 95% of people have access to electricity, over 90% of our electricity still comes from fossil fuels like coal and gas. These energy sources are harmful to the environment because they release a lot of pollution and carbon dioxide. Also they are not sustainable and our fossil fuel reserve is finishing very quickly.

I started thinking — what could be a better, cleaner, and more sustainable option for a country like Bangladesh?

While exploring different renewable energy options, I came across two interesting ideas: floating wind turbines and rice husk-based electricity. Floating wind turbines were interesting but too expensive to be a practical alternative. But rice husk — which is a by-product of rice processing — seemed very promising. Bangladesh produces a lot of rice, and rice husk is usually thrown away or burned, which causes air and water pollution. I found that although some countries were using rice husk to generate electricity, those methods were not eco-friendly and still produced pollution.

At the same time, I was also attending different events related to the United Nations' Sustainable Development Goals (SDGs). I even got the chance to speak at the Youth Summit organized by the United Nations Youth and Student Association of Bangladesh (UNYSAB), one of the biggest youth summits of the South Asian region. There, I met many people working on sustainability, and I learned a lot about clean energy and environmental solutions. With all that knowledge, I started thinking deeply about how we could use rice husks in a better way. And I started reading about rice husk's properties and how we can utilize rice husk in different ways.

That's how the idea of *EcoHusk* came to life. We designed a complete, eco-friendly, zero-waste system that uses rice husk to produce:

- Electricity
- Activated carbon
- Nitrogen gas
- Clean, purified drinking water
- Eco-friendly bricks and concrete mixtures (made from rice husk ash)

The most important thing about this system is that **nothing is wasted**. Every by-product is reused in another step of the system, making it a perfect circular solution.

Later, we also realized that this idea is not only suitable for Bangladesh — it could be extremely useful for China as well. China is the largest rice-producing country in the world, and it generates a massive amount of rice husk every year. Sadly, a lot of it is either dumped into water or openly burned, which causes serious environmental pollution. But since China already has all the machines and technologies needed for this system available in its domestic market, implementing this project here is very much possible and cost-effective.

In short, *EcoHusk* is a powerful and practical solution that turns agricultural waste into valuable resources, supports sustainability, reduces pollution, and promotes a cleaner future for both Bangladesh, China, and many other rice-producing countries.

# 2. Research & Development Process

Once the idea of *EcoHusk* took shape, I shared it with my team members, and we began discussing how to turn this concept into a complete and working solution. We identified the main stages of our proposed ecosystem — from gasification to electricity generation, water purification, and brick production — and divided these parts among ourselves for further research. Each team member focused on specific sections to study their feasibility and real-world applications.

After researching each stage of the system separately, we were very encouraged to find that the whole ecosystem could actually be implemented in real life. All the components — from gasifiers to carbon activation, water treatment, and brick-making — were already available in existing technologies. The challenge was to connect them in a smart and eco-friendly way that avoided waste and pollution.

### Overcoming Key Challenges

One of the biggest challenges we faced during the early development phase was realizing that most of the gasifiers currently used for rice husk energy production are not environmentally friendly. They use **open combustion**, which releases large amounts of **carbon dioxide ($CO_2$)** and harmful gases into the atmosphere.

To solve this problem, our team members who study **mechanical engineering and material science** came up with a solution: use a **closed combustion system** with **controlled oxygen** levels. This special type of gasifier does not release significant amounts of $CO_2$, making it much more eco-friendly. We chose to modify an existing **downdraft gasifier** by adding a **declined suction net** inside the **pyrolysis zone**, which allowed us to collect carbon particles efficiently. These carbon particles can later be processed into **activated carbon**, which is a highly valuable material used in batteries and medical filters.

### Research Tools and Design Process

To support our concept with global insights, we studied various rice husk power plants in countries like **India, Nigeria, and the Philippines**. This helped us understand what worked and what didn't in those regions. We then used **SolidWorks** to design a complete 3D model of our *EcoHusk* ecosystem.

Every machine and component — from the gasifier to the water treatment units and brick production equipment — was carefully modeled and visualized.

We also used **3D printing** to create physical models of the entire system, which helped us explain the concept clearly in exhibitions and competitions. These visual representations made it easier for others to understand how each part of the system fits into the bigger picture and contributes to a zero-waste circular economy.

In short, our research and development process involved brainstorming, technical innovation, design, and collaboration — all aimed at building a cleaner, smarter, and more sustainable future using rice husk.

# 3. Technical Approach

The *EcoHusk* project is based on a smart, closed-loop system that transforms rice husk — an agricultural by-product — into multiple useful outputs without creating any waste. The entire ecosystem is designed to be sustainable, efficient, and environmentally friendly. The process is divided into five key stages:

### Step 1: Modified Downdraft Gasification Process

The process starts with collecting rice husks, which are sent into a specially **modified downdraft gasifier**. In this stage:

- A **closed combustion system** with a **controlled oxygen environment** is used instead of traditional open burning.
- This helps **minimize $CO_2$ emissions** and environmental pollution.
- Inside the **pyrolysis zone**, we've installed a **declined suction net** to collect carbon particles, which would otherwise be wasted or pollute the air.
- The gasification process produces:
    - **Unprocessed syngas**
    - **Carbon particles**
    - **Rice Husk Ash (RHA)**

### Step 2: Electricity Generation & Nitrogen Separation

The unprocessed syngas produced in Step 1 is then processed in the following way:

- It enters a **cyclone separator**, which extracts **pure nitrogen gas**.
- The purified syngas is then fed into a **gas turbine**, where it is burned to generate **renewable electricity**.
- The system can produce approximately **1.6–1.8 kilowatt-hours per kilogram** of rice husk, adding up to around **32 terawatt-hours per year** on a national scale of China.

### Step 3: Activated Carbon Production

- The carbon particles collected in the pyrolysis zone are sent to a **carbon activation plant**.
- Here, they are thermally treated to create **high-quality activated carbon**.
- This material has important industrial uses — especially in **battery production**, **medical filtration**, and **air/water purification systems**.

### Step 4: Water Purification Using Rice Husk Ash

- The **RHA (Rice Husk Ash)** collected during gasification is used in **water treatment plants**.
- Thanks to its high **silicon dioxide ($SiO_2$)** content, RHA can remove salt and other impurities from water.
- It can reduce water salinity from **35,000 ppm (seawater level)** to **below 500 ppm**, making it suitable for **drinking**, especially in coastal areas.

### Step 5: RHA Brick and Concrete Production

- After water purification, the **used RHA** is dried in a **drying chamber**.
- The dry ash is then used to make **eco-friendly bricks and concrete mixtures** (for its pozzolanic properties) rather then throwing them away in the environment.
- Replacing 50% of cement with RHA:
  - Reduces concrete production cost by **25%**
  - Increases **durability**
  - **Lowers indoor temperature** by up to **6°C**
  - Reduces noise by **10 dB**
  - Maintains a water absorption rate of just **19% of its own weight**

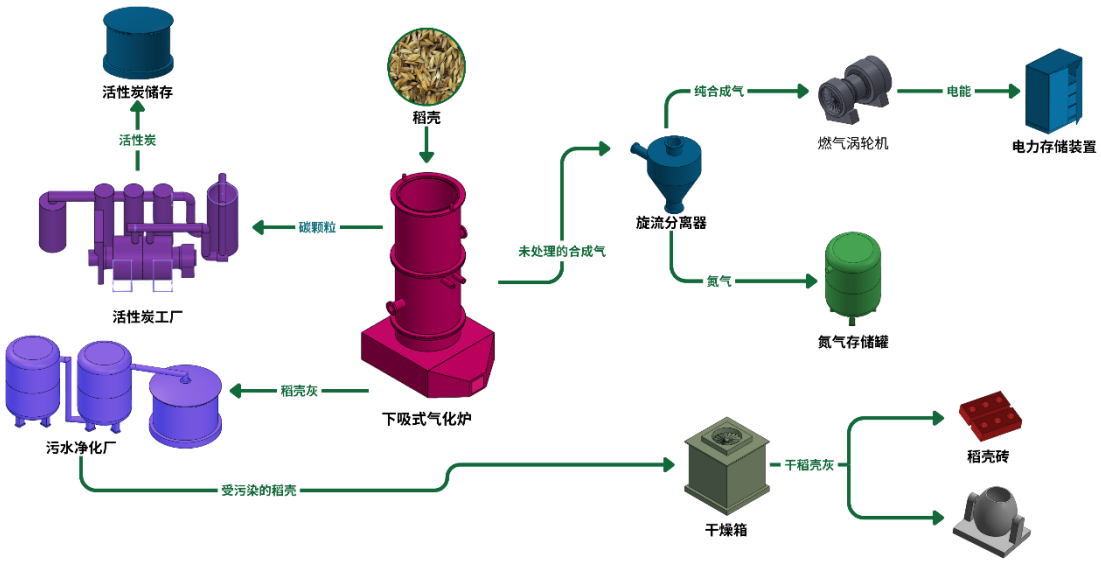


图1：生态稻壳供应链的完整三维模型

What makes this approach unique is that **every by-product is reused**:

- The syngas gives electricity
- The carbon becomes activated carbon
- The RHA purifies water
- The used RHA is recycled into bricks

All technologies used in this ecosystem are either already available or can be manufactured using machines easily sourced in **China**. The process is fully scalable, adaptable for both rural and industrial setups, and designed to support both **environmental protection** and **economic growth**.

# 4. Technical Advantages

The *EcoHusk* system is not just a new method — it is a **technological upgrade** that offers multiple advantages over traditional rice husk usage and existing biomass energy systems. It combines energy production, material recycling, and environmental protection in a single integrated process.

Here are the key technical advantages:

1. Zero-Waste Ecosystem

Unlike conventional systems that produce waste or harmful by-products, *EcoHusk* creates a **circular ecosystem**:

- Every stage produces something valuable.
- All by-products are reused in other stages (e.g., used ash becomes construction material).
- This ensures **no part of the rice husk goes to waste**.

**2.** Closed Combustion = Minimal Emissions

Traditional rice husk combustion methods release **carbon dioxide and pollutants** into the air, contributing to climate change and air pollution. In contrast:

- *EcoHusk* uses a **closed combustion system** in a **controlled oxygen environment**.
- This significantly **reduces $CO_2$ emissions** and **prevents the release of harmful gases**.

**3.** Advanced Gasifier Technology

- The system uses a **modified downdraft gasifier** with an added **declined suction net** to collect carbon particles.
- Most existing systems do not collect these carbon particles, which results in **material loss and pollution**.
- *EcoHusk* converts this carbon into **activated carbon**, a high-value product.

**4.** Multi-Stage Output: Energy + Clean Water + Materials

Most rice husk-based power systems focus only on **electricity**. But *EcoHusk* goes further:

- Produces **electricity**, **nitrogen gas**, **activated carbon**, **clean water**, and **eco-bricks** — all from one input.
- This **multi-output design** increases the economic and environmental value of the system.

**5.** Enhanced Building Materials

- Traditional bricks require a lot of cement and contribute to $CO_2$ emissions during production.
- *EcoHusk* bricks, made with **rice husk ash**, are **lighter, more durable**, and **more eco-friendly**.
- Benefits include:
    - **25% cost savings**
    - Lower indoor temperature (**up to 6°C**)
    - Noise reduction (**10 dB**)
    - Lower water absorption (**19%**)

**6.** Scalability & Local Suitability

- All required machines (gasifiers, turbines, separators, drying chambers, etc.) are **already available** in countries like **China** and **India**.
- This makes the system **easy to implement and scale**, especially in rice-producing regions.
- Since China and Bangladesh both generate millions of tons of rice husk annually, this system has huge **local and national potential**.

In summary, *EcoHusk* stands out because it's not just about producing energy — it's about doing it **cleanly, efficiently, and sustainably**, while also creating useful by-products that support other industries. It's an all-in-one solution for a greener future.

# 5. Technical Achievements

So far, our team has successfully completed the **initial research and development** phase of the *EcoHusk* project. Through teamwork, technical study, design modeling, and strategic planning, we have built a strong foundation for this innovative, zero-waste ecosystem based on rice husk utilization.

A key recognition of our work came in **2024**, when our project was awarded the **"Best Team Award"** at the **第五届中外学生科技创新大赛** (5th China-Foreign Students Scientific Innovation Competition) held at **Yangzhou University**. This achievement was a significant milestone for us and proved that our idea has real innovation potential and academic value.

### What We've Accomplished So Far:

- Completed **theoretical research** on each stage of the ecosystem
- Studied global rice husk energy systems and environmental impacts
- Designed the entire system in **3D using SolidWorks**
- Created **3D-printed visual models** for demonstration purposes
- Identified practical machinery and materials that are available in local markets

### Our Next Steps:

With enough **organizational and financial support**, we are ready to move forward to the **experimental stage**. As part of this, we plan to:

- **Personally visit** rice husk power generation plants in countries like **India, Nigeria, and the Philippines**
- **Collect real-world data**, ash samples, and operational feedback
- Begin **small-scale laboratory experiments** to validate the effectiveness of each stage, especially water purification and activated carbon production

Most importantly, we have plan to build a **small-scale prototype** of our **modified downdraft gasifier**. This prototype will be a working version of our core system and will allow us to:

- Test the feasibility of **closed combustion** in controlled oxygen environments
- Validate the effectiveness of **carbon particle collection**
- Analyze the system's **energy efficiency**, **emission levels**, and **ash output**

This hands-on testing will provide the essential data we need to optimize our model, support potential patent applications, and prepare for pilot implementation on a larger scale.

# 6. Economic Benefits

One of the strongest aspects of the *EcoHusk* project is that it is not only environmentally sustainable but also **economically viable**. It transforms agricultural waste into multiple valuable products while reducing costs in construction, energy, and water purification. This makes it highly attractive for governments, investors, and communities seeking both economic and ecological returns.

### Low Cost, High Value

Our initial cost analysis shows that the full implementation of the *EcoHusk* system — including gasifiers, turbines, carbon activation units, water treatment facilities, drying chambers, and brick-making tools — would require a total investment of around **$350,000 to $500,000**.

While this may seem like a large figure, it is quite cost-effective compared to the long-term value it creates:

- **Electricity** from rice husk is renewable and can offset fossil fuel costs.
- **Activated carbon** has a high market demand, especially in battery, healthcare, and water purification industries.
- **Nitrogen gas** is useful in many industrial applications.
- **Clean drinking water** is critical in coastal and water-scarce areas.
- **Eco-friendly bricks** reduce the need for traditional cement, lowering both construction costs and emissions.

Together, these outputs not only reduce environmental impact but also generate **multiple income streams**.

## Strong Return on Investment (ROI)

- Using just the rice husk waste that is otherwise dumped or burned, our system can produce up to **32 terawatt-hours of electricity per year** on a national scale (e.g., in China or Bangladesh).
- Replacing 50% of cement with rice husk ash in concrete reduces production cost by around **25%**.
- Bricks made from RHA offer **better insulation and durability**, which can lower cooling and maintenance costs for buildings.

The system also reduces the **costs of waste management**, which is a major expense in agricultural and urban areas.

## Market Potential

The market potential of *EcoHusk* is strong in several sectors:

- The global demand for **activated carbon** is rising due to its use in energy storage and medical products.
- The need for **water purification** is growing rapidly, especially in **coastal regions** where seawater salinity is high.
- There is increasing interest in **eco-friendly construction materials**, such as RHA bricks, because of rising cement prices and environmental regulations.
- The **renewable energy** sector continues to expand globally due to sustainability goals and climate action plans.

Given that all necessary machines and materials are available in **China**, the project can be implemented with **low logistical barriers** and **locally sourced technology**.

## Scalability and Funding Opportunities

Our system is designed to be **scalable** — it can be adapted to small rural villages or large industrial zones. This opens up opportunities for:

- **Government grants** in green energy and rural development
- **Private sector investment** in renewable energy and construction
- **International support** from sustainability-focused organizations

With initial funding, we can begin building a **pilot project or demonstration facility**. This would help attract further investment, validate our economic model, and open doors to commercial expansion.