

Startup-Led Pathways to Sustainability: Exploring the Determinants and Impacts of Green Innovation in Indian Startups

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Abstract

Indian startups are becoming a force for good change and a tool for creating sustainable development in the current world where environmental change is increasing. This evaluation will examine how Indian start-ups are making an impact on sustainable development through green innovation in response to the increasing number of environmental challenges. The growth of the start-up ecosystem in India has been massive in recent years around both social and ecological issues; examples are provided by Ecozen solutions and Recykal which are amongst the top innovators globally for their ability to innovate in the areas of waste management and sustainable agriculture, respectively. The report identifies several elements that lead to successful sustainable innovation such as access to government policies, green finance, digital transformation, market demand/consumer awareness and an increasing amount of consumer demand for environmentally friendly products. In addition, it highlights obstacles to sustainable innovation; for example, such as insufficient funding, an exceedingly complex regulatory environment, and low levels of consumer awareness about eco-friendly products. The research also evaluates both the external and internal drivers of the organisations before analyzing how drivers influence green innovation and what their impact is on the economic and environmental performance of the company. The findings demonstrate that through the implementation of sustainable practices, organisations can increase the competitiveness, revenues and decrease their costs associated with sustainable entrepreneurship initiatives. Using successful case studies that show this connection between reducing negative environmental impacts, as well as creating economic resilience for the organisation. The conclusion shows that the higher the level of emissions reduction, the better the environmental benefit that can be gained by the company through green innovation.

Keywords: Indian Start-ups, Sustainable Development, Green Innovation, Sustainable Entrepreneurship, Green Finance, Environmental Performance.

1. BACKGROUND AND RATIONALE

The global pursuit of sustainability has affected the perception of innovative enterprise manners and potential within the context of the contemporary global economy. As climate change; environmental degradation; and social disparity are continuing to worsen, green innovation (i.e., developing products,

services, and systems that reduce environmental impact) has arisen as a significant facet of sustainable development. Through this new approach, start-ups can also create dynamic, transformative environments that can lead the way in developing environmentally sustainable technological advances; therefore, offer new approaches to industrial practices; and ultimately foster equitable development. Typically having tight organizational structures, high levels of adaptability, and purpose directed leaders (vs. larger companies), start-ups can undertake the practical experiment of innovative business concepts that offer a balance between economic viability and environmental responsibility.

As countries like India continue to develop their economies and populations while also creating sustainable practices, their entrepreneurial businesses are increasingly focused on solving issues other than technology and financial issues. Companies such as Ecozen Solutions, Recykal, Log9 Materials, and Ossus Bio Renewables are helping to solve energy shortages, reduce waste accumulation, provide better food production for farmers and improve the air quality of urban centers. Most importantly, through their eco-innovative business practices, they provide evidence that on a global level there is also value added by creating employment opportunities and as a result create stronger economies and maintaining global competitiveness.

2. REVIEW OF LITERATURES

Desai and Aggarwal (2024) utilized GRI's standard to examine sustainability-based disclosures made by Indian businesses during 2020-2021, thereby establishing that there is a greater awareness of sustainability-related disclosures among companies in India — 58% report on nearly all of their material subjects — as companies have adapted their reports to better match their own industry's needs. The findings of the two researchers indicate that there is an increase in the levels of corporate transparency surrounding the sustainability reports produced by Indian companies, as evidenced under GRI Standards. **Singh (2024)** studies the effect of Sustainability on People, Planet and Profit in the Business Operations. It analyzes the relationship between Sustainability of Business Practices, Corporate Responsibility, and Energy Efficiency with respect to Competitiveness and Financial Performance. The Forces that drive Sustainability are Ethics and Consumer Demand. The Application of AI and Renewable Energy to Enhance Operational Sustainability and Environmental Preservation is also explored by this study; ultimately it concludes that Sustainability is a Fundamental Component of Innovation and Corporate Responsibility.

Ecological and technological stages of sustainable marketing in India were analysed by **Dave and Gudla (2023)**. The study considered sustainable marketing as one which promotes packaging and products that are ecologically friendly. This study has also explored consumer scepticism through case studies including Walmart and McDonald's, and there are recommendations for collaboration and government-supported innovation based on these case studies. Findings of this study suggest that sustainable marketing will be essential for environmental preservation in India.

Thomas and Bhaumik (2023) investigated the relationship between corporate sustainability and ESG practices for publicly listed companies in India from 2017 to 2021, analyzing company ESG scores and ROA from Thomson Reuters Refinitiv. The findings from several regression analyses revealed that, while there was no substantial negative impact from companies' environmental practices, there were substantial positive impacts from their combined ESG scores and social governance practices. This study demonstrates a need for sustainable practices and can help inform policy development related to corporate sustainability.

Through the use of bibliometric analysis of 506 documents, **Ghosh et al. (2024)** examine the ways in which Indian businesses will meet net zero emissions by 2070. In addition to pointing out gaps in funding, green taxonomy, and training, this research provides recommendations to businesses and governments on how to promote sustainable practices in India.

According to Munot (2024), sustainable (business) practices are beneficial and have a number of challenges associated with implementing these types of (business) practices. CSR, sustainable innovation, ethical sourcing and environmental sustainability were all considered in this study. Some of the benefits that were cited include tax advantages; efficiency in operation; consumer purchasing demand. Some of the challenges related to implementation of sustainable business practices are limited resources; concerns with "green washing"; and transition costs associated both with implementation and your organisation being perceived as being 'Green'. The conclusion reached in the study is that although there are initial costs related to the implementation of sustainable business practices, there will be long-term benefits from sustainable practices.

3. RESEARCH GAP

Even though there is an increasing worldwide awareness about the importance of green innovation and sustainability, the past research has been insufficient in exploring the role of startups in driving sustainable development in India through green innovation. Most of the prior research studies have covered larger companies only and not smaller ones (startups); therefore, there is little to no evidence currently demonstrating how the smaller companies are promoting sustainability through new and innovative ways (green) of operating. Additionally, previous studies tended to have a large emphasis on the technological and environmental dimensions of green innovation and to have neglected important areas such as economic, political and institutional factors that influence and shape how sustainable businesses operate within the economy.

The relationship between internal factors (e.g. corporate culture, innovative thinking, and managerial style), and external factors (such as access to capital, level of government support, quality of workplace environment, and consumer education) has not been extensively researched or studied in relation to India. On top of that, not many people have tried to connect green innovation with both environmental and economic results for startups in India. Therefore, this study seeks to empirically examining how Indian startups promote sustainability through green innovation, the key factors that drive or hinder such initiatives, and how all of this affects their performance in the real world.

4. RESEARCH OBJECTIVES

1. To investigate the role of Indian startups in promoting sustainable development through green innovation.
2. To identify the key factors that promote or hinder sustainable innovation among Indian Start-ups.
3. To assess the impact of green innovation on the environmental and economic performance of startups.
4. To investigate the Challenges and barriers faced by Indian Startups in adopting green innovation, such as financing, regulations, infrastructure, and customer awareness.

5. RESEARCH METHODOLOGY

This study uses a descriptive and empirical approach. this research work is based on in-depth qualitative analysis of accessible secondary data. The data collected from published research paper in journals,

newspapers, company official websites, published proceedings of conference with the main focus on latest research conducted in context of green entrepreneurial contribution in promoting sustainability and how they are performing their green practices. In this Study Various Case studies of Indian start-up contributing to sustainable development through green innovation are also taken in to consideration.

6. DISCUSSION / ANALYSIS

❖ SUSTAINABLE DEVELOPMENT THROUGH GREEN INNOVATION: CASE STUDY ON INDIAN STARTUPS

1. Ecozen Solutions (Pune):

Ecozen Solutions was founded in 2010 by three IIT Kharagpur graduates: Devendra Gupta, Prateek Singh, and Vivek Pandey based out of Pune, India, with a focus on developing clean energy solutions for Agriculture in India. The company's two main products - Ecofrost (solar cold storage) and Ecotron (smart irrigation controllers) are designed to help farmers reduce their dependence on fossil fuels and reduce their post-harvest losses through the use of clean renewable energy. Their innovative approach to incorporating renewable energy into agricultural practices helps to empower rural populations to increase their productivity while providing support to move towards a more climate-resilient agricultural system within India.

2. Econscious (Delhi):

Founded in 2020 by Sonal Shukla and Vaibhav Verma, Econscious is a company that repurposes waste plastic into useful items, including furniture, planters and other home and garden accessories. The goal of Econscious is to create economic value by turning waste into usable products and promoting the idea of the circular economy by designing and producing sustainable products.

3. Recykal (Hyderabad and other cities):

The first of our featured companies, Recykal, was founded in 2017 by Abhay Deshpande, Anirudha Jalan, and Abhishek Deshpande. Recykal is a technology-enabled platform that brings together the waste generators and the recyclers, as well as the producers of products using recycled materials. Recykal is a platform that enables users to collect, track, and recycle their waste in an efficient manner, and also enables users to gauge the level of accountability in the recycling process (this process is made transparent and data-driven). In addition to being a major contributor to building India's circular economy and enabling recycled materials to be produced by new technology, Recykal's innovative business model supports better and more sustainable practices for managing waste.

4. Scrapji (Mumbai Metropolitan Region):

Scrapji provides a tech-enabled platform for waste collection and offers scheduled pickups, transparent pricing, and a focus on the employment and safety of women workers. Scrapji creates convenience, professionalism, and equality in urban waste management systems. Scrapji utilizes technology combined with a commitment to inclusivity to provide dignified work opportunities for women in the informal waste industry while increasing the efficiency of recycling.

5. Log9 Materials (Bangalore):

Log9 Materials is a future-focused clean tech company that has developed fuel cells created from aluminium (aluminium fuel cells) and cutting-edge battery systems that power the electric mobility of vehicles (clean energy/mobility solutions) as well as renewable energy products. Log9 Materials' founders were IIT Roorkee innovators. Log9 Materials is creating next-generation technologies that promote energy

independence for India by supporting the transition of electric vehicles (EVs) and ultimately the transition to a sustainable/low carbon future.

6. Green Bio:

Green Bio has designed a line of biodegradable and compostable PLA bottles and Packaging Materials, which decompose naturally within 180 days. These provide an alternative to single-use plastics, as they can be produced in larger quantities and therefore are a scalable solution to the issue of plastic waste. By focusing on sustainable packaging, Green Bio helps promote responsible consumption on the part of consumers while also providing an alternative to the harmful effects of manufacturing products from fossil fuels and creating waste to dispose of.

7. Ossus Bio renewables:

Ossus Bio renewables has developed an innovative method to convert chemical and waste materials into clean, renewable fuel via hydrolysis, thereby helping to provide industries with a sustainable source of energy while reducing their ecological footprint.

8. Nepra Resource Management (Known as "Let's Recycle")

Nepra Resource Management, known as 'Let's Recycle' operates as India's chief network for dry waste recycling. Each day, through its collaborations with varying organizations throughout several Indian cities, it manages over 500 tonnes of dry waste. This collaboration has had several positive outcomes. It helped generate employment for numerous individuals, bolster local economies, and encourage the adoption of environmentally sound methods.

7. FACTOR PROMOTING SUSTAINABLE INNOVATION IN INDIAN START-UPS

- 1. Government Policies and Support:** In addition, several government programs provide support for sustainable businesses; these include Start-up India, Make in India, and Atal Innovation Mission which promote innovation, create new business opportunities and provide economic and regulatory incentives.
- 2. Access to Finance:** New financial tools often prove helpful for start-ups aiming for sustainability. Green Bonds, ESG Investing, and Impact Funds are methods that can lend support toward this goal.
- 3. Organizational Culture and Leadership on Sustainability:** When senior leadership considers environmental responsibility for their organization as a priority, they are adding an integrated SD plan into their strategic plan. Organizational culture that supports creativity and ethics creates a culture of innovation at the organization level.
- 4. Technological Advancements and Collaborations:** The Technology that is being developed in Renewable Energy, Waste Management & Circular Economy along with Collaborative Partnerships with the Research Academy is driving innovation in those sectors.
- 5. Market Demand and Consumer Awareness:** By increasing the demand for environmentally friendly or "green" products, new business prospects will appear, as well as an opportunity for businesses in that industry to acquire a competitive advantage over traditional products.
- 6. Education and Skills:** The availability of Entrepreneurship Programs focusing on Sustainability and the support of local Governments and NGOs provide new entrepreneurs with the Technical Knowledge to be successful.
- 7. Digital Transformation:** AI, IoT, and Blockchain Technologies are improving efficiency through optimized Resources, Supply Chains, and Transparency.

8. **Global Partnerships:** Collaborating with Organizations such as the United Nations Development Programme (UNDP), The World Bank and Global Accelerators provide Organizations with Expertise, Funding, and Best Practices.
9. **Corporate Social Responsibility Relationships:** Corporations can provide Mentoring and Financial Support to Foster Sustainable Innovation Ecosystems.
10. **Incubators:** Incubators provide technical, Financial and mentoring Assistance for Start-ups Focusing On sustainability.

8. FACTORS HINDERING SUSTAINABLE INNOVATION IN INDIAN START-UPS

1. Lack of Access to Sustainable Finances

Many start-ups today have difficulty obtaining financing for sustainably based business models (due to policies designed to encourage sustainable development). Traditional Venture Investors often seek short-term returns on investments, which makes it difficult for start-ups to provide for the long-term investments required to implement Sustainable Business Models.

2. Lack of Product Knowledge and Expertise

An inadequate understanding of Sustainable Technologies, Circular Economic Models and Green Certification Standards (by entrepreneurs and very small start-up companies) greatly limits their ability to develop Sustainable Innovations.

3. Initial Cost and Infrastructure Limitations

Many Sustainable Technologies require an upfront financial investment in Research & Development (R&D), Materials, and Equipment. In addition, many Sustainable Innovations are hindered by problems with infrastructures such as; unreliable or inconsistent access to Renewable Energy or unsuccessful Waste Management Systems that are not cost-effective.

4. Government Support and Regulatory Environment

Although there are government initiatives to support green businesses and sustainable startups, the regulatory environment is complex and often inconsistent across states. The lack of clear guidelines for the implementation and enforcement of sustainability regulations also inhibits startup participation in sustainable business practices, as inconsistency discourages many startup companies from fully utilizing and implementing sustainable business practices.

5. Market and Consumer Preferences

Due to price sensitivity and low levels of consumer willingness to spend more for eco-friendly products, the potential profitability of sustainable innovations is diminished. This often creates difficulty for startups to achieve both their sustainability and profit targets.

6. Insufficient Research & Development Capabilities of Startups

Start-Ups have limited access to cheap R&D facilities that are required for the development of clean technology. There is a lack of collaboration between universities and industries. This results in limited opportunities for joint research and innovation.

7. Implementation of Fragmented Sustainability Policies

There are many regulations related to sustainability at the national level, but the implementation of these regulations is different for states due to the absence of coordination and the administrative inefficiency of the implementing agencies for sustainability regulations.

There is no coordinated policy framework available for startups to implement sustainability regulations.

8. Consumer Awareness Outside of Urban Areas Is Limited

The growth of awareness about sustainability among urban consumers has increased at a rapid pace; but there is still relatively low consumer awareness in rural (and/or suburban) areas, which has restricted examples of potential markets for sustainable products/solutions.

9. Lack of Standardized Sustainability Metrics

There is no standardized way to measure or report sustainability performance for startups. Without having common metrics, it will be difficult for investors and stakeholders to assess the real impact of sustainable innovations.

10. Workforce and Talent Retention Challenges

Startups are challenged in finding and retaining qualified people who have skills and expertise in sustainability, green engineering or environmental management. High turnover and limited access to employee training affect the long-term viability of sustainable initiatives.

9. EVALUATING GREEN INNOVATION'S EFFECTS ON START-UPS' ECONOMIC & ENVIRONMENTAL PERFORMANCE

“Green Innovation” refers to increasing the environmental impact of products, processes, or services while increasing the efficiency and sustainability of those products, processes, or services. Start-Ups' decision to "go green" is a major opportunity for growth and cost reduction. Therefore, in order to better understand how Green Innovation affects both environmental performance and economic performance of Start-Ups we must evaluate the effects of Green Innovation on Start-Ups in India.

9.1 EFFECTS ON ENVIRONMENTAL PERFORMANCE

- **Reducing Greenhouse Gases:** By utilizing renewable energy sources, implementing energy efficient technology, or using a low-emission process, Start-Ups will reduce their production of greenhouse gases (GHG) and other pollutants. These reductions are helpful in combating climate change.
- **Using Raw Materials More Efficiently:** Adopting a Circular Economy Model will allow Start-Ups to minimize the amount of raw materials they consume while still providing customers with goods and services using only the most essential raw materials. Therefore, when Start-Ups adopt Circular Economy practices, they will be reducing waste throughout the process of operating their businesses.
- **Improving Waste Management and Environmental Practices:** Some of the applications of Green Innovation include enhancing methods of managing waste, producing products using cleaner-production processes, and adopting “green disposal options.” Consequently, new ventures utilizing these approaches will reduce their contribution towards polluting our air, water, and soil.
- **Supporting Global Sustainability Initiatives:** Green Innovations will be supported by start-ups and enhance the supporting efforts of the UN Sustainable Development Goals (SDGs). Examples of the SDGs include; clean energy, responsible consumption, and climate action.

9.2 EFFECTS ON ECONOMIC PERFORMANCE

1. **Diminished Income through Lower Costs.** Improved Resource Management; Reduction of Consumer-generated Waste; and Higher Levels of Energy Efficiency will contribute to lower Operating Expenses, which results in an increase in Net Income or Profitability.
2. **Boosting Revenue:** Improved Sales Growth through Eco-friendly Products and services that create opportunities in foreign markets, attract new customers and create opportunities for higher price points (ie. through enhanced perceived value).

3. **Gaining Competitive Advantage:** Marketable Competitive Advantage by leveraging Green Business Practices enables New Ventures to differentiate themselves and increase Recognition and Loyalty from Consumers.
4. **Attracting Investment:** Attract Additional Sources of Capital through increased support from Government Agencies promoting Green Technology through Grants and loans, Socially Responsible Investors or Impact Investor-backed loans, and Venture Capital Investors more inclined to support Sustainable Startups.
5. **Ensuring Long -Term Resilience:** Building Sustainable Long-term business resilience by having Capacity to adapt to Supply Chain disruptions, Changes in legislation and Regulations, and Trend Shifts in marketplace favouring Products and Services designed to be eco-friendly.

10. CASE STUDY - OSSUS BIORENEWABLES PVT LTD

Ossus Bio-renewables is a Bangalore based Climate-Tech startup founded in 2017 that produces Green Hydrogen from Industrial Wastewater. The company's flagship product - OB Hydra Cel Bioreactor, employs Microbes and Low-Energy Electrochemical processes for treating wastewater while generating hydrogen as a byproduct, enabling Industries to sustainably manage effluent. This means that the hydrogen produced is High Value Clean Fuel.

10.1 ENVIRONMENTAL IMPACT

1. **Wastewater Treatment:** Industrial Wastewater (Effluents) are treated and thus reduce water pollution and decrease the environmental hazards associated with these effluents.
2. **Green Hydrogen Production:** The use of Organic Waste helps convert it into Clean Hydrogen and thereby relieve dependency upon Fossil Fuels and reduce emissions of Greenhouse Gases.
3. **Resource Efficient:** Wastewater (and not Fresh Water) is used to produce Hydrogen, as well as to integrate principles of Circular Economy; therefore, conserving Natural Resources.

10.2 ECONOMIC IMPACT

1. **Lower Costs for Industries:** The Reduced Logistics, Fuel and Wastewater Treatment by producing Hydrogens on site creates cost savings for the industries.
2. **Competitive Advantage:** Hydrogen produced at an average price of less than US\$ 1.00 per kilogram (kg), versus traditional suppliers.
3. **Increasing Confidence and Investment:** Raised US\$ 2.4 Million in funding for scaling operations, diversifying into new sectors and providing multiple revenue streams through the sale of hydrogen and installation of reactors.
4. **Business Model Innovation:** By combining Waste Treatment with Fuel Production, new models such as 'Building, Owning, operating' and 'Hydrogen as a Service' can be implemented; creating new business models.

11. CHALLENGES AND BARRIERS IN ADOPTING GREEN INNOVATION BY INDIAN STARTUPS

1. **Funding and Financial Constraints:** The financial burden and requirement for a startup to seek capital can restrict the growth and expansion of a green startup.
2. **Policy and Regulatory Challenges:** Policy/regulatory hurdles create barriers to entry when entering the green space due to variances by state on regulatory compliance, lack of clear government incentives

(i.e., subsidies, tax credits, etc.), and add to the uncertainty when planning the future of their green business.

3. **Inadequate Infrastructure:** The infrastructure to support sustainable solutions is needed (i.e. creating renewable energy power grids and establishing renewable energy recycling centers, as well as locations to plug-in and charge electric cars) in order to keep start-up operational expenses down and support them in reaching customers in multiple markets.
4. **Consumer Awareness and Market Acceptance:** Consumers have little or no understanding of the benefits associated with using eco-friendly products, due to many consumer perceiving them as more expensive or more inconvenient than their traditional counterparts. As such, this lack of awareness and perceived inconvenience limits the level of demand for eco-friendly products and reduces the rate of adoption.
5. **Human Resource and Technical Expertise:** Developing Green Innovations requires skilled professionals in areas like renewable energy, environmental compliance and sustainability. It can be difficult for early-stage companies to find this type of talent, thus they have to hire highly priced consultants to help them which adds needless costs to their operations.
6. **Market and Competitive Pressures:** Established companies that are selling traditional products at a much lower price create a challenging competitive environment for early-stage companies. The startup companies may not be able to compete on price, which limits their ability to grow revenue and reinvest in their innovative product development efforts.
7. **Supply Chain and Raw Material Issues:** Many Sustainable Products require materials that are hard to come by or rarely produced commercially available materials, such as recycled plastics and/or bio-based polymers. With supply chains not being reliable and the associated costs for producing these materials being so high, obtaining materials to manufacture can often be very difficult due to uncertainty.
8. **Technological Barriers:** Startups have limited access to advanced Green Technologies and modern research facilities. This slowed down the newly developed product, thereby delaying the startup company's ability to implement the latest cutting-edge technologies.
9. **Stakeholder Engagement:** Apart from the customer, other stakeholders, such as the government, various businesses, and the community, may also have little knowledge and understanding concerning green innovation. Lack of collaboration and synergy from such groups may prove to have negative consequences for the growth and success of entering into the market on the part of the startup business enterprise itself.
10. **Risks and Uncertainties:** Green startups have to deal with changing environments marked by various uncertainties such as changes in laws, the emergence of new technologies, as well as the possibility that customers may not accept the product. Investors understand these uncertainties as a challenge to the growth of green start-up businesses.
11. **Cultural/Behavioural Barriers:** The behaviors and cultural activities of individuals tend to influence their decisions, which involve relying on single-use plastic and traditional forms of energy, and make it extremely challenging for them to change their preferences with regard to sustainable behaviours and/or practices. The start-ups have to face this challenge using resources and time to effect these behaviours and/or practices.

12. CONCLUSION

The Indian startup ecosystem has been influenced by multiple factors such as economics, technology, policy and culture. Some of the most important enablers of sustainable innovation are Government initiatives, Digital Transformation and increasing awareness among consumers about the importance of sustainability. On the other hand, some of the greatest hindrances to the development of sustainable innovation in the startup ecosystem in India include lack of funding, lack of development of an R&D department within companies, and lack of consistency in policies by the Indian government. To address the issues and hindrances that Startups face in implementing Sustainable innovation into businesses and industries in India, there is a need to collaborate efforts between the Indian government, Academia, and Private Investors and Organizations. The creation of stronger Financial Support Systems, the establishment of a Unified set of Sustainability Metrics and the promotion of Education and Skills Development will contribute to empowering Start-ups with the tools needed to produce Inclusive and Sustainable Growth. The role that Start-ups will have in helping India achieve its Net Zero and Sustainable Development Goals (SDGs) will be imperative in creating a Greener and Resilient Economy.

Green innovations offer a double advantage to Start-ups, as they reduce the environmental impact with a decrease in carbon footprint, preservation of Natural Resources, and control of Waste, while on the other side, they enhance Economic Performance through Cost Savings, Market Diversification, and appeal to investors. By implementing Sustainable practices in their primary Operations, Indian Start-ups will benefit from long term Growth as well as positively Impacting the Environment.

Green innovation is led primarily by Indian startups, but many Indian startups experience substantial difficulty in developing and implementing their green innovation projects, due to insufficient capital resources, regulation issues, lack of supporting infrastructure, technology challenges, market access, inability to establish sustainable supply chains, the inability to identify proper stakeholder support, and cultural challenges. Overcoming these challenges requires government support, financial incentives, and infrastructure to enable the process of green innovation.

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