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A Clean and Efficient Energy Solution for Climate Change Mitigation and Energy Crises in Pakistan: The Atmospheric Vortex Engine †

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Abstract: Heat carried upward by atmospheric convection produces mechanical energy. An atmospheric vortex engine (AVE) uses a synthetic tornado-like vortex to capture mechanical energy from upward heat convection. The vortex is created by tangentially introducing warm or humid air into a circular wall base. Heat sources include solar energy, warm sea water, warm, humid air, and industrial waste. Earth's natural surface collects heat, eliminating the need for solar collectors. The AVE uses the same thermodynamic principles as the solar chimney, but it uses centrifugal force in a vortex instead of a chimney and the earth's surface instead of a collector. Turbogenerators nearby generate mechanical energy. Since the AVE uses less fuel to generate the same amount of electricity, it could reduce global warming. An AVE increases thermal power plant efficiency by lowering its cold-source temperature from the base of the troposphere to the tropopause. The AVE process could reduce global warming by lifting heat above greenhouse gases to radiate toward space. Since Pakistan is most affected by climate change and has many energy crises, this study aims to change engineers' mindsets from inefficient conventional energy sources to more efficient non-conventional, cleaner energy sources.

Keywords: AVE; Pakistan; energy sector; clean energy; feasibility of thermal power plants; sustainable energy; climate change

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1. Introduction

Pakistan is facing many challenges, but the most severe ones are climate change and energy shortages. It is primarily an agricultural country. Agriculture constitutes the largest sector of the country's economy. The majority of the population are, directly or indirectly, dependent on this sector. It accounts for half of the employed labor force, 24% of GDP, and most foreign exchange earnings. The first issue is climate change. The global surface temperature of Pakistan rises every year, despite natural variability. This means the temperature rise has severely disrupted Pakistan's climate [1]. These factors have caused a drastic increase in CO_2 emissions, which has increased global warming and climate change in Pakistan. Climate change will affect precipitation patterns and glacier melting, especially monsoon rain onset and intensity. As a result, water-dependent industries like agriculture and energy will be significantly impacted. The country's second problem is energy shortage due to a lack of new projects and a rising population. Pakistan had 43,775 MW installed capacity on 30 June. It has 26,683 MW of thermal (coal and gas) energy, 3620 MW nuclear, 10,635 MW hydropower, 1838 MW wind, 530 MW solar, and 369 MW biogas. This causes a

9000 MW shortage at peak demand. Pakistan frequently experiences multiday blackouts. The nation's electricity distribution infrastructure is also outdated and poor. Pakistan has 64 thermal power plants that generate over half of its electricity. These plants' thermal processes are inefficient and carbon intensive. They release large amounts of waste residual thermal energy. Power plant residual thermal energy powers the AVE. N. Louat and L. M. Michaud introduced the concept of AVE. This system replaces the conventional large solar chimney (designated as 82) with an innovative air vortex approach.

AVE is promising and produces clean, natural power [2]. The novel AVE uses atmospheric vortices caused by differences in temperature between warm ground air and colder altitude air. Controlled vortices generate electricity from atmospheric energy in AVEs. The AVE is a solar chimney/updraft tower. Solar updraft towers have a tall vertical tower, a base-mounted transparent solar collector, and a tube inlet turbine. The height and diameter of these affect the solar updraft tower's heat-to-work conversion efficiency. The 200 m tower, 10 m diameter, and 250 m solar collector of Madrid's Manzanares solar updraft tower had 0.2% efficiency. The cost of tower construction limits their efficiency. The Energy Manager estimates that the vortex will be 30 m wide and 15 km long; Figure 1 shows this clearly. One AVE generates 200 MW. Instead of a tower wall, the AVE uses tornado flow characteristics and an artificial vortex, so tower height does not limit efficiency. Tower construction avoidance reduces electricity costs [3]. Canadian engineer Louis Michaud and AVE Technology Energy Corporation built a working prototype. It was the largest (12 feet in diameter) with a 60-foot vortex. Vortex Engines control tornado and thunderstorm energy.

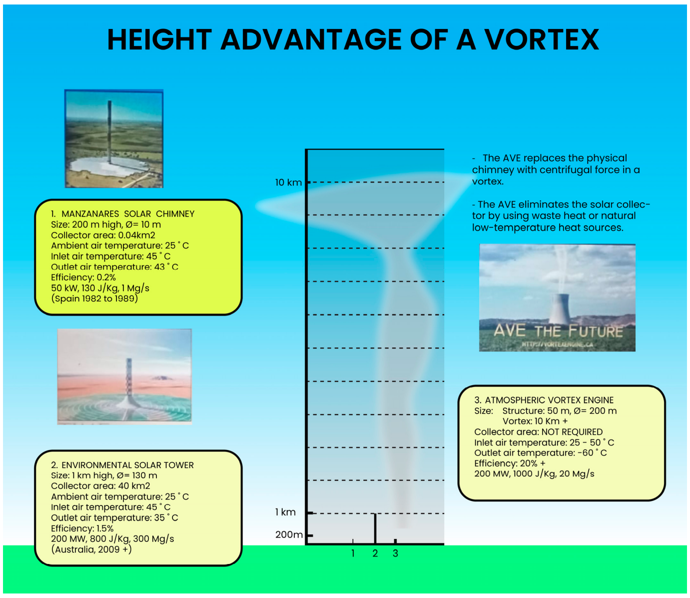

Figure 1. Comparison between AVE, solar chimney and solar tower.

Airflow powers turbines and generators easily. This study examines whether Pakistan's unique environment and geography can support AVEs. AVE technology's suitability with diverse topographies, climatic conditions, and wind patterns offer a compelling opportunity to evaluate its viability in producing net-zero carbon, cost-effective energy in Pakistan, which gets more than half its energy from thermal power plants, which is thermally inefficient and emits greenhouse gases [4]. Pakistani thermal power plant residual heat sources are investigated for power generation. AVE heats the atmosphere at the bottom and cools it at the top. Tangentially allowing air into the circular wall base creates the vortex. Vortex heat moves from areas of high temperatures to those of low temperatures [5]. Warm, humid air from the sides enters the AVE circularly through entry ducts. A vacuum that develops in the center of the swirling air holds the vortex together as it grows. The turbine generates electricity by drawing in more air from the heated air circulation vortex as illustrated in Figure 2. The vortex's swirling walls replace the tower's brick walls, resembling a solar chimney [6]. Once created, the vortex heats with ambient air. A large circular roof aperture condenses cylinder air. Louis Michaud created controlled tornadoes to capture energy [7].

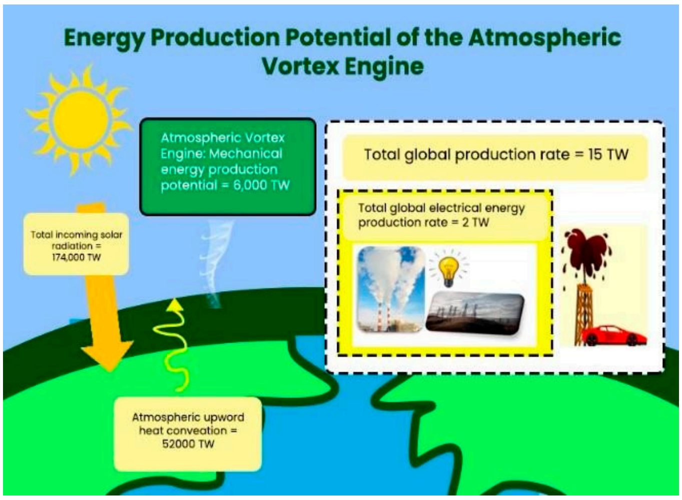

Figure 2. Energy potential of the Atmospheric Vortex Engine.

Once created, the vortex heats with ambient air. Cylinder air converges through a large, circular roof aperture. Louis Michaud created controlled tornadoes to capture energy. These ideas have been established since Grasso L. D. and Cotton W. R.'s numerical simulations in the 1990s. Numerical simulation and CFD analysis have shown the technology works at a small scale, but no full-scale model has been built. In this research paper, a vortex tower prototype was tested. The prototype produced mechanical energy. The vane-shaped inlets created vortices and increased airflow. The findings suggest vortex towers can generate renewable energy. Research is needed to improve vortex tower design and efficiency [8]. Convective and artificial vortices generate power. The atmosphere naturally creates convective vortices, which AVEs can create. Solar, warm sea water, humid air, and industrial heat can power AVEs. Reference [9] explores scaling vortex towers and optimizing AVEs for greater electrical energy output. The study emphasizes convective and artificial vortices as promising avenues in renewable energy solutions. It discusses renewable energy technology to reduce air pollution, global warming, and climate change. Technology shifts from fossil fuels to renewables. Technology reduces carbon emissions and promotes green energy. Developing technology could have a big impact [10]. The 1975 AVE proposal and 1999 discussion describe its solar chimney-like properties. Warm air is admitted tangentially into a cylindrical wall to create an AVE convective vortex or dynamic chimney. The vortex is heated by ambient air or peripheral heat exchangers using warm seawater or waste industrial heat. Mechanical energy comes from peripheral turbo generators. The AVE converts waste heat into work, improving thermal power plant efficiency. Wet and natural draught cooling towers have been briefly compared to show the AVE's ability to produce air slightly cooler than the sea surface temperature using seawater heat [11].

2. Methodology

Through a thorough literature review using a variety of data sources, the viability of Atmospheric Vortex Engines (AVEs) in the context of thermal power plants and the tropical environment of Pakistan was evaluated. This research mainly used online resources like Google Scholar, Science Direct, and Wikipedia because there was a dearth of material on this subject, including commercially viable devices [12]. The study will focus on the following points. The first is the fundamentals of AVE technology, especially its capacity to use waste thermal energy from running thermal power plants. The second is how AVE is predicted to affect CO_2 emissions reduction, thermal efficiency improvement, and problems related to Pakistan's rising oil and gas prices. The third is the environmental aspects which are anticipated to affect AVE efficiency in tropical areas, such as sun radiation, temperature variations, wind speeds, humidity levels, and local topography. Lastly, the AVE technology's drawbacks and difficulties will be discussed, emphasizing the need for additional study and development [13].

3. Analysis

The innovative Atmospheric Vortex Energy (AVE) technology can generate renewable energy from the atmosphere. Temperature differences create air vortices in AVEs. The vortex drives an electricity-generating turbine. AVEs in Pakistan can be powered by two main heat sources. The first is thermal power plant residual heat. Pakistan's 64 thermal power plants generate over half of its electricity. These plants are inefficient and emit lots of greenhouse gases. The waste heat from these plants could be used to generate electricity with zero emissions using AVEs [14]. The second heat source for Pakistani AVEs is sunlight. Pakistan has 8–9 h of sunlight per day and 55% clear skies. This makes Pakistan ideal for solar power, and AVEs could capture and generate electricity. AVEs have been shown to be technically feasible in small projects. The performance of AVEs in large-scale applications is still unknown. The efficiency and effectiveness of the AVE depend on its design. AVEs should be designed to withstand high temperatures and humidity and built with local materials. The economic viability of AVEs in Pakistan is being assessed. However, AVEs should be cheaper than solar and wind power. Pakistan's renewable energy incentives may also contribute to the increased affordability of Autonomous Vehicle Energies (AVEs).

Shifting the focus to thermal power plants, Pakistan currently operates 64 such plants. They include GENCOs and IPPs. They generate over half of Pakistan's energy. They are thermally inefficient and emit large amounts of CO_2, which is worsening Pakistan's climate. Rising oil and gas prices are also affecting power production. The residual heat energy they release will power AVE. The AVE can use waste thermal energy to heat the bottom of the tower, creating a convective vortex that drives the vortex turbine at the bottom. High solar radiation and air–ground temperature differences can cause the initial vortex in an AVE in tropical areas like Pakistan. However, wind speed, humidity, and topography will also affect AVE efficiency in these areas. The location and climate of Pakistan will determine AVE's suitability. Some parts of Pakistan may have consistent, high winds that boost AVE effectiveness, while others may have weak winds that reduce it [15–18].

4. Conclusions and Recommendations

In conclusion, AVEs may help Pakistan to achieve sustainability. Despite technical optimization, integration, and regulation issues, the country's abundant wind resources offer AVE implementation prospects. AVEs can help Pakistan transition to clean energy and mitigate climate change if stakeholders collaborate, policies are strong, and environmental assessments are done. AVE technology is experimental, so future research should focus on system design, stability, and safety. This can be done through rigorous analysis, advanced modeling, simulation, and lab and field testing. System efficiency and reliability should be improved to make AVE technology viable. This involves developing new methods to optimize energy conversion, reduce energy losses, and boost system performance. Given the potential impacts of AVE technology on local ecosystems and communities, a robust and transparent risk assessment is essential. This involves assessing risks, benefits, and socio-environmental impacts.

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