

## RENEWABLE ENERGY MODERN ACHIEVEMENTS AND PERSPECTIVES

**Ablyametov Siyar Murat o'g'li**

*Student, Department of Electrical Machines, Tashkent State Technical University*

**Toirov Olimjon Zuvurovich**

*Doctor of Technical Sciences, Professor, Head of the Department of Electrical Machines, Tashkent State Technical University*

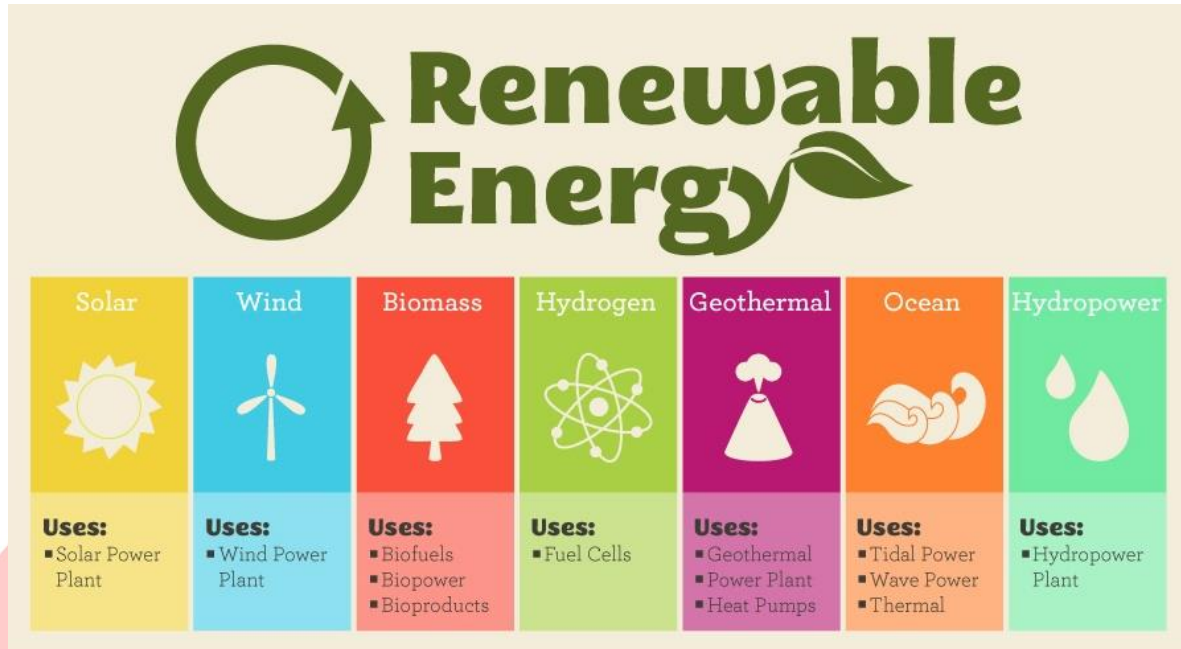
**Abduganiev Javokhir Sherzod o'g'li**

*student of the Department of Alternative Energy Sources, Tashkent State Technical University*

**Annotation.** This article aims to shed light on the crucial role and cutting-edge achievements of renewable energy in shaping our planet's future. We'll explore the environmental implications of using renewable energy, discuss the latest technologies in this field, and examine global programs working towards reducing harmful emissions. Through this exploration, we hope to offer a comprehensive understanding of how embracing renewable energy can bring about positive transformations in our world.

Renewable energy refers to energy derived from naturally occurring and replenishable sources, presenting an eco-friendly alternative to conventional fossil fuels. The inception of harnessing renewable energy can be traced back to the late 19th century when French scientist Augustin Mouchot pioneered solar energy utilization. Mouchot's solar-powered engine, showcased at the 1878 Paris Universal Exposition, marked a seminal moment in the pursuit of sustainable energy solutions. Over time, numerous technologies have emerged to harness renewable resources, contributing to a diverse energy landscape. Solar power, derived from sunlight through photovoltaic cells, and wind energy, harnessed through wind turbines, are prominent examples. Additionally, hydropower, geothermal energy, and biomass play significant roles in the renewable energy spectrum. In recent decades, advancements in solar technology, exemplified by increasingly efficient solar panels, and innovations in wind turbine design have propelled the growth of renewable energy globally. Countries and regions are investing heavily in renewable infrastructure, with initiatives like Germany's Energiewende and China's push for solar power exemplifying the global commitment to a sustainable energy transition. Moreover, the integration of smart grids, energy storage solutions, and the exploration of emerging technologies such as tidal and wave energy underscore the dynamic evolution within the renewable energy sector. As the world collectively grapples with climate change concerns, the adoption and development of renewable energy sources stand as pivotal components in the ongoing efforts to mitigate environmental impact and secure a sustainable energy future.

**"The sun is a giant fusion reactor in the sky, providing more energy in a single hour than the entire world consumes in a year. Harnessing this power through solar technology is not just smart; it's essential for a sustainable future."**  
**– Elon Musk**

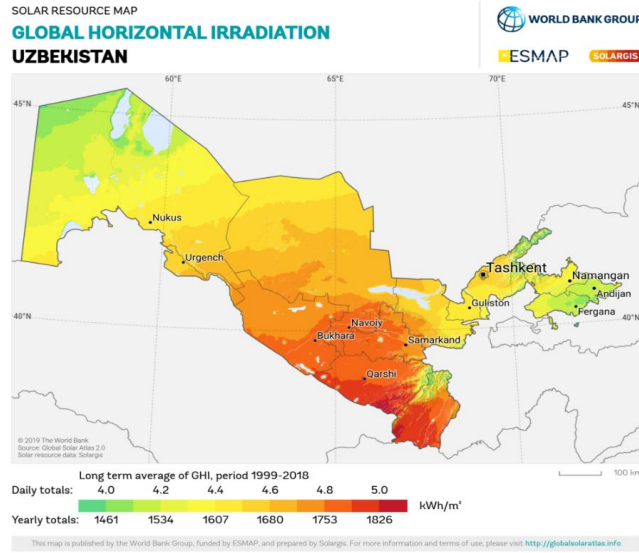


### Synopsis of historical facts

In tracing the historical evolution of renewable energy, a significant milestone emerges in the late 19th century when French scientist Augustin Mouchot pioneered solar energy utilization. Mouchot's groundbreaking work, showcased at the 1878 Paris Universal Exposition, marked an early exploration into harnessing the power of sunlight for practical applications. Moving into the 20th century, the development of hydropower gained prominence. In 1931, the first large-scale hydroelectric power plant, the Hoover Dam in the United States, became operational, symbolizing a monumental leap in harnessing the energy potential of flowing water. This period also witnessed notable advancements in wind energy, exemplified by the Smith-Putnam wind turbine, erected in 1941, which laid the foundation for modern wind power technology. The latter half of the 20th century witnessed a surge in interest in renewable energy sources. In 1973, the oil crisis prompted increased exploration of alternative energy, leading to the establishment of the U.S. Department of Energy in 1977. The subsequent decades saw accelerated research and development, with the first solar photovoltaic (PV) cells becoming commercially available in 1956 and experiencing significant improvements in efficiency over time. The turn of the 21st century brought about a paradigm shift in renewable energy with a focus on grid integration and policy initiatives. Germany's Energiewende, initiated in 2000, exemplifies a comprehensive national strategy aimed at transitioning to renewable energy and enhancing energy efficiency. Simultaneously, advancements in wind

turbine technology, marked by larger and more efficient designs, contributed to the increasing global capacity of wind power.

Recent years have witnessed a proliferation of renewable energy technologies and a growing emphasis on international collaboration. Global programs, such as the Paris Agreement established in 2015, underscore the collective commitment to mitigate climate change by promoting the adoption of renewable energy and reducing carbon emissions. Uzbekistan has great potential for solar energy due to its high levels



of solar radiation and large areas of barren land that can be used for solar power plants. The government of Uzbekistan has implemented several initiatives to promote the use of solar power, including the development of large-scale solar power plants and the introduction of incentives for individuals and businesses to install solar panels. Some of the benefits of solar power in Uzbekistan include reduced dependence on fossil fuels, lower greenhouse gas emissions,

and improved energy security. (source)

### Groundbreaking innovations in Solar panels system

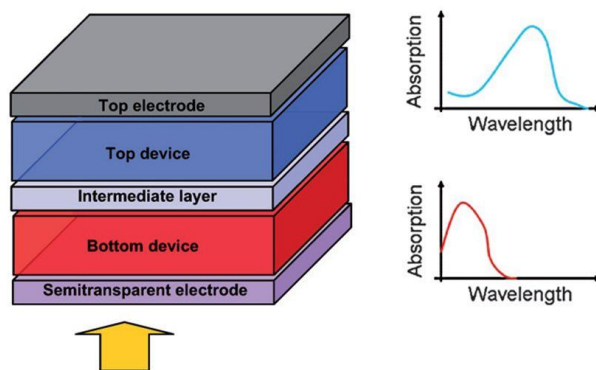


*Tesla.com*

Over the temporal expanse of the preceding decade, a discernible metamorphosis has been observed within the domain of solar panel technology. The confluence of escalated production rates and heightened competition among solar panel manufacturers has engendered a substantial augmentation in the efficiency of solar panels. This resultant paradigm shift has facilitated an unprecedented acme in efficacy and cost-effectiveness, thereby delineating a conspicuous leap forward in the solar industry. The solar sector has borne witness to a persistent trajectory of expansion, concomitant with an incessant impetus toward innovation in solar technology. This

phenomenon is prominently manifested in the continual evolution of solar panel technology, encompassing not only the refinement of solar efficiency but also the augmentation of energy storage capacities, the advent of printable solar technology, and the adoption of avant-garde approaches to solar design. The undulating tide of innovation presently underway underscores the unwavering dedication of the solar industry to advancing and optimizing the manifold benefits intrinsic to solar technology. The main tenet of solar panel work is elucidated in the picture below Light rays, portrayed as streams of tiny photon particles, are captured by solar panels and transformed into a flow of electrons. While each cell generates only a few watts of electricity—insufficient to power a standard room light bulb—when combined in several dozen solar panels, their collective power becomes substantial enough to illuminate an entire house. By installing multiple panels on a roof, it becomes feasible to run various appliances, such as TVs and water heaters, using standard 220 V sockets. The fundamental principle behind the operation of an autonomous solar battery lies in aggregating the capacities of the solar system. However, autonomy comes with a notable drawback—dependence on weather conditions. In regions like Ukraine, characterized by an ample number of cloudy days, solar panels are typically deployed as alternative energy sources or in locations, where connecting to a centralized power grid is impractical. Within the realm of solar panel technology, a particularly auspicious innovation has emerged in the form of tandem solar cells. In stark contrast to conventional solar cells, which are confined to capturing a designated range of sunlight wavelengths, tandem solar cells adopt a stratified approach. These cells employ multiple layers of materials, each adept at capturing distinct wavelengths of light. This stratagem endows them with the capacity to harness a broader spectrum of sunlight, thereby effecting a substantial amplification in their overall efficiency and consequential energy output. The incorporation of tandem solar cells heralds a paradigmatic advancement, transcending the limitations inherent in traditional solar cell technology.

### Tandem solar cells



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### Tandem solar cells

The integration of building-integrated photovoltaic (BIPV) systems represents a progressive stride in solar technology, seamlessly merging with architectural elements such as roofs, canopies, curtain walls, and diverse building integrations. Diverging from the conventional, these BIPV systems transcend mere functionality, elevating aesthetics to a paramount consideration. This innovative approach ensures that BIPV systems not only harmonize with the building's style but also contribute to its visual appeal.

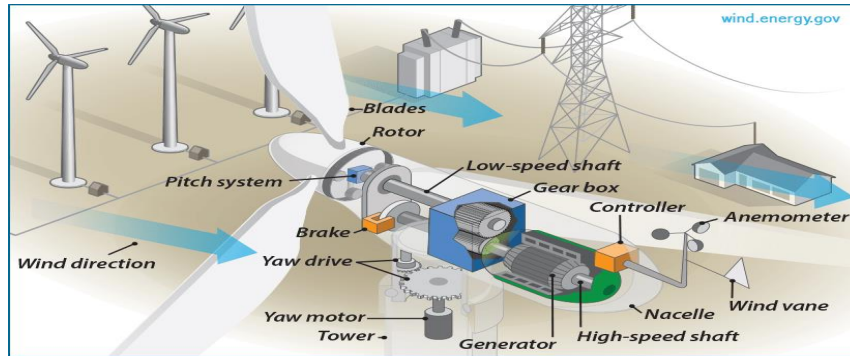
Opting for BIPV systems translates into tangible advantages for homeowners, as the adoption of this technology not only yields substantial savings on building materials but also results in noteworthy reductions in power costs. The assimilation of solar panels into the building structure obviates the need for additional expenditures related to panel mounting, thereby enhancing cost-effectiveness.

Furthermore, the incorporation of BIPV systems seamlessly permits natural light ingress akin to traditional architectural glass, enhancing the overall illumination within the building. The versatility of BIPV technology renders it eminently manageable for integration into existing architectural blueprints, presenting a straightforward and facile mounting process. In the broader context, leveraging BIPV solar technology for expansive structures or residential abodes emerges as a judicious and farsighted investment, promising enduring returns and aligning with sustainable building practices. The example of BIPV technology integrated can be seen in the picture below:



BIPV technology integrated

## Perspectives and operation of wind turbines



The working of a wind turbine involves several key components and processes that efficiently convert wind energy into electrical power. Here is a detailed breakdown of the mechanisms inside a typical horizontal-axis wind turbine:

1. **Rotor Blades** - The process begins with the rotor blades, typically made of lightweight and durable materials like fiberglass or carbon fiber. - The aerodynamic design of the blades allows them to efficiently capture wind energy.

2. **Nacelle** - The rotor blades are connected to a central hub, and this assembly is known as the rotor. The rotor is mounted on a nacelle, which is positioned at the top of the tower.

3. **Yaw System** - The entire nacelle can rotate horizontally, following the direction of the wind. This adjustment is facilitated by the yaw system, ensuring that the rotor is always facing into the wind.

4. **Gearbox** - Inside the nacelle, there is a gearbox that increases the rotational speed of the blades. The gearbox is necessary because the rotor's low-speed rotation is not suitable for generating electricity efficiently.

5. **Generator** - The high-speed shaft from the gearbox is connected to a generator. Most modern wind turbines use synchronous generators or asynchronous generators (induction generators). - As the rotor blades spin, they turn the generator's rotor, inducing a magnetic field that generates an electrical current.

6. **Control System** - Wind turbines are equipped with sophisticated control systems that monitor wind speed and direction. These systems adjust the angle of the blades and control the yaw mechanism to optimize energy capture.

7. **Brakes** - Brakes are integrated into the system to stop the rotor in high winds or during maintenance.

8. **Tower** - The tower provides height to the turbine, allowing it to access stronger and more consistent wind currents at elevated altitudes.

9. **Transformer** - The electrical current produced by the generator is typically low voltage. It passes through a transformer located either within the nacelle or at the base of the tower to increase the voltage for efficient long-distance transmission.

10. **Power Grid Connection** - The converted electrical power is then transmitted through cables down the tower to a substation, where it is

connected to the power grid.

### Vertical Wind Turbine (VWT) technology

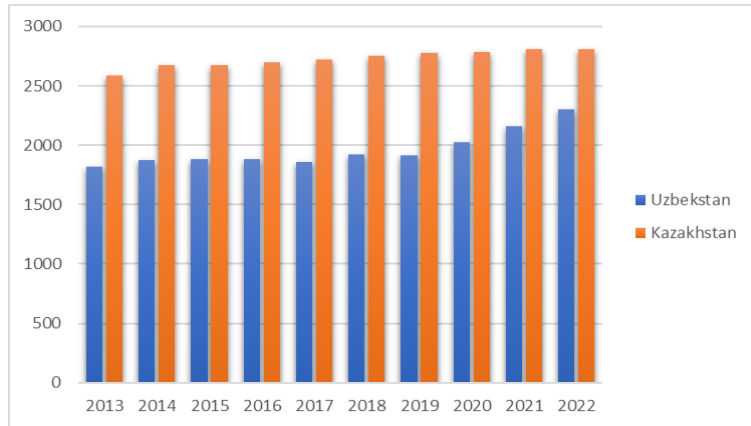
Wind turbines, as denoted by their nomenclature, are meticulously engineered apparatuses purposed with the conversion of wind's kinetic energy into mechanical energy, subsequently transmuted into electrical power. Noteworthy within the pantheon of wind turbine classifications is the vertical axis wind turbine (VAWT), distinctive in its axial orientation where the primary rotor shaft aligns vertically. This configuration confers specific advantages, differentiating it from its horizontal axis counterparts. The salient feature of the VAWT lies in the perpendicular alignment of its primary rotor shaft, diverging from the horizontal orientation prevalent in traditional wind turbines. This departure from the norm imparts distinctive advantages to VAWTs. The inherent vertical axis design engenders a higher degree of adaptability, enabling VAWTs to harness wind from diverse directions with enhanced efficacy. Moreover, VAWTs exhibit a more compact footprint and operational efficiency, making them particularly suitable for constrained spatial environments. This inherent design characteristic also facilitates simplified maintenance procedures and heightened structural stability, contributing to the overall durability of the turbine system. In juxtaposition to horizontal axis wind turbines, VAWTs demonstrate an innate capacity to capitalize on lower wind speeds, broadening their operational range and rendering them more versatile in varying environmental conditions. These unique attributes position vertical axis wind turbines as compelling alternatives within the broader spectrum of wind energy harvesting technologies.



### Darrie's rotor

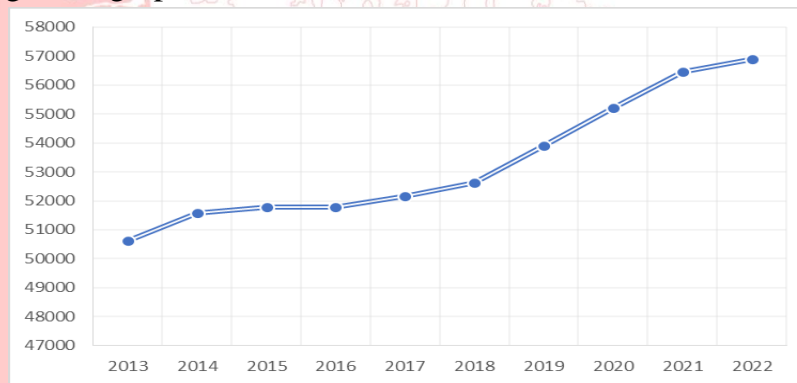
Preeminent noticeable fact is that Darrie's rotor besides the fact of hard technology performs 3.5 times better in contradistinction to analogies.

The Ecological meaning of renewable energy and statistics



**total renewable energy (MW)**

According to IRENA, the total number of generated energy from renewable sources in Uzbekistan in 2022 figured 2301 MW which is considerably lower than in Kazakhstan with 2807 MW. Now, lets take a look at the statistics of Russian Federation through line graph:



**total renewable energy (MW)**

From the figure above its clearly comprehensive that Russian Federation generated over 10 times more than Uzbekistan, but the question is in its actual eco-friendly factors and possible pollution attributable to used materials. The pursuit of renewable energy sources stands at the forefront of global efforts to address the intertwined challenges of energy sustainability and environmental conservation. While renewable technologies offer promising alternatives to traditional energy sources, the energy efficiency of these systems and their ecological implications are critical considerations for comprehensive evaluation.

**Energy Efficiency:** Renewable energy technologies, encompassing solar, wind, hydro, geothermal, and biomass, have garnered attention for their potential to mitigate greenhouse gas emissions and reduce reliance on finite fossil fuel resources. The energy efficiency of these systems varies but generally demonstrates a positive environmental impact compared to conventional counterparts.

**Solar Energy:** Photovoltaic (PV) systems, harnessing sunlight to generate electricity, have seen advancements in efficiency with evolving technologies.





**Battery Technologies:** Energy storage, critical for renewable integration, relies on batteries that often contain materials like lithium and cobalt. Responsible sourcing, recycling initiatives, and the development of alternative battery chemistries are essential for minimizing ecological repercussions.

**Hydropower:** Large-scale hydropower projects can disrupt aquatic ecosystems, affecting fish migration and altering river habitats. Advances in fish-friendly turbine designs and sustainable dam operations aim to mitigate these impacts.

**Conclusion.** In navigating the complex landscape of renewable energy, a holistic approach is paramount. Rigorous life cycle assessments, sustainable material sourcing, and ongoing technological innovation collectively contribute to advancing the energy efficiency and mitigating the ecological concerns associated with renewable energy deployment. As the world strives for a sustainable energy future, a balance between technological progress and environmental stewardship remains pivotal. Encapsulating the above explanations and examples, its necessary to highlight the necessity of renewable energy sources and create environmentally and user-friendly technologies with easy-to-integrate systems. The modern solutions for the aforementioned concerns can be solved using the smart technologies and retrospective developments like Darrie's rotor to provide extensive efficiency and accelerate the advancements in the field discoursed.

