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Hydropower/hydroelectricity dam

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ABSTRACT

Hydropower, also known as hydroelectricity, denotes the process of converting mechanical energy derived from the movement of flowing water into electrical energy. This phenomenon is intricately connected to the natural water cycle, a perpetual sequence facilitated by the sun's energy. The renewable nature of hydropower stems from the continuous replenishment of the water cycle, ensuring a sustained and dependable energy source. Typically, hydroelectric power plants incorporate essential components such as a water reservoir, a gate or valve for regulating water discharge from the reservoir, and an outlet directing the water post-descent. The elevation of water, notably just prior to cascading over a dam or descending downhill, results in the accumulation of potential energy. Subsequently, this potential energy undergoes conversion into kinetic energy as the water descends, ultimately contributing to the rotation of turbine blades. The kinetic energy harnessed from the flowing water is then utilized to generate electricity, a process integral to the overall functionality of the hydroelectric power plant. The resultant electrical power is subsequently distributed to the plant's consumer base, thereby exemplifying the effectiveness and sustainability of hydropower as a vital component within the renewable energy landscape.

Keywords: Hydropower, Hydroelectricity, Mechanical Energy, Flowing Water, Electrical Energy

I. INTRODUCTION

Hydropower, constituting a renewable energy resource, represents a significant form of energy, contributing approximately 96 percent to the renewable energy sector in the United States. This clean energy source, along with other renewables such as geothermal, wave, tidal, wind, and solar power, plays a pivotal role in mitigating environmental impact. Unlike certain power plants that deplete resources and contribute to air, land, and water pollution, hydroelectric power plants stand out as

Environmentally Friendly Alternatives.

The origins of hydroelectric power lie in the flow of water, specifically the winter and spring runoff from mountain streams and clear lakes. The force of gravity propels falling water, enabling the rotation of turbines and generators to produce electricity. This energy source has been integral to the growth of the United States' electric power industry, with both small and large hydroelectric power developments playing crucial roles in its early expansion.

In addressing the nation's evolving energy demands driven by population growth and technological advancements, hydroelectric power has historically been a cornerstone. Although its share in the overall electric energy production has diminished over time, currently supplying approximately 10 percent of the United States' electrical generating capacity, its importance endures. Hydroelectric power's responsiveness to rapid load fluctuations and system disturbances sets it apart in the national power grid, complementing base load plants powered by combustion or nuclear processes.

The Bureau of Reclamation's 58 powerplants across the Western United States contribute significantly, generating an average of 42 billion kWh annually. This substantial output equates to meeting the residential electricity needs of over 14 million people, presenting a formidable contribution to the national energy landscape.

Highlighting its efficiency, modern hydroelectric plants boast an impressive efficiency rate of around 90 percent. Moreover, these plants exhibit environmental advantages by avoiding air pollution, conserving the non-consumable fuel, and presenting extended project lifespans relative to other energy generation methods. Consequently, hydroelectric projects remain compelling sources of electric power, aligning with sustainability goals and environmental considerations.

II. LITERAL REVIEW

Hydroelectricity, or hydropower, is a longstanding and widely utilized renewable energy source, involving the harnessing of flowing or falling water to generate electricity. Hydroelectric dams, crucial to this process, control water release to drive turbines and generators. This review outlines key aspects of hydroelectric dams, covering historical evolution, types, environmental impacts, and prospects.

Historical Evolution:

Originating in the late 19th century, the first hydroelectric power station at Niagara Falls emerged in 1881. Technological advancements since then, exemplified by projects like the Hoover Dam, have increased efficiency and capacity.

Types of Hydroelectric Dams:

1. Run-of-River Dams: Rely on natural river flow.
2. Reservoir Dams: Store water for better energy control.
3. Pumped Storage Dams: Use two reservoirs at different elevations for energy storage and release.

Environmental and Social Impacts:

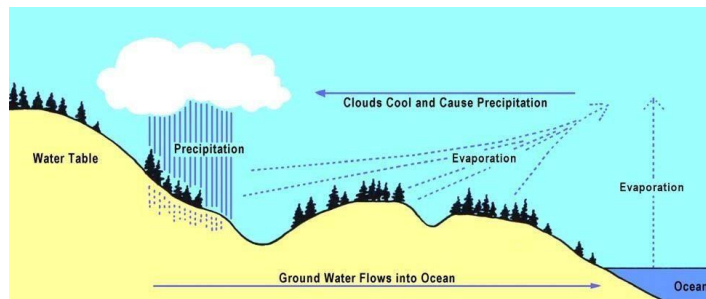
While offering benefits, hydroelectric dams pose environmental and social challenges. Large reservoir dams can alter ecosystems, disrupt habitats, and displace communities. Mitigation measures and careful planning are crucial to minimize negative impacts.

Renewable Energy and Climate Change:

Hydroelectricity is vital in the renewable energy mix, minimizing greenhouse gas emissions. It provides stable, baseload power, aiding in the balance of intermittent renewable sources like wind and solar.

III. HOW HYDROPOWER WORKS

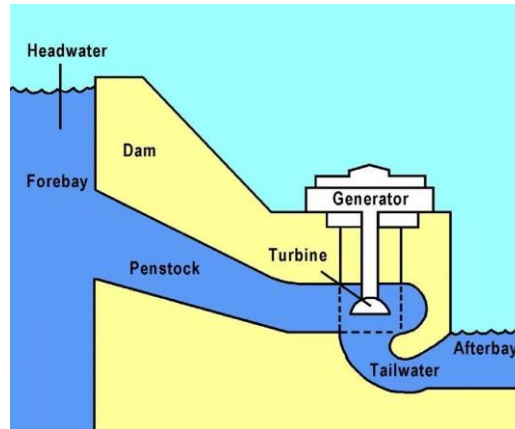
Hydroelectric power harnesses the energy of water in motion, driven by the sun-powered hydrologic cycle. In this cycle, atmospheric water precipitates to the Earth's surface, where it either evaporates, percolates into the soil, or becomes runoff. Evaporation from water bodies, including oceans, lakes, and reservoirs, completes the cycle. Moisture in the soil can become groundwater, re-entering water bodies through springs or underground streams. Groundwater may return to the atmosphere through evaporation, ensuring a continuous, renewable water resource.



GENERATING POWER

In nature, energy changes forms rather than being created or destroyed. Generating electricity involves converting kinetic energy from flowing water to mechanical energy in a turbine, then transforming it into electricity in a generator. This process, known as hydroelectric power or hydropower, occurs at hydroelectric powerplants. Dams are essential for reliable water supply, acting like batteries by storing water for power generation. Water, channeled through a penstock, drives turbine blades, turning the generator rotor to produce electricity. Michael Faraday discovered this concept in 1831, demonstrating that rotating magnets within copper coils generate electricity. Once the water completes its

task, it continues its natural flow for other purposes.



TRANSMITTING POWER

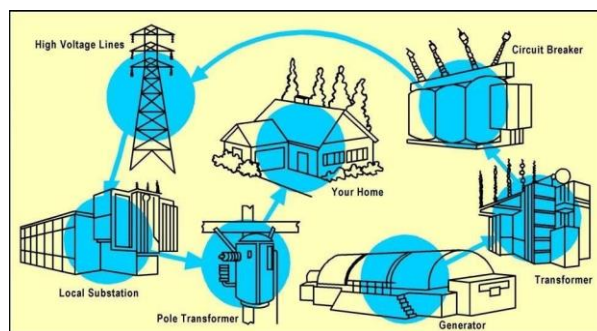
After electricity is generated, it travels from remote dams through vast transmission networks. Transformers raise the voltage for long-distance travel, and at local substations, it's reduced for distribution. Transformers in neighborhoods further adjust the voltage for home use. Electricity is measured and billed by the kilowatt-hour.

Various power sources, including hydroelectric, fossil fuels, nuclear, gas-turbine, solar, geothermal, and wind, contribute to the power grid. The "power grid" facilitates electricity interchange among different systems to meet demands. Your location influences the power source; for instance, Washington relies on hydroelectricity, while Ohio mainly uses coal.

Electric utilities, ranging from large regional systems to small community providers, can be private or publicly owned. Federal Government surplus power is distributed through power marketing administrations to preference power customers, often non-profit entities.

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HOW POWER IS COMPUTED

Before developing a hydroelectric power site, engineers assess potential energy output by considering water discharge and vertical falling distance (head). The head, creating water pressure, determines turbine type. Greater head or faster water flow results in higher pressure and more power.

The theoretical horsepower (THP) from a site is calculated using the formula: $THP = (Q \times H) / 8.8$, where Q is flow rate in cubic feet per second, H is head in feet, and 8.8 is a constant. This provides an initial estimate, refined by a more complex formula accounting for losses due to friction and mechanical device efficiency.

To determine electrical power, the mechanical measure (horsepower) is converted to watts. One horsepower equals 746 watts (U.S. measure).

TURBINES

Two main turbine types, impulse, and reaction, have various variations, chosen based on operational studies and cost estimates, primarily

dictated by site conditions.

Reaction Turbine: Operates with the wheel fully submerged, reducing turbulence. It works akin to a rotating lawn sprinkler, where water under pressure escapes from the blades' ends, causing rotation. This type is widely used.

Impulse Turbine: Uses the kinetic energy of water striking its buckets or blades for rotation. The wheel is enclosed, and the shaped buckets or blades turn the water flow about 170 degrees inside the housing before it exits at the bottom.

UPRATING

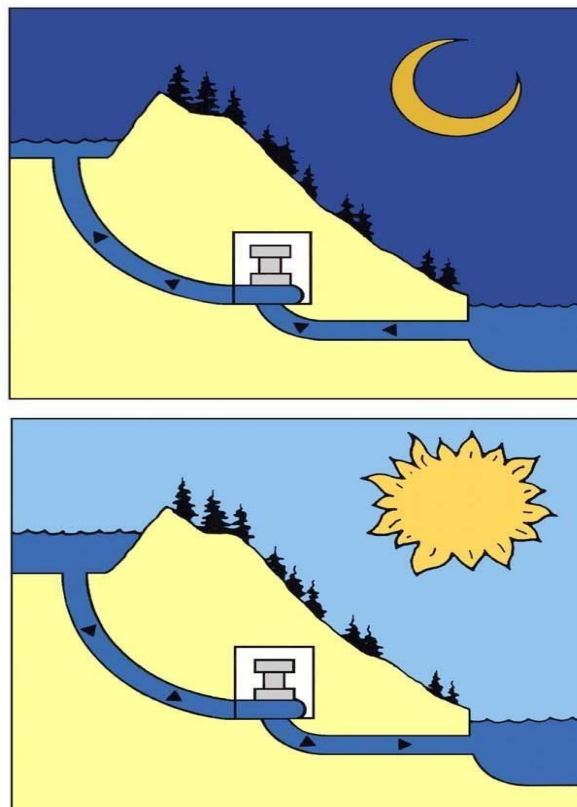
Upgrading existing hydroelectric units is a cost-effective and environmentally friendly method to enhance power generation. Since 1978, Reclamation's uprating program has added over 1,600,000 kW at an average cost of \$69 per kilowatt, significantly lower than the cost of new peaking capacity through oil-fired generators (over \$400 per kilowatt). This program essentially provides the equivalent of a major hydroelectric facility like Hoover Dam at a fraction of the cost and environmental impact compared to alternative generation methods.

LOW-HEAD HYDROPOWER

A low-head dam has a water drop below 65 feet and a generating capacity under 15,000 kW. While large, high-head dams offer more power at lower costs, their construction may be restricted by site limitations, environmental concerns, or economic factors. In contrast, numerous small dams and canal elevation drops provide opportunities for small generating plants. The key advantage lies in generating power near the demand, minimizing transmission losses.

PUMPED STORAGE

Pumped storage is a method of storing water in a reservoir above a powerplant during low-demand periods, like at night, and releasing it during high-demand periods to generate power. This functions like a battery, efficiently responding to peak power demands. Pumped storage's advantage lies in the ability of hydroelectric units to start quickly and make rapid output adjustments, operating efficiently for short or extended durations. Construction costs are generally low due to the relatively small size of pumped storage reservoirs compared to conventional hydropower facilities.



HYDROPOWER, ENVIRONMENT & SOCIETY

People and their actions are part of the natural world, relying on natural resources for building, energy, clothing, and food. The growing built environment increases our reliance on electricity, often generated using non-renewable resources, impacting the environment.

Human activities, especially resource extraction and energy use, have varying environmental impacts. Growth in population and energy demand complicates the situation. The solution involves careful planning, examining alternatives, and pursuing efficient, acceptable methods.

Hydroelectric facilities offer advantages: they do not deplete limited resources, cause pollution, have low failure rates, and provide reliability. Reservoirs offer scenic and recreational benefits while supporting wildlife. Existing facilities can be upgraded or new ones added without significant environmental impact. Considerations like remote dam locations, underground powerplants, and environmental features can

enhance harmony with nature.

In reconciling natural and built environments, tradeoffs and compromises are inevitable. Balancing ecological, economic, technological, and social perspectives is crucial. Water's value must be acknowledged, with wasted water considered a loss. Delaying balanced hydropower development unnecessarily depletes vital resources.

IV. CONCLUSION

Reclamation contributes significantly to the country's power needs, generating over 42 billion kWh annually, meeting the residential requirements of 14 million people or the energy equivalent of 80 million barrels of oil. With the restructuring of the electric power industry, hydropower gains importance due to its clean, reliable, and instantly responsive nature.

Hydropower's operational advantages, including rapid load adjustment and pumped storage for electricity storage, are crucial in the evolving market. Its role in peaking power, load following, and frequency control enhances system reliability, preventing failures and blackouts. This, coupled with its emission-free and renewable characteristics, adds vital value to the electric system, supporting the success of the national experiment in deregulating the electric industry.

Utilizing water, a valuable resource, hydropower aligns with Reclamation's commitment to effective project management, meeting current and future energy needs while prioritizing environmental protection.

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