

## HYDRO ENGINE-BASED SUSTAINABLE POWER GENERATION IN E-BIKE

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### ABSTRACT

This abstract explores the integration of a Hydro engine with pressure pumps into electric bikes to enhance their efficiency and sustainability. The proposed system utilizes water as a renewable energy source to generate electricity through a compact water engine. Pressure pumps are incorporated to efficiently manage the flow and utilization of water within the system. The following principles used in the Hydro Engine are Energy Conversion, Pressure Pumping. This research explores the development of a hydro-engine system for e-bikes, leveraging the Pelton turbine mechanism for sustainable power generation. The system utilizes pressure tanks to rotate the turbine, which is connected to gears and ball bearings to minimize friction. The generated energy is then transferred through a chain pulley system to propel the bike's rear wheel with an efficiency target of 80%. This paper presents the design, development, and evaluation process of the hydro engine system for e-bikes, highlighting its potential for environmentally friendly transportation.

**Keywords:** water as fuel, pressure pump, performance, and low emissions, environmental free.

### 1. INTRODUCTION

The concept of integrating a hydro-engine into e-bikes draws inspiration from similar systems used in large scale hydroelectric power generation. By harnessing the kinetic energy generated during the bike's movement, this technology aims to supplement or even replace the need for external charging, thereby reducing the environmental footprint associated with e-bike use.

The hydro-engine typically consists of a small turbine or generator integrated into the bike's drive train. As the bike moves, the flowing water drives the turbine or generator, converting mechanical energy into electrical energy. This electricity can then be used to directly power the bike's electrical components, such as lights and displays, or stored in the bike's battery for later use.

Hydro engine-based sustainable power generation in e-bikes builds upon principles of regenerative braking, which have been widely implemented in electric vehicles and hybrids. In this system, the kinetic energy generated during braking or coasting is captured and converted into electrical energy, which can then be used to recharge the vehicle's battery.

The hydro-engine system utilizes the natural motion of the bike's wheels to drive the turbine or generator. As the bike is pedaled or descends downhill, the rotation of the wheels creates a flow of water past the turbine blades, which in turn generates electricity. This electricity can be used to supplement the power from the bike's battery, extend its range, or power additional electrical components such as lights, displays, or accessories.

The integration of hydro-engine technology into e-bikes involves the installation of a small turbine or generator within the bike's drive train system. This turbine is designed to harness the mechanical energy produced by the movement of the bike, rather than relying solely on the braking process.

Hydro engine-based sustainable power generation in e-bikes is an innovative approach to enhancing the sustainability and autonomy of electric bicycles. Traditional e-bikes rely on batteries for power, which require periodic recharging from external sources, often relying on grid electricity, which may not always be sourced sustainably.

Overall, hydro engine-based sustainable power generation represents an exciting avenue for advancing the eco-friendliness and autonomy of e-bikes, contributing to a greener and more sustainable transportation future.

#### Overview

Implementing a sustainable power generation system based on a hydro engine in an e-bike involves harnessing energy from the rider's motion to generate electricity, thus promoting eco-friendly transportation. This process begins with integrating a hydraulic motor into the drivetrain system, which acts as a generator to convert mechanical energy into electrical energy. As the rider pedals, the motion drives the hydraulic motor, which in turn generates electricity.

A hydraulic pump is utilized to pressurize hydraulic fluid, which flows through hydraulic lines to power the motor and subsequently returns to a reservoir for continuous cycling. Control systems regulate the flow of hydraulic fluid and adjust power generation levels based on riding conditions and user preferences.

Power generated by the hydro engine is stored in a battery pack or supercapacitors, providing auxiliary power for the e-bike's electric motor or other onboard systems. This sustainable power generation system reduces reliance on external charging sources and contributes to overall energy efficiency and environmental sustainability.

Thorough testing is conducted to optimize performance and reliability, ensuring seamless integration with the e-bike's existing components. Maintenance procedures are established to uphold system functionality and longevity, offering a sustainable and renewable energy solution for e-bike propulsion.

## 2. REVIEW OF LITERATURE

**Small Hydro Power Generation using Pump as Turbine:** Energy supply that is sustainable, effective, and economical has a strong association with socioeconomic growth, particularly in developing countries such as Pakistan. Due to the ever increasing gap between supply and demand, Pakistan has become an energy-deficient nation, with most people having no-to-limited access to power. Pakistan has been suffering from power shortages and an energy crisis because of its strong reliance on fossil fuels to provide expensive electricity. Therefore, this paper offers a novel concept for developing Pakistan's energy by producing small-hydropower using Pump-As-Turbine (PAT), which is a form of renewable energy with lower environmental impact and has not been used in Pakistan previously. PATs have shown several advantages over traditional hydro-turbines, such as minimum expenses, low complexity, short delivery time, ease of spare parts, easy installation, availability in a large number of standard sizes, and massive production for a broad-range of heads and flow rates. According to technical standards, any sort of pump could be used as PAT, including radial, mixed, single-stage, multi-stage, etc. for power generation, which are capable of producing 5kW–1000kW of power, depending on their usage. However, Pakistan has shown little to no interest in exploring small/micro hydropower generation (PATs technology). Thus, this study offers public awareness and forward thinking regarding the use of advanced SHPs and draws the interests of legislators and different investors via solid recommendations about the cost-effective and environmentally friendly technology (PAT).

**Water Injection for Higher Engine Performance and Lower Emissions:** The influence of variable water injection by mass on the performance and emission characteristics of a gasoline direct injection (GDI) engine under light load conditions has been investigated and the results are presented in this paper. The study involved the injection of water into the cylinder at an angle of 640 °CA over an injection duration of 10 °CA. Gasoline was directly injected into the cylinder with a fixed injection timing duration starting from 660 °CA to 680 °CA and determined the flow rate of fuel. The results indicated that a 15% water injection by mass used together with fuel gave the best engine performance due to the increase in the indicated mean effective pressure and efficiency resulting from the cooling of certain parts of the engine. Water injection also demonstrated a decrease in NO<sub>x</sub> emissions (ppm), as well as soot emissions.

**Water fuel Engine with power generation:** This essay gives A hydrogen vehicle is an alternative fuel vehicle that uses hydrogen as its onboard fuel for motive power. The term may refer to a personal vehicle, such as an automobile, or any other vehicle that uses hydrogen in a similar fashion, such as an aircraft. The power plants of such vehicles convert the chemical energy of hydrogen to mechanical energy either by burning hydrogen in an internal combustion engine or by reacting hydrogen with oxygen in a fuel cell to run electric motors. The widespread use of hydrogen for fueling transportation is a key element of a proposed hydrogen economy. Hydrogen fuel does not occur naturally on Earth and thus is not an energy source, but is an energy carrier. Currently, it is most frequently made from methane or other fossil fuels. However, it can be produced from a wide range of sources (such as wind, solar, or nuclear) that are intermittent, too diffuse, or too cumbersome to directly propel vehicles. Integrated wind-to-hydrogen plants, using electrolysis of water, are exploring technologies to deliver costs low enough, and quantities great enough, to compete with traditional energy sources.

**HYDROGEN-BIKE EQUIPPED WITH HYBRID POWER UNIT:** In the innovative context of smart cities, new mobility concepts are needed that combine high performance, ecofriendly energy, and human safety. In this study, an experimental analysis is made on an electric bike prototype equipped with a new hybrid power unit. Numerical simulations and actual measurements demonstrate the remarkable performance of the hydrogen bike in terms of energy consumption and very limited electromagnetic emissions.

### HYDRO ENGINE COMPONENTS:

1. Tank
1. Batteries
1. Motors
1. Pressure Meter
1. Micro Controller
1. Turbine
1. Gear System

1. Solar Panel

1. BMS

1. Pressure Pumps

1. Boost Converter

1. Voltage Regulator

**BATTERIES:** A Lithium battery has the best combination of total weight and capacity. The specific capacity of lithium-ion batteries is the highest of all existing types and this is their main advantage. Lithium-ion battery pack to provide as much energy for as little weight as possible. Lithium-ion batteries are also great at holding their charge and have long battery life.

**MOTORS:** An electric motor is an electrical machine that converts electrical energy into mechanical energy. Most electric motors operate through the interaction between the motor's magnetic field and electric current in a wire winding to generate force in the form of torque applied on the motor's shaft.

**PRESSURE METER:** A pressure meter is a device used to measure the pressure of a fluid or gas within a closed system. It typically consists of a gauge or sensor that detects the pressure and displays it in units such as pounds per square inch (PSI), bar, pascal, or others depending on the application.

**MICRO CONTROLLER:** The core of the solution lies in the integration of a microcontroller into the e-bike speed control system. The microcontroller will be responsible for real-time monitoring of motor performance, allowing for immediate adjustments to speed and power output as per rider inputs.

**TURBINE:** A turbine is a turbomachine with at least one moving part called a rotor assembly, which is a shaft or drum with blades attached. Moving fluid acts on the blades so that they move and impart rotational energy to the rotor. Early turbine examples are windmills and waterwheels. A steam turbine with the case opened.

**GEAR SYSTEM:** A gear train or gear set is a machine element of a mechanical system formed by mounting two or more gears on a frame such that the teeth of the gears engage. Gear systems consist of several gears and are major components of many engineering applications such as drive trains in cars. In operating gear systems, non-smooth dynamics such as gear hammering or high-frequency oscillations may occur.

**SOLAR PANEL:** A solar panel is a device that converts sunlight into electricity by using photovoltaic cells. PV cells are made of materials that produce excited electrons when exposed to light.

**BMS:** Battery management system (BMS) is technology dedicated to the oversight of a battery pack, which is an assembly of battery cells, electrically organized in a row \* column matrix configuration to enable the delivery of a targeted range of voltage and current for a duration of time against expected load scenarios.

**PRESSURE PUMPS:** A pressure pump is a device used to increase the pressure of a fluid, typically water or air. These pumps are commonly used in various applications such as water supply systems, irrigation, firefighting, and pneumatic systems.

**BOOST CONVERTER:** A boost converter or step-up converter is a DC-to-DC converter that increases voltage, while decreasing current, from its input (supply) to its output (load).

**VOLTAGE REGULATOR:** A voltage regulator is a system designed to automatically maintain a constant voltage. It may use a simple feed-forward design or may include negative feedback. It may use an electromechanical mechanism or electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages.

**WORKING PRINCIPLE:** A hydro engine typically refers to a hydroelectric generator, which converts the energy of flowing water into electricity. It works by harnessing the kinetic energy of moving water to spin a turbine connected to a generator, which then produces electricity. The amount of electricity generated depends on factors like the volume and speed of the water flow, as well as the efficiency of the turbine and generator system.

A hydro engine with pressure pumps typically refers to a hydraulic system that uses pressurized water to drive a turbine or motor.

1. Water Source: Water is collected from a natural source such as a river or reservoir.

2. Pressure Pumps: The collected water is pumped to increase its pressure. This is often done using mechanical pumps powered by electricity or other energy sources.

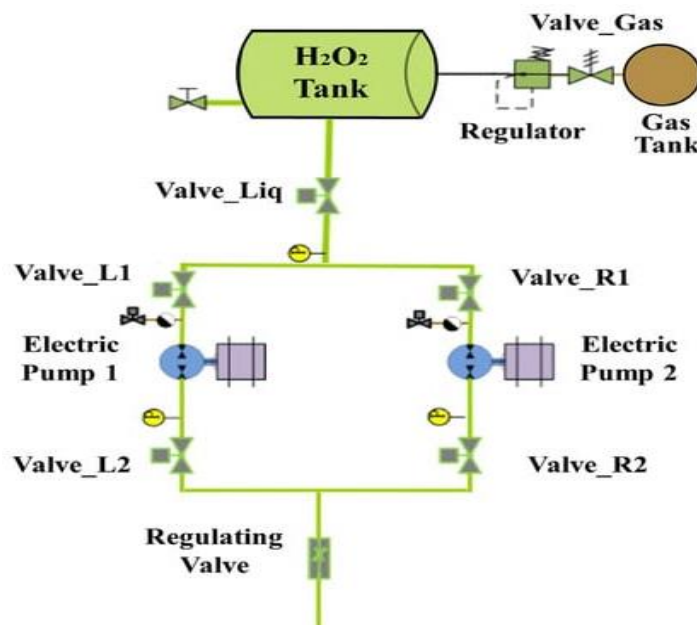
3. High-Pressure Water: The pressurized water is then directed to a turbine or motor.

4. Turbine or Motor: The high-pressure water flows through the turbine or motor, causing it to spin or generate mechanical power.

5. Electricity Generation: If the system is designed for electricity generation, the spinning turbine is connected to a generator, which converts the mechanical energy into electrical energy.

6. Power Output: The generated power can be used for various applications, such as powering machinery, generating electricity for homes or industries, or driving hydraulic systems in vehicles.

**EXPERIMENTAL SETUP:**



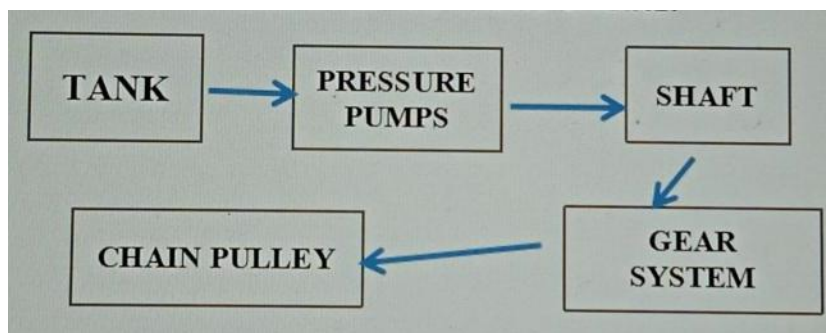
The function of a PAT is comparable to that of any turbine, to convert the kinetic and pressure energy of the fluid into mechanical energy of the runner. They are commonly commercialized as composite pump and motor/generator units, coupled by a fixed shaft to an asynchronous induction-type motor unit. The water is first pumped by using a water pump and then injected into the inlet manifold by using the petrol injector. The injection of the water into the engine is controlled by using the PIC controller board.

The experiment involves a water-fueled engine with a turbine mechanism powered by pressure pumps. The pressure pumps are responsible for generating pressure within the system, which is then used to drive the turbine mechanism of the engine.

The setup likely includes a water reservoir or source, from which water is pumped into the system using the pressure pumps. As the water flows through the turbine mechanism, it causes the turbine to rotate, thus generating mechanical energy.

This mechanical energy can then be harnessed for various purposes, such as powering machinery or generating electricity. The experiment aims to demonstrate the feasibility and efficiency of using water as a fuel source for engines, particularly by utilizing pressure pumps and turbine mechanisms.

**BLOCK DIAGRAM OF THE HYDRO ENGINE:**



The Hydro Engine block you're referring to sounds like a system that harnesses hydraulic power to generate mechanical energy.

1. Tank: This holds the hydraulic fluid, typically oil or water, which is used to transmit power in the system.
2. Pressure Pumps: These pumps pressurize the hydraulic fluid, creating the force necessary to drive the system. They usually work in conjunction with valves to control the flow of fluid.
3. Shaft: The shaft is likely a component that transfers rotational motion from one part of the system to another. It could be driven by the hydraulic power generated by the pressure pumps.
4. Chain Pulley: A chain pulley system could be used to transmit power from the shaft to another component, such as a gear system or an external load.
5. Gear System: Gears are used to transmit power efficiently from one part of the system to another. They can change the speed and torque of the system as needed for different applications.



### WORKING:

In the relentless pursuit of sustainable transportation solutions, the emergence of water-fueled engines in electric bikes (E-bikes) marks a significant milestone. This essay explores in detail the workings of a water-fueled engine in an E-bike, integrating pressure pumps and a turbine mechanism to propel the vehicle into the future of clean mobility.

At the heart of this revolutionary system lies the water reservoir, a fundamental component storing the fuel needed to power the engine. Water, abundantly available and environmentally benign, serves as the primary source of energy in this innovative setup. From the reservoir, water is directed towards the next stage of the process: the pressure pumps.

Pressure pumps play a pivotal role in the operation of the water-fueled engine. These pumps, typically electrically driven, pressurize the water to high levels, enhancing its energy potential. The pressurized water then flows into the turbine mechanism, where the magic unfolds.

The turbine mechanism, a marvel of engineering ingenuity, harnesses the energy stored in pressurized water to generate mechanical motion. Comprising a turbine wheel or a series of precisely crafted blades, this mechanism transforms the pressure of the water into kinetic energy. As the high-pressure water courses through the turbine, it imparts rotational motion to the turbine blades or wheel, initiating a mesmerizing dance of energy conversion.

The next link in the chain of transformation is the shaft connection. The rotational energy generated by the turbine is transmitted to a shaft, serving as the conduit for transferring power to the bike's drivetrain. Through gears or direct mechanical linkage, the rotational motion of the shaft is efficiently channeled towards the ultimate objective: propelling the E-bike forward.

Enter the electric motor, the beating heart of the water-fueled engine. Connected to the shaft, the electric motor converts the rotational energy into electrical energy. This electrical energy powers the motor, which in turn drives the bike's wheels, providing the necessary propulsion for locomotion. The seamless integration of mechanical and electrical systems epitomizes the elegance and efficiency of this groundbreaking technology.

Furthermore, the system incorporates a regeneration feature, enhancing its sustainability and energy efficiency. Some of the electrical energy produced by the motor is redirected to power the pressure pumps, creating a closed-loop system. This regenerative process minimizes energy losses and maximizes the utilization of available resources, reinforcing the system's eco-friendliness and viability as a sustainable transportation solution.

### CALCULATIONS OF DESIGN:

#### 1. Pressure Calculation:

Potential Energy (P.E)=mgh

m=mass

g=gravity

h=head

(distance from the turbine to the water Source)

Pressure(P)=P.E/A

P.E= Potential Energy

A= An Area of Cross-Section

#### 1. Weight Calculation:

Minimum Load = Weight of the Bike + Capacity of the Turbine Mechanism

Maximum Load=Frame Capacity+ Turbine Mechanism

Capacity+Safety Margin

Desired Safety margin = 20% safety Margin

### FUTURE SCOPE OF HYDRO ENGINE IN E-BIKE:

Suggestions for further improvements on hydro engine-based sustainable power generation in e-bikes.

**Turbine Efficiency Optimization:** Invest in research to optimize turbine designs for improved efficiency in capturing water kinetic energy. This could involve exploring innovative blade geometries, materials, and manufacturing techniques to enhance performance while minimizing energy losses.

**Compact and Lightweight Design:** Focus on developing compact and lightweight hydro engine systems that minimize added weight and bulkiness on e-bikes. This could involve redesigning components for space optimization, using lightweight materials, and integrating components to reduce overall size and weight.

**Variable Operating Conditions Adaptability:** Enhance the adaptability of hydro engine systems to variable operating conditions, such as fluctuating water flow rates and changing terrain profiles. Develop adaptive control algorithms and system configurations that optimize performance across a wide range of operating conditions for improved efficiency and reliability.

**Regenerative Braking Integration:** Explore the integration of regenerative braking systems to capture and store energy during deceleration for later use. Develop efficient energy recovery mechanisms and control strategies to maximize the capture and storage of kinetic energy, thereby extending the range of e-bikes and reducing reliance on external charging.

**Battery Management and Integration:** Investigate advanced battery management systems and integration techniques to optimize the interaction between hydro-engine power generation and battery storage. Develop smart charging algorithms and energy management strategies that balance power generation, storage, and consumption for optimal efficiency and performance.

**Durability and Reliability Enhancement:** Enhance the durability and reliability of hydro engine components to withstand harsh operating conditions and ensure long-term performance. Research materials engineering, surface treatments, and protective coatings to improve corrosion resistance, erosion resistance, and fatigue strength of critical components.

**Environmental Impact Mitigation:** Implement environmental impact mitigation measures to minimize the ecological footprint of hydro-engine installations. This could involve adopting fish-friendly turbine designs, sediment management practices, and habitat restoration initiatives to promote environmental sustainability and ecosystem conservation.

**User Experience Enhancement:** Prioritize user experience enhancement through ergonomic design, intuitive controls, and enhanced ride comfort. Conduct user feedback sessions and usability testing to gather insights into user preferences and incorporate them into design refinements aimed at optimizing user satisfaction and acceptance.

#### Potential applications beyond e-bikes

Expanding the application of hydroengine-based sustainable power generation beyond e-bikes opens up a wide range of potential opportunities across various sectors.

**Micro-Mobility Solutions:** Besides e-bikes, hydro-engine technology can be adapted for other micro-mobility solutions such as electric scooters, skateboards, and personal watercraft. By integrating hydro engines into these platforms, it's possible to extend their range, improve energy efficiency, and reduce reliance on conventional charging methods.

**Off-Grid Power Generation:** Hydro engine systems can be deployed in off-grid or remote areas to generate sustainable power for various applications, including off-grid lighting systems, communication equipment, and small-scale appliances. These systems can harness local water resources, such as rivers, streams, or irrigation canals, to provide reliable and renewable energy solutions where grid connectivity is limited or unavailable.

**Water Pumping and Irrigation:** Hydro-engine technology can be utilized for water pumping and irrigation applications in agriculture, horticulture, and landscaping. By harnessing water kinetic energy, hydro-engine-powered pumps can efficiently lift water from wells, rivers, or reservoirs to irrigate crops, water gardens, or supply livestock, offering a sustainable alternative to diesel or electric pumps in rural areas.

**Rural Electrification Projects:** In rural and underserved communities, hydro engine systems can play a vital role in electrification initiatives, providing clean and affordable electricity for lighting, household appliances, and small-scale businesses. By leveraging local water resources, these systems can empower communities to become self-sufficient in energy generation, improving living standards and socioeconomic development.

**Waterway Navigation and Transport:** Hydro engine technology can be integrated into waterway navigation and transport systems, including boats, ferries, and small vessels. By replacing conventional combustion engines with hydro engines, watercraft can reduce emissions, noise pollution, and environmental impact while enhancing energy efficiency and operational sustainability.

**Emergency and Disaster Response:** Hydro-engine systems can serve as reliable power sources for emergency and disaster response operations, providing essential electricity for emergency shelters, medical facilities, communication networks, and critical infrastructure during natural disasters or humanitarian crises. Their resilience and ability to operate independently of grid infrastructure make them invaluable assets in emergencies.

**Environmental Monitoring and Research:** Hydro engine-powered monitoring platforms can be deployed for environmental research, monitoring, and conservation efforts in aquatic ecosystems, including rivers, lakes, and marine habitats. These platforms can support data collection, water quality monitoring, habitat assessment, and ecological research, contributing to environmental stewardship and conservation initiatives.

**Hybrid Renewable Energy Systems:** Integrating hydro engine technology into hybrid renewable energy systems alongside solar, wind, or biomass power sources can enhance system reliability, stability, and energy resilience. By combining multiple renewable energy sources, hybrid systems can leverage complementary energy generation profiles to optimize overall energy output and meet diverse energy demands sustainably.

**FINAL RECAP:**

A hydro engine with pressure pumps is a hydraulic system that utilizes pressurized water to drive a turbine or motor. It works by collecting water from a natural source and pumping it to increase its pressure. The high-pressure water is then directed to a turbine or motor, where it generates mechanical power through spinning. This mechanical power can be used directly for various applications or converted into electricity using a generator. Overall, the principle involves harnessing the energy of pressurized water to produce mechanical or electrical power.

**3. CONCLUSION**

In conclusion, the integration of hydro engines into electric bikes (E-bikes) represents a promising advancement in sustainable transportation technology. By leveraging the power of water as a fuel source, coupled with innovative components like pressure pumps and turbine mechanisms, hydro-powered E-bikes offer a compelling alternative to traditional combustion engines.

The key advantages of hydro engines in E-bikes include their environmental sustainability, energy efficiency, and reduced dependency on fossil fuels. Water, as a clean and abundant resource, mitigates the carbon footprint associated with transportation, contributing to cleaner air and a healthier environment. Additionally, the regenerative capabilities of hydro systems further enhance their efficiency by minimizing energy losses and optimizing resource utilization.

Furthermore, hydro-powered E-bikes offer versatility and adaptability, making them suitable for various urban and rural mobility needs. Their silent operation and smooth acceleration provide a comfortable and enjoyable riding experience, appealing to a wide range of users.

However, challenges such as infrastructure development, energy storage, and scalability need to be addressed to realize the full potential of hydro-powered E-bikes. Investments in research, development, and infrastructure are essential to overcome these hurdles and accelerate the adoption of this transformative technology.

In essence, hydro engines in E-bikes represent a significant step toward a cleaner, greener future of transportation. As we continue to innovate and refine these systems, they have the potential to revolutionize urban mobility, reduce emissions, and pave the way for a more sustainable and resilient transportation ecosystem.

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