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Renewable Energy-Powered Model School

The world relies on many different resources to create needed energy in order to function in our society. Many buildings, such as schools, do so in order to keep the lights on. Although this is needed, the traditional ways of gaining this energy can be unsustainable with irreversible damage. An example of this could be the outdatedly expensive HVAC systems by schools. This system is essential for the students' health and focus, but it’s not only expensive, it also uses a large amount of energy and creates environmental harm. This would then call for low-cost renewable alternatives. This would introduce the possibility of a water wheel powered ventilation system into school facilities that would provide a sustainable and cost-effective alternative to traditional HVAC systems, lowering energy usage and carbon emissions, while also offering lessons that will build understanding of environmental impact and provide innovative hands-on STEM learning.

Guaranteeing good ventilation in schools is not simply a matter of comfort, it is also a public health and educational necessity. As the U.S. Government Accountability Office (GAO) reports about 41% of school districts needed to update or replace HVAC systems in half or more schools; this is a staggering 36,000 schools nationwide that relied on outdated systems (GOA, 2020). With this level of infrastructure lag, advancements in cost-effective and sustainable ventilation solutions for schools is clearly necessary. This would then enter the idea of a water-wheel-driven ventilation system, where it merges century old ways with modern sustainability goals. This creates a low-maintenance, renewable, and simple way of creating an

overall renewable way to make energy. By locating a waterwheel-driven ventilation system within the architecture of a school, a water supply can be used to circulate air, lessening dependence on electric fans and lessen fossil fuel consumption—melding technological history with current sustainability objectives. Water-wheel technologies owing the potential to serve as the premise for school ventilation options represents a brilliant intersection of the work of engineers from the past and the promise of a more sustainable future. The National Park Service is documenting the application, for example, renewable energy and water use in the 19th century was the use of a 22-foot diameter breast-wheel at Hopewell Furnace powered air-blast machinery; pumping pistons pumped compressed air into a furnace, clearly indicating a water wheel could mechanically move air (not electricity) using reliable low-carbon energy (Elverson, 2020). By utilizing water to podcast the principles relied upon for ventilation systems designed into educational buildings, designers could take advantage of reliable water flows to turn fans or air movers to limit electrical demand and avoid fossil fuels.

In the heart of sustainable ways, a school model was created to explain the flow of energy and how the water wheel would provide ventilation for a school. In this model, water wheel-powered ventilation uses the mechanical energy harnessed from the action of rotation. In this system, the water wheel is an overshoot where the water is simply being dumped directly over top of the wheel, using both the weight of the water and motion, to produce the action needed to drive the system. The overshoot system presents a more effective design in comparison to other styles of wheels, such as an undershoot that only relies on the kinetic energy of water flow because the water is directed under the wheel. As the wheel rotates, there is a simple stick that connects the wheel to the ventilation fan within the school building (or the cardboard-made school). As the wheel spins, the stick transfers rotational energy to the fan, causing it to spin and

circulate through the classroom. This model would demonstrate the basic principle of a water wheel system with the stick acting as a direct transmission of energy that would mirror modern day systems with a shaft, generator, and wires. With the continued innovation of the system, such as changing the stick into a generator, would transform this practical system to a scalable mechanism. In a design like this, the water wheels rotation would drive the generator, converting mechanical energy into electrical energy. This electricity would then be transmitted to the school through wiring to power the ventilation system, or even powering more than just that.

HVAC systems typically used in schools limit airborne infections. They are expensive to operate and have an environmental cost. A study published by the National Center for Biotechnology Information modeled ventilation upgrades across over 111,000 U.S. schools and found that achieving safe indoor air quality through improved HVAC systems could cost approximately $20.1 per square meter annually—or about $308 per student per year (Cai, 2022). In terms of energy use and ongoing operational costs, these systems stretch school budgets and indirectly contribute to GHG emissions and climate change. In contrast, the water wheel project developed for Fort Worth provides a valid example of low-energy sustainable infrastructure. Originally designed to collect trash from waterways, this water wheel is powered entirely by solar and river current energy, requiring no fossil fuels to operate (City of Fort Worth, 2022). While the Fort Worth water wheel was not conceived as a ventilation system, it demonstrates the opportunity for sustainable mechanical systems to operate on renewable energy with little maintenance.

A water powered ventilation system installed in a school has numerous advantages economically, environmentally, and educationally. The first benefit is it's a very inexpensive method after the initial installation, with ongoing costs typically associated with electric powered ventilation eliminated or greatly reduced by utilizing a free and renewable resource in the form

of flowing water. Secondly, this method of ventilation does not produce carbon emissions, which aligns with green building practices while also minimizing the school's environmental footprint. Thirdly, constant airflow utilized in water-powered ventilation ensures a continuous supply of fresh air for improving indoor air quality, allowing for the possibility for improved student health, focus, and learning success. And last but not least, it provides educational opportunities for students to see renewable energy in action, and how renewable energy and physics principles work. In addition, it is an experiential learning method used for engaging students on how creativity and innovation can solve environmental problems. The invention of new methods of teaching not only have meaningful functions, but also builds the culture of caring for our environment and community contexts in which they learn.

With the introduction of a water wheel, it not only has many benefits but also real world impacts, specifically in regions with access to flowing water and limited electrical infrastructure. By using an energy source that is renewable and site-specific, schools can localize energy use, rely less on fossil fuels, and ultimately reduce energy operational costs, once again allowing more freed up resources to be used in educational programs. In addition to sustainably and locally nourishing ventilation systems, a water wheel system can also support healthier learning environments on a continuous basis by providing fresh air without requiring any grid electricity. This can truly be beneficial for remote and underrepresented communities that are traditionally short on resources. Having a visible water wheel also acts as a daily and tangible reminder of clean energy, which serves to encourage eco-awareness lifestyles in both students and staff. Cumulatively, value-added water wheel economic and ecological systems may help reduce overall carbon footprint and promote additional opportunities (education, research, and development) related to off-grid eco-technology adaptation in education. By combining

emotional value with functional value in resource use behaviours, water wheels with ventilation systems may create an overall benefit to schools and the communities they serve both now and in the future.

With an increasing demand for sustainable and cost-effective infrastructure, especially in public education, water wheel-powered ventilation systems could provide one possible solution to a rich and complex problem. By modernizing and revitalizing ancient hydromechanical principles, we may be able to mitigate existing ventilation needs in schools, while reducing energy dependence and environmental footprint. The simplicity of the prototype project using water to directly drive a mechanical connection suggests functional off-grid/system solutions are feasible and scalable. With continued innovation, such systems can eventually be developed as fully closed-loop energy recovery systems, producing electrical energy and supplying power to surrounding school activities beyond ventilating spaces. Systems like these are even more valuable when considering they provide experiential learning opportunities for students and are deeper learning opportunities when a STEM context is considered. Therefore, water wheel-powered ventilators may be an excellent candidate to integrate into school buildings. It is not just an engineering solution but a decision to provide healthier learning environments, demonstrate fiscal conservatism, and sustain educational futures.

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