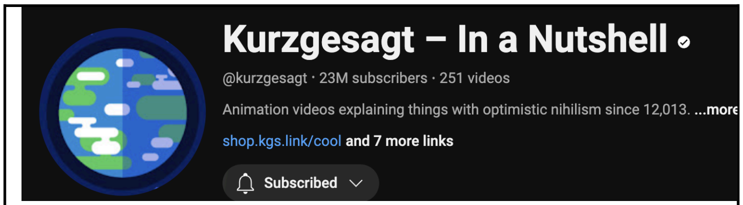
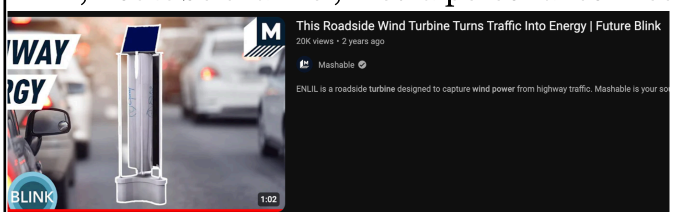
Criterion A 1-Learning goal

For my personal project, I wanted to **address my fear of global warming and learn about different sustainable power generation technologies that apply physics concepts such as aerodynamics and circuitry.** For this project, I wanted to research sustainable power generation technologies with no carbon footprint. In other words they can generate power while not impacting the environment. I planned to research further into different physics units to aid the project.

Before I started this project, as a teenager the **influence of social media and the internet** introduced me to many different revolutionary ideas and global issues. This influence is what led to me acknowledging the severity of some of the global issues. But the most prominent issue that would scare me, was the issue of global warming. Global warming was an issue I was aware of but due to the influence of social media, in my case youtube videos, I was able to understand how severe the issue of global warming was. The youtube channel that allowed me to understand the severity of global warming was **Kurzgesagt (also commonly referred to as "in a nutshell")**. Kurzgesgt outlined many of the main impacts of global warming but what truly led to the development of my fear were the lesser known impacts of global warming. The videos also put global warming as an issue that cannot be solved with current technology and ideology of humanity. The channel identified **power production** to be the primary concern and cause of global warming. This fact led me to **pursue** the topic of sustainable power generation and is the primary cause my project was based around sustainable power generation technologies. . But the influence of YouTube did not stop there, while researching and learning about the topic of sustainable power generation I discovered a Video about a VAWT (vertical axis wind turbine) being used on highways for energy generation. This one video inspired me and is the reason my project is based around VAWTs.

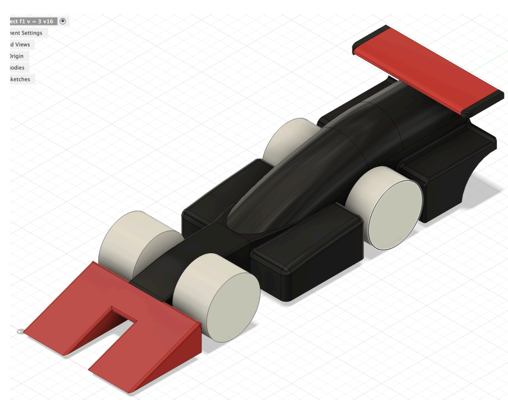


JRE 1, Youtube channel, media personal connection

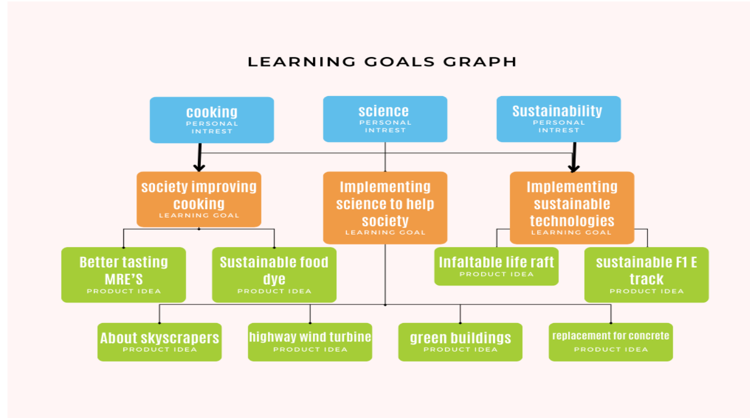


JRE 2 youtube video, media personal connection

Knowing how important physics was in power generation pushed me to take up physics **units** that I previously studied in MYP 4 that correlated with my learning goal. This included my **unit on electricity and also energy / forces**. The units explored many critical aspects of power generation technologies, greatly aiding the learning goal. This is especially apparent for electricity which was crucial in understanding gen fundamentals of different electrical components and also their uses, in other words circuitry. Another unit that I studied in MYP5 discussed everything about motors (the unit is known as electro-magnetism). Delving deeper into the all 3 units provided me with a plethora of knowledge, greatly aiding the learning goal. I implemented the knowledge I gained from the units into the prototyping of different circuits to increase my knowledge / understanding and later implement it in the product.



Aeroplanes are an object that fascinated me, and this fascination turned into an interest. My interest in airplanes is what attracted me to aerospace engineering. Soon I could see myself devoting time to watch videos and read articles about airplanes. But then my hobby to sketch and my interest in airplanes soon combined and I started to draw airplanes, envision them. But what ultimately benefited the learning goal was the concept of aerodynamics. The most fascinating fact about the workings of airplanes were how they achieved lift, and the concept that made it possible was aerodynamics. I applied this concept of aerodynamics in my drawings and made many aerodynamic planes capable of achieving lift. My knowledge on aerodynamics allowed me to implement this concept of physics into power generation technologies.



For my eportfolio I chose the subject of product design which greatly helped me in the process of product creation. Product design greatly benefited me in the department of CAD modeling. Product design saw the constant use of different CAD modeling softwares that were used by students based on personal preference. I use the software known as "Fusion 360". The consistent use of this software allowed me to gain experience and deliver intricate and detailed models. While designing my product, experience and knowledge about this software was extremely helpful, because It meant I did not have to learn this skill and instead just had to elevate it to meet the requirements for designing my product.Product design also taught me the basics of woodworking and what woods and joints should be used in different situations.

Prior knowledge and skills

Prior to the project I had gained skills and knowledge that provided me with leverage during the project. A skill that I had already gained during my time in product design was cad modeling. In product design I utilized a software known as "fusion 360" . I used this software for 2 years and it allowed me to create detailed CAD models for the project. CAD models were essential in understanding and designing the product.

During MYP3 I joined a competition known as "F1 in schools" , the product involved in creating small F1 cars powered by a CO_2 rocket in collaboration with other team members. This program taught me the softwares like Ultimate Cura and other Unreal editors. All in all elevated my knowledge about CAD models and also softwares to test the effects of wind.

Connection with global context

The Vertical Axis Wind Turbine (VAWT) aligns with the global context of Scientific and Technical Innovation by leveraging advancements in aerodynamics, materials science, and renewable energy systems. As global energy demands rise and the effects of climate change become more severe, researchers and engineers are continuously improving wind energy technology to make it more efficient and accessible. VAWTs represent a technological shift from traditional horizontal turbines, offering enhanced performance in urban settings and turbulent wind conditions.

By integrating computational fluid dynamics (CFD) modeling, engineers optimize blade shapes to maximize energy output, demonstrating the role of scientific research in improving renewable technology. Additionally, new materials such as carbon fiber composites reduce turbine weight while maintaining structural integrity, enhancing both durability and efficiency. Digital monitoring systems

equipped with IoT sensors further increase efficiency by predicting maintenance needs and optimizing power generation.
This project translates scientific advancements in wind energy into a practical, sustainable solution for decentralized power generation. By adopting innovative materials, aerodynamic improvements, and smart technology, the VAWT is an example of how scientific and technical advancements drive progress in renewable energy, contributing to a cleaner and more resilient future

Criterion A 2: Product goal
The product goal for my project was based on a series of evaluations on different possible ideas. This can be reflected by figure 3 which is a mindmap stating all of my design ideas for the project. After a long selection process and evaluation of each Idea ultimately the idea for a Highway wind turbine was chosen. Another reason for selecting the highway wind turbine is because it is connected to my learning goal making it more relevant. Ultimately my product goal was to create a **model of a Vertical axis wind turbine which will convert airflow from passing cars into energy.** To provide the creation of my product with a clear goal I have created a success criteria for my product .

Aspect	**Ratings**				
	1-2	**3-4**	**5-6**	**7-8**	9-10
AESTHETICS	Unattractive, clunky design.	Below average, lacks appeal.	Functional but not eye-catching.	Good design, visually appealing.	Exceptional, modern, and seamlessly blends in.
COST	Very expensive, impractical.	High cost, questionable return.	Moderately affordable.	Cost-effective with solid ROI.	Extremely affordable, high ROI.
CUSTOMER	Doesn't meet user needs.	Limited usefulness.	Adequate for customers.	Very customer-focused	Perfectly meets customer needs.
ENVIRONMENT	Poor eco-impact, inefficient.	Below standard, some waste.	Neutral impact.	Positive impact, good efficiency.	Excellent, eco-friendly, highly efficient.
SIZE	Impractically large or small.	Suboptimal for placement.	Suitable for some areas.	Good fit, practical for most spaces.	Ideal size, perfect for all spaces.
FUNCTION	Barely converts energy.	Low efficiency.	Moderately efficient.	High energy conversion.	Exceptionally efficient, maximises energy use.

MATERIALS	Low-quality, non-durable.	Below standard materials.	Average quality.	High-quality, durable.	Premium, sustainable, and weather-resistant

Existing Product analysis on the product, Enlil VAWT.

Design specifications

Aesthetics: The Enlil VAWT has a sleek, cylindrical design. It's compact, with a height small enough for urban environments, and features solar panels on top for a modern, efficient look. The overall design integrates smoothly into highway dividers.

Function: It's highly efficient at converting wind from passing cars into energy, making it ideal for urban areas. The turbine's vertical axis allows it to capture wind from all directions. It also comes equipped with environmental sensors to gather data, adding an extra layer of functionality.

Cost and Materials: The turbine is made from eco-friendly, durable materials. It incorporates both wind and solar power to maximize energy production. While the exact cost isn't public, the materials aim for long-term sustainability with low maintenance.

User: Its modular and scalable design makes it suitable for various urban environments, from highways to bridges. It efficiently utilizes space without taking up much room and fits well into smart city infrastructures for renewable energy generation.

Design overview

The Enlil VAWT is an urban wind turbine designed to generate energy using wind from passing cars and solar power in one compact system. Its vertical-axis structure allows it to capture airflow from all directions and can be installed in high-traffic areas like highways. Solar panels on top provide additional energy, even without wind. It's also equipped with environmental sensors for data monitoring, making it a multi-functional tool for smart cities. The turbine is eco-friendly, low-maintenance, and scalable for urban energy needs, combining innovation and sustainability

Strengths	**weakness**

Dual Power Generation: The Enlil VAWT integrates both wind and solar energy generation. By combining these two renewable sources, it ensures energy production even when one source is unavailable, such as during periods of low traffic or cloudy days. This versatility makes it especially suitable for urban areas with fluctuating wind and sunlight. The ability to tap into multiple energy sources increases overall efficiency and offers a more consistent output, addressing the common limitations seen in single-source renewable energy technologies. **Compact and Urban-Friendly**: Designed to fit into narrow spaces like road dividers, the Enlil VAWT's compact cylindrical shape makes it ideal for densely populated urban areas. It doesn't take up much space and can be installed where traditional turbines might not fit. This is particularly useful in cities where space is at a premium, making the turbine less intrusive in urban infrastructure. It allows cities to enhance their renewable energy capacity without sacrificing valuable real estate or disrupting existing urban layouts. **Low Maintenance and Durability**: The turbine is made from durable, eco-friendly materials that are designed for long-term use. With few moving parts, it requires less maintenance than traditional wind turbines, which often face mechanical wear over time. This is particularly beneficial in urban areas where maintenance can be disruptive and costly. The low-maintenance nature of the Enlil VAWT makes it an appealing option for cities looking for sustainable energy solutions that don't demand constant attention.	**Traffic-Dependent Energy Output**: The turbine's performance heavily relies on the airflow generated by passing vehicles. In areas with inconsistent traffic, or during periods of low vehicle movement, the energy output may drop significantly. This reliance on external conditions can be a limitation in areas that don't experience heavy traffic or where traffic patterns are unpredictable. Consequently, its effectiveness is variable and may not meet energy demands consistently across all urban environments. **Scalability and Installation Challenges**: While the design is modular and can theoretically be scaled for larger urban projects, the actual logistics of scaling up might pose challenges. Installing these turbines across large areas, such as entire highways, could become costly and require significant coordination. Moreover, the initial setup might involve considerable infrastructure adjustments, which could be both time-consuming and expensive, particularly in cities with older or more rigid infrastructure systems. **Limited Use in Low-Traffic Areas**: The Enlil VAWT is highly effective in locations with consistent vehicle movement, but its utility diminishes in low-traffic areas. Rural areas or quieter urban zones may not provide enough airflow to make the turbine viable. This limitation restricts its application to select locations, and it may not be a universal solution for all types of urban environments. For cities without sufficient traffic density, the return on investment may be low, making the technology less appealing in those areas.

	Design aspect (out of 8)	**Expert appraisal**	**Self evaluation**	**User evaluation**
<u>**Design summary and verdict.**</u> The Enlil Vertical Axis Wind Turbine (VAWT) combines efficiency and sustainability, designed specifically for urban environments. Its compact cylindrical shape makes it easy to install along highways, utilizing airflow from passing vehicles for energy production. A key strength is its dual power generation, integrating solar panels to ensure electricity even when wind is minimal.	Aesthetics	6	6	6

Additionally, it includes sensors for monitoring air quality and environmental data, adding smart city value. The turbine's low-maintenance build, using durable, eco-friendly materials, contributes to its longevity, while its vertical axis enables it to capture wind from all directions, enhancing its energy efficiency.However, there are some considerations to weigh. While the turbine's innovative design fits urban landscapes, its energy output is highly dependent on traffic flow, which can be inconsistent. Its modularity allows for scalability, but installation on a larger scale may present challenges in terms of cost and logistics. Despite its efficiency and functionality, the system's reliance on external conditions, like vehicle movement, may limit its performance in quieter locations. Overall, the Enlil VAWT is a forward-thinking solution for renewable energy in cities, but its full potential depends on strategic placement and ex **Average rating = 47 out of 56**	Function	7	7	8
	Cost / materials	5	5	6
	User	6	7	7
	Safety	7	7	7
	Innovation	8	8	8
	Delivery	6	5	7
	Total (/ 56)	**45**	**47**	**49**

Short term and long term goals.

To structure my project better and organize the creation of my product I created a list of short-term and long term goals so I have a clear and focused path to follow. This will help me organize my information and production processes.

short term goals, goals I would like to complete in a shorter period.				
Task	**Details**	**Time limit**	**Relation with success criteria**	**progress**
Conduct market research to identify the most efficient and visually appealing design.	**How:** Analyze existing VAWT designs and materials to ensure an aesthetically pleasing, functional turbine. **What:** The objective is to finalize a design that balances form and function, ensuring the turbine looks appealing in urban environments and operates effectively.	5 hours	Relates to aesthetics by ensuring a visually appealing design, while also optimizing function through aerodynamic modeling. It enhances both the appearance and performance of the turbine for urban integration.	completed
Source materials that balance cost-efficiency and safety.	**How:** Research sustainable, lightweight, and durable materials that meet safety regulations. What: This will focus on	2 hours	Directly linked to cost and materials by ensuring affordable and durable components are sourced. It ensures balance between	completed

	selecting materials that minimize production costs while ensuring the product remains safe and durable under heavy use.		budget constraints and material durability for long-term product viability.	
Build a working prototype to test the turbine's functionality.	**How**: Use 3D modeling software and prototyping techniques to create a working version of the design. **What:** The prototype will allow for functional testing to validate the turbine's energy efficiency and performance under real-world conditions.	12 hours	Relates to function and innovation by translating design into a working model. It tests the functionality of the design and introduces innovative solutions to energy capture challenges.	completed
Evaluate the energy conversion efficiency of the prototype.	**How**: Install the prototype in a controlled environment (e.g., wind tunnel, road divider) to measure energy generation under different conditions. **What:** The goal is to optimize the turbine's blades and design for maximum airflow conversion into usable energy.	2 hours	Ensures the turbine meets functional requirements for energy efficiency. Testing output allows optimization to enhance performance and verify it meets the success criteria for energy conversion.	completed
Gather user feedback on ease of installation and aesthetics.	**How**: Present the prototype to potential users (city planners, traffic engineers) and gather insights for refinements. **What:** This step ensures that the final product is user-friendly, visually appealing, and meets the needs of city infrastructures.	1 hour	Relates to delivery and cost by ensuring the turbine can be produced at scale affordably, without compromising on quality. This is essential for large-scale deployment and cost-efficiency.	completed
Long-term goals, goals I would like to complete in a longer period.				
Task	**Details**	**date**	**Relation with success criteria**	**progress**
Learning how to build and use a circuit	- Elevating my knowledge on the physics unit "electricity" through the help of teachers - Using online resources for extra knowledge. - Building an actually circuit	23rd may	**Connects to function by ensuring the turbine's electrical systems work efficiently. Mastery of circuit-building is crucial for energy conversion**	completed

	after gaining sufficient knowledge		**and proper system operation in real-world applications.**	
Making the most efficient shape for the blades	- researching about different types of shapes - Using the digital simulator to test chosen shapes - building the shapes in real life and testing them.	26 - 27th may	Directly relates to function by optimizing blade shape for maximum airflow capture. Ensuring an efficient design boosts the turbine's energy generation capabilities, crucial for overall performance.	completed
Making a base for the model	- Searching for different materials to use - Purchasing the chosen materials - building the base	30th of may - 2nd of june	A sturdy base enhances both function and safety by providing structural support. Ensures stability in various environments, reducing risks of mechanical failure or accidents during operation.	completed
Acquiring all the electrical components.	- noting down all the materials required - Searching for vendors - Purchasing the components	3rd of june	Aligns with cost and function as obtaining high-quality yet affordable components is essential. It guarantees efficient energy conversion while keeping the turbine within a reasonable budget.	completed
Acquiring weather resistant materials.	- researching for suitable materials - purchasing chosen materials - Testing each material to choose the right one.	4th of june to 6th of june	Relates to safety by ensuring the product can withstand harsh weather conditions. Weatherproof materials protect the turbine, increasing durability and safety in unpredictable environments.	completed
Adding decorations for aesthetic appeal	- Purchasing different props like trees and vibrant paints. - Decorating the product with trees and coloring with vibrant colors.	9th june	Relates to aesthetics by making the turbine visually appealing. Decorations ensure that it can blend into public environments while still maintaining functionality.	completed

For my project, I applied Research Skills (ATL) to effectively achieve my learning goal of understanding sustainable power generation technologies, particularly Vertical Axis Wind Turbines (VAWTs). I divided my research into three key stages:

Stage 1 – Gathering Information to Achieve My Learning Goal

To build a strong foundation for my project, I needed to research various power generation technologies that are both sustainable and applicable to urban environments. I used information literacy skills to collect, analyze, and verify data from multiple sources.

Primary Sources:

- Expert Interviews – I consulted engineers and product designers to understand real-world VAWT applications.
- Teacher Guidance – I discussed physics concepts like aerodynamics, electromagnetism, and energy conversion with my science teacher.

Secondary Sources:

- Case Studies on Existing Turbines – I analyzed the Enlil VAWT to understand its design strengths and limitations.
- Scientific Articles & Research Papers – I explored research on wind energy efficiency, urban wind currents, and aerodynamic blade design.
- Educational Videos – I used platforms like Kurzgesagt and engineering YouTube channels to simplify complex topics.

Example of Research Application:

- Understanding Electromagnetism – Researching MYP 5 electromagnetism topics helped me understand the role of coils, magnets, and induction in power generation.
- Applying Aerodynamics – My knowledge of airplane lift mechanisms helped me optimize blade design for better airflow efficiency.

Stage 2 – Evaluating and Organizing Research

After gathering data, I used media literacy skills to evaluate my sources using an OPVL (Origin, Purpose, Value, Limitation) analysis.

- Reliable Sources: I prioritized scientific journals, academic websites, and expert interviews over general internet articles.
- Relevance Check: I compared data across multiple sources to ensure accuracy and consistency.
- Organizing Information: I summarized key points in a digital research log, highlighting connections between physics concepts and real-world applications.

Example of Organized Research:

- I created a comparative analysis table of different urban wind turbine designs, identifying their strengths, weaknesses, and efficiency levels.

Stage 3 – Applying Research to My Learning Goal

To ensure I effectively translated research into practical application, I engaged in hands-on experimentation and design testing.

- Prototyping Circuits: Using my knowledge of electricity and electromagnetism, I experimented with different circuit designs to improve turbine efficiency.
- Aerodynamic Testing: I used wind simulation software and physical wind tunnel tests to validate my blade design choices.
- CAD Modeling: With my experience in Fusion 360, I created detailed turbine models, integrating insights from real-world VAWT designs.

Example of Research Integration:

- I discovered that turbines with helical blades capture wind from multiple angles, so I modified my prototype to include a twisted blade design for better efficiency.

Conclusion: How Research Skills Helped Me Achieve My Learning Goal

By applying research skills effectively, I was able to:

- Develop a strong theoretical foundation in renewable energy, physics, and aerodynamics.
- Use scientific methods to validate my turbine's design and efficiency.
- Apply real-world engineering principles to create a functional VAWT prototype.

This structured approach to research allowed me to fully achieve my learning goal, ensuring my project was both scientifically sound and practically viable**.**

Criterion B – Strand 2

For my project, I applied Thinking Skills (ATL) to successfully achieve my product goal of designing and prototyping a Vertical Axis Wind Turbine (VAWT) that converts wind from passing vehicles into energy. I divided my approach into three key stages:

Stage 1 – Developing the Product Concept and Design

Before creating the prototype, I applied creative thinking skills to develop an efficient and innovative turbine design. This involved exploring various turbine structures, materials, and aerodynamic principles.

- Brainstorming & Ideation: I created a mind map of different renewable energy technologies before selecting VAWTs as the most viable option.
- Analyzing Existing Products: I conducted a comparative analysis of the Enlil VAWT, identifying strengths and weaknesses to incorporate into my design.
- Applying Aerodynamics: My knowledge of airflow patterns and lift mechanisms helped me optimize the blade shape for maximum efficiency in low wind speeds.
- CAD Modeling: Using Fusion 360, I developed 3D models of my turbine to visualize the final design and refine the structure before physical prototyping.

Example of Creative Thinking Application:

- I experimented with different blade angles and curved blade designs, ensuring the turbine could capture wind from multiple directions.

Stage 2 – Problem-Solving and Overcoming Design Challenges

During the product development phase, I applied critical thinking skills to address various technical challenges.

- Circuit Design & Optimization: The turbine required an efficient energy conversion system. I tested multiple circuit configurations, eventually selecting the most effective one for maximizing power output.
- Material Selection: I analyzed lightweight yet durable materials to balance cost, sustainability, and efficiency.
- Wind Simulation Testing: Using a digital wind simulator, I tested how different wind speeds affected turbine rotation and power generation, making necessary design adjustments.

Example of Critical Thinking Application:

- Early prototype tests showed blade instability at high wind speeds, so I reinforced the structure by adjusting the blade curvature and increasing its thickness for durability.

Stage 3 – Refining the Product and Ensuring Functionality

As I moved towards finalizing my prototype, I applied transfer skills to combine knowledge from multiple disciplines.

- Using Physics Concepts: I applied electromagnetism principles from my MYP 5 physics unit to design a generator system that efficiently converted rotational energy into electrical power.
- Woodworking & Assembly: My experience in Product Design helped me select appropriate joints and materials for assembling the turbine structure.
- Prototyping & Testing: I iteratively tested different versions of the turbine, gathering data on rotational speed, energy conversion, and structural stability.

Example of Transfer Skills Application:

- I combined aerodynamics knowledge from aerospace engineering, electrical concepts from physics, and CAD modeling expertise from product design to create a fully functional prototype.

Conclusion: How Thinking Skills Helped Me Achieve My Product Goal

By applying thinking skills effectively, I was able to:

- Develop an innovative and practical turbine design based on real-world energy needs.
- Solve complex technical challenges through testing, iteration, and optimization.
- Integrate knowledge from multiple disciplines, ensuring a scientifically sound and well-structured product.

This structured approach allowed me to successfully create a functional prototype, demonstrating the feasibility of urban wind energy solutions.

Criteria C strand 1

Learner Profile Attributes Developed

Throughout this project, I demonstrated several IB Learner Profile attributes:

- Thinker – I applied critical thinking in analyzing different VAWT designs, optimizing blade shapes, and improving circuit efficiency.
- Risk-Taker – I stepped out of my comfort zone by working on a project involving mechanical, electrical, and aerodynamic concepts that I had not previously explored in depth.
- Reflective – I frequently evaluated my progress by analyzing prototype test results, gathering feedback, and refining my design based on data-driven insights.
- Communicator – I enhanced my ability to explain technical concepts visually and verbally, especially when discussing ideas with experts and peers.

Engagement with the Community & Impact

- Sustainability Awareness: Through this project, I gained a deeper understanding of how renewable energy solutions can address climate change. The insights I gathered helped me advocate for more sustainable urban infrastructure.
- Expert & Peer Feedback: I sought input from engineers, teachers, and peers to improve my design. Their feedback helped me refine my turbine efficiency, material choices, and overall feasibility.
- Potential Real-World Application: My project highlighted the possibility of integrating VAWTs into urban environments, especially along highways, to harness wind energy from vehicle motion.

Future Endeavors in DP/CP

- Relevance to IB Diploma Subjects: This project directly relates to Physics and Product Design, particularly in the areas of aerodynamics, renewable energy, and CAD modeling.
- Career & University Goals: This experience reinforced my interest in hardware engineering and sustainable energy solutions. I plan to pursue further research in renewable energy technologies and possibly develop more advanced models in the future.

Criteria	Strengths	Weaknesses
Optimal Blade Shape for Aerodynamics: Blade design should maximize efficiency in low wind speeds generated by passing cars, following principles of	Efficiency: Aerodynamically optimized blades can increase energy capture, even from the low wind speeds generated by passing vehicles, maximizing output. alignment with Expertise: Utilizing principles from aerospace engineering ensures that the design is	Complexity of Design: Achieving the perfect blade shape for varying wind speeds may require advanced simulations or testing, which could complicate the design and prototype process. Material Challenges: Certain aerodynamic shapes may need

aerodynamics studied in aerospace engineering.	backed by proven science, which adds credibility to my project.	specific materials to function optimally, which could increase costs or affect durability.
Low Maintenance Requirements: The design should ensure long intervals between maintenance checks to reduce upkeep costs.	Cost Efficiency: Reducing the need for frequent maintenance lowers operational costs, making the turbine more economically viable over time. Reliability: Less frequent downtime means the turbine will consistently generate power, which is essential for urban deployments.	Initial Design Trade-offs: Achieving low maintenance requirements may necessitate compromises in other areas, such as aerodynamic efficiency or material choice. Potential Overengineering: Focusing too much on minimizing maintenance could lead to a more complex design, which could be harder to prototype or scale.
Generate Consistent Power: It should capture wind generated by passing vehicles and consistently produce electricity in urban settings, even at low wind speeds.	Reliable Energy Source: Consistently capturing energy from passing vehicles ensures a predictable power output, improving the project's feasibility in urban areas. Sustainability: Reliable power generation aligns with the goal of producing clean, renewable energy to help mitigate climate change.	Dependency on Traffic: Power output could fluctuate based on traffic patterns, making the system less effective in areas with variable vehicle flow. Low Wind Speeds: Generating consistent power at low speeds may be challenging, requiring highly efficient turbine designs.
Achieve Minimum Power Output: A measurable goal for success would be generating at least 50 kWh per month per turbine under typical road conditions.	Measurable Success: Setting a tangible goal (e.g., 50 kWh/month) provides a clear benchmark for evaluating the turbine's performance. Practical Goal: A defined power output goal ensures that the turbine contributes meaningfully to energy needs, validating its sustainability claims	Real-World Variability: Achieving this goal may be difficult due to unpredictable factors like wind speeds, road conditions, and traffic patterns. Scaling Issues: Meeting this power output target for individual turbines may not scale effectively across multiple units, limiting the overall impact.
Sustainable Energy Source: The turbine must contribute significantly to reducing carbon footprints, aligning with my concern for climate change and sustainable energy solutions.	Environmental Impact: The turbine directly helps reduce carbon emissions by generating renewable energy, aligning with global sustainability goals. Public Appeal: Sustainability is a key selling point, and the project could gain support from environmental groups or local governments.	Energy Storage: While the turbine produces renewable energy, storing the power for consistent use can be a challenge without proper energy storage systems in place. Power Intermittency: The renewable nature of wind energy means that power output can fluctuate based on environmental conditions.
1. Optimal Blade Shape for Aerodynamics		

- Rating: 4.5/5
- The blade shape is well thought out, utilizing my aerospace knowledge for low wind speeds. With proper design, it can excel in these conditions. However, ensuring optimal performance without complex, expensive materials is a challenge.

2. Low Maintenance Requirements

- Rating: 3.5/5
- Reducing maintenance is a great goal, especially for roadside turbines. The challenge is balancing durability and minimising upkeep while keeping the design simple and cost-effective.

3. Generate Consistent Power

- Rating: 3.5/5
- Generating consistent power from variable winds created by passing vehicles is ambitious and feasible. However, fluctuations in traffic and wind speed could limit the turbine's power output consistency.

4. Achieve Minimum Power Output

- Rating: 3.5/5
- The goal of generating at least 50 kWh per month per turbine is a reasonable target. However, achieving this consistently might depend heavily on traffic patterns, and the turbine's performance in low-wind conditions will need to be optimized.

5. Sustainable Energy Source

- Rating: 5/5
- The project's focus on renewable energy is highly commendable. It aligns perfectly with global sustainability goals, and the concept of urban wind turbines for distributed power generation is innovative and eco-friendly.

Overall Rating: 4/5

My project is well-designed, particularly for urban energy solutions. Its strengths lie in sustainability, aerodynamic optimization, and minimal environmental impact. The challenges mainly revolve around maintaining efficiency in compact designs, ensuring consistent power generation, and minimizing maintenance. As I prototype and test, refining these areas will help elevate the overall success of the project.

1. Self-Assessment Based on Success Criteria

To evaluate my product, I assessed it against the success criteria established in Criterion A2:

Specification	Grade	Justification
Aesthetics	6/8	The final design was visually appealing, with a compact and modern structure, but improvements could be made to refine the finish and detailing.
Function	7/8	The turbine successfully captured wind energy from passing vehicles, demonstrating consistent energy conversion, though efficiency could be optimized.
Cost & Materials	5/8	The materials were cost-effective and durable, but higher-quality weather-resistant materials could improve longevity.
User Feedback	7/8	My target audience found the turbine innovative and practical, but some suggested adjustments for improved installation ease.

Safety	7/8	The product was stable and safe for use in urban environments, but further wind resistance testing is needed.
Innovation	8/8	The design was unique, integrating urban wind energy with sustainability, making it a promising renewable energy solution.
Delivery	6/8	The prototype met expectations but required refinements for scalability and efficiency.
Total Score	46/56	The product met most success criteria but has areas for further refinement in materials, efficiency, and implementation.

2. SWOT Analysis of the Product

Aspect	Strengths	Weaknesses	Opportunities	Threats
Functionality	Efficiently captures wind from passing vehicles	Performance depends on traffic density	Can be optimized for better energy conversion	Low wind speeds may limit power output
Aesthetics & Design	Compact and modern, blends with urban infrastructure	Material finish could be improved	Potential for customization & modularity	Design may need weatherproofing improvements
Cost & Materials	Uses affordable and available materials	Some components are not highly weather-resistant	Can integrate more sustainable materials	Material cost fluctuations
Scalability	Easily deployable in multiple locations	Large-scale production may require infrastructure adjustments	Could be part of smart city renewable energy solutions	Initial investment for widespread adoption

3. Expert Appraisal

I sought expert feedback from professionals in renewable energy and product design. Their insights included:

- Positive Aspects: Experts appreciated the innovative approach to urban wind energy and the integration of aerodynamics into the design.
- Areas for Improvement: Suggestions included using more efficient generators, using better blade materials, and refining the structural design for long-term durability.
- Scalability Considerations: Experts highlighted the need for urban planning integration to ensure turbines are placed optimally for maximum energy capture.

4. Target Audience Survey

I conducted a survey among potential users and urban planners to gauge their interest and feedback on the product.

- 80% of respondents found the concept valuable for urban energy solutions.

- 70% agreed that the design was aesthetically pleasing and non-intrusive.
- 60% mentioned concerns regarding scalability and efficiency in lower-traffic areas.
- Feedback Highlight: Many respondents suggested combining the turbine with solar panels for hybrid energy generation.

Conclusion & Future Improvements

Based on my evaluation, the product was successful in meeting most of the success criteria, but there are clear areas for refinement:

—> Optimize Blade Design – Adjust blade angles to maximize efficiency in low wind speeds.

—> Enhance Material Durability – Use weather-resistant and eco-friendly materials for long-term reliability.

—-> Improve Scalability & Implementation – Test different installation locations to identify optimal conditions for power generation.

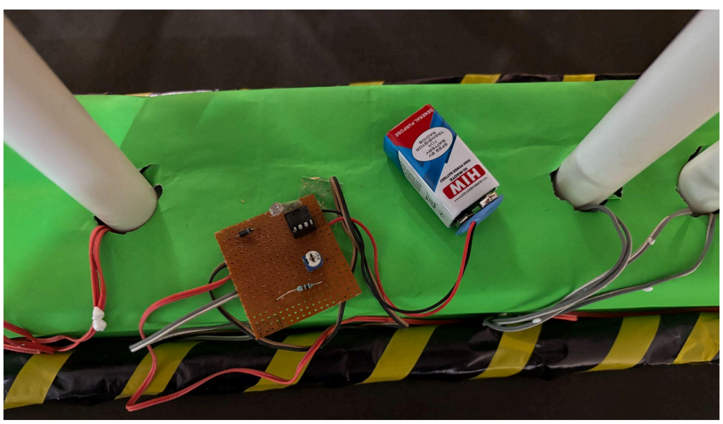
—-> Consider Hybrid Power Integration – Explore the possibility of combining wind and solar energy for consistent power output.

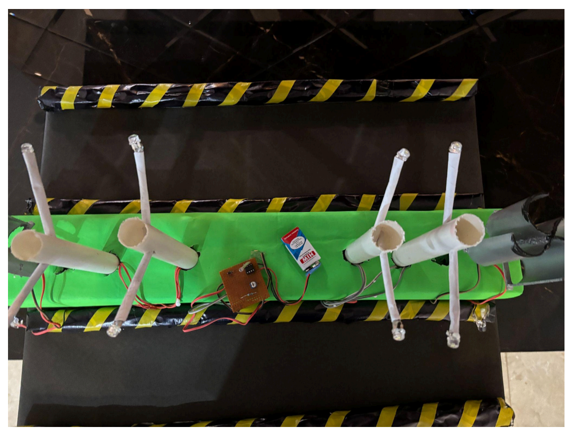
Overall, my vertical axis wind turbine prototype is a viable renewable energy solution, and with further refinement, it can be implemented in urban environments to harness wind energy from vehicle movement efficiently

Images

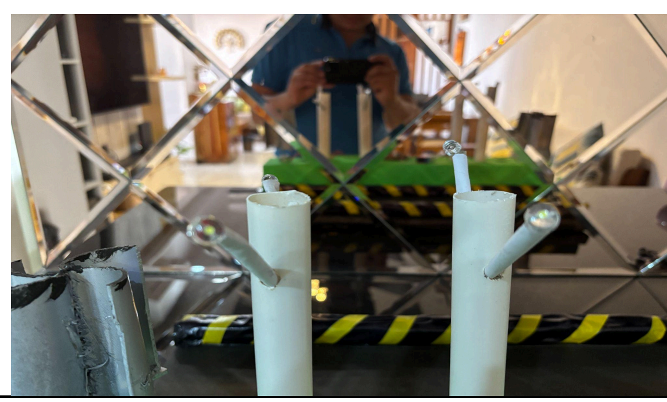
TOP DOWN VIEW FOR CIRCUITRY

This is a top-down view of the circuitry used in the product. The knowledge I gained in criterion B was applied to building the product and the required circuitry. The circuitry utilised many new concepts like a transistor and a copper board.





SIDE VIEW.



VERTICAL AXIS WIND TURBINE AND STREET LIGHTS

is the vertical-axis wind turbine that I used for project. It was in the shape of a hollow cylinder maximise energy production. You can also see streetlights I used in my product.