DECARBONIZATION OF ST KITTS BASSETERRE PORT USING RENEWABLE ENERGY-POWERED MICROGRID

IMO CARES PROJECT

SYG
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Executive summary of the proposal

SYG TECH has been selected as one of the technology providers for the IMO CARES Maritime Technology Global Challenge. As a part of the IMO CARES initiative, SYG TECH has been allowed to demonstrate the decarbonization potential of its technology at the Basseterre Deep Water Harbor in St. Kitts and Nevis in a pilot demonstration.

The SYG TECH technology encompasses a Vertical Axis Wind Turbine incorporating a novel and effective “storm protection” feature. This innovative feature retracts the turbine’s wings (propellers) to the main body of the wind turbine in such a way that it effectively transforms the turbine into a "utility pole". Although seemingly simple, this patented feature causes significant consequences in reducing weight, increasing safety, ease of installation, and installation near inhabited locations. The feature reduces capital expenditure (CAPEX) and lowers operational expenditure (OPEX). Besides these advantages, the new feature enables brand-new wind turbine applications which may significantly help lower GHG emissions.

SYG TECH will demonstrate the decarbonization potential of its technology in St. Kitts SCASPA Deep Sea Port. The SCASPA Port HQ and its facilities will be converted into a renewable energy-powered “microgrid”. The installation of the SYG TECH turbine at the SCASPA Sea Port microgrid alone is expected to cut 46% of the port's GHG emissions.

Studies have shown that microgrids can be made carbon neutral if wind, solar, and storage are used in an appropriately mixed manner. Appendix J demonstrates a suggested proper mixture of wind, solar, and storage that would make the SCASPA microgrid 100% carbon neutral.

GHG reduction of the proposed solution will be monitored online 24/7 and the data will be accessible by all the stakeholders. GHG reduction data will be reported monthly to all stakeholders.

The practical application possibilities of SYG TECH's technology are expected to significantly impact GHG reduction in the maritime. The SYG TECH technology can be extended to Offshore applications, District Heating & Cooling applications as well as power generation onboard ships. The other application possibilities of the SYG TECH technology are given in Appendix G part of this report.

1.0 Introduction

1.1 Background: Overview of the technology and its impact on the industry.

The International Maritime Organization (IMO) has issued a global technology challenge to reduce GHG emissions in maritime operations. SYG TECH participated in the challenge by proposing the use of a modified wind turbine technology for maritime operations. This innovative technology promises to increase the utilization of wind energy in applications by reducing weight, and noise, increasing safety, and decreasing CAPEX. With these features, it is expected that the turbine technology will be feasible for use even in applications where wind energy is rarely used before.

SYG TECH achieves this by incorporating a "storm protection" feature to vertical axis wind turbines (VAWT), which reduces the wind profile of the wind turbine when wind speed reaches storm velocities. (Fig.1) According to IEC regulations, wind turbines must be constructed in a way that allows them to survive wind velocities of 180-220 km/hr. While wind turbines are designed to operate within wind velocities of 4-25 m/sec, (10-90 km/hr) they are expected to withstand storm speeds exceeding 55 m/sec (200 km/hr) even if it happens occasionally.

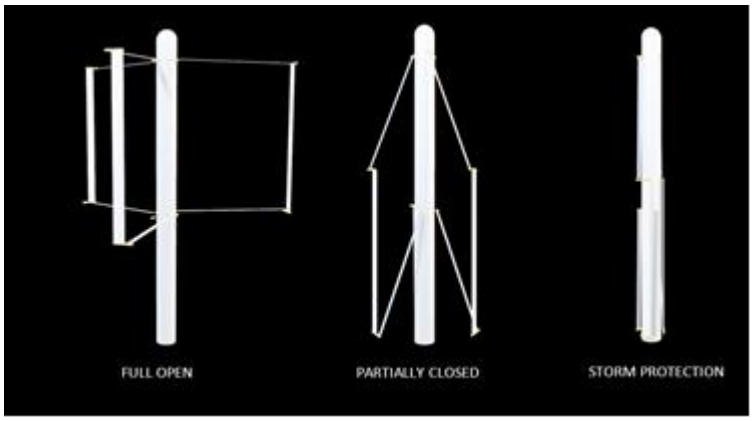
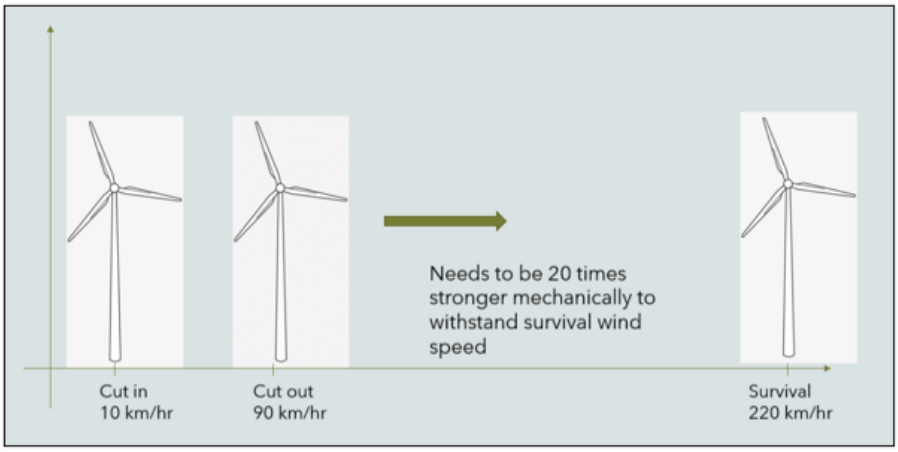


Figure 1 Storm protection feature closes the turbine like an umbrella to decrease the wind load on the structure. Partial opening enables speed regulation and maximum power generation even in high wind conditions.

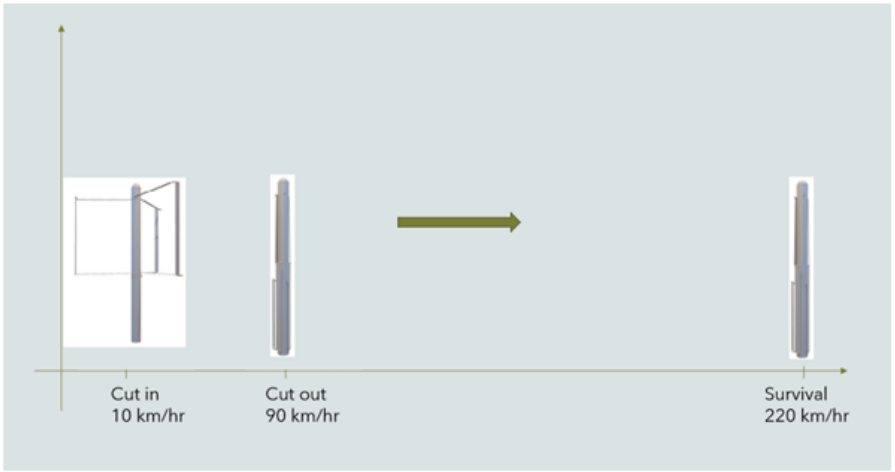
Wind energy is proportional to the cubic power of the wind speed and its power at hurricane speeds is enormous. National Hurricane Centre (NHC) reports that 178-208 km/h range winds are powerful enough to snap and uproot trees. Reducing the wind profile of a wind turbine to a “utility pole” significantly reduces the force acting on the turbine thus reducing the structural strength requirements. The reduction in structural strength requirement, in turn, translates into reduced structural material usage, less weight, simpler foundation, and fewer equipment components, such as brakes, in the design.

Experimental implementations have shown significant weight reductions due to the storm protection feature. With the resultant reduction, the storm-protected turbine weighs only 1/10th of a comparable classical wind turbine of medium power scale (10-100 KW range).

The storm protection feature is a patented technology and SYG TECH holds patents in the EU, USA, Japan, Singapore, South Africa, and New Zealand.



Classical HAWT technology turbine wind profile can not be reduced even if the propellers are feathered for minimum drag. Due to this, the components and foundation has to be built strongly.



New vertical axis turbine with storm protection can fold the turbine like an umbrella during storms. This reduces the profile of the turbine to a "pole". This reduces the structural strength requirements, weight and the cost.

Figure 2 Comparison of classical HAWT and modern VAWT with storm protection features.

SYG TECH proposes to use the modified wind turbine for generating electrical power for the SCASPA port microgrid. We propose to build a renewable-powered microgrid for SCASPA port where renewable wind energy will provide an estimated 46% of the power needed by the port.

Figure 3 The state of wind turbines after a hurricane. This is what happens when the wind reaches Category 3 hurricane-level wind speeds of 178-208 km/h. There is also Category 4 and 5 which reaches up to 257 km/h wind speeds.

1.2 Objectives:

This project is being proposed as a part of the IMO CARES effort to reduce maritime CHG emissions. The objectives of the project can be summarized as follows:

1. Reduction of GHG emissions by utilizing the technology
2. Decrease dependence on fossil fuel, reduce costs
3. Increase the use of renewable energy in maritime operations
4. Help achieve Sustainable Development Goals SDGs,
    - SDG 11. Target 5 promoting sustainable energy and transport systems in human settlements
    - SDG 7. Target 7.2: By 2030, increase substantially the share of renewable energy in the global energy mix
        - Target 7.a
        - Target 7.b
        - Target 13.b

2.0 Project Description

2.1 Technology Overview: Description of the Maritime Technology to be Demonstrated.

The proposed technology of SYG TECH is a patented technology that features a very effective "storm protection" feature. SYG TECH technology is patented in the USA, EU, Japan, Singapore, South Africa, and New Zealand. The technology folds the wings of the turbine in high winds to protect the structure of the turbine. In the folded form the turbine turns into a "utility pole". The "pole" configuration decreases the wind profile, reduces structural strength requirements, increases storm resilience, and increases safety. The reduced weight, increased safety, decreased noise, omnidirectional operation ability as well simplified foundation requirements make the new SYG TECH turbine ideal for microgrid power generation.

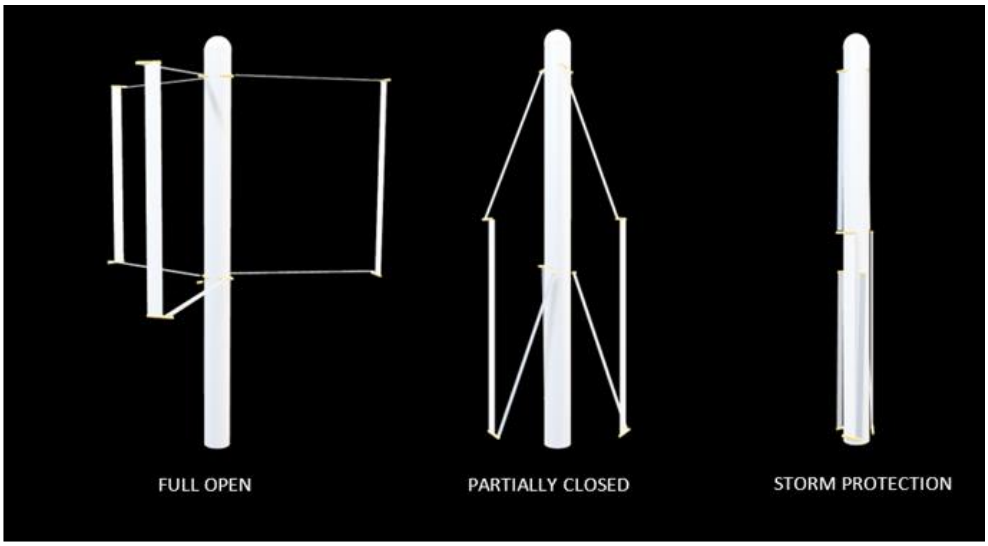


Figure 11 SYG TECH turbine incorporates a very effective storm protection feature which turns the turbine to a "pole"

In addition to these features, the new turbine is modular and scalable. It can be stacked on top of each other to scale up the power provided the foundation is prepared accordingly.

The proposed wind turbine for the SCASPA Port Microgrid would be erected near the SCASPA port facilities and would have a wind-swept area of 200 m^2 and an estimated nameplate power of 70 kW at 12 m/sec wind.

The stakeholders were given the option of two different configurations for the wind turbine. These two options are shown in Figure 12 below.

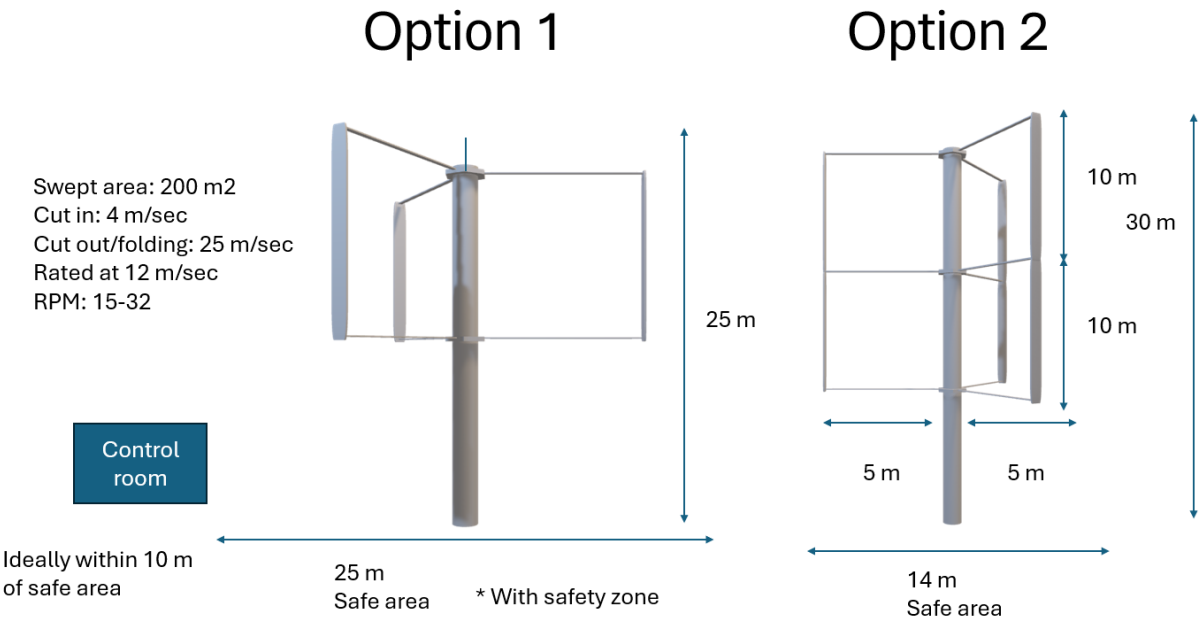


Figure 12 Two options were presented to stakeholders: In option 1 turbine swept area is wide but short in height, and in option 2 the turbine sweeping area is tall but narrow.

Both options have the same estimated nameplate capacity and similar cut-in and cut-out wind velocities. Option 1 is 25 meters tall with a 25-meter rotational diameter including the safety zone around the rotational area.

Option 2 is 30 meters tall with a 14-meter rotational diameter including the safety zone around the rotational area.

The main difference between the two options is the rotational diameter (width) of the turbine.

The stakeholders selected Option 2 as the preferred option for the wind turbine. Both options have the storm protection feature integrated into the turbine.

Foundation depth and tilt-down feature

The turbine installation requires a foundation of a 1-meter diameter, 7-meter deep hole dug using suitable auger cranes. (The rule of thumb is 1 meter underground for every 5 meters above ground + 1 meter for safety) The technique is known as "screw pile foundation" or "planted section pole foundation" and is frequently used for erecting utility power poles. St. Kitts electric company SKELEC uses similar auger cranes to install power poles on the island. SYG TECH expects foundation holes to be dug and prepared at the installation site according to specifications that will be provided in due time.

SYG TECH officials recommended adding a “tilt down” feature to the turbine. The tilt-down feature enables tilting down the turbine on the ground for added protection as well as servicing. Tilt down feature has the following advantages:

1. In case of a hurricane, it gives the ability to lower the turbine for further storm protection.
2. Tilted-down mode makes servicing easier by giving access to all parts of the turbine at ground level.

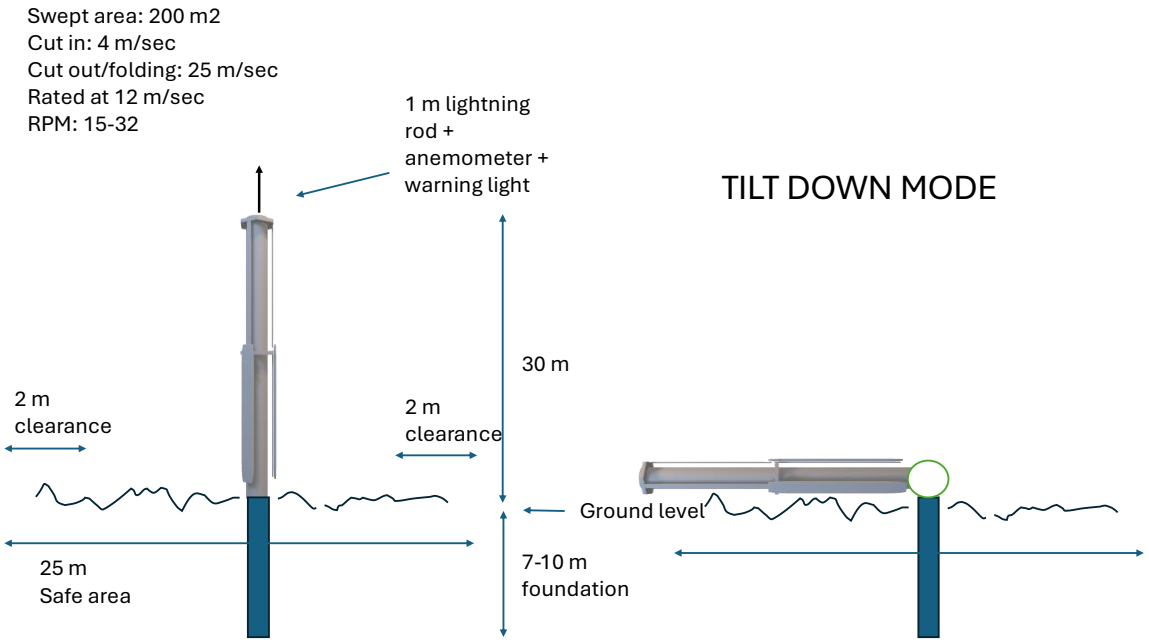


Figure 13 Foundation length and the tilt-down mode for the turbine.

As St. Kitts and Nevis are situated in a region prone to hurricanes, SYG TECH officials have recommended the inclusion of a tilt-down feature. This is in response to witnessing buildings being damaged during a hurricane on the island. The SYG TECH turbine is equipped with an automatic storm protection feature that closes the turbine wings when wind speeds reach cut-off levels. In this mode, the turbine turns into a "utility pole" that can withstand high winds. The "storm protection" mode is controlled automatically by the smart operating system of the SYG TECH turbine and does not require user intervention. The system is expected to function automatically. However, the tilt-down feature is not automatic and needs to be activated manually. This feature is intended for use during severe storms or maintenance procedures.

Tilting down is not an automatic process. Although it is power-assisted, the tilt-down procedure is a manual procedure that requires removing several bolts and activating power assist to lower the turbine. It is expected that the procedure will take 2-3 hours. This procedure should be done only in case of severe hurricane warnings before the hurricane arrives on the island.

3.0 Data Collection Methods

3.1 The outline of the SCASPA Renewable Powered Microgrid

The proposed SCASPA Port Renewable Microgrid is expected to be as follows:

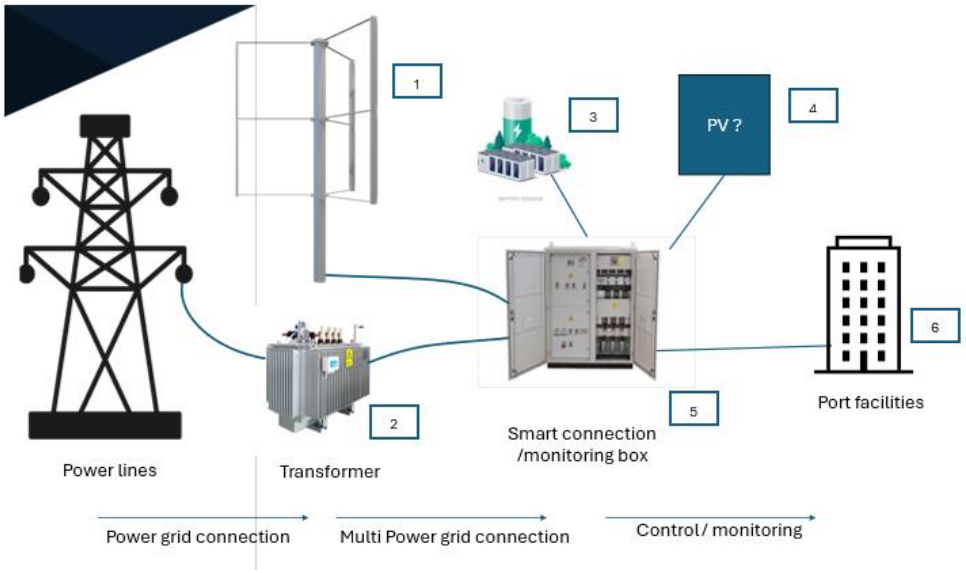


Figure 15 Outlook of the SCASPA Microgrid

In this diagram that shows the equipment in the SCASPA Microgrid, #1 represents the SYG TECH wind turbine, #2 represents the SKELEC Utility company transformer powering the SCASPA port, #3 represents the Battery Storage system, #4 represents additional renewable energy systems like PV, #5 represents the smart connection box of the microgrid, and #6 represents the SCASPA port facilities that demand electrical power.

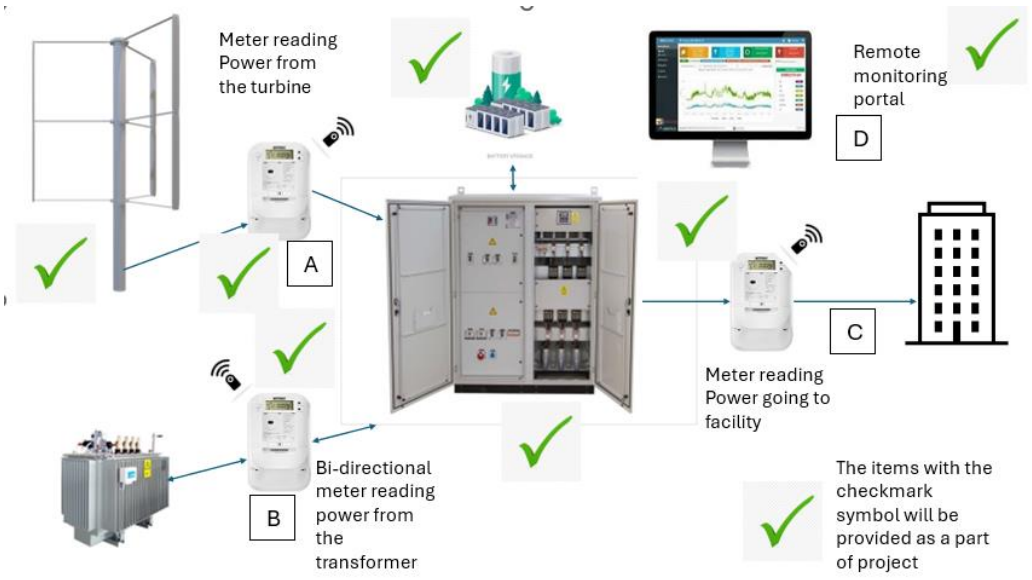


Figure 16 The monitoring scheme of SCASPA Microgrid

The diagram above shows how the power generation and consumption of the SCASPA Microgrid will be monitored remotely.

In this infographic screen, the meters shown with symbols A, B, and C are smart meters that can be monitored remotely over an internet connection. The meters A and C are unidirectional meters that can monitor energy flowing in one direction, whereas the meter B is a bidirectional meter that can measure power flow in two directions. This means that Smart meter B can measure the power flow from the SKELEC utility company grid to the SCASPA Microgrid, as well as the power delivered to the SKELEC utility grid from the SCASPA Microgrid when there is excess power generated in the microgrid.

The remote monitoring portal marked as D in the infographic allows monitoring of the data coming from smart meters at remote locations. The system operates over the internet connection and allows the monitoring of data remotely from any location in the world.

Upon granting permission from SCASPA, the information presented in Remote monitoring portal D could be monitored by involved stakeholders like IMO, MTCC, EU, and any other stakeholders simultaneously.

4.0 Scalability and Replicability

4.1 Scalability Analysis: Assessment of the potential for scaling the technology.

SYG TECH wind turbine technology has excellent scalability potential and can be applied to many similar ports. The idea is to turn a part of the port into a “microgrid” which will be powered by renewable means. Microgrids may be for powering port buildings, providing power for cold ironing, or any other application that demands electrical power.

The factors that positively affect the scalability of the SYG TECH turbine are summarised as follows:

1. Simple foundation technology. SYG TECH turbine, because of its lightweight nature, uses simple foundation techniques similar to the ones used for erecting power utility poles. This means it can be installed quickly in a less costly manner.
2. Safety. SYG TECH turbine folds its wings at cutoff velocity and high winds. This makes it safer around inhabited areas.

3. Quiet operation. Unlike its HAWT counterparts, the SYG TECH turbine is not noisy during operation.
4. Overall cost is less. Since wind is available day and night, the storage requirement of SYG TECH turbines is much less than that of PV systems. Combining SYG TECH and PV generates an optimum solution with less dependence on storage.

5.0 Conclusion

5.1 Summary

Project's goals, expected outcomes, and significance.

Our earth is going through a climate crisis, and we must cut down CHG emissions. The solutions we find need to be practical as well as affordable so that they can be applied on a massive scale all around the world.

SYG TECH wind turbine technology has been developed with this intention in mind. The simple solution we present in this project makes wind energy applicable to microgrid power generation in many inhabited areas including ports.

Our technology results in a significant reduction of weight, reducing weight to 1/10 of a classical turbine. This translates into many new application possibilities as well as reduced costs.

In this project, we try to prove that the SYG TECH turbine can make a port carbon-neutral practically and affordably. This can be applied on a massive scale to many ports.

In short, we believe our technology can be instrumental in cutting down CHG emissions in the maritime industry. We would be very happy to use our technology for the benefit of mankind. Let us make our world a better place together.