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Wind-Solar Driven Natural Electric Hybrid Ventilators

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1. Introduction

The new millennium has commenced with great concern arising from the unnatural contingencies of energy utilization that have the potential to destroy the very environment which sustains life. In recent times, such environmental awareness is rapidly resulting in favourable realignment of peoples' attitudes towards lifestyles and products whose production, usage and maintenance are less harmful to nature. It is in this context that we will discuss Wind Driven Natural-Solar/Electric Hybrid ventilator.

Ventilation of domestic, commercial and industrial building is necessary to provide an optimum or at least a satisfactory environment. Such requirements are detailed in publications by organisations such as standards Australia [1] Current ventilation devices are using wind or solar energy are configured to rely exclusively on one of these natural sources of power [2,3]. Proper ventilation requires also that there be a movement or circulation of the air within the space and that the temperature and humidity be maintained within a range that allows adequate evaporation of perspiration from the skin. It was formerly believed that the discomfort, headache, and lethargy were caused entirely by the increase in the amount of carbon dioxide and the decrease in the oxygen content of the air. There is now evidence to show [4] that the deleterious effects may also result largely from interference with the heat-regulating mechanism of the body. Despite the wide distribution of air pollutant sources, the concentration of indoor pollutants may be the dominant risk factor in relation to personal exposure, as most people spend an average of 87% and 6% of their time within buildings and enclosed vehicles, respectively [5]. Indoor exposure may pose more harmful health effects, as the indoor concentrations of many pollutants are often higher than those typically encountered outside [6]. To maintain a safe working environment, many dwellings and factories now need adequate fresh air exchange to remove gaseous, process emissions and/or heat build up.

The high priority placed on indoor air quality from health considerations has prompted New York as the first state in the USA to pass legislation effective from December, 2008 to require landlords to notify tenants, prospective tenants and building occupants of indoor air

Source: Wind Power, Book edited by: S. M. Muyeen,
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test results [7]. This is a ground breaking requirement that will no doubt be followed by other places in the world. Although conventional air conditioning (AC) is thought to improve air quality by lowering ambient outdoor allergens, reports of adverse health associations of AC, such as cold and flu, various respiratory problems, sick building syndrome, rising levels of eye, nose and throat irritation, headache, allergic irritations, and so forth are long standing [8]. Proper AC maintenance and other interventions such as the use of ultraviolet irradiation of cooling coils are often suggested to reduce these effects [8]. However, these solutions are usually very expensive.

Under these circumstances, wind driven rotating ventilators, which use natural energy and are cheap to manufacture, install and maintain, can become very cost effective non-polluting means of alleviating the problems by (a) lowering temperatures in homes and buildings during summer by cooling roof spaces and even removing trapped ceiling heat through ceiling grilles and (b) improving air quality through reduction of impurity levels caused by human respiration and chemical emissions – mainly volatile organic compounds, from carpets, furniture, paints, cleaning products and the like.

The author has been pioneering roof top ventilator research, design and performance studies for over a decade at the University of New South Wales in Australia [2-3, 9-11] for over a decade. Work on wind driven ventilators started at the University of New South Wales when Edmonds Products Australia Pty Ltd required testing of their ventilators designed to operate on rooftops of dwellings to meet a single regulatory requirement, that is can the ventilators withstand hurricane wind forces, that is wind forces of a minimum velocity of 215 km/ hr without being ripped off from so that damage to the roof and its surroundings could be avoided. The experiments were essentially in the form of 'destructive testings'. These studies lead to substantially strengthening of the spindle rods and rotors used so that they could withstand the loads generated by high wind.

Subsequent studies lead to the aerodynamic investigation of the performance of these ventilators. The major issue that were investigated involved the efficient operation of these ventilators in low speeds. The studies lead to modifications to the rotors that lead to substantial performance of the Edmonds ventilators to the tune of 15% increase in air extraction efficiency.

Another problem that required attention was the operation of these ventilators in adverse weather conditions of rain. The objective was to ensure that rain did not sip through into roof cavities and buildings causing dampness and the associated health problems. A purpose built mobile rain chamber that could be joined to an existing open circuit wind tunnel was built to investigate the effect of rain on the operation of these ventilators. These studies have lead to specific modifications to the ventilator base holder to redirect the rain particles and obstruct their entry to the inside of dwellings without any penalties to the performance of these ventilators.

However, the dependency on wind depends that the operation of ventilation system based purely on the availability of wind makes its operation twenty four hours a day and whenever required a difficult proposition. A hybrid Wind Solar Driven Natural Electric ventilation system, with solar system complementing primarily as an alternative natural energy source, appears to offer a viable engineering solution that will also help reduce electricity usage compared to conventional air-condition systems thereby contributing significantly towards lower depletion of resources such as oil, coal or gas. This consideration has lead to the novel concept of a hybrid ventilator the 'ECOPOWER' that won the 2008

AIRAH award of Excellence in the HVAC-Achiever category. The award recognizes a distinguished Australian product, invention or innovation in heating, ventilation and air conditioning.
Most of the above works were experimentally based and conducted primarily on real and industrial models with substantial funding from the Australian Research Council in collaboration with industry funding from Edmonds Products Australia Pty Ltd (now part of CSR as CSR Edmonds Australia Pty Ltd) at the Aerodynamics Laboratory of the University of New South Wales. The present paper is basically organised around these activities of the author and his team starting from purely wind driven ventilator to the hybrid ventilation concept to contribute towards the cause of providing higher air quality and comfort with minimum impact to environment.

2. A brief look at various ventilation devices

Ventilation devices powered by energy sources that are renewable non-renewable or a combination of both, may be discussed under the following four headings:

i. ***Ventilation through natural convection:*** This form of ventilation is the simplest means of ventilation and relies upon natural convection. The roof a building contains hot air due to heating caused by the sun. The areas of occupation generally contain air that is much cooler. To allow natural convection to occur, provision is made for a vent at the top of the roof cavity. This allows the hot air to rise out of the roof cavity and escape. Opening windows and doors in the areas of occupation allows cooler air to be drawn into the building by the hot, rising air in the roof cavity.
This cool air will itself be drawn into the roof cavity and heated, causing it to rise and escape through the roof vent, and perpetuate the cycle. The simplicity and elegance of this method of ventilation is thus readily apparent (Fig. 1).

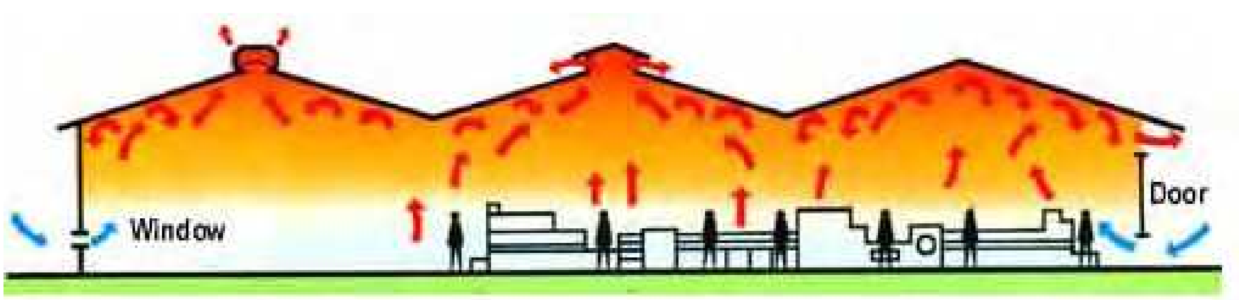


Fig. 1. Ventilation by Natural Convection (Image: www.lomanco.com)

ii. ***Wind Cowlings:*** Various attempts have been made to enhance natural convection by using ambient wind to assist the exit of hot air from the building. Specially shaped "cowlings" are situated upon vertical pipes which conduct hot air out of the building. The cowlings have a similar cross-section to an airplane wing, the low pressures generated over the curved side of the cowling being used to assist in the extraction of stale air from the building.
The use of cowlings to enhance air extraction is applicable for domestic and commercial uses. When used for commercial purposes, the size of the cowlings can become appreciable (Fig 2). To ensure that the cowlings are orientated correctly with respect to the prevailing wind, a facility for swivelling is provided.

Fig. 2. Air extraction cowlings, University of Nottingham
(Image: Designing with Solar Power, D. Prasad & M. Snow, 2005)

iii. ***Turbine Ventilator:*** The third type of ventilation method uses wind powered centrifugal pumps. These are the "whirlybirds" (Fig 3) with which many people are familiar. Most of these simple devices combine the function of turbine and pump into one, single rotating assembly. That is, one set of blades is used to both spin the device and extract the stale air.

Fig. 3. Cylindrical centrifugal ventilator at the University of New South Wales

Some designs are slightly different in that they have separate blade groups for spinning the device and extracting the air. These blade groups are stacked vertically, but are still part of a single rotating assembly.

Fig. 4. Spherical centrifugal ventilators at the University of New South Wales

These ventilators operate as drag devices, and hence, the angular velocity of the device cannot exceed the ambient wind speed. The difference in the coefficient of drag on the convex and concave sides of the blades causes the device to rotate (Fig 4). This rotation forces exhaust air to be drawn into the centre of the pump, where it is subsequently centrifuged out of the device.

iv. ***Solar Ventilator:*** The fourth type of ventilation method uses solar power exclusively to operate an air extraction fan (Fig.5). This fan is usually of the axial type.

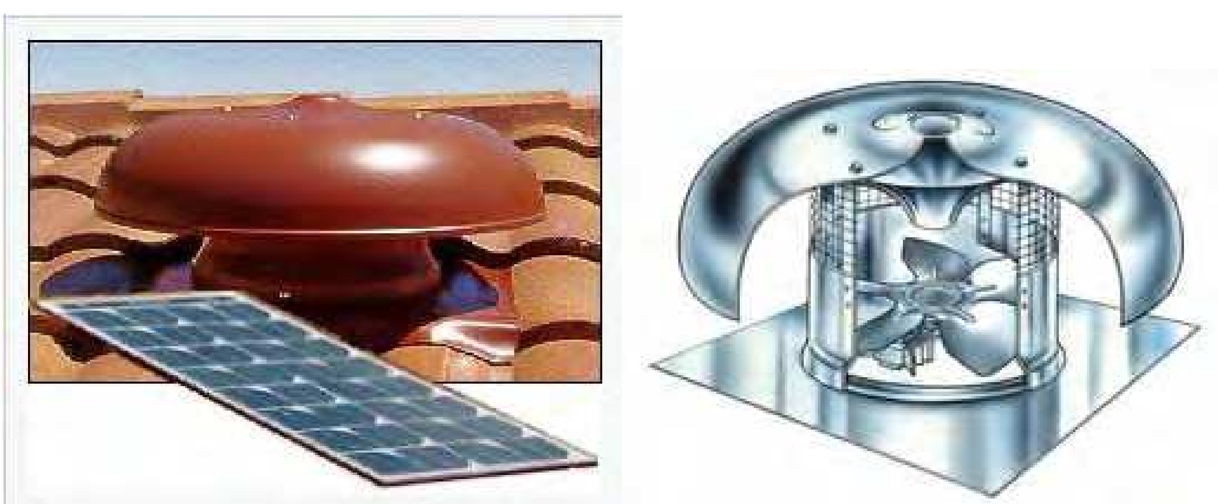


Fig. 5. External and internal views of solar powered ventilator (Image; www.edmonds.com.au)

For many commercial buildings, Australian Standards demand a minimum flow rate of fresh air, and a minimum number of air-changes per hour. Such requirements are usually met with mains-powered air extraction fans.

Such fans are usually axial types, and are very similar in concept and construction to the solar ventilator of figure 4. The main difference between the two lies in the absence of the solar panel and the requirement for hard-wiring to a mains power source.

v. ***Mains powered ventilators:*** They include various forms of ventilation devices that are powered by mains electricity supply. These are essentially dependent on the non-renewable powered systems. Although they are the most reliable systems, they come at a cost to environment and hence the push to seek greener alternatives.

vi. ***Hybrid ventilators:*** If human comfort, convenience and reliability are sought with equal concern for environmental impact, it appears that a compromise solution may be the most effective. Thus some form of hybrid solution may be explored that will provide air extraction capacity at all times and operate in all conditions. This would make it useful for applications that require a continuous flow rate of air.

The hybrid solution will have high initial costs, but these can be offset by designing the device such that the use of mains electricity is minimised. The use of solar power may be promoted by sizing the solar array such that sufficient power is available for good ventilator performance during marginal light conditions. Using, for example, a standard "whirlybird" as the basis of the hybrid ventilator may also allow the wind to power the device.

Attempts can be made to improve the performance of the device with respect to the ability to extract energy from the wind. The current wind driven device uses a single element to act simultaneously as both a turbine and pump. Due to this compromise, neither the tasks of spinning the ventilator nor extracting air is performed in an optimum manner.

The use of wind power can be promoted by physically separating the turbine and pump. The turbine can then be optimised to extract energy from low speed wind more effectively.

Each of the methods of air extraction discussed above has its own advantages and disadvantages. These are summarised in Table 1 to highlight where a hybrid solution will be useful.

3. Towards hybrid ventilation solution

In this section, various attempts made by the author and his team at the University of New South Wales leading towards the development of concepts in favour of hybrid ventilation systems are described.

The most important parameter by which ventilation device is sold is by air extraction or volumetric flow rate. The experimental procedure used was formulated after considering testing procedures outlined in Australian Standards on the classification and performance testing of natural ventilators [12], and the measurement of fluid flow in closed conduits [13] Consideration was also given to general wind tunnel testing procedures at low wind speeds [14] The aim of the project was to discover performance benefits on a comparative basis. The procedures outlined in Australian Standards are designed to produce exact quantitative values for the purposes of classification and calibration.

General scientific testing methods were more appropriate for this situation. This included such procedures as keeping external variables constant whilst a given variable of interest was tested, taking measurement values as a mean over a given time interval, and the use of due care when instruments were set up and calibrated. Adhering to standard scientific

	Advantages	Disadvantages
Natural convection	- Uses renewable energy - Simple - Cheap - Very Reliable.	- Marginal flow rate - Cannot guarantee flow rates required for occupational health and safety - Less effective at night
Wind cowlings	- Uses renewable energy - Improved air Extraction rate compared with natural convection - Relatively simple - Reliable	- Low flow rate - Flow rate not guaranteed. - Less effective at night - Cowling may impede natural convection
Wind powered centrifugal ventilator	- Uses renewable energy - Flow rate good - Simple - Reliable	- Cannot guarantee flow rate - Relies exclusively on wind energy for operation - Flow rate depends on wind strength - Combined pump and turbine design a compromise - Can be expensive
Solar powered axial ventilator	- Uses renewable energy - Flow rate good - Relatively simple - Reliable	- Cannot guarantee flow rate - Relies exclusively on solar Energy for operation - Flow rate depends on light levels - High initial cost
Mains powered ventilator	- Flow rate excellent - Flow rate continuous - Operates at all times and in all conditions	- Relies completely on mains power (non –renewable energy) - High initial cost
Hybrid solution	- Flow rate very good - Flow rate continuous - Powered mainly by renewable energy - Operates at all times and in all conditions	- May sometimes rely on mains power - High initial cost - Complex - May be less reliable mechanically

Table 1. Advantages and disadvantages of current ventilation technologies

testing protocols provided rapid evidence of performance trends, and confidence in the trends being genuine. The purpose of the project was to discover these performance trends, which had a higher priority than obtaining extremely precise measurements.

Experimental set-up

The testing of various ventilation devices was undertaken in the aerodynamics laboratory at the University of New South Wales. The ventilators were screwed to the top of an inlet tube fitting and placed at the exit of a low speed jet wind tunnel [15]

The inlet tube fitting was used to stabilize the airflow to the ventilation devices while they were under test. The inlet tube arrangement had a total centreline length of approximately 2660 mm, which was measured from the inlet plane between the top of the vertical tube and

ventilator mounting flange. The 900 elbow had seven turning vanes mounted internally to reduce losses as the air negotiated the bend. The air entering the inlet cone was under the ambient conditions of the laboratory, and was not conditioned in any way.
A precision anemometer equipped with a long sensor probe was used to take velocity measurements across the flow profile in the inlet tube fitting (Fig 6). The anemometer sensor probe was used to take individual air velocity readings as averages over a one minute interval. The anemometer probe was traversed using a laboratory stand equipped with a precision vertical screw adjustment.
Readings were taken at each centimetre across the central 12 cm of the inlet tube (Fig 7), which had an overall internal diameter of 14.625 cm. The velocity at the inside tube walls was assumed to be zero. These 15 air velocity measurements (13 measured plus 2 assumed) were averaged to get the mean velocity of the flow profile in the tube. This velocity was then used with the internal tube diameter to determine the volumetric flow rate.

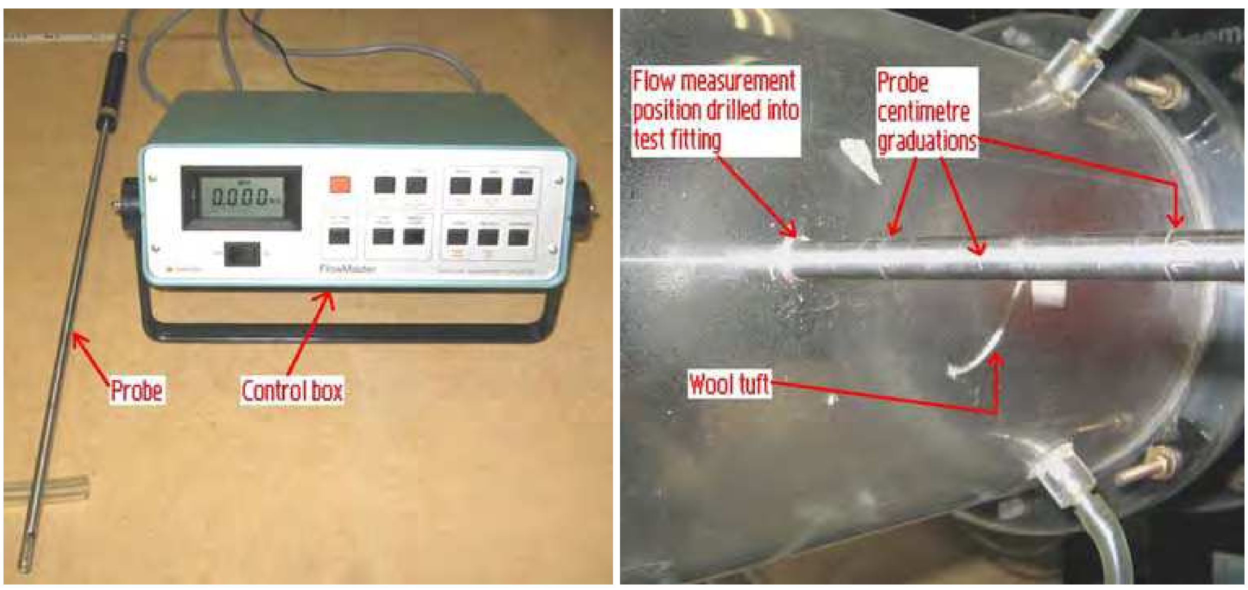


Fig. 6. Precision anemometer / centimetre graduations on probe

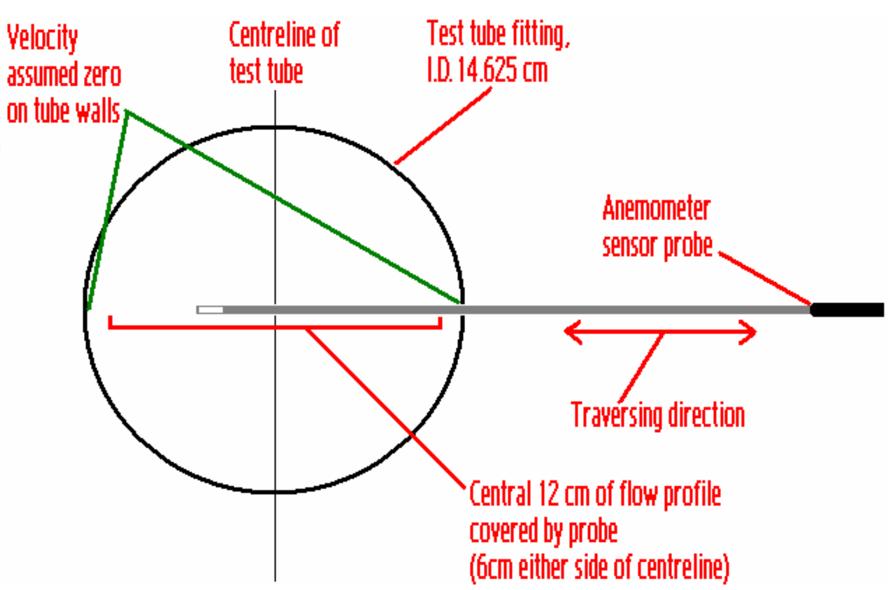


Fig. 7. Velocity measurements across flow profile in test tube fitting

Tests on Standard turbine ventilator

The testing of the standard turbine ventilator (Fig 8) is a commercially available turbine ventilator manufactured by CSR Edmonds Pty Australia Ltd was carried out to serve as a benchmark. The rotating element was 200 mm in diameter whilst the blades had a height of 47.5 mm. The device operated by using a small portion of the blades to extract energy from the incident wind. This energy spun the device which extracted stale air by centrifugal action.

Fig. 8. Standard turbine ventilator by Edmonds
(Image: www.edmonds.com.au)

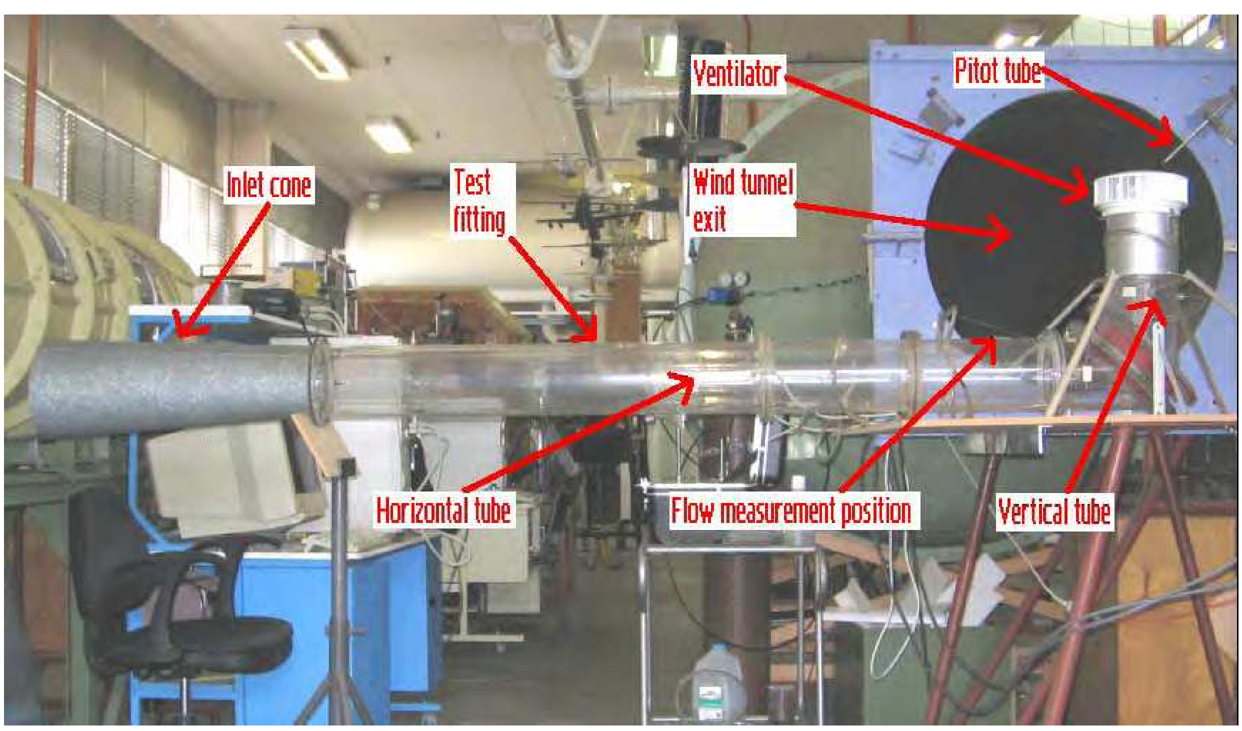
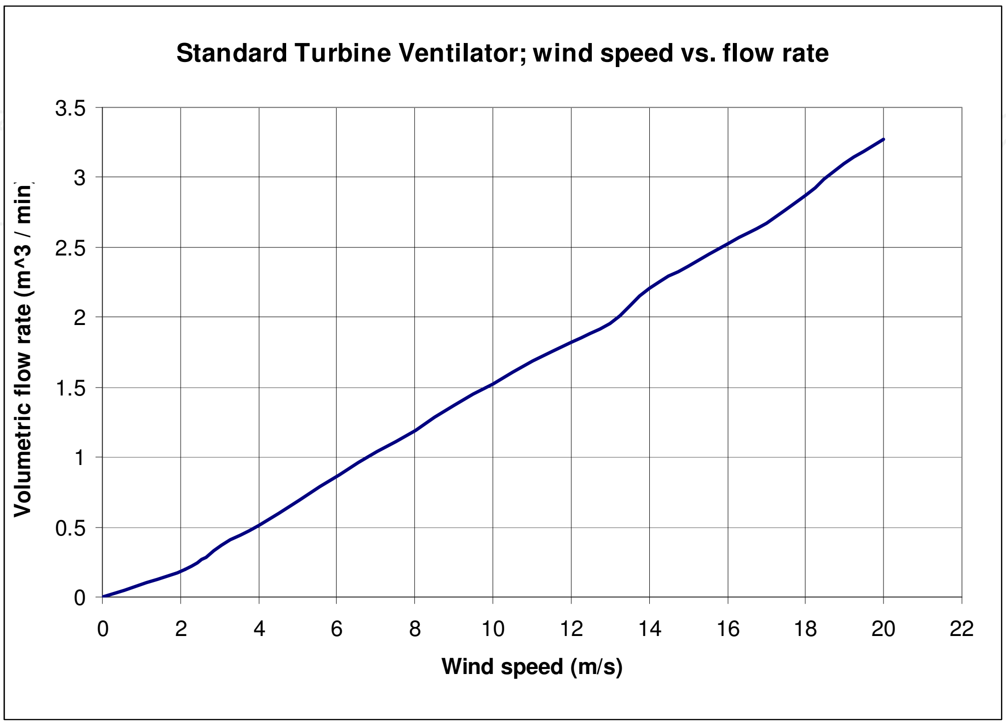
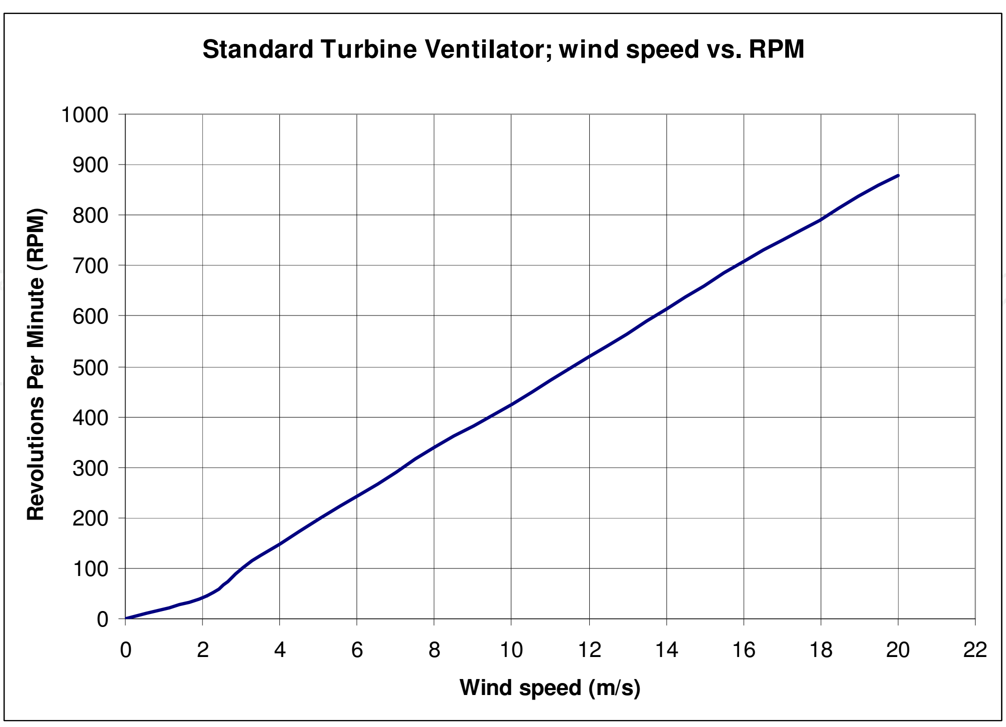


Fig. 9. Ventilator test fitting located at wind tunnel exit

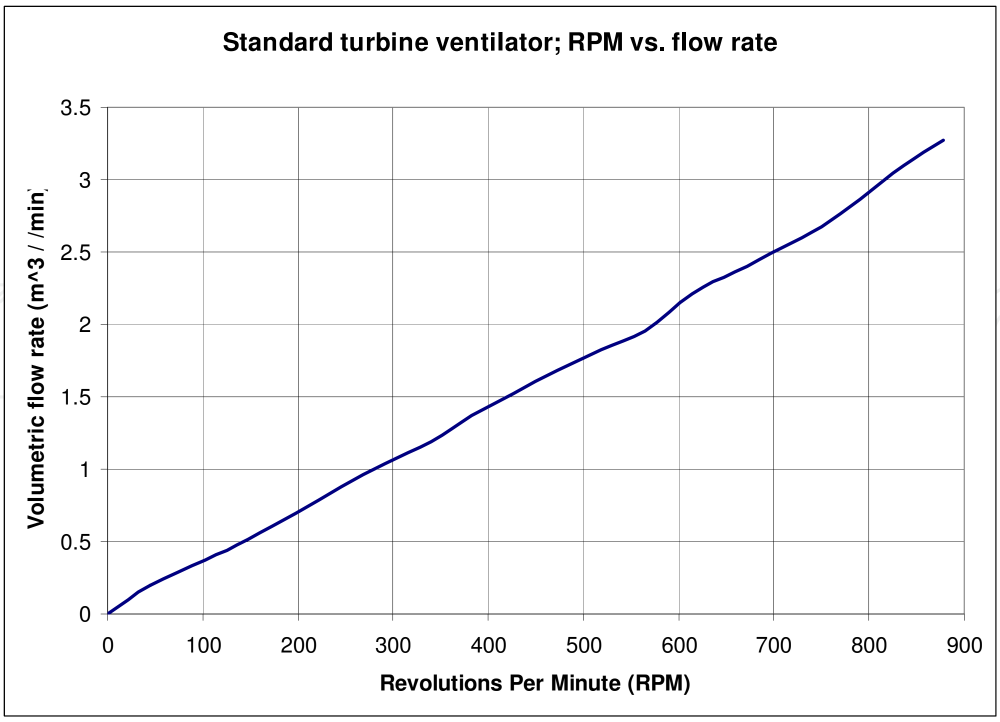
The three graphs (Graphs 1-3) were established as the benchmark for comparison with other modes of ventilation. The only feature worth noting is the linear relationship that exists between wind speed and volumetric flow that is the higher the wind speed the higher is the volume flow rate.



Graph 1. Standard turbine ventilator; wind speed vs. volumetric flow rate



Graph 2. Standard turbine ventilator: Wind speed vs. RPM



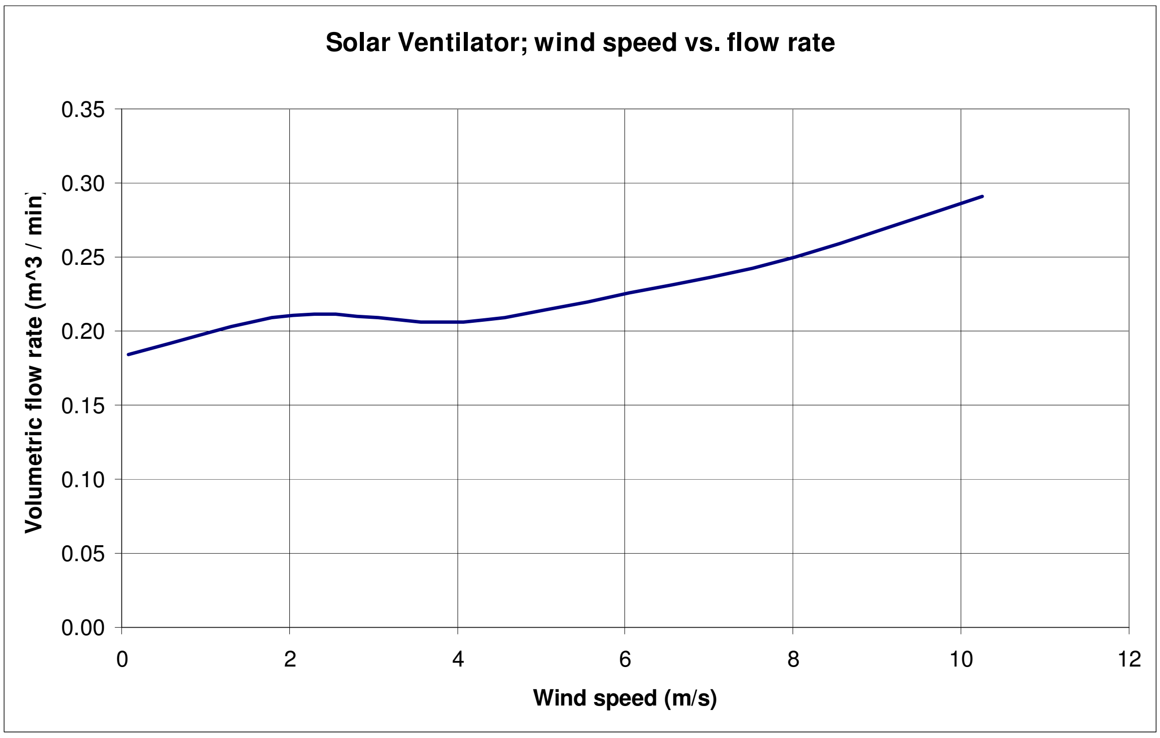
Graph 3. Standard turbine ventilator; RPM vs. volumetric flow rate

Tests on Standard Solar powered ventilator

The solar powered ventilator used in this study was a single unit that contained the solar cell, motor, and fan (Fig 10).

Fig. 10. Solar powered ventilator

The Solar Ventilator was a commercial ventilator intended for use on water vessels, trailers and camper vans. The device uses an axial fan to extract stale air. The stale air is drawn into the inlet situated on the bottom of the device by the 5-bladed axial fan. This air then travels through internal passages where it is subsequently expelled through the annular outlet. The diameter of the propeller and inlet is approximately 98mm. The diameter of the outlet annulus is approximately 246 mm with a height of 5mm. The device was chosen as it was intended for the same applications as the turbine ventilator, and it had the same overall physical size, which facilitated testing on the same apparatus.
The performance of the solar ventilator was severely hampered by the small size of the fan, the tortuous internal flow path and the very small height (and subsequent area) of the exit



Graph 4. Solar ventilator; wind speed vs. volumetric flow rate

annulus. One of the intended applications of the solar ventilator is the ventilation of boat cabins. As a consequence, the ventilator is designed to keep water out, and the ventilation ability of the device suffers.

Due to the poor flow characteristics of the device, the only useful data was collected when the device was operating at full voltage conditions. This voltage was an average of 1.0195 volts, which was close to the figure collected from the outside sun survey. Under full voltage conditions, the volumetric flow rate was about 0.194 m^3/ min at zero wind tunnel speed.

A cross wind of 10 m/s gave a flow rate approaching 0.3 m^3/ min. The inclusion of cross wind in the air extraction capability of the solar ventilator seemed to be the intent of the manufacturer, as they quoted a flow rate of 680 ft^3/hr (0.3209 m^3/min) under normal conditions. The physical arrangement of the solar ventilator made it impossible to get RPM readings whilst the device was mounted on the test tube fitting.

Graph 4 shows the relationship between wind speed and volumetric flow rate for a variety of cell voltages. As seen in this Graph 4, the advantage of the solar ventilator was lost regardless of the cell voltage at wind speeds above 10 m/s. The advantage of higher cell voltages was most apparent at zero and low wind speeds, which was the most important consideration for the project. Both graphs indicated the performance benefit of the design at zero and low wind speed when a reasonable amount of sunlight was present.

Tests on Hybrid Ventilator: Standard ventilator with solar ventilator on top

A solution to the problem of zero wind speed operation was conceived to be a ventilator that could be powered by the wind and the sun. The hybrid device was constructed from the two ventilators both powered by renewable energy.

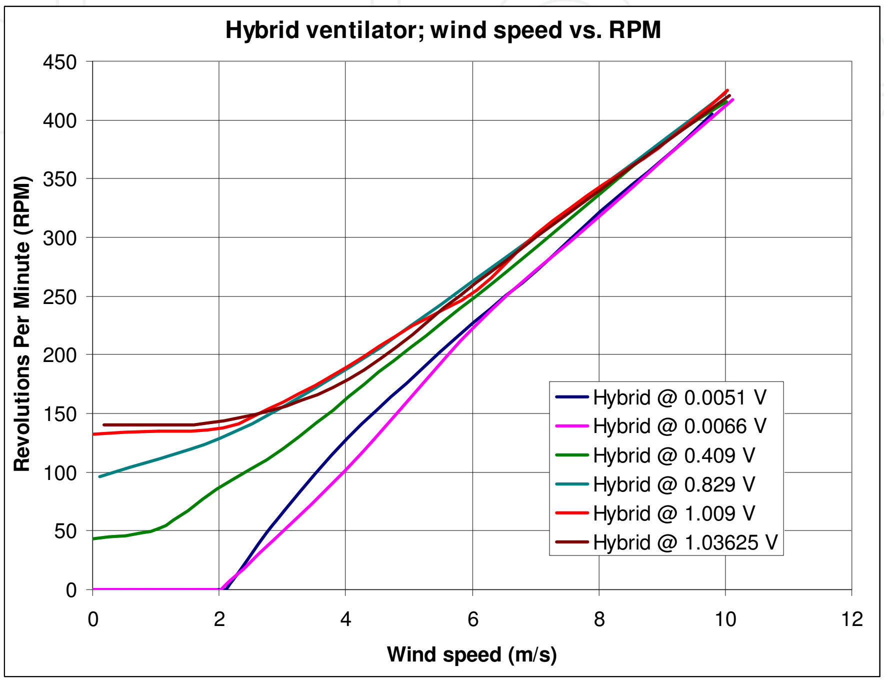
Fig. 11. Constituent parts of wind-solar hybrid ventilator

Fig. 12. Test set-up of wind-solar hybrid ventilator

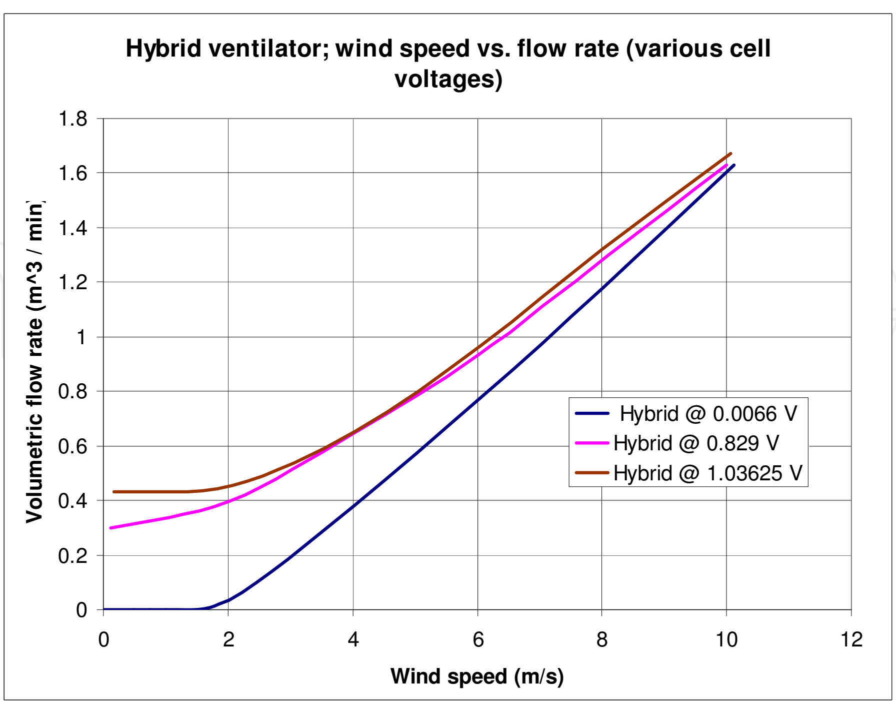
The solar cell and motor from the solar ventilator was combined with the Edmonds turbine ventilator to produce the Solar-Wind Hybrid design (Fig 11). The test set-up is shown in Fig 12.

The feasibility and shortcomings of the initial hybrid design were confirmed by comparing the performance characteristics of the three devices. The solar ventilator was compared with the hybrid device at the same voltage levels whilst the turbine ventilator was compared to the hybrid device at the same wind speeds.

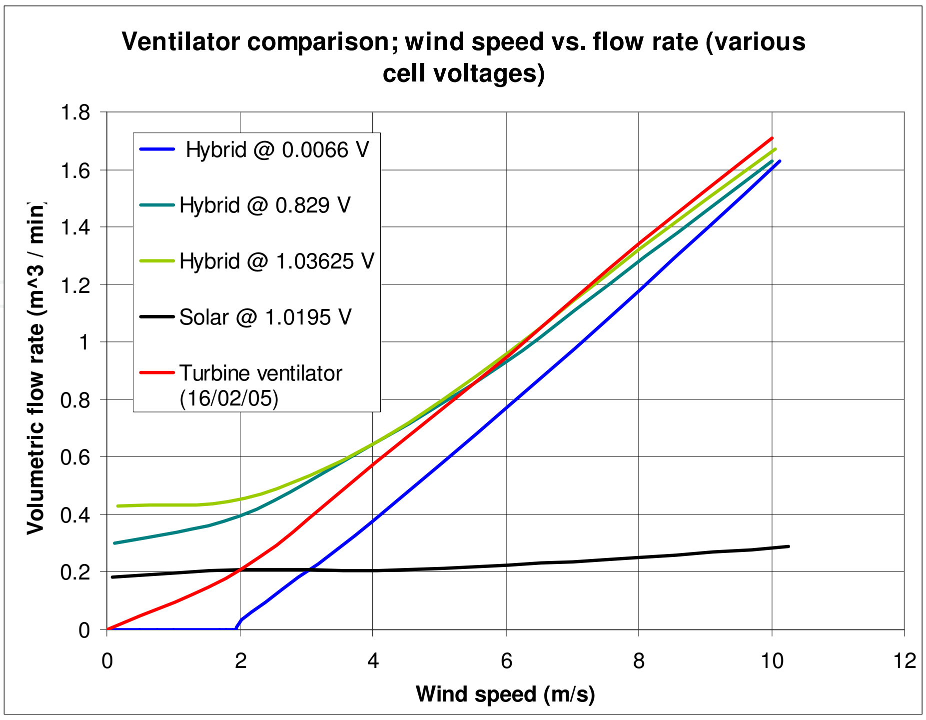
Graph 5 represents the rotational speed of the hybrid ventilator under various wind speeds and cell voltages. The performance chart shows the convergence of the RPM under various cell voltages above 10 m/s. The important characteristic for the project was the RPM advantage enjoyed at zero and low wind speeds (below 4m/s wind speed) when cell voltages were at 0.409 V and above. The cell voltage of 1.03625V was slightly less than the cell voltage achieved under ideal conditions during the sun survey. Despite the low power output of the cell, there was enough energy to spin the turbine ventilator at approximately 140 RPM under ideal sun conditions with no wind. Part power of 0.409V was able to spin the ventilator at around 43 RPM. This would certainly give some ventilation capacity at zero wind speed.



Graph 5. Solar-Wind Hybrid ventilator; wind speed vs. RPM for various cell voltages



Graph 6. Solar-Wind Hybrid ventilator; wind speed vs. flow rate for various cell voltages



Graph 7. Ventilator comparison; wind speed vs. volume flow rate

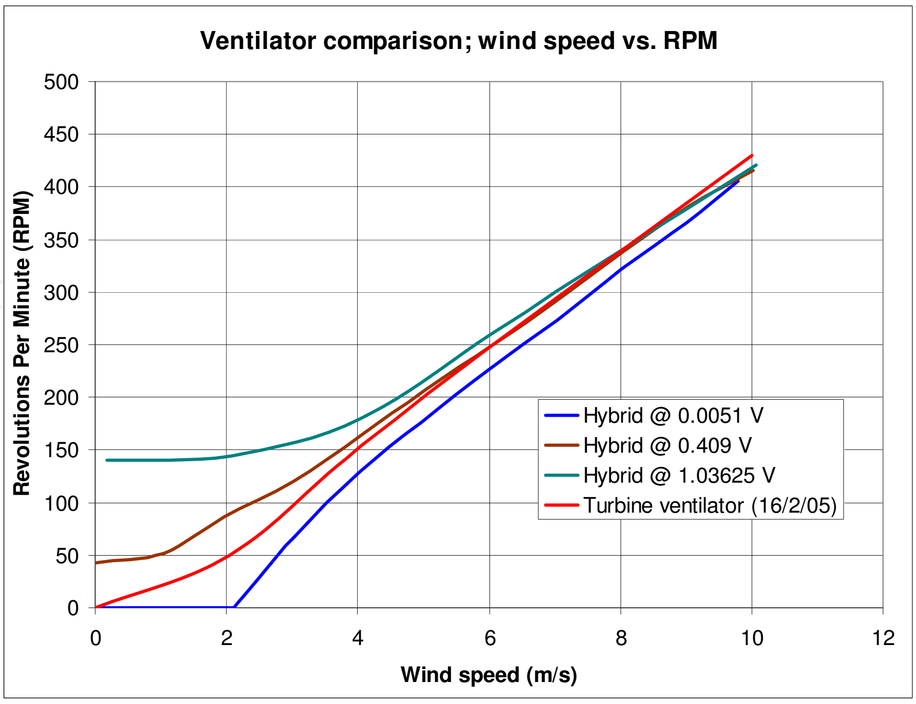
Graph 6 shows the relationship between wind speed and volumetric flow rate for a variety of cell voltages. As with Graph 5, the advantage of the Wind-Solar Hybrid ventilator was lost regardless of the cell voltage at wind speeds above 10 m/s. The advantage of higher cell voltages was most apparent at zero and low wind speeds, which was the most important consideration for the project. Both graphs indicated the performance benefit of the design at zero and low wind speed when a reasonable amount of sunlight was present.

Graph 7 reveals the performance of the ventilators under different wind and sun conditions. The first point of interest was the vastly superior performance of the hybrid device compared to the solar ventilator. The performance curve for the solar ventilator was taken under full cell voltage conditions. When compared to the hybrid ventilator under the same power level, the hybrid ventilator had much better volume flow rate.

Even under zero wind conditions, the hybrid ventilator had a higher flow rate than the solar ventilator subjected to 10 m/s wind speed. This advantage was enjoyed even when the hybrid ventilator was subjected to less than full power.

When compared at 10 m/s wind speed, the hybrid ventilator had a flow rate more than 5 times greater than the solar ventilator. The performance curves starkly illustrated the higher efficiency of the hybrid ventilator compared to the standard solar ventilator. Such a performance advantage added to the weight behind the feasibility of the hybrid device.

The Wind-Solar Hybrid device also compared well with the turbine ventilator. Graphs 7 and 8 showed that the performance advantage of the Solar-Wind Hybrid ventilator under full power was not lost to the turbine ventilator until the wind speed was above 6.5 m/s (Graph 7). Even under part power conditions of 0.409V, the hybrid device had an advantage of up to around 5 m/s wind speed (Graph 8). For the zero to low wind speed regime (less than 4m/s), the hybrid device enjoyed an advantage even under less than ideal sun conditions.



Graph 8. Comparison of Solar-Wind Ventilator with Standard Wind or Turbine Ventilator; wind speed vs. RPM

The most important finding was that the hybrid ventilator enjoyed a performance advantage above both the turbine and solar ventilators at the zero to low wind speed regime (0-4 m/s). This advantage was apparent even under less than ideal sun conditions.

The major shortcoming of the hybrid device was operations under wind power alone (zero cell voltage). The performance of the hybrid device under such conditions lagged behind the turbine ventilator for all wind speeds. The performance of the hybrid device under such conditions also lagged behind the solar ventilator below a wind speed of 3 m/s. This performance deficit under zero cell voltage was attributable to the wind having to back-drive the electric motor, which acted as a generator under such

Tests on Hybrid Ventilator with a horizontal axis wind turbine

The test fitting was modified to accommodate the horizontal axis configuration and the use of an additional test stand containing the propeller and bearing housing was required (Fig 13). The combined test set-up with standard ventilator is shown in Fig 14.

Graph 9 is a performance plot of wind speed vs. RPM, which is a measure of the effectiveness at which energy is extracted from the wind. The numbers refer to the blade pitch angles of the propeller.

The horizontal axis design exhibited superior performance to the turbine ventilator (dark blue line) at blade pitch angles above 37.5°. The blade pitch angle of 75° (purple line) gave the best performance. For any given wind speed, the horizontal axis ventilator with a 75° blade pitch angle managed to extract enough energy to spin at 2.5 times the rotational velocity of the standard turbine ventilator.

Beyond an angle of 75°, the performance of the horizontal axis ventilator dropped off, as the blade chord was becoming perpendicular to the incident wind.

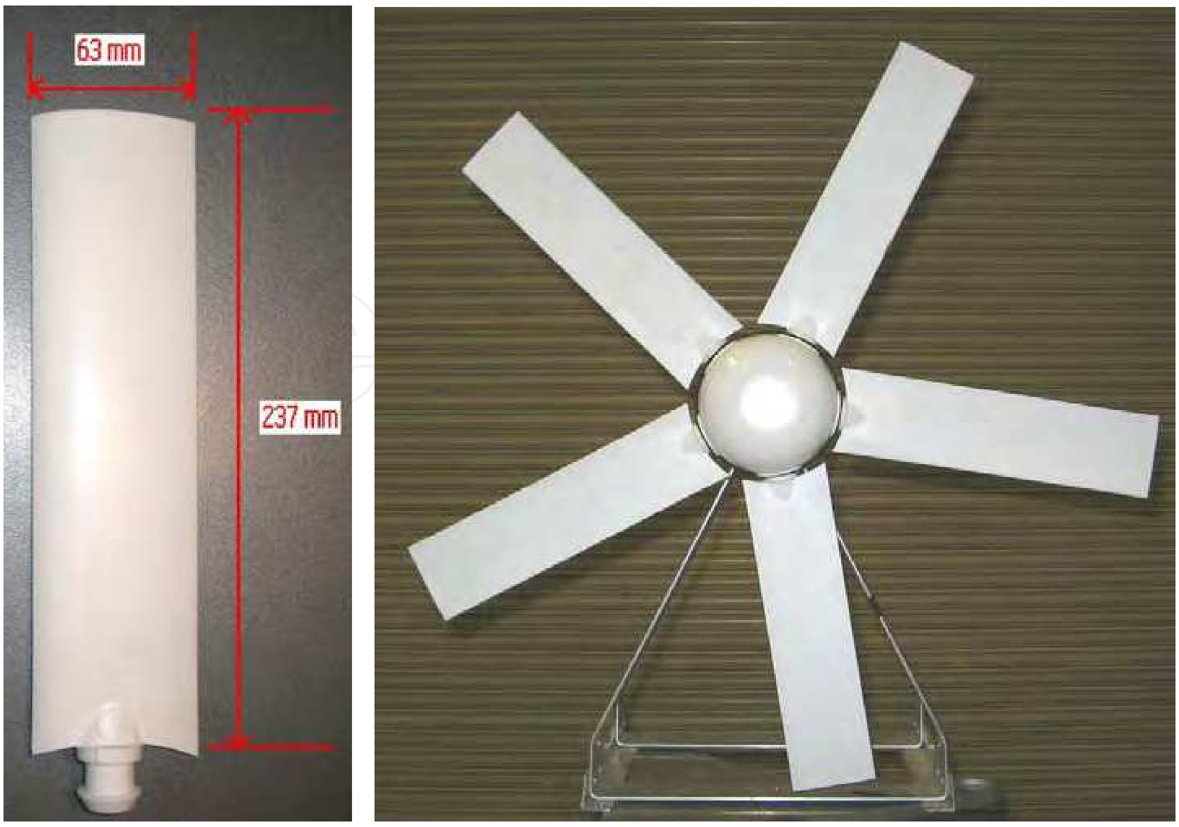


Fig. 13. Individual blade / complete propeller

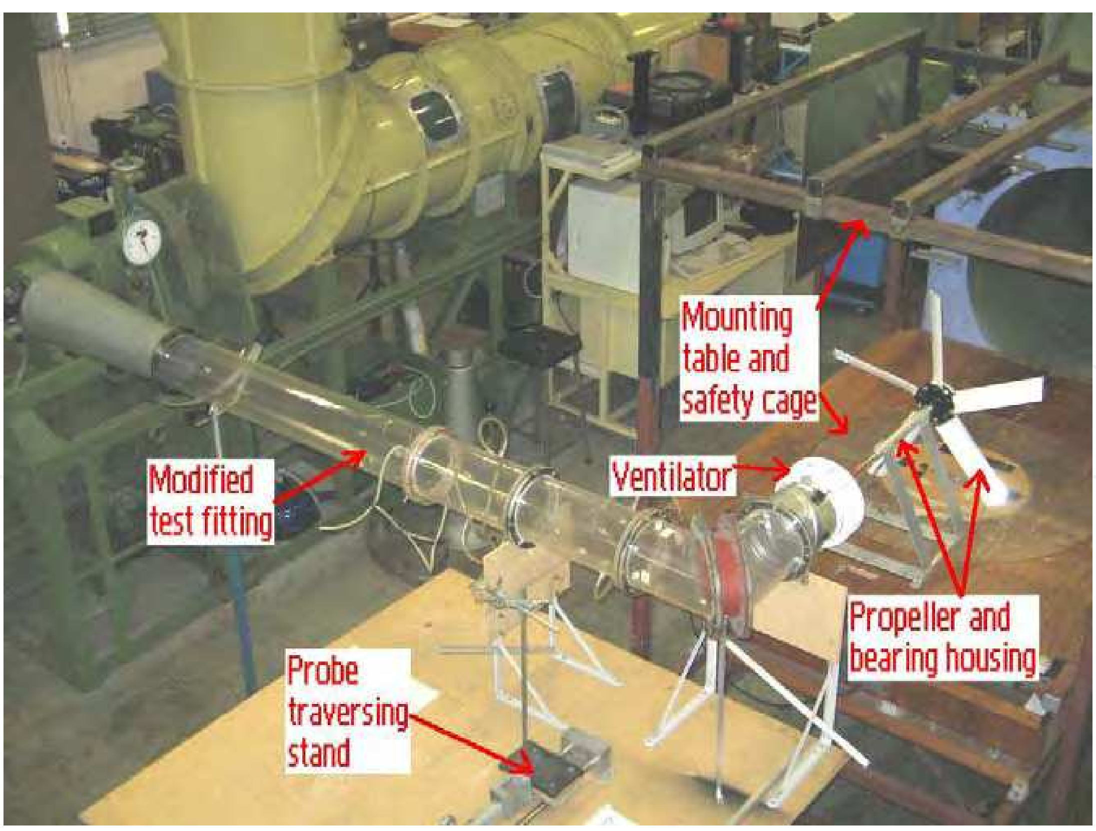
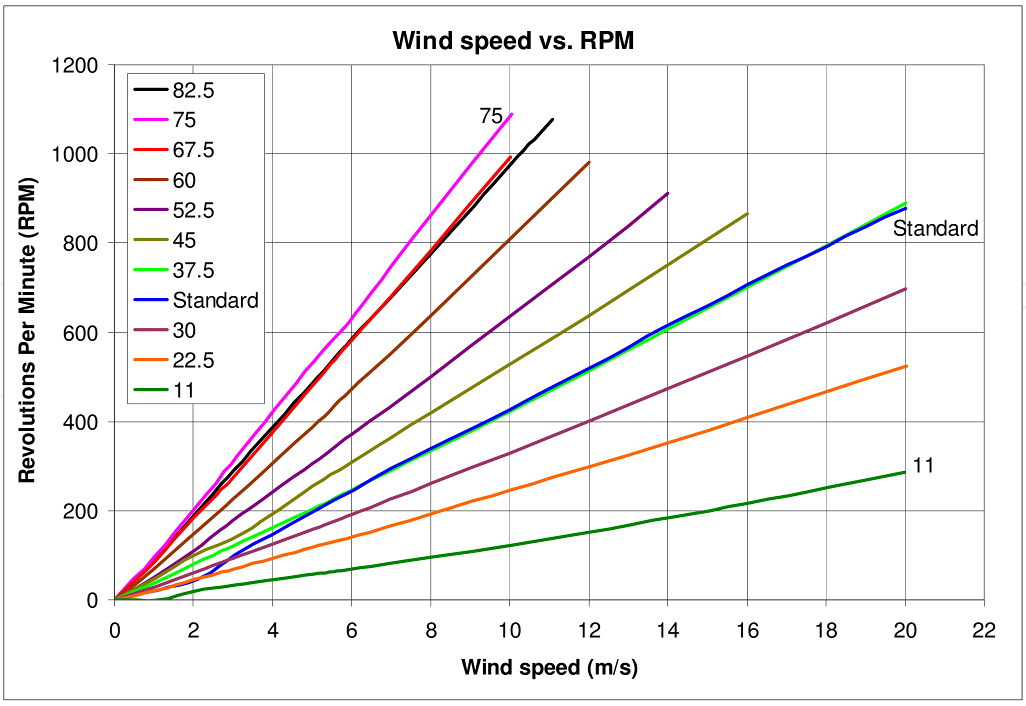
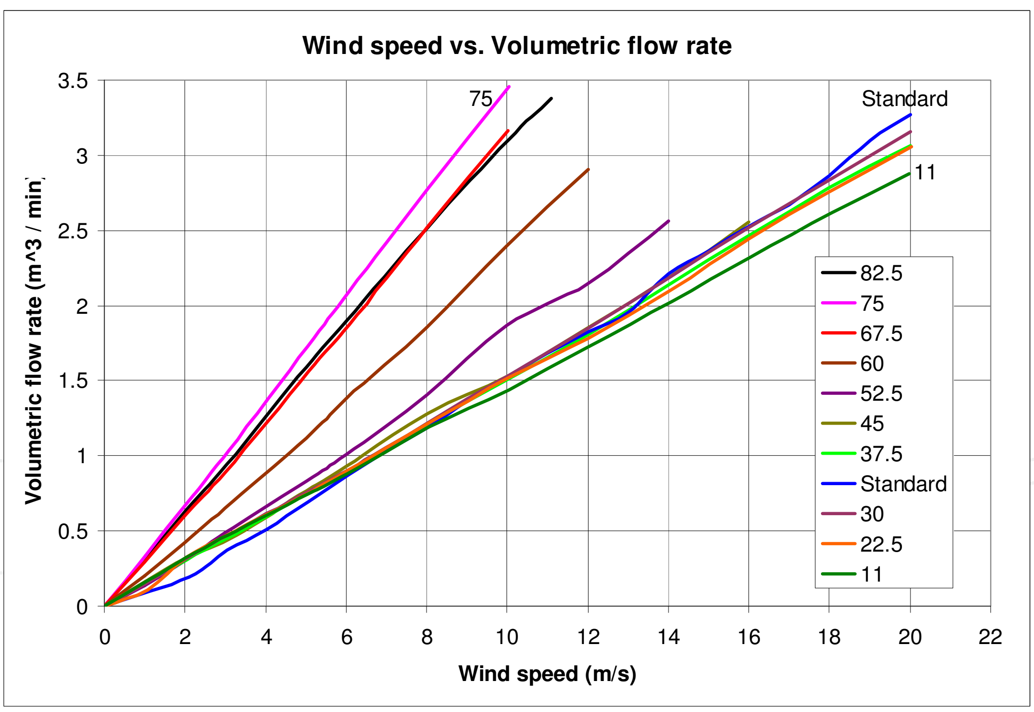


Fig. 14. Horizontal axis ventilator test set-up



Graph 9. Wind speed vs. RPM



Graph 10. Wind speed vs. volumetric flow rate

Graph 10 is a performance plot of wind speed vs. volume flow rate. Again, the 75° pitch angle (purple line) proved to have the best performance. For any given wind speed, the horizontal axis ventilator with a 75° blade pitch angle managed to create an air flow that was more than 2 times greater compared with the standard turbine ventilator (dark blue line).

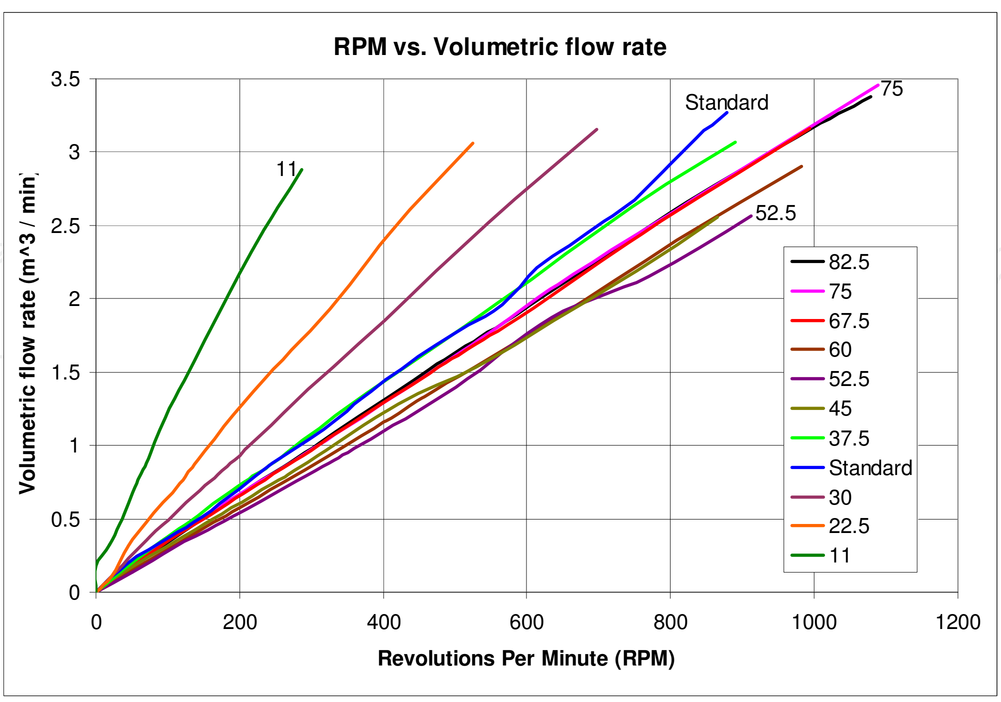
An interesting observation was the performance of the horizontal axis ventilator with blade angles below 37.5°. Compared with graph 9, the volume flow rate did not drop off as dramatically as RPM for the shallower pitch angles (blade chord approaching parallel with incident wind). Such an interesting result was accounted for by the cross-flow of incident wind across the ventilator (pump) due to the horizontal axis configuration. The following performance graphs quantify the phenomenon.

Graph 11 is the performance plot of RPM vs. volumetric flow rate, which indicates the effectiveness of the pump with respect to rotational velocity. The 11° pitch angle proved to have the best pump performance with respect to RPM. It was somewhat unfortunate that this shallow blade pitch angle never produced enough RPM to exploit the advantage. The standard turbine ventilator proved to have slightly better performance than the horizontal axis ventilator at a blade pitch of 75°.

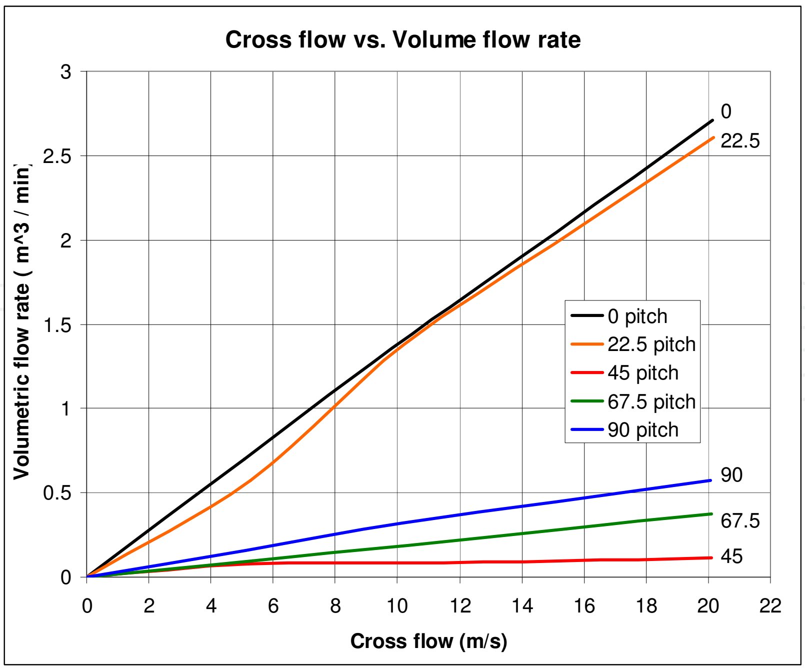
A surprising result was that a blade pitch angle of 52.5° produced the worst pump performance with respect to RPM. This may be accounted for by the combined swirl and axial velocity of the incident wind after it has passed through the propeller disc. This particular combination of swirl and axial velocities seemed to minimize the beneficial cross-flow effect. The actual flow rates induced by the cross-flow appear in the following performance chart.

Graph 12 gives an indication of the volume flow rate induced by cross flow across the ventilator (pump). This data was taken by restraining the propeller, and gives a rough indication of the significance of cross flow.

A blade pitch angle of 11° gave the most amount of induced flow rate, with a blade angle of 45° giving the least amount. This data confirms the results plotted on performance Graph 11. As the incident wind passes through the propeller disc, energy is extracted which rotates the device. The propeller induces a residual swirl on the incident wind as it leaves the propeller disc. The results indicate that at blade angles around 45°, the residual swirl was of such a magnitude and direction as to significantly reduce the amount of cross-wind induced flow.



Graph 11. RPM vs. volume flow rate



Graph 12. Cross flow vs. volume flow rate

4. Conclusions

Current building ventilators individually rely upon a single source of energy for operation. The turbine ventilator relies entirely of the prevailing wind conditions with no facility to extract energy from the sun. The solar ventilator is at the complete mercy of ambient solar radiation conditions and cannot extract energy from the wind.

The initial Wind-Solar hybrid ventilator was considered a solution to the problem of turbine ventilator operation at zero wind speeds. Air extraction capability at zero wind speed was provided by using an electric motor and solar cell to power the turbine ventilator. The significant findings upon testing of this hybrid design were the vastly improved flow rate performance compared with a purely solar powered ventilator; comparable performance with the standard turbine ventilator, and the vastly improved operational flexibility of the device. The standard turbine ventilator acting as a centrifugal pump provided much better air flow compared to an axial propeller subjected to the same power input. The hybrid design had slightly less performance than the turbine ventilator alone. This was mainly due to the back-driving of the electric motor under zero solar radiation conditions, and the crudity of the device.

The performance level of the hybrid device was vastly improved by removing the solar cell from atop the rotating ventilator and decoupling the electric motor on overrun with a one way bearing. The combination of the turbine ventilator and solar powered ventilator provided a hybrid design that had vastly improved flexibility of operation compared to the individual constituent components.

The horizontal axis ventilator was a solution to the marginal performance of a turbine ventilator at low wind speeds. Testing of the horizontal axis ventilator found significantly improved performance at low wind speed conditions. The device extracted more than double the volume flow rate of air and spun at more than twice the RPM for any given wind speed condition.

The overall conclusion is that a continuous pre-determined volume air-extraction ventilator that relies predominantly on renewable energy is entirely possible.

5. Future possibilities

With environmental issues taking centre stage and government and private funding forthcoming, future possibilities may result in completely different philosophies and different models of energy usage and human life style. The performance criteria of high volume air extraction rate of natural ventilators that rely on wind and sun may be replaced by the philosophy of providing an optimum temperature, humidity and air circulation levels. From a consideration of this philosophy the concept of the Wind-Electric Hybrid ventilator, the 'ECO-POWER' was conceived with the collaboration of CSR Edmonds Australia Pty Ltd as an alternative to the conventional air conditioning units. The electric power currently is drawn from the mains power supply. Various improvements are still needed to make this type of ventilator a commercial reality for both domestic and industrial applications. A computer aided drawing of the ventilator is shown in figure 15.

Fig. 15. A Computer aided image of Wind-Electric ECO-POWER

From the studies presented in this chapter at least, a system is entirely feasible that involves the convergence of the hybrid ventilation of standard wind powered design with possibly horizontal axis design and solar powered models. This with further improvements in electricity storage capabilities and efficient electronic control module, a vastly improved single cost effective ventilation system is just around the corner.
With rapid improvements in the performance of solar cells, electronics and power storage systems and continuous drop in costs of their production, together with the emergence of new technologies, it is not unrealistic to expect future ventilators to evolve with many innovative concepts and ideas currently unheard of.

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