

WIND ENERGY SYSTEM

Field of the Invention

- 5 The present invention relates to a wind energy system, particularly, though not exclusively, for building.

Background of the Invention

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- Wind turbines are currently available for mounting on the roof of a building to drive a generator for generating electricity to at least partially meet the electrical power needs of the building. Applicant has previously
15 devised an energy conversion system for a building comprising one or more wind turbines that are disposed along a ridge of a pitched roof. The system also comprises a cover supported by the pitched roof where the cover has a pitch less than the pitch of the pitched roof.
20 The cover and the roof structure together create a wind tunnel that directs wind to flow through the wind turbines.

- Further details of Applicant's abovementioned system are
25 provided in Singapore patent application No. 200716868-5.

The present invention is a result of further research and development in the area of wind energy systems.

30 Summary of the Invention

According to one aspect of the present invention there is provided a wind energy system comprising:

- 35 a wind tunnel module having first and second openings at opposite ends, and an intermediate portion located between the first and second openings, each opening having

substantially the same cross sectional area, the wind
tunnel module reducing in cross sectional area from each
opening in a direction toward the intermediate portion,
wherein the intermediate portion has a substantially
5 constant cross sectional area;

one or more wind turbines supported in or adjacent
the intermediate portion; and

10 at least one electric generator driven by at least
one of the wind turbines.

Each opening may be configured to receive wind incident at
an angle of up to 60 degrees from either side thereof.

15 The intermediate portion may be in the form of a flexible
or otherwise bendable tube.

The wind tunnel module may further comprise first and
20 second tunnel portions, one at each end of the
intermediate portion, the first tunnel portion having a
mouth defining the first opening and the second tunnel
portion having a mouth defining the second opening.

25 The wind tunnel module may further comprise a first
turbine housing located adjacent one end of the
intermediate portion and a second turbine housing located
adjacent an opposite end of the intermediate portion.

30 The wind energy system may comprise two wind turbines.

An electric generator may be provided for each wind
turbine.

35 In an alternate embodiment, a single generator may be
provided which is driven by both of the wind turbines.
This embodiment may be particularly useful in a high and

strong wind environment, but is not limited to such an environment. At least one of the generators may be mounted in a hub of a turbine. It is envisaged in embodiments where the wind energy system comprises two turbines, that
5 the wind turbines may have the same or different wind flow characteristics. In particular, in some embodiments, the turbines may be provided with different numbers of blades.

In one embodiment, one or more of the wind turbines is
10 provided with a plurality of radially extending blades and an outer circumferential surface surrounding an outer radial edge of the blades. One or more of the wind turbines may further comprise an intermediate circumferential surface intersecting the turbine blades at
15 a radial location intermediate of an axis of rotation of the turbine and the outer circumferential surface.

The wind energy system may further comprise a covering overlying the wind tunnel module. The covering may
20 comprise first and second portions that are adjustably coupled together to enable adjustment of an angle between the portions along a line perpendicular to a direction of extent of the intermediate portion.

25 A further aspect of the present invention provides a wind energy conversion system for a building comprising: a plurality of wind energy systems in accordance with the first aspect of the present invention wherein the wind energy systems are arranged side by side and, a waterproof
30 covering overlying the plurality of wind energy systems, the covering having opposite longitudinal edges that extend to at least cover the intermediate portion of each wind energy system. The cover may comprise first and second portions adjustably coupled together to enable
35 adjustment of an angle between the portions along a line perpendicular to a direction of extent of the intermediate portions.

A further aspect of the present invention provides a wind tunnel module comprising first and second openings at opposite ends, and an intermediate portion located between the first and second openings, each opening having
5 substantially the same cross sectional area, the wind tunnel module reducing in cross sectional area from each opening in a direction toward the intermediate portion of the wind tunnel module, wherein the intermediate portion has a substantially constant cross sectional area.

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Yet a further embodiment of the invention provides a wind energy system comprising: a wind tunnel having open opposite ends to allow wind to pass in either direction through the tunnel; two wind turbines, one located at or
15 near each end; and, an electric generator driven by the wind turbines. In this embodiment the wind turbines may be configured to provide a collective Betz limit of up to 0.83.

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Brief Description of the Drawings

Embodiments of the present invention will now be described by way of example only with reference to the accompanying
25 drawings in which:

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Figure 1 is a schematic perspective view of one embodiment of a wind energy system applied to a roof of a building;

Figure 2 is a view of section AA of the system depicted in Figure 1;

Figure 3 is a front elevation view of one embodiment
35 of a wind turbine that may be incorporated into a wind energy system;

Figure 4 is a representation of a further wind turbine that may be incorporated in a wind energy system;

Figure 5 is a representation of another wind energy turbine that may be incorporated in the system; and,

Figure 6 is a schematic plan view of wind coverage at a broad end of a wind tunnel incorporated in the wind energy system.

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Detailed Description of Preferred Embodiment

Referring to the accompanying drawings and in particular Figures 1 and 2 an embodiment of a wind energy system 10 according to the present invention comprises a wind tunnel module 12 having openings 14a and 14b (hereinafter referred to in general as "openings 14") at opposite ends. The openings 14 have substantially the same cross sectional area although the cross sectional area of the wind tunnel module 12 decreases from the openings 14 in a direction toward an intermediate portion 16 of the tunnel module 12. The intermediate portion 16 has a substantially constant cross sectional area. The system 10 may comprise one or more wind turbines 18a, 18b or 18c (hereinafter referred to in general as "turbines 18") as exemplified in Figures 3-5 respectively. The turbines 18 are mounted in the system 10 in or adjacent the intermediate portion 16. At least one electric generator (not shown) is also provided which is driven by at least one of the wind turbines 18.

In the embodiment depicted, the system 10 is one of a plurality of identical adjacent systems 10 mounted side by side on a pitched roof 20 with the intermediate portion 16 spanning a ridge 22 of the roof 20.

Turbine housings 24a and 24b (hereinafter referred to in general as "housings 24") are located at respective opposite ends of the intermediate portion 16. The housings 24 have an inner diameter which is similar to
5 that of the intermediate portion 16. The housings 24 also act as a coupling between the intermediate portion 16 and respective tunnel portions 26a and 26b of the wind tunnel module 12.

10 With reference to Figure 6, each opening 14 is configured to enable the wind tunnel module 12 to receive wind incident at an angle α of up to 60 degrees from either side of the opening (which is equivalent to an angle α with a longitudinal axis Y of the opening 14 and tunnel
15 26). Figure 6 also illustrates one possible shape and configuration of side walls 25 of the tunnel portion 26 which provide the decrease in cross sectional area of the wind tunnel module 12 from the opening 14 in a direction toward an intermediate portion 16 of the tunnel module 12.

20 When the system 10 comprises two wind turbines 18, each turbine is mounted in a respective housing 24. Wind W entering one of the openings 14 flows through the adjacent tunnel portion 26 the intermediate portion 16, the other
25 tunnel portion 26 and exits from the opposite opening 14. As the cross sectional area of the wind tunnel module 12 (and specifically the tunnel portions 26) decreases in a direction from the opening 14 toward the intermediate portion 16, there is an accompanying increase in wind
30 velocity. It is known that the power output from a wind turbine is proportional to the cube of wind velocity. Therefore increasing wind velocity will improve power output.

35 It is also known that the kinetic energy of the wind cannot be harnessed with 100% efficiency. Specifically, Betz law establishes that the maximum conversion of

kinetic energy to mechanical energy using a wind turbine is about 59%. The more kinetic energy a wind turbine extracts from the wind, the more the wind is slowed as it passes through the wind turbine. For a wind turbine to be
5 100% efficient the wind speed would need to drop to zero as it leaves the turbine. However, if this speed were to drop to zero then no air would leave the turbine and thus no energy would be extracted because no wind could enter the turbine.

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Some embodiments of the system 10 attempt to provide a composite system where total energy efficiency may be greater than the Betz limit for a single turbine. In one embodiment of the system 10 which may be particularly well
15 suited to high or strong wind environments, where, say, the wind predominantly enters the wind tunnel module 12 from the opening 14a, a ten blade turbine 18a as shown in Figure 3 may be installed in the housing 24a and a six blade turbine 18b as depicted in Figure 4 may be installed
20 in the housing 24b. In this configuration wind energy is harnessed by the ten blade turbine 18a initially and subsequently harnessed by the six blade turbine 18b. Each of the turbines 18 is connected to a generator or alternate via a gear box (not shown) for converting the
25 wind energy into electrical energy.

When the wind W first enters the tunnel module 12 from the opening 14a and the raw wind power is 100% of the power for harvesting.

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The percentage of wind power harvested at the first turbine is,

$$\text{Percentage of Wind Power Harvested at the 1st Turbine} = \eta_{\text{turb}}$$

35

where η_{turbine} is the efficiency of the turbine.

Disregarding the power losses due to friction in the wind tube, the wind power which passed through the first turbine reaches the second turbine is,

5 ***Percentage of Wind Power arriving at the 2nd Turbine = $1 - \eta_{turb}$***

The second turbine also has the efficiency of $\eta_{turbine}$. The compounded efficiency of the dual turbine module is,

10
$$\begin{aligned}\eta_{dual\ turb} &= \eta_{turb} + \eta_{turb}(1 - \eta_{turb}) \\ &= \eta_{turb}[1 + (1 - \eta_{turb})] \\ &= \eta_{turb}[2 - \eta_{turb}]\end{aligned}$$

$\eta_{dual\ turb} = 2\eta_{turb} - \eta_{turb}^2$
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15 Ideal efficiency of the Dual Turbine System would be at Betz Limit. (i.e. having ideal turbines at 59% efficiency)

$$Ideal\ \eta_{dual\ turb} = 2\ \eta_{Betz} - \eta_{Betz}^2$$

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As illustrated above, the use of two turbines in a single module for project sites with strong wind can increase the Betz Limit from 0.59 to 0.83 collectively.

25 In a medium wind environment, and with the wind W predominantly entering the tunnel module 12 from the opening 14a, a ten blade turbine 18a as depicted in Figure 3 may be installed in the housing 24a, while a three blade turbine 18c as depicted in Figure 5 may be installed in
30 the housing 24b. In this embodiment, a generator or alternator may be coupled to only the turbine 18a in the housing 24a, with the turbine 18c not connected to a generator. The three blade turbine 18c acts as a wind pressure compensating turbine that stabilises back
35 pressure in the tunnel module 12 for the turbine 18a to smooth air flow. In addition, the turbine 18c may act as

a suction pump to draw more air through the opening 14a. This action of the turbine 18c may be better understood by considering strong and weak wind situations. In a strong wind the turbine 18c will rotate at speed from the air
5 passing through the upstream turbine 18a. When the wind strength decreases its speed decays slowing due to the principle of conservation of momentum and thus the turbine acts to draw more air into the tunnel from the end housing the turbine 18a.

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In yet a further variation of the system 10, for low wind environments, the system 10 may be provided with only a single turbine being either a 10 or 6 blade turbine 18a, 18b as shown in Figures 3 and 4 installed in the housing
15 24a assuming the predominate direction of the wind W is such that it mostly enters the tunnel module 12 from the opening 14a. No turbine is installed in the housing 24b thereby removing air flow resistance through the tunnel module 12.

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To facilitate easier installation of one or more systems 10 on a roof 20, the intermediate portion 16 may be made from a flexible material or from a bendable structure. This enables a system 10 to closely conform to the pitch
25 high roof 20 with the system 10 bending at a location approximately midway of the length of the flexible portion 16 about the ridge 22. The tunnel portions 26 are typically made from rigid material such as plastics or metal.

30

A covering 30 may be placed over the module 10. The covering 30 may indeed act as additional roof covering providing a water proof barrier. The covering 30 has opposite longitudinal edges 32 which in the depicted
35 embodiment extend marginally beyond an upper extremity of each opening 14 of the tunnel portions 26. However, in alternate embodiments, it is envisaged that the covering

30 be configured so that its edges 32 at a minimum extend to at least cover the intermediate portion 16.

5 The covering 30 comprises two portions or panels 34 that are adjustably coupled together for example by way of a hinge 36 so as to enable the adjustment of an angle between the portions 34.

10 Forming the covering 30 from two portions or panels 34 connected by a hinge 36 and the adoption of a flexible intermediate portion 16 offers collectively a safety feature under an extreme wind storm. In such extreme weather conditions, coupling between the intermediate portion 16 and respective tunnel portions 26a and 26b of
15 the wind tunnel module 12 can be removed, allowing strong wind to escape vertically by lifting the respective portion or panel up.

20 When multiple systems 10 are provided on a roof 20 and disposed side by side as depicted in Figure 1 the covering 30 may similarly be extended to cover the multiple modules 10.

25 Referring to Figures 3-5, the turbines 18 are depicted as comprising a central hub 40, the plurality of radially extending blades 42, an outer circumferential wall or ring 44, and an intermediate circumferential wall or ring 46. The outer ring 44 is connected with and surrounds or covers the radial outer edge of each blade 46. The
30 intermediate ring 46 is spaced between the hub 40 (and thus an axis of rotation of the turbine) and the outer ring 44. Intermediate wall 46 connects with each of the blades 42.

35 As is readily apparent, the substantive difference between the turbines 18a, 18b and 18c resides in the number of blades 42. The difference in the number of blades

provides each of the turbines 18 with different air flow characteristics and accordingly different wind to mechanical energy conversion efficiency. However, the different air flow characteristics and efficiency may also
5 be achieved by varying the twist, or angle of attack of each blade 42.

Now that embodiments of the invention have been described in detail it will be apparent to those skilled in the
10 relevant arts that numerous modifications and variations may be made without departing from the basic inventive concepts. For example, while embodiments that have been described comprising one or two turbines 18, it is envisaged that more than two turbines may be provided in
15 various circumstances. For example, a third turbine may be provided at location substantially midway through the intermediate portion 16. Further, while the systems 10 are depicted as being mounted on a pitched roof, they may be mounted on a flat roof. Indeed it is also envisaged
20 that the systems may be mounted on a vertical wall to take advantage of either up draft (in which case the wind tunnel modules 12 are generally vertically aligned); or "tunnel effect" where buildings may channel wind to flow across the vertical walls of the buildings, in which case
25 the wind tunnel modules 12 are generally horizontally aligned.

All such modifications and variations together with others that would be obvious to a person of ordinary skill in the
30 art are deemed to be within the scope of the present invention the nature of which is to be determined from the above description and the appended claims.

CLAIMS:

1. A wind energy system comprising:
a wind tunnel module having first and second openings
5 at opposite ends, and an intermediate portion located
between the first and second openings, each opening having
substantially the same cross sectional area, the wind
tunnel module reducing in cross sectional area from each
opening in a direction toward the intermediate portion,
10 wherein the intermediate portion has a substantially
constant cross sectional area;
one or more wind turbines supported in or adjacent
the intermediate portion;
at least one electric generator driven by at least
15 one of the wind turbines; and
wherein the intermediate portion is in the form of a
flexible or otherwise bendable tube.
2. The wind energy system according to claim 1 further
20 comprising first and second tunnel portions, one at each
end of the intermediate portion, the first tunnel portion
having a mouth defining the first opening and the second
tunnel portion having a mouth defining the second opening.
- 25 3. The wind energy system according to claim 2 wherein
the first and second tunnel portions are of identical
configuration and symmetrically disposed about a ridge of
a roof.
- 30 4. The wind energy system according to any one of claims
1 to 3 further comprising a first turbine housing located
adjacent one end of the intermediate portion and a second
turbine housing located adjacent an opposite end of the
intermediate portion.
- 35 5. The wind energy system according to any one of claims
1 to 4 comprising two wind turbines.

6. The wind energy system according to claim 5 wherein the wind turbines have the same wind flow characteristics in either direction with respect to the wind energy system.

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7. The wind energy system according to claim 5 wherein the wind turbines have different wind flow characteristics.

10 8. The wind energy system according to claim 7 wherein the wind turbines have a different number of radially extending blades.

15 9. The wind energy system according to any one of claims 1 to 8 wherein one or more of the wind turbines is provided with a plurality of blades radially extending from a central axis of rotation of the turbine, each blade having a radially outer end distant the axis of rotation.

20 10. The wind energy system according to claim 9 wherein one or more of the wind turbines is provided with an outer circumferential surface surrounding the radially outer ends of the blades.

25 11. The wind energy system according to claim 9 or 10 wherein one or more of the wind turbines comprises an intermediate circumferential surface intersecting the turbine blades at a radial location intermediate of the axis of rotation of the turbine and the radially outer
30 ends.

12. The wind energy system according to any one of claims 1 to 11 further comprising a covering overlying the wind tunnel module.

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13. The wind energy system according to claim 12 wherein the covering comprises first and second portions that are

adjustably coupled together to enable adjustment of an angle between the first and second portions along a line perpendicular to a direction of extent of the intermediate portion.

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14. A wind energy conversion system for a building comprising: a plurality of wind energy systems accordingly to any one of claims 1 to 11 wherein the wind energy systems are arranged side by side and, a waterproof
10 covering overlying the plurality of wind energy systems, the covering having opposite longitudinal edges that extend to at least cover the intermediate portion of each wind energy system.

15 15. The wind energy conversion system according to claim 14 wherein the cover comprises first and second portions adjustably coupled together to enable adjustment of an angle between the portions along a line perpendicular to a direction of extent of the intermediate portions.

20

16. A wind tunnel module comprising: first and second openings at opposite ends, and an intermediate portion located between the first and second openings, each opening having substantially the same cross sectional
25 area, the wind tunnel module reducing in cross sectional area from each opening in a direction toward the intermediate portion of the tunnel, wherein the intermediate portion has a substantially constant cross sectional area and is in the form of a flexible or
30 otherwise bendable tube.

17. A wind tunnel module according to claim 16 comprising first and second tunnel portions, one at each end of the intermediate portion, the first tunnel portion having a
35 mouth defining the first opening and the second tunnel portion having a mouth defining the second opening.

18. A wind tunnel module according to claim 16 or 17
comprising a first turbine housing located adjacent one
end of the intermediate portion and a second turbine
housing located adjacent an opposite end of the
5 intermediate portion.

19. The wind tunnel module according to claim 18 wherein
one or both of the wind turbines are provided with a
plurality of extending blades radially extending from a
10 central axis of rotation of the turbine, and each blade
has a radially outer end distant the axis of rotation.

20. The wind tunnel module according to claim 19 wherein
one or both of the wind turbines are provided with an
15 outer circumferential surface surrounding the radially
outer ends of the blades.

21. The wind tunnel module according to claim 19 or 20
wherein one or both of the wind turbines comprise an
20 intermediate circumferential surface intersecting the
turbine blades at a radial location intermediate of the
axis of rotation of the turbine and the radially outer
ends.

22. The wind tunnel module according to any one of claims
25 16 to 21 wherein the wind turbines have the same wind flow
characteristics in either direction with respect to the
wind tunnel module.

23. The wind tunnel module according to any one of claims
30 16 to 21 wherein the wind turbines have different wind
flow characteristics.

24. A wind energy system according to any one of claims
35 1-13 wherein the openings are configured to receive wind
at an angle of up to 60 degrees from either side thereof.

25. A wind energy conversion system according claim 14 or
15 wherein the openings are configured to receive wind at
5 an angle of up to 60 degrees from either side thereof

26. A wind tunnel module according to any one of claims
16-23 wherein the openings are configured to receive wind
at an angle of up to 60 degrees from either side thereof.
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27. A wind energy system comprising: a wind tunnel having
open opposite ends each end having the same configuration
and cross sectional area to allow wind to pass in either
direction through the tunnel; two wind turbines, one
15 located at or near each end; and, an respective electric
generators driven by each of the wind turbines.

28. The wind energy system according to claim 27 wherein
the wind turbines are configured to provide a collective
20 Betz limit of up to 0.83.

29. A wind energy system comprising:
a wind tunnel module having first and second openings
at opposite ends, and an intermediate portion located
25 between the first and second openings, each opening having
substantially the same cross sectional area, the wind
tunnel module reducing in cross sectional area from each
opening in a direction toward the intermediate portion,
wherein the intermediate portion has a substantially
30 constant cross sectional area;

a first turbine housing located adjacent one end of
the intermediate portion and a second turbine housing
located adjacent an opposite end of the intermediate
portion; and,
35 at least one electric generator driven by at least
one of the wind turbines.

30. The wind energy system according to claim 29 further comprising first and second tunnel portions, one at each
5 end of the intermediate portion, the first tunnel portion having a mouth defining the first opening and the second tunnel portion having a mouth defining the second opening.

31. The wind energy system according to claim 29 or 30
10 wherein the wind turbines have the same wind flow characteristics in either direction with respect to the wind energy system.

32. The wind energy system according to claim 29 or 30
15 wherein the wind turbines have different wind flow characteristics.

33. The wind energy system according to claim 32 wherein
20 the wind turbines have a different number of radially extending blades.

34. The wind energy system according to any one of claims
29 to 33 wherein one or both of the wind turbines are provided with a plurality of extending blades radially
25 extending from a central axis of rotation of the turbine, each blade having a radially outer end distant the axis of rotation.

35. The wind energy system according to claim 34 wherein
30 one or both of the wind turbines are provided with an outer circumferential surface surrounding radially outer of the blades.

36. The wind energy system according to claim 34 or 35
35 wherein one or both of the wind turbines comprises an intermediate circumferential surface intersecting the turbine blades at a radial location intermediate of the

axis of rotation of the turbine and the radially outer ends.

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37. The wind energy system according to any one of claims 29 to 36 further comprising a covering overlying the wind tunnel module.

10 38. The wind energy system according to claim 37 wherein the covering comprises first and second portions that are adjustably coupled together to enable adjustment of an angle between the first and second portions along a line perpendicular to a direction of extent of the intermediate
15 portion.

39. A wind energy conversion system for a building comprising: a plurality of wind energy systems accordingly to any one of claims 29 to 38 wherein the wind energy
20 systems are arranged side by side and, a waterproof covering overlying the plurality of wind energy systems, the covering having opposite longitudinal edges that extend to at least cover the intermediate portion of each wind energy system.

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40. The wind energy conversion system according to claim 39 wherein the cover comprises first and second portions adjustably coupled together to enable adjustment of an angle between the portions along a line perpendicular to a
30 direction of extent of the intermediate portions.

41. A wind energy system according to any one of claims 29-38 wherein the openings are configured to receive wind at an angle of up to 60 degrees from either side thereof.

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42. A wind energy conversion system according claim 39 or
40 wherein the openings are configured to receive wind at
5 an angle of up to 60 degrees from either side thereof

43. The wind energy system according to any one of claims
30 to 38 wherein the first and second tunnel portions are
of identical configuration and symmetrically disposed
10 about a ridge of a roof.

44. A wind energy system comprising:
a wind tunnel module having first and second openings
at opposite ends, and an intermediate portion located
15 between the first and second openings, each opening having
substantially the same cross sectional area, the wind
tunnel module reducing in cross sectional area from each
opening in a direction toward the intermediate portion,
wherein the intermediate portion has a substantially
20 constant cross sectional area;

one or more wind turbines supported in or adjacent
the intermediate portion, at least one of the wind
turbines being provided with a plurality of radially
extending blades and an outer circumferential surface
25 surrounding an outer radial edge of the blades; and
at least one electric generator driven by at least
one of the wind turbines.

45. The wind energy system according to claim 44 further
30 comprising first and second tunnel portions, one at each
end of the intermediate portion, the first tunnel portion
having a mouth defining the first opening and the second
tunnel portion having a mouth defining the second opening.

35 46. The wind energy system according to claim 45 wherein
the first and second tunnel portions are of identical

configuration and symmetrically disposed about a ridge of a roof.

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47. The wind energy system according to any one of claims 44 to 46 further comprising a first turbine housing located adjacent one end of the intermediate portion and a second turbine housing located adjacent an opposite end of the intermediate portion.

48. The wind energy system according to any one of claims 44 to 47 comprising two wind turbines.

15 49. The wind energy system according to claim 48 wherein the wind turbines have the same wind flow characteristics in either direction with respect to the wind energy system.

20 50. The wind energy system according to claim 48 wherein the wind turbines have different wind flow characteristics.

25 51. The wind energy system according to claim 50 wherein the wind turbines have a different number of radially extending blades.

52. The wind energy system according to any one of claims 44 to 51 wherein one or more of the wind turbines comprises an intermediate circumferential surface intersecting the turbine blades at a radial location intermediate of an axis of rotation of the turbine and the outer circumferential surface.

35 53. The wind energy system according to any one of claims 44 to 53 further comprising a covering overlying the wind tunnel module.

54. The wind energy system according to claim 53 wherein the covering comprises first and second portions that are
5 adjustably coupled together to enable adjustment of an angle between the first and second portions along a line perpendicular to a direction of extent of the intermediate portion.

10 55. The wind energy system according to any one of claims 44 to 54 wherein the openings are configured to receive wind at an angle of up to 60 degrees from either side thereof.

15 56. The wind energy system according to any one of claims 48 to 51 wherein the first and second wind turbines are configured to provide a collective Betz limit of up to 0.83.

20 57. A wind energy system comprising:
a wind tunnel module having first and second openings at opposite ends, and an intermediate portion located between the first and second openings, each opening having substantially the same cross sectional area, the wind
25 tunnel module reducing in cross sectional area from each opening in a direction toward the intermediate portion, wherein the intermediate portion has a substantially constant cross sectional area;
a covering overlying the wind tunnel module;
30 one or more wind turbines supported in or adjacent the intermediate portion; and
at least one electric generator driven by at least one of the wind turbines.

35 58. The wind energy system according to claim 57 further comprising first and second tunnel portions, one at each end of the intermediate portion, the first tunnel portion

having a mouth defining the first opening and the second
tunnel portion having a mouth defining the second opening.

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59. The wind energy system according to claim 58 wherein
the first and second tunnel portions are of identical
configuration and symmetrically disposed about a ridge of
a roof.

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60. The wind energy system according to any one of claims
57 to 59 further comprising a first turbine housing
located adjacent one end of the intermediate portion, a
second turbine housing located adjacent an opposite end of
15 the intermediate portion and a turbine in each turbine
housing.

61. The wind energy system according to claim 60 wherein
the wind turbines have the same wind flow characteristics
20 in either direction with respect to the wind energy
system.

62. The wind energy system according to claim 60 wherein
the wind turbines have different wind flow
25 characteristics.

63. The wind energy system according to claim 62 wherein
the wind turbines have a different number of radially
extending blades.

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64. The wind energy system according to any one of claims
57 to 63 wherein one or more of the wind turbines are
provided with a plurality of extending blades radially
extending from a central axis of rotation of the turbine,
35 and each blade has a radially outer end distant the axis
of rotation.

65. The wind energy system according to claim 64 wherein one or more of the wind turbines are provided with an
5 outer circumferential surface surrounding the radially outer ends of the blades.

66. The wind energy system according to claim 64 or 65 wherein one or more of the wind turbines comprise an
10 intermediate circumferential surface intersecting the turbine blades at a radial location intermediate of the axis of rotation of the turbine and the radially outer ends.

67. The wind energy system according to claim any one of claims 57 to 66 wherein the covering comprises first and second portions that are adjustably coupled together to enable adjustment of an angle between the first and second portions along a line perpendicular to a direction of
20 extent of the intermediate portion.

68. The wind energy system according to any one of claims 60 to 63 wherein the first and second wind turbines are configured to provide a collective Betz limit of up to
25 0.83.

69. The wind energy system according to any one of claims 59 to 68 wherein the openings are configured to receive wind at an angle of up to 60 degrees from either side
30 thereof.

70. A wind energy system comprising:
a wind tunnel module having first and second openings at opposite ends, and an intermediate portion located
35 between the first and second openings, each opening having substantially the same cross sectional area and configured to receive wind at an angle of up to 60 degrees from

either side thereof, the wind tunnel module reducing in cross sectional area from each opening in a direction
5 toward the intermediate portion, wherein the intermediate portion has a substantially constant cross sectional area;
one or more wind turbines supported in or adjacent the intermediate portion; and
at least one electric generator driven by at least
10 one of the wind turbines.

71. The wind energy system according to claim 70 further comprising first and second tunnel portions, one at each end of the intermediate portion, the first tunnel portion
15 having a mouth defining the first opening and the second tunnel portion having a mouth defining the second opening.

72. The wind energy system according to claim 71 wherein the first and second tunnel portions are of identical
20 configuration and symmetrically disposed about a ridge of a roof.

73. The wind energy system according to any one of claims 70 to 72 further comprising a first turbine housing
25 located adjacent one end of the intermediate portion ,and a second turbine housing located adjacent an opposite end of the intermediate portion.

74. The wind energy system according to any one of claims 70 to 73 comprising two wind turbines.
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75. The wind energy system according to claim 74 wherein the wind turbines have the same wind flow characteristics in either direction with respect to the wind energy
35 system.

76. The wind energy system according to claim 74 wherein
the wind turbines have different wind flow
5 characteristics.

77. The wind energy system according to claim 76 wherein
the wind turbines have a different number of radially
extending blades.

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78. The wind energy system according to any one of claims
70 to 77 wherein one or more of the wind turbines are
provided with a plurality of extending blades radially
extending from a central axis of rotation of the turbine,
15 and each blade has a radially outer end distant the axis
of rotation.

79. The wind energy system according to claim 78 wherein
one or more of the wind turbines are provided with an
20 outer circumferential surface surrounding the radially
outer ends of the blades.

80. The wind energy system according to claim 78 or 79
wherein one or more of the wind turbines comprise an
25 intermediate circumferential surface intersecting the
turbine blades at a radial location intermediate of the
axis of rotation of the turbine and the radially outer
ends.

30 81. The wind energy system according to any one of claims
70 to 80 further comprising a covering overlying the wind
tunnel module.

82. The wind energy system according to claim 81 wherein
35 the covering comprises first and second portions that are
adjustably coupled together to enable adjustment of an
angle between the first and second portions along a line

perpendicular to a direction of extent of the intermediate portion.

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83. The wind energy system according to any one of claims 74 to 77 wherein the wind turbines are configured to provide a collective Betz limit of up to 0.83.