


WIND ENERGY TECHNOLOGY




Small Wind Generators


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Indonesia

Training Course on Renewable Energy Part II - MEMR
CASINDO



Introduction to Wind Energy



This presentation uses material from the training course "*The implementation of Wind Energy*" organized by ECN and Arrakis, which was held at ECN, the Netherlands from 1992 to 2003.


This presentation is intended for educational purposes and should by no means used commercially.

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WELCOME !

Structure of this Presentation





- General description of small wind generators
- Technical aspects
 - Applications
 - Stand alone systems
 - Hybrid systems
 - Control and safety systems
 - Control box
 - Batteries
- System sizing
- Cost of small wind generators
- Criteria for selection
- Trends

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Where is this?

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Where is this?

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Where is this?

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Some Examples of Small Wind Generators (1)

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Ampair 100

Rutland 913

Typical application

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Some Examples of Small Wind Generators (2)

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Air 300

Windseeker

Typical application

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Some Examples of Small Wind Generators (3)

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Air 300 in high wind

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Some Examples of Small Wind Generators (4)

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QuiteRevolution

Ropatec

Typical application

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Some Examples of Small Wind Generators (3)

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VAWT Vertical Axis Wind Turbine Videos

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Database Small Wind Generators

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<http://www.allstatewindturbines.com/>

Database Small Wind Generators

441 Small Wind Generators from 166 manufacturers:

- 372 Horizontal Axis Wind Turbines (HAWT)
- 69 Vertical Axis Wind Turbines (VAWT)

Image	Turbine	Producer	Type	Power (rated, W)	Output kWh / year	Price \$	Spec sheet pdf	URL www	E-mail contact
	500 W WindMax Hybrid Wind Generators	WindMax Green Energy	HAWT	485	500	450	pdf	www	contact
	2000 W WindMax Hybrid Wind Generators	WindMax Green Energy	HAWT	2000	3000	2100	pdf	www	contact
	650W max WindMax	WindMax Green Energy	HAWT	650	0	350	pdf	www	contact

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Large and Small Wind Generators

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Large Wind Generators

- Rated power > 100 kW
- Often installed in groups
- No tail
- Gearbox (often)
- Power to the electric grid
- Requires 6 m/s average site
- Costs 1 US\$ /W installed
- Electricity costs: < 10 USc/kWh

Small Wind Generators

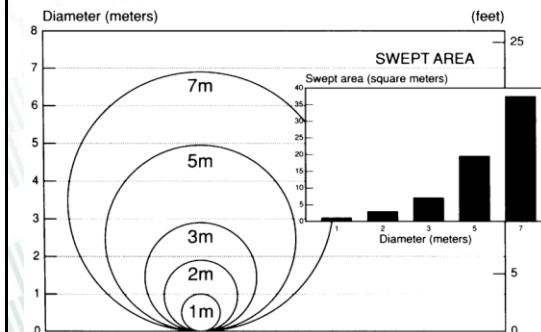
- Rated power < 10 kW
- Stand alone operation
- Tail
- No gearbox
- Battery charging or local grid
- Requires 4 m/s average site
- Costs depend on size ≈ 2-10 US\$ /W installed
- Electricity costs: > 10 USc /kWh

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Relative Size of Small Wind Generators

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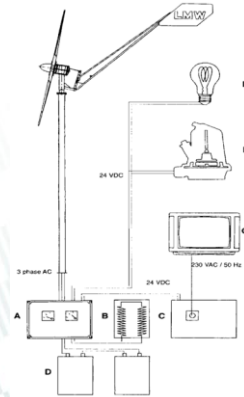
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System Layout

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- AC or DC generator
- Control unit
- Dump load
- Batteries
- Appliances
12, 24 or 48 V
220 V with inverter

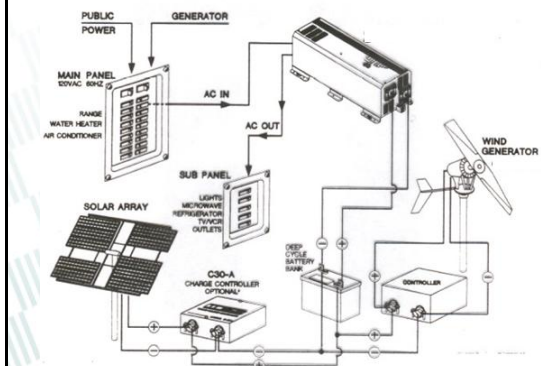


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System Layout

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Control and Safety Systems

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Control is required to:

- Limit the power generated
- Limit the rotational speed (blade damage)
- Limit the wind forces on the structure

Methods of control:

- Changing the angle of attack
- Rotate the turbine around a vertical axis
 - hinged side vane and eccentric mounting
 - inclined hinged tale vane and eccentric mounting
 - tale vane with spring and eccentric mounting
- Rotate the turbine around a horizontal axis
- Aerodynamic brakes
- PM generator short circuit

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Changing the angle of attack

Hinged side vane

Rotating the turbine around a horizontal axis

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Control System of "Windpol"

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Control and Safety Mechanisms

Tale vane with spring and external mounting

Inclined hinge tale vane and external mounting

Electrical Control Diagram:

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    graph LR
      DC_LOADS --> RECTIFIER[RECTIFIER]
      RECTIFIER -- AC --> AC_LOAD[AC LOAD]
      AC_LOAD -- AC --> AC_LOADS
  
```

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Some Examples of Small Wind Generators (3)

Furling Videos

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Control Box

Functions of the control box:

- rectification of the alternating current
- battery over-load protection
- battery under-load protection or indication
- electric brake
- dump load
- lightning protection
- metering of voltage and current

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Sizing Wind Energy Systems

Basic sizing questions:

- What should be the size of the wind generator?
- How many batteries are required?

Lack of information:

- Average wind speed and wind distribution
- Energy produced by the wind generator
- Energy required by the user

Considerations:

- Minimal cost with acceptable capacity and quality
- Minimal risk of shortage of energy

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Determination of the Daily Energy Requirement ETC

Appliance	Rated power (W)	Hours per day in use (hours)	Energy per day Wh/day
Lights	5*20	5	500
Refrigerator	300	12	3600
Radio	25	4	100
TV	200	3	600
Total	625		4800

Total amount of energy required: 4.8 kWh/day

Considerations:

- Power rating of wind generator \approx average load
- (Peak load can be delivered by the battery bank)
- Wind generator supplier may be over optimistic

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Quick Estimate of Available Energy ETC

$$E_{an} = b A V_{av}^3$$

- E_{an} energy generated during a year (kWh)
 V_{av} average annual wind speed (m/s)
 A swept area of the rotor (m^2)
 b conversion factor (depends on average wind speed)

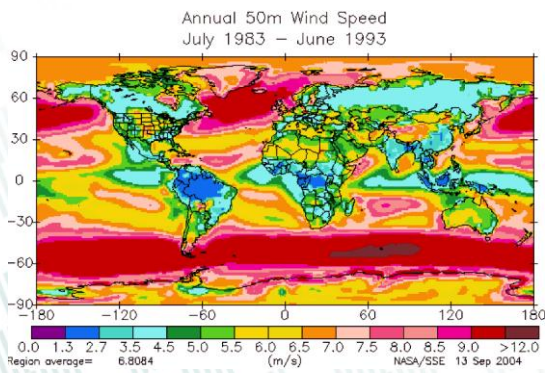
Example:

	LMW250	LMW600	LMW1003	
diameter	1,7	2,2	3,12	
V_{av} (m/s)	kWh/year	b	kWh/year	b
4	305	2,10	580	2,38
5	525	1,85	975	2,05
6	750	1,53	1420	1,73
7	945	1,21	1855	1,42
8	1105	0,95	2240	1,15
				3815
				0,97

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Global windspeed at 50m ETC



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Bergy 1500 Power Curve ETC

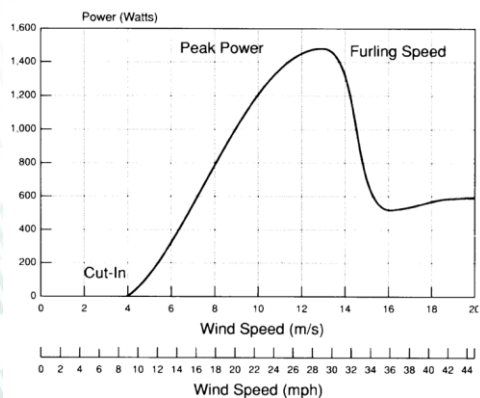
NASA Surface Data Wind Speeds Indonesia

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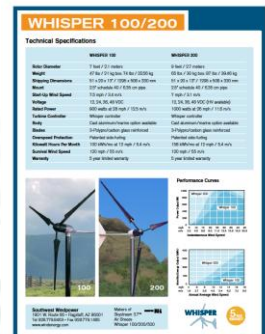
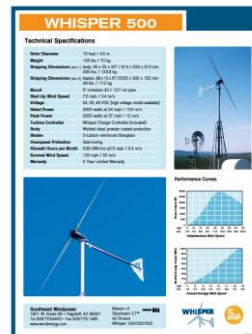
Bergy 1500 Power Curve ETC



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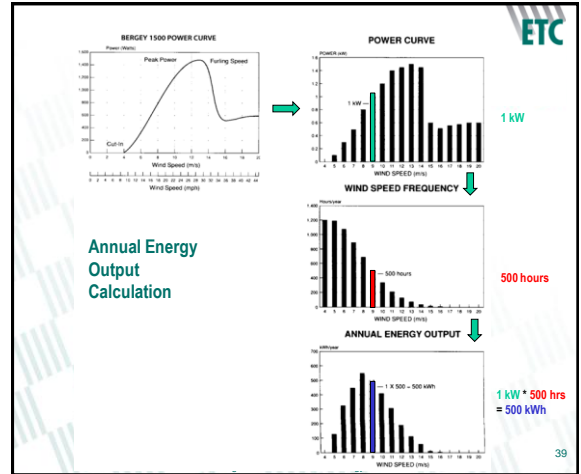
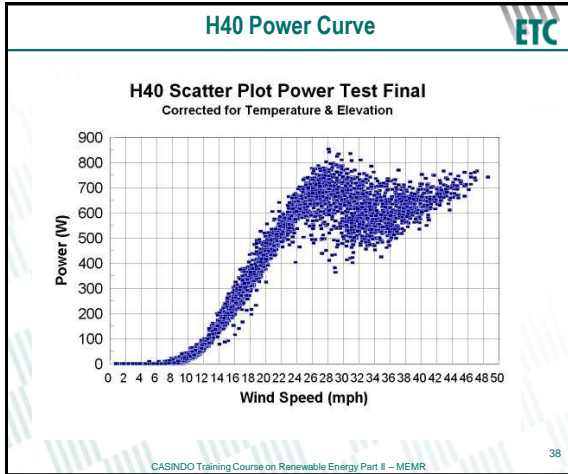
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Whisper Power Curves ETC



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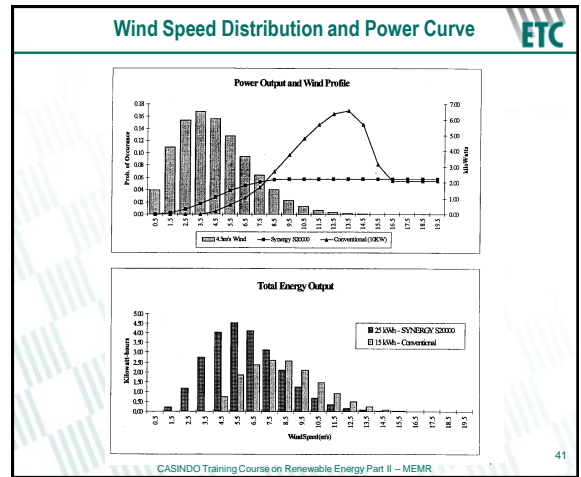
Annual Energy Output Calculation

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Wind Speed Bin (m/s)	Instantaneous Power (kW)	Hours/Year	Energy (kWh/yr)
4	0	1,201	0
5	0.1	1,188	119
6	0.3	1,072	322
7	0.5	892	446
8	0.8	691	553
9	1	500	500
17	0.55	4	2
18	0.575	2	1
19	0.6	1	0
20	0.6	0	0
Annual Energy Output (kWh/yr) =			3,025

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Cost of Wind Generator System

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Do not compare apples with oranges:

Apart from power rating, consider also:

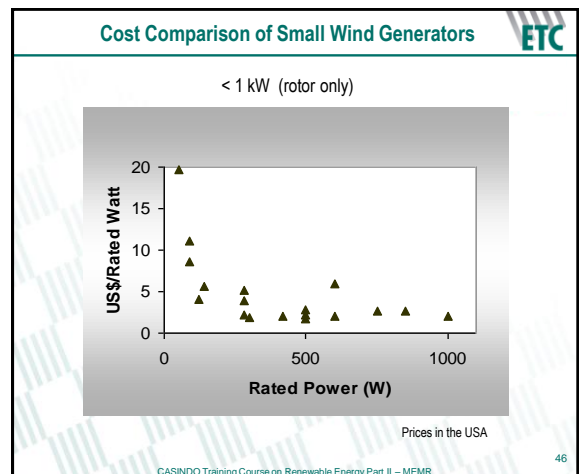
- tower
- control unit
- type and capacity of batteries, etc.

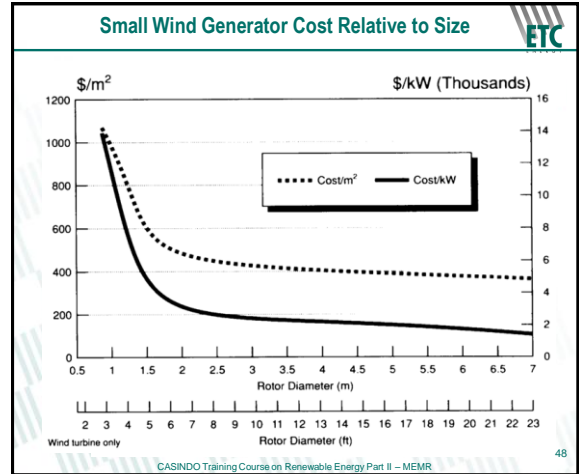
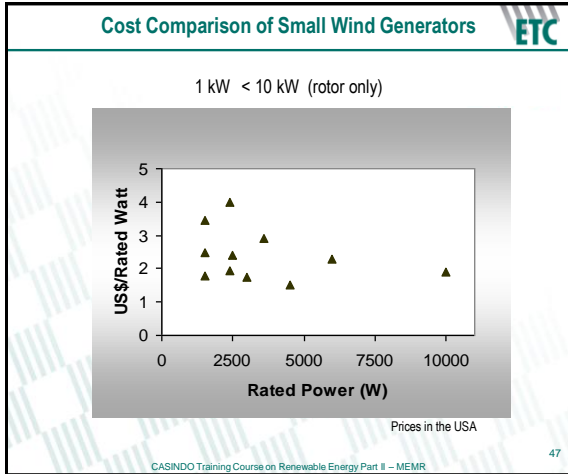
Look also to "hidden" costs such as:

- installation cost
- cost of servicing and maintenance
- cost of spare-parts

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- ### Criteria for Selection
- Power output and availability
 - Suitability to specific site conditions, such as survival wind speed, climatic conditions (humidity, salt, extreme temperatures)
 - Remote installation and operation
 - Reliability of wind generator and ALL system components
 - Required maintenance
 - Initial and recurrent costs
 - Warranty
 - After-sales services
 - Availability of spare-parts
 - Credibility and sustainability of the manufacturer and supplier
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- ### Trends
- Number of manufacturers is increasing
 - Proven manufacturers have dealers in other countries
 - Increase of small wind generators that operate in hybrid systems with diesel or PV systems
 - Improved components because of new materials and by design
 - Special manufacturer methods and processes
 - Mass production
 - Interest of utilities in small wind turbines
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Further Reading

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WIND RESOURCES

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QUESTIONS ?

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