Are Hurricanes a Constraint to Wind Development in the Caribbean ?

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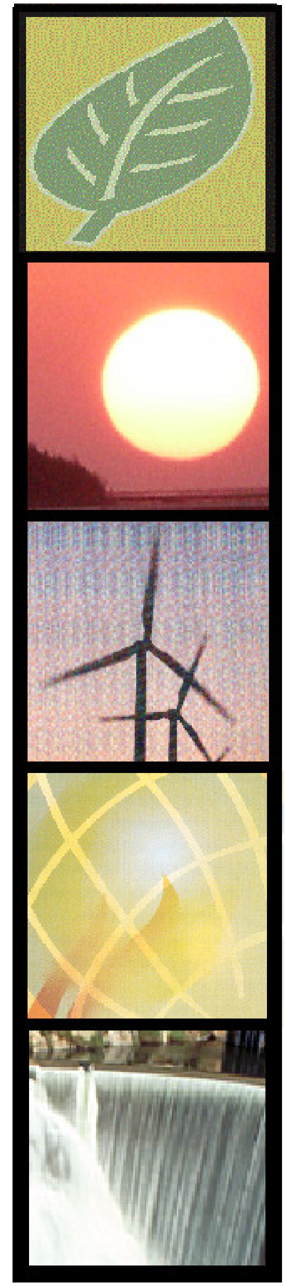
Caribbean Renewable Energy Development Project - CREDP

Caribbean Environmental Forum

5th Caribbean Environmental Forum and Exhibition (CEF 5),
2nd Caribbean Sustainable Energy Forum &
15th Annual Wider Caribbean Waste Management Conference (ReCaribe)
21st to 25th June 2010
Montego Bay, JAMAICA

Coping with Copenhagen: Water, Waste, Energy, Health...

Contents



Who am I?

Introduction

Benjamin Jargstorf (Dip.-Ing. equals M.Sc.)

- electrical engineer, sociologist
- studied at
  - Technische Universität Braunschweig (Technical University of Braunschweig/Brunswig, Germany)
  - Free University of Berlin (Institute of Sociology)
  - University of Cambridge (King's College, UK)
  - University of Nairobi (Environmental Science)
- working experience in more than 50 countries
- specialising in RE since 1985

Factor 4 Energy Projects GmbH

Introduction

- limited company registered at Schwerin (Mecklenburg-Vorpommern, Germany)
- office in Wismar on the Baltic Sea
- founded 1996 – name from the report of Club of Rome: „Factor Four: Doubling Wealth - Halving Resource Use"
- **... industrial society can only survive, when *half* the natural resources is used with *twice* the efficiency ...** thus, a factor 4 is needed.
- renewable energy and energy efficiency: wind energy, solar energy, biomass use, energy planning (master plans), financing of RE etc.

Introduction

Factor 4 Current Projects ...

- 50 MW wind park Macedonia (feasibility study with EU financing)
- 100 % renewable energy island Galápagos (3 to 24 MW wind park, PV, wind/diesel system)
- 500 kW PV plant parallel to diesel power (San Pedro de Atacama, Chile)
- several wind/diesel systems in Nicaragua (IADB financing)
- feasibility study wind park Nauru (UNDP South Pacific)
- wind park planning in the Caribbean (S. Lucia, S. Vincent, Antigua)

Factor 4 - World-wide Experiences

Saffir/Simpson Hurricane Scale (1974)

Scale Number (Category)	Central Pressure (Millibars)	Central Pressure (Inches)	Winds (Mph)	Surge (Feet)	Damage
1	> 979	> 28.91	74-95	4 to 5	Minimal
2	965-979	28.50-28.91	96-110	6 to 8	Moderate
3	945-964	27.91-28.47	111-130	9 to 12	Extensive
4	920-944	27.17-27.88	131-155	13 to 18	Extreme
5	< 920	< 27.17	> 155	> 18	Catastrophic

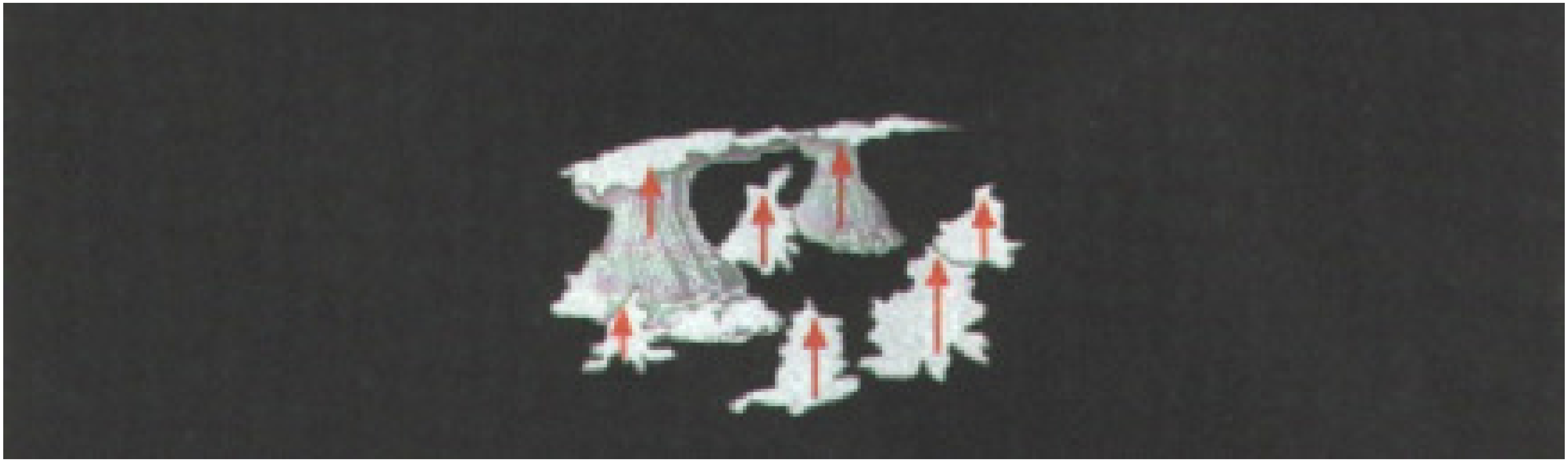
Source: Eric S. Blake, "The Deadliest, Costliest, And Most Intense United States Tropical Cyclones From 1851 to 2004 (And Other Frequently Requested Hurricane Facts), August 2005

Hurricane/Cyclone/Typhoon Scale 1-5

	Wind speed (m/s) *	Storm surge (m)	Damage description
1	33-42	1.0-1.7	Some damage to trees, shrubbery, and unanchored mobile homes
2	43-49	1.8-2.6	Considerable damage to shrubbery and tree foliage; some trees blown down. Damage to poorly constructed signs and roofs on buildings. Major damage to mobile homes.
3	50-58	2.7-3.8	Foliage torn from trees; large trees and poorly constructed signs blown down. Some damage to roofing materials and structures of buildings. Mobile homes destroyed.
4	59-69	3.9-5.6	Shrubs and trees blown down; destruction of all signs and mobile homes. Extensive damage to roofing materials, windows and doors. Complete failure of roofs on many small houses.
5	70+	5.7	Shrubs and trees blown down. Severe damage to windows and doors. Complete failure of roofs on many houses and industrial buildings. Some complete building failures. Small buildings overturned or blown away.

* maximum 1-minute average

Tropical Whirl Storms – 1 of 4



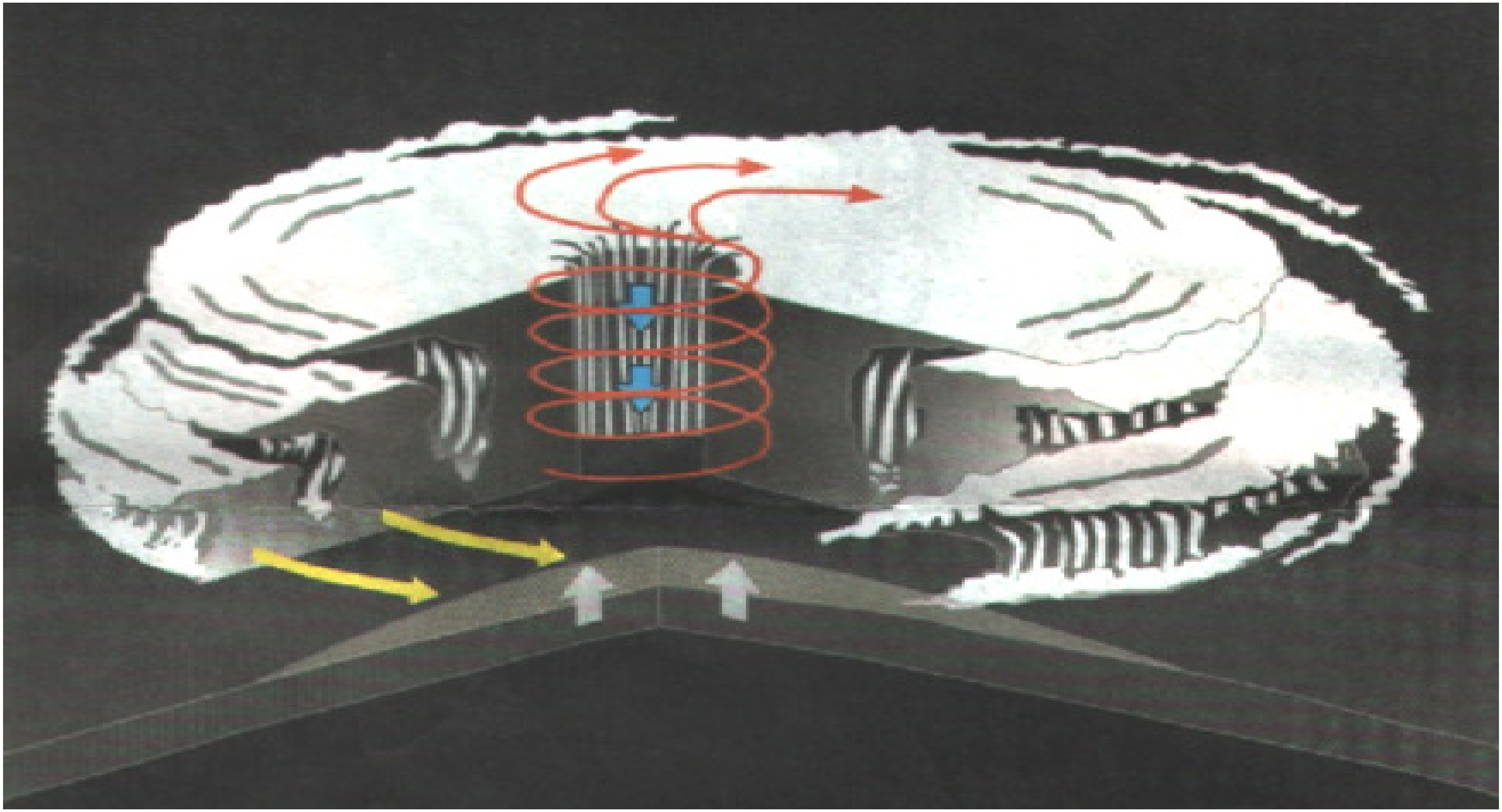
Source: K. Emanuel

Tropical Whirl Storms – 2 of 4

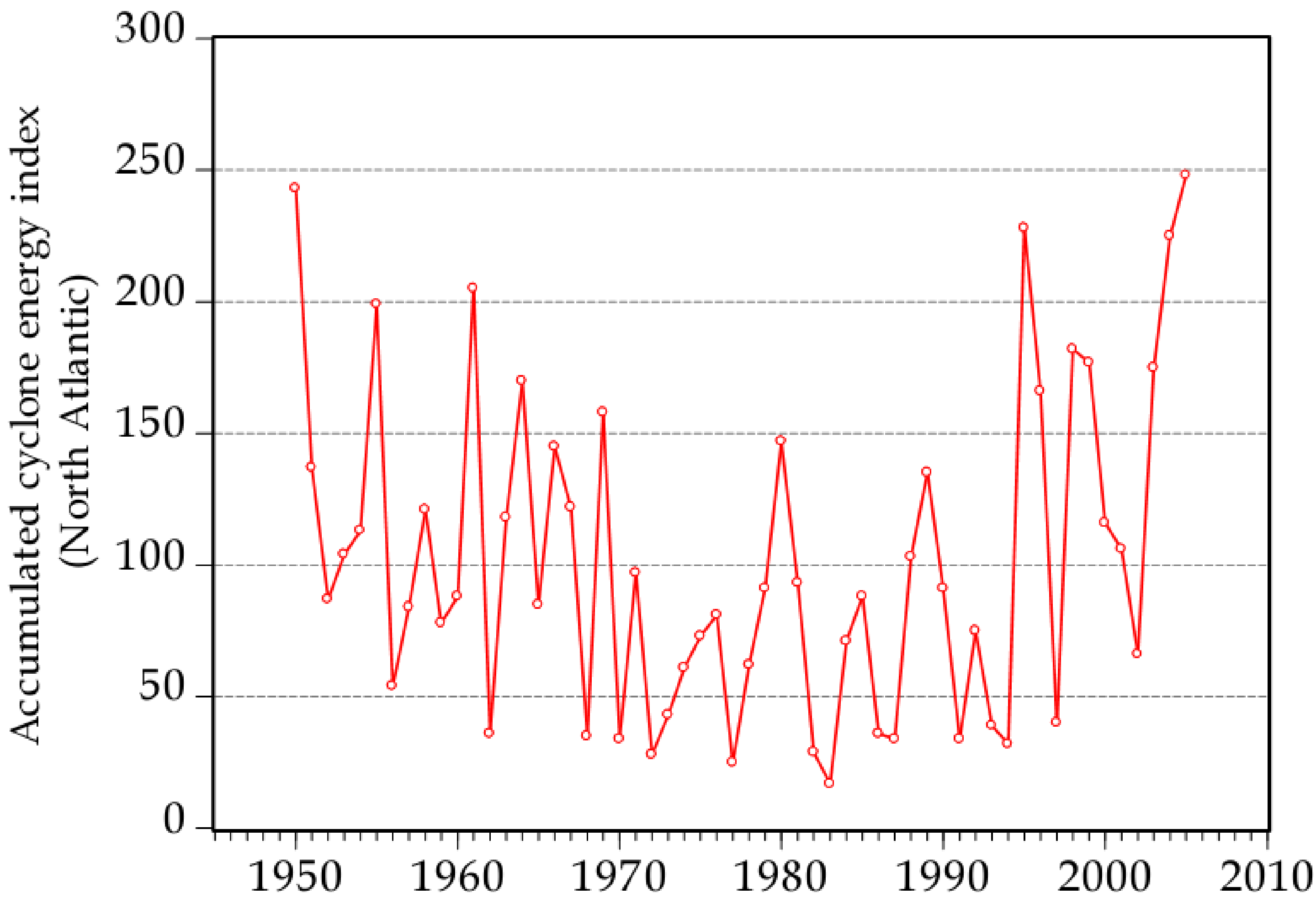
Source: K. Emanuel

Tropical Whirl Storms – 3 of 4

Tropical Whirl Storms – 4 of 4

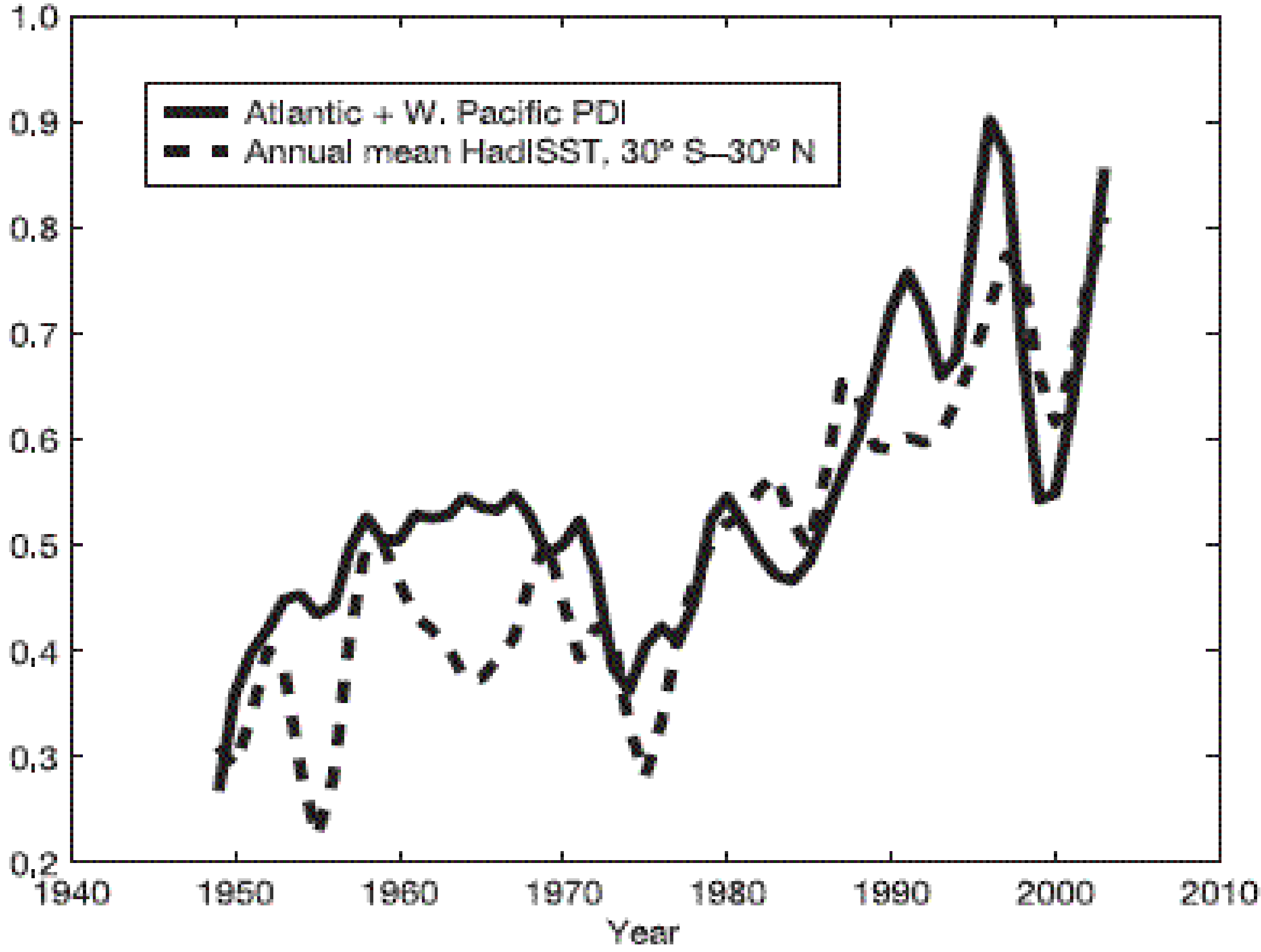


Cyclone Energy Index 1950 - 2006



Source: William Nordhaus, "Economics of Hurricanes in the US", 2006

Intensity of Hurricanes 1950 - 2005

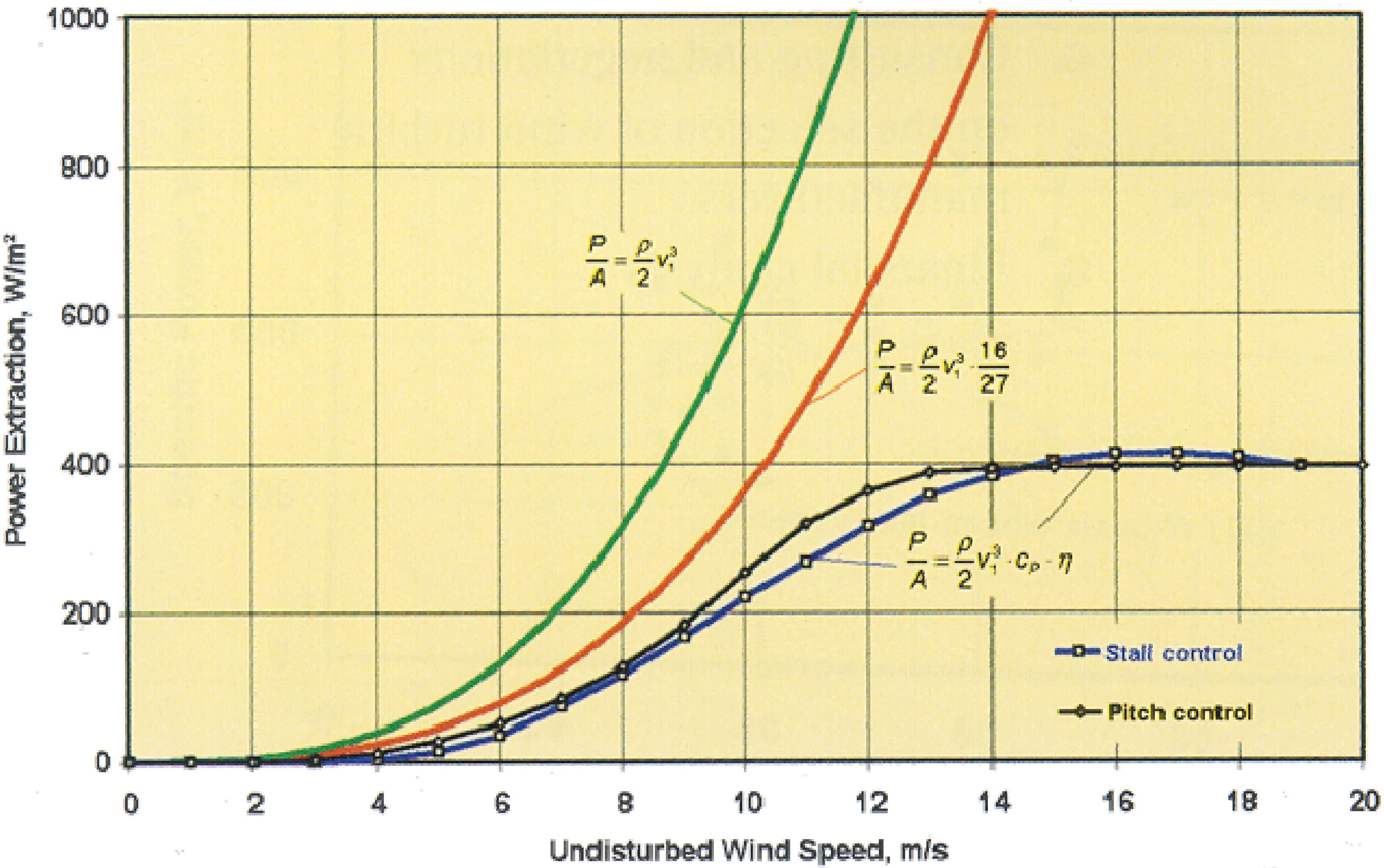


Source: Kerry Emanuel, MIT

Hurricane Risks

- during hurricanes, instantaneous wind speed in excess of 70 m/s can be reached
- IEA Wind Class 1 – turbines for an annual average wind speed of 10 m/s
- designed for max. 50 m/s as 10 min average
- as a rule of thumb 1 sec average has 50 % higher wind speed than 10 min average (depends on Weibull k-factor)
- thus: Wind Class 1 turbine can survive 75 m/s …
- … but is not designed to do so

Power in the Wind



Hurricane Power

70 m/s = 3.5 x 20 m/s

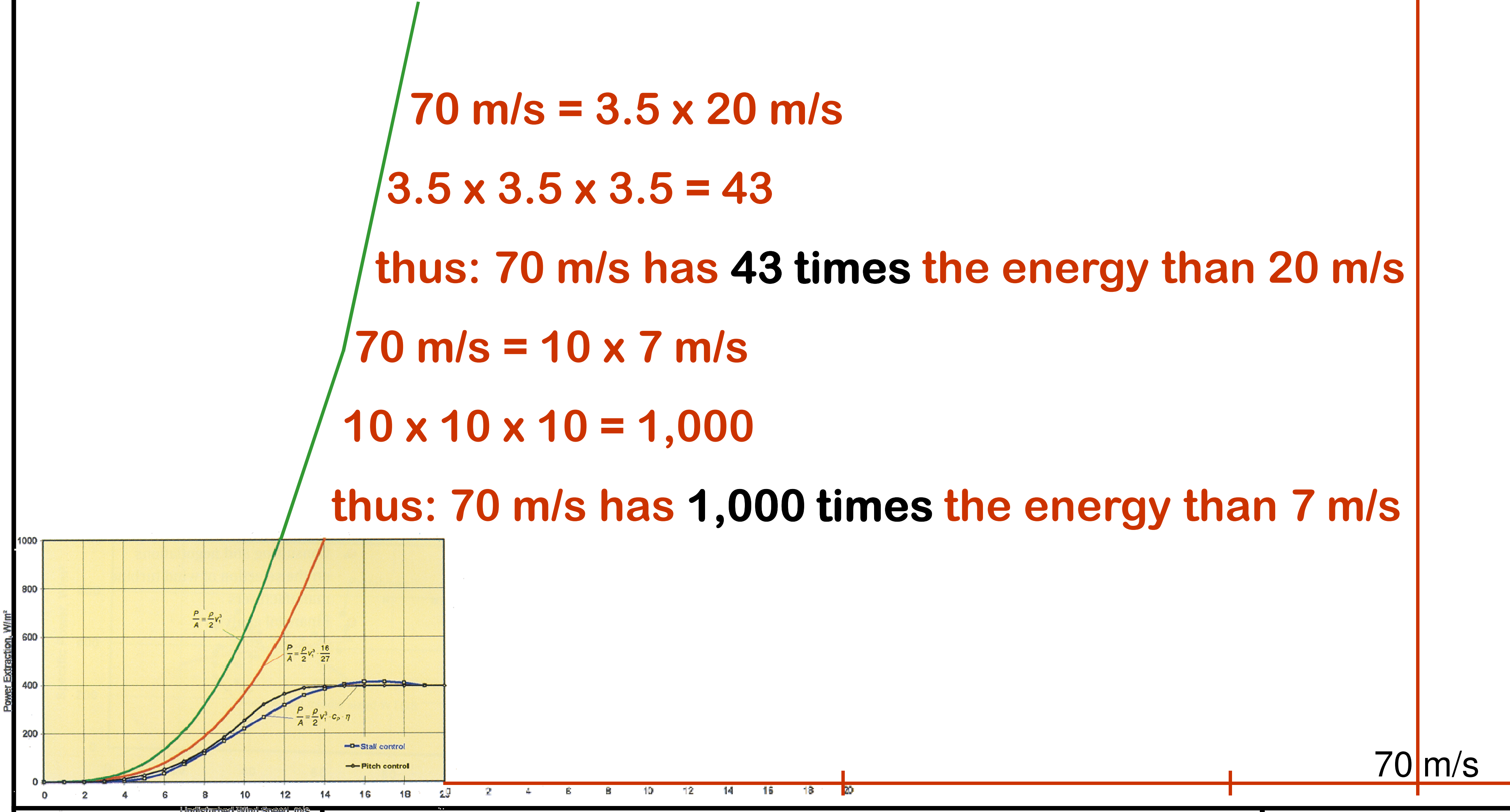
3.5 x 3.5 x 3.5 = 43

thus: 70 m/s has **43 times** the energy than 20 m/s

70 m/s = 10 x 7 m/s

10 x 10 x 10 = 1,000

thus: 70 m/s has **1,000 times** the energy than 7 m/s



IEC 61400-1 Design Requirements

Table 1 – IEC Classes for Wind Turbines (source: IEC 61400-1, 2nd editon, dated 1999-02)

Wind Turbine Class		I	II	III	IV	S
V_{ref}	m/s (mph)	50(111)	42.5 (95)	37.5 (84)	30 (67)	Values to be specified by the designer
V_{ave}	m/s (mph)	10 (22)	8.5 (19)	7.5 (17)	6 (13)	
A	I_{15}	0.18	0.18	0.18	0.18	
	a	2	2	2	2	
B	I_{15}	0.16	0.16	0.16	0.16	
	a	3	3	3	3	

where:
the values apply at hub-height, and
A designates the category for higher turbulence characteristics,
B designates the category for lower turbulence characteristics,
I_{15} is the characteristic value of the turbulence intensity at 15 m/s,
a is the slope parameter to be used in the Normal Turbulence Model equation.

for hurricanes?

Cyclone 03A on June 8, 1998 Gujurat

Huge Damage to Indian Wind Industry

111 Turbines uprooted in Main Field

Manufacturer	Type/size	Concept	Tower	Damages	
				uprooted	blade only
Suzlon	350 kW	stall	lattice	48	
REPL Bonus	320 kW	stall	lattice	28	
Vestas	200/225 kW	pitch	lattice	15	16
Micon	600 kW	stall	tubular	10	
BHEL	200 kW	stall	lattice	4	7
NEPC	225/250 kW	pitch	tubular	4	
AMTL	250 kW	stall	tubular	2	
Enercon	230 kW	pitch	tubular		3
				111	**26**

Source: C.M. Raman, CEO Enercon India in an email to B.J.

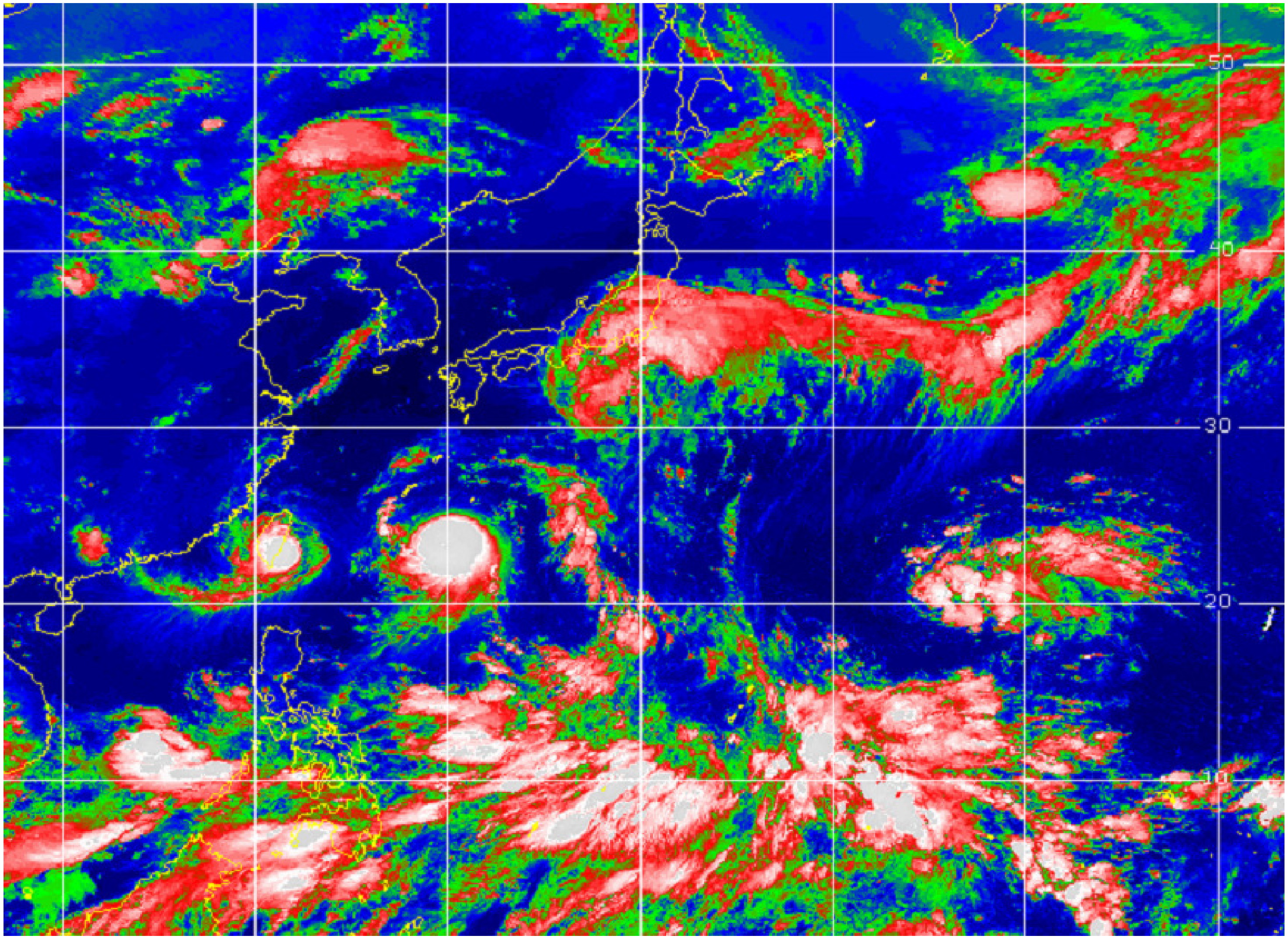
Lessons learnt

- damages with "classic" stall turbines higher
- damages with lattice tower higher
- "magical survivers" (individual turbines) in the middle of totally destructed wind parks
- in total, 27 MW of wind installation destroyed in a few hours
- problems to insure wind turbines after the Gujurat Cyclone
- … but also: no economic way to build wind turbines to withstand cyclones
- biggest problem: no electricity during cyclones

Typhoon Sangmei, Zheijang, 6. Aug 2006

Typhoon Sangmei, Zheijang Province 2006

Typhoon Sangmei, Zheijang Province 2006



View from the Wind Park

Hurricanes a Constraint to Wind Energy Development ?

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宁波天安集团象山高压电器厂制造

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Wind Park Changnan Xiaguan – 28 Turbines

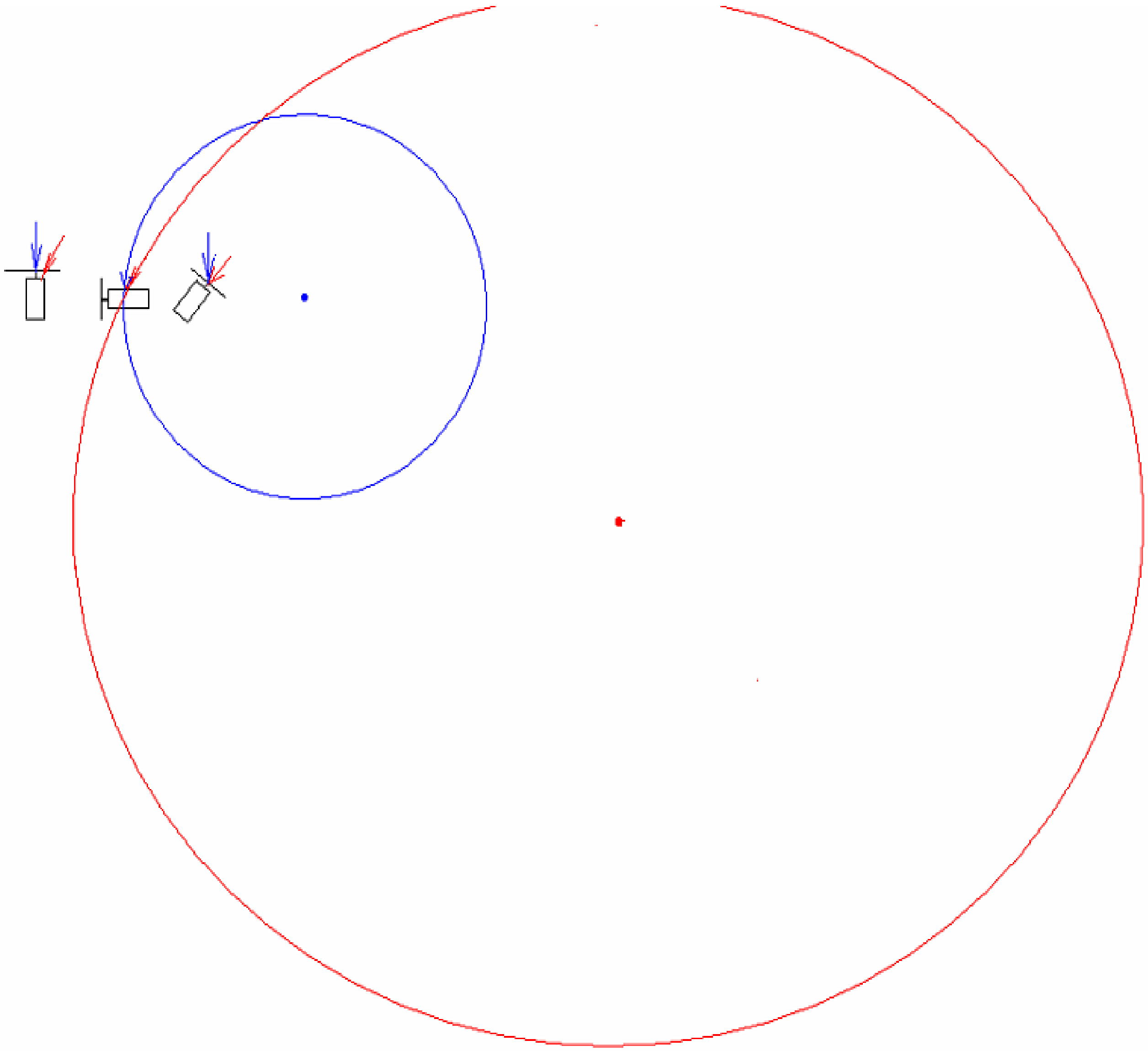
Maxium Wind Speed 78 m/s (3 sec)

SCADA System of Wind Park: 57.9 m/s

Survivors of Typhoon “Sangmei”

- turbines which were facing the wind directly
- reason is easy: the load values for designing turbines according to IEA have the highest safety margins for this direction
- interviews with manufactures showed:
  - do not ask for “special” hurricane turbine specifications
  - do not consider collapsible towers for turbines > 250 kW
  - employ standard WC Ia machines, possibly with lower hub heights and/or shorter blades
  - provide stand-by power in the case of hurricanes to keep the “noose” of the wind turbine always in the wind – also when grid is de-energized

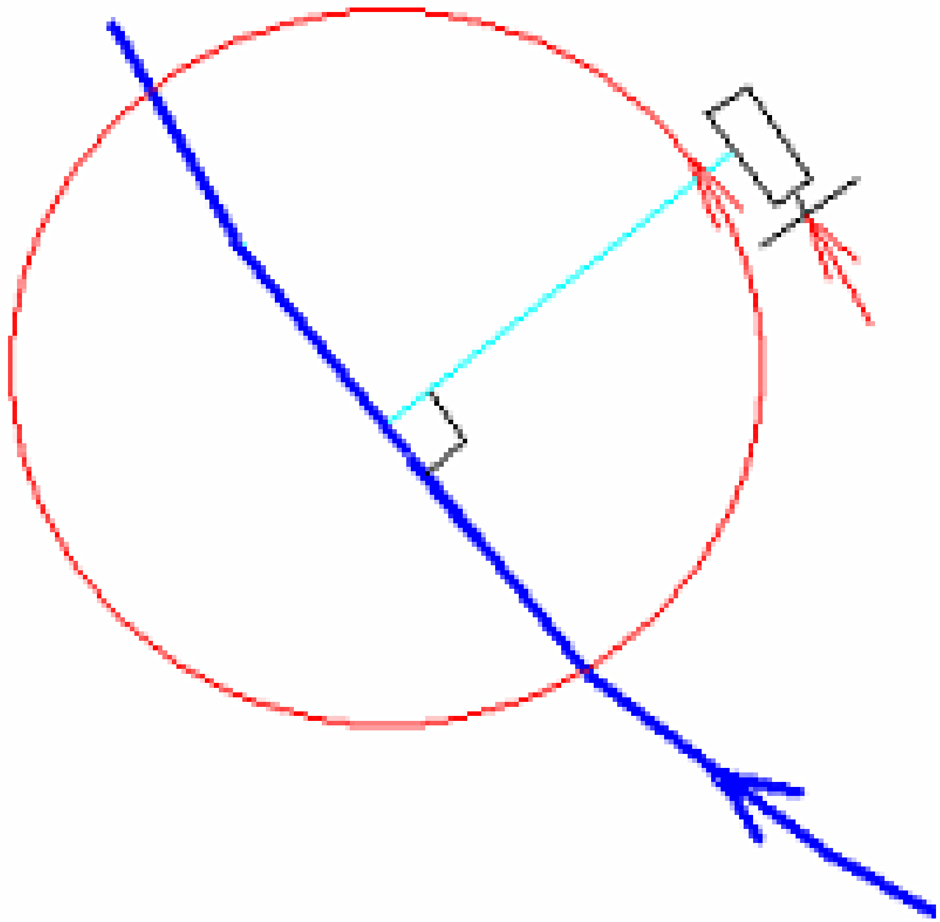
Survivor Turbine (intact)



Survival arrangements

Source: "桑美"台风肆虐浙江鹤顶山风电场分析, 胡传煜 2006年8月 (Damage report)

Survival arrangements (Vestas turbine)



Source: "桑美"台风肆虐浙江鹤顶山风电场分析, 胡传煜 2006年8月 (Damage report)

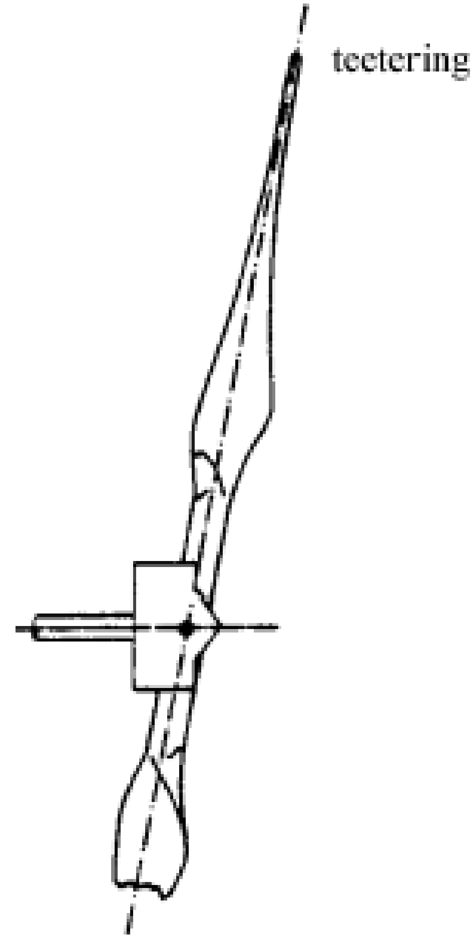
Miyako Island Japan

Unique Approach Vergnet

‚Hurricane-proof' Turbine

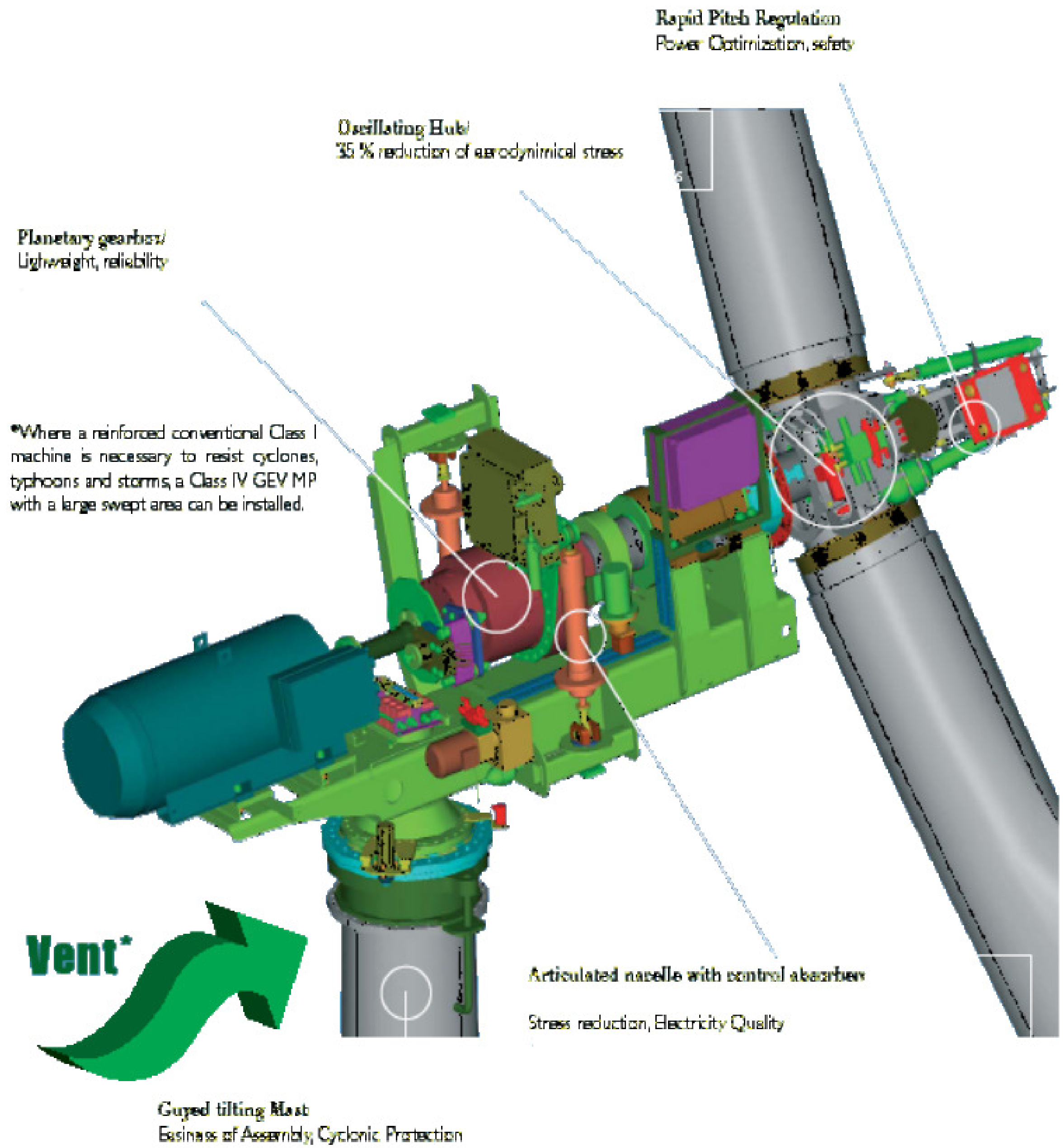
- Vergnet concept
  - light-weight turbine
  - two-bladed rotor
  - teetering hub
  - down-wind turbine
  - collapsible tower
- 20 kW, 60 kW, 220 kW
- current production
  - 275 kW turbine
  - 1 MW turbine (prototype July 2008)

principle of teetering hub ⇨

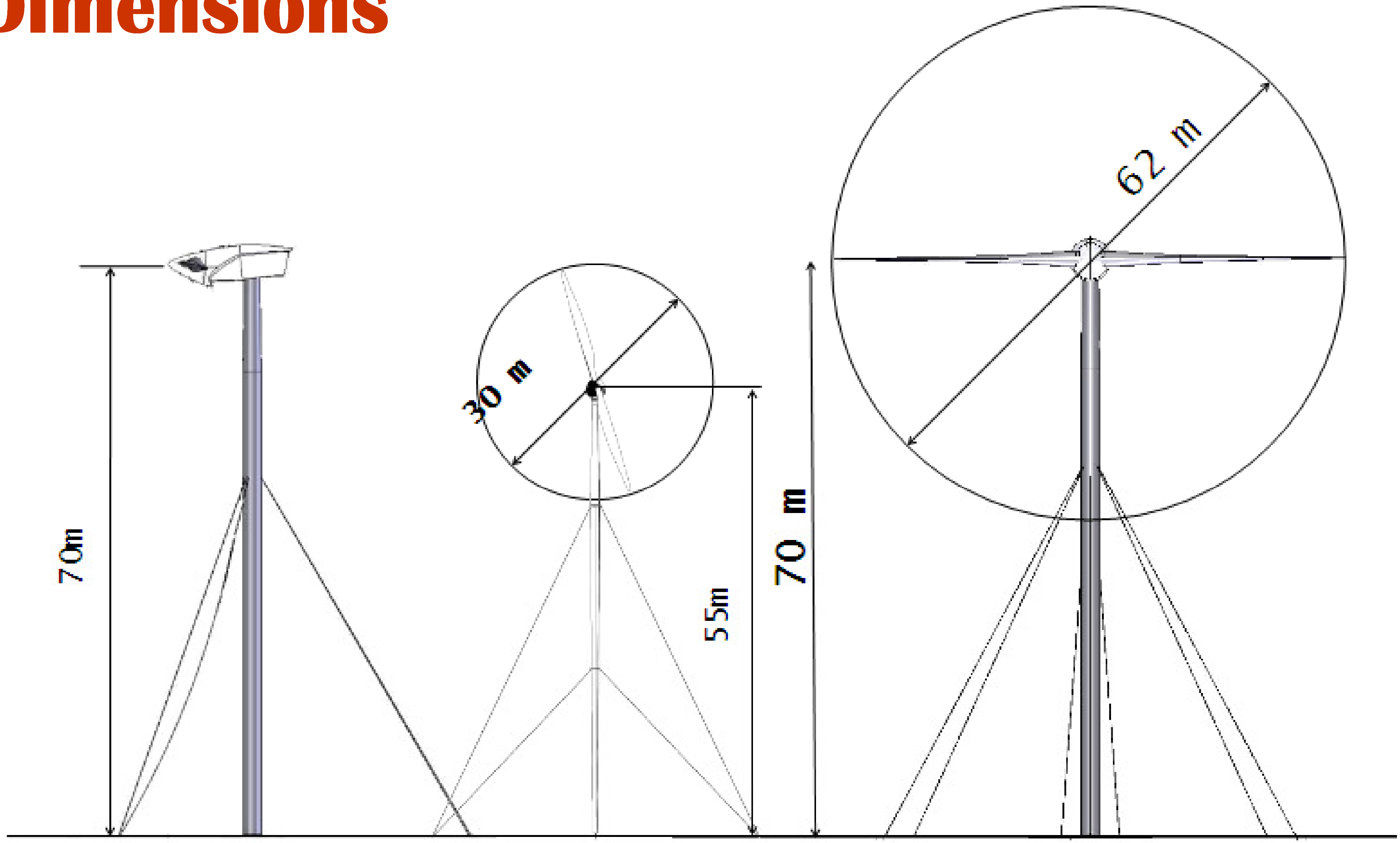


relieves the rotor shaft of alternating bending loads due to the spatially inconsistent oncoming air stream and reduces the dynamic proportion of the flapwise (alternating) bending moments at the blade root

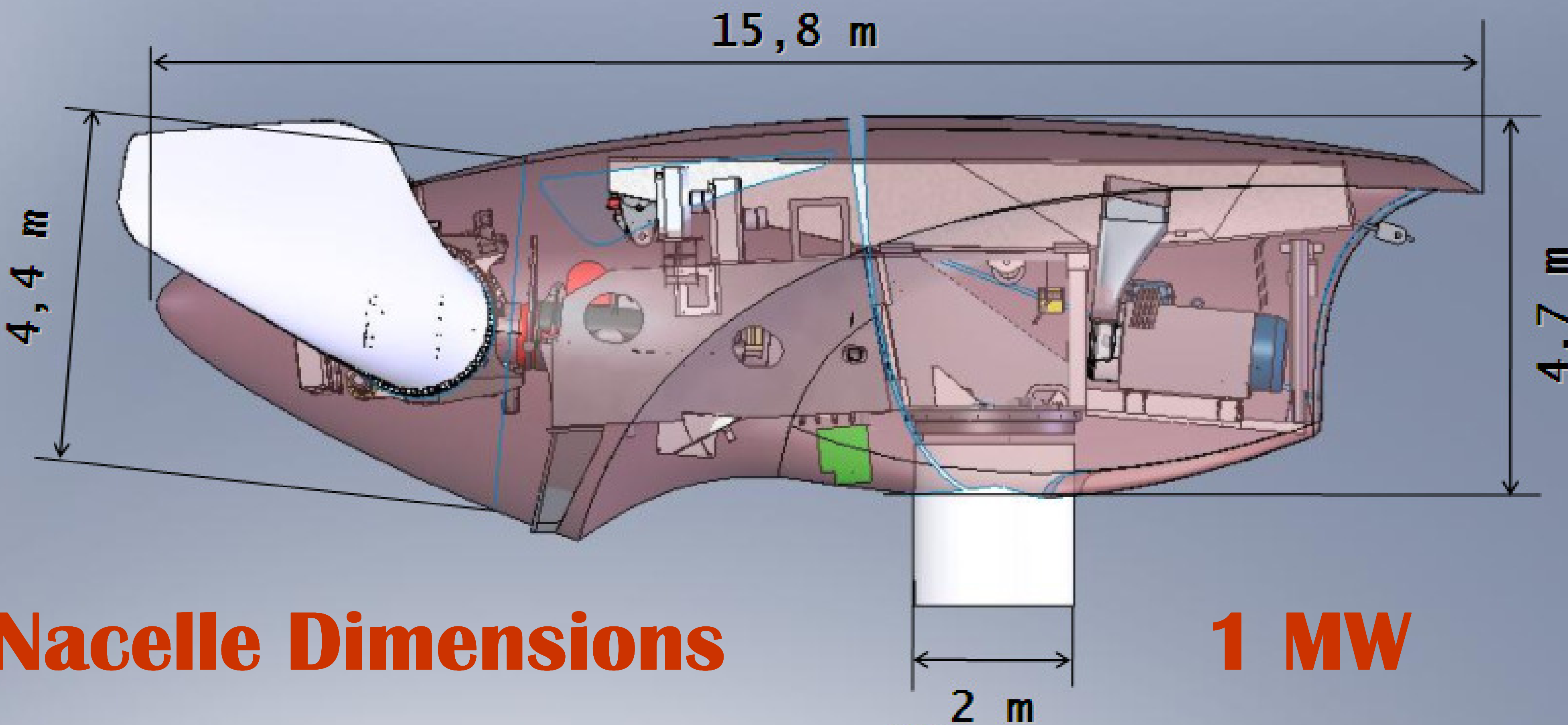
Vergnet Concept



Dimensions



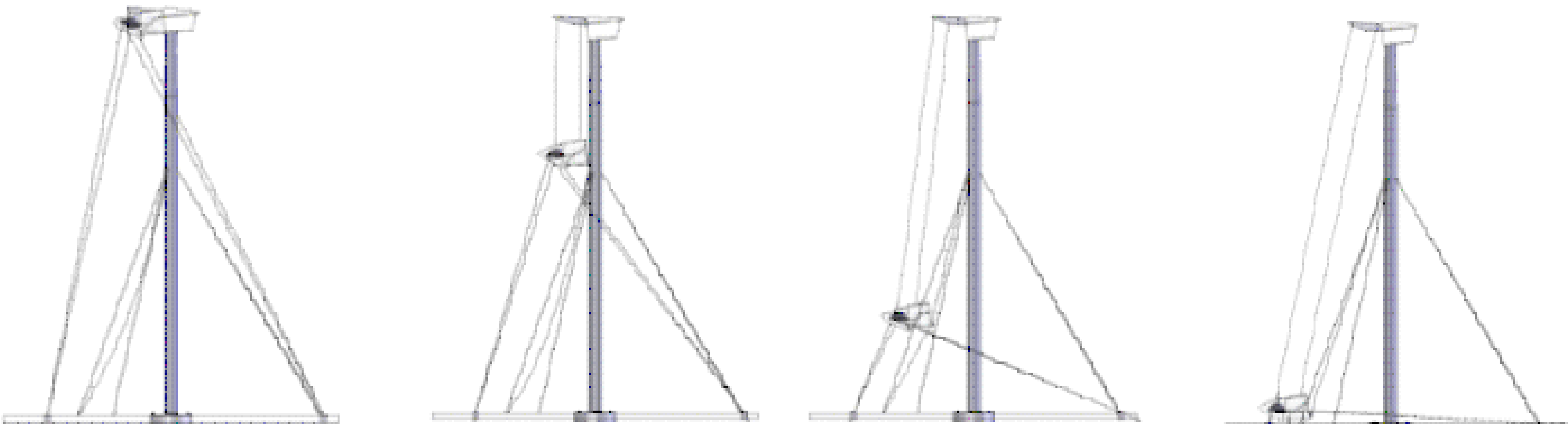
1,000 kW **275 kW** **1,000 kW**



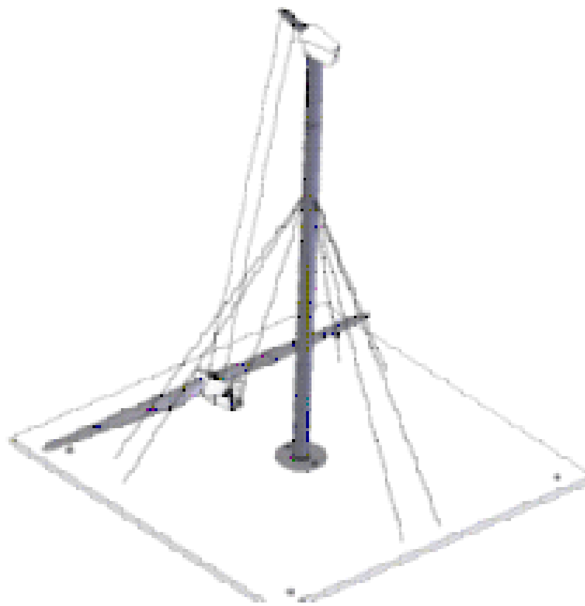
Nacelle Dimensions

1 MW

Vergnet 1 MW – Installation of Tower

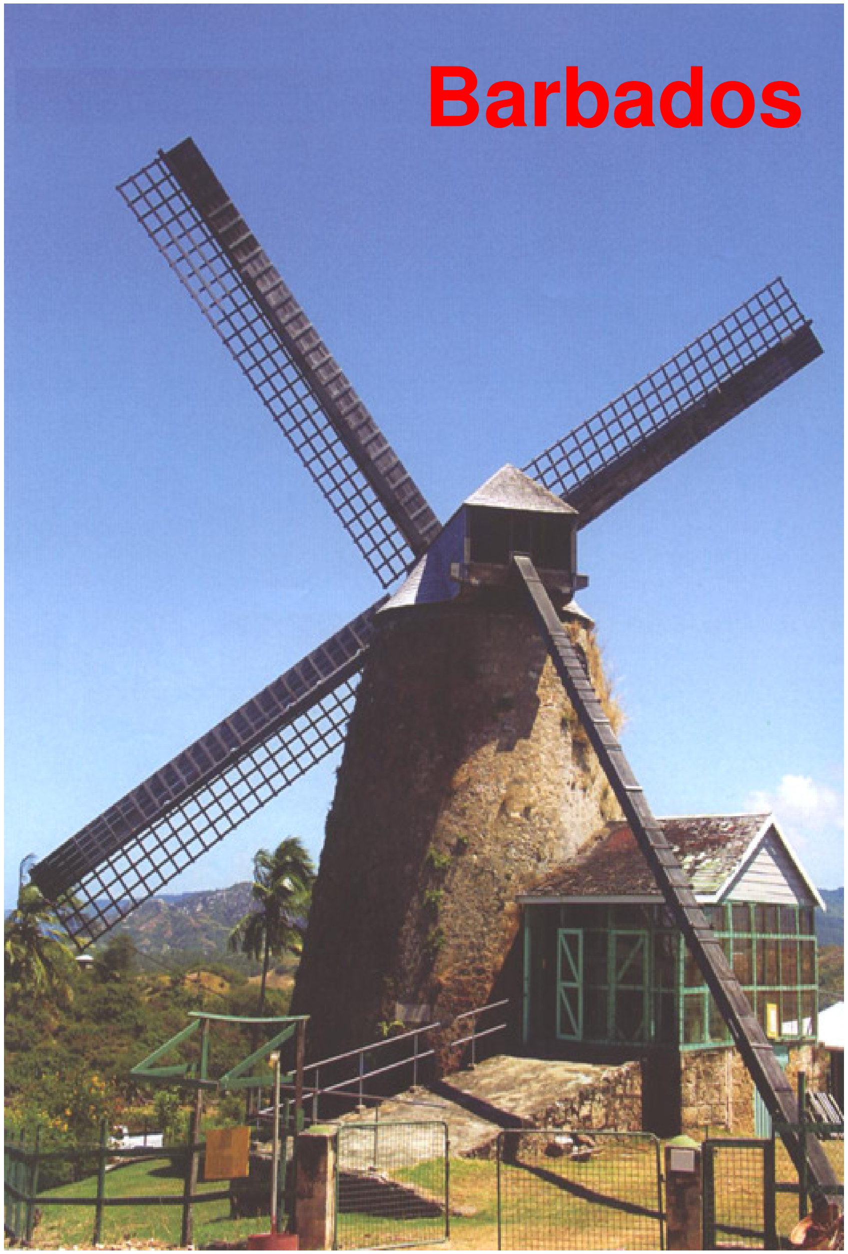


Vergnet 1 MW - Lowering of Rotor anticipating a Tropical Whirl Storm

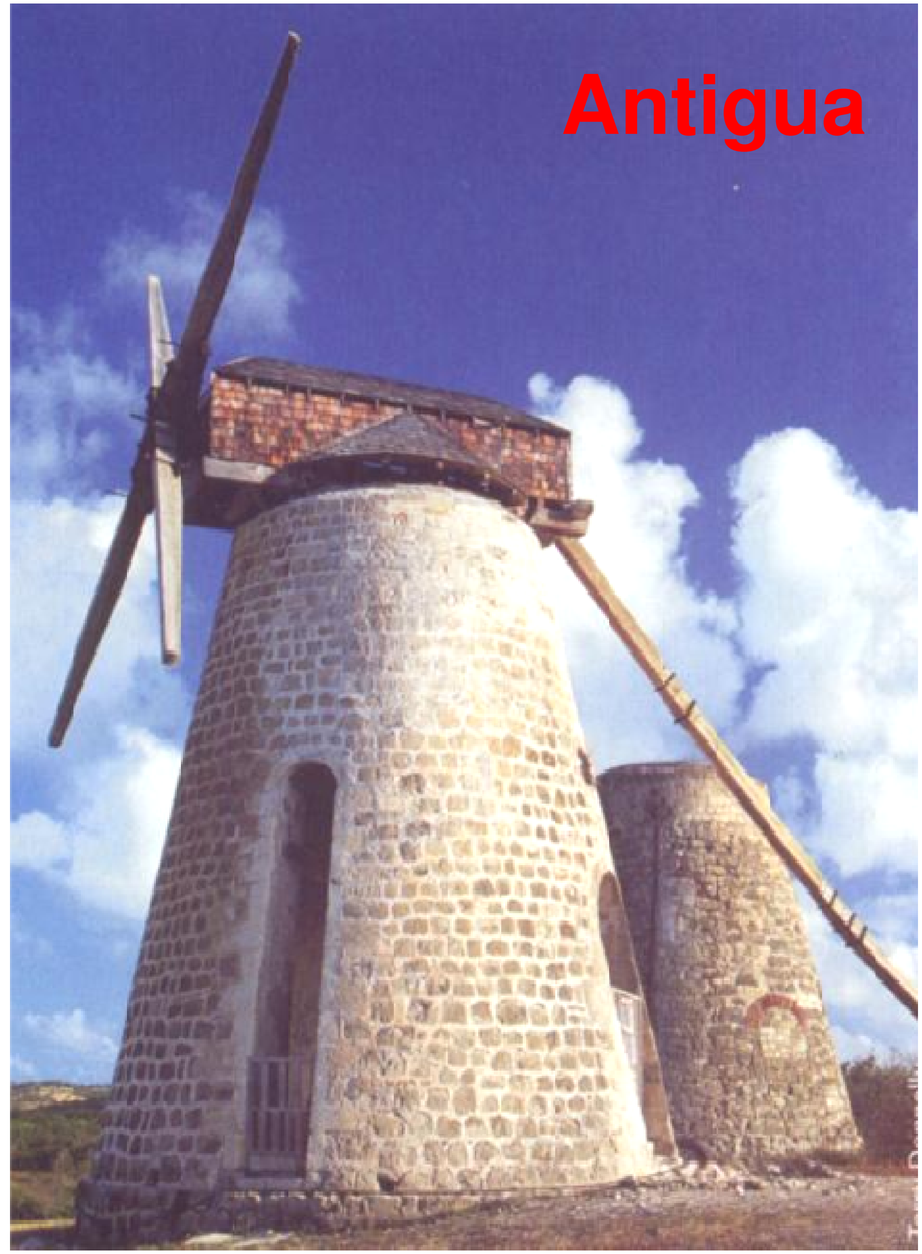


Summary Lifting/Lowering Rotor/Turbine

- 275 kW turbine: 2 people 1 hours
- 1,000 kW turbine: 2 people 3 hours
- turbine/rotor on the ground exposed to debris flying through the air
- risk of lowering during beginning of hurricane conditions (tropical depression, rain, storm etc.)
- in the pre-hurricane times man-power is practically not available (every-one secures his own house…)
- guy wires
  - corrosion risk, high maintenance requirements
  - visual impact



Wind in the Caribbean



Current Situation

Caribbean

- excellent wind resources
- practically 100 % dependency on imported fuels
- wind development currently only in Jamaica, Cuba, Curacao, Bonnaire and Guadeloupe/La Desirade
- many island with plans, but no realization (St. Lucia, St. Vincent, Barbados, Nevis/St. Kitts, Antigua, Grenada etc.)
- some individual turbines erected, but not in operation (Dominica, Grenada) = **counterproductive for wind energy reputation!**

Why retarded wind development?

Caribbean

- lack of interest by utility companies on account of fuel surcharge
- “bad reputation” of renewable (= non-dispatchable) energies
- conflicting land use interests for potential wind park sites (tourism etc.)
- high property prices

- hurricanes are not on this list – or at least not among the first 10 important reasons

Summary

How to deal with Tropical Whirl Storms

- prerequisite for survival of turbines: electricity
- install stand-by generator in strong, concrete building
- make sure, generator has enough power for all azimuth drives of the wind park, inclusive own consumption of park and turbines (SCADA)
- software change: turbine disconnected, but azimuth drive permanently active "Hurricane Mode"
- if possible, opt for stronger version of azimuth drive
- foundations with higher safety factors
- tubular tower (if possible) with higher safety factors
- and then ...

- … prey to God.

The End.

Contact:

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