

Kleine en middelgrote windturbines

Frits Ogg

KIVI Mini seminar Windenergie 19 oktober 2016

**SMALL
WiND**



Welt-Windenergie Verband
Asociación Mundial de la Energía Eólica
世界风能协会
세계풍력에너지협회
Всемирная Ветроэнергетическая Ассоциация

Inhoud



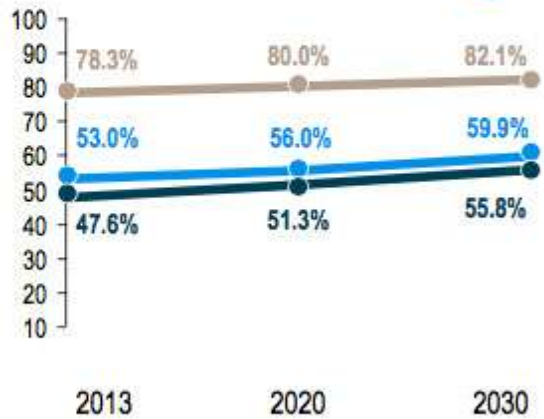
- Urbanisatie – Ruraal, bad-grid, nut van klein en middelgroot
- Definitie klein middel groot
- Logistiek
- Markt voor kleine en middelgrote windturbines
- Energie management, Power Quality en condition monitoring
- Zelfbouw
- Belemmeringen
- Toepassingen klein, middelgroot en groot

Urbanisatie – Ruraal

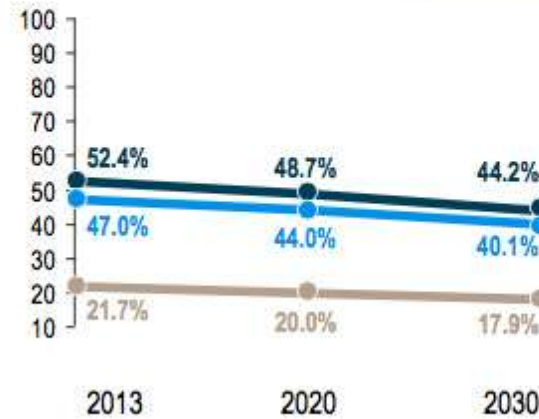


People living in urban and rural areas

Urban



Rural



— World — Developed countries — Developing countries

Keydifferences.com
Consultancy.uk

Urban-rural

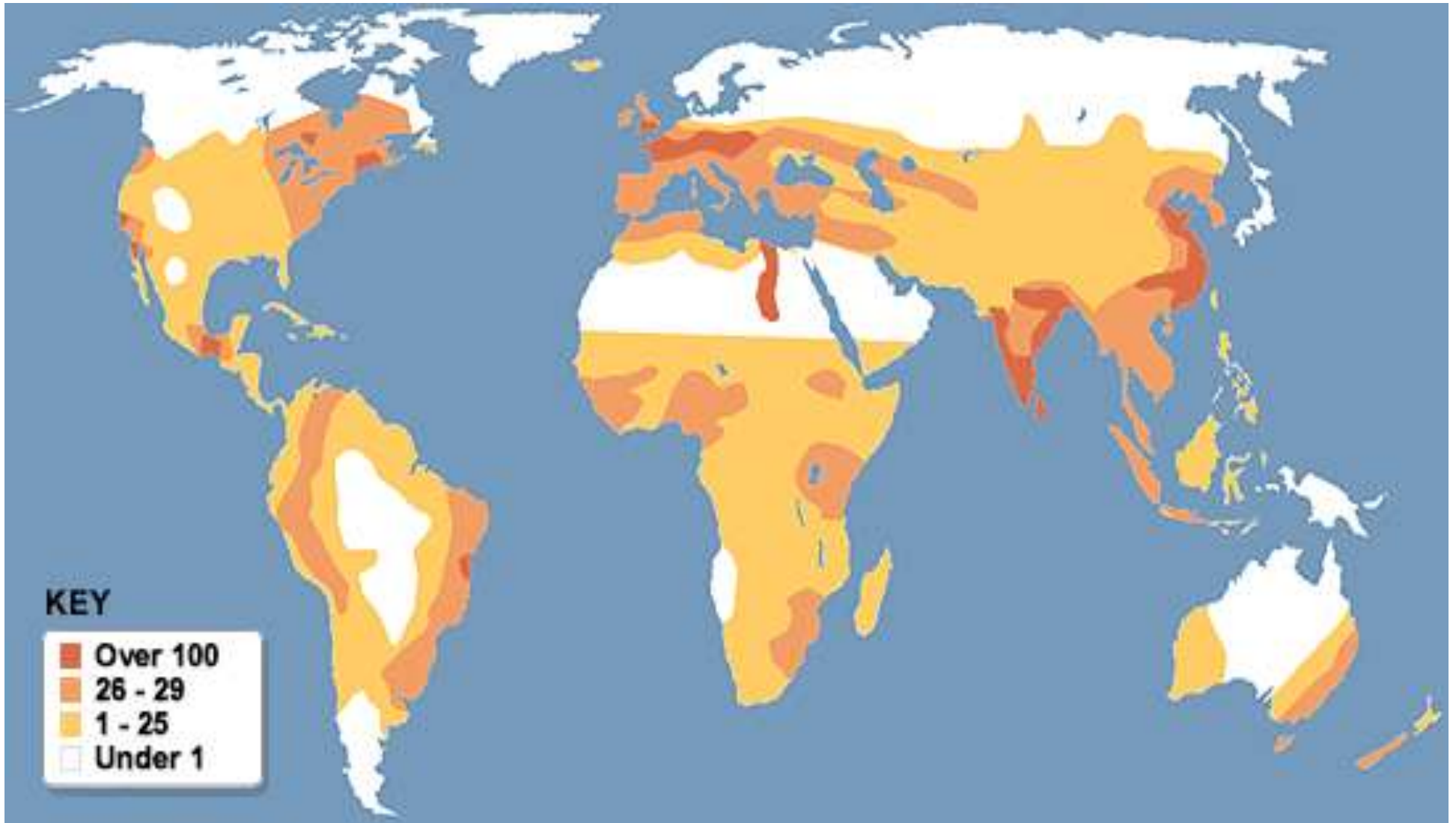
De helft van de wereldbevolking leeft in het gele gebied, de andere helft in het zwarte



<http://metrocosm.com>

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Urban-rural



Elektriciteits gebruik: Afrika

Country	National Electrification rate (%)	Adults Literacy rate (%)	Country	National Electrification rate (%)	Adults Literacy rate (%)
South Sudan	1	27	Angola	30	71
Liberia	2	48	Namibia	30	82
Central African Republic	3	59	Eritrea	32	73
Chad	4	39	Congo	35	79
Sierra Leone	5	48	Sudan	35	73
Democratic Republic of Congo	9	64	Gambia	35	56
Malawi	9	66	Mozambique	39	59
Burundi	10	85	Zimbabwe	40	86
Guinea	12	30	Comoros	45	78
Niger	14	36	Nigeria	45	59
Somalia	15	38	Djibouti	50	-
Madagascar	15	65	Cameroon	54	75
Uganda	15	78	Senegal	55	58
Burkina Faso	16	36	Sao Tome and Principe	59	75
Rwanda	17	70	Gabon	60	91
Guinea-Bissau	20	60	Botswana	66	87
Kenya	20	78	Equatorial Guinea	66	95
Mauritania	21	61	Ghana	72	76
Ethiopia	23	49	South Africa	85	94
Tanzania	24	71	Cabo Verde	94	87
Côte d'Ivoire	26	60	Seychelles	97	92
Zambia	26	63	Morocco	99	68
Togo	27	66	Algeria	99	80
Swaziland	27	89	Egypt	100	74
Mali	27	39	Libya	100	91
Lesotho	28	79	Mauritius	100	90
Benin	28	38	Tunisia	100	83

SOURCES: CIA; IEA/UNESCO

Uit: "Light over Africa"
www.folkecenter.net

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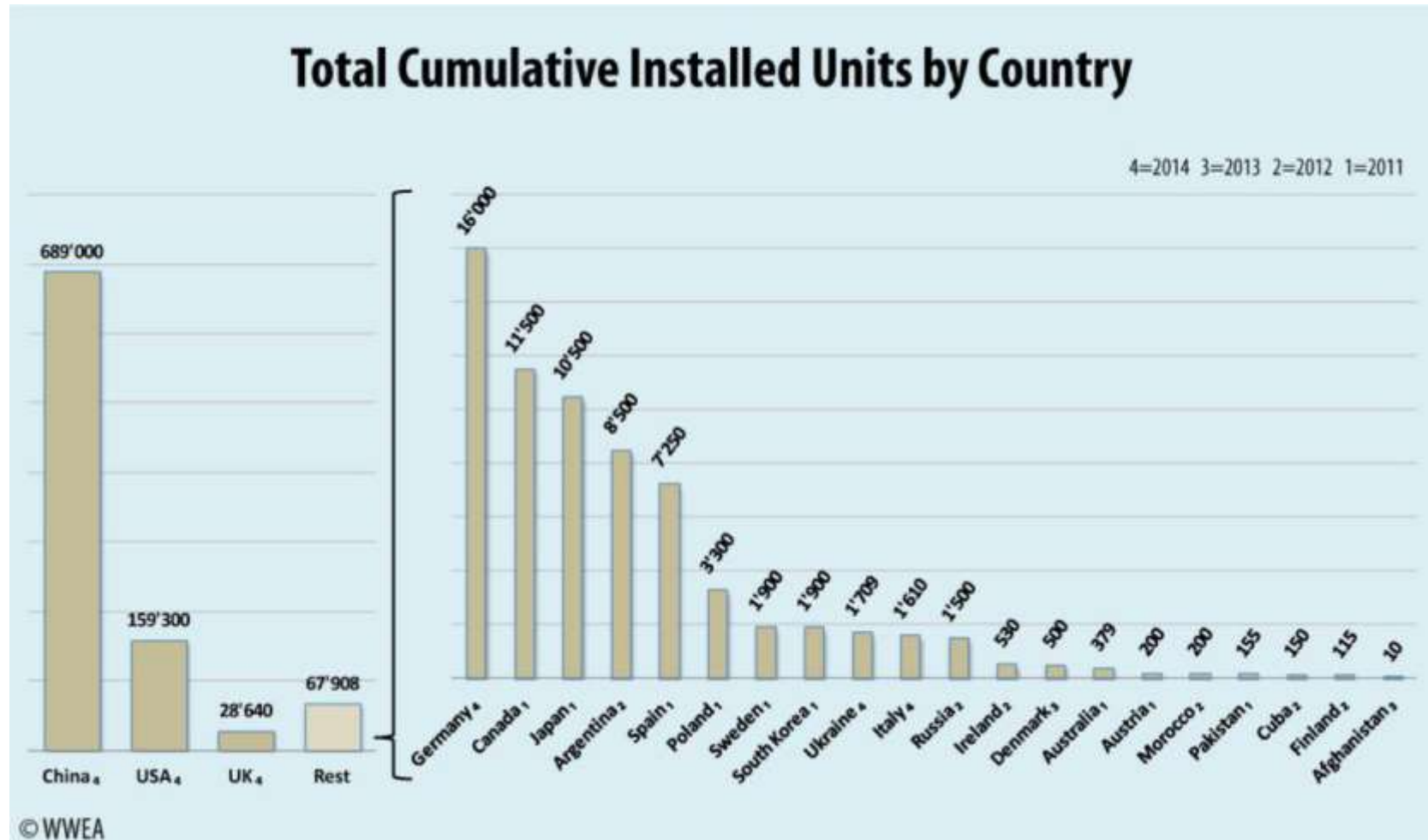
Waarom focussen op kleinere windturbines

- 90% onshore is ruraal met een zwak of geen elektriciteitsnet
- Wijdverbreid gebruik van diesel in rurale gebieden (3kW>4GW), klimaatverandering en het grote potentieel van wind
- Bijdrage aan de watervoorziening en de waterzuivering (niet energie maar water is wereldwijd de grote uitdaging!)
- Mogelijkheden voor lokale community wind (100-1000kW, vooral bij lange zwakke voedingslijnen
- Logistieke problemen bij gebruik van MW turbines
- Progressieve energievraag voor telecom (3G, 4G, 5G, DATA)

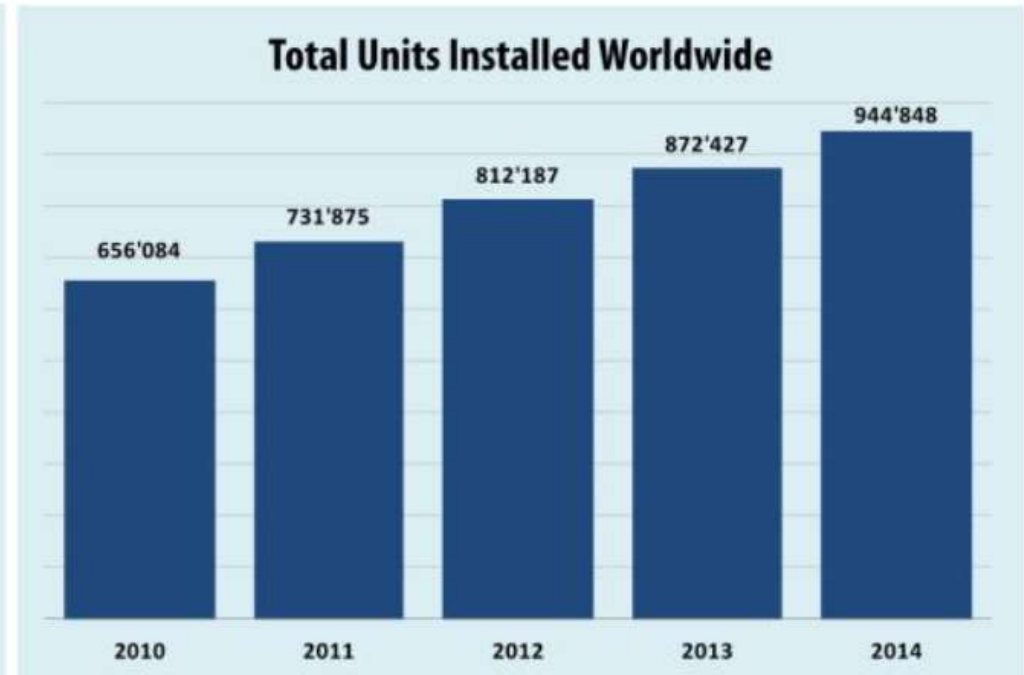
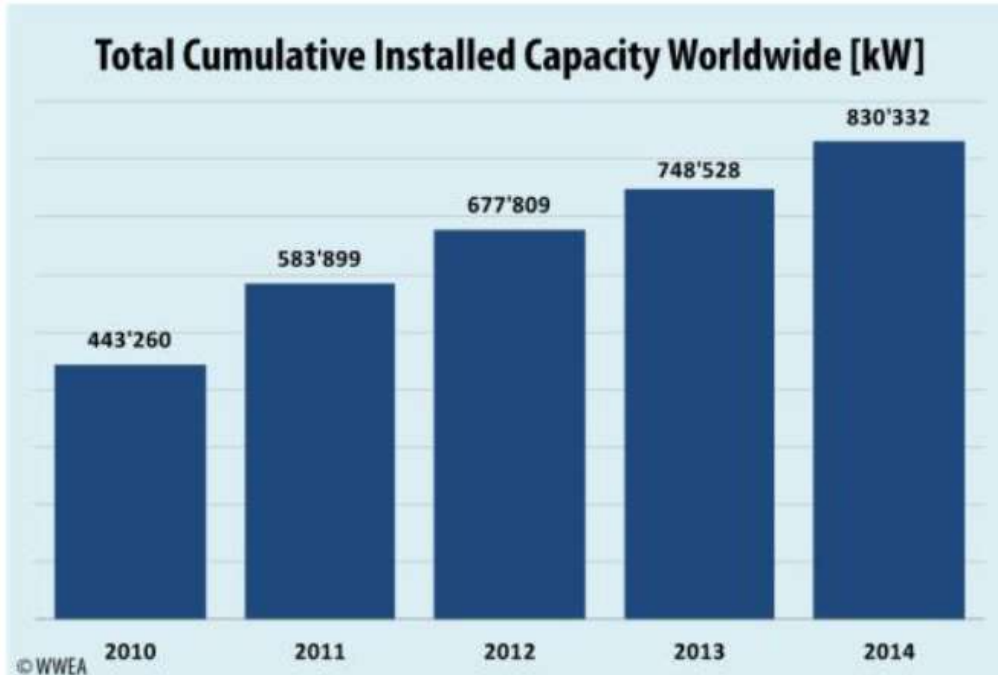
Table 2: Proposed grid categorisation

	Size (kW)	Capability	Complexity
Stand-alone systems	0 – 0.1		
Pico-grid	0 – 1	<ul style="list-style-type: none"> • Single controller 	
Nano-grid	0 – 5	<ul style="list-style-type: none"> • Single voltage • Single price • Controllers negotiate with other across gateways to buy or sell power 	<ul style="list-style-type: none"> • Both grid-tied and remote systems • Preference for DC systems • Typically serving single building or single load • Single administrator
Micro-grid	5 – 100	<ul style="list-style-type: none"> • Manage local energy supply and demand • Provide variety of voltages • Provide variety of quality and reliability options • Optimise multiple-output energy systems 	<ul style="list-style-type: none"> • Incorporate generation • Varying pricing possible
Mini-grid	0 – 100 000	<ul style="list-style-type: none"> • Local generation satisfying local demand • Transmission limited to 11 kV 	<ul style="list-style-type: none"> • Interconnected customers

Total CIU by country <100kW

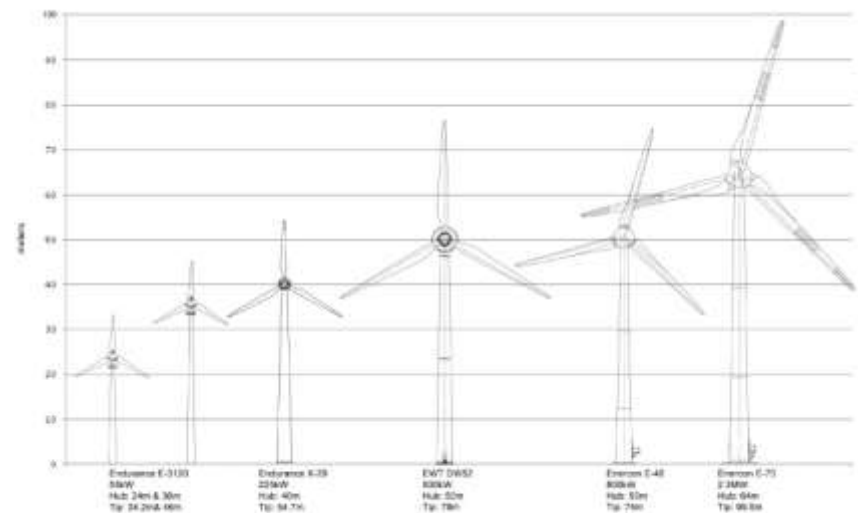


Total installed capacity/units worldwide



Nationale definities van middelgroot

- Bijna ieder land heeft zijn eigen definitie voor kleine, middelgrote en grote windturbines
- Vaak gebaseerd op discutabele generator en rotor groottes (binnenland en kust!)



Aeoluspower.com

Hoe klein is middelgroot?



De definitie zou gebaseerd moeten zijn op basis van gebruik & met generator groottes binnen een range.

- **Small** (Windturbines, dekawatt windturbines)

Just to supply one household or less from 10W to ~ 10 kW

- **Medium** (Kilowattwindturbines)

To big for a household and to small for a village (SME!), ~10 kW to ~ 100 kW

- **Large Medium** (Kilowattwindturbines)

Fit's SME & communities, ~100kW to ~300kW

- **Large** (Kilowattwindturbines)

to great for a rural grid, ~ 300kW to ~ 1MW

- **Extra Large** (Megawattwindturbines) > 1MW



Selected Prefixes and Their Meaning		
G	billion (U.S.)	giga
M	million	mega
k	thousand	kilo
h*	hundred	hecto*
da*	ten	deka*
d*	tenth	deci*
c*	hundredth	centi*
m	thousandth	milli
μ	millionth	micro
n	billionth (U.S.)	nano

Difficult Logistics Not To Be Under Estimated



2012 had tough weather conditions

>>> 164 days with ports closed



Logistiek



Ruhnu Island
Vestas V27 225kW

[Www.danvest.com](http://www.danvest.com)

Markt voor klein

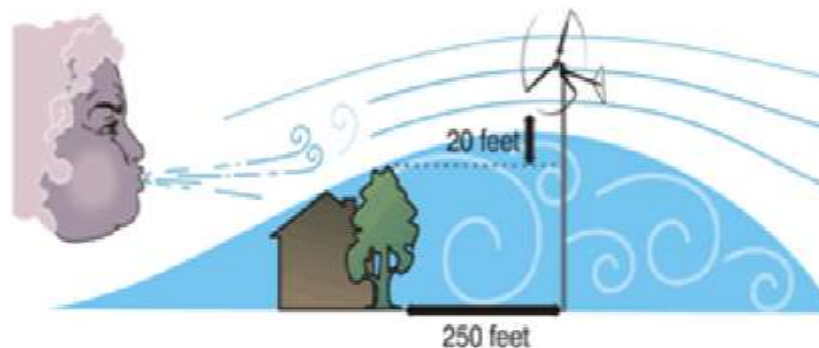
- Windmeten, Speelgoed
- Telemetrie
- Recreatie, woonboten
- Huishouden (turbulentie)
- Telecom base station



[Www.kidwind.org](http://www.kidwind.org)



[Www.fortiswindenergy.com](http://www.fortiswindenergy.com)



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Markt voor middelgroot

- No-Grid (b.v. Afrika, India)
- Bad Grid (No 24/7 electricity, meestal samen met zon PV en/of diesel)
- Eilanden (Brandstof transport kosten en klimaat verandering)
- Mijnen (afgelegen locaties => brandstof transport kosten)
- Ontziling & Watervoorziening (Geen brandstofkosten)
- Waterstof productie (ITM Power Hydrogen Fuel station, 225 kW)*
- Zwakke netten (realiseren verzwaring kostbaar, zelfs in verstedelijkte gebieden, Vlieland!)
- Lokale opwek (Sandy, New York)
- Kleinere hindercirkel (Shadow, Noise, Urbanised area)
- Community wind & Telecom (charging mobile phones & more, GSMA: 200.000 communities)



[Www.ITMPower.com](http://www.ITMPower.com)

Markt voor middelgroot 2

- Community wind (communities “at the end of the line” max 300kW)* **
- Natural parks & Sensitive habitat (st.Helena, oil-spill risk)
- Heating support of CHP (Distributed energy, Denmark)
- Moeilijk bereikbare plekken, logistiek! (Enercon, Bonaire 12x E44 900 kW)
- Emergency power @ Manmade & Natural disasters (telecom, ook urban!)
- Leger, Festivals en andere mobiele toepassingen (burdening cost of fuel)
- Orkaan gevoelige gebieden (omlaag halen van rotor of turbine < 275 kW)
- Retrofit / Refurbishment / Hergebruik van “repowered windturbines”
Zie b.v. ook: windpostcoderoos.nl
-

*



THE SMALL
WIND CO-OP

<http://smallwind.org.uk>

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Rescoop.eu
European Federation of
groups and cooperatives of citizens
for Renewable Energy

Energie management, SCADA, Power Quality en condition monitoring



i – electricity

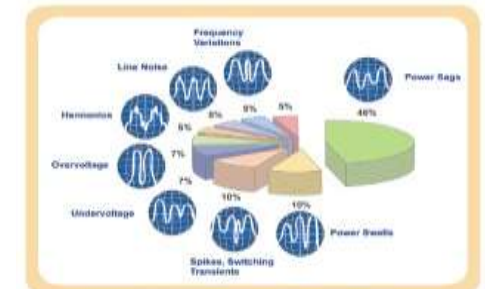


Figure 1 - 2001 EPRI 2001 Study of typical PQ phenomena

<http://reliabilityweb.com>

[Www.hyteps.nl](http://www.hyteps.nl)

[Www.4top.nl](http://www.4top.nl)



komatsu.com.au

18

[Www.ecogrid.eu](http://www.ecogrid.eu)

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Zelfbouw

- Hugh Piggott
- [Www.scoraighwind.com](http://www.scoraighwind.com)
- [Www.I-love-windpower.com](http://www.I-love-windpower.com)



Belemmeringen

- Veiligheid, betrouwbaarheid
- Certificering (SWCC, smallwindcertification.org)
- Regelgeving & Lokatie (ashoogte, turbulentie)
- Automatisering (IoT, SCADA, Power Quality, Condition monitoring)
- Financiële Back-up fabrikanten klein & middelgrote windturbines (maitenergy.it)
- Charlatans (& media & politiek & ambtenaren)

Toepassingen telemetrie – UNAVCO



<http://www.unavco.org>

Polenproject Antarctica Foto's: Thomas Nylen



Toepassingen klein



Windchallenge



Easywind

Telecom

**Pye Dunlite
2 kw Wind-powered
Generators**

efficient, cost-effective power supplies for remote sites



PROVEN DESIGN FEATURING HIGH RELIABILITY WITH MINIMAL MAINTENANCE

EASY INSTALLATION - HEAVIEST COMPONENT (27 kg / 60 lb)

Wind-powered generators, though simple in principle, require considerable design expertise to fulfil their function efficiently and safely. Dunlite wind-powered generators have a proven record of providing reliable, economical power supplies and have been used extensively by telecommunications, navigational aids and disaster services in many parts of the world over the last 30 years. With their minimal maintenance requirements, Dunlite generators have definite advantages for small power requirements - particularly in isolated areas where any maintenance is a major operation.

The Dunlite generator is a lightweight machine which provides a maximum continuous output of 2 kW and can be supplied to operate at 24V, 48V or 120V DC. It comprises an alternator, driven by a variable-pitch propeller through a gearbox to achieve generating speed. A tail fin maintains the correct position of the machine in relation to wind direction. The complete assembly pivots in a horizontal plane on a fixed base, the electrical power being transmitted by slip rings to the generator. As the generator is used to supply DC, rectification of the

VOLTAGE OPTIONS: 24V, 48V or 120V DC

SUITABLE FOR ANY CLIMATE

SYSTEM PLANNED & SUPPLIED COMPLETE TO LAST DETAIL

output is carried out at the alternator terminals by a sliding contact located within the alternator frame.

To obtain optimum performance from the equipment, the machine must be used in conjunction with storage batteries. The sophisticated automatic voltage regulator and control equipment is housed in a control box, which can be located away from the generator installation but adjacent to the batteries. When an AC supply is required, this can be obtained through an inverter.

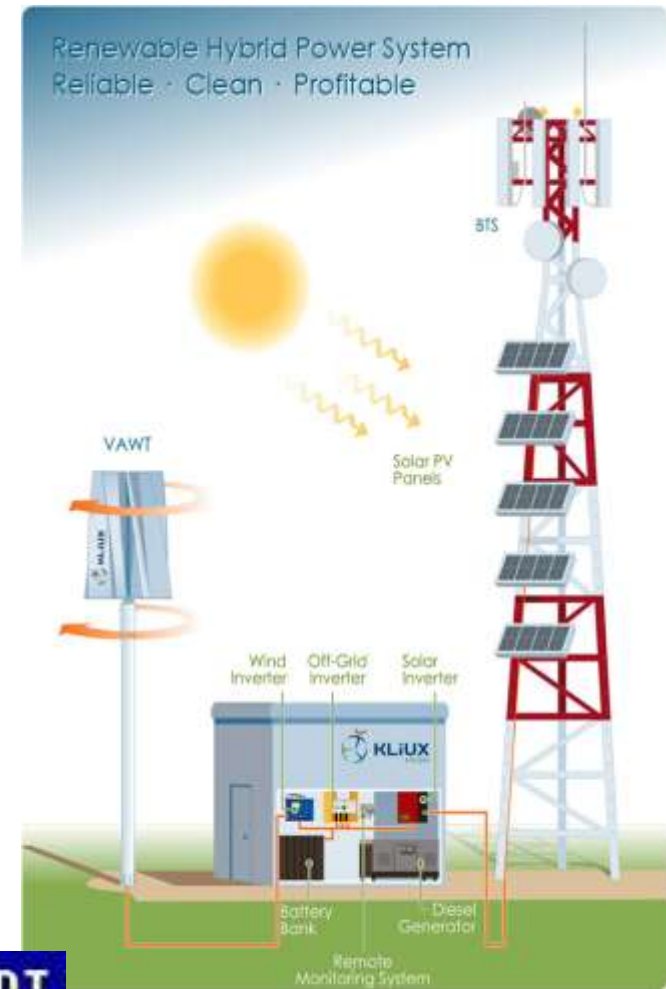
The alternational system described will derive from the constant revolution, using a single generator to convert a DC supply to a AC, by complex arrangements involving both an exciter from conventional generating equipment. The control circuitry used to regulate the exciter supply varies into a secure, analog supply are designed to meet the specific operating conditions.



1974 !



AERIAL FUEL TRANSPORT



2015

More applications telecom 2



Stectel.com



Bergey.com



Xzeres.com



Fig. 4 The trunked radio system on the Brandeckopf tower near Offenburg, Germany, which is used for communicating with and monitoring a regional railway line, is operated with a PV hybrid system. Source: Steca Elektronik GmbH

Steca.com

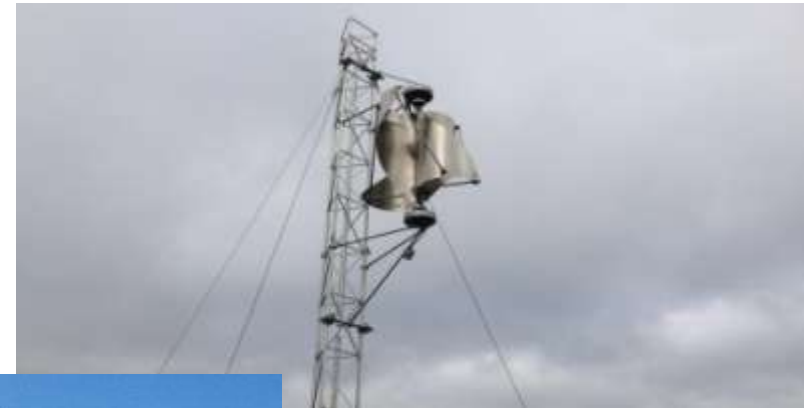


Zephyr.com

More applications telecom 3



Kestrelwind.co.za



Icwind.is



Leturbines.com



Wishenergy.com

Toepassingen middelgroot



[Www.gaiawind.com](http://www.gaiawind.com) 11kW

[Www.thisted.dk/thymollen](http://www.thisted.dk/thymollen) 6kW



Toepassingen middelgroot 2



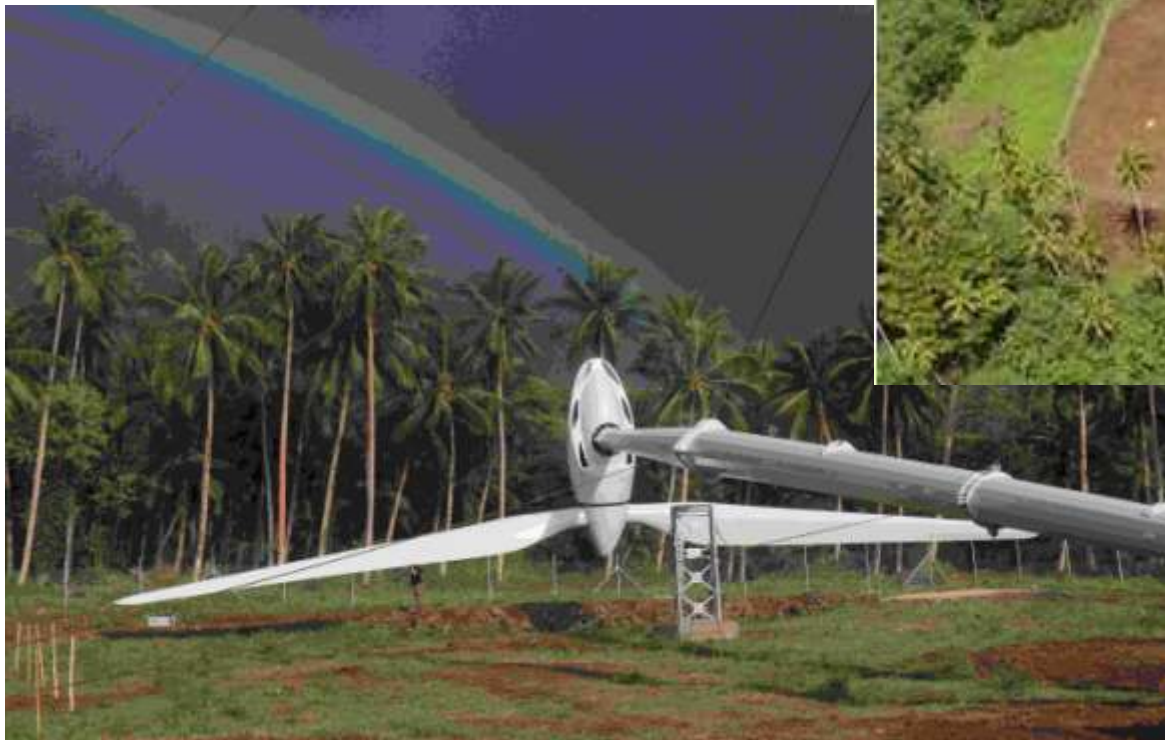
Toepassingen middelgroot 3



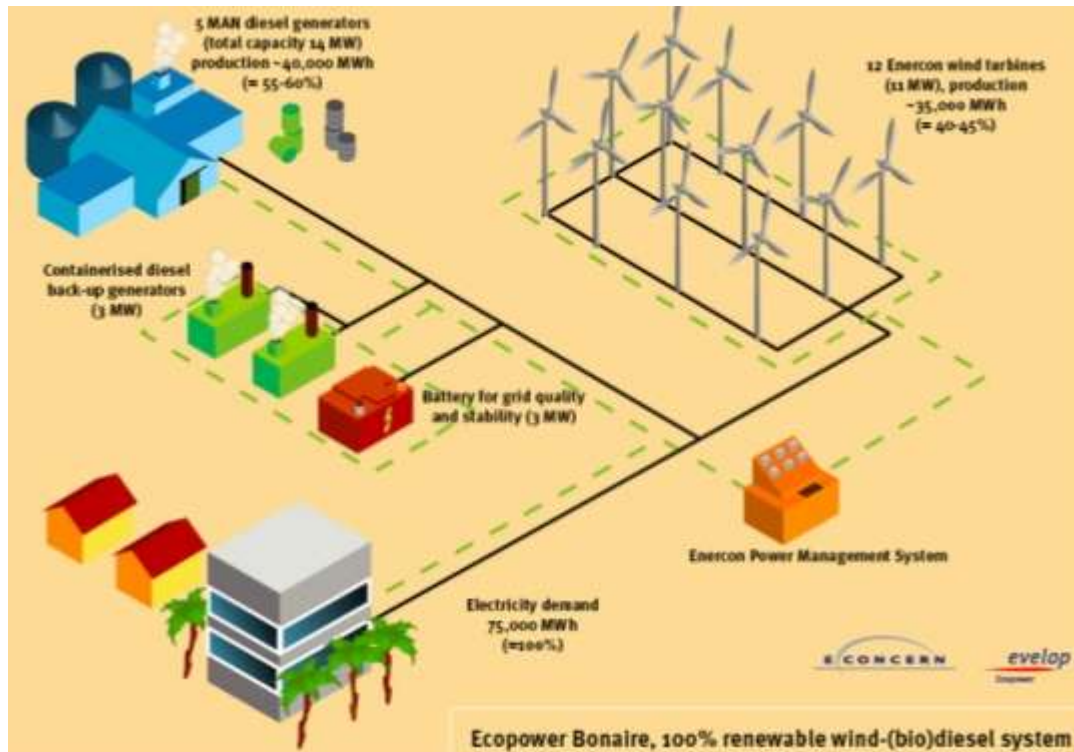
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WES, www.windenergysolutions.nl st. Helena eiland 12 x 80kW, >100% wind

Toepassing middelgroot



Toepassingen groot



Bonaire, ENERCON
12 x 850 kW

Toepassingen groot 2



VARIABLE REACTANCE

MECHANICALLY CHANGING PERMEABILITY

$$L = \frac{\mu N^2 A}{l}$$

l = Inductance (H of Henry)
 N = Number of turns
 A = Area of coil (m^2)
 l = Length of coil (m)
 μ = Magnetic permeability
 $\mu = \mu_0 \mu_r$ (μ_r relative)
 μ_0 (vacuum) = $4 \pi \times 10^{-7}$ H/m
 μ_r (air) = 1 (practical purpose)
 μ_r (iron) = 5000

REACTIVE POWER
 (V = 400V, F = 50 Hz)

$$Q = \frac{V^2}{2\pi fL}$$

For 2 star windings connected in series, our reactance is:
 • L_{air} (Iron extracted) = 6,2 mH \Rightarrow 82 kVAR
 • L_{iron} (Iron inserted) = 1,3 mH \Rightarrow 372 kVAR
 This allows simulate different Client Power Factor

[Www.gamesacorp.com](http://www.gamesacorp.com)
 Zaragoza – Off grid
 simulation 850KW

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Foto's: Frits Ogg

Thank you for your attention

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Voor meer opensource informatie:
<https://nl.linkedin.com/in/fritsogg>

