VARIABLE WIND SOLUTIONS

Breakthrough Wind Turbine Power Generation Solutions

April, 2010

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***Voltage Regulation Solution* (VRS)**

Breakthrough power generation solution for wind & hydrokinetic turbines.

Reduces turbine costs. Optimizes performance & efficiency.

- First power generation solution designed specifically for optimal performance and cost-effectiveness in low and variable-speed winds
- "All-in-one" power generation and conditioning solution combines low-RPM AC generators with advanced electronics to deliver grid-quality electricity
- Patent-pending VRS beta units successfully tested and results documented
- Completed VC-led A round in 2008

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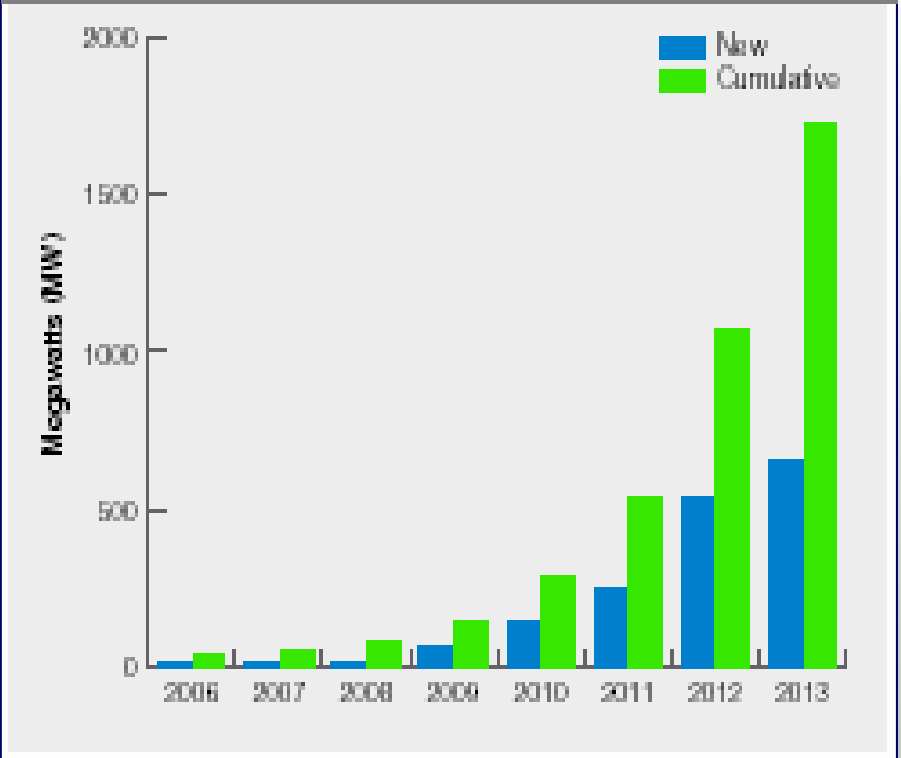
2008 Small Wind Turbine Market (<100kW)

U.S Sales	Global Sales
17.3 MW	38.7 MW
78% growth over 2007	53% growth over 2007
10,500 units	19,000 units
$77 million in sales	$158 million in sales

U.S. Small Wind Turbine Market Projections



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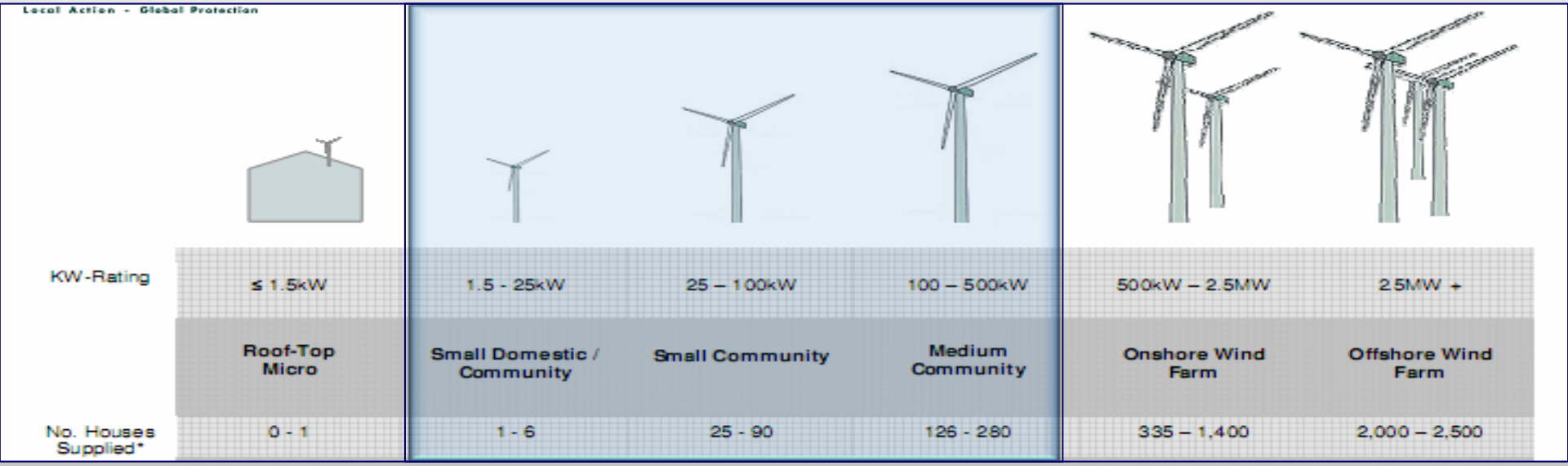
Market Drivers & Sectors

1. Feed In Tariffs (FIT)
2. Renewable Portfolio Standards (RPS)
3. Incentives (ITCs, etc.)
4. Carbon trading
5. Electricity price fluctuations
6. Awareness, energy independence, etc.



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You Need to Understand Wind ….

1. The faster the wind, the more power it contains (all other things being equal)

   $P = 0.5 \times rho \times A \times V^3$

   P = power in watts

   rho = air density (about 1.225 kg/m^3 at sea level, less higher up)

   A = rotor swept area, exposed to the wind (m^2)

   V = wind speed in meters/sec

2. The higher the tower, the higher the wind speed (typically)

3. The larger the rotor's swept area, the more power can be extracted from the wind

…. to Understand Wind Turbine Performance.

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Case Study: Quiet Revolution

Rotor Dimensions

5m x 3m

Output

4.2 kW @ 11m/s

1.5 kW @ 8 m/s

0.8 kW @ 6 m/s

Cost

> $55,000

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The Problem being Addressed

- Today's turbines use power generation and conditioning solutions that are not optimal for variable, low, and medium speed winds.
- Yet small turbines with these solutions are typically installed close to where people live, where there are only low, medium, and variable-speed winds.
- *As a result*, small wind turbines are:
  1. Too expensive
  2. Not efficient

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Competing Power Generation Methods

Method	Pros	Cons
PMG with inverter	- Gearless - Variable speed operation	- Expensive (~$1,000-$1,200/kW) - Low overall efficiency when not operating in preferred RPM range
Induction generator with controller	- Generator (without controller) is cost competitive with AC synchronous generators - Simple and reliable	- Cannot operate off-grid without additional expensive electronics to provide grid reference - Requires gearbox and stable RPMs

Neither solution is cost-effective in low, medium, and variable-speed winds.

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The Goal

Small wind turbines need to become *more efficient*, *affordable*, *and cost-competitive* to achieve significant market penetration (AWEA, NREL, DOE).

- **More affordable** per kW:
  - Drop from $4,000-$7,000/kw down to ~$1,500/kW
  - Be less reliant on legislation and financial incentives

- **More efficient** and reach rated capacity in lower and mid-speed winds (<8-9 m/s) rather than higher speed winds (11-13+ m/s)

http://www.awea.org/smallwind/pdf/09_AWEA_Small_Wind_Global_Market_Study.pdf,
http://www.awea.org/smallwind/documents/31958.pdf

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The VRS Voltage Regulation Solution

- An electronic card that modifies the intensity of the magnetic field of AC synchronous (squirrel cage) generators to allow the generator's shaft to rotate at variable speed ($\acute{\omega}_{nom} \pm 60\%$), yet still deliver a stable output voltage.
- The VRS turns AC synchronous generators into variable-speed machines optimized for low, medium, and variable-speed winds.
- The VRS can be used with any rotor design.

Many companies have successfully developed rotors and mechanical assemblies.

But very few know how to generate electricity efficiently and cost-effectively.

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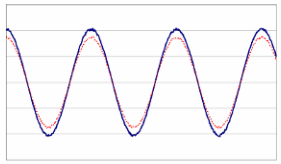
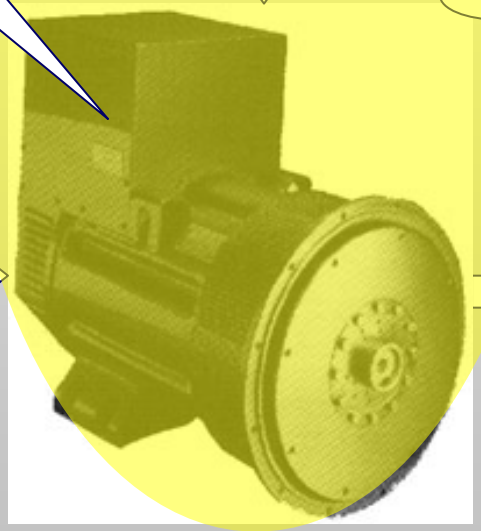
System Block Diagram

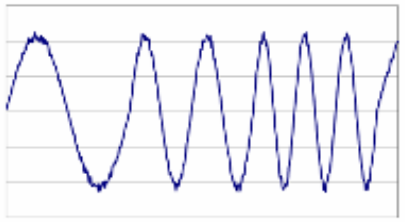


Output:
Grid-synchronized Voltage

Multi-Pole Low-RPM AC Brushless Synchronous Generator

Standard Wind Inverter





Output:
Constant Amplitude Variable Frequency

Wind Interface Module

Solution (2)

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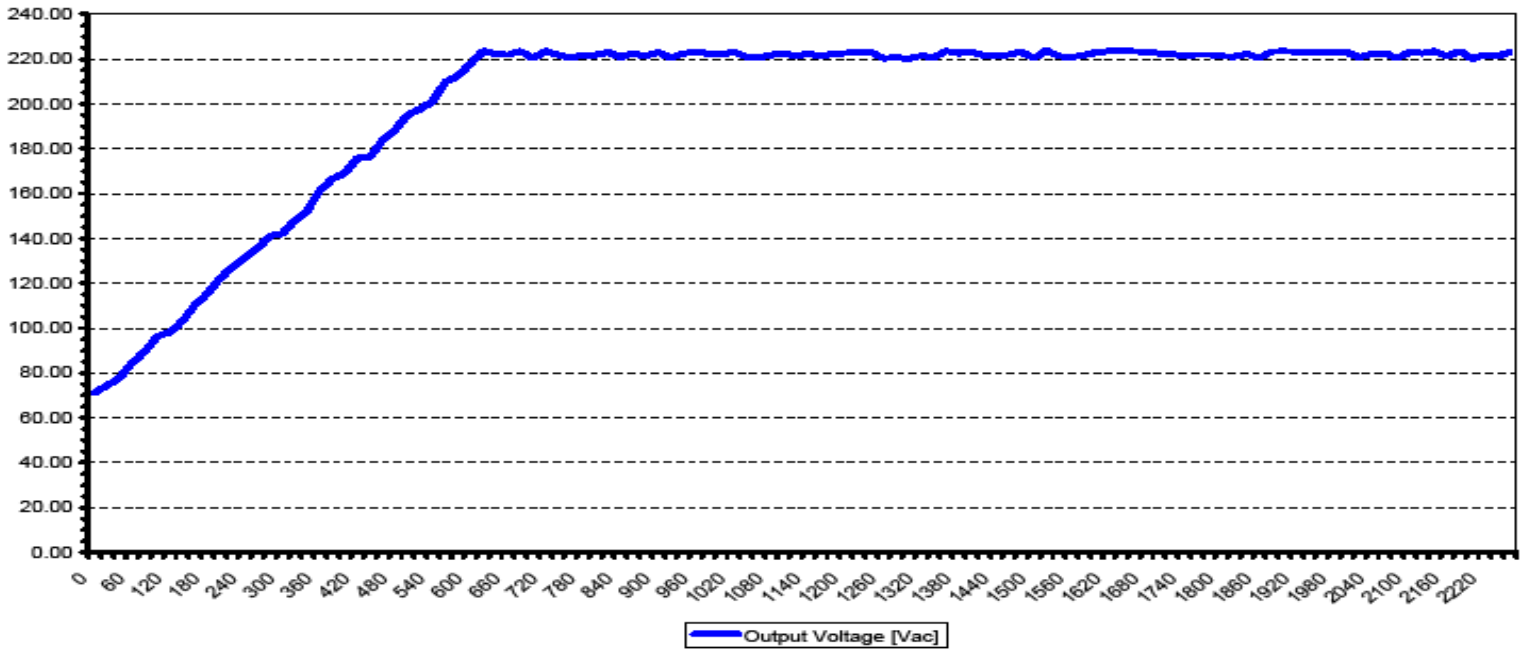
RPM vs. Voltage



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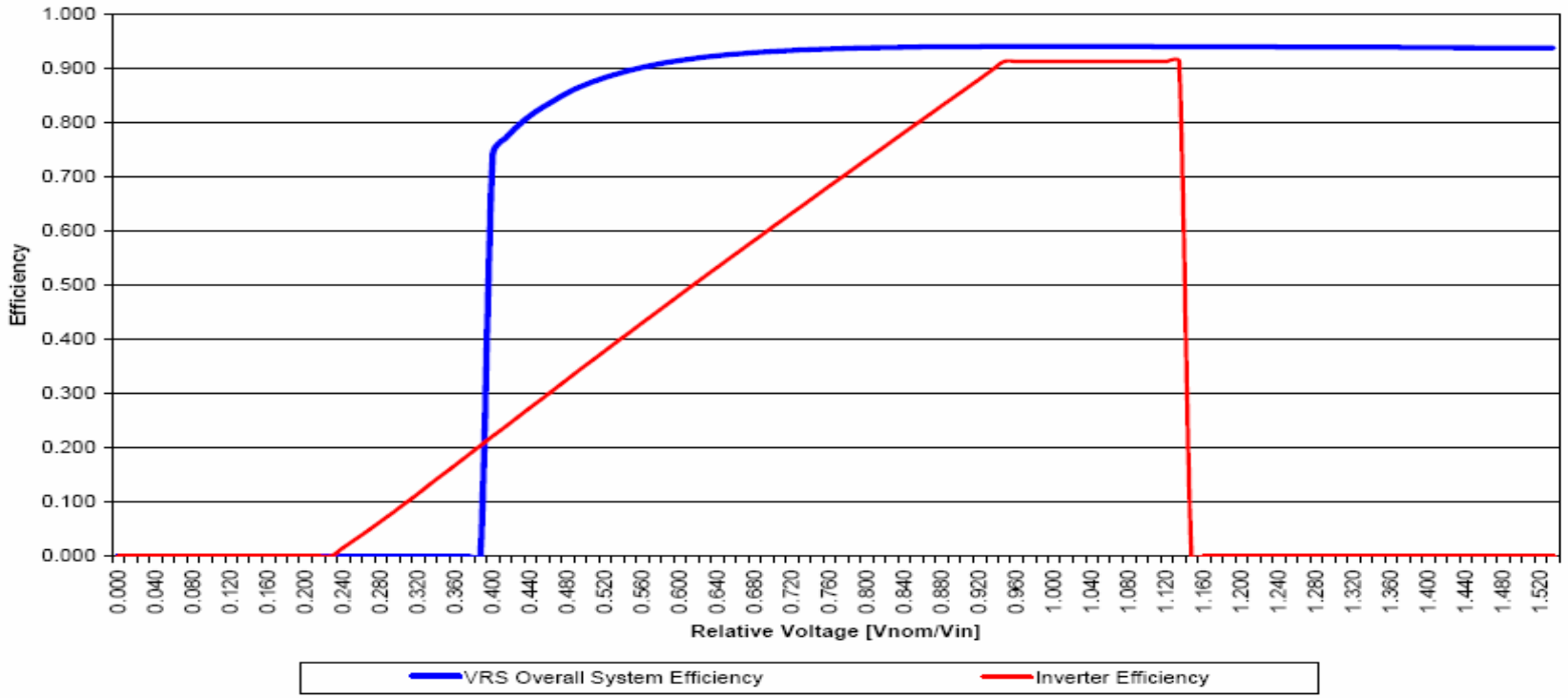
VRS vs. Inverter Efficiency



Efficiency

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Value Proposition

Variable Wind Solution's breakthrough technology enables:

- Reduced turbine costs (no PMG, optimized blade, generator & electronics sizing)
- Improved turbine efficiency (inverter can operate at peak efficiency)
- Reduced turbine complexity (no gearbox)
- Improved ROI
- Wider range of locations where wind turbines can be installed

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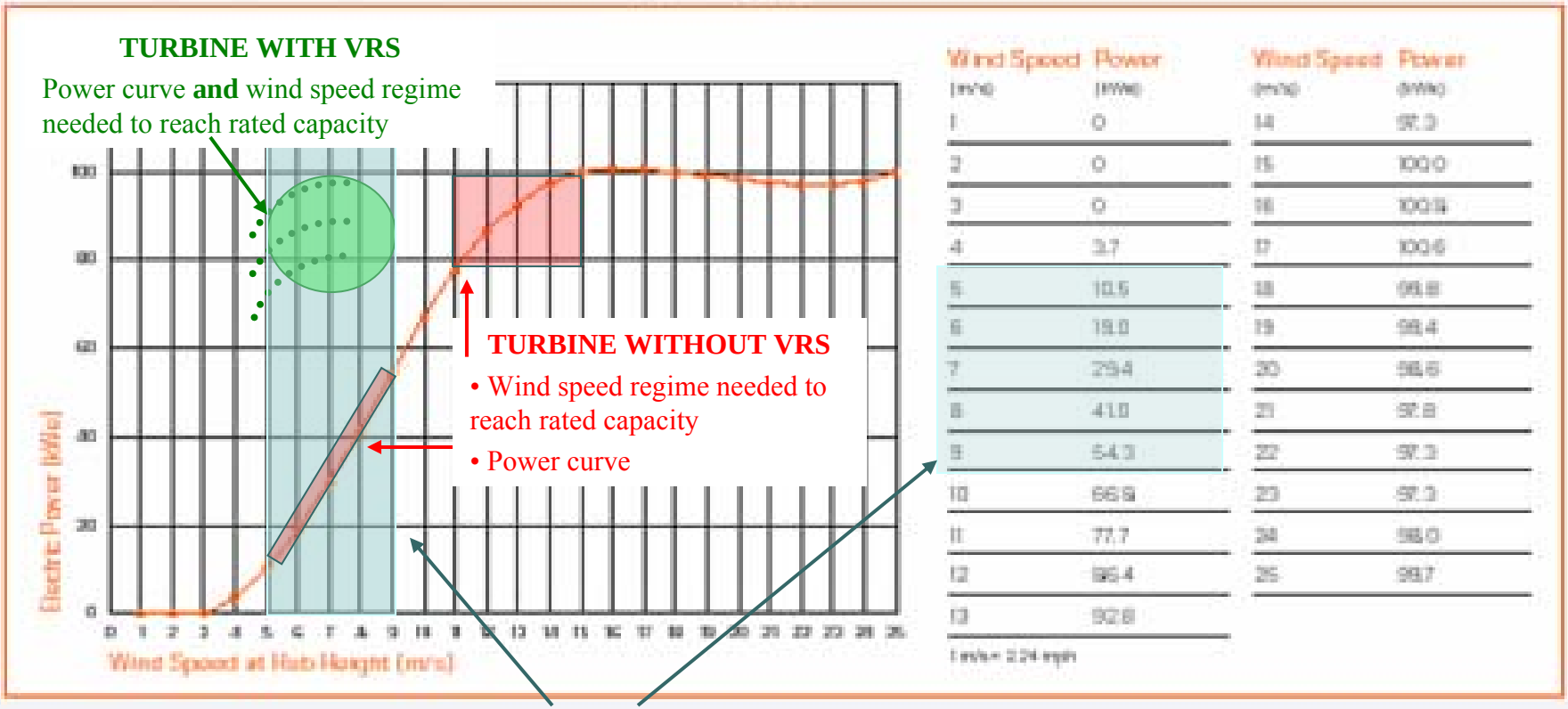
Picture

Case Study: Northern Power vs. Variable Wind Solutions



Section of power curve relevant to the target market's wind regime

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Product Pipeline

Integrated Power Generation & Conditioning Solutions:

OEM Development Package – **open generator** (shaft, rotor, stator) & electronics that can be integrated into OEM turbine assemblies, framework, chassis, etc.

Plug-&-Play Package – **closed generator** & electronics for direct mounting into OEM wind turbine nacelles

Wind Turbines – **complete turbines** optimized for low, medium, and variable speed winds (~ 3m - 12m blade radius; ~ 5 kW - 60 kW @ 7m/s)

OEM Devlp't
Plug & Play
Turbines

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Business Model

Product	Revenue Model	Customer	Marketing Strategy
Generator & Electronics	Sale of components package; technology licensing	Wind and hydrokinetic OEMs; wind turbine renovators	Conferences & trade shows; Pilot projects; JVs
Small Wind Turbines	Sale of turbines	Residential customers; commercial/ industrial customers	Big-box stores; Renewable Energy solution providers
Wind Farms	Sale of turbines; OR Sale of turbines at-cost + % of revenue from sale of electricity	RE solution providers, commercial/ industrial customers	JVs w/ RE solution providers; direct to industrial/commercial customers

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Let's Work Together

Investors

Total investment sought: 10 million Euro, in 2 tranches:

1.5 million Euro – complete development, certification, pilot sites

8.5 million Euro – commercial scale-up & execution

Strategic Partners

R&D cooperation – continued development

Wind farm developers – commercialization

Wind turbine OEMs – licensing or commercialization

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Thank you for your time.

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