Disclaimer: The views expressed are those of Paul Gipe and are not necessarily those of the sponsor.

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Distributed Wind Turbines
for
Commercial & Agricultural Applications
by
Paul Gipe

Paul Gipe, wind-works.org
Distributed Wind: What is It?

Thy, Denmark

Paul Gipe, wind-works.org
Not a Wind Farm

• Not a Large Number of Units
• Limited Geographically

Paul Gipe, wind-works.org
Buffalo Ridge, MN
Single Turbines

• Connected to Load
• Small or Large Wind Turbines

Alberta, Canada

Montana, USA
Small Groups or Clusters

- Not Necessarily Connected to Load
- Small or Large Wind Turbines
Distributed Wind

• Not Wind Farms
• Single or Multiple Turbines
  Limited in Number—Not Limited in Size
• Often Serving a Specific Load
  Schools, Factories, Parks, Farms, Businesses
  Typically at Distribution Voltage
• Until 1981 All Wind was Distributed
  Denmark = Distributed Wind

Paul Gipe, wind-works.org
Distributed Wind—Not Well Known in California

- Diverse Topography
- Varied Wind Resource
- Lots of People
- Few SMEs

Small to Medium-Size Enterprises
2004 Palmdale Water District

Paul Gipe, wind-works.org
Scheid Vineyards, Greenfield, CA

© Scheid Vineyards

Paul Gipe, wind-works.org
What’s It Take?

• Got Wind?
  Well Exposed Site

• Load
  Offsetting Purchased Power

• Will
  Takes an Iron Will to Do Wind

• Wind Turbine
  Many are Called but Few are Chosen

Paul Gipe, wind-works.org
Solar Instead?

• Cheaper?
  Solar is the Price Leader

• More Reliable?
  Nearly Foolproof

• Easier?
  Simpler Permitting

• Get’s the Job Done
  With the Least Fuss

Paul Gipe, wind-works.org
Solar--However

- Isn’t as Exciting
- Doesn’t Stand Out
- Far More Commonplace

Paul Gipe, wind-works.org
Wind Turbines Rise Above Solar

- More Prominent Statement
- Essential Part of Sustainability

Not a Panacea—Part of the Solution

Yorkshire, England

Paul Gipe, wind-works.org
Format

• What Works
• What Doesn’t—a Very Long List
• How to Use the Wind
• The Silent Revolution
• Distributed Wind Examples
• NPS 100, Subsidies & Leases
• Wrap Up
Overview of Wind Energy

Paul Gipe, wind-works.org

Wörstadt, Rheinland-Pfalz, Germany
Wind Energy Has Come of Age

Noordoostpolder, The Netherlands
Paul Gipe, wind-works.org
Montefalcone, Italy
Galicia, Spain

Paul Gipe, wind-works.org
Large Wind Turbines

Paul Gipe, wind-works.org

Whitelee, Glasgow, Scotland
Medium-Size Wind Turbines

Paul Gipe, wind-works.org 2012, Girvan Community Hospital, Scotland
Small Wind Turbines

Tehachapi, California

Paul Gipe, wind-works.org
Why Wind?

- Reduces Use of Fossil & Nuclear Fuels
- Most Cost-Effective of New Renewables
- Relatively Benign

Paul Gipe, wind-works.org
Why Now?

• **Wind Works**
  Greater Reliability

• **Productivity Improved**
  More Efficient
  Taller Towers

• **Costs Declined**
  Economies-of-Scale

---

Paul Gipe, wind-works.org
Northern Ireland

40 m, 500 kW

80 m, 1.8 MW

Kincardine, Ontario

Paul Gipe, wind-works.org
We Know What Works
...and What Doesn’t

Eole, Cap Chat

© Vortec

Paul Gipe, wind-works.org
Wind is Modular

• Quickly Installed
• When Needed
• As Needed
• Where Needed
• By Anyone

Paul Gipe, wind-works.org
Wind is Flexible

- **Scale**
  - Large or Small Projects
- **Location**
  - Near or Far
- **Time**
  - Short Lead Times
- **Ownership**
  - Local or Absentee

Paul Gipe, wind-works.org
### High Penetration is Possible

<table>
<thead>
<tr>
<th></th>
<th>Percent Wind</th>
<th>TWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>4.5%</td>
<td>13.5</td>
</tr>
<tr>
<td>Germany</td>
<td>18%</td>
<td>107.0</td>
</tr>
<tr>
<td>Iowa</td>
<td>37%</td>
<td>20.1</td>
</tr>
<tr>
<td>Denmark</td>
<td>39%</td>
<td>12.8</td>
</tr>
</tbody>
</table>

*Multiple Sources; 2012
Paul Gipe, wind-works.org
Cowley Ridge, Alberta*
Wind Energy’s Benefits

• Clean & Green (Mostly)
  No SO\textsubscript{x}, NO\textsubscript{x}, or CO\textsubscript{2}
• Renewable
  Net Positive Energy Balance (4-6 months)
• Domestic: Not Subject to Embargo
• Does Not Consume Water
• Modular = Flexible
• . . . and Can Be Removed

Paul Gipe, wind-works.org
Wind Energy’s Impacts

• Aesthetics or Intrusiveness
• Erosion & Scarring from Roads
  Length, Width, Number and Slope
• Shadow Flicker & Disco Effect
• Climate?
• Noise--They are Audible
• Wildlife
  Habitat Disruption
  Bird & Bat Kills: Collisions, Electrocutions

Paul Gipe, wind-works.org
Birds & Bats

• Before & After Studies of Big Projects
• Studies Necessary for Small Projects?

Cros de Gerand, France

Paul Gipe, wind-works.org
Birds & Bats

• Serious Problem
  Tarifa?
  Altamont Pass (900-1,300 Raptors/yr)
• A Concern Elsewhere
• No Quick Fixes--No Panaceas
  Stripes & Whistles Don’t Work
Birds & Bats: Swept Area

• **Eliminate Horizontal Perches & Roosts**
  No Lattice Towers with Horizontal Members

• **Avoid Heavy Concentrations of Birds**

• **Mortality Rate**
  Function of Swept Area, Not Rotor RPM!

Paul Gipe, wind-works.org
Greenhouse Gas Emissions IPCC

Paul Gipe, wind-works.org

Not a Surprise!
Years to Energy Payback IPCC

- Wind
- Coal New
- Nuclear
- Hydro
- Coal Old
- Gas CC
- Geothermal
- Brown coal
- Gas
- PV

Paul Gipe, wind-works.org
Mortality Rate

• 85 Deaths in 40 years
• Most in Construction
• Highest Mortality Rate
  USA & NL
• 3 with Small Turbines

Paul Gipe, wind-works.org
Mortality Rate

- One Child
- One Pilot
- One Suicide
- One Prank Death
- One Heart Attack
- 5 in One Accident
  (2012 China)

1979 WTSU, Canyon, TX

Paul Gipe, wind-works.org
Occupational Mortality in Power Generation

Paul Gipe, wind-works.org

Deaths/TWh

Coal
Oil
Gas
Nuclear
Hydro
Wind

From Multiple Sources

Paul Gipe, wind-works.org
Wind’s Mortality Rate

- Including Latent Mortality
- 2 Orders of Magnitude < Coal
- 1 Order of Magnitude < Oil
- 1/3 that of Gas
- Comparable to Hydro

Three Mile Island, PA

Paul Gipe, wind-works.org
Public Safety

- No Passerby Killed or Injured
- Ice Throw
  Max. 100 m
  1.5 X Height
  Post Warnings
- Blade Throw
- Suicides
  Attractive Nuisance

Paul Gipe, wind-works.org
Back In the Mists of Time

The Beginning

130 Years of Wind Generation
Brush Dynamo

- Upwind
- Self-Regulating
- DC w/ Batteries

1888, Charles Brush, Cleveland, Ohio

© Western Reserve Historical Society

Paul Gipe, wind-works.org
Poul La Cour

- Active Yaw
- Upwind
- Self-Regulating
- DC w/ Batteries
- Later Hydrogen

1891, Askov, Denmark

© Poul la Cour Fonden
Paul Gipe, wind-works.org
FL Smidth Aeromotor

- 3-Blades
- Upwind
- Active Yaw
- AC
- Interconnected

1944, Skagen, Denmark

© Danmarks Vindkrafthistoriske Samling
Paul Gipe, wind-works.org
Wind Well Known by 1920s
Certainly by 1950s

- 1919 First Interconnected (DK)
- Early 1920s La Cour (DK)
- 1925 Darrieus (F)
- 1927 Betz (DE)
- 1928 Betz (in English)
- 1940 Hütter (DE), Putnam (USA)
- 1955 Golding (GB)
- 1957 Vadot (F)

Paul Gipe, wind-works.org
Smith-Putnam 1.25 MW, 1941
53 m, Downwind, ~700 hrs
Growian
100 m, 3 MW, Downwind, 1981
~400 hrs

Kaiser-Wilhelm Koog, Germany
Gedser—The Godfather

- 1957-67, & 1978 (US DOE)
- 3-Blades
- Upwind, Active Yaw
- Pitchable Blade Tips

Paul Gipe, wind-works.org
Tvind
54 m, ~1 MW
1978-Present!

© T vind kraft

Paul Gipe, wind-works.org

2012, Denmark
Those Crazy Danes

The Grasshopper

1980, Risø Test Station
Roskilde, Denmark

Paul Gipe, wind-works.org
Crazy Danes--Vestas

Yes, That Vestas

1980, Lem, Denmark

Paul Gipe, wind-works.org
Meanwhile
In a Land Far Away
Riding the Wind—Into an Industry

~1975-1976, Wind-King, Southeastern Montana

Don’t try this at home!

Paul Gipe, wind-works.org
In the Beginning--There Was Salvage

~1976, Southeastern Montana

Dave Ellis, Wind Cowboy

Jacobs

Paul Gipe, wind-works.org
Salvage Machines

- Abundant
- Cheap
- Worked

Especially Jacobs

Mormon Point, Grand Teton NP

Paul Gipe, wind-works.org
Been There—Done That: VAWTs

Paul Gipe & Assoc.
VAWTs Omnidirectional? Sure—but So Are HAWTs

Paul Gipe, wind-works.org
VAWTs
Drag Devices (Paddles)

Paul Gipe, wind-works.org
~1930s, Texas Tech Museum
Savonius or “S” Rotors

2013, Indianapolis, Indiana
Cantilevered Darrieus

~1981, Alcoa 10 kW, Somerset, Pennsylvania

Paul Gipe, wind-works.org
VAWTs

Darrieus

2 Blades

~1979 Installed, DAF-Indal
Atlantic Wind Test Site, PEI

Paul Gipe, wind-works.org
VAWTs

Darrieus

4 Blades

~Late 1980s, Adecon, Pincher Creek, Alberta

Paul Gipe, wind-works.org
Giromills
Articulating Straight Blade VAWT

Paul Gipe, wind-works.org
Giromill (McDonnell Aircraft)

Paul Gipe, wind-works.org
Giromill (McDonnell Aircraft)

- High Hype
- As Good as Betz
- Complex
- Costly
- DOE Boondoggle
Variable Geometry VAWT
(Musgrove)
Cleaning Up After Cleanfield

- Early 2000s
- Student Project!
- Wind Tunnel Tests
- Volts—No Amps

Paul Gipe, wind-works.org
Cleaning Up After Cleanfield

- 2007 Still No Testing
- 2009 A “Success” by OCE
  OCE: a Dumping Ground for Tory Politicians
- After a Decade Still No Results
- 2013 Defaults on $1.3 Mil Loan

Paul Gipe, wind-works.org
VAWTs Magnet for Hustlers & Charlatans

- Pyramidal Power
- Celebrity Endorsers
  - Jay Leno, Ed Begley
- Globe & Mail
  - Next Alexander Graham Bell
- More Energy than in the Wind

Magwind, Whitby Ontario

Paul Gipe, wind-works.org
Bergey’s VAWT

Yes, That Bergey

1979, Mike Bergey

© Bergey Windpower

Paul Gipe, wind-works.org
## VAWT-HAWT Poor Comparison

<table>
<thead>
<tr>
<th></th>
<th>Swept Area (m²)</th>
<th>Tested Power (kW)</th>
<th>Mass (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UGE VAWT</td>
<td>16.6</td>
<td>1.5</td>
<td>756</td>
</tr>
<tr>
<td>Bergey 6</td>
<td>30</td>
<td>5.5</td>
<td>350</td>
</tr>
</tbody>
</table>

Just a little background—summary stats.

Paul Gipe, wind-works.org
VAWT-HAWT Poor Comparison

- HAWT 2X Effic.
- HAWT 1/4 Specific Mass
- HAWT Self-Regulating

Tested to IEC 61400-12-1

Paul Gipe, wind-works.org
FloWind’s Generation in California

The World’s Most Successful VAWT

Year

Million kWh/yr

Paul Gipe, wind-works.org
Those Who Don’t Build VAWTs

- Adecon
- Alcoa
- Bergey Windpower
- Bristol Aerospace
- DAF-Indal
- Herman Drees
- Dornier

- FloWind
- Heidelberger
- Sir Robert McAlpine
- McDonnell Aircraft
- Vestas
- ... and Many More

Paul Gipe, wind-works.org
VAWTs

- Less Power
- Not Self-Regulating
- More Mass
- More Expensive
- Why Bother?
Monsieur Darrieus & His Invention

- φ Rotor
- H-Rotor
- Giromill
- In Wind
- In Water

Paul Gipe, wind-works.org
Monsieur Darrieus & His Invention

- Patent Filed 1926, Granted 1931
- 1927: 8 m dia HAWT
- 1929: 20 m dia HAWT
- 1930: 10 m dia HAWT
- 1944: H-Rotor Wind Tunnel Model
- **Darrieus Never Built a Darrieus!**
VAWTs
Are the Energy Source of the Future
and
They Always Will be
--Mark Mayhew
Been There—Done That: DAWTs

Paul Gipe, wind-works.org 2015, Ogin, Antelope Valley, California
DAWTs—Old as the Hills at Least the California Hills Just as Questionable Then as Now

1927, Dew Oliver’s Blunderbuss, San Gorgonio Pass
Diffuser Augmented Wind Turbines
DAWTs or Ducted Turbines

2005, Enflo, Germany

1997-2001, Vortec, New Zealand

Paul Gipe, wind-works.org
DAWTs: Wind Energy’s Curse

Elena: Top Dog of Hype
Mon Dieu! Elena Doubling Down

- Double Diffusers--Double Rotors
- Contra-Rotating
- ~2-4 Times Betz Limit
- ~10 Times Rational

Paul Gipe, wind-works.org
Maison de l’Air Poisson d’Avril?

2010, Elena 30, Paris
Diffuser Augmented Small Wind Turbines
Elena 30: 2-4 X Betz Limit

Paul Gipe, wind-works.org
Politicians Love DAWT{s & VAWT{s

- Anything to Avoid Serious Decisions
- Denis Baupin, Maire-adjoint (Verts)
  “. . . nous ne souhaitons pas deteriorer son paysage” (We don’t wish to spoil the Paris cityscape)
- . . . with Real Wind Turbines!

Paul Gipe, wind-works.org
Honeywell Windtronics?
Honeywell Windtronics?

• It’s a Bicycle Wheel!

Paul Gipe, wind-works.org
Windtronics: An Example

• Creating Strawmen--to Knock Down

• Most Small Wind Turbines Use Direct Drive--Not Gearboxes!

Paul Gipe, wind-works.org
Windtronics: An Example

- Creating Strawmen--to Knock Down

How to redesign a turbine to start at 0.5 (1/2) mph

- There is No Energy in the Wind @ 2 mph
- Who Cares if it Turns @ 2 mph?
- If You Want a Kinetic Sculpture
  “Buy a Whirligig”--They’re Much Cheaper

Mick Sagrillo

Paul Gipe, wind-works.org
Windtronics: An Example

• Makes Claim to Big Endorsement
  Honeywell

• But, Read the Fine Print

  The Honeywell Trademark is used under license from Honeywell International Inc. Honeywell International Inc. makes no representation or warranties with respect to this product.

• Honeywell Licenses Name Only
Windtronics: An Example

• No Testing, No Certification

Product Certification
ETL listed, conforming to UL 1741 and CAN/CSA C22.2 No.107.1.

• Misleading the Unsophisticated
UL/CSA Certifies Only the Electrical Components
Not the Wind Turbine as a Wind turbine

Paul Gipe, wind-works.org
Honeywell Windtronics 2008-2013

- Hoodwinked State of Michigan
- Hoodwinked Province of Ontario
  $2.7 million
- Hoodwinked Ace Hardware
- Need One?

Paul Gipe, wind-works.org
SheerWind-Invelox DAWT

• Nature Conservancy
  “Won’t Kill Birds. . .

• Michigan National Guard
  3 of Them!

• Denmark “Chimney”

• “Constant Wind”

Paul Gipe, wind-works.org

Wikimedia Commons
FloDesign-Ogin & the Big Boys

• Kleiner Perkins VCs
  Al Gore, Arpa (DOE), MIT . . .
• Alberta & NZ Pension Funds
• $300 million?
  10 Times that of Vortec
• The Walking Dead
• Finally Kaput

Paul Gipe, wind-works.org
The Problem with DAWTs

• Shrouds Are Expensive
• No High Wind Protection
  Tower & Foundation
• Always Underperforms Projections
• No Real Advantage
• Yeah, Ok, It’s Different . . .

Paul Gipe, wind-works.org
Zombie Wind
DAWTs from the Grave

• Honeywell Windtronics—Tam Energy
• FloDesign-Ogin—Is it Really Dead?

Paul Gipe, wind-works.org