Wind 101 Environment
Shadow Flicker
Noise
Birds & Bats
Land Area Occupied

Paul Gipe, wind-works.org
Shadow Flicker Zone

Analysis Software is Available
Noise

• Distinctly Audible
  They Are Not Silent
  They Will Be Heard

• Great Reductions in Noise

• But Noise is Constant--Ever-Present
  Except During Calms

• Small Turbines Are Noisiest
  For Their Size
Noise Footprint

Paul Gipe, wind-works.org
Calculated & Measured Noise Emissions
Source Sound Power Levels at 8 m/s

Sound Power Level (dBA)

- **1980s**
- **1990s**
- **1999**
- **Small**
- **Micro**
- **H40**

\[ L = 22 \log D + 72 \]

\[ L = 22 \log D + 65 \]

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## Noise Limits

### Selected Noise Limits, Sound Pressure Levels in dBA

<table>
<thead>
<tr>
<th>Location</th>
<th>Day Commercial</th>
<th>Day Mixed</th>
<th>Day Residential</th>
<th>Day Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>65</td>
<td>60</td>
<td>55</td>
<td>50</td>
</tr>
<tr>
<td>Night</td>
<td>50</td>
<td>45</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>Netherlands</td>
<td>50 (Leq)</td>
<td>45</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>Night</td>
<td>40</td>
<td>35</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Denmark(^1)</td>
<td>40</td>
<td>45</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>England(^2)</td>
<td>L(_{50}) 45</td>
<td>L(_{50}) 40</td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>Day</td>
<td>L(_{50}) 75</td>
<td>L(_{50}) 65</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Night</td>
<td>L(_{50}) 75</td>
<td>L(_{50}) 65</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Minnesota</td>
<td>L(_{10}) 80</td>
<td>L(_{10}) 70</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>Night</td>
<td>L(_{10}) 80</td>
<td>L(_{10}) 70</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>Kern County, Calif.(^3)</td>
<td>L(_{8.3}) 45</td>
<td>L(_{90}) 45</td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>Riverside County, Calif.</td>
<td>L(_{90}) 45</td>
<td></td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>Palm Springs, Calif.(^4)</td>
<td>L(_{90}) 50</td>
<td></td>
<td></td>
<td>60</td>
</tr>
</tbody>
</table>

1. Not to exceed 45 dBA beyond 400 m from wind turbine.
2. L\(_{50}\) approx. 350 m from the nearest turbine.
3. L\(_{8.3}\), not to exceed 50 dBA.
4. 50 dBA if lot is actually used as residential.

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Noise Community Response

<table>
<thead>
<tr>
<th>Amount by which Noise Exceeds Background Level</th>
<th>Estimated Community Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>dB</td>
<td>Category</td>
</tr>
<tr>
<td>0</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
<td>Little</td>
</tr>
<tr>
<td>10</td>
<td>Medium</td>
</tr>
<tr>
<td>15</td>
<td>Strong</td>
</tr>
<tr>
<td>20</td>
<td>Very Strong</td>
</tr>
</tbody>
</table>

Source: Harvey Hubbard, Kevin Shepherd, NASA, 1990.
Note: This table was derived for noise sources other than wind turbines and neighbors could be either more or less sensitive to wind turbine noise than that indicated here.

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Birds & Bats

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

Cros de Gerand, France

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Birds & Bats

• Bats
  Appalachian Mts & Buffalo Ridge (MN)
  Bat Conservation Society Report
  Cause Unknown & Further Research Needed
  Seasonal Shut Down Possible

• Birds, Altamont Pass
  Issue Unresolved
  Disaster for Raptors & Wind Energy

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## Birds Killed in the Altamont Pass

<table>
<thead>
<tr>
<th>Per Year</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>1,766</td>
<td>4,721</td>
</tr>
<tr>
<td>Raptors</td>
<td>881</td>
<td>1,300</td>
</tr>
<tr>
<td>Raptors/MW</td>
<td>1.5</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Land Area Required - Rectilinear

160-250 kW: Mojave, California

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750 kW: Lake Benton, Minnesota
1 MW: White Deer, Texas

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Land Area Required

- ~1% of Land Used
- Schleswig-Holstein, Germany
  - 1% = 50% of Consumption, Today
  - 2% = 100% of Consumption, 2020

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## Schleswig-Holstein Wind Density

<table>
<thead>
<tr>
<th>Region</th>
<th>kW/km²</th>
<th>kW/capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schleswig-Holstein</td>
<td>208</td>
<td>1.2</td>
</tr>
<tr>
<td>Sachsen-Anhalt</td>
<td>178</td>
<td>1.5</td>
</tr>
<tr>
<td>Brandenburg</td>
<td>156</td>
<td>1.8</td>
</tr>
<tr>
<td>Niedersachsen</td>
<td>148</td>
<td>0.9</td>
</tr>
<tr>
<td>Denmark</td>
<td>76</td>
<td>0.6</td>
</tr>
<tr>
<td>Iowa</td>
<td>30</td>
<td>1.4</td>
</tr>
</tbody>
</table>

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## Wind Density in Northwest Schleswig-Holstein

<table>
<thead>
<tr>
<th>Area</th>
<th>MW</th>
<th>kW/km²</th>
<th>Population</th>
<th>kW/capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nordfriesland Kreis 2010</td>
<td>847</td>
<td>414</td>
<td>165,707</td>
<td>5.1</td>
</tr>
<tr>
<td>Friedrich-Wilhelm-Lübke-Koog</td>
<td>47.5</td>
<td>3,519</td>
<td>164</td>
<td>290</td>
</tr>
<tr>
<td>Dithmarschen Kreis 2010</td>
<td>718</td>
<td>511</td>
<td>135,136</td>
<td>5.3</td>
</tr>
</tbody>
</table>

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Smaller projects require less land area than large projects because of “edge” effects. DEWI Spring 2011.

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Aesthetic Guidelines:
Design As If People Matter

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Increasing Acceptance #1

“Your Own Pigs Don’t Stink”

Jutland, Denmark

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Public Opinion Surveys

• “Beauty is in the Eye of the Beholder”
  True, But Most People Agree on “Beauty”

• Broad Support ~ 70%-90%
  On Both Sides of the Atlantic

• In the Abstract!
  Benefits Global
  Impacts Local

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Acceptance of Wind Energy

Pre-Project

Percent Acceptance

During Project

Post-Installation

Time

Source: L. Arkesteijn, Energy Connection

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Power Plant Acceptance

Ratings

WIND

BIOMASS

FOSSIL

NUCLEAR

Visual Quality
Health & Safety
Environmental Impact
Overall

Thayer, R. Consumer Attitude and Choice

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Increasing Acceptance #2

• Minimize Wind’s Footprint
  Physical--Roads, Foundations, Buildings
  Environmental & Visual

• Seek Harmony
  with Neighbors & the Environment

• Wind as a part of the Landscape

• Not a Wind Landscape
  as in California

• NIMBY to POOL

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Aesthetic Design--Not New Idea

Poorly designed wind farms are often characterized by monotonous design, visual disorder, insensitivity to the land forms and poor erosion control. Careful planning can eliminate all of these problems.

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CalPoly 1984
Provide Distinct Visual Units

WECS SHOULD BE CLUSTERED IN VISUAL UNITS

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CalPoly 1984
Keep Ancillary Structures Off Hills & Ridges

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Chris Blandford Assoc.
Provide Visual Uniformity

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Keep Them Clean

Use a Drip Pan or a Diaper (Nappie)

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Bury All Intra-Project Lines

Paul Gipe, wind-works.org
Bury All Intra-Project Lines

Paul Gipe, wind-works.org
Avoid Visual Clutter

Paul Gipe, wind-works.org, 2003, with Telephoto Lens
Avoid “Industrialization”
Avoid Mixing Types

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Use Open Spacing

Don’t Get Greedy

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Remove Dead Turbines
Remove Headless Horsemen

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Dress for Success

Nacelle Covers
Nose Cones

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Minimize Roads

- Use Existing Roads
- Use Existing Tracks
- Minimize Width
- Minimize Radius
- Harden Where Needed

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. . . Or Eliminate Roads

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Minimize Physical Footprint

. . . Especially in Arid Terrain

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Avoid Steep Slopes

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No Mountain-Top Removal!

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Avoid Cell (Mobile) Phones

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No Billboards

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No Logo!

Or Subtle Logo Only

Paul Gipe, wind-works.org
No Logo!

Or Subtle Logo Only
Revegetate Site

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Use Proper Proportions

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Eliminate Fencing Sends the Wrong Message . . . “Keep Out, Danger”

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Inform Public

Simpler is Better

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Provide Parking

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Provide Access

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Avoid Garish Patterns

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Tvind, Denmark
Use White, Off-White, or Gray

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Keep Sites Tidy

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Remove Trash & Litter

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Remove “Bone” or Scrap Yards

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Spring Forth . . . Organically

Avoid Surface Expression of Foundation

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Pay Attention to Detail

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Harmonize Structures
With Other Structures on Landscape

Buildings

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Harmonize Structures
Transformers (Use Architectural Façades)

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Harmonize Structures

Place Transformers Inside Towers

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Harmonize Structures

• Harden Access Where Needed
• Paint Over Graffiti

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In Sum . . . Be A Good Neighbor

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Wind Energy is Compatible With Most Existing Land Uses

... With Rural Residential

Yorkshire, England

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Thyborøn-Harboøre Vindmøllelaug

... With Harbors

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With Dikes & Breakwaters

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Zeebrugge, Belgium
. . . With Row Crops
. . . With Grazing
. . . With Vineyards

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Donzere, France
... With Some Parks

Depending Upon the Level of Protection

Wellington (Brooklyn), NZ

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... With Outdoor Recreation

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. . . With Cycling

Royd Moor, England

Westerwald, Germany

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. . . With Commercial Uses

Westerwald, Germany

Lauwersoog, the Netherlands

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Lauersoog, Netherlands: 4x?
With Urban Skyline

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. . . With Schools

- 1999-2013
- 12 million kWh
- 850,000 kWh/yr
- Generation posted on School Web site!

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Forest City, Iowa
With Tourism

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Chateau de Lastours, France
... With Tourism

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With Historical Sites
Lynetten Co-op København

Trekroner

Lynetten

Little Mermaid

Map © Google.com

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Nevada, Iowa 2x250 kW

...With Rural Villages

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With Sewage Treatment Plants

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Ringkøbing, Denmark: 75 kW, +20 Year
Lackawanna, New York

... And Urban Renewal
Lackawanna, New York
. . . With Walking & Jogging

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Dunkerque, France
With Hiking

Tehachapi Pass, California

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With Religious Sites

Montefalcone, Italy

White Deer, Texas

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Druiberg--
German Sacred Ground

- In the Distance--Brocken
- Harz Mts. Highest Point
- Site of Goethe’s Witches’ Sabbath in “Faust”

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