

# WIND ENERGY

## History:

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Wind energy is not a new technology. As early as 200 BC simple windmills were used to pump water in China and vertical axis windmills were used in Persia and the Middle East to grind grain. The Dutch reinvented the windmill after the 11 th century to drain water from marshes and lakes. The 19 th century brought the technology to America where it was used largely for pumping water and creating electricity on farms and ranches. Though the industrial revolution led to a reduction in the use of this technology, the first large scale wind turbines were produced in the late 1800's in Europe and the 1940's in the US.

Increasing oil prices in the 1970's revived an interest in wind energy. Old technologies were updated to turn wind power into useable electricity feeding the utility grid of the United States and Europe.<sup>1</sup>

## Wind:

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Ultimately, all renewable energy except geothermal and tidal power comes from the sun, a total of 174,423,000,000,000 kilowatt hours of energy per hour.<sup>2</sup> About 1 to 2 percent of this energy is converted into wind energy. Temperature differences between the equator and the poles create air circulation: warm air at the equator rises and moves towards the poles where the air cools and sinks. Because the earth rotates, the wind tends to rotate counterclockwise around low pressure areas in the Northern Hemisphere and clockwise around low pressure areas in the Southern Hemisphere. This phenomenon is known as the Coriolis force. These wind patterns are called geostrophic winds, or global winds, which are affected by temperature and pressure differences and are found 1000 meters above the earth's surface. Local winds are affected by the earth's surface, mountains, and bodies of water, and may differ slightly from global winds. Overall wind direction, then, is determined by a combination of global and local wind patterns.<sup>3</sup>

## Energy:

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Wind power is converted into energy when the force of the wind becomes torque, or turning force, acting on the rotor blades. The amount of energy generated depends on the density of the air, the rotor area, and the wind speed.

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1 US Department of Energy, "History of Wind Energy," [http://www1.eere.energy.gov/windandhydro/wind\\_history.html](http://www1.eere.energy.gov/windandhydro/wind_history.html).

2 Danish Wind Energy Association, "Where Does Wind Energy Come From?" <http://www.windpower.org/en/tour/wres/index.htm>.

3 Ibid.

## Resources:

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### **Books:**

#### **Wind Energy Basics: A Guide to Small and Micro Wind Systems**

by Paul Gipe

[http://www.amazon.com/Wind-Energy-Basics-Guide-Systems/dp/1890132071/ref=sr\\_1\\_1?ie=UTF8&s=books&qid=1249935076&sr=1-1](http://www.amazon.com/Wind-Energy-Basics-Guide-Systems/dp/1890132071/ref=sr_1_1?ie=UTF8&s=books&qid=1249935076&sr=1-1)

#### **Wind Energy Handbook**

by Tony Burton, David Sharpe, Nick Jenkins, Ervin Bossanyi

[http://www.amazon.com/Wind-Energy-Handbook-Tony-Burton/dp/0471489972/ref=sr\\_1\\_2?ie=UTF8&s=books&qid=1249935076&sr=1-2](http://www.amazon.com/Wind-Energy-Handbook-Tony-Burton/dp/0471489972/ref=sr_1_2?ie=UTF8&s=books&qid=1249935076&sr=1-2)

#### **Wind Power, Revised Edition: Renewable Energy for Home, Farm, and Business**

by Paul Gipe

[http://www.amazon.com/Wind-Power-Revised-Renewable-Business/dp/1931498148/ref=sr\\_1\\_3?ie=UTF8&s=books&qid=1249935076&sr=1-3](http://www.amazon.com/Wind-Power-Revised-Renewable-Business/dp/1931498148/ref=sr_1_3?ie=UTF8&s=books&qid=1249935076&sr=1-3)

#### **Wind Energy: Fundamentals, Resource Analysis and Economics**

by Sathyajith Mathew

[http://www.amazon.com/Wind-Energy-Fundamentals-Resource-Economics/dp/3540309055/ref=sr\\_1\\_4?ie=UTF8&s=books&qid=1249935076&sr=1-4](http://www.amazon.com/Wind-Energy-Fundamentals-Resource-Economics/dp/3540309055/ref=sr_1_4?ie=UTF8&s=books&qid=1249935076&sr=1-4)

#### **Wind Energy Explained (Hardcover)**

by James F. Manwell, Jon G. McGowan, Anthony L. Rogers

[http://www.amazon.com/Wind-Energy-Explained-James-Manwell/dp/0471499722/ref=sr\\_1\\_5?ie=UTF8&s=books&qid=1249935076&sr=1-5](http://www.amazon.com/Wind-Energy-Explained-James-Manwell/dp/0471499722/ref=sr_1_5?ie=UTF8&s=books&qid=1249935076&sr=1-5)

#### **Wind Energy Basics, Second Edition: A Guide to Home- and Community-Scale Wind-Energy Systems**

by Paul Gipe

[http://www.amazon.com/Wind-Energy-Basics-Second-Community-Scale/dp/1603580301/ref=sr\\_1\\_6?ie=UTF8&s=books&qid=1249935076&sr=1-6](http://www.amazon.com/Wind-Energy-Basics-Second-Community-Scale/dp/1603580301/ref=sr_1_6?ie=UTF8&s=books&qid=1249935076&sr=1-6)

#### **The Homeowner's Guide to Renewable Energy: Achieving Energy Independence through Solar, Wind, Biomass and Hydropower**

by Dan Chiras

[http://www.amazon.com/Homeowners-Guide-Renewable-Energy-Independence/dp/086571536X/ref=sr\\_1\\_7?ie=UTF8&s=books&qid=1249935076&sr=1-7](http://www.amazon.com/Homeowners-Guide-Renewable-Energy-Independence/dp/086571536X/ref=sr_1_7?ie=UTF8&s=books&qid=1249935076&sr=1-7)

#### **Wind EnergyThe Facts: A Guide to the Technology, Economics and Future of Wind Power (European Wind Energy Associati) (Hardcover)**

by European Wind Energy Association (EWEA)

[http://www.amazon.com/Wind-EnergyThe-Facts-Technology-Economics/dp/1844077101/ref=sr\\_1\\_8?ie=UTF8&s=books&qid=1249935076&sr=1-8](http://www.amazon.com/Wind-EnergyThe-Facts-Technology-Economics/dp/1844077101/ref=sr_1_8?ie=UTF8&s=books&qid=1249935076&sr=1-8)

#### **Generating Wind Power**

by Niki Walker

[http://www.amazon.com/Generating-Wind-Power-Energy-Revolution/dp/0778729273/ref=sr\\_1\\_9?ie=UTF8&s=books&qid=1249935076&sr=1-9](http://www.amazon.com/Generating-Wind-Power-Energy-Revolution/dp/0778729273/ref=sr_1_9?ie=UTF8&s=books&qid=1249935076&sr=1-9)

#### **Power From the Wind: Achieving Energy Independence**

by Dan Chiras, Mick Sagrillo, and Ian Woofenden

[http://www.amazon.com/Power-Wind-Achieving-Energy-Independence/dp/086571620X/ref=sr\\_1\\_10?ie=UTF8&s=books&qid=1249935076&sr=1-10](http://www.amazon.com/Power-Wind-Achieving-Energy-Independence/dp/086571620X/ref=sr_1_10?ie=UTF8&s=books&qid=1249935076&sr=1-10)

**Wind Turbines: Fundamentals, Technologies, Application, Economics**

by Erich Hau

[http://www.amazon.com/Wind-Turbines-Fundamentals-Technologies-Application/dp/3540242406/ref=sr\\_1\\_11?ie=UTF8&s=books&qid=1249935076&sr=1-11](http://www.amazon.com/Wind-Turbines-Fundamentals-Technologies-Application/dp/3540242406/ref=sr_1_11?ie=UTF8&s=books&qid=1249935076&sr=1-11)

**Grid Integration of Wind Energy Conversion Systems**

by Siegfried Heier

[http://www.amazon.com/Grid-Integration-Energy-Conversion-Systems/dp/0470868996/ref=sr\\_1\\_12?ie=UTF8&s=books&qid=1249935076&sr=1-12](http://www.amazon.com/Grid-Integration-Energy-Conversion-Systems/dp/0470868996/ref=sr_1_12?ie=UTF8&s=books&qid=1249935076&sr=1-12)

**Renewable Energy Made Easy: Free Energy from Solar, Wind, Hydropower, and Other Alternative Energy Sources**

by David Craddock

[http://www.amazon.com/Renewable-Energy-Made-Easy-Alternative/dp/1601382405/ref=sr\\_1\\_13?ie=UTF8&s=books&qid=1249935832&sr=1-13](http://www.amazon.com/Renewable-Energy-Made-Easy-Alternative/dp/1601382405/ref=sr_1_13?ie=UTF8&s=books&qid=1249935832&sr=1-13)

**Developing Wind Power Projects: Theory and Practice**

by Tore Wizelius

[http://www.amazon.com/Developing-Wind-Power-Projects-Practice/dp/1844072622/ref=sr\\_1\\_14?ie=UTF8&s=books&qid=1249935832&sr=1-14](http://www.amazon.com/Developing-Wind-Power-Projects-Practice/dp/1844072622/ref=sr_1_14?ie=UTF8&s=books&qid=1249935832&sr=1-14)

**Wind Energy (Fueling the Future)**

by Elizabeth Raum

[http://www.amazon.com/Wind-Energy-Fueling-Future-Elizabeth/dp/143291572X/ref=sr\\_1\\_15?ie=UTF8&s=books&qid=1249935832&sr=1-15](http://www.amazon.com/Wind-Energy-Fueling-Future-Elizabeth/dp/143291572X/ref=sr_1_15?ie=UTF8&s=books&qid=1249935832&sr=1-15)

**Wind Energy: Renewable Energy and the Environment**

by Robert Foster, James Witcher, Vaughn Nelson , Majid Ghassemi, Luz Elena Mimbela, Abbas Ghassemi

[http://www.amazon.com/Wind-Energy-Renewable-Environment/dp/1420075683/ref=sr\\_1\\_16?ie=UTF8&s=books&qid=1249935832&sr=1-16](http://www.amazon.com/Wind-Energy-Renewable-Environment/dp/1420075683/ref=sr_1_16?ie=UTF8&s=books&qid=1249935832&sr=1-16)

**Aerodynamics of Wind Turbines**

by Martin O. L. Hansen

[http://www.amazon.com/Aerodynamics-Wind-Turbines-Martin-Hansen/dp/1844074382/ref=sr\\_1\\_17?ie=UTF8&s=books&qid=1249935832&sr=1-17](http://www.amazon.com/Aerodynamics-Wind-Turbines-Martin-Hansen/dp/1844074382/ref=sr_1_17?ie=UTF8&s=books&qid=1249935832&sr=1-17)

**Wind Energy Systems for Electric Power Generation**

by Manfred Stiebler

[http://www.amazon.com/Energy-Systems-Electric-Generation-Technology/dp/3540687629/ref=sr\\_1\\_18?ie=UTF8&s=books&qid=1249935832&sr=1-18](http://www.amazon.com/Energy-Systems-Electric-Generation-Technology/dp/3540687629/ref=sr_1_18?ie=UTF8&s=books&qid=1249935832&sr=1-18)

**Homebrew Wind Power**

by Dan Bartmann and Dan Fink

[http://www.amazon.com/Homebrew-Wind-Power-Dan-Bartmann/dp/0981920101/ref=sr\\_1\\_19?ie=UTF8&s=books&qid=1249935832&sr=1-19](http://www.amazon.com/Homebrew-Wind-Power-Dan-Bartmann/dp/0981920101/ref=sr_1_19?ie=UTF8&s=books&qid=1249935832&sr=1-19)

**Wind Power for Dummies**

by Ian Woofenden

[http://www.amazon.com/Wind-Power-Dummies-Ian-Woofenden/dp/0470496371/ref=sr\\_1\\_20?ie=UTF8&s=books&qid=1249935832&sr=1-20](http://www.amazon.com/Wind-Power-Dummies-Ian-Woofenden/dp/0470496371/ref=sr_1_20?ie=UTF8&s=books&qid=1249935832&sr=1-20)

**Wind Energy Comes of Age**

by Paul Gipe

[http://www.amazon.com/Energy-Comes-Wiley-Sustainable-Design/dp/047110924X/ref=sr\\_1\\_21?ie=UTF8&s=books&qid=1249935832&sr=1-21](http://www.amazon.com/Energy-Comes-Wiley-Sustainable-Design/dp/047110924X/ref=sr_1_21?ie=UTF8&s=books&qid=1249935832&sr=1-21)

**Wind Power Plants: Fundamentals, Design, Construction and Operation**

by Robert Gasch and Jochen Twele

[http://www.amazon.com/Wind-Power-Plants-Fundamentals-Construction/dp/1902916387/ref=sr\\_1\\_22?ie=UTF8&s=books&qid=1249935832&sr=1-22](http://www.amazon.com/Wind-Power-Plants-Fundamentals-Construction/dp/1902916387/ref=sr_1_22?ie=UTF8&s=books&qid=1249935832&sr=1-22)

**Profiting from Clean Energy: A Complete Guide to Trading Green in Solar, Wind, Ethanol, Fuel Cell, Carbon Credit Industries, and More**

by Richard W. Asplund

[http://www.amazon.com/Profiting-Clean-Energy-Complete-Industries/dp/0470117990/ref=sr\\_1\\_23?ie=UTF8&s=books&qid=1249935832&sr=1-23](http://www.amazon.com/Profiting-Clean-Energy-Complete-Industries/dp/0470117990/ref=sr_1_23?ie=UTF8&s=books&qid=1249935832&sr=1-23)

**The Pros and Cons of Wind Power**

by Richard Spilsbury and Louise Spilsbury

[http://www.amazon.com/Pros-Cons-Power-Energy-Debate/dp/1404237453/ref=sr\\_1\\_24?ie=UTF8&s=books&qid=1249935832&sr=1-24](http://www.amazon.com/Pros-Cons-Power-Energy-Debate/dp/1404237453/ref=sr_1_24?ie=UTF8&s=books&qid=1249935832&sr=1-24)

## Case Studies:

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### **Near North Apartments**

Located near the former site of Cabrini Green, Near North Apartments is a single room occupancy building that has dedicated half of its 96, 250 sq foot units to the homeless and disabled. Helmut Jahn designed the SRO to have reduced operating costs by taking advantage of solar and wind energy and through the utilization of water runoff. The eight turbines, designed at the University of Illinois, with the city-donated photovoltaics are expected to generate 15% of the total building power.

## References:

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Danish Wind Energy Association, "Where Does Wind Energy Come From?" <http://www.windpower.org/en/tour/wres/index.htm>.

US Department of Energy, "History of Wind Energy," [http://www1.eere.energy.gov/windandhydro/wind\\_history.html](http://www1.eere.energy.gov/windandhydro/wind_history.html).