

# ME/ESE 4470

## Wind and Tidal Power

### Wind Resource

# Wind Resource

## A. Introduction

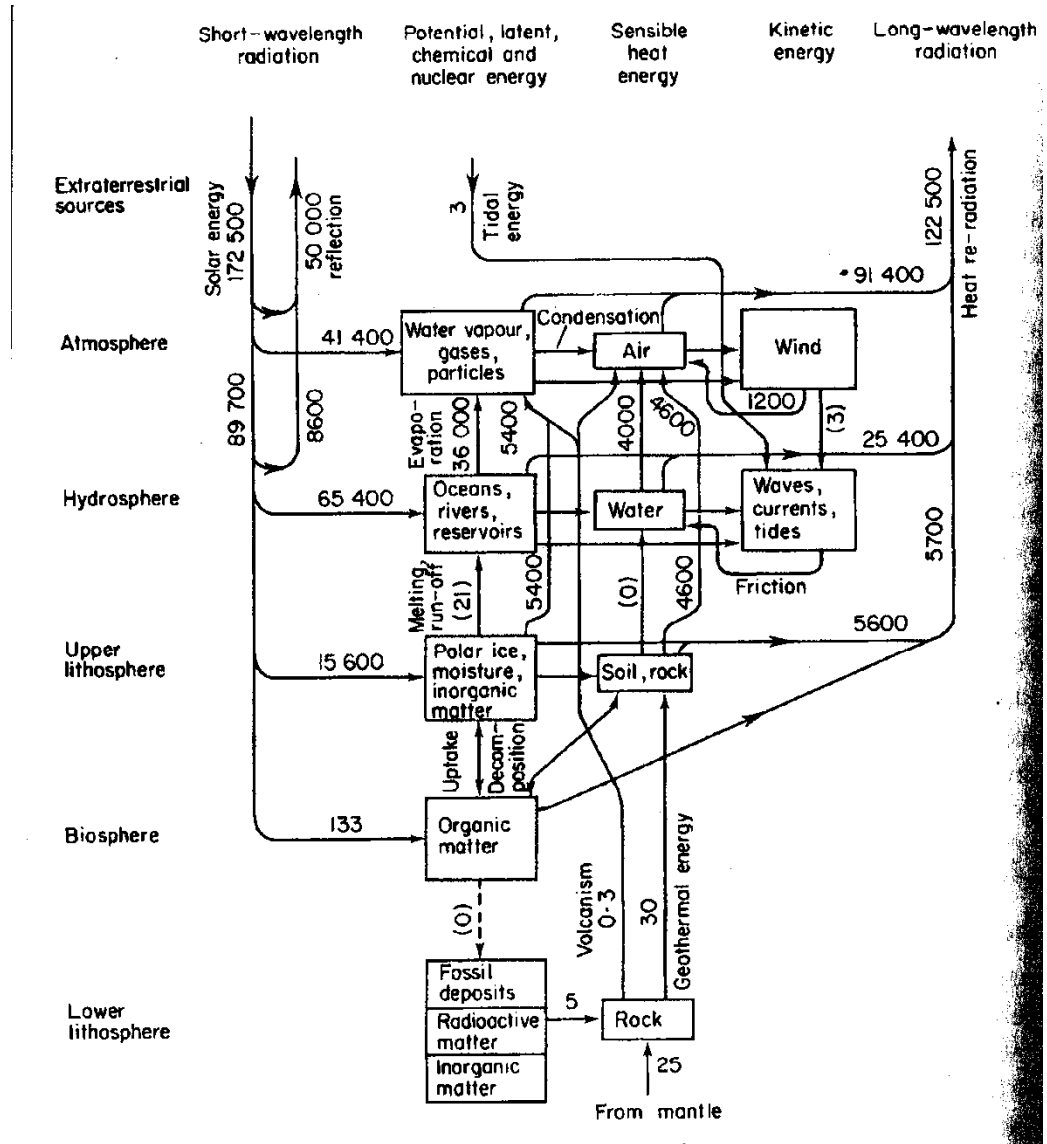
### 1. Motivation for Understanding Wind Resource



# Wind Resource

## A. Introduction

### 2. Wind Resource – Where Does it Come From and How Does it Fit in the Bigger Picture?

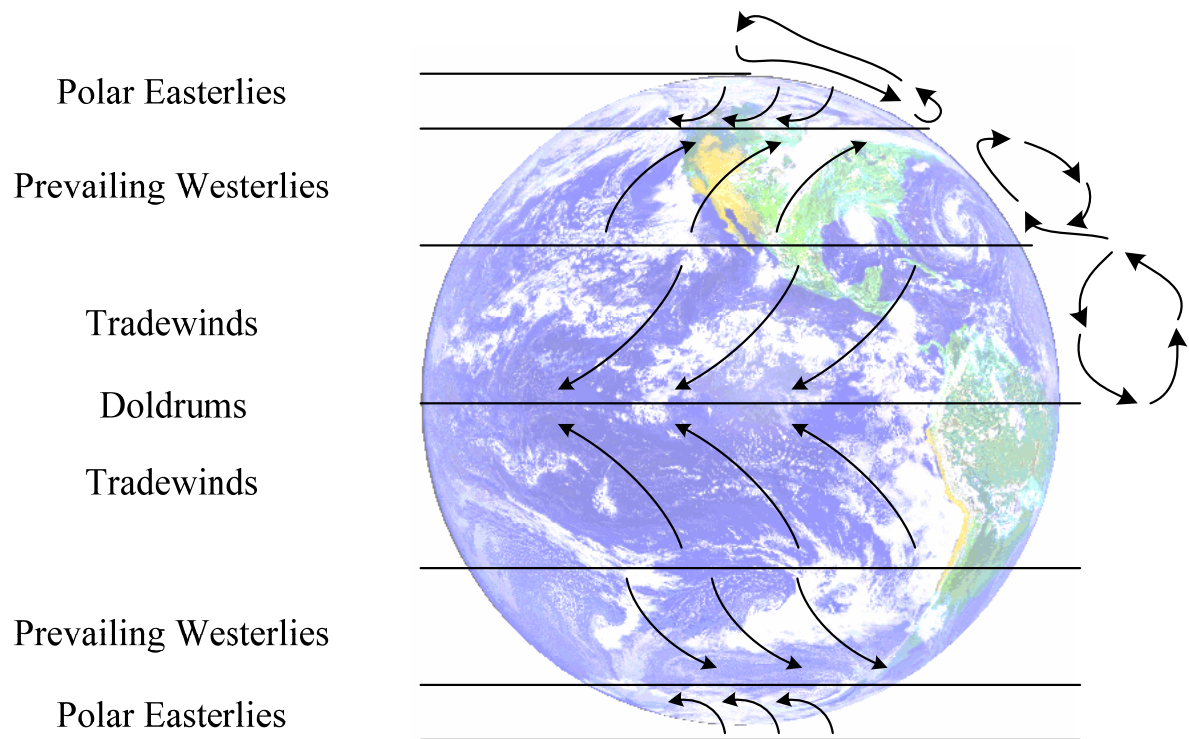


Sorenson, Renewable Energy, 2<sup>nd</sup> Edition

# Wind Resource

## B. Wind Motion

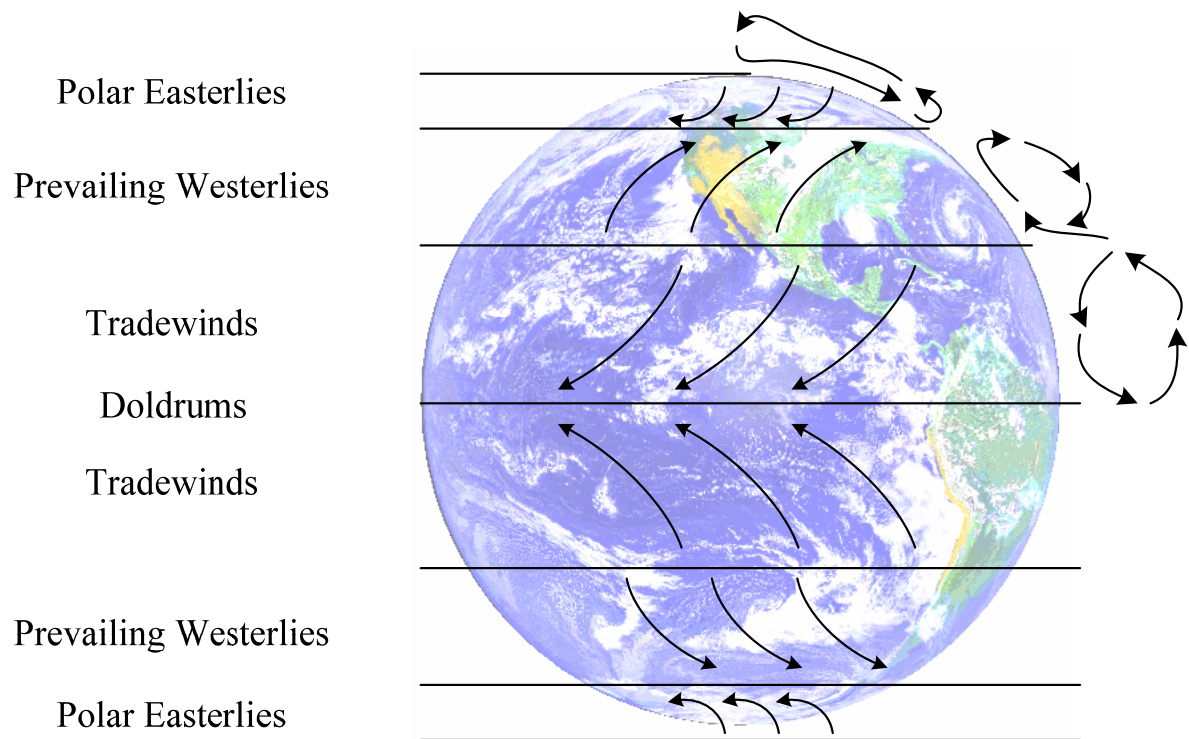
### 1. Macroscopic Motions



# Wind Resource

## B. Wind Motion

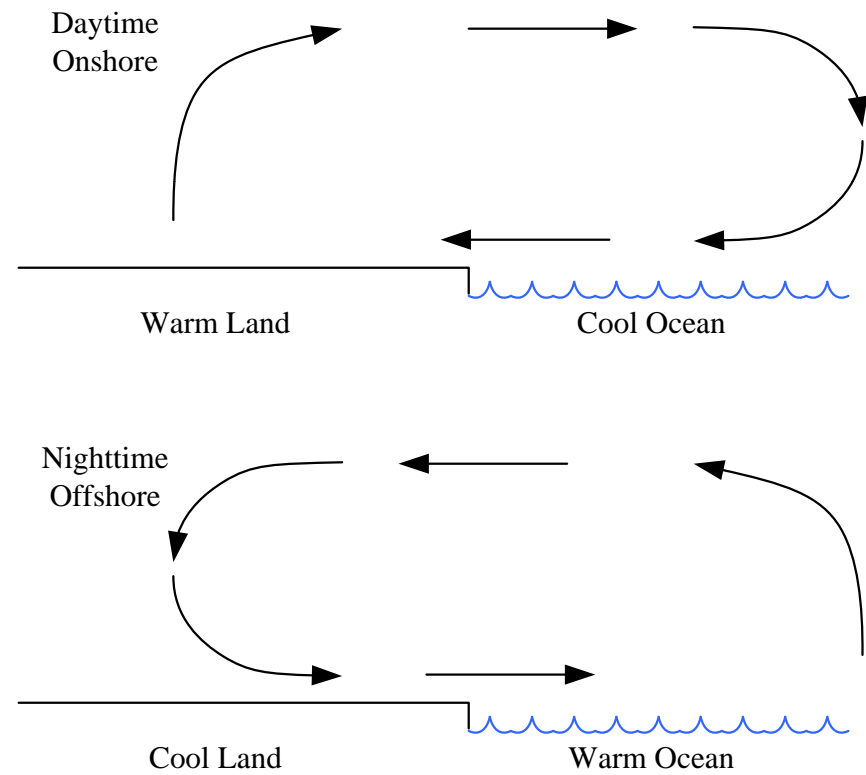
### 1. Macroscopic Motions



# Wind Resource

## B. Wind Motion

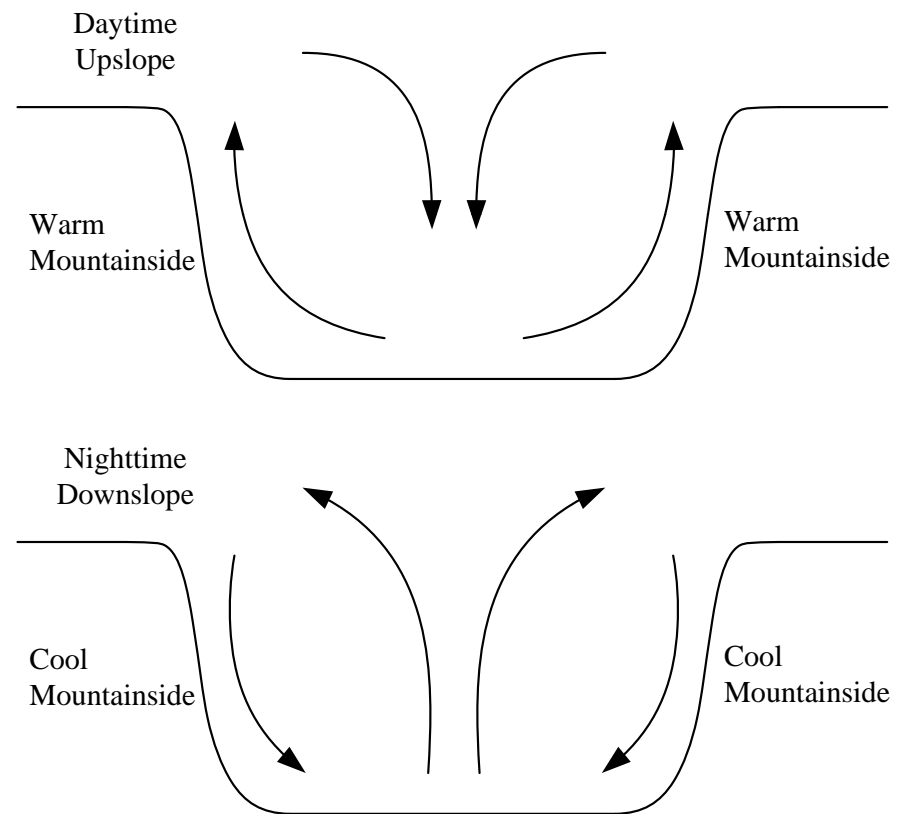
### 2. Microscopic Motions



# Wind Resource

## B. Wind Motion

### 2. Microscopic Motions



# Wind Resource

## B. Wind Motion

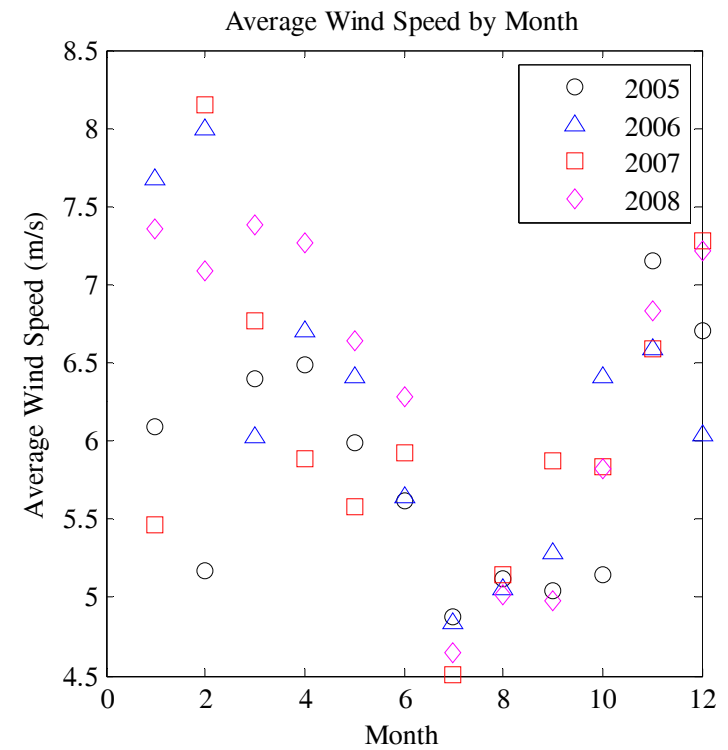
### 3. Time Variation



# Wind Resource

## B. Wind Motion

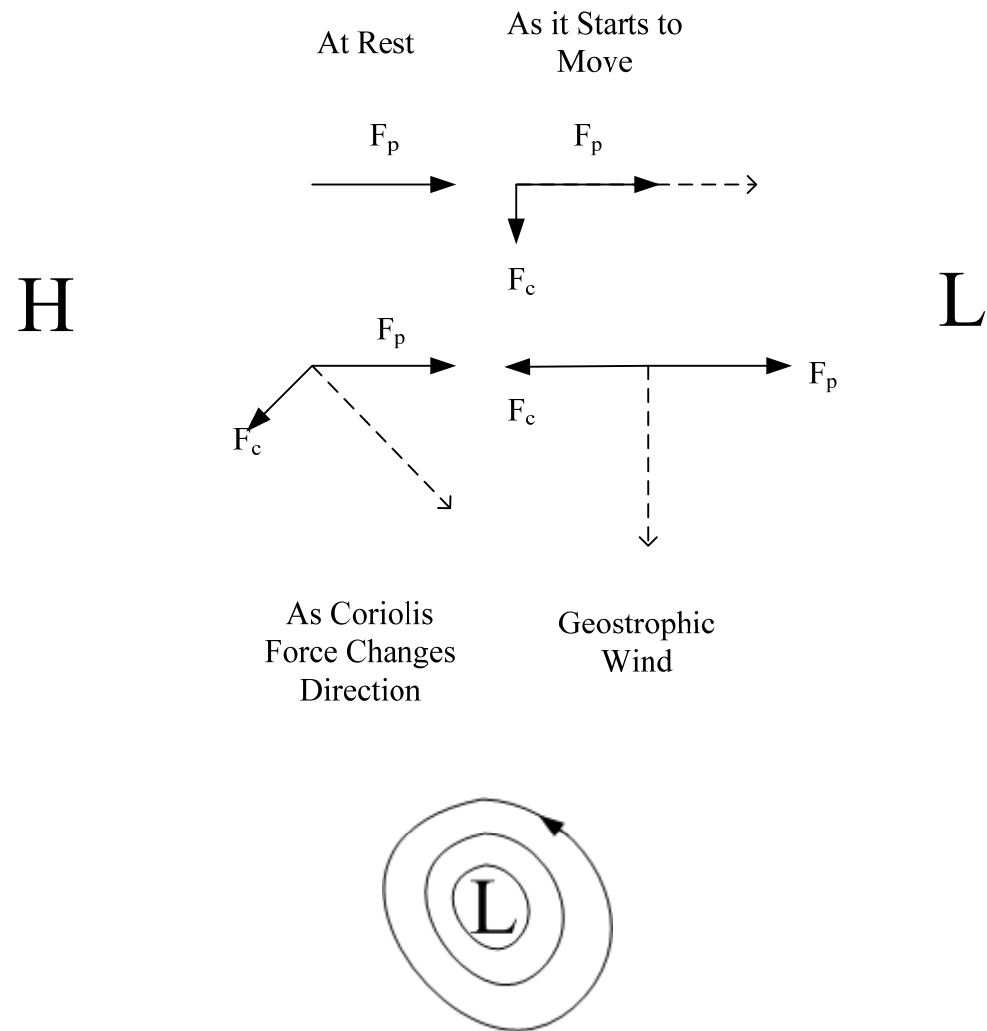
### 3. Time Variation



# Wind Resource

## B. Wind Motion

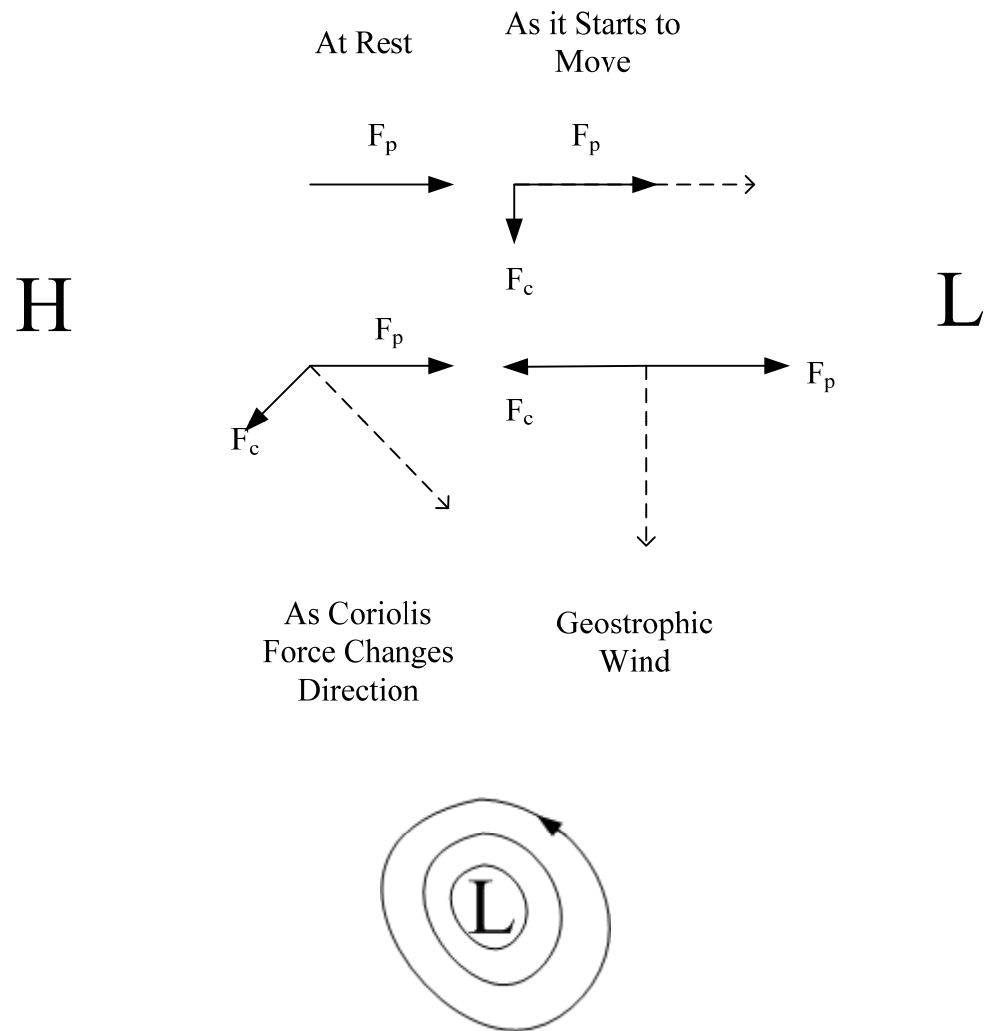
### 4. Mechanics



# Wind Resource

## B. Wind Motion

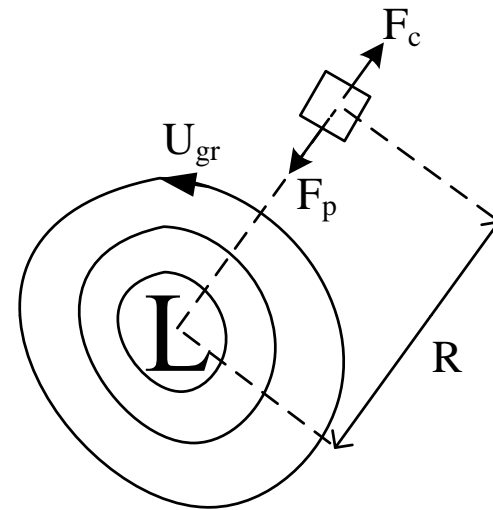
### 4. Mechanics



# Wind Resource

## B. Wind Motion

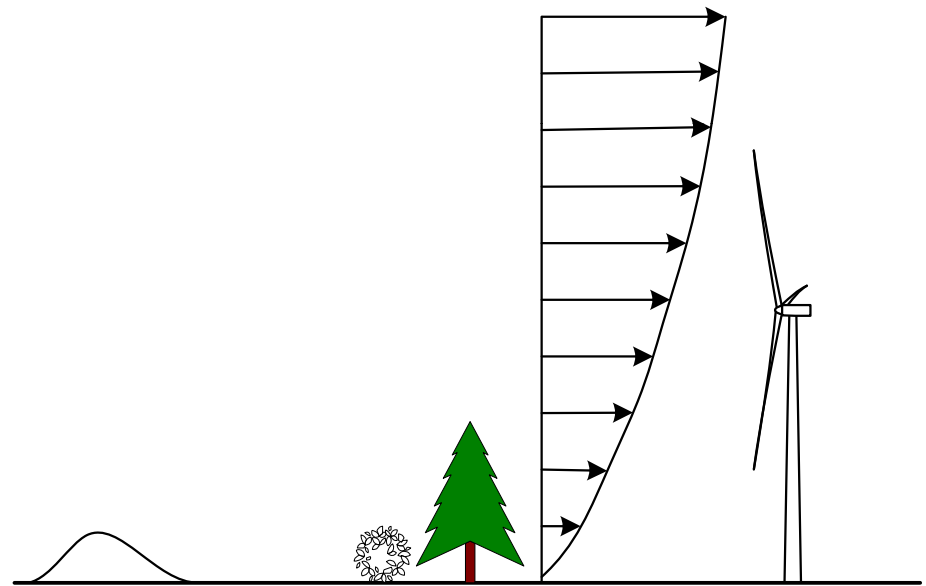
### 4. Mechanics



# Wind Resource

## C. Atmospheric Boundary Layer

### 1. Why is it Important to Wind Energy?

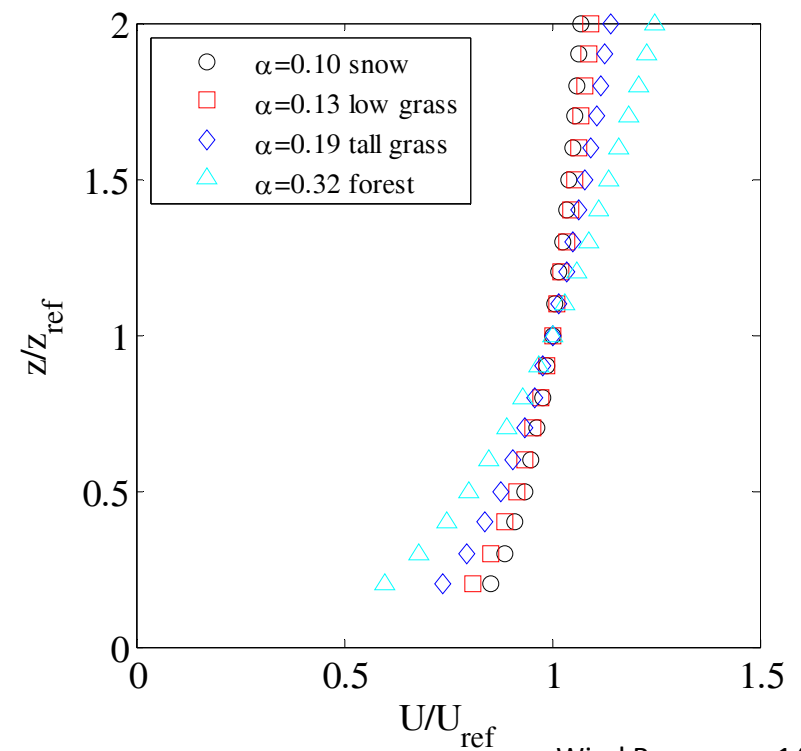


# Wind Resource

## C. Atmospheric Boundary Layer

### 2. Wind Variation with Height

#### a. Power Law

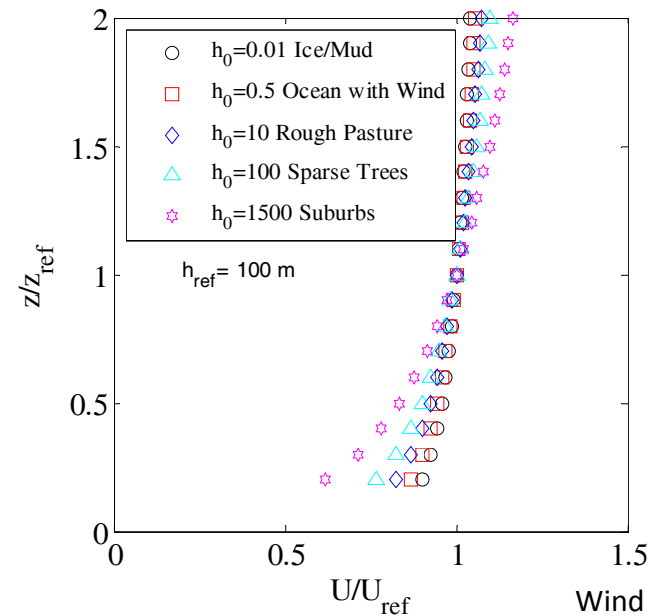
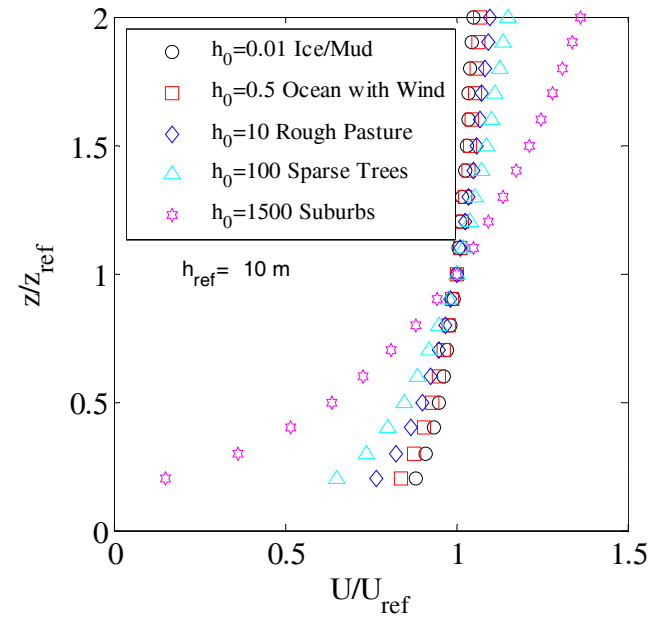


# Wind Resource

## C. Atmospheric Boundary Layer

### 2. Wind Variation with Height

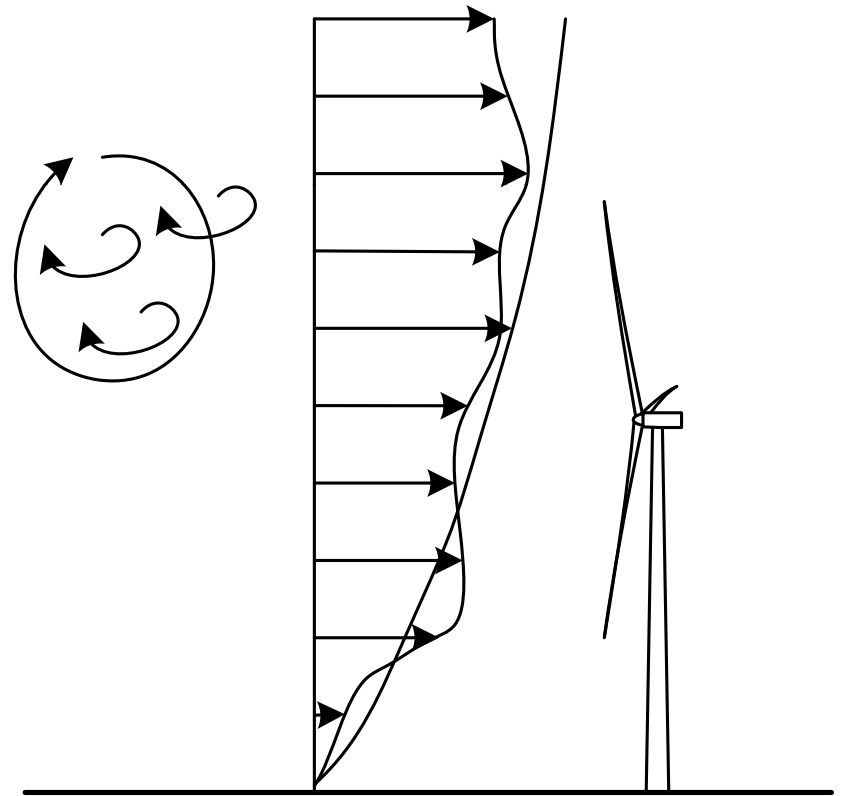
#### b. Logarithmic Law



# Wind Resource

## C. Atmospheric Boundary Layer

### 3. Turbulence

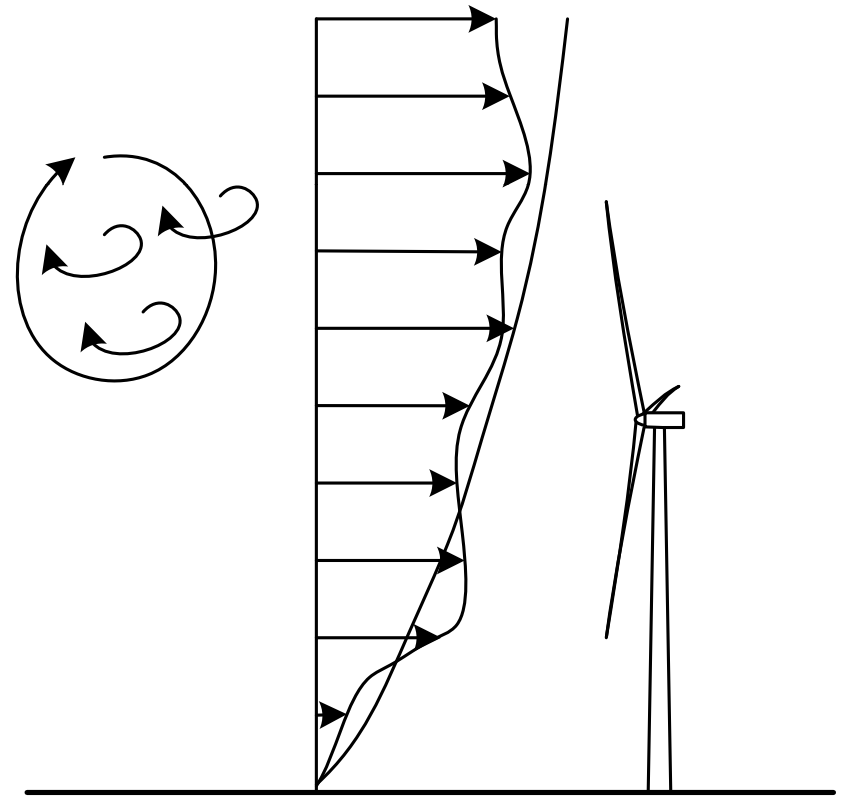




# Wind Resource

## C. Atmospheric Boundary Layer

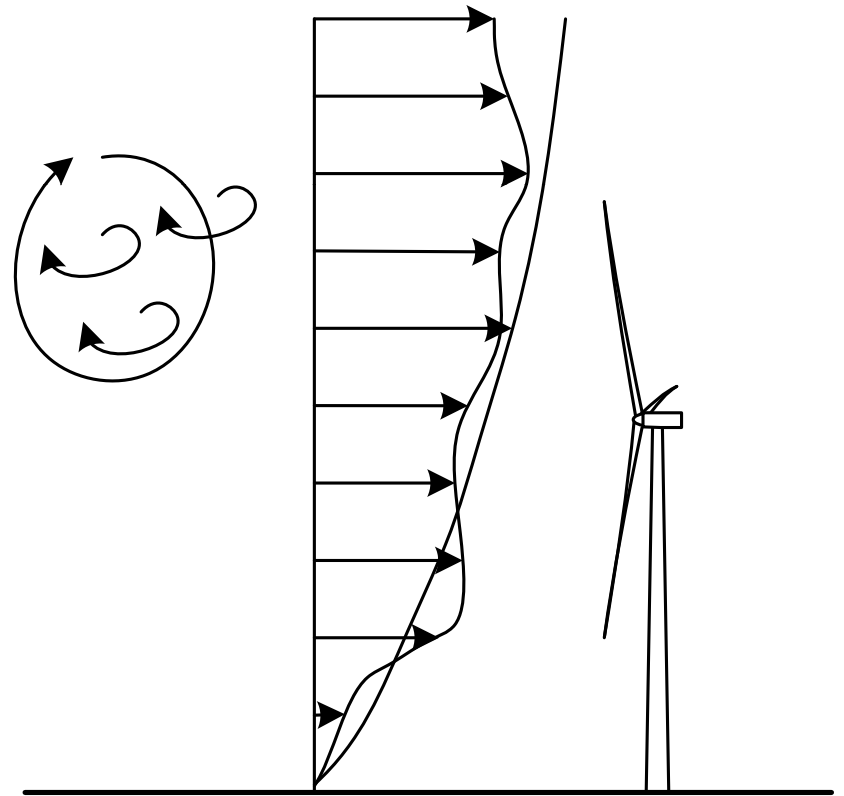
### 3. Turbulence



# Wind Resource

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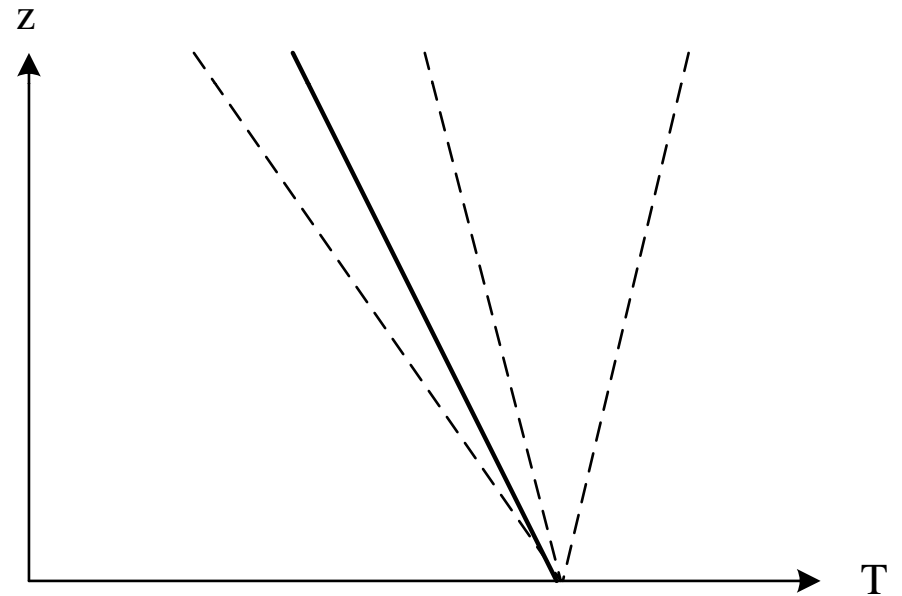
### 3. Turbulence



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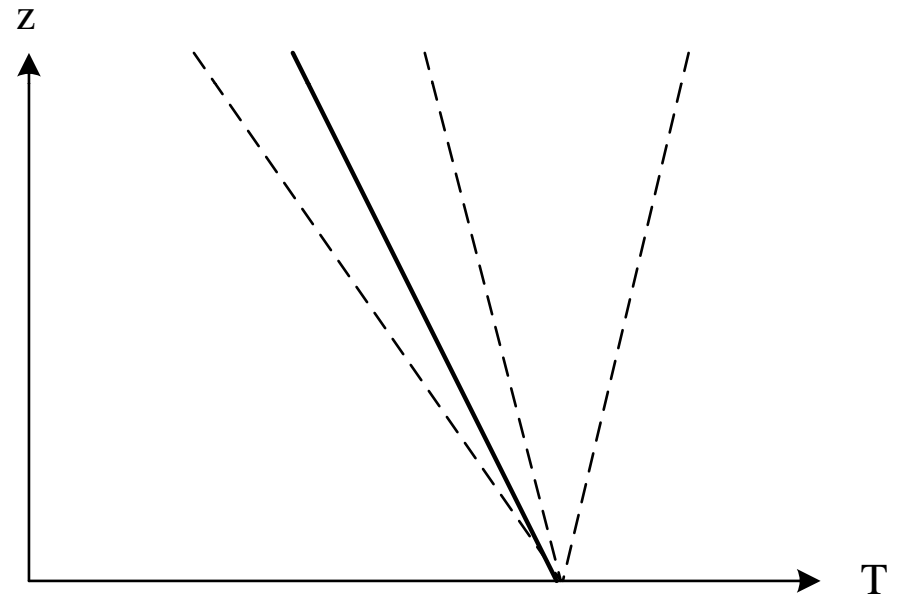
### 4. Vertical Variation of Temperature and Stability



# Wind Resource

## C. Atmospheric Boundary Layer

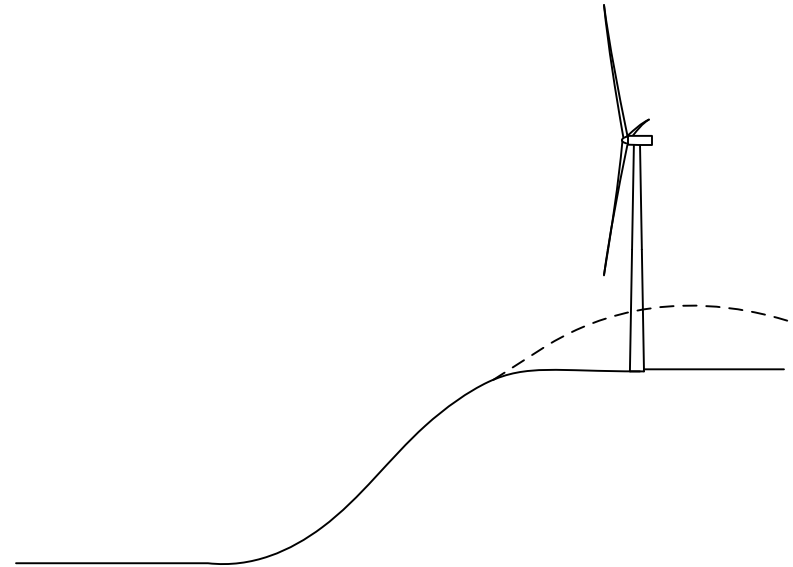
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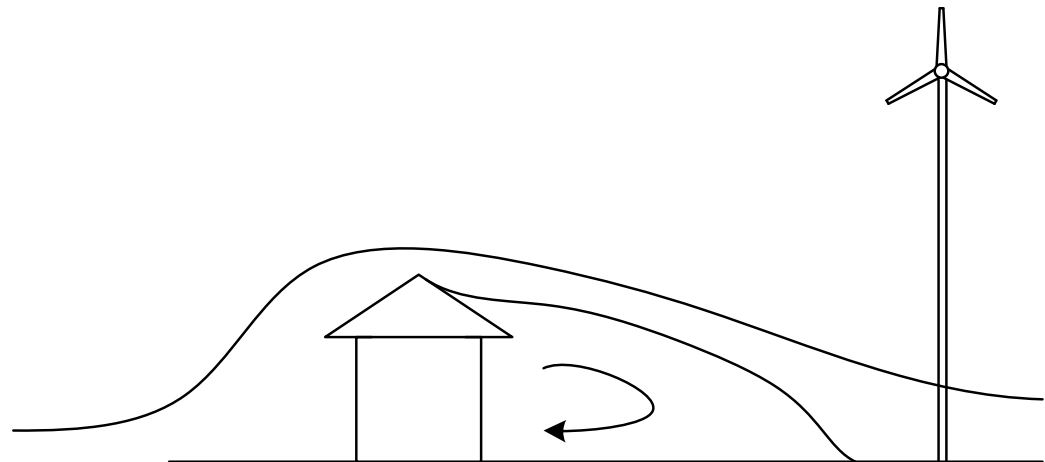
### 4. Terrain Effects



# Wind Resource

## C. Atmospheric Boundary Layer

### 4. Terrain Effects



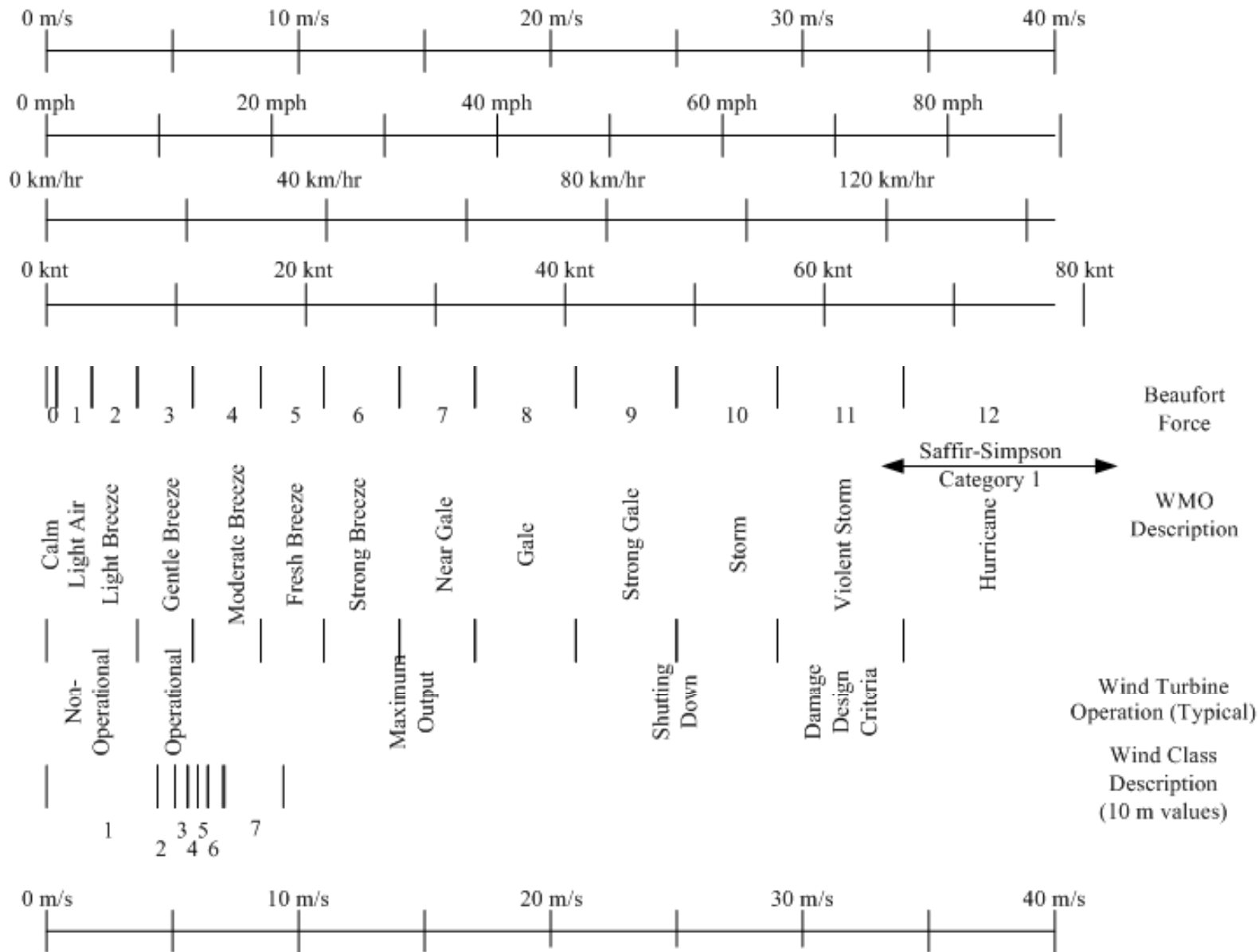
# Wind Resource

## D. Characterization of the Wind

### 1. Introduction

### 2. Wind Speed and Direction

# Wind Resource





# Wind Resource

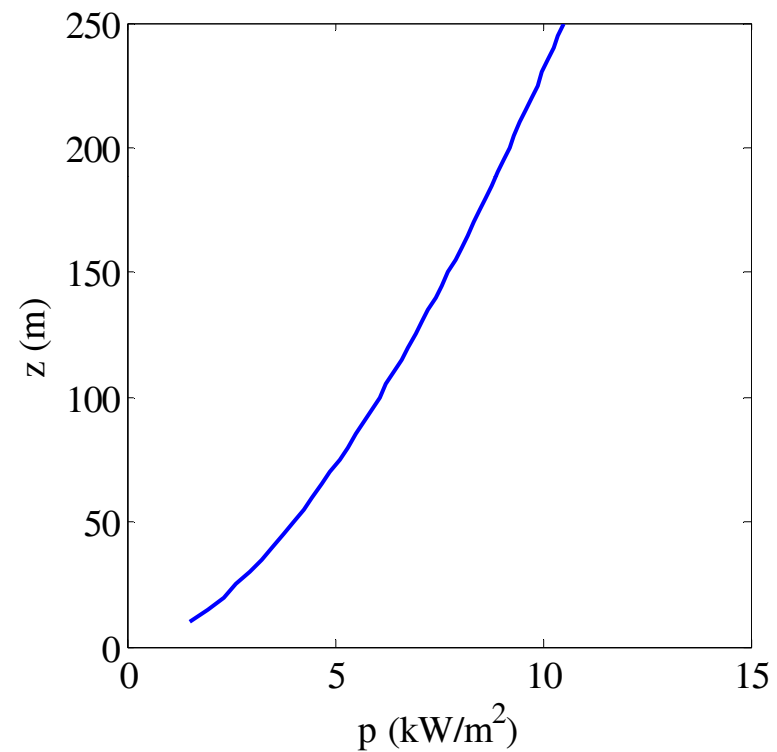
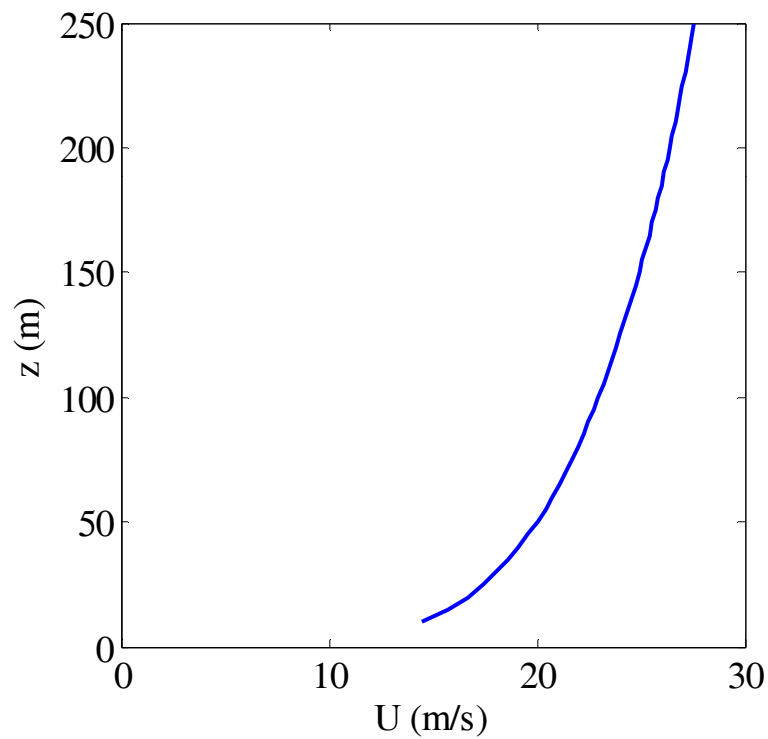
## D. Characterization of the Wind

### 3. Kinetic Energy and Power in the Wind

# Wind Resource

## D. Characterization of the Wind

### 3. Kinetic Energy and Power in the Wind

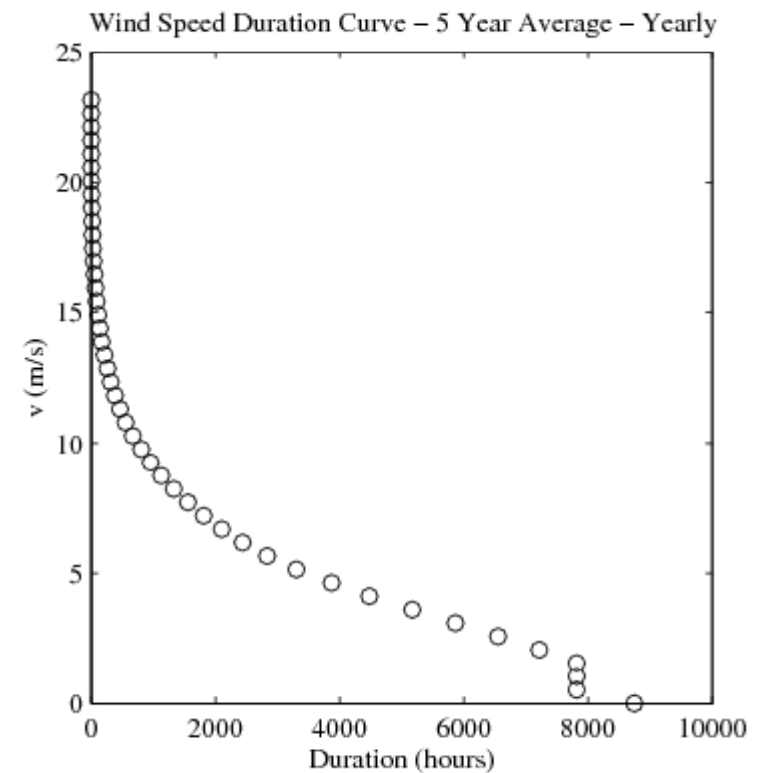


# Wind Resource

## D. Characterization of the Wind

### 4. Statistical Description of the Wind

#### a. Wind Speed Duration Curve

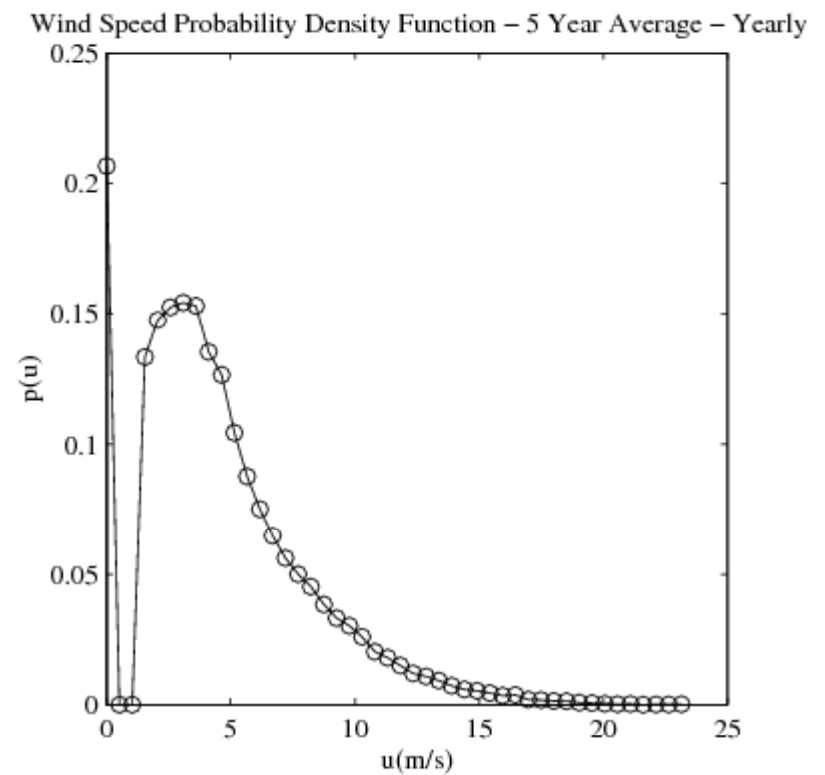


# Wind Resource

## D. Characterization of the Wind

### 4. Statistical Description of the Wind

#### b. Probability Density Function

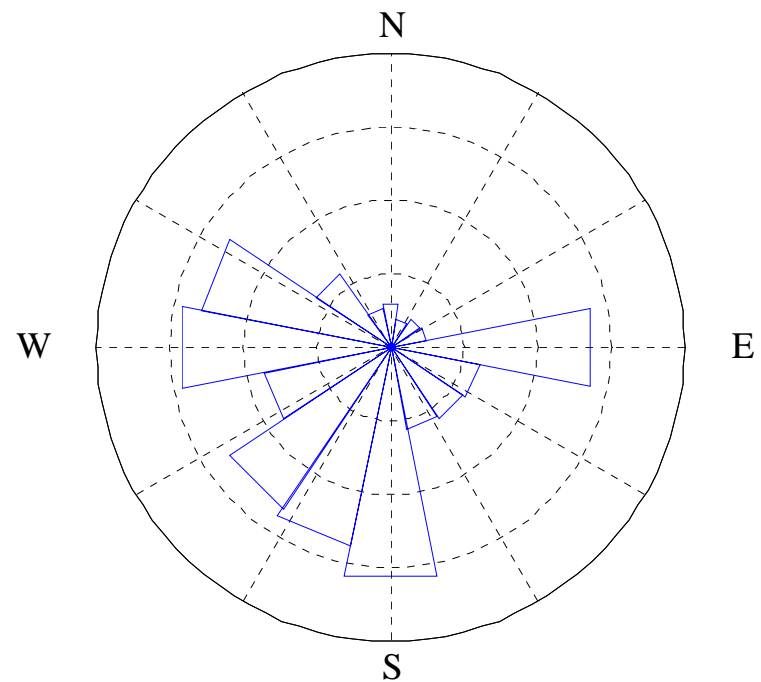


# Wind Resource

## D. Characterization of the Wind

### 4. Statistical Description of the Wind

#### c. Wind Rose (direction)

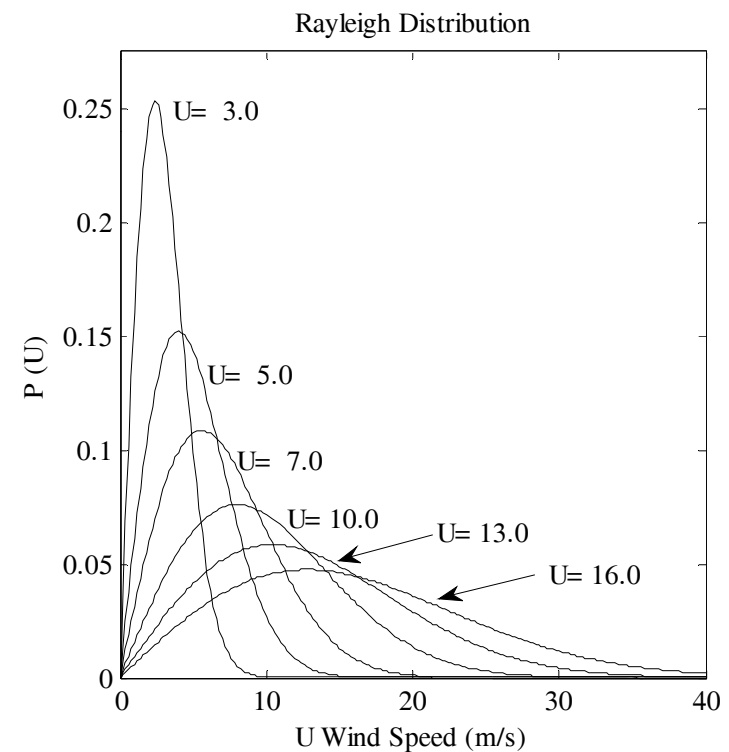


# Wind Resource

## D. Characterization of the Wind

### 4. Statistical Description of the Wind

#### d. Statistical Models of the Wind

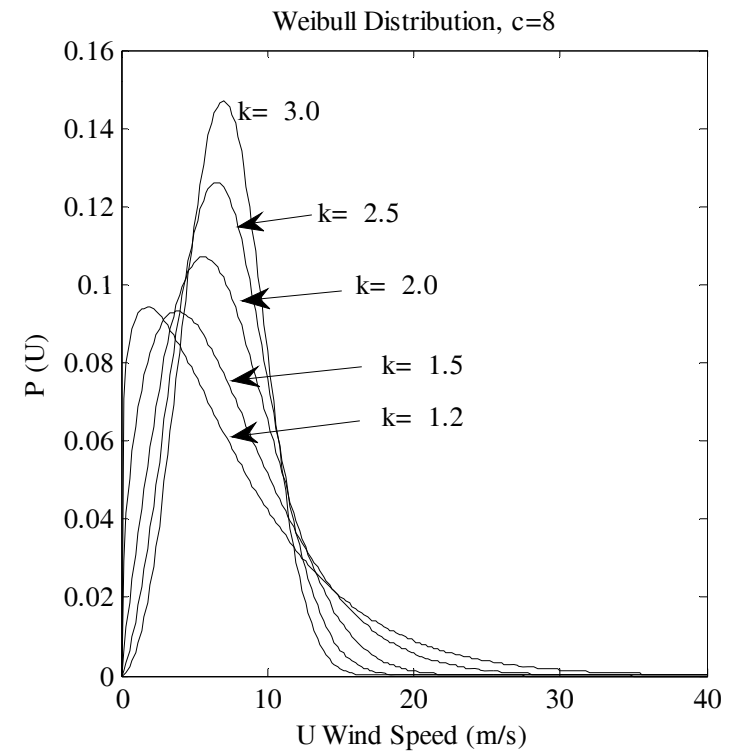


# Wind Resource

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### 4. Statistical Description of the Wind

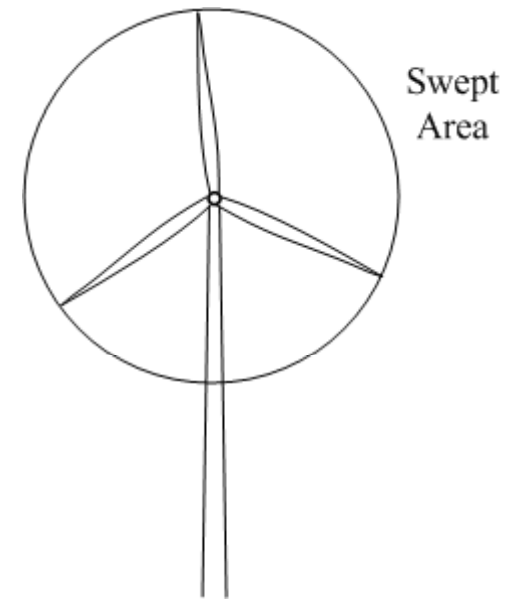
#### d. Statistical Models of the Wind



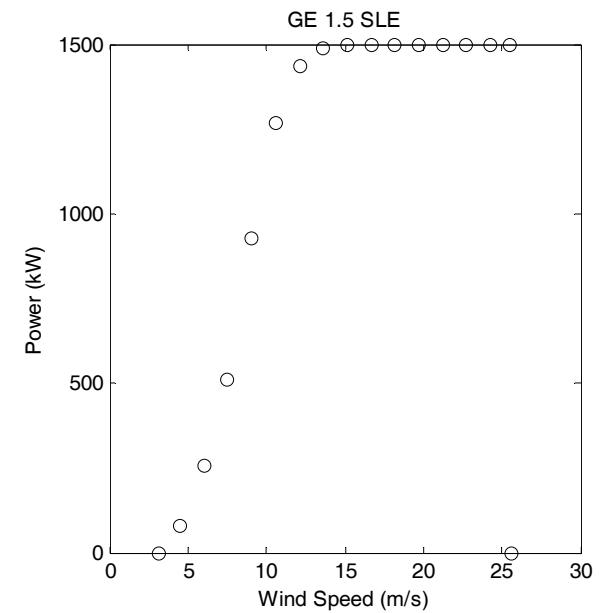
# Wind Resource

## E. Power Production Estimation

### 1. Swept Area



### 2. Statistical





# Wind Resource

## E. Wind Speed Instrumentation

### 1. Met Tower



# Wind Resource

## E. Wind Speed Instrumentation

### 1. Remote Sensing

a) Sodar

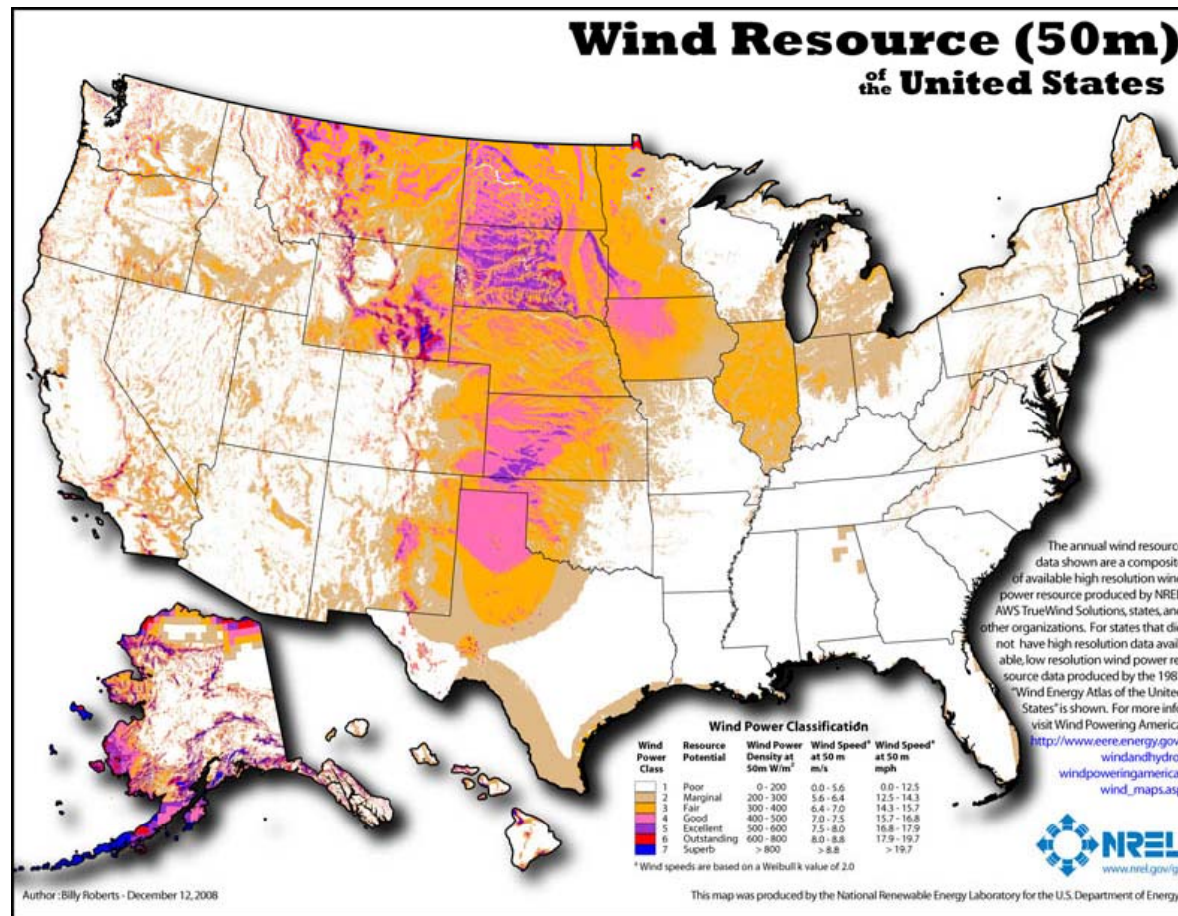
b) Lidar



# Wind Resource

## E. Resources for Wind Speed Estimation

### 1. United States Annual Wind Resource Potential










# Wind Resource

## E. Resources for Wind Speed Estimation

### 1. United States Annual Wind Resource Potential

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#### Wind Power Classification

Wind Power Class		Resource Potential	Wind Power Density at 50m $\text{W/m}^2$	Wind Speed <sup>a</sup> at 50 m m/s	Wind Speed <sup>a</sup> at 50 m mph
	1	Poor	0 - 200	0.0 - 5.6	0.0 - 12.5
	2	Marginal	200 - 300	5.6 - 6.4	12.5 - 14.3
	3	Fair	300 - 400	6.4 - 7.0	14.3 - 15.7
	4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
	5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
	6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
	7	Superb	> 800	> 8.8	> 19.7

<sup>a</sup>Wind speeds are based on a Weibull k value of 2.0

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## E. Resources for Wind Speed Estimation

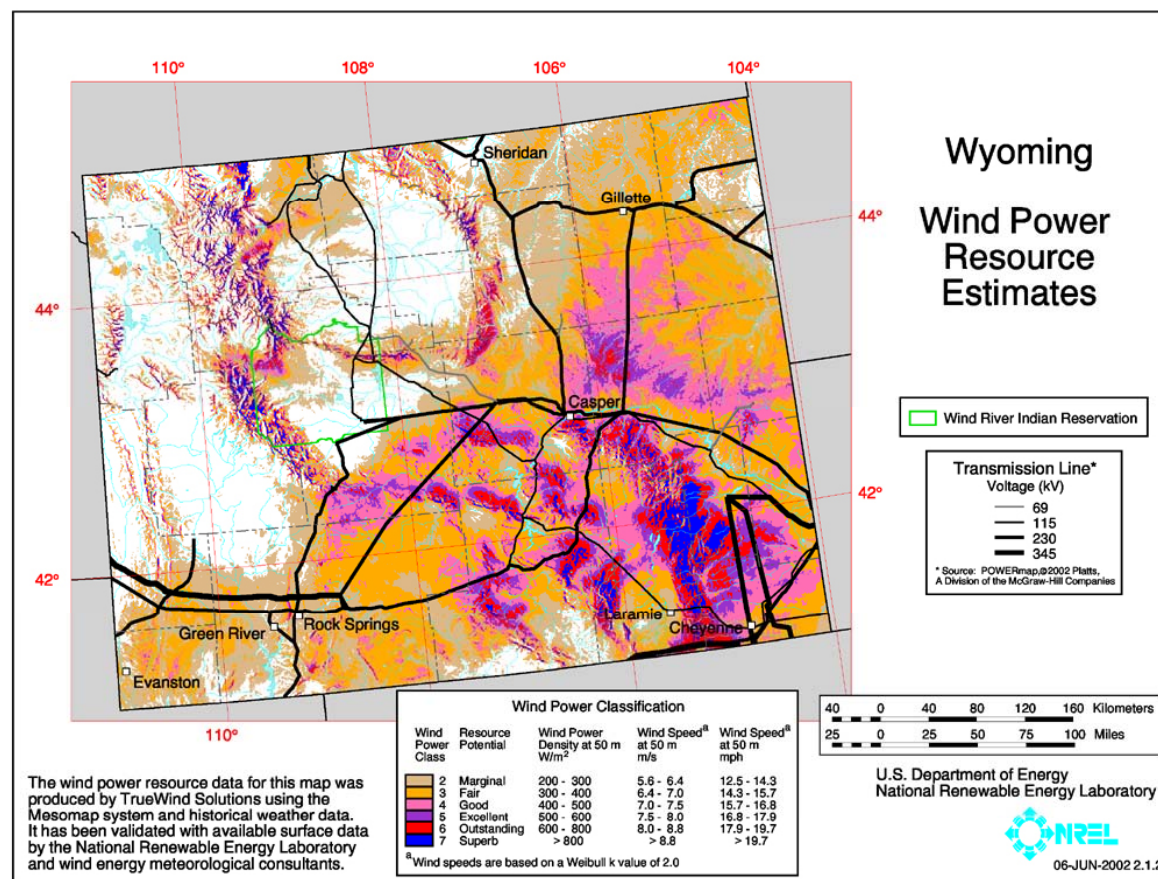
### 1. United States Annual Wind Resource Potential



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