The Solar Store

Special Use Permit Packet

An Itemized Consideration for Variances to Municipal Codes (18.05.080) and Reasonable Consideration for N.R.S. 278

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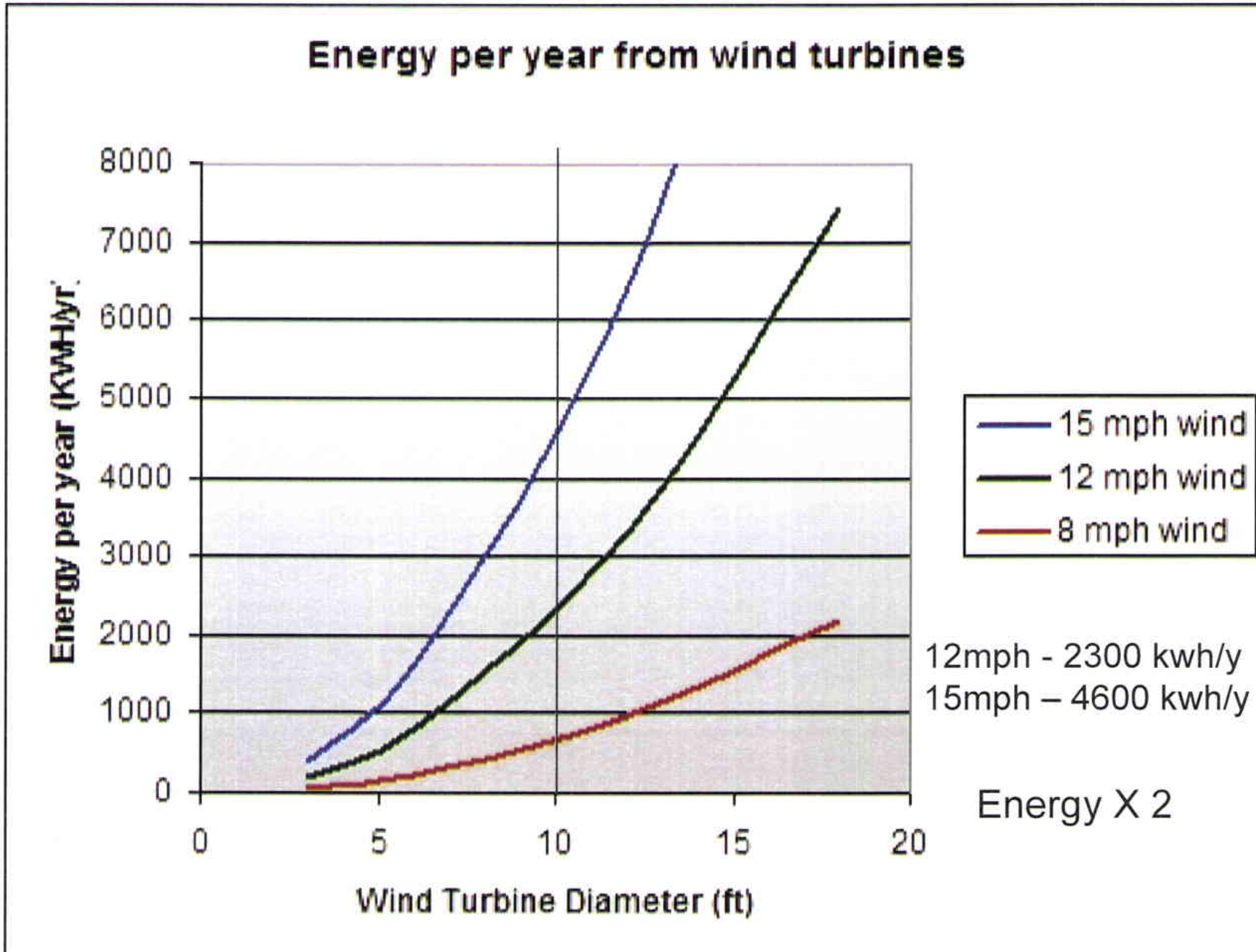

12mph - 2300 kwh/y
15mph – 4600 kwh/y

Energy X 2

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I. Wind Energy Conversion Standards

Location

The Size of Parcel for 7300 Schulz Ranch is 2.48 acres. The horizontal axis wind turbine has not been placed above any drainage areas, property easements, or over any power-lines per 18.02(2a.) There will be one wind energy conversion system (WECS) generator on this parcel.

Setbacks for the WECS will exceed current restrictions as set forth in 18.05(2)Standards(c.) setbacks. A minimum of 1.1 times the total extended height to the property lines is a “unreasonable restriction” per N.R.S. 278. This application seeks a variance to address this shortfall. A tower height of 160’ feet is needed to produce good wind results as data will show. The property although more than an acre can not accommodate a WECS even if it were placed in the center of the parcel. It should be noted and shown that telephone pole's, power lines, and cell phone towers require no such easements and are potentially more hazardous than wind generators could ever be. Who in their right mind is going to be outside playing in a wind storm!

A Height Maximum of 60 feet is completely unreasonable Per N.R.S. 278. For this particular turbine, " The Bergey Excel" the manufacturer beginning tower size is 60'. Typical tower sizes are from 60' to 160'. In the instance of the smallest tower available and designed for the Bergey Excel the total system height is 60' + 11' for the blades.

FAA REQUIREMENTS

The Federal Aviation Administration outlines specific guidelines for runways longer than 3600'. In this case FAA requirements apply to structures less than 200' and within the glide slope of a 100 to 1 ratio. . So in the case of a WECS being 10,000 within the runway you have to be under 100' to satisfy this requirement 14CFR 77.13 (1) *. So in the case of 3.8 miles (20,000feet) the glide slope would be 200'. In the case of 7300 Schulz Dr the airport is 6.8 miles from the airport and the glide slope requirement does not apply. Lighting requirements are not addressed for structures less than 200'.

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Access Considerations

Access to this wind turbine will be limited. All restrictions to climbing step bolts will limit access from below 12 feet above the ground. All step bolts below 12 feet are to be removed and stored apart from the WECS so that they will not be readily accessible to the public. Labeling will be consistent with 18.05 (2)(f)ii. That will insure proper safety and means of disconnect and access.

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Noise Considerations

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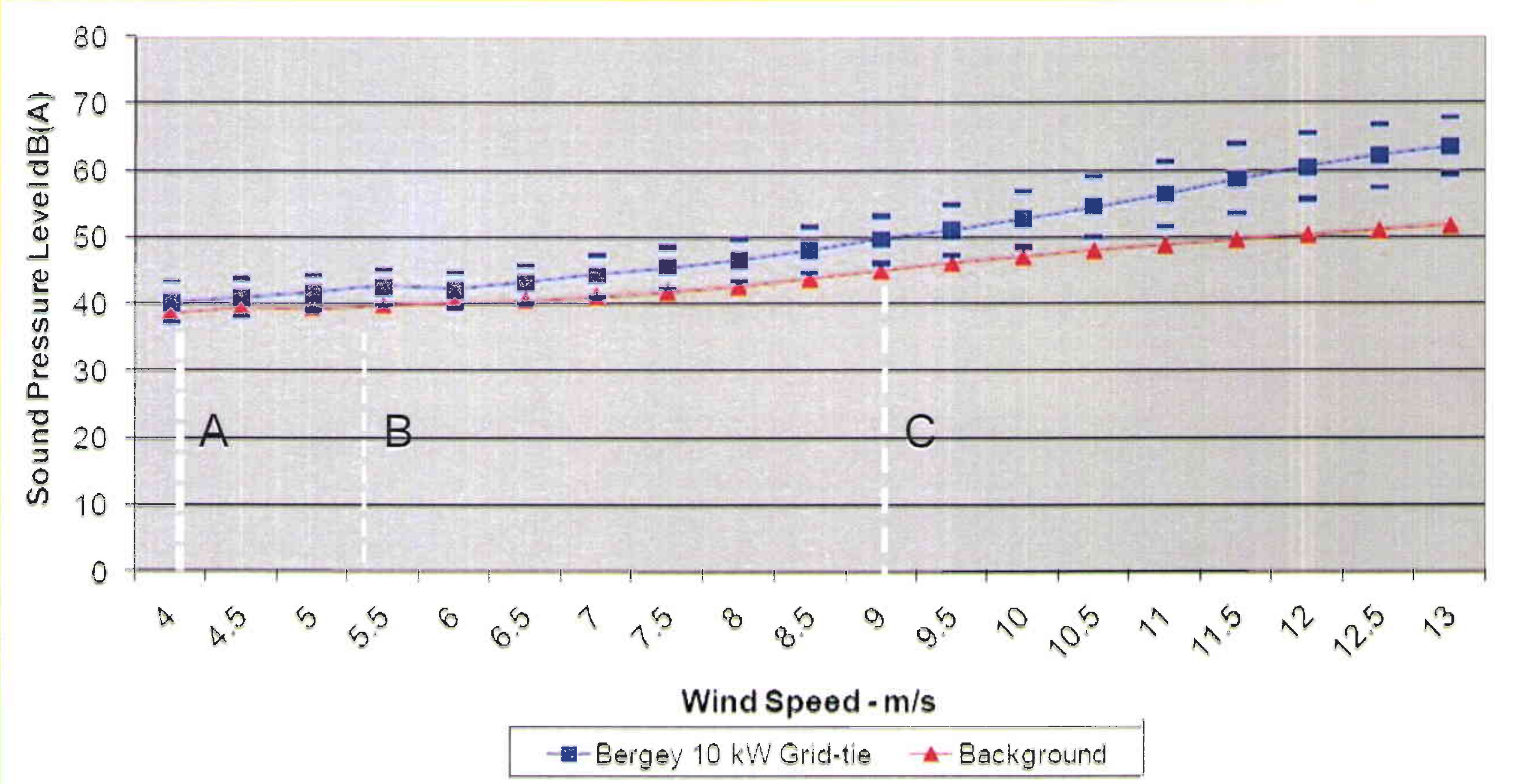
Acoustic Characteristics -Bergey Excel-S 10kw



Independent test – USDA-ARS Lab Bushland ,Tx (June (2010)

A - at 4 m/s (8.9 mph) background noise equiv. to wind machine sound

B - 10 yr average wind at 50m height is 5.1m/s (11.4 mph)

C – Code requirement 50 dba at wind speed of 8.8 m/s (19.5 mph)

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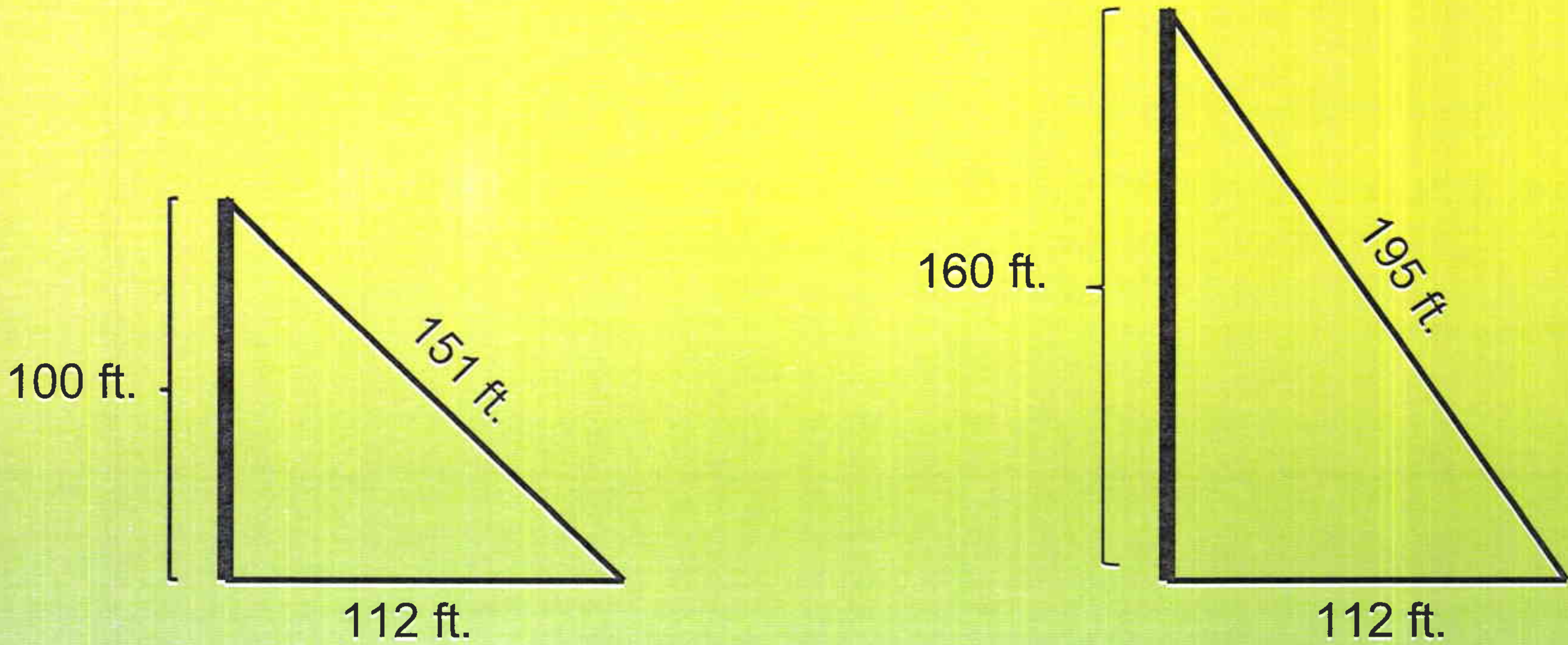
Noise Standards (section 18.05 2h i) - continued



Change in level do to change in distance
DB =20 Log (151/195) = -2.3 DB

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Noise Standards (section 18.05 2h i)

- Code requirements for a 50DB(A) level at the property line can be satisfied for wind speeds of less than 19.5 mph.

- The acoustic data presented is for a hub height of 100 ft , measured at a slant range of 151 feet. (approx 112 feet from tower base) The 160 ft tower will have a slant range of 195 feet at the same point.

- Because of the added height (and slant range), noise will be reduced an additional 2.3DB This amounts to meeting code with wind speeds less than 22 mph. This requirement can be met at least 95% of the time.

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Noise Standards (section 18.05 2h i) - continued

- Noise requirement for the abutting properties of one acre or less is 25 dBA. This will be impossible to meet at any property line. Three properties are in this class, two are unoccupied.

- A quiet library is 40dBA, while a quiet bedroom at night is 30dBA A whisper or background in a recording studio is 20dBA (see other attachments)

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Noise Standards (section 18.05 2h i) - continued

- The background noise created by an 8.9 mph wind is equivalent to 40 dB(A). This almost masks the sound of the wind machine. See previous charts (line A on the acoustics chart)

- This requirement should be stricken from municipal ordinance as it is an unreasonable restriction per N.R.S 278.02 . It is an unreasonable standard enacted to prohibit wind.

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FAA Recommendations

- There are not any regulations that state a special luminare or coloring is needed for this project. It will be less than 200 feet in height

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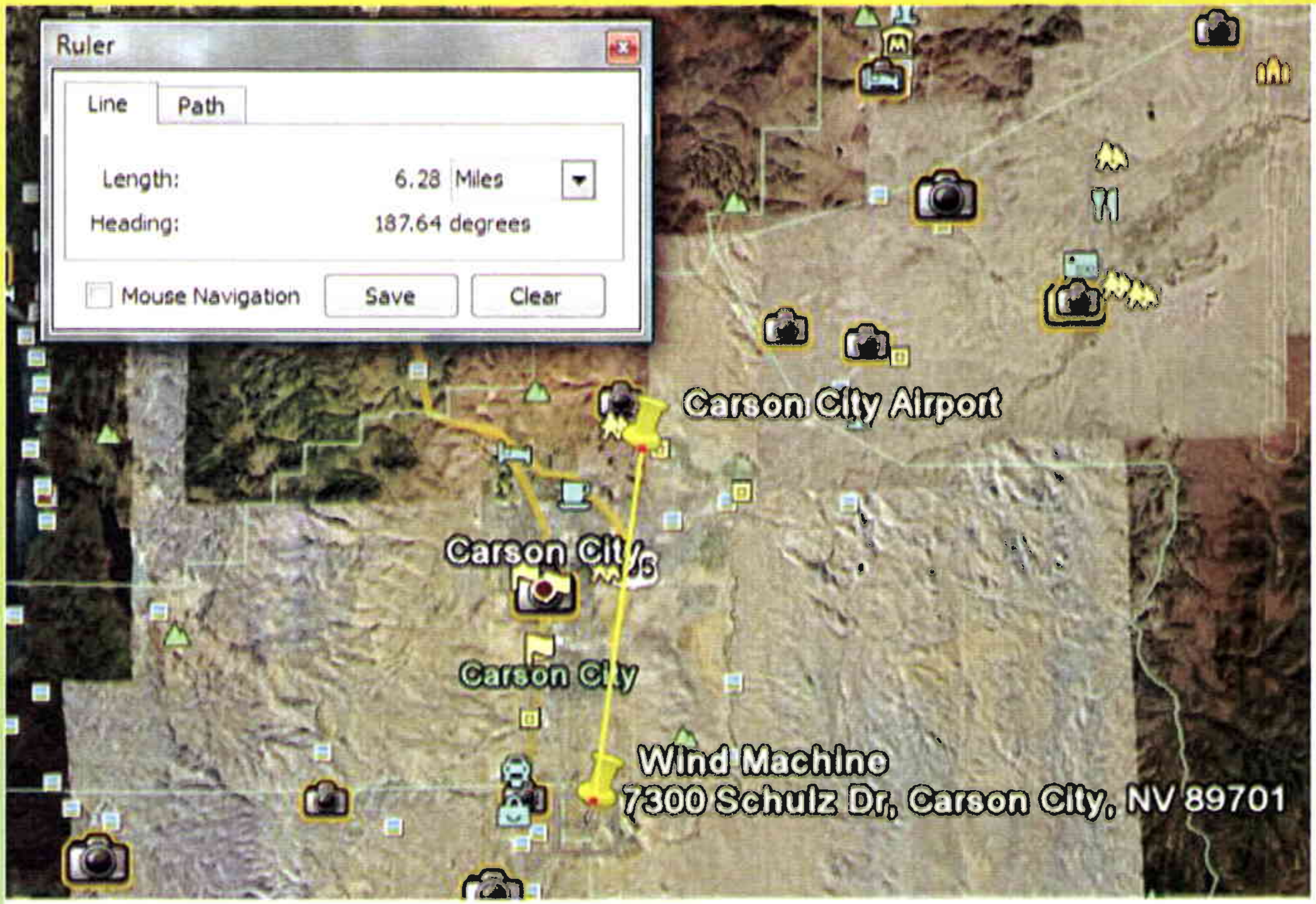
FAA Recommendations continued



Carson City Airport - has two 6100 ft runways - FAA 77.18 applicable under glide slope of 100 to 1 ,out to 20000 feet horizontal (3.8 miles)
-- 7300 Schultz not impacted - located 6.28 miles from airport
-- Tower height limited to 200 feet

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Site History

In 1979 At 7300 Schulz Drive Joe Goni moved on to the property. A 14' X 72' Mobile Home was placed on the property at that time. A Barn was erected later in 1997. In 2008 a 4 bay Garage was approved in conjunction with a special use permit .

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Project Overview: A 10 Kilowatt 10kw Bergey Excel

Bergey Wind Corporation was created in 1973 by Carl Bergey in the infamous area of Oklahoma known as "Tornado Alley". Originally an Aircraft designer Carl sought to design a wind generator that would have the ability to withstand any amount of wind. Unlike most other wind generators of today the Bergey Excel does not have a "destruct speed" In the case of the Bergey Excel the design was intended that one subsystem failure not lead to other events triggering a "cascading failure". With the Bergey Wind Generator there are minimal moving parts and the wind generator is designed to withstand all conditions ; even freewheeling in a total grid failure.

In this installation a 160' tower is intended recover energy created by the east slope affect known as the zephyr wind that comes into Eagle Valley. The Wind Generator itself has a swept wind area of 23 feet. From top to bottom the WECS will measure 171 feet. This Manufacture sells towers that range in size from 60 to 160 feet. To add for the additional radius of the blades an additional eleven feet is the sum to equal the total structures height.

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Project Overview: A 10 Kilowatt 10kw Bergey Excel

To insure proper installation with respect to foundation and bolt integrity it is often a building departments' request to have in a third party to inspect the anchor bolt fastening. To insure that a proper overall installation is done proper it is the policy of Bergey Wind Corporation that only, "Factory Trained and Qualified Dealers " purchase and install these turbines. Additional cut sheets and literature can be found in the appendices to this package or for even more information go to Bergey.com .

Specifications:

- Rated Power:
  - Burgey 10 KW 195 kwh/mo @ 12 mph
  - Burgey BWC approx. 2000 kwh/mo
- Turbine Size
  - Burgey 10,000 Watts
  - Burgey – 7.5 kw (dc) charging, 10kw to grid inverter
- 24v, 48v, 120v, 240v DC Output
- External GridTek inverter
- Costs $55K-$155K depending on configuration
- Tower Heights from 60ft to 160ft
- Rotor Diameter: 23 feet
- Design Life - 30yr; 5yr nominal maintenance
- 10 Year Warranty *

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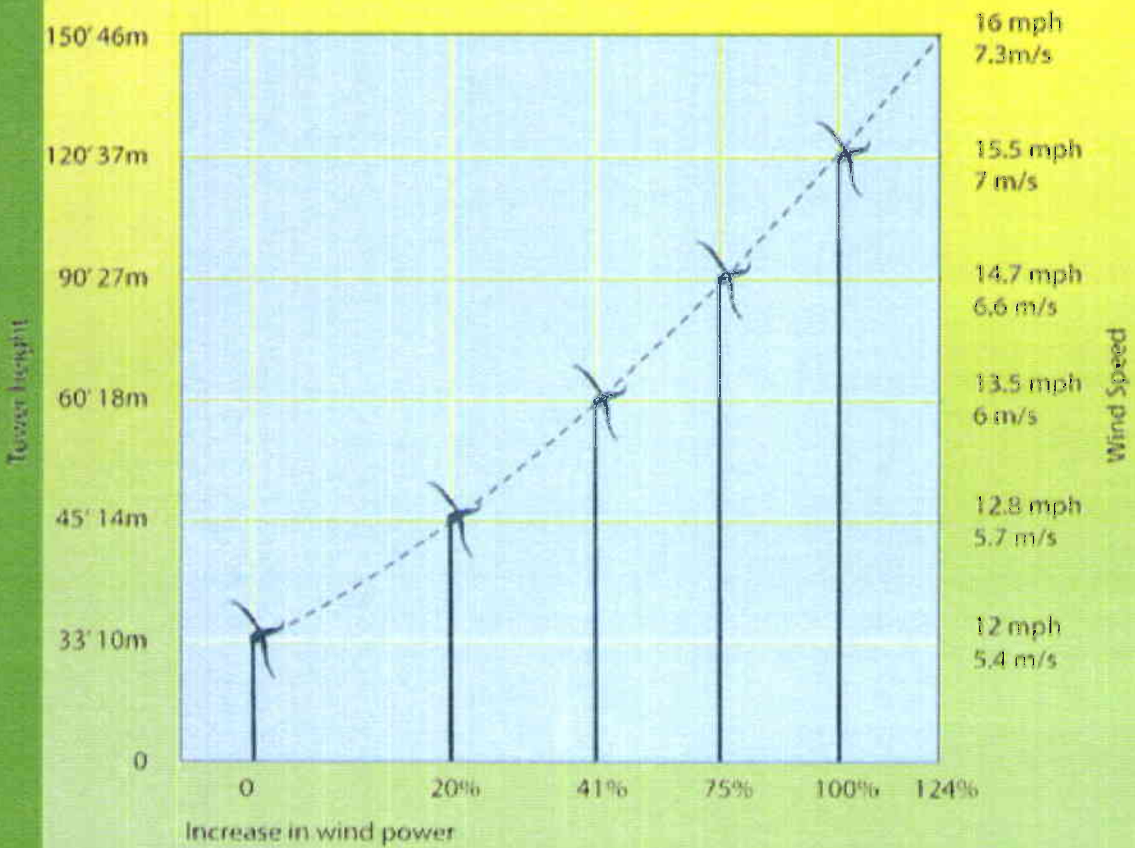
Tower Height Makes a Big Difference



$$V / V_o = (H / H_o)^{\alpha}$$

V	wind speed at new height
H	new height
H_o	original height
V_o	original velocity
α	(alpha) wind shear exponent

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Wind Speed changes with height

Height	Wind speed
90ft	13.7mph
60ft	13.5mph
30ft	12.3mph
15ft	11.2mph
0ft (surface)	10.0mph

If you find it is 10 mph on the ground, a turbine on a 60' tower will experience a 13.5 mph wind

Creates 2.5 times More Energy

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Height Considerations

- Maximize Energy Production
  - Highest practical and economical height
  - Site positioning to avoid ground turbulence
  - Site positioning / height to capture prevailing wind
  - Site positioning for a practical installation
- Satisfy All Safety (FAA) Requirements
- Meet All Building Code Requirements
- Perform Trade Offs as Needed

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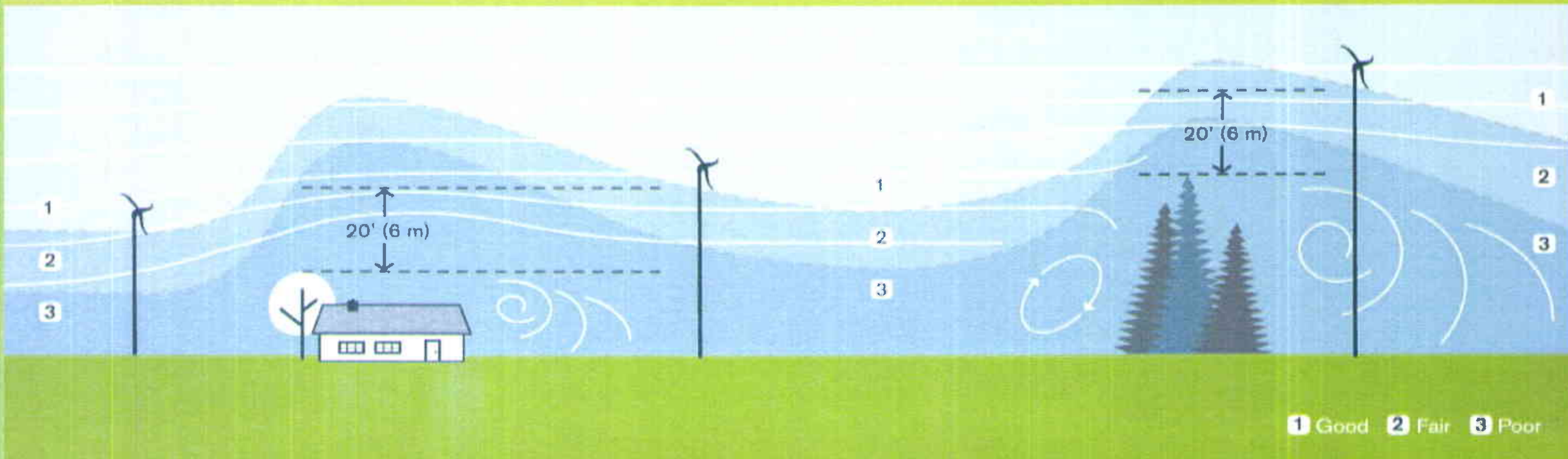
Turbine/Tower placement

- Open space with prevailing wind
- Turbulence
- Features—trees, buildings, landscape
- 30/120 rule



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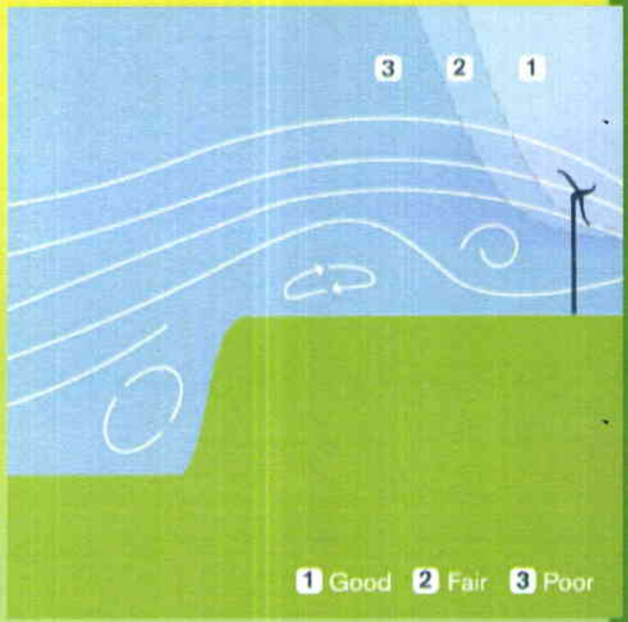
Natural Features

Coast or Lakeside

Ridge top



Mesa

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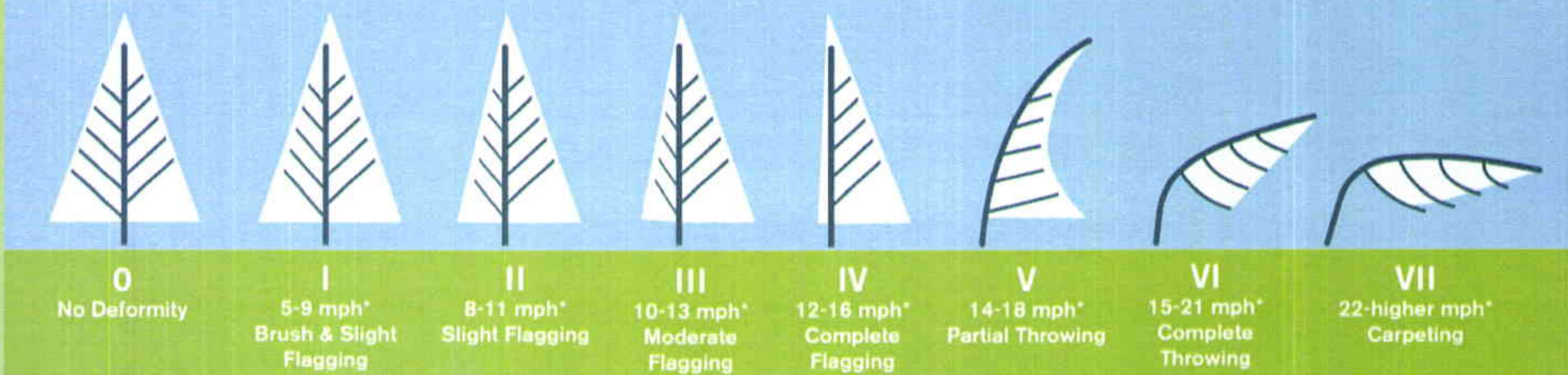
How Much Wind Do I Have ?

- On Site Anemometer
- Rainbowsolar.com – Link to NREL
- NV Energy
- NASA Surface Meteorological Data
- Analysis Software e.g. 3Tier
- Biological Indicators

Griggs-Putnam Index



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Schulz Ranch Specific Plan Area

It was found in SPA-SR-1.2 **Policies and Land Use** that

A variety of setbacks is encouraged

And

Larger buffer lots are required on the perimeter of the project

And

A minimum setback of 30' is established from adjoining properties

The Schulz Ranch Plan does not appear to be impacted by a towering wind generator on a adjacent property. It is also known that the SPA – SR – 1.2 Schulz Ranch Specific Plan Area has been put indefinitely on hold. Currently the land is owned by a bank and no longer in the ownership of a developer.

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Residential Wind Generators

- Small Wind Turbines 400 – 50,000 watts

←< 3KW→
Southwest
Wind

← 10KW →
Bergey
Wind Power

- The Average American Family Uses Between

10,000 – 15,000 Kilowatt Hours Per Year

- It is estimated that this WECS will Generate 14,000 KWH Annually

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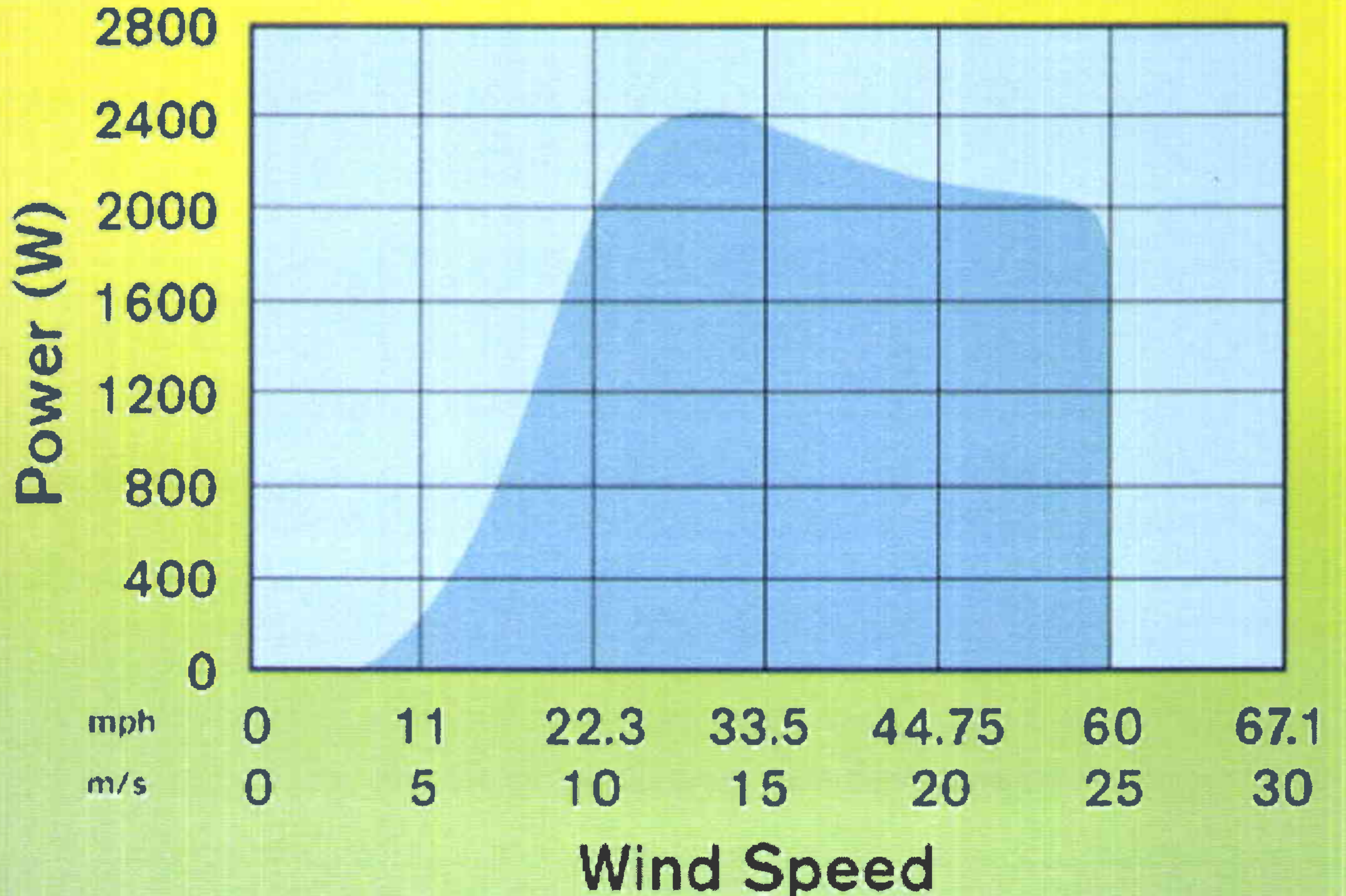
Power – Rate of Energy Production



Data measured and compiled by USDA ARS Research Lab, Bushland, TX

The Power Curve – Varies Among Turbines

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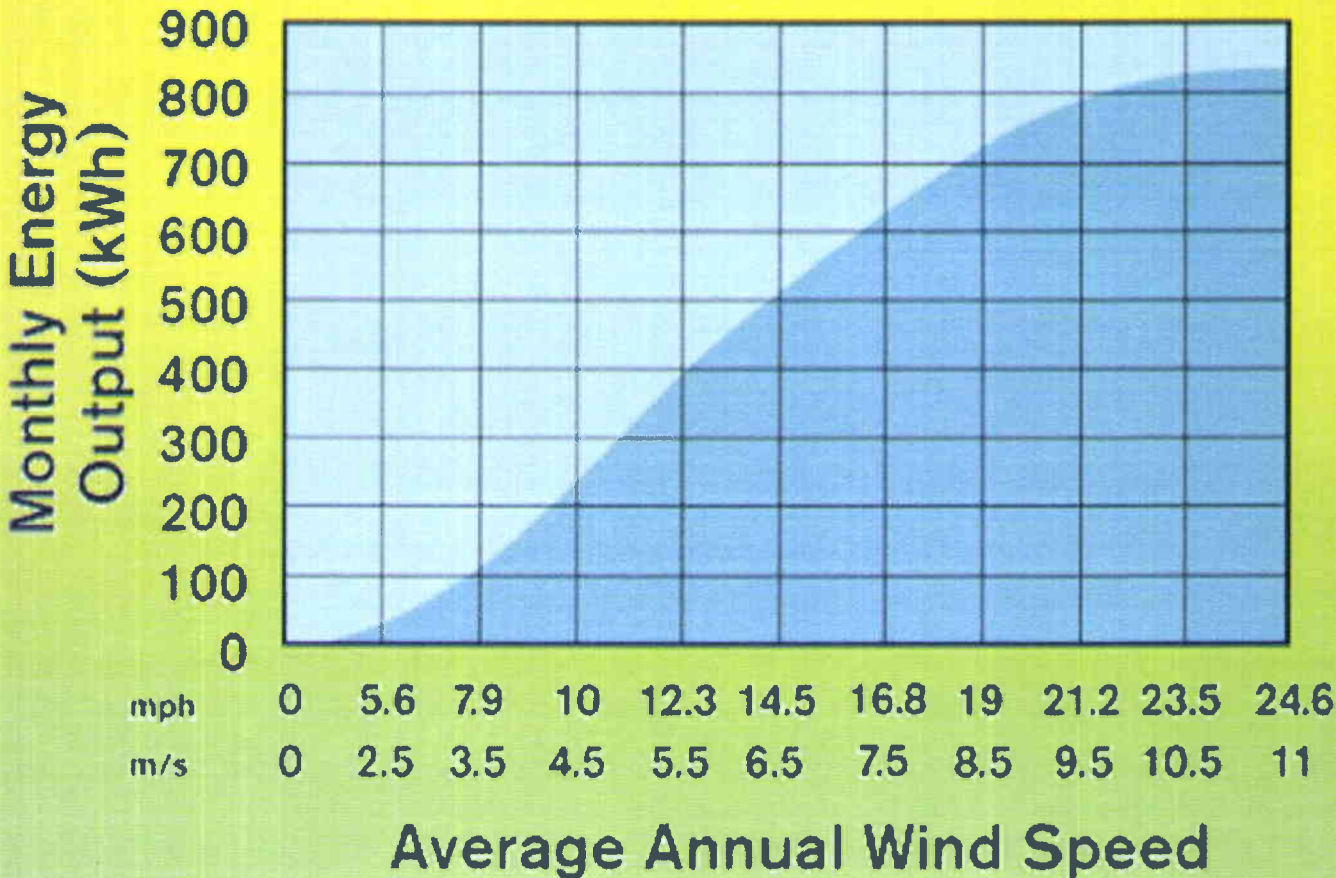
Energy – Is What We Buy



Power Over Time

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Laws, Ordinances and Homeowner Associations

- NRS. Ch.278.0208

  Restrictions for the use of system for obtaining solar or wind energy prohibited

  AB 236 now part of NRS

NRS Material

- PURPA ACT - 1978

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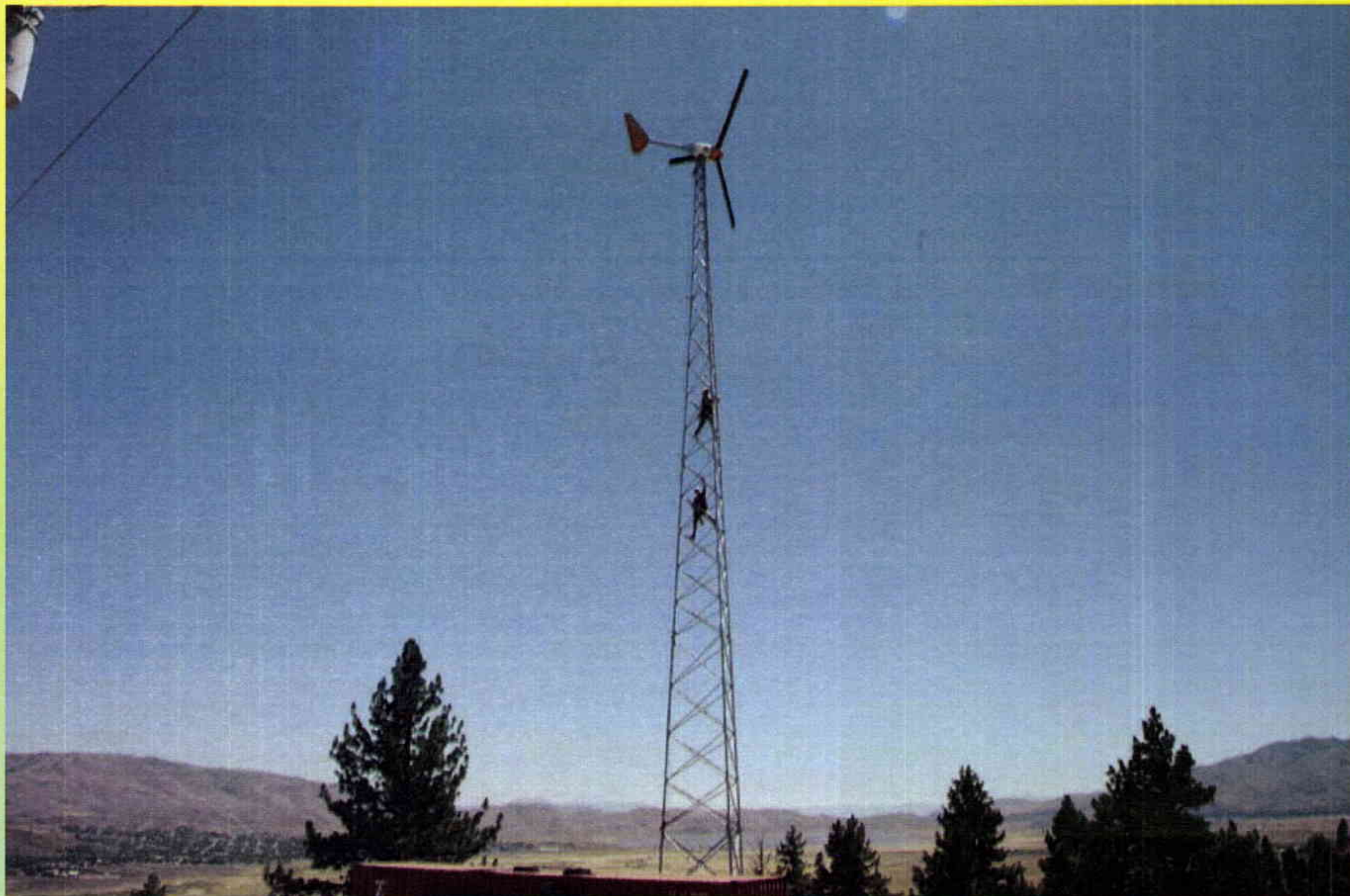
The Bergey Excel



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Simulated View from Racetrack & Schulz Looking West

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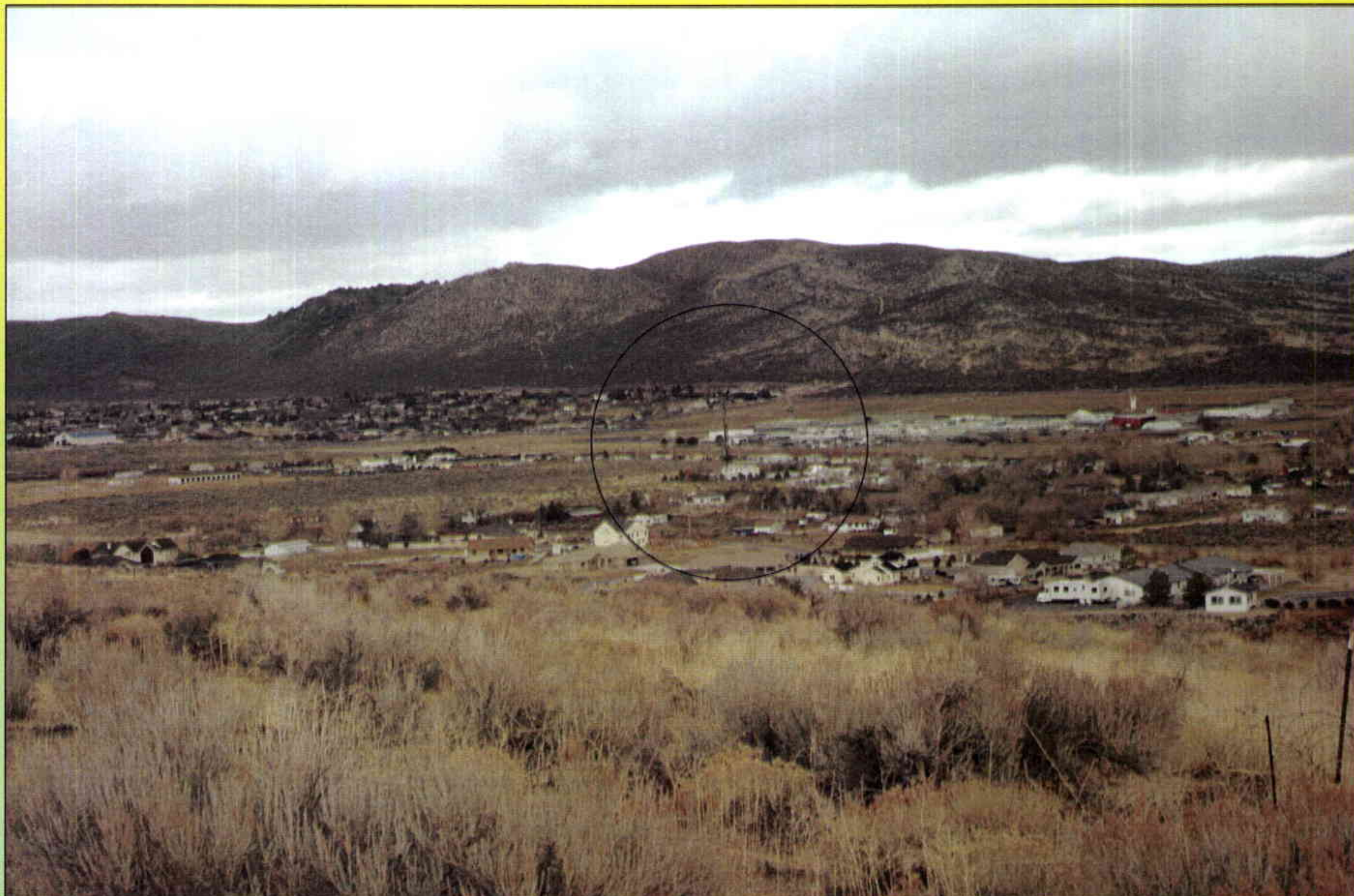
Simulated View From N. Sunridge – Looking North East



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Goni Wind Machine Project Summery Appendix A
Findings and Recommendations to County Commissioners

It is the purpose of this special use application to secure approval for the installation and operation of a Bergey 10 kw wind machine at 7300 Schulz Drive. In order to maximize energy production, it is proposed to mount the Berger Excel-S on a 160 feet (50m) free standing lattice tower. Great effort has been made to ensure minimal impact to the surrounding area, while maximizing the system performance.

This effort has included an independent wind study using the 3 Tier wind models, the Bergey performance projection software and assurance that the structure satisfies all title 14 Code of Federal part 77 regulations. (FAA 14CFR part 77) Wind turbine third party acoustic data from USDA-ARS labs is also presented. The selection of the 160 feet tower is required to capture prevailing winds over Sunridge while increasing performance from poor to fair, resulting in a 37% improvement in wind machine annual output compared to a 60 ft. hub height.

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To accommodate these efforts, variances from the ordinance standards for maximum height, setbacks and noise limits shall be requested. Special use permit requests variances for the following:

Private Use Wind Energy Conversion Systems:

Section 2. Standards

c. Setbacks

"A minimum of 1.1 times the total extended height from the project property lines adjacent to a residence"

Remove this requirement for this project.

Rationale : Even the shortest tower available for the Bergey Excell-S will not meet this requirement. Accept for one property, the adjacent properties are either undeveloped, bank owned or owned by the Goni family. See variance request for exceeding the 60 ft height limit.

Section 2. Standards

d. Height

"the maximum total extended height of Wind Energy Conversion Systems is 60 feet."

Remove this requirement for this requirement

Rationale: Even the shortest tower available for the Bergey Excell-S will not meet this requirement. Manufacturers have learned through experience that there is little or no energy at lower heights. Several including Skystream, Bergey and others no longer make towers for the lower heights. A wind analysis using 3Tier and NASA surface meteorological data for this height (60 ft) at this location indicate poor or marginal energy production. Going to a height of 100 to 160 feet will give "fair" performance at this location. Wind energy is an exponential function of hub height and is also related to surrounding manmade and natural features. A height of 160 ft will better capture the prevailing winds from the southwest direction (over Indian Hills).

Section 2. Standards

h. Noise

i) "No wind machine or combinations of wind machines on a single parcel shall create noise that exceeds a maximum of 25 decibels (dBA) at any property line where the property on which the wind machine is located or the abutting property is one acre or less or a maximum of 50 decibels (dBA) at any other property line."

Remove this Requirement for this project.

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Rationale: The 25 decibel requirement is totally unreasonable or is in error. Perhaps it might mean 25 dBA above the ambient noise ? See the attached charts and independent sound level reports from the USDA and AWEA (American Wind Energy Association).

A whisper in a quiet library, a quiet rural area, a quiet bedroom at night all exceed this sound level by 5 dBA That is to say 25 dBA is less than half of even these quiet levels.

The 50dBA limit

As seen in the independent sound reports, the 50dBA requirement can be satisfied for wind speeds of less than 8.9 m/s or 19.5 mph for a tower of approximately 100 ft at a distance of about 100 ft from the property line. This is far above the wind average for this area. According to Section 2 h. of the code “levels may be exceeded during short term events such as severe wind storms”

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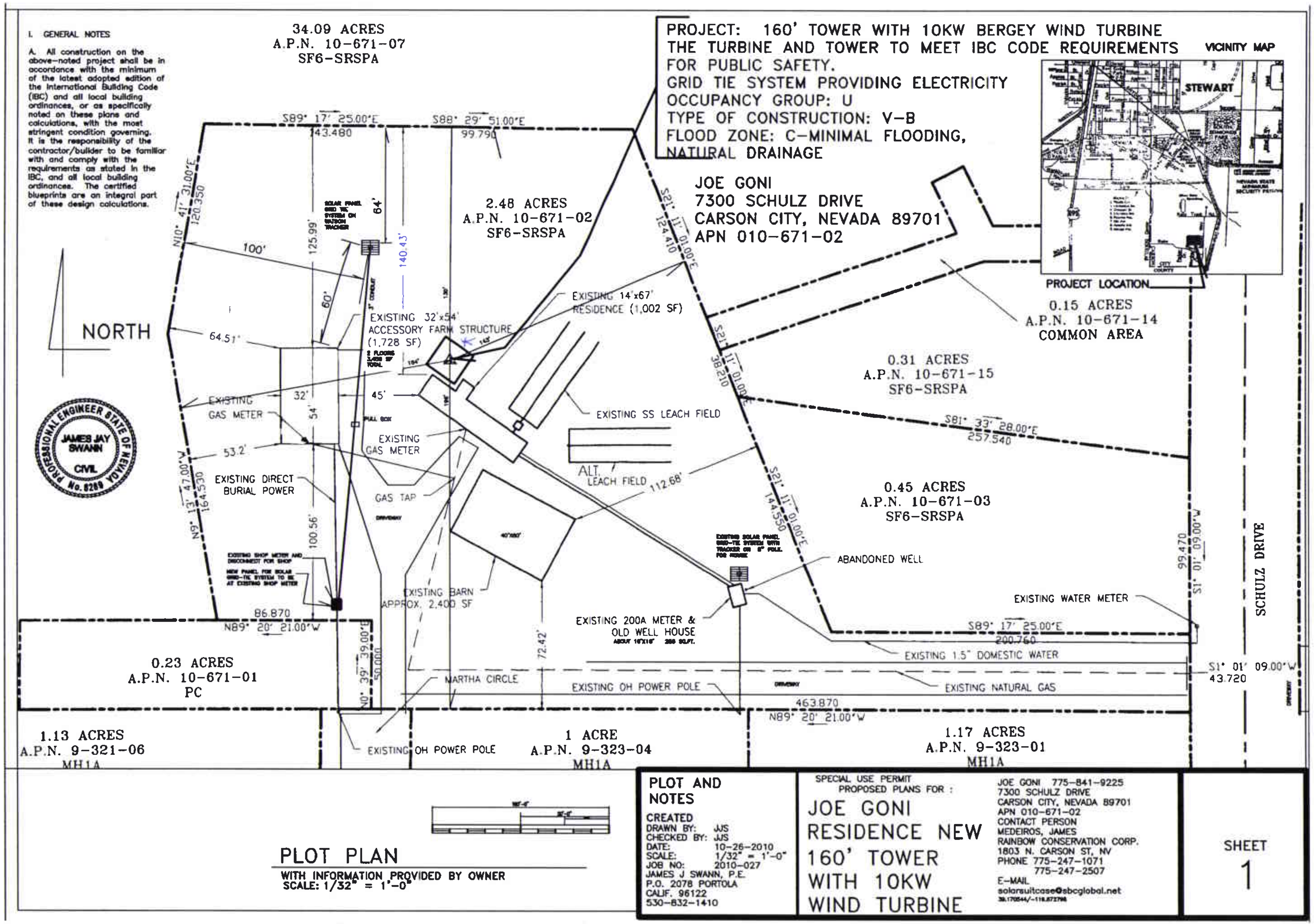
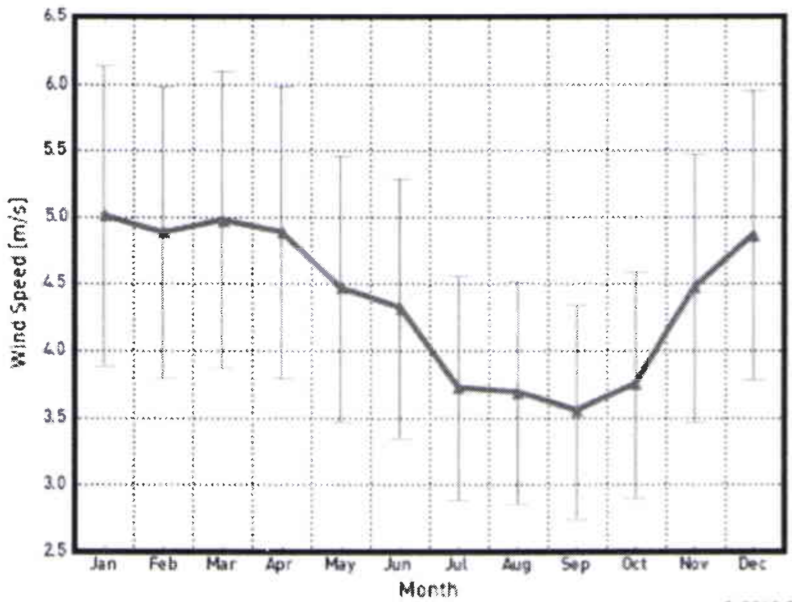
Because the slant distance between the wind machine and the property line increases with tower height, sound is further attenuated by the amount 20 log(d1/d2). Where d1 is the slant range at 100 ft height and d2 is the slant range at the 160 ft height. This is approximately 2.5 dBA less. The higher the tower the less the sound.

To support the sound reports, we have conducted independent sound measurements on an identical wind machine. The residential neighborhood had similar terrain and vegetation. Wind speeds have been measured using a calibrated anemometer.



*Old location turbine

- Hub Height: **20 meters**
- Latitude: **39.104°** Longitude: **-119.753°**
- Your highest wind month is: **January**
- Your lowest wind month is: **September**



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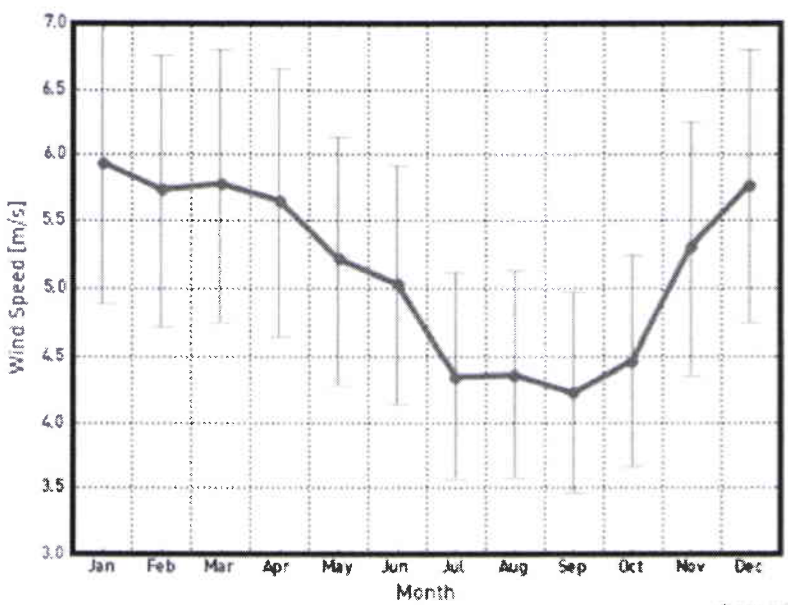
- Hub Height: **50 meters**
- Latitude: **39.104°** Longitude: **-119.753°**
- Your highest wind month is: **January**
- Your lowest wind month is: **September**



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SSE Homepage | Find A Different Location | Accuracy | Methodology | Parameters (Units & Definition)

ATMOSPHERIC SCIENCE DATA CENTER

NASA Surface meteorology and Solar Energy - Available Tables

Latitude 39.104 / Longitude -119.753 was chosen.

Geometry Information

Elevation: **1600** meters
averaged from the
USGS GTOPO30
digital elevation model

Northern boundary
40

Western boundary
-120

Center
Latitude **39.5**
Longitude **-119.5**

Eastern boundary
-119

Southern boundary
39

Show A Location Map

Meteorology (Wind):

Monthly Averaged Wind Speed At 50 m Above The Surface Of The Earth (m/s)

Lat 39.104 Lon -119.753	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
10-year Average	5.59	5.59	5.38	5.12	5.34	5.35	5.15	4.91	5.27	5.30	5.65	5.72	5.36

Minimum And Maximum Difference From Monthly Averaged Wind Speed At 50 m (%)

Lat 39.104 Lon -119.753	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Minimum	-8	-10	-16	-12	-13	-8	-11	-9	-9	-16	-11	-12	-11
Maximum	9	17	15	11	8	6	12	10	7	10	8	12	10

It is recommended that users of these wind data review the SSE Methodology. The user may wish to correct for biases as well as local effects within the selected grid region.	*All height measurements are from the soil, water, or ice/snow surface instead of "effective" surface, which is usually taken to be near the tops of vegetated canopies.*

Parameter Definition *Units Conversion Chart*

SSE Homepage | Find A Different Location | Accuracy | Methodology | Parameters (Units & Definition)

ATMOSPHERIC SCIENCE DATA CENTER

NASA Surface meteorology and Solar Energy - Available Tables

Latitude 39.104 / Longitude -119.753 was chosen.

Geometry Information

Elevation: **1600** meters
averaged from the USGS GTOPO30 digital elevation model

Northern boundary **40**

Western boundary **-120**

Center
Latitude **39.5**
Longitude **-119.5**

Eastern boundary **-119**

Southern boundary **39**

Show A Location Map

Meteorology (Wind):

Monthly Averaged Wind Speed At 10 m Above The Surface Of The Earth For Terrain Similar To Airports (m/s)

Lat 39.104 Lon -119.753	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
10-year Average	4.42	4.42	4.25	4.04	4.22	4.23	4.07	3.88	4.16	4.19	4.46	4.51	4.23

It is recommended that users of these wind data review the SSE Methodology. The user may wish to correct for biases as well as local effects within the selected grid region.	***All height measurements are from the soil, water, or ice/snow surface instead of "effective" surface, which is usually taken to be near the tops of vegetated canopies.***

Parameter Definition ***Units Conversion Chart***

Back to SSE Data Set Home Page

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BERGEY WINDPOWER

July 14, 2010

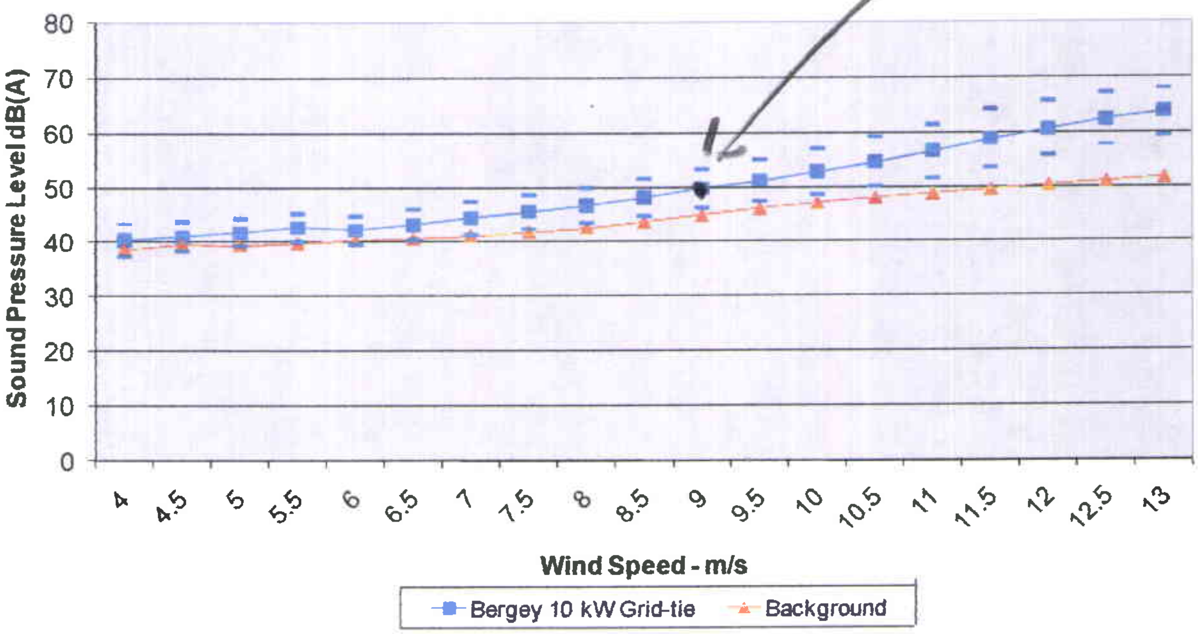
Acoustic Characteristics of the Bergey Excel-S 10 kW Wind Turbine

The following noise level data were taken by the USDA Agricultural Research Service in Bushland, Texas. USDA-Bushland is a contractor to the U.S. Department of Energy and has been field testing small wind turbines since the 1970's. This acoustics testing was conducted in support of certification of the BWC Excel-S to AWEA 9.1-2009. Per the AWEA standard, the tests were conducted in accordance with IEC 61400-11, "Wind Turbine Generator Systems, Part 11 - Acoustic Noise Measurement Techniques".

The sampling microphone was a calibrated Larson Davis Model 824, which was placed 34.2m (112 ft) from the base of the 30m (100 ft) wind turbine tower. The slant distance was 46m (151 ft). Wind speed was taken at a height of 10 m (33 ft)

50Db @ 9 m/s (21mph)

Noise Data Collected on Bergey 10 kW Grid-tie, 30.5 m tower
USDA-ARS Lab near Bushland, TX (June 2010)



The data range provided is 4 m/s – 13 m/s because the calculation of the turbine component of the total sound pressure was calculated using background sound data at the same site from an earlier test on another brand of wind turbine and that test range was 4 – 13 m/s. Background sound levels must be taken with the wind turbine shutdown and that is more difficult to achieve on the Bergey Excel than the other brand previously tested. New background sound data over a wider range is currently being gathered. We do not believe there will be any significant differences in the results when this newer background data is available.

The calculation of the wind turbine contribution to total sound levels for follows the guidelines in IEC 61400-11.

For a typical 5 m/s (11.2 mph) average wind speed site the wind speed will be below 11 m/s (25 mph) over 95% of the time. In this range the Excel-S wind turbine will add just 1 – 6 dBA to the background. As a general rule it takes 3 dBA added before a person will perceive a separate noise source.

AWEA Rated Sound Level: 52.1 dBA

The Rated Sound Level is the sound level at 60 m (197 ft) that the wind turbine will not exceed 95% of the time in a 5 m/s (11 mph) average wind speed site. The previous version of the BWC Excel-S had an AWEA Rated Sound Level of 54.7 dBA. The new version is quieter because the more powerful neodymium alternator has reduced the rated rotor speed from 300 RPM to 240 RPM.

The Sound Power Level is the total noise right at the source – the top of the tower. For the BWC Excel-S turbine the Sound Power Level corresponding to the AWEA Rated Sound Level is 91.0 dBA. Sound diminishes with distance. The Sound Pressure Level is the sound a listener would hear at the distance given, in this case 60m (197 ft)

The binned sound pressure and sound power level data is provided on the following page.

2010 Excel-S Acoustics Test Data
Bushland, 46 m Slant Distance

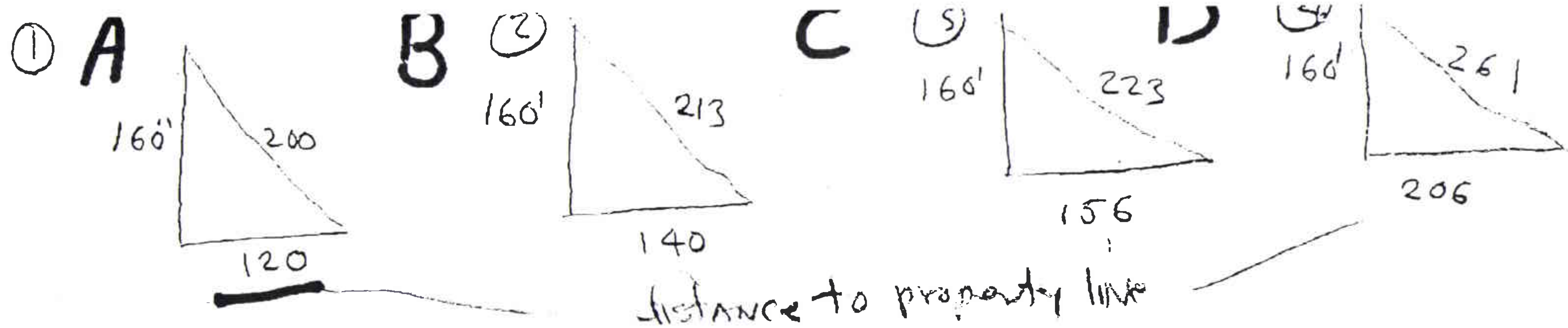
Wind Bin (m/s)	Recorded Sound Pressure Level (dBA)	Std Dev	Backgrd Sound Pressure Level* (dBA)	Turbine Sound Pressure Level (dBA)	Turbine Sound Power Level (dBA)
1	37.08	0.35			
1.5	36.14	0.55			
2	36.70	1.68			
2.5	38.57	3.05			
3	39.18	3.03			
3.5	39.94	3.27			
4	40.39	3.04	38.7	40.39	78.5
4.5	41.06	2.75	39.55	41.06	79.2
5	41.76	2.47	39.48	41.76	79.9
5.5	42.71	2.66	39.84	42.71	80.9
6	43.51	2.66	40.31	42.21	80.4
6.5	44.56	2.81	40.67	43.26	81.4
7	45.75	3.01	41.2	44.45	82.6
7.5	46.87	3.10	41.87	45.57	83.7
8	48.08	3.24	42.65	46.78	84.9
8.5	49.55	3.41	43.72	48.25	86.4
9	51.04	3.60	44.91	49.83	88.0
9.5	52.40	3.78	46.14	51.23	89.4
10	53.92	4.17	47.17	52.89	91.0
10.5	55.53	4.53	48.13	54.66	92.8
11	57.31	4.92	48.91	56.63	94.8
11.5	59.35	5.22	49.73	58.85	97.0
12	61.07	4.88	50.48	60.67	98.8
12.5	62.69	4.71	51.17	62.37	100.5
13	64.02	4.24	51.85	63.75	101.9
13.5	65.44	3.79			
14	66.60	3.29			
14.5	67.39	3.12			
15	68.10	3.04			
15.5	68.92	3.40			
16	69.60	3.18			
16.5	70.02	2.63			
17	71.42	1.82			
17.5	71.79	1.71			
18	71.53	3.22			
18.5	72.14	2.30			
19	73.00	1.13			
19.5	70.10	4.93			
20	62.00	0.00			

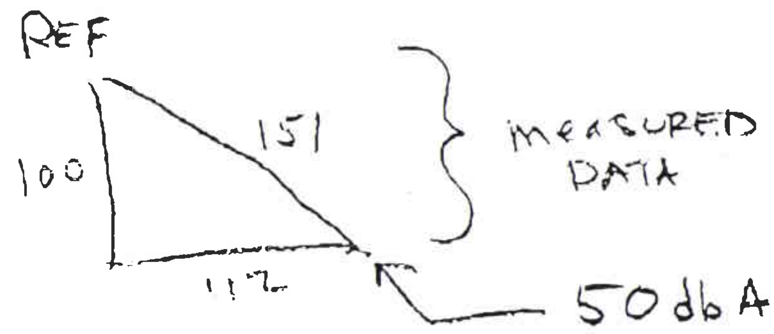
* - From 2006 test on another turbine

Sound Levels at a Distance from the Turbine

Sound Power Level is defined as the sound level at a distance of 1 meter (3.3 ft) from the source, which we take as the center of the rotor or, in other words, hub height. As a person gets farther and farther away from the wind turbine, the intensity of the sound they will hear reduces as the square of the distance. The following table provides the AWEA Rated Sound Levels at different distances from the base of the turbine, assuming a 30m (100 ft) tower. These levels do not include a contribution from background noise levels.

Distance from Turbine (meters)	Distance (feet)	Slant Distance (m)	Sound Press. Level (dBA)
30	98.42	42.4	53.5
60	196.85	67.1	49.5
90	295.27	94.9	46.5
120	393.70	123.7	44.2
150	492.12	153.0	42.4
180	590.55	182.5	40.8
210	688.97	212.1	39.5
240	787.40	241.9	38.4
270	885.82	271.7	37.4
300	984.25	301.5	36.5
330	1,082.67	331.4	35.6
360	1,181.10	361.2	34.9
390	1,279.52	391.2	34.2





ALL Property Lines ARE under the 50dbA maximum

⇓

At there boundries @ 19.5 mph

Reduction of DBA

Case			
A ①	$20\log\left(\frac{151}{200}\right) =$	−2.44 db	A 47.56 dbA
B ②	$20\log\left(\frac{151}{213}\right) =$	−3 dbA	B 47 dbA
C ③	$20\log\left(\frac{151}{223}\right) =$	−3.3 dbA	C 46.7 dbA
D ④	$20\log\left(\frac{151}{261}\right) =$	−4.75 dbA	D 45.25 dbA

Attn: Planning

WindCad Turbine Performance Model

BWC EXCEL-S, Grid - Intertie

Tier/neo-SH3055-23-BWC

Prepared For:	Joe Goni
Site Location:	7300 Schulz Drive
Data Source:	AWEA Standard
Date:	12/24/2010

10 kW

Inputs:

Ave. Wind (m/s) =	5.1
Weibull K =	1.59
Site Altitude (m) =	1,500
Wind Shear Exp. =	0.200
Anem. Height (m) =	50
Tower Height (m) =	50
Turbulence Factor =	0.0%

Results:

Hub Average Wind Speed (m/s) =	5.10
Air Density Factor =	-14%
Average Output Power (kW) =	1.63
Daily Energy Output (kWh) =	39.1
Annual Energy Output (kWh) =	**14,285**
Monthly Energy Output =	1,190
Percent Operating Time =	63.3%

Weibull Performance Calculations

Wind Speed Bin (m/s)	Power (kW)	Wind Probability (f)	Net kW @ V
1	0.00	9.31%	0.000
2	0.00	12.36%	0.000
3	0.12	13.25%	0.016
4	0.37	12.76%	0.047
5	0.76	11.45%	0.087
6	1.30	9.72%	0.127
7	2.03	7.90%	0.160
8	2.96	6.17%	0.183
9	4.14	4.66%	0.193
10	5.54	3.41%	0.189
11	7.08	2.43%	0.172
12	8.64	1.68%	0.145
13	9.80	1.14%	0.111
14	10.14	0.75%	0.076
15	10.40	0.48%	0.050
16	10.47	0.30%	0.032
17	10.48	0.19%	0.020
18	10.43	0.11%	0.012
19	10.28	0.07%	0.007
20	9.86	0.04%	0.004
2008, BWC	Totals:	98.19%	1.631

Weibull Calculations: Wind speed probability is calculated as a Weibull curve defined by the average wind speed and a shape factor, K. To facilitate piece-wise integration, the wind speed range is broken down into "bins" of 1 m/s in width (Column 1). For each wind speed bin, instantaneous wind turbine power (W, Column 2)) is multiplied by the Weibull wind speed probability (f, Column 3). This cross product (Net W, Column 4) is the contribution to average turbine power output contributed by wind speeds in that bin. The sum of these contributions is the average power output of the turbine on a continuous, 24 hour, basis.
Best results are achieved using annual or monthly average wind speeds. Use of daily or hourly average speeds is not recommended.

Instructions:

Inputs: Use annual or monthly **Average Wind** speeds. If **Weibull K** is not known, use K = 2 for inland sites, use 3 for coastal sites, and use 4 for island sites and trade wind regimes. **Site Altitude** is meters above sea level. **Wind Shear Exponent** is best assumed as 0.18. For rough terrain or high turbulence use 0.22. For very smooth terrain or open water use 0.11. **Anemometer Height** is for the data used for the **Average Wind** speed. If unknown, use 10 meters. **Tower Height** is the nominal height of the tower, eg.: 24 meters. **Turbulence Factor** is a derating for turbulence, site variability, and other performance influencing factors -- typical turbulence has already been incorporated into the model. Use 0.00 (0%) for level sites with limited obstructions. Use -0.10 (negative 10%) for flat, clear sites on open water. Use 0.05 to 0.15 (5% to 15%) for rolling hills or mountainous terrain.

Results: Hub Average Wind Speed is corrected for wind shear and used to calculate the Weibull wind speed probability. **Air Density Factor** is the reduction from sea level performance. **Average Power Output** is the average continuous equivalent output of the turbine. **Daily Energy Output** is the average energy produced per day. **Annual** and **Monthly Energy Outputs** are calculated using the Daily value. **Percent Operating Time** is the time the turbine should be producing some power.

Limitations: This model uses a mathmatical idealization of the wind speed probability. The validity of this assumption is reduced as the time period under consideration (ie, the wind speed averaging period) is reduced. This model is best used with annual or monthly average wind speeds. Use of this model with daily or hourly average wind speed data is not recommended because the wind will not follow a Weibull distribution over short periods. The data used in creating the power curve was generated at the BWC test site in Norman, OK. Consult Bergey Windpower Co. for special needs. ***Your performance may vary.***

Noise Sources and Their Effects

Noise Source	Decibel Level	comment
Jet take-off (at 25 meters)	150	Eardrum rupture
Aircraft carrier deck	140	
Military jet aircraft take-off from aircraft carrier with afterburner at 50 ft (130 dB).	130	
Thunderclap, chain saw. Oxygen torch (121 dB).	120	Painful. 32 times as loud as 70 dB.
Steel mill, auto horn at 1 meter. Turbo-fan aircraft at takeoff power at 200 ft (118 dB). Riveting machine (110 dB); live rock music (108 - 114 dB).	110	Average human pain threshold. 16 times as loud as 70 dB.
Jet take-off (at 305 meters), use of outboard motor, power lawn mower, motorcycle, farm tractor, jackhammer, garbage truck. Boeing 707 or DC-8 aircraft at one nautical mile (6080 ft) before landing (106 dB); jet flyover at 1000 feet (103 dB); Bell J-2A helicopter at 100 ft (100 dB).	100	8 times as loud as 70 dB. Serious damage possible in 8 hr exposure
Boeing 737 or DC-9 aircraft at one nautical mile (6080 ft) before landing (97 dB); power mower (96 dB); motorcycle at 25 ft (90 dB). Newspaper press (97 dB).	90	4 times as loud as 70 dB. Likely damage 8 hr exp
Garbage disposal, dishwasher, average factory, freight train (at 15 meters). Car wash at 20 ft (89 dB); propeller plane flyover at 1000 ft (88 dB); diesel truck 40 mph at 50 ft (84 dB); diesel train at 45 mph at 100 ft (83 dB). Food blender (88 dB); milling machine (85 dB); garbage disposal (80 dB).	80	2 times as loud as 70 dB. Possible damage in 8 h exposure.
Passenger car at 65 mph at 25 ft (77 dB); freeway at 50 ft from pavement edge 10 a.m. (76 dB). Living room music (76 dB); radio or TV-audio, vacuum cleaner (70 dB).	70	Arbitrary base of comparison. Upper 70s are annoyingly loud to some people.
Conversation in restaurant, office, background music, Air conditioning unit at 100 ft	60	Half as loud as 70 dB. Fairly quiet
Quiet suburb, conversation at home. Large electrical transformers at 100 ft	50	One-fourth as loud as 70 dB.

Library, bird calls (44 dB); lowest limit of urban ambient sound	40	One-eighth as loud as 70 dB.
Quiet rural area	30	One-sixteenth as loud as 70 dB. Very Quiet
Whisper, rustling leaves	20	
Breathing	10	Barely audible

[modified from **http://www.wenet.net/~hpb/dblevels.html**] on 2/2000. SOURCES: Temple University Department of Civil/Environmental Engineering (www.temple.edu/departments/CETP/environ10.html), and *Federal Agency Review of Selected Airport Noise Analysis Issues*, Federal Interagency Committee on Noise (August 1992). Source of the information is attributed to *Outdoor Noise and the Metropolitan Environment*, M.C. Branch et al., Department of City Planning, City of Los Angeles, 1970.

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Deutsche Version

• Decibel Table – Loudness Comparison Chart •

Table of Sound Levels (dB Scale) and the corresponding Units of Sound Pressure and Sound Intensity (Examples)

To get a feeling for decibels, look at the table below which gives values for the sound pressure levels of common sounds in our environment. Also shown are the corresponding sound pressures and sound intensities.
From these you can see that the decibel scale gives numbers in a much more manageable range. Sound pressure levels are measured without weighting filters. The values are averaged and can differ about ±10 dB. With sound pressure is always meant the effective value (RMS) of the sound pressure, without extra announcement. The amplitude of the sound pressure means the peak value.
The ear is a sound pressure receptor, or a sound pressure sensor, i.e. the ear-drums are moved by the sound pressure, a sound field quantity. It is not an energy receiver. When listening, forget the sound intensity as energy quantity. The perceived sound consists of periodic pressure fluctuations around a stationary mean (equal atmospheric pressure).

This is the change of sound pressure, which is measured in pascal (Pa) ≡ 1 N/m^2 ≡ 1 J/m^3 ≡ 1 $kg/(m \cdot s^2)$. Usually p is the RMS value.

Table of sound levels L (loudness) and corresponding sound pressure and sound intensity

Sound Sources Examples with distance	Sound Pressure Level L_p dBSPL	Sound Pressure p N/m^2 = Pa	Sound Intensity I W/m^2
Jet aircraft, 50 m away	140	200	100
Threshold of pain	130	63.2	10
Threshold of discomfort	120	20	1
Chainsaw, 1 m distance	110	6.3	0.1
Disco, 1 m from speaker	100	2	0.01
Diesel truck, 10 m away	90	0.63	0.001
Kerbside of busy road, 5 m	80	0.2	0.0001
Vacuum cleaner, distance 1 m	70	0.063	0.00001
Conversational speech, 1 m	60	0.02	0.000001
Average home	50	0.0063	0.0000001
Quiet library	40	0.002	0.00000001
Quiet bedroom at night	30	0.00063	0.000000001
Background in TV studio	20	0.0002	0.0000000001
Rustling leaves in the distance	10	0.000063	0.00000000001
Threshold of hearing	0	0.00002	0.000000000001

**The sound level depends on the distance between the sound source and the place of measurement, possibly one ear of a listener.
The sound pressure level L_p in dB without the given distance *r* to the sound source is really meaningless. Unfortunately this error (unknown distance) is quite often.**

Noise is a sound that disturbs or harms.

Assumption: The maximum sound pressure is 194 dBSPL. That cannot be exceeded because the average air pressure of 101325 Pa.
L = 20 · log (101325 / 0,00002) = **194 dB**. This theoretical idea is not correct, because a chaotic noise can also be asymmetrical.
There is no upper noise limit. A typical false statement: "No noise levels can exceed 194 dB ever". Is the end at 194 dB? In addition to this perception threshold is discussed more often a physical limit to 194 dB. Sound is nothing more than a minor disturbance of air pressure and 194 dB is theoretically the same as the disturbance itself. But even louder noise is possible.

Ultrasound between 20 kHz and 1.5 GHz does not belong to our human hearing.
Infrasound below about 16 Hz is insensitive to the human ear.

The total sound power is emitted by the sound source. Sound power levels are connected to the sound source and are independent of distance.
Sound pressure levels vary substantially with distance from the source.

**Sound pressure *p* in pascals (newtons per square meter) is not the same physical quantity as intensity *J* or *I* in watts per square meter.
... and the sound power (acoustic power) does not decrease with distance *r* from the sound source - neither with 1 / *r* nor as 1 / r^2.**

Sound Field Quantities 😊	Sound Energy Quantities
Sound pressure, sound or particle velocity, particle displacement or particle amplitude, (voltage, current, electric resistance).	Sound intensity, sound energy density, sound energy, acoustic power. (electrical power).
Inverse Distance Law 1/*r*	Inverse Square Law 1/r^2

The reference sound pressure level for 0 dBSPL is the sound pressure p_0 = 20 µPa = 20 × 10^{-6} Pa = 2 × 10^{-5} Pa = 0.00002 Pa or N/m². That is the threshold of hearing. (The reference sound intensity is I_0 = 10^{-12} W/m².)
Pa = Pascal.

There is no "dBA" value given as threshold of human hearing.
These values are not given as dBA, but as dBSPL, that means **without any weighting filter.**

$$L_p = 20\ \log_{10}\left(\frac{p}{p_0}\right)\ \text{in dB} = L_I = 10\ \log_{10}\left(\frac{I}{I_0}\right)\ \text{in dB}$$

Differentiate between sound pressure p as a "sound **field** quantity" and sound intensity I as a "sound **energy** quantity". $I \approx p^2$ for progressive plane waves. When it comes to our ears and the hearing, it is recommended that the inappropriate expression of the sound energy parameters, such as sound power (acoustic power) and sound intensity to leave aside. So we are just listening to the sound pressure as sound field quantity, or the sound pressure level SPL.

The sound pressure level decreases in the free field with 6 dB per distance doubling.
That is the 1/*r* law.

Often it is argued the **sound pressure** would decrease after the $1/r^2$ law (inverse square law). **That's wrong.**
The sound pressure in a free field is inversely proportional to the distance from the microphone to the source. ***p* ~ 1/*r*.**

How does the sound decrease with increasing distance?
Damping of sound level with distance

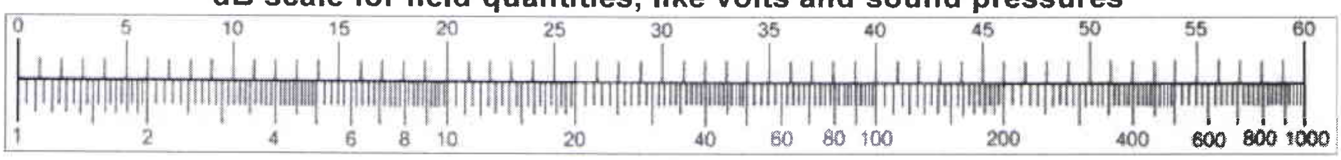
Relation of sound intensity, sound pressure and **distance law**:

$$I \sim p^2 \sim \frac{1}{r^2}$$

From this follows $$p \sim \frac{1}{r}$$

Note: The often used term "**intensity** of sound pressure" is not correct. Use "magnitude", "strength", "amplitude", or "level" instead.
"Sound intensity" is sound power per unit area, while "pressure" is a measure of force per unit area. Intensity (sound energy quantity) is not equivalent to pressure (sound field quantity).

dB scale for field quantities, like volts and sound pressures



ratio

The sound pressure is the force F in newtons N of a sound on a surface area A in m^2 perpendicular to the direction of the sound.
The SI-unit for the sound pressure p is N/m^2 = Pa. $p \sim 1/r$.

Note - Comparing dBSPL and dBA:

There is no conversion formula for measured dBA values to sound pressure level dBSPL or vice versa. That is only possible measuring one single frequency.

There is no "dBA" curve given as threshold of human hearing.

The weighted sound level is neither a physiological nor a physical parameter.

Words to bright minds: Always wonder what a manufacturer is hiding when they use A-weighting. *)

*) **http://www.google.com/search?q=Always+wonder+what+a+manufacturer+Rane&filter=0**

Readings of a pure 1 kHz tone should be identical, whether weighted or not.

How loud is dangerous? Typical dbA levels

190 dBA	Heavy weapons, 10 m behind the weapon (maximum level)
180 dBA	Toy pistol fired close to ear (maximum level)
170 dBA	Slap on the ear, fire cracker explodes on shoulder, small arms at a distance of 50 cm (maximum level)
160 dBA	Hammer stroke on brass tubing or steel plate at 1 m distance, airbag deployment very close at a distance of 30 cm (maximum level)
150 dBA	Hammer stroke in a smithy at 5 m distance (maximum level)
130 dBA	Loud hand clapping at 1 m distance (maximum level)
120 dBA	Whistle at 1 m distance, test run of a jet at 15 m distance
	Threshold of pain, above this fast-acting hearing damage in short action is possible
115 dBA	Take-off sound of planes at 10 m distance
110 dBA	Siren at 10 m distance, frequent sound level in discotheques and close to loudspeakers at rock concerts, violin close to the ear of an orchestra musicians (maximum level)
105 dBA	Chain saw at 1 m distance, banging car door at 1 m distance (maximum level), racing car at 40 m distance, possible level with music head phones
100 dBA	Frequent level with music via head phones, jack hammer at 10 m distance
95 dBA	Loud crying, hand circular saw at 1 m distance
90 dBA	Angle grinder outside at 1 m distance
	Over a duration of 40 hours a week hearing damage is possible
85 dBA	2-stroke chain-saw at 10 m distance, loud WC flush at 1 m distance
80 dBA	Very loud traffic noise of passing lorries at 7.5 m distance, high traffic on an expressway at 25 m distance
75 dBA	Passing car at 7.5 m distance, un-silenced wood shredder at 10 m distance
70 dBA	Level close to a main road by day, quiet hair dryer at 1 m distance to ear
65 dBA	**Bad risk of heart circulation disease at constant impact is possible**
60 dBA	Noisy lawn mower at 10 m distance
55 dBA	Low volume of radio or TV at 1 m distance, noisy vacuum cleaner at 10 m distance
50 dBA	Refrigerator at 1 m distance, bird twitter outside at 15 m distance
45 dBA	Noise of normal living; talking, or radio in the background
40 dBA	**Distraction when learning or concentration is possible**
35 dBA	Very quiet room fan at low speed at 1 m distance
25 dBA	Sound of breathing at 1 m distance
0 dBA	Auditory threshold

From a dB-A measurement no accurate description of the expected noise volume is possible.

Table of the Threshold of pain

What is the threshold of pain?

You can find the following rounded values in various audio articles:

Sound pressure level L_p	Sound pressure p
140 dBSPL	200 Pa
137.5 dBSPL	150 Pa
134 dBSPL	**100 Pa**
120 dBSPL	20 Pa

The Psychoacoustic Loudness

Notice: Psycho acousticians tell us, that a 10 dB increase of level give the impression of the doubling the loudness (volume).
Your loudspeakers need 10 times more power.
If you have 6 violins as source, then you have to tenfold the violins; you need 60 violins to double the psycho-acoustic loudness (volume).

Half loudness ≡ level:	–10 dB	Double loudness ≡ level:	+10 dB
Half sound pressure ≡ level:	–6 dB	Double sound pressure ≡ level:	+6 dB
Half power ≡ level:	–3 dB	Double power: ≡ level	+3 dB
fourfold power ≡ level:	+6 dB	Tenfold power ≡ level:	+10 dB
Double distance ≡ level:	–6 dB	Double sources (Double power)=+3 dB	

Sound Level Comparison Chart and the Factors

Table of sound level dependence and the change of the respective factor to subjective volume (loudness), objective sound pressure (voltage), and sound intensity (acoustic power)

How many decibels (dB) change is double, half, or four times as loud?

How many dB to appear twice as loud (twofold)? Here are all the different factors.
Factor means "how many times" or "how much" ... Doubling of loudness.

Level Change	Volume Loudness	Voltage Sound pressure	Acoustic Power Sound Intensity
+40 dB	16	100	10000
+30 dB	8	31.6	1000
+20 dB	4	10	100
+10 dB	2.0 = double	3.16 = √10	**10**
+6 dB	1.52 fold	2.0 = double	4.0
+3 dB	1.23 fold	1.414 fold = √2	2.0 = double
- - - - ±0 dB - - - -	- - - - 1.0 - - - - - - -	- - - - 1.0 - - - - - - -	- - - - - 1.0 - - - - -
−3 dB	0.816 fold	0.707 fold	0.5 = half
−6 dB	0.660 fold	0.5 = half	0.25
−10 dB	0.5 = half	0.316	0.1
−20 dB	0.25	0.100	0.01
−30 dB	0.125	0.0316	0.001
−40 dB	0.0625	0.0100	0.0001
Log. quantity	**Psycho quantity**	**Field quantity**	**Energy quantity**
dB change	**Loudness multipl.**	**Amplitude multiplier**	**Power multiplier**

The psycho-acoustic volume or loudness is a subjective sensation size.

Is a 10 dB or 6 dB sound level change for a doubling or halving of the loudness (volume) correct?
About the connection between sound level and loudness, there are various theories. Far spread is still the theory of psycho-acoustic pioneer Stanley Smith Stevens, indicating that the doubling or halving the sensation of loudness corresponds to a level difference of 10 dB. Recent research by Richard M. Warren, on the other hand leads to a level difference of only 6 dB. *) This means that a double sound pressure corresponds to a double loudness. The psychologist John G. Neuhoff found out that for the rising level our
hearing is more sensitive than for the declining level. For the same sound level difference the change of loudness from quiet to loud is stronger than from loud to quiet.
It is suggested that the sone scale of loudness reflects the influence of known experimental biases and hence does not represent a fundamental relation between stimulus and sensation.
<u>*) Richard M. Warren, "Elimination of Biases in Loudness Judgments for Tones"</u>

It follows that the determination of the volume (loudness) which is double as loud should not be dogmatically defined. More realistic is the claim:

A doubling of the sensed volume (loudness) is equivalent to a level change approximately between 6 dB and 10 dB.

Subjectively perceived loudness (volume), objectively measured sound pressure (voltage), and theoretically calculated sound intensity (acoustic power)

Psychoacoustic: Relationship between phon and sone

Conversion of sound units (levels)
Calculations of Sound Values and their Levels
Conversion of voltage V to dBm, dBu, and dBV

The total sound power is emitted from the sound source. The sound power level and the sound power is connected firmly with the sound source and is really independent of the distance. On the other hand, the SPL varies significantly with the distance from the sound source.

Question: What is the standard distance to measure sound pressure level away from equipment?
There is no standard distance. It depends on the size of the sound source and the sound pressure level.

Sound pressure p in pascals is not the same physical quantity as intensity I in watts per square meter.
... and the sound power (acoustic power) does not decrease with distance r from the sound source - neither with $1/r$ nor as $1/r^2$.

Often the **sound pressure** as a **sound field quantity** is mixed incorrectly with the **sound intensity** as a **sound energy quantity**. But $I \approx p^2$.

Note: The radiated sound power (sound intensity) is the cause - and **the sound pressure is the effect**.
The effect is of particular interest to the sound engineer.
The effect of temperature and sound pressure.

Acousticians and sound protectors (noise fighters) need the sound intensity (acoustic intensity). As a sound designer you don't need that. Look out more for the sound pressure that makes an effect to your ears and to the microphones.

Sound pressure and Sound power – Effect and Cause

Ratio magnitudes and levels

The decibel is defined as a 20 times logarithm of a ratio of linear quantities to each other and as a 10-fold logarithm of a ratio of quadratic quantities to each other.
Ratios of electric or acoustic quantities, such as electric voltage and the sound pressure is referred to as factors, such as reflection factor.
Ratios of square quantities to one another, such as power and energy are called grades, such as efficiency.
Logarithmically ratios of electric or acoustic quantities of the same unit, we express as measures such as transfer factor, or level, such as sound pressure level.
Levels are measured in decibels - dB in short.

If the output voltage level is 0 dB, that is 100%, the level of −3 dB is equivalent to 70.7% and the level of −6 dB is equivalent to 50% of the initial output voltage.
This applies to all field quantities; e.g. sound pressure.

If the output power level is 0 dB, that is 100%, the level of −3 dB is equivalent to 50% and −6 dB is equivalent to 25% of the initial output power.
This applies to all energy quantities; e.g. sound intensity.

Try to understand this.

Conversion of sound pressure to sound power and vice versa

The sound pressure changes depending on the environment and the distance from the sound source. In contrast, the sound power of a sound source is location-independent.

Formulas for conversion:
Acoustical power (sound power) $P_{ac} = I \cdot A$ in watts

Sound intensity $I = p_{eff}^2 / Z_0$ in W/m^2 = P_{ak} / A in W/m^2

Perfused area $A = 4 \cdot \pi \cdot r^2$ in m^2
Distance measurement point from the sound source r in meters (has only meaning with sound pressure, not with sound power)

Acoustic impedance of air Z_0 = 413 N·s/m^3 at 20 °C

Sound pressure p_{eff} in Pa = N/m^2
In point-like sound sources spherical areas A shall be inserted.
Depending on the arrangement following sections are taken into account:
Solid sphere - sound source anywhere in the room, $Q = 1$
Hemisphere - sound source on the ground, $Q = 2$
Quarter Sphere - sound source on the wall, $Q = 4$
Eighth sphere - sound source in the corner, $Q = 8$

Q = direction factor and area $A = (4 \cdot \pi \cdot r^2) / Q$

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DECIBEL (dB)

Acoustics / Noise

A unit of a logarithmic scale of power or intensity called the *power level* or *intensity level.* The decibel is defined as one tenth of a *bel* where one bel represents a difference in level between two intensities I_1, I_0 where one is ten times greater than the other. Thus, the intensity level is the comparison of one intensity to another and may be expressed:

$$\text{Intensity level} = 10 \log_{10} (I_1 / I_0) \text{ (dB)}$$

For instance, the difference between intensities of 10^{-8} watts/m^2 and 10^{-4} watts/m^2, an actual difference of 10,000 units, can be expressed as a difference of 4 bels or 40 decibels.

Because of the very large range of SOUND INTENSITY which the ear can accommodate, from the loudest (1 watt/m^2) to the quietest (10^{-12} watts/m^2), it is convenient to express these values as a function of powers of 10. This entire range of intensities can be expressed on a scale of 120 dB. (The physicist Alexander Wood once compared this range from loudest to quietest to the energy received from a 50 watt bulb situated in London, ranging from close by to that received by someone in New York.) See: DYNAMIC RANGE.

The result of this logarithmic basis for the scale is that increasing a sound intensity by a factor of 10 raises its level by 10 dB; increasing it by a factor of 100 raises its level by 20 dB; by 1,000, 30 dB and so on. When two sound sources of equal intensity or power are measured together, their combined intensity level is 3 dB higher than the level of either separately. Thus, two 70 dB cars together measure 73 dB under ideal conditions. However, note that when the AMPLITUDE of a single sound is doubled, its level rises 6 dB.

Sound Example: Ramp descending at 6 dB per event, followed by a ramp descending at 3 dB.

0 dB is defined as the THRESHOLD OF HEARING, and it is with reference to this internationally agreed upon quantity that decibel measurements are made. In some situations, such as tape recording, a given intensity level is assigned 0 dB, and other levels are measured in negative decibels in comparison to it.

See: AUDIOGRAM, LEVEL RECORDER, VU METER, ZERO LEVEL VU. See also: HEARING LEVEL, LOUDNESS LEVEL, SOUND LEVEL, SOUND POWER LEVEL, SOUND PRESSURE LEVEL.

Decibels may be qualified as dBA, dBB, dBC, indicating the weighting network of the SOUND LEVEL METER with which the measurement was made. The term became accepted in the 1920s and since then noise measurement has generally come to rely on the decibel scale and others derived from it.

See: NOISE, NOISE LEVEL, NOISE RATING, NOISE & NUMBER INDEX, PERCEIVED NOISE LEVEL, TRAFFIC NOISE INDEX. Compare: EQUIVALENT ENERGY LEVEL.

These newer systems have brought environmental factors and frequency content to bear on the measurement of LOUDNESS. The PHON scale attempts to account for the subjective response of the ear to loudness, which is not possible with the decibel measurement of intensity. See also: EQUAL LOUDNESS CONTOURS.

See INVERSE-SQUARE LAW for variation of decibel measurement with distance, and SOUND PRESSURE LEVEL for scale according to which decibel measurements may be combined. Appendix D gives a conversion chart of voltage and power ratios to decibels.

Threshold of hearing	0 dB	Motorcycle (30 feet)	88 dB
Rustling leaves	20 dB	Foodblender (3 feet)	90 dB
Quiet whisper (3 feet)	30 dB	Subway (inside)	94 dB
Quiet home	40 dB	Diesel truck (30 feet)	100 dB
Quiet street	50 dB	Power mower (3 feet)	107 dB
Normal conversation	60 dB	Pneumatic riveter (3 feet)	115 dB
Inside car	70 dB	Chainsaw (3 feet)	117 dB
Loud singing (3 feet)	75 dB	Amplified Rock and Roll (6 feet)	120 dB
Automobile (25 feet)	80 dB	Jet plane (100 feet)	130 dB

Typical average decibel levels (dBA) of some common sounds.

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INVERSE-SQUARE LAW

Acoustics / Noise

The law by which the mean-square SOUND PRESSURE LEVEL varies inversely as the square of the distance from the source. The general rule of thumb is that, under ideal conditions (no reflecting surfaces or other background sound or interference), a sound level drops 6 dB for every doubling of the distance from the source. If the two distances in question are d_1 and d_2, then the decibel difference DD is:

$$DD = 10 \log (d_1/d_2)^2 = 20 \log (d_1/d_2)$$

The table below can be used to find the correction for distance such as in the case of distances quoted in noise measurement specifications, assuming ideal conditions. Take the given distance on the left-hand column and find the correction in the vertical column under the distance for which the correction is desired. Add the correction to the given level to find the corrected level.

For a discussion of environmental effects, see SOUND PROPAGATION. Note that this table applies only to point sources and FREE FIELD conditions. See: SIMPLE SOUND SOURCE.

Corrected Distance (ft)

Given Distance (ft)	3	5	10	15	20	25	30	40	50	60	70	80	90	100
3	0	- 4.4	-10.5	-14.0	-16.5	-18.0	-20.0	-22.5	-24.4	-26.0	-27.4	-28.5	-29.5	-30.5
5	4.4	0	- 6.0	- 9.5	-12.0	-14.0	-15.6	-18.1	-20.0	-21.6	-22.9	-24.1	-25.1	-26.0
10	10.5	6.0	0	- 3.5	- 6.0	- 8.0	- 9.5	-12.0	-14.0	-15.6	-16.9	-18.1	-19.1	-20.0
15	14.0	9.5	3.5	0	- 2.5	- 4.4	- 6.0	- 8.5	-10.5	-12.0	-13.4	-14.5	-15.6	-16.5
20	16.5	12.0	6.0	2.5	0	- 1.9	- 3.5	- 6.0	- 8.0	- 9.5	-10.9	-12.0	-13.1	-14.0
25	18.0	14.0	8.0	4.4	1.9	0	- 1.6	- 4.1	- 6.0	- 7.6	- 8.9	-10.1	-11.1	-12.0
30	20.0	15.6	9.5	6.0	3.5	1.6	0	- 2.5	- 4.4	- 6.0	- 7.4	- 8.5	- 9.5	-10.5
40	22.5	18.1	12.0	8.5	6.0	4.1	2.5	0	- 1.9	- 3.5	- 4.9	- 6.0	- 7.0	- 8.0
50	24.4	20.0	14.0	10.5	8.0	6.0	4.4	1.9	0	- 1.6	- 2.9	- 4.1	- 5.1	- 6.0
60	26.0	21.6	15.6	12.0	9.5	7.6	6.0	3.5	1.6	0	- 1.3	- 2.5	- 3.5	- 4.4
70	27.4	22.9	16.9	13.4	10.9	8.9	7.4	4.9	2.9	1.3	0	- 1.2	- 2.2	- 3.1
80	28.5	24.1	18.1	14.5	12.0	10.1	8.5	6.0	4.1	2.5	1.2	0	- 1.0	- 1.9
90	29.5	25.1	19.1	15.6	13.1	11.1	9.5	7.0	5.1	3.5	2.2	1.0	0	- 0.9
100	30.5	26.0	20.0	16.5	14.0	12.0	10.5	8.0	6.0	4.4	3.1	1.9	0.9	0

Decibel corrections for variations in distance from source. An example:

a sound source of 60 dB is measured at 50 feet; if the measurement were at 15 feet, the level would be 60 + 10.5 = 70.5 dB under ideal conditions.

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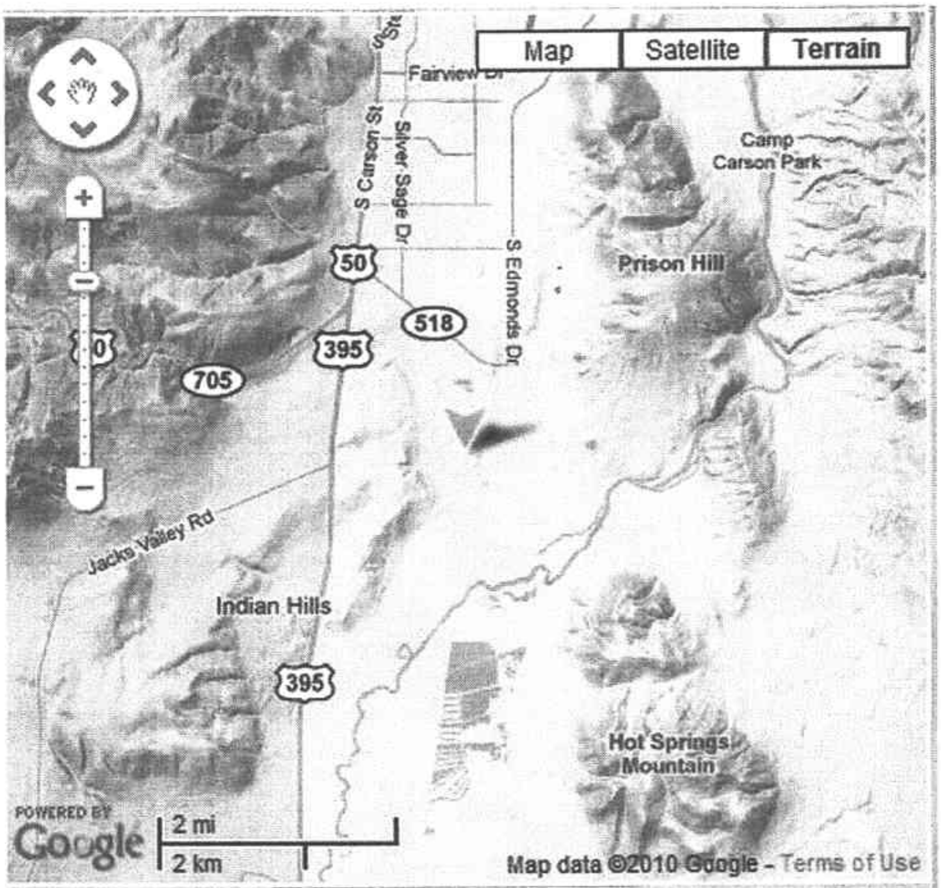
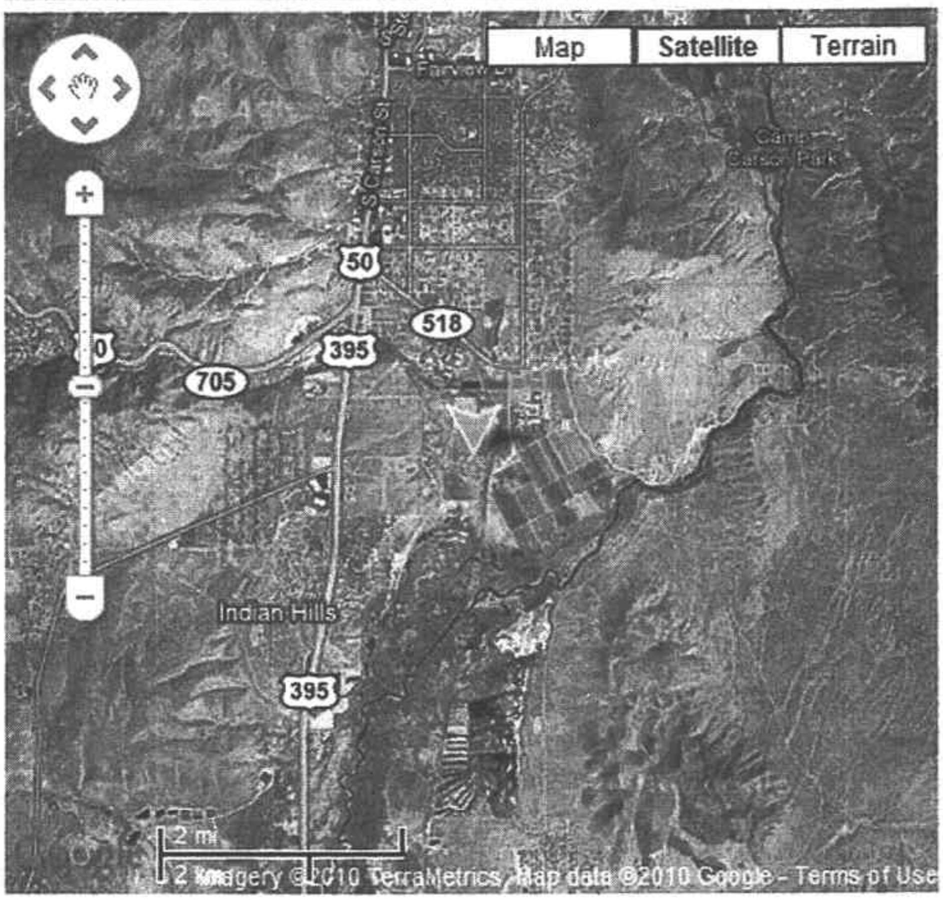
3 Tier Showing Location of Analsys

7300 Schulz Drive



SAT



WindCad Turbine Performance Model

BWC EXCEL-S, Grid - Intertie

Tier/neo-SH3055-23-BWC

Prepared For: **Joe Goni**
Site Location: **7300 Schulz Drive**
Data Source: **AWEA Standard**
Date: **12/24/2010**

10 kW

Inputs:

Ave. Wind (m/s) =	4.4
Weibull K =	1.53
Site Altitude (m) =	1,500
Wind Shear Exp. =	0.200
Anem. Height (m) =	20
Tower Height (m) =	20
Turbulence Factor =	0.0%

Results:

Hub Average Wind Speed (m/s) =	4.40
Air Density Factor =	-14%
Average Output Power (kW) =	1.19
Daily Energy Output (kWh) =	28.5
Annual Energy Output (kWh) =	10,406
Monthly Energy Output =	867
Percent Operating Time =	55.4%

Weibull Performance Calculations

Wind Speed Bin (m/s)	Power (kW)	Wind Probability (f)	Net kW @ V
1	0.00	12.17%	0.000
2	0.00	14.91%	0.000
3	0.12	14.91%	0.018
4	0.37	13.42%	0.050
5	0.76	11.26%	0.085
6	1.30	8.94%	0.116
7	2.03	6.78%	0.137
8	2.96	4.95%	0.146
9	4.14	3.49%	0.144
10	5.54	2.38%	0.132
11	7.08	1.58%	0.112
12	8.64	1.02%	0.088
13	9.80	0.64%	0.063
14	10.14	0.39%	0.040
15	10.40	0.24%	0.025
16	10.47	0.14%	0.015
17	10.48	0.08%	0.008
18	10.43	0.04%	0.005
19	10.28	0.02%	0.003
20	9.86	0.01%	0.001
2008, BWC	Totals:	97.37%	1.188

Weibull Calculations: Wind speed probability is calculated as a Weibull curve defined by the average wind speed and a shape factor, K. To facilitate piece-wise integration, the wind speed range is broken down into "bins" of 1 m/s in width (Column 1). For each wind speed bin, instantaneous wind turbine power (W, Column 2)) is multiplied by the Weibull wind speed probability (f, Column 3). This cross product (Net W, Column 4) is the contribution to average turbine power output contributed by wind speeds in that bin. The sum of these contributions is the average power output of the turbine on a continuous, 24 hour, basis.
Best results are achieved using annual or monthly average wind speeds. Use of daily or hourly average speeds is not recommended.

Instructions:

Inputs: Use annual or monthly **Average Wind** speeds. If **Weibull K** is not known, use K = 2 for inland sites, use 3 for coastal sites, and use 4 for island sites and trade wind regimes. **Site Altitude** is meters above sea level. **Wind Shear Exponent** is best assumed as 0.18. For rough terrain or high turbulence use 0.22. For very smooth terrain or open water use 0.11. **Anemometer Height** is for the data used for the **Average Wind** speed. If unknown, use 10 meters. **Tower Height** is the nominal height of the tower, eg.: 24 meters. **Turbulence Factor** is a derating for turbulence, site variability, and other performance influencing factors -- typical turbulence has already been incorporated into the model. Use 0.00 (0%) for level sites with limited obstructions. Use -0.10 (negative 10%) for flat, clear sites on open water. Use 0.05 to 0.15 (5% to 15%) for rolling hills or mountainous terrain.

Results: **Hub Average Wind Speed** is corrected for wind shear and used to calculate the Weibull wind speed probability. **Air Density Factor** is the reduction from sea level performance. **Average Power Output** is the average continuous equivalent output of the turbine. **Daily Energy Output** is the average energy produced per day. **Annual** and **Monthly Energy Outputs** are calculated using the Daily value. **Percent Operating Time** is the time the turbine should be producing some power.

Limitations: This model uses a mathmatical idealization of the wind speed probability. The validity of this assumption is reduced as the time period under consideration (ie, the wind speed averaging period) is reduced. This model is best used with annual or monthly average wind speeds. Use of this model with daily or hourly average wind speed data is not recommended because the wind will not follow a Weibull distribution over short periods. The data used in creating the power curve was generated at the BWC test site in Norman, OK. Consult Bergey Windpower Co. for special needs. ***Your performance may vary.***

3 Tier Data

wind rose
direction of winds

- Hub Height: **20 meters**
- Latitude: **39.104°**   Longitude: **-119.753°**
- Your prevailing wind direction is from the: **West South West (WSW)**