Site Overview - Halstead High School

Address: Halstead High School, 521 W6th Street, Halstead, KS 67056-2197

Halstead High School (HHS) is a fully qualified public high school located in the city of Halstead, which belongs to Harvey County, Kansas. It serves students from grade 9 to 12. HHS primarily serves the towns of Halstead and Bentley, Kansas. The school is also a part of the Unified School District No.440 which includes, Bentley Primary School, Halstead Middle School and Halstead High School. Its mission is to engage students in educational activities and prepare them to make positive contributions in the society.

The school colors are royal blue and white, with black as a complementary color. Mascot of HHS is a Dragon. HHS competes as a 3A school under the Kansas State High School Association. They are also a part of MCAA League. The school is well known for its exceptional fine arts productions such as music and drama plays.

The annual Halstead Fine Arts and Crafts festival can be found in the link http://artfair.halsteadkansas.com/. Among the noteworthy sporting events of HHS, annual Adolph Rupp Basketball Tournament, the Halstead Wrestling Invitational and the Conrad Nightingale Track Meet are popular.

Some of the notable alumni of HHS can be listed as follows.

- **Adolph Rupp**, legendary basketball coach at the University of Kentucky
- **Jim Roper**, winner of the first NASCAR race
- **Conrad Nightingale**, competed in the 1968 Summer Olympics
- **Bobby Berger**, champion bull rider
- **Dennis Latimore**, competed in Division I-A basketball for both the University of Arizona and Notre Dame

The official web site of SSH is can be found in the following link.
http://www.usd440.com/High_School_/index.cfm?NavID=35&SubNavID=0

Wind Analysis

According to the geological location, surroundings, wind charts and www.windnavigator.com, Halstead High School has annual average wind of 6.29 m/s at 30 m hub height. The location that HHS authority have selected to put the wind turbine is the ideal location of the entire premises with the best annual average wind speed of 6.29 m/s according to the "Windnavigator" website.

Another advantage of HHS is that, it is few miles away from the wind data collection point located at Harvey that has access to the hourly wind data through http://wdl.agron.ksu.edu/ website. Harvey wind data collection site is much closer to the Halstead High School than the Hesston data collection site, the other wind data collection point located in Harvey County. Therefore, wind roses are more accurate when they calculated using the data from Harvey than from Hesston. So, for the calculation of annual power production of the wind turbine was calculated using wind data obtained from Harvey and the value obtained for the annual average wind speed was 6.565 m/s at 30 m hub height. Moreover, the actual calculated value of annual average wind speed is considerably higher than the predicted (6.29 m/s) value.

Wind roses that are illustrated below are generated using the Matlab Software using annual hourly wind data for the Harvey wind data site.

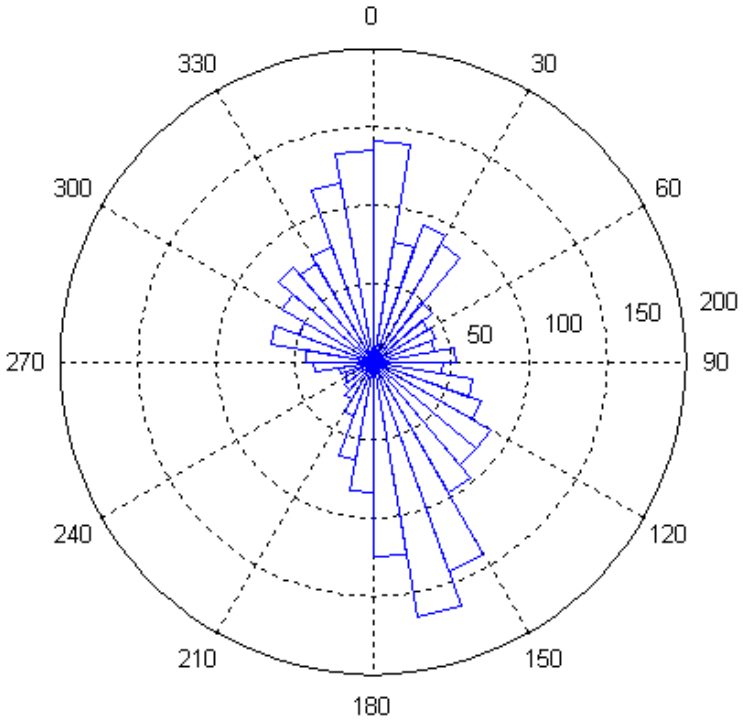

Figure 1: Wind Speed 0 to 8 mph

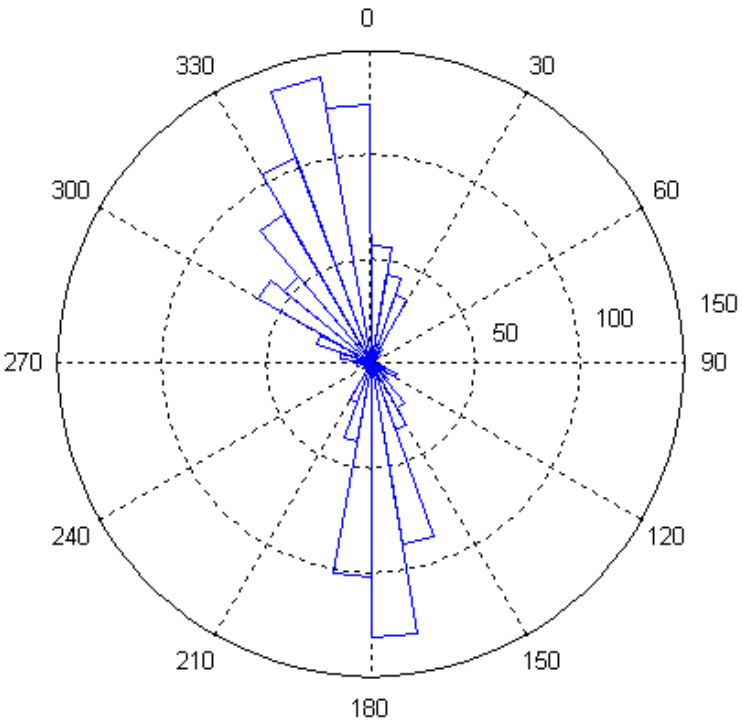

Figure 2: Wind Speed 8 to 20 mph

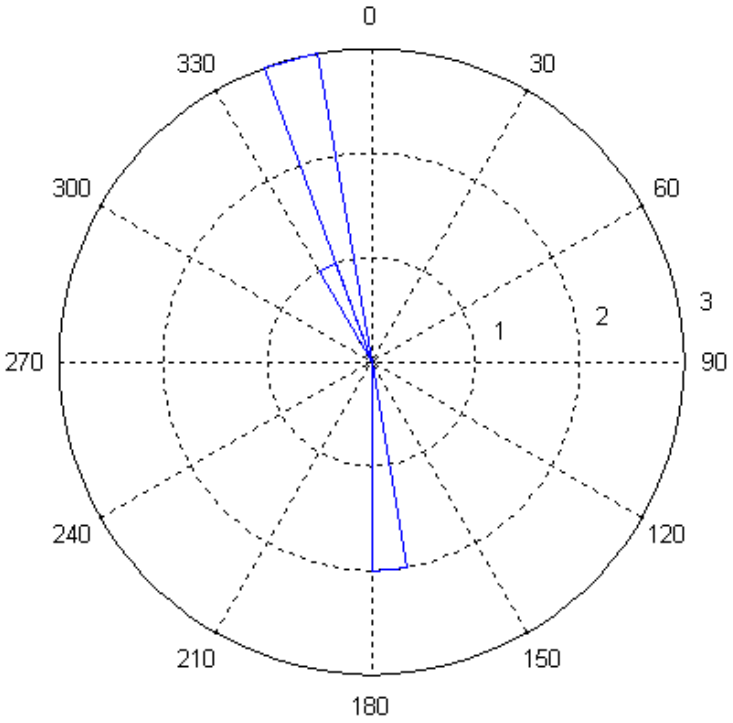

Figure 3: Wind Speed 20 to 26 mph

Table 1: Halstead Annual Power Production

Skystream 3.7 Performance Review

Prepared for : Halstead High School
Location : 521, W6th Street, Halstead, KS 67056-2197

Inputs			Results		
Avg. Wind Speed (m/s)	=	6.565	Total Annual Power (kWh)	=	6487.556
Weibull Factor	=	2	Monthly Energy Output	=	540.6296
Scale Factor	=	7.412049	Percentage of operation	=	99.64947
Hub Height (m)	=	30			

Production Analysis

Wind Speed (m/s)	Power (kW)	Probability	Power (kWh)
1	0	0.035747722	0
2	0	0.067696006	0
3	0	0.092710467	0
4	0.1	0.10882577	95.33137453
5	0.2	0.115477079	202.3158431
6	0.4	0.113428151	397.4522398
7	0.65	0.104448267	594.7284329
8	0.95	0.090848251	756.039141
9	1.35	0.075003626	886.9928776
10	1.75	0.058971571	904.0341879
11	2.1	0.044261703	814.2382896
12	2.3	0.031768682	640.0754104
13	2.4	0.021834015	459.0383391
14	2.45	0.014384023	308.7099121
15	2.4	0.009090661	191.1220644
16	2.3	0.005515258	111.1214252
17	2.25	0.003213855	63.34507654
18	2.2	0.00179958	34.68149719
19	2.2	0.000968642	18.66766264
20	2.2	0.000501349	9.662002222

Average wind speed at the site has calculated using the annual wind speed data gathered by the Halstead Wind Data Collection Site. I selected calculated average wind speed over Wind Navigator wind speed because, calculated average annual wind speed is based on real data for the same site. Weibull factor is considered as 2 since it's an inland site.

The Weibull distribution of the Skystream 3.7 illustrated below. According to the calculations for the Weibull distribution, Skystream 3.7 produces average of **540.6 kWh** of power each month and **6487.55 kWh** annually.

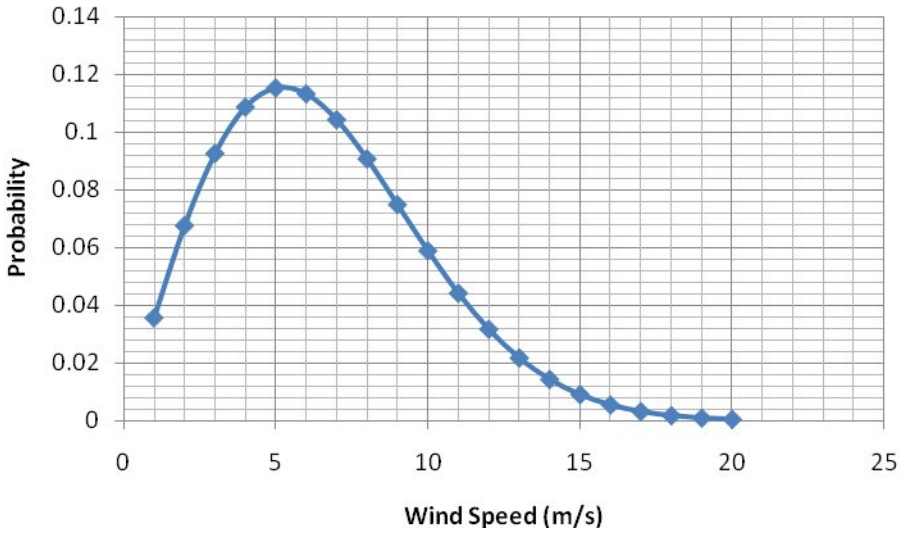

Figure 3: Weibull Distribution

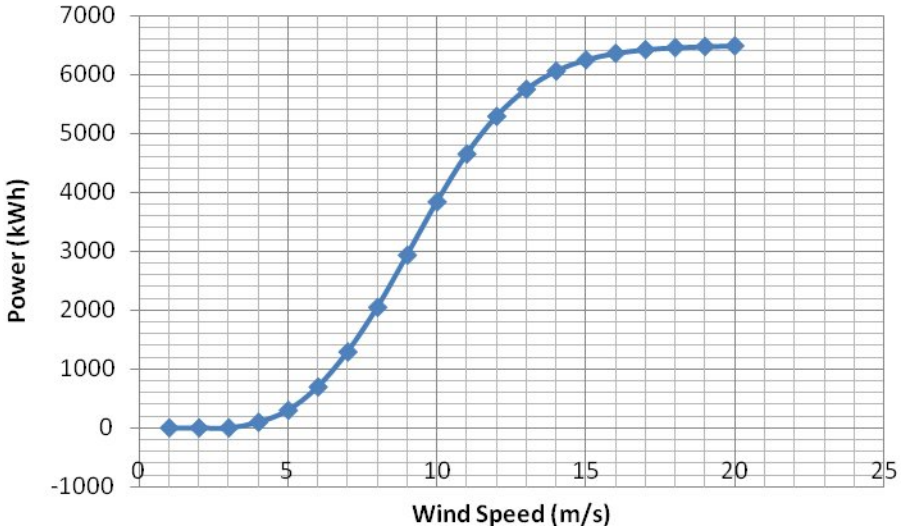

Figure 4: Halstead Cumulative Power

Southwest Windpower approves five different heights of monopole towers, specifically designed for the Skystream 3.7 wind turbine. Standard towers that Southwest Windpower offers are listed below with their predicted average wind speed and predicted annual power that can be produced by Skystream 3.7 in HHS wind site.

Table 2: Hub Height, Annual Power Output variation

Hub Height (m)	Avg. Wind Speed (m/s)	Annual Power (kWh)
10	5.347666	4150.536
13.7	5.694347	4742.215
18.3	5.96787	5361.537
21.3	6.437134	5699.443
23	6.827126	5873.325

Foundation Analysis

Foundation analysis is critical for the stability and production of the wind turbine. Soil type is one of the main factors effecting when choosing a foundation type. The figure 5 illustrated below shows the soil type distribution in the Halstead High School premises.

The area which the school authority prefers to install the turbine is the best place to install the turbine according to the wind data and soil data for the HHS wind site. According to the Figure 4, red rectangle near the ground represents the position where the turbine is planned to install. According to the soil analysis carried out with the use of soil data fromhttp://websoilsurvey.nrcs.usda.gov web site, the area is consist of soil type "3725-Detroit silt clay loam, rarely flooded" which is suitable for a wind turbine installation.

According to the "Towers and Foundation" user manuals issued by the Southwest Windpower, soil type 3725 is categorized as class 5 soil type and zone 3 wind zone. Therefore, there are three foundation choices for the HHS wind site as shown in Table 3.

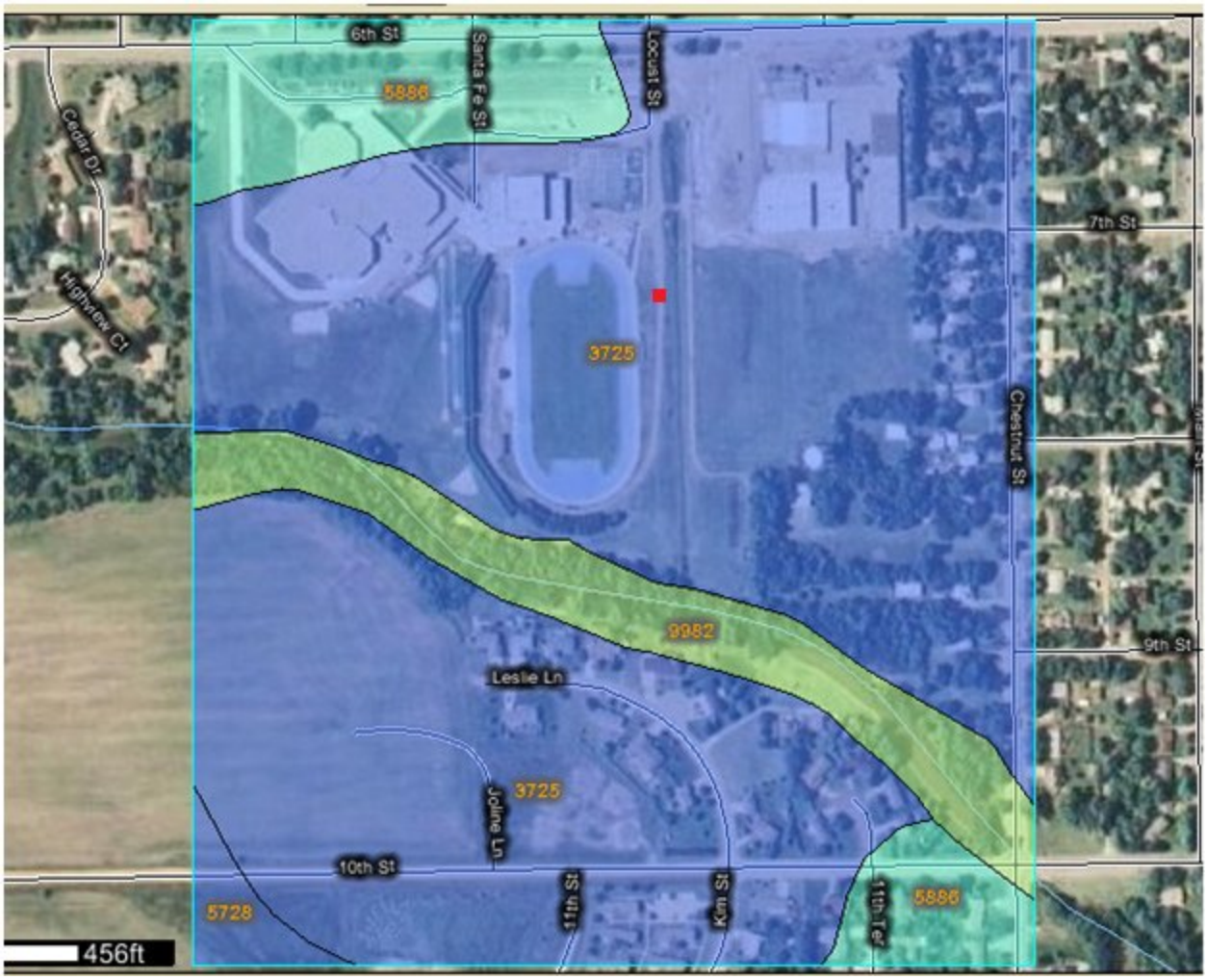

Figure 5: HHS Soil Analysis

According to the foundation user manual issued by the Southwest Windpower HHS wind site is categorized with “class 5” soil type and “zone 3” wind. So they are recommending the following foundation types based on the tower heights.

Table 3: Foundation Analysis

Foundation	Tower Heights	Foundation Type
Foundation- Wind Zone 3, Monopole	45 ft (13.7 m)	15 ‘ pier
Foundation Alternative – Pier	45 ft (13.7 m)	10’ pad
Smart Foundation	33 ft - 60 ft	Smart foundation

Note: The monopole tower foundation user manuals that are related to HHS wind site can be found in the ***Appendix I***.

Economic Analysis

Skysteam 3.7 wind turbine power output for the HHS wind site as illustrated in Table 2 shows that the power produced by the wind turbine is not sufficient to power up the entire school. But, since the HHS wind site has "Class 3" wind (6.565 m/s at 30 m hub height) that produces acceptable amount of power, which saves money for the school in long terms. In order to maximize the actual cost associate with this project US Energy Information Administration (EIA) projections for the resident consumers during 2008 to 2011 were used. Table 4 illustrates the annual and increase rate of the electricity projected by EIA official website http://www.eia.doe.gov/emeu/steo/pub/contents.html.

Table 4: Increase rate of electricity cost

Cost of Electricity ($/kWh)				Increase rate of electricity cost (%)			
2008	2009	2010	**2011**	2008-09	2009-10	2010-11	**Average**
0.1126	0.1155	0.1156	**0.1176**	2.5	0.1	1.7	**1.43**

Considering the annual electricity increase rate of 1.43% per year actual cost of electricity on year 2011 will be $0.1176 /kWh. The wind turbine "Skystream 3.7" guaranteed life time is 20 years with an annual inflation rate of 3%. By using these factors the present savings of the electricity can be calculated.

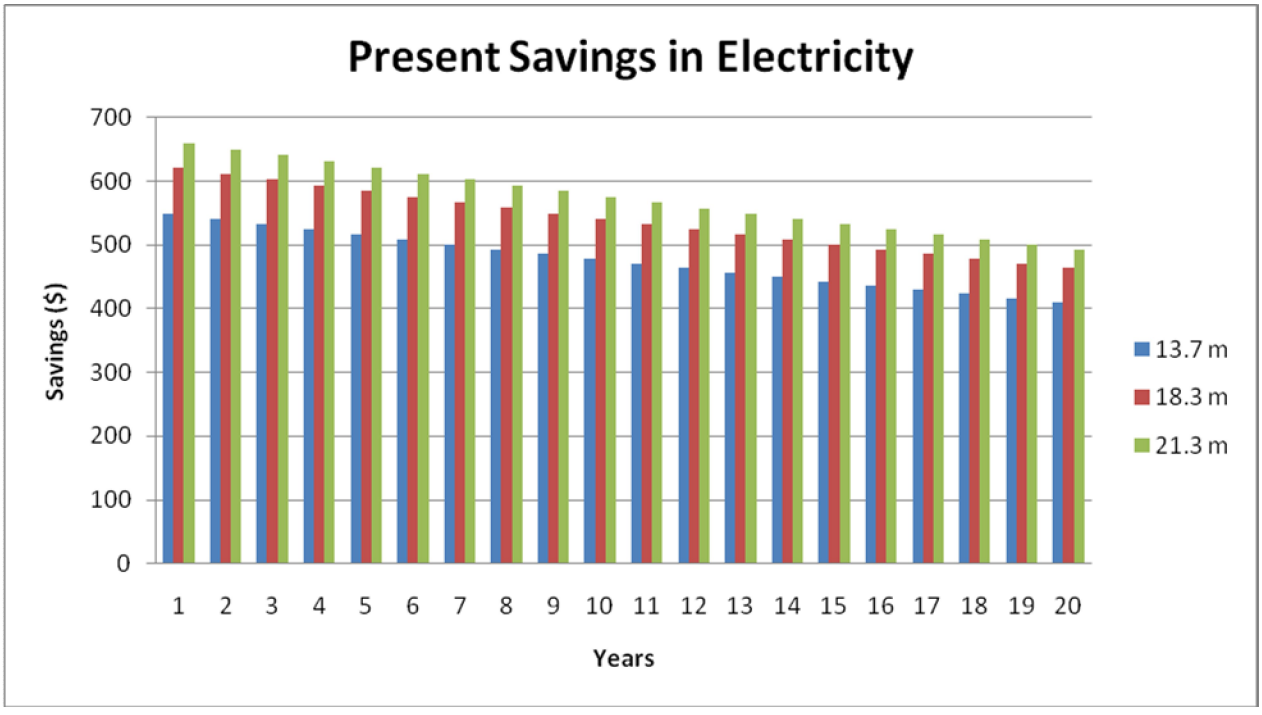

Figure 6: Present savings in electricity

Table 5: Present savings in electricity

Annual inflation rate (r %)	**3**		
Actual cost of electricity (Ce)	**0.1176**		
Annual electricity increase rate (e %)	**1.43**		
Present Savings in Electricity			
Annual energy production/ kWh	**4742.215**	**5361.537**	**5699.443**
Number of years	Savings in different hub heights		
	13.7 m	**18.3 m**	**21.3 m**
1	549.18	620.91	660.04
2	540.81	611.44	649.98
3	532.57	602.12	640.07
4	524.45	592.94	630.31
5	516.46	583.91	620.71
6	508.59	575.01	611.24
7	500.83	566.24	601.93
8	493.2	557.61	592.75
9	485.68	549.11	583.72
10	478.28	540.74	574.82
11	470.99	532.5	566.06
12	463.81	524.38	557.43
13	456.74	516.39	548.93
14	449.78	508.52	540.57
15	442.92	500.77	532.33
16	436.17	493.13	524.21
17	429.52	485.62	516.22
18	422.97	478.21	508.35
19	416.53	470.92	500.6
20	410.18	463.75	492.97
Total savings ($)	9529.66	10774.22	11453.24

The formula that was used to calculate the annual savings of electricity cost can be illustrated as follows.

$$PSE_n = \frac{AEP * C_e * (1+\frac{e}{100})^n}{(1+\frac{r}{100})^n}$$; $/years

PSE_n : Present savings of energy in *n* number of years
AEP : Annual energy production
C_e : Actual cost of energy

e : Annual electricity increase rate
r : Annual inflation rate

Table 6: Installation Cost

Description	Cost
Turbine	3250
Tower	3555
Foundation Materials	1197
Electrical Connection Materials	1198.6
Total Cost	9200.60

$$\text{The payback period for the system} = \frac{\text{Total cost associate with the WT system}}{\text{Ann. Savings}}$$

Effect of different hub heights for the annual energy production has illustrated in table 5 Therefore, using table 5 and “Payback period for the system” equation, different payback period for different hub heights can be calculated.

Note: Most of the costs associates with the wind turbine system are funded by the community of the school area and the government. Therefore, the cost that the school has to bare is around $4000 in total, which can be paid back in 10 years according to the annual energy production.

Environmental Issues

The wind turbine is planning to be installed near the playground and towards the centre of the HHS. The red square represents the wind turbine in the figure 5. There is a large free space east side of the wind turbines location. The play ground is in the west side and trees on the south are over 600 feet's away from the wind turbine. Therefore, the disturbances due to sound generated by the wind turbine and the flickering feature produced when the turbine is rotating will be minimized.

Figure 7: Environmental Issues

Recommendations

The Halstead High School wind site is a good wind site that can produce around 6000 kWh of power per year at 30m hub height, that can saves more than $11,000 in twenty years of time.

The place that the school authority has chosen to put the wind turbine is the ideal place in the HHS premises with minimum environment effect.

The school can use 45 feet monopole tower or higher to produce assumed power. The school authority might go to smart foundation if they can bear the cost which will increase the payback period. But the ideal foundation is the “15 ft pier”.