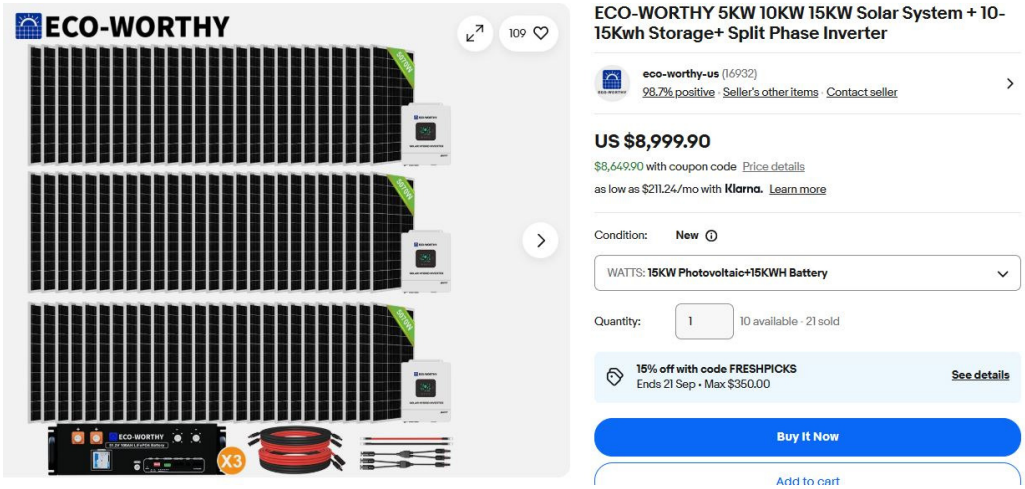
ECE 111 - Homework #5:

Renewable Energy

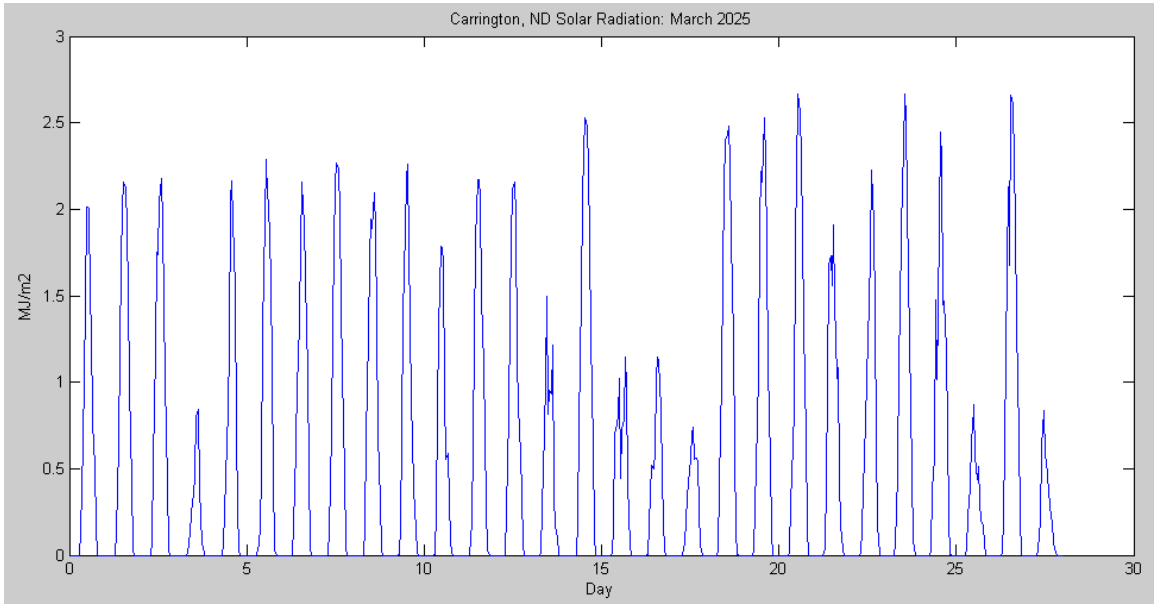
Solar Energy

A 15kW split phase solar power system with a 15kWh battery sells on ebay for $8,649 (September 19, 2025). Is this a good buy?



Problem 1) Load 4-weeks worth of solar energy data from NDAWN. Plot the solar ratiation vs. hour in Matlab

```
>> MJ = Data(:,2);
>> hr = [1:672]';
>> plot(hr/24,MJ)
>> xlabel('Day');
>> ylabel('MJ/m2');
>> title('Carrington, ND Solar Radiation: March 2025')
```



Problem 2) Calculate the kWh generated over these 28 days for the array

- 78 panels
- Each panel has an area of 0.89 square meters
- Panel efficiency = 21.5%

If the sun has a solar intensity of 1MJ/m2, then the power in kW is

$$k = \left(1\frac{MJ}{m^2}\right)(78)(0.89m^2)\left(\frac{1{,}000{,}000J}{1MJ}\right)\left(\frac{1Wh}{3600J}\right)\left(\frac{1kWh}{1000Wh}\right)(0.215) = 4.0495kWh$$

The total energy produced over these 28 days is then

```
>> kWh = sum(MJ)*4.0495
kWh =  1401.4
```

From March 1 - 28, 2025, I'd expect the solar panels will produce 1401.4 kWh.

Problem 3) Calculate

- The total energy produced over the month in kWh,
- The value of this energy, assuming 11 cents per kWh, and
- The number of pounds of coal this array offsets over this month (assuming 1.78 lb of coal = 1kWh)

```
>> kWh = sum(MJ)*4.0495

kWh =  1401.4

>> Dollars = kWh * 0.11

Dollars =  154.1560

>> Pounds = kWh * 1.78

Pounds =  2494.5
```

Over these 28 days, the solar panels should

- Reduce my utility bill by $154 (assuming net metering or I use all the energy I produce), and
- Offset 2494 pounds of coal.

Problem 4) How many years will it take for this solar panel array to pay for itself?

- Assume each month is the same (kind of iffy)
- How many months (or years) will it take to generate $8,649?

```
>> Dollars_Per_Year = Dollars * 365/28

Dollars_Per_Year =   2009.5

>> Years = 8649 / Dollars_Per_Year

Years =    4.3041
```

This suggests that the solar panels are a really good investment

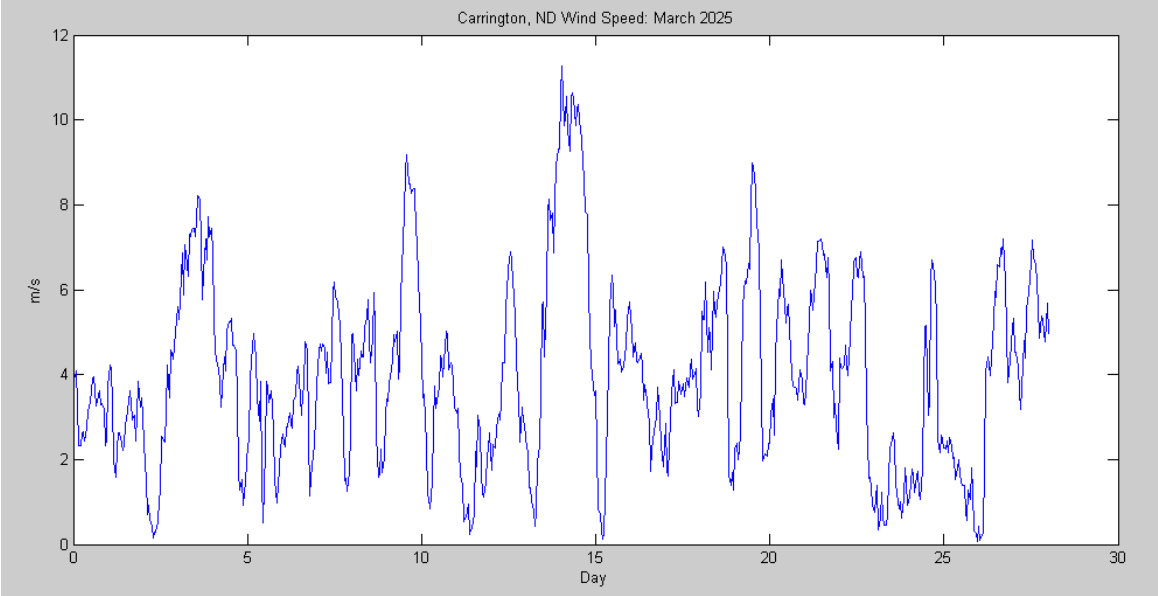
- Even with *no* subsidies, solar is actually a good investment in North Dakota
- Less so if you have to pay someone to install the panels (doubles or tripples the cost)

Wind Energy

Problem 5) Load the 4-weeks worth of average wind-speed data from NDAWN. (any town in North Dakota or Minnesota). Plot this in MATLAB as wind speed vs hour.

https://ndawn.ndsu.nodak.edu/

```
>> Data = [ <paste data from NDAWN> ];
>> Wind = Data(:,2);
>> hr = [1:672]';
>> plot(hr/24,Wind)
>> xlabel('Day');
>> ylabel('m/s');
>> title('Carrington, ND Wind Speed: March 2025')
```



Problem 6) Write a function in Matlab where you pass the wind speed at 120m (about 1.8x the wind speed at the ground) and it returns the power generated by a Vestas V120-2.2 MW

Wind Speed (m/s)	0..3	4	5	6	7	8	9	10	11	12	13+
kW	0	16	152	335	604	873	1,212	1,559	1,864	2,079	2,200

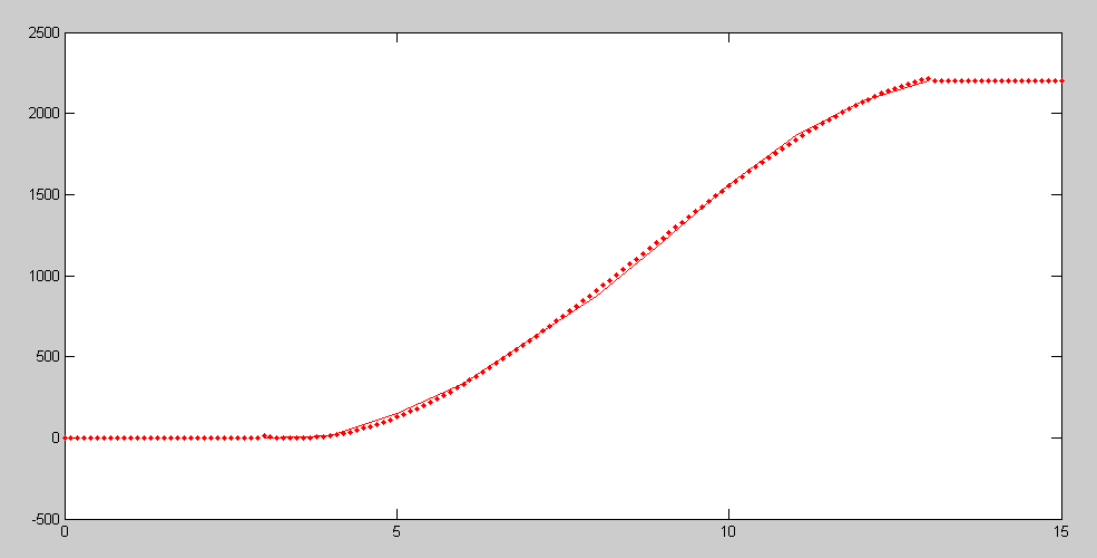
https://www.vestas.com/content/dam/vestas-com/global/en/brochures/onshore/2MW_Platform_Brochure_.pdf.coredownload.inline.pdf

6a) Determine a function in Matlab to approximate this curve.

```
function [kW] = PowerCurve( Wind )

x = [3,4,5,6,7,8,9,10,11,12,13]';
y = [0 16 152 335 604 873 1212 1559 1864 2079 2200]';

B = [x.^3, x.^2, x, x.^0];
A = inv(B'*B)*B'*y;

kW = 0*Wind;
for i=1:length(Wind)
    if(Wind(i) < 3)
        kW(i) = 0;
    elseif(Wind(i) > 13)
        kW(i) = 2200;
    else
        kW(i) = [Wind(i)^3, Wind(i)^2, Wind(i), 1]*A;
    end
end

plot(x,y,'r',Wind,kW,'r.')
end
```

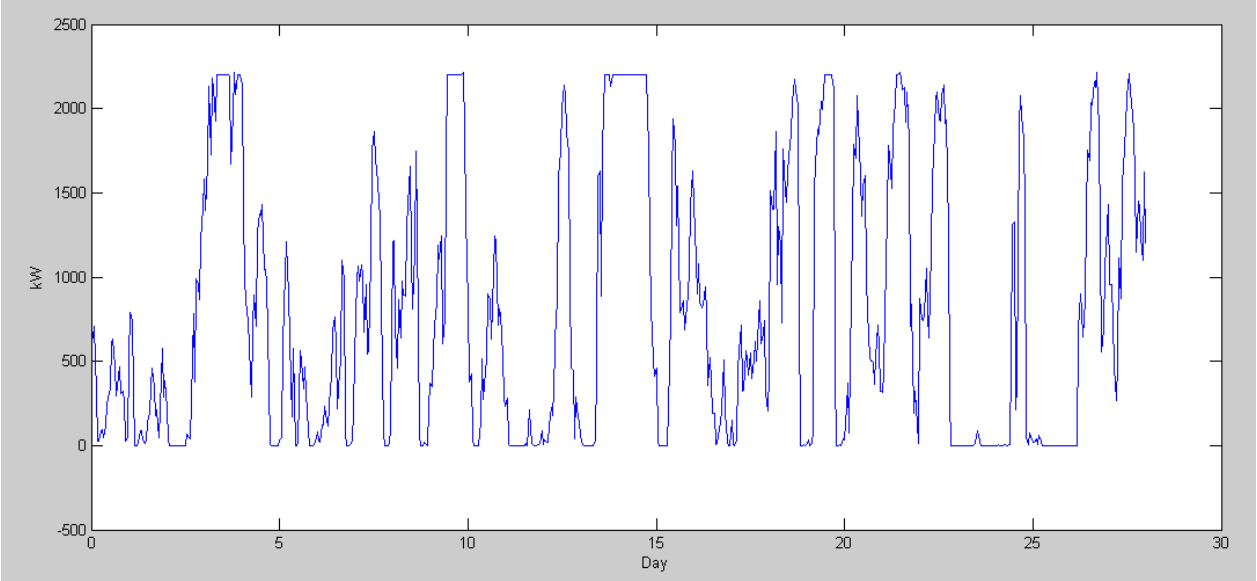
Checking:

```
>> x = [0:0.1:15]';
>> kW = PowerCurve(x);
```



6b) Use this function to compute how much power a Vestas V136-3.45MW wind turbine would produce from the wind data your found in problem 5.

```
>> kW = PowerCurve(Wind*1.8);
>> plot(hr/24, kW)
>> xlabel('Day');
>> ylabel('kW');
```



Problem 7) Calculate

- The total energy produced over the month in kWh,
- The value of this energy, assuming 11 cents per kWh, and
- The number of pounds of coal this array offsets over this month (assuming 1.78 lb of coal = 1kWh)

```
>> kWh = sum(kW) * 1

kWh =  5.3648e+005

>> Dollars = kWh * 0.11

Dollars =  5.9012e+004

>> Pounds = kWh * 1.78

Pounds =  9.5493e+005
```

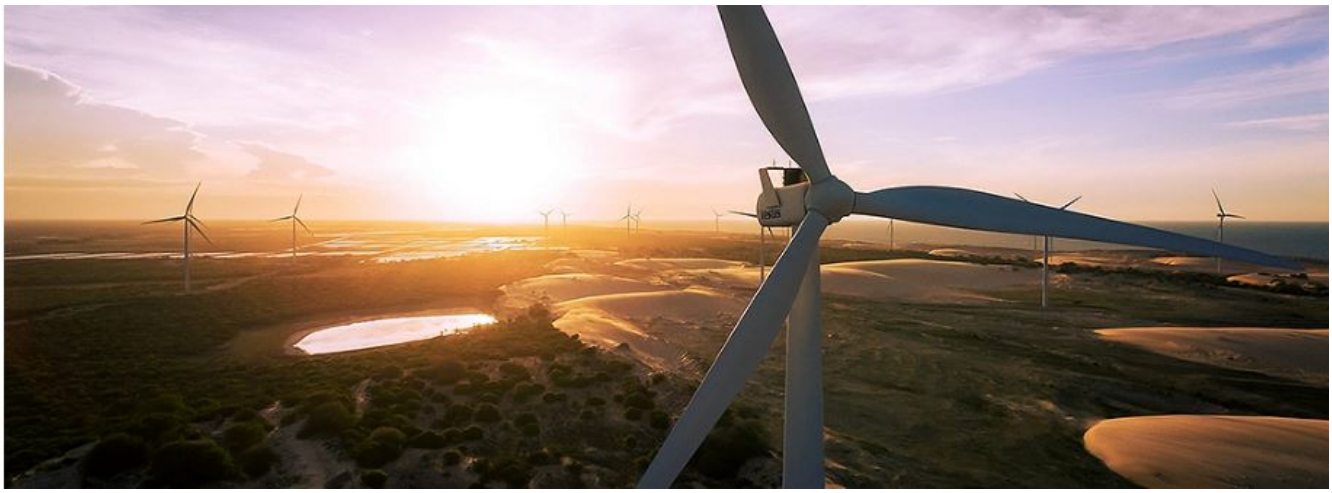
In 28 days, a single wind turbine

- Produces 536,480 kWh,
- Worth $59,012, and
- Offsets 954,930 pounds of coal.

Problem 8) Assume this wind turbine costs $2.86 million to build ($1300 / kW). How long will it take for this wind turbine to pay for itself?

```
>> Dollars_Per_Year = Dollars * 365/28

Dollars_Per_Year =  7.6927e+005

>> Years = 2.86e6 / Dollars_Per_Year

Years =    3.7178
```

Even without any tax subsidies, wind energy is a very good investment. Kind of hard to beat zero fuel cost.



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