

ECE 111 - Homework #5:

Renewable Energy

Solar Energy

A 7080W solar power system with a 32kWh battery sells on ebay for \$8,399.99 (August 11, 2026). Assuming \$0 in tax credits, is this a good buy?



ECO-WORTHY

FINAL PRICE \$7900

499

ECO-WORTHY Official Store (22929)

99.5% positive · Seller's other items · Message

US \$8,399.99 or Best Offer

\$7,899.99 with coupon code [Price details](#)

as low as \$403.27/mo with [Klarna](#). [Learn more](#)

Condition: New

Quantity: 1 More than 10 available · 44 sold

20% off with code BRANDS20 Ends 16 Aug · Max \$500.00 [See details](#)

Buy It Now

Add to cart

1) Load 4-weeks worth of solar energy data from NDAWN. (any town in North Dakota or Minnesota). Plot this in MATLAB as wind speed vs hour.

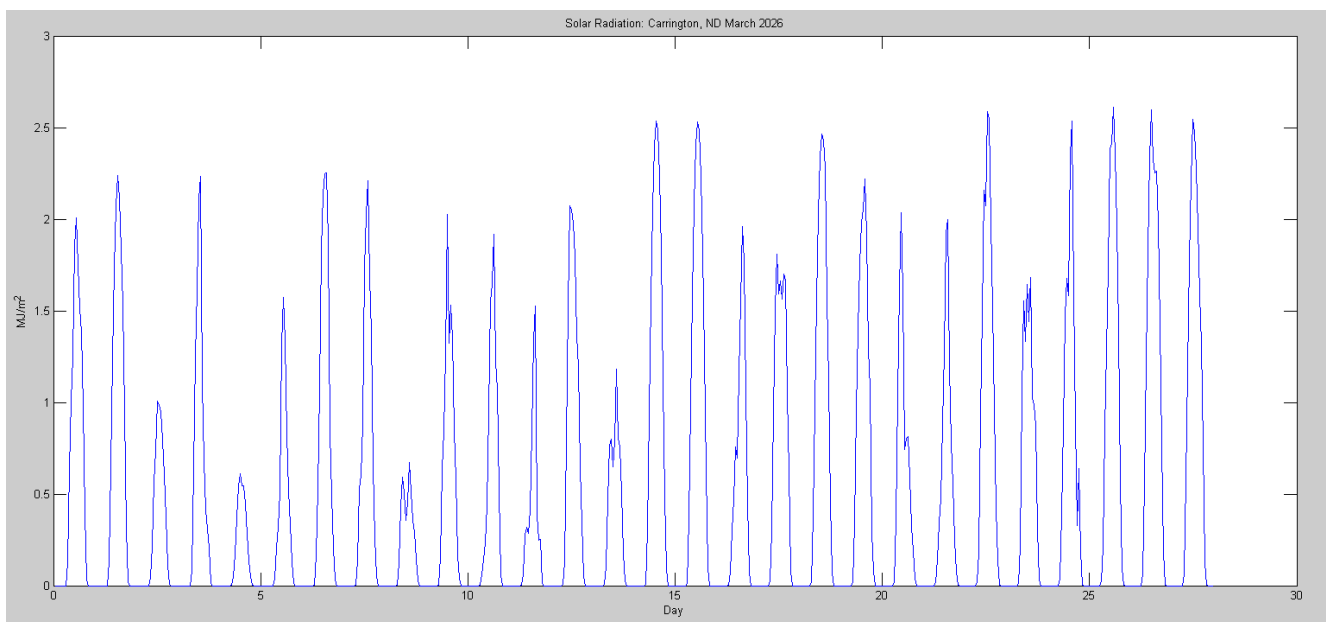
- Month = September or March (around the equinox - kind of a fair date)
- <https://ndawn.ndsu.nodak.edu/>
- Hourly Data
- Solar Radiation - Total (MJ/m^2)

Plot the solar radiation vs. hour in Matlab

```
>> size(MJ)

    672     1

>> hr = [1:672]';
>> plot(hr/24, MJ)
>> xlabel('Day');
>> ylabel('MJ/m^2')
>> title('Solar Radiation: Carrington, ND March 2026')
```



Hourly solar intensity for March 2026 in Carrington, ND

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

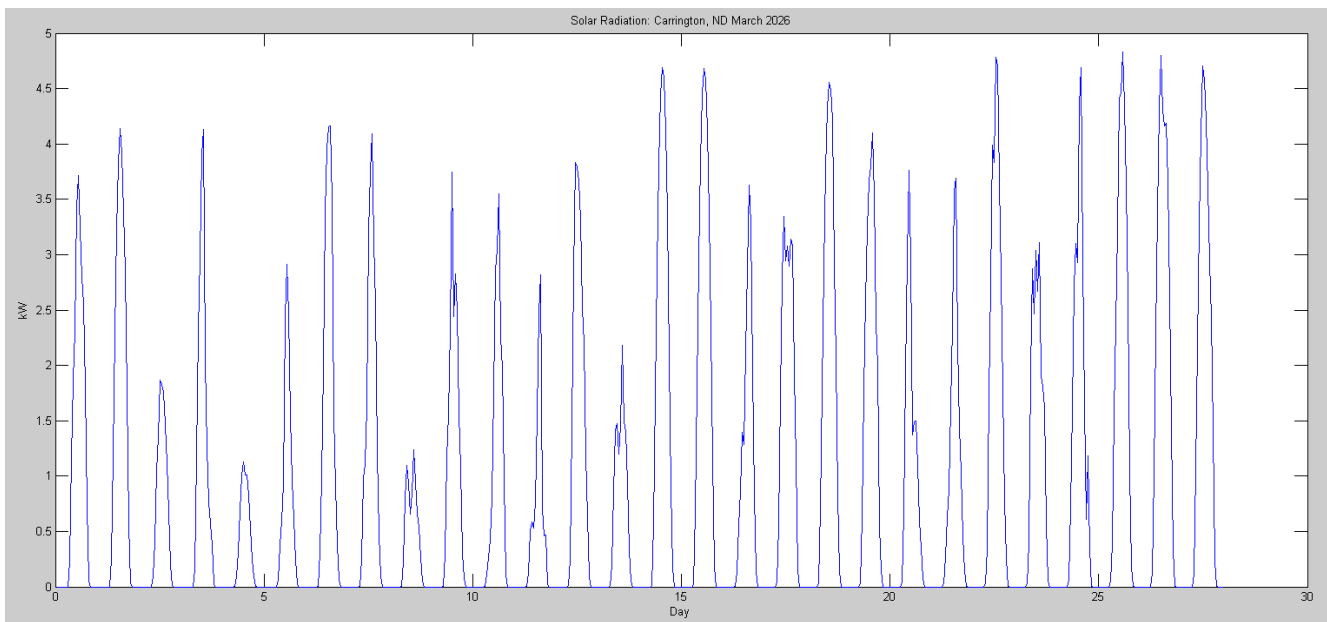
- 12 panels
- Each panel has an area of 2.58 square meters
- Panel efficiency = 21.5%

The conversion from MJ/m² to kWh produced is

$$k = \left(1 \frac{\text{MJ}}{\text{m}^2}\right) (12) (2.58 \text{m}^2) \left(\frac{1,000,000 \text{J}}{1 \text{MJ}}\right) \left(\frac{1 \text{Wh}}{3600 \text{J}}\right) \left(\frac{1 \text{kWh}}{1000 \text{Wh}}\right) (0.215) = 1.8490 \text{kWh}$$

Changing the y-axis to kW

```
>> k = 12*2.58*1e6/3600/1e3*0.215  
  
k = 1.8490e+000  
  
>> kW = k*MJ;  
>> plot(hr/24, kW)  
>> xlabel('Day');  
>> ylabel('kW')  
>> title('Solar Radiation: Carrington, ND March 2026')
```



Predicted Energy Production for Solar Panels

3) Calculate

The total energy produced over the month in kWh,

```
>> kWh = sum(kW * 1)
kWh = 6.4390e+002
```

The value of this energy, assuming 11 cents per kWh, and

```
>> Dollars = kWh * 0.11
Dollars = 7.0829e+001
```

The number of pounds of coal this array offsets over this month (assuming 1.78 lb of coal = 1kWh)

```
>> Pounds = kWh * 1.78
Pounds = 1.1461e+003
```

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 \$8,399?

```
>> years = 8399 / (Dollars * 365 / 28)
years = 9.0967e+000
```

With all of these assumptions, these solar panels should pay for themselves in 9.09 years

- This solar array is not a good investment from a purely economic standpoint

But, it's close

- If prices drop by 23%, it would be economic (battery, panels, inverters)
- If electricity prices increase to 13.5 cents / kWh, it would be economic
- If the sun was 23% brighter (western North Dakota), it would be economic

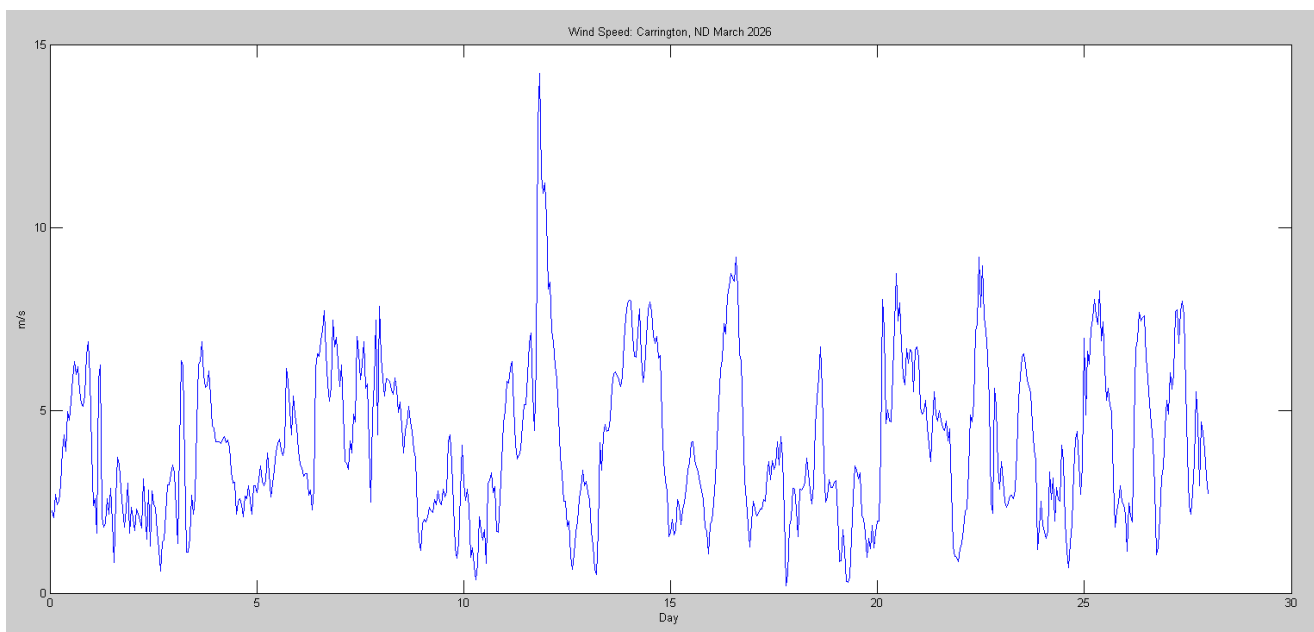
Wind Energy

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/>

In matlab

```
>> Wind = [ <paste data> ];  
  
>> size(Wind)  
  
ans =  
  
    672     1  
  
>> hr = [1:672]';  
>> plot(hr/24, Wind)  
>> xlabel('Day');  
>> ylabel('m/s')  
>> title('Wind Speed: Carrington, ND March 2026')
```



Measured wind speed @ 2m in Carrington, ND for March 20267

6) Write a function in Matlab where you pass the wind speed at 199m (about 2.1x the wind speed at the ground) and it returns the power generated by a Vestas V172-7.2MW

Wind Speed (m/s)	0..3	4	5	6	7	8	9	10	11	12	13+
kW	0	260	654	1,180	1,788	2,485	3,709	4,888	5,645	6,622	7,200

https://www.vestas.com/content/dam/vestas-com/global/en/brochures/onshore/4MW_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 = [0 260 654 1180 1788 2485 3709 4888 5645 6622 7200]';

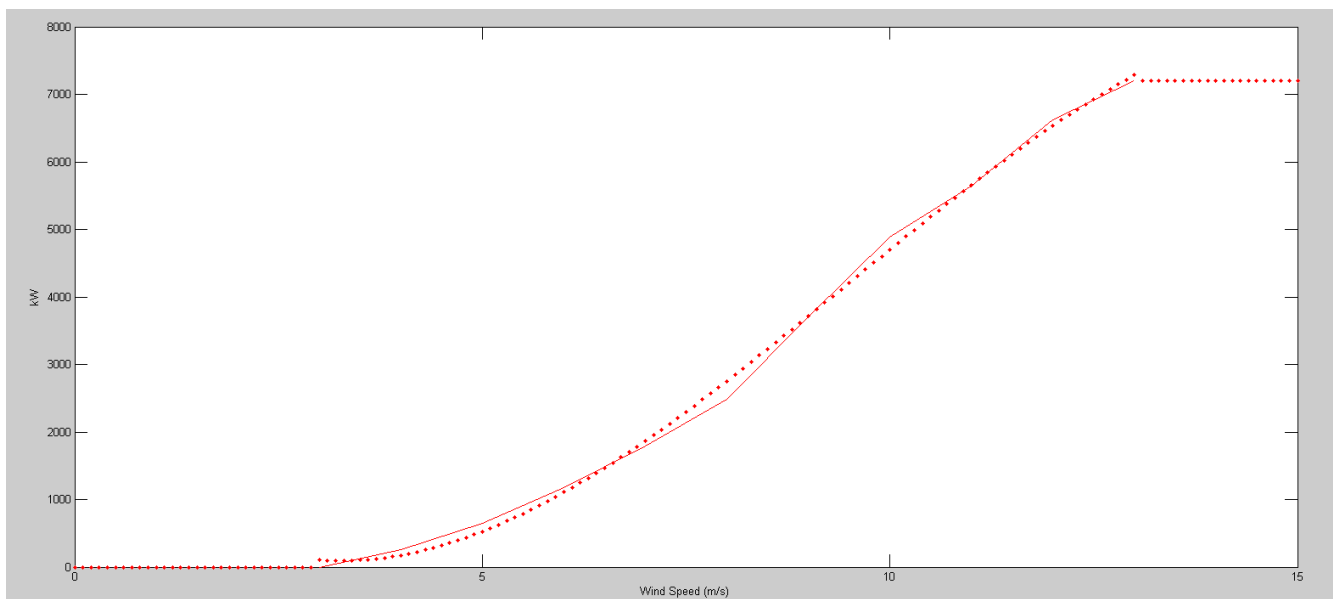
B = [x.^3, x.^2, x, x.^0];
A = inv(B'*B)*B'*y;

kW = 0*Wind;
for i=1:length(Wind)
    if(Wind(i) < 3)
        kW(i) = 0;
    elseif(Wind(i) > 13)
        kW(i) = 7200;
    else
        kW(i) = [Wind(i)^3, Wind(i)^2, Wind(i), 1]*A;
    end
end

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

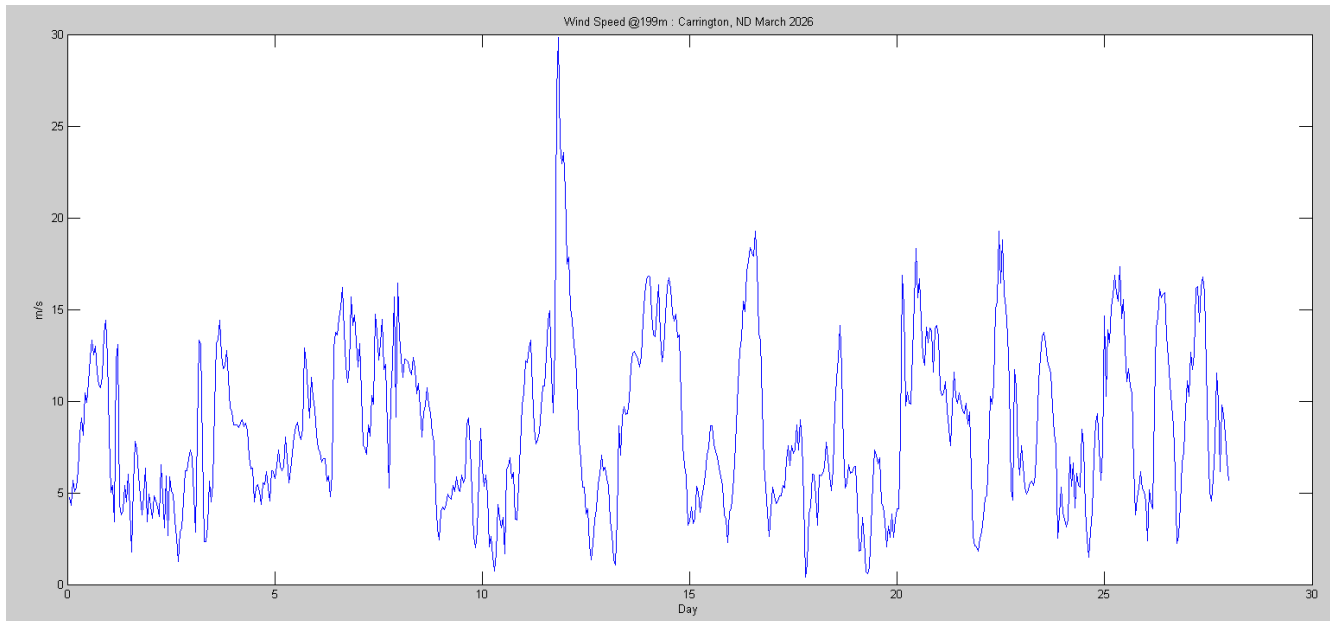
Check this function by plotting wind speed vs. kW for 0 - 15 m/s

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

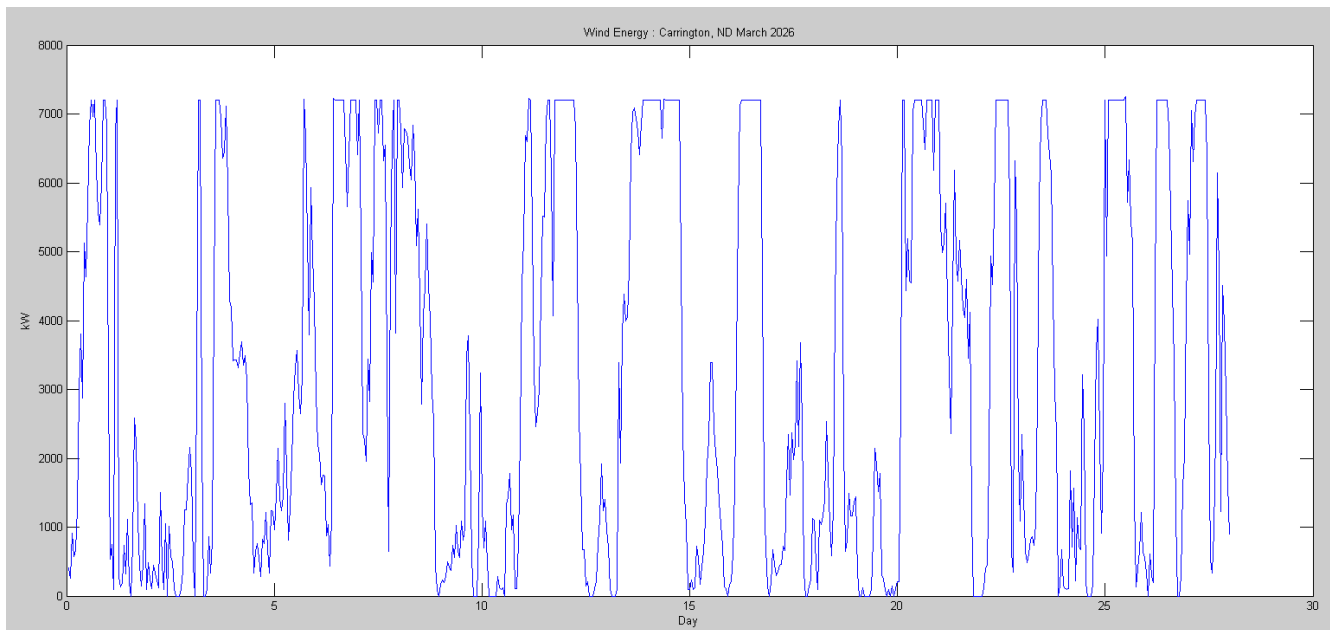


6b) Use this function to compute how much power this wind turbine would produce from the wind data your found in problem 5.

```
>> plot(hr/24, Wind * 2.1)
>> xlabel('Day');
>> ylabel('m/s')
>> title('Wind Speed @199m : Carrington, ND March 2026')
```



```
>> kW = PowerCurve(Wind * 2.1);
>> plot(hr/24, kW);
>> xlabel('Day');
>> ylabel('kW')
>> title('Wind Energy : Carrington, ND March 2026')
```



7) Calculate

The total energy produced over the month in kWh,

```
>> kWh = sum(kW)

kWh = 2.1779e+006
```

The value of this energy, assuming 11 cents per kWh, and

```
>> Dollars = kWh * 0.11

Dollars = 2.3957e+005
```

The number of pounds of coal this array offsets over this month (assuming 1.78 lb of coal = 1kWh)

```
>> Pounds = kWh * 1.78

Pounds = 3.8767e+006
```

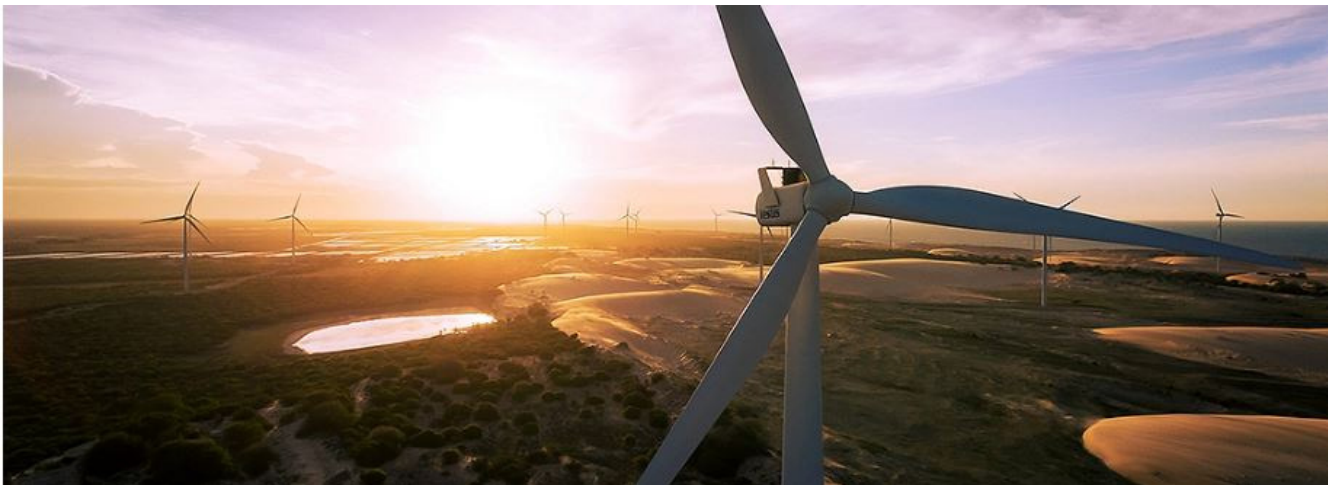
8) Assume this wind turbine costs \$9.36 million to build (\$1300 / kW). How long will it take for this wind turbine to pay for itself?

```
>> years = 9.36e6 / (Dollars * 365 / 28)

years = 2.9971e+000
```

Assuming every month is like May 2026, it would take 2.997 years for this wind turbine to pay for itself

- Followed by 17 years of profit
- Wind energy is very economic in North Dakota



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