In [1]:

```
import os
import numpy as np
import pandas as pd
import pvlib #For simulation of PV performance
import matplotlib.pyplot as plt
import pathlib
from pvlib.pvsystem import PVSystem
```

In [75]:

```
pv = r"C:\Users\suraj\Desktop\July 01_10to16.xlsx"
pv_data = pd.read_excel(pv)
pv_data.index = pd.to_datetime(pv_data[['Year', 'Month', 'Day', 'Hour', 'Minute','Second'
```

In [77]:

```
pv_data.head(3) #getting the first five rows of dataset
```

Out[77]:

| | Date | Time | concatenated time | hour | minute | second | Year | Month | Day | Hour | ... |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **2022-07-01 10:00:00** | 2022-07-01 | 10:00:00 | 2022-07-01 10:00:00 | 10 | 0 | 0 | 2022 | 7 | 1 | 10 | ... |
| **2022-07-01 10:00:06** | 2022-07-01 | 10:00:06 | 2022-07-01 10:00:00 | 10 | 0 | 6 | 2022 | 7 | 1 | 10 | ... |
| **2022-07-01 10:00:12** | 2022-07-01 | 10:00:12 | 2022-07-01 10:00:00 | 10 | 0 | 12 | 2022 | 7 | 1 | 10 | ... |

3 rows × 22 columns

In [78]:

```
data = pv_data[['GHI', 'DHI', 'DNI', 'Tamb', 'WindVel']]
data.head(3)
```

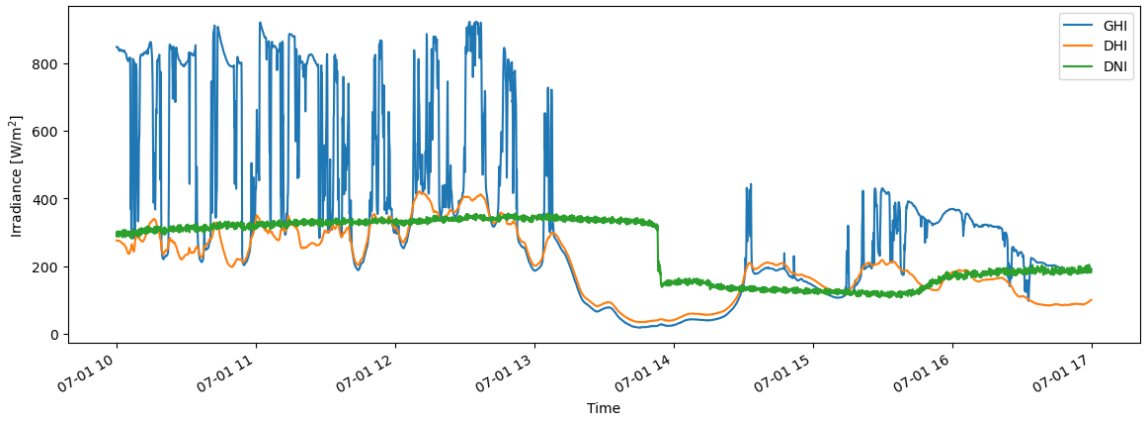
Out[78]:

| | GHI | DHI | DNI | Tamb | WindVel |
|---|---|---|---|---|---|
| **2022-07-01 10:00:00** | 847.999 | 275.935 | 299.8246 | 31.211 | 0.754 |
| **2022-07-01 10:00:06** | 847.746 | 275.463 | 287.3870 | 31.212 | 0.652 |
| **2022-07-01 10:00:12** | 846.808 | 274.904 | 300.8661 | 31.332 | 1.130 |

## Plotting irradiance data for better understanding of data set

In [79]:

```
jul=data.loc['2022-07-01']
jul[['GHI', 'DHI', 'DNI']].plot(figsize=(14,5))
plt.ylabel('Irradiance [W/m$^2$]');
plt.xlabel('Time');
```




# POA Irradiance

In [80]:

```
location = pvlib.location.Location(latitude=59.531220, longitude=12.620120)
times = data.index
solar_position = location.get_solarposition(times)
solar_position.head()
```

Out[80]:

| | apparent_zenith | zenith | apparent_elevation | elevation | azimuth | equation_of_t |
|---|---|---|---|---|---|---|
| **2022-07-01 10:00:00** | 38.657165 | 38.670630 | 51.342835 | 51.329370 | 152.381628 | -3.893 |
| **2022-07-01 10:00:06** | 38.651300 | 38.664762 | 51.348700 | 51.335238 | 152.417212 | -3.893 |
| **2022-07-01 10:00:12** | 38.645442 | 38.658901 | 51.354558 | 51.341099 | 152.452804 | -3.893 |
| **2022-07-01 10:00:18** | 38.639591 | 38.653047 | 51.360409 | 51.346953 | 152.488403 | -3.893 |
| **2022-07-01 10:00:24** | 38.633746 | 38.647200 | 51.366254 | 51.352800 | 152.524010 | -3.893 |

In [81]:

```
poa_irr = pvlib.irradiance.get_total_irradiance(surface_tilt=40,surface_azimuth=180,dni=d
                                                ghi=data['GHI'],
                                                dhi=data['DHI'],
                                                solar_zenith=solar_position['apparent_zer
                                                solar_azimuth=solar_position['azimuth'],
                                                model='isotropic')
poa_irr
```

Out[81]:

| | poa_global | poa_direct | poa_diffuse | poa_sky_diffuse | poa_ground_diffuse |
|---|---|---|---|---|---|
| **2022-07-01 10:00:00** | 554.480813 | 286.024816 | 268.455996 | 243.656737 | 24.799260 |
| **2022-07-01 10:00:06** | 542.225674 | 274.193862 | 268.031811 | 243.239950 | 24.791861 |
| **2022-07-01 10:00:12** | 554.600692 | 287.089922 | 267.510770 | 242.746341 | 24.764430 |
| **2022-07-01 10:00:18** | 548.048657 | 280.004409 | 268.044247 | 243.263792 | 24.780456 |
| **2022-07-01 10:00:24** | 549.153718 | 281.769117 | 267.384601 | 242.599759 | 24.784842 |
| **...** | ... | ... | ... | ... | ... |
| **2022-07-01 16:59:30** | 124.877643 | 33.291628 | 91.586014 | 86.022259 | 5.563756 |
| **2022-07-01 16:59:36** | 127.574248 | 35.328006 | 92.246242 | 86.672163 | 5.574079 |
| **2022-07-01 16:59:42** | 125.810878 | 33.174895 | 92.635982 | 87.062459 | 5.573523 |
| **2022-07-01 16:59:48** | 128.147130 | 35.132292 | 93.014838 | 87.420083 | 5.594755 |
| **2022-07-01 16:59:54** | 127.637187 | 33.566827 | 94.070360 | 88.473528 | 5.596831 |

4193 rows × 5 columns

In [82]:

```
aoi=pvlib.irradiance.aoi(surface_tilt=45,surface_azimuth=180,
                         solar_zenith=solar_position['apparent_zenith'],
                         solar_azimuth=solar_position['azimuth'])
iam=pvlib.iam.ashrae(aoi)
effective_irradiance=poa_irr['poa_direct'] * iam + poa_irr['poa_diffuse']
effective_irradiance['2022-07-01 14:21:18']
```

Out[82]:

```
160.82770765630568
```

# PV cell temperature

In [83]:

```
all_parameters = pvlib.temperature.TEMPERATURE_MODEL_PARAMETERS['sapm']['open_rack_glass_
cell_temperature = pvlib.temperature.sapm_cell(poa_irr['poa_global'],data['Tamb'],
                                               data['WindVel'],**all_parameters)
cell_temperature.head()
```

Out[83]:

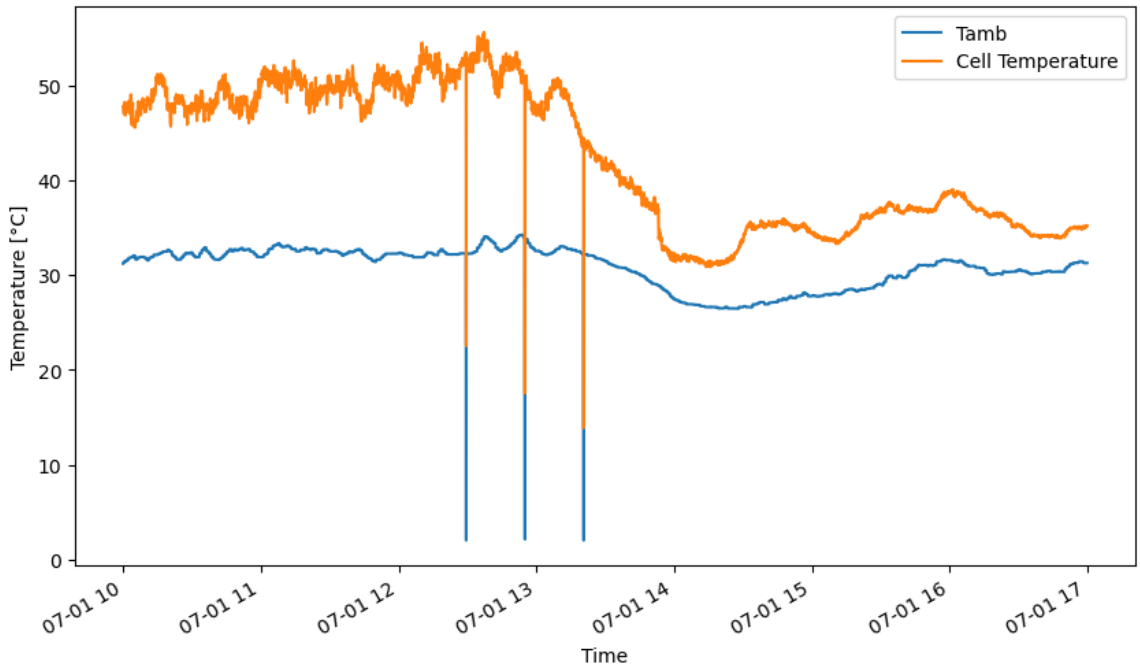
```
2022-07-01 10:00:00    47.776245
2022-07-01 10:00:06    47.523027
2022-07-01 10:00:12    47.486376
2022-07-01 10:00:18    47.036052
2022-07-01 10:00:24    47.981548
dtype: float64
```

In [84]:

```
plt.figure(figsize=(10,6))
data['Tamb'].plot()
cell_temperature.plot()
plt.legend(['Tamb', 'Cell Temperature'])
plt.ylabel('Temperature [°C]');
plt.xlabel('Time')
```

Out[84]:

```
Text(0.5, 0, 'Time')
```



# PV module and inverter selection from database

In [85]:

```
cec_modules = pvlib.pvsystem.retrieve_sam('CECMod') #database modules

PV_module_cec = cec_modules['Lightway_Green_New_Energy_LW200_29_P1650x990'] #200W moduel
```

In [86]:

```
cec_params=pvlib.pvsystem.calcparams_cec(effective_irradiance=effective_irradiance,
                                         temp_cell=cell_temperature,
                                         alpha_sc=PV_module_cec.alpha_sc,
                                         a_ref=PV_module_cec.a_ref,
                                         I_L_ref=PV_module_cec.I_L_ref,
                                         I_o_ref=PV_module_cec.I_o_ref,
                                         R_sh_ref=PV_module_cec.R_sh_ref,
                                         R_s=PV_module_cec.R_s,
                                         Adjust=PV_module_cec.Adjust)
```

In [87]:

```
dc_result=pvlib.pvsystem.singlediode(*cec_params,method='newton')
dc_result.head()
```

Out[87]:

| | i_sc | v_oc | i_mp | v_mp | p_mp | i_x | i_xx |
|---|---|---|---|---|---|---|---|
| **2022-07-01 10:00:00** | 4.274613 | 31.733315 | 3.863964 | 25.703790 | 99.318514 | 4.179922 | 2.860857 |
| **2022-07-01 10:00:06** | 4.179814 | 31.732784 | 3.778854 | 25.731460 | 97.235418 | 4.087231 | 2.802823 |
| **2022-07-01 10:00:12** | 4.274777 | 31.776288 | 3.864509 | 25.746487 | 99.497522 | 4.179956 | 2.861934 |
| **2022-07-01 10:00:18** | 4.223303 | 31.822435 | 3.818712 | 25.807722 | 98.552258 | 4.129492 | 2.831476 |
| **2022-07-01 10:00:24** | 4.234259 | 31.686823 | 3.827313 | 25.669543 | 98.245383 | 4.140601 | 2.835135 |

# PV system

In [88]:

```
system=PVSystem(modules_per_string=20,strings_per_inverter=1,surface_tilt=40)
```

In [89]:

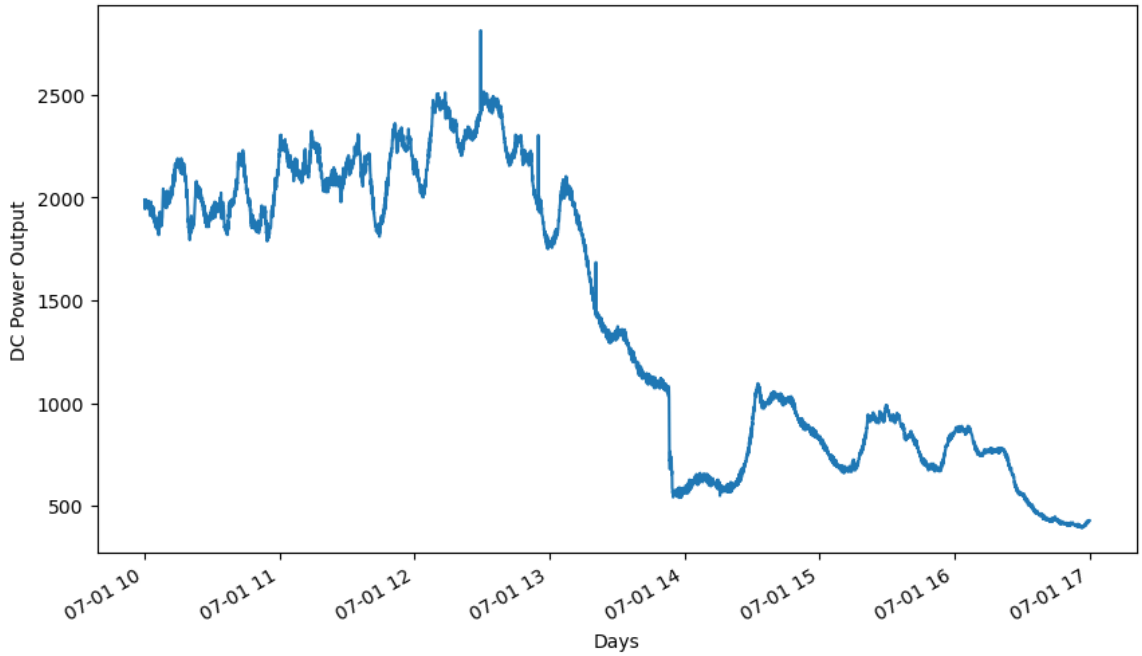
```
dc_result_scaled=system.scale_voltage_current_power(dc_result)
p_mp_dc=dc_result_scaled['p_mp']
p_mp_dc
```

Out[89]:

```
2022-07-01 10:00:00    1986.370276
2022-07-01 10:00:06    1944.708365
2022-07-01 10:00:12    1989.950447
2022-07-01 10:00:18    1971.045161
2022-07-01 10:00:24    1964.907663
                             ...
2022-07-01 16:59:30     421.223608
2022-07-01 16:59:36     429.000188
2022-07-01 16:59:42     424.399744
2022-07-01 16:59:48     430.965043
2022-07-01 16:59:54     430.732664
Name: p_mp, Length: 4193, dtype: float64
```

In [90]:

```
p_mp_dc_single_day=p_mp_dc['2022-07-01']
p_mp_dc_single_day.plot(figsize=(10,6))
plt.xlabel('Days');
plt.ylabel('DC Power Output');
```



In [91]:

```
ac_result=pvlib.inverter.pvwatts(dc_result_scaled.p_mp,
                                 pdc0=4900,
                                 eta_inv_nom=0.97,
                                 eta_inv_ref=0.9637)
ac_result.head(5)
```

Out[91]:

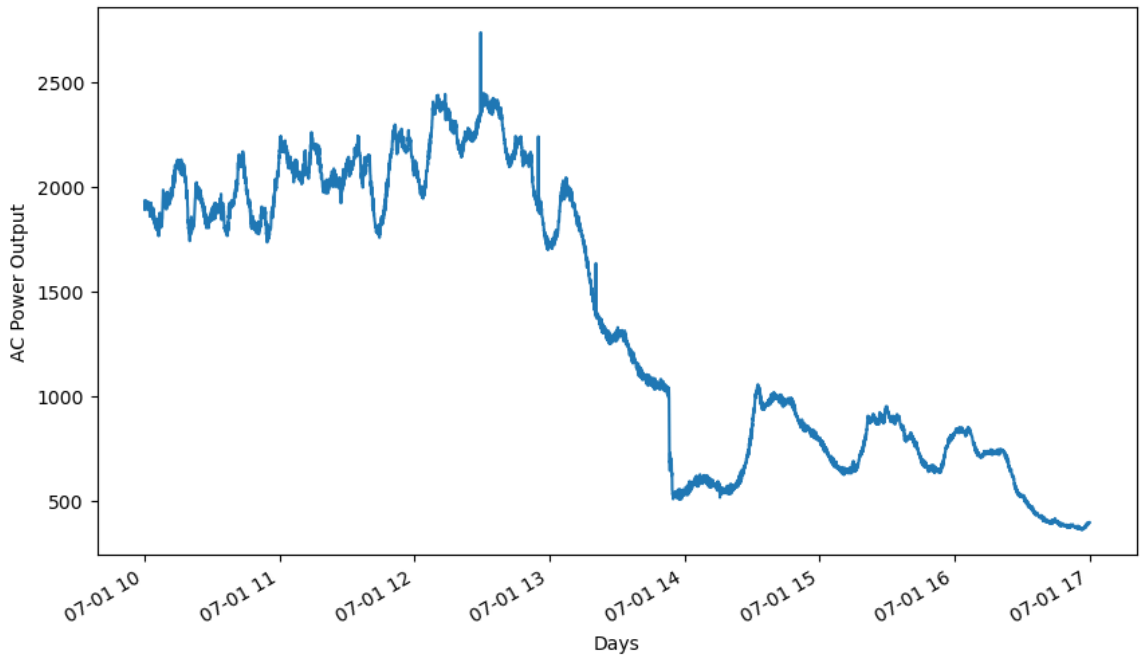
```
2022-07-01 10:00:00    1928.735801
2022-07-01 10:00:06    1887.942004
2022-07-01 10:00:12    1932.240833
2022-07-01 10:00:18    1913.731360
2022-07-01 10:00:24    1907.721849
Name: p_mp, dtype: float64
```

In [92]:

```
single_day=ac_result['2022-07-01']
single_day.plot(figsize=(10,6))
plt.xlabel('Days');
plt.ylabel('AC Power Output')
```

Out[92]:

```
Text(0, 0.5, 'AC Power Output')
```

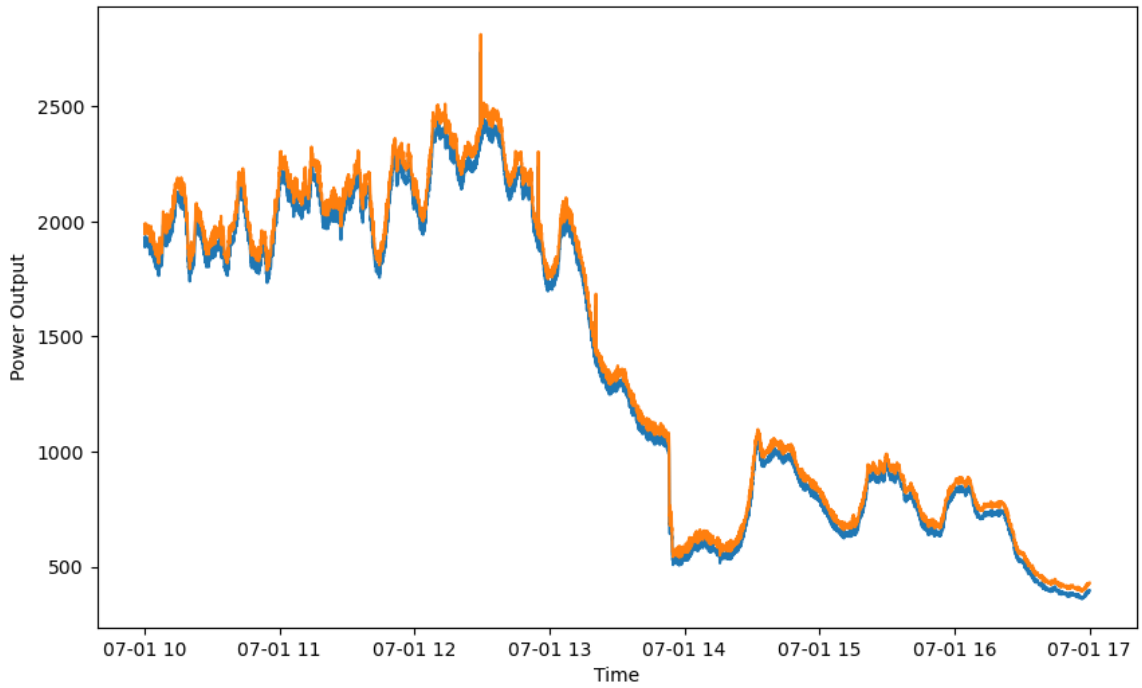


In [93]:

```
plt.figure(figsize=(10,6))
plt.plot(ac_result['2022-07-01'])
plt.plot(p_mp_dc_single_day['2022-07-01'])
plt.xlabel('Time');
plt.ylabel('Power Output')
```

Out[93]:

```
Text(0, 0.5, 'Power Output')
```




In [94]:

```
ac_result['2022-07-01']
```

Out[94]:

```
2022-07-01 10:00:00    1928.735801
2022-07-01 10:00:06    1887.942004
2022-07-01 10:00:12    1932.240833
2022-07-01 10:00:18    1913.731360
2022-07-01 10:00:24    1907.721849
                             ...
2022-07-01 16:59:30     388.267366
2022-07-01 16:59:36     395.961633
2022-07-01 16:59:42     391.409932
2022-07-01 16:59:48     397.905626
2022-07-01 16:59:54     397.675715
Name: p_mp, Length: 4193, dtype: float64
```

In [95]:

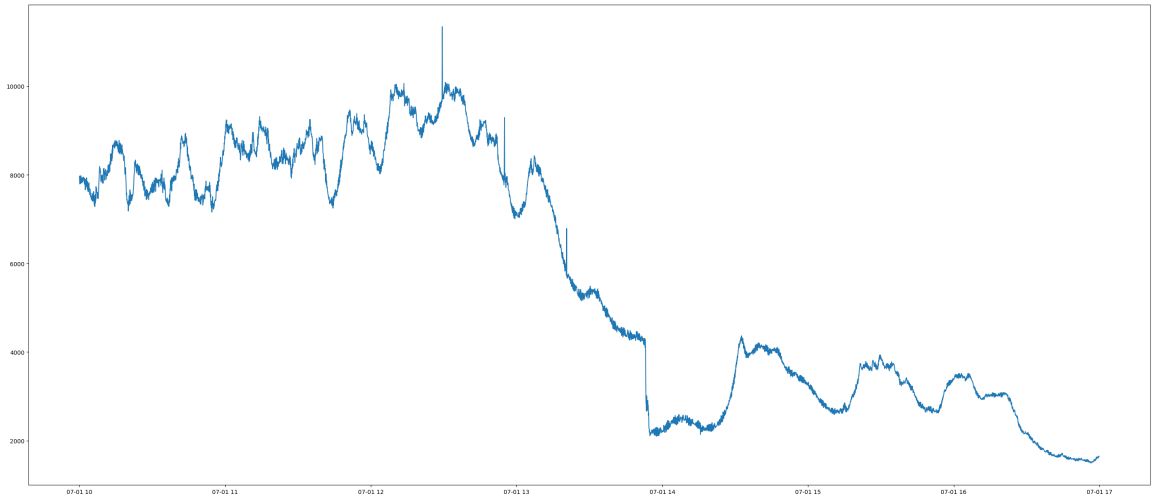
```
physical_power_output=pv_data['power_o/p_physical_model']
actual_power_output=pv_data[['Actual Power ouput']]
```

In [96]:

```
plt.figure(figsize=(35,15))
plt.plot(physical_power_output)
```

Out[96]:

```
[<matplotlib.lines.Line2D at 0x28a40ca6130>]
```

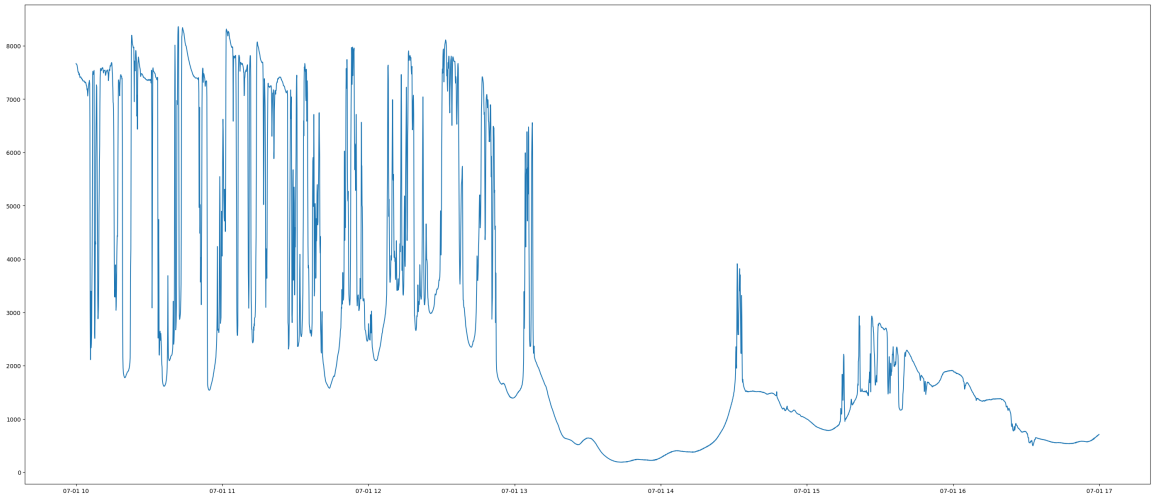



In [97]:

```
plt.figure(figsize=(35,15))
plt.plot(actual_power_output)
```

Out[97]:

```
[<matplotlib.lines.Line2D at 0x28a429a34c0>]
```




In [ ]: