RTSVaticOutput-AllStochastic-Apr02DataProcessedFunctionNew2

January 30, 2022

Process RTS sample scenarios to understand input-output relationship between RTS scenarios and Vatic outputs: (i) total daily system costs; (ii) lost load; (iii) renewable curtailment. The aggregated solar, wind, load assets are considered below.

[1]:
```
import pandas as pd
import bz2
import dill as pickle
import pandas as pd
import csv
import matplotlib.pyplot as plt
from numpy import mean
import numpy as np
import math
```

[2]:
```
pd.options.display.max_rows
pd.options.display.max_columns
pd.set_option('display.max_rows', None)
pd.set_option('display.max_columns', None)
pd.set_option('display.width', None)
Forecast = pd.read_csv("C:\\Users\\Mahashweta␣
 ↪Patra\\Downloads\\ProcessedData\\Forecast.csv")
WindForecast=Forecast['WindForecast']
SolarForecast=Forecast['SolarForecast']
LoadForecast=Forecast['LoadForecast']

Mean = pd.read_csv("C:\\Users\\Mahashweta Patra\\Downloads\\ProcessedData\\Mean.
 ↪csv")
WindMean=Mean['WindMean']
SolarMean=Mean['SolarMean']
LoadMean=Mean['LoadMean']
time= Mean['time']
#print(WindMean)
WindScenarios = pd.read_csv("C:\\Users\\Mahashweta␣
 ↪Patra\\Downloads\\ProcessedData\\WindScenariosAggregated.csv")
SolarScenarios=pd.read_csv("C:\\Users\\Mahashweta␣
 ↪Patra\\Downloads\\ProcessedData\\SolarScenariosAggregated.csv")
LoadScenarios=pd.read_csv("C:\\Users\\Mahashweta␣
 ↪Patra\\Downloads\\ProcessedData\\LoadScenariosAggregated.csv")
```

```
VaticOutput = pd.read_csv("C:\\Users\\Mahashweta␣
↪Patra\\Downloads\\ProcessedData\\VaticOutput.csv")
LoadShedHour = pd.read_csv("C:\\Users\\Mahashweta␣
↪Patra\\Downloads\\ProcessedData\\LoadShedHour.csv")
```

[3]:
```
def plotScens(xTime, yScens,yFrcst,yMean, ax=None, legend=0, **plt_kwargs):
    if ax is None:
        ax = plt.gca()

    ci9 = np.quantile(yScens, 0.9, axis=0)
    ci975 = np.quantile(yScens, 0.975, axis=0)
    ci995 = np.quantile(yScens, 0.995, axis=0)
    ciMax = np.max(yScens,axis=0)
    ci1 = np.quantile(yScens, 0.1, axis=0)
    ci025 = np.quantile(yScens, 0.025, axis=0)
    ci005 = np.quantile(yScens, 0.005, axis=0)
    ciMin = np.min(yScens, axis=0)
    ax.fill_between(xTime, ci005, ci995, color='gray', alpha=.15)
    ax.fill_between(xTime, ci025, ci975, color='b', alpha=.2, label=r'CI␣
↪$95\%$')
    ax.fill_between(xTime, ci1, ci9, color='b', alpha=.2)
    ax.fill_between(xTime, ciMin, ciMax,color='gray',alpha=0.07)
    ax.
↪plot(xTime,yFrcst,'-o',color='darkorange',linewidth=2,markersize=8,label='Forecast')
    ax.plot(xTime, yMean,'--b', label='Mean')
    ax.set_xlim(left=-0.25,right=23.25)
    ax.set_xticks([0,6,12,18,24])
    ax.set_xticklabels(('0', '6', '12', '18', '24'), fontsize='12',␣
↪horizontalalignment='right')
    if legend > 0:
        ax.legend(fontsize=12)
    #ax.plot(x, y, **plt_kwargs) ## example plot here
    return(ax)
```

[4]:
```
#from PlotingFunction import *
#Ploting(time,␣
↪WindScenarios,WindForecast,WindMean,SolarScenarios,SolarForecast,SolarMean,␣
↪LoadScenarios,LoadForecast,LoadMean, VaticOutput, LoadShedHour)
```

```
Traceback (most recent call last):

  File "C:\Users\Mahashweta␣
↪Patra\anaconda3\lib\site-packages\IPython\core\interactiveshell.py", line␣
↪3437, in run_code
    exec(code_obj, self.user_global_ns, self.user_ns)

  File "<ipython-input-4-447d3b2271bb>", line 1, in <module>
```

```
    from PlotingFunction import *

  File "C:\Users\Mahashweta Patra\PlotingFunction.py", line 17
    def Ploting(time,␣
↪WindScenarios,WindForecast,WindMean,SolarScenarios,SolarForecast,SolarMean,␣
↪LoadScenarios,LoadForecast,LoadMean, VaticOutput, LoadShedHour):
    ^

SyntaxError: import * only allowed at module level
```

[4]:

```
fig = plt.figure(figsize=(15,3))
ax = fig.add_subplot(1,3,1)
ax.set_ylabel("Wind Scenarios",fontsize=15)
ax = plotScens(time, WindScenarios,WindForecast,WindMean, ax=ax)
plt.grid(linewidth=0.25)
ax.tick_params(labelsize=15)

#plt.plot( WindScenarios.T,'gray')
#plt.plot(time,WindForecast,'green')
#plt.plot(time, WindMean,'r')
plt.xticks([0,6,12,18,24], ('0', '6', '12', '18', '24'), fontsize='11',␣
↪horizontalalignment='right')
plt.show
plt.grid()
ax.tick_params(labelsize=15)

ax = fig.add_subplot(1,3,2)
ax.set_ylabel("Solar Scenarios",fontsize=15)
ax = plotScens(time, SolarScenarios,SolarForecast,SolarMean, ax=ax)

#ci9 = np.quantile(SolarScenarios, 0.9, axis=0)
#ci975 = np.quantile(SolarScenarios, 0.975, axis=0)
#ci995 = np.quantile(SolarScenarios, 0.995, axis=0)
#ci1 = np.quantile(SolarScenarios, 0.1, axis=0)
#ci025 = np.quantile(SolarScenarios, 0.025, axis=0)
#ci005 = np.quantile(SolarScenarios, 0.005, axis=0)
#ax.fill_between(time, ci005, ci995, color='gray', alpha=.1)
#ax.fill_between(time, ci025, ci975, color='b', alpha=.2)
#ax.fill_between(time, ci1, ci9, color='b', alpha=.3)
#plt.plot(time,SolarForecast,'-o',color='darkorange',linewidth=2,markersize=8)
#plt.plot(time, SolarMean,'--b')
#plt.xticks([0,6,12,18,24], ('0', '6', '12', '18', '24'), fontsize='11',␣
↪horizontalalignment='right')


#plt.plot(SolarScenarios.T,'gray')
#plt.plot(time,SolarForecast,'green')
```

```
#plt.plot(time, SolarMean,'r')
#plt.show
plt.grid(linewidth=0.25)
ax.tick_params(labelsize=15)

ax = fig.add_subplot(1,3,3)
ax.set_ylabel("Load Scenarios",fontsize=15)
#plt.plot(LoadScenarios.T,'gray')
ci95 = np.quantile(LoadScenarios, 0.95, axis=0)
ci99 = np.quantile(LoadScenarios, 0.99, axis=0)
ci1 = np.quantile(LoadScenarios, 0.01, axis=0)
ci5 = np.quantile(LoadScenarios, 0.05, axis=0)
ax.fill_between(time, ci1, ci99, color='b', alpha=.1)
ax.fill_between(time, ci5, ci95, color='b', alpha=.2)
ax = plotScens(time, LoadScenarios,LoadForecast,LoadMean, ax=ax)
#plt.plot(time,LoadForecast,'-o',color='green',linewidth=2,markersize=10)
#plt.plot(time, LoadMean,'--rx')
plt.xticks([0,6,12,18,24], ('0', '6', '12', '18', '24'), fontsize='11',␣
 ↪horizontalalignment='right')
plt.show
#plt.grid()
ax.tick_params(labelsize=15)

GenerationCostAll=VaticOutput['GenerationCostAll']
LoadSheddingAll=VaticOutput['LoadSheddingAll']
RenewableCurtailmentAll=VaticOutput['RenewableCurtailmentAll']
#print(GenerationCost)
#print(np.fromiter(GenerationCost, dtype=int))
fig = plt.figure(figsize=(15,3))
ax = fig.add_subplot(1,3,1)
ax.set_ylabel("Generation Cost",fontsize=15)
ax.hist(GenerationCostAll, bins=20, color='lightblue')
plt.locator_params(axis="x", nbins=4)
plt.grid(linewidth=0.25)
ax.spines['top'].set_visible(False)
ax.spines['right'].set_visible(False)
ax.spines['left'].set_visible(False)
plt.xticks(fontsize=14)
plt.yticks(fontsize=12)

ax = fig.add_subplot(1,3,2)
ax.set_ylabel("Load Shedding",fontsize=15)
ax.hist(LoadSheddingAll, bins=20, color='lightblue')
plt.locator_params(axis="x", nbins=4)
plt.grid(linewidth=0.25)
ax.spines['top'].set_visible(False)
ax.spines['right'].set_visible(False)
```

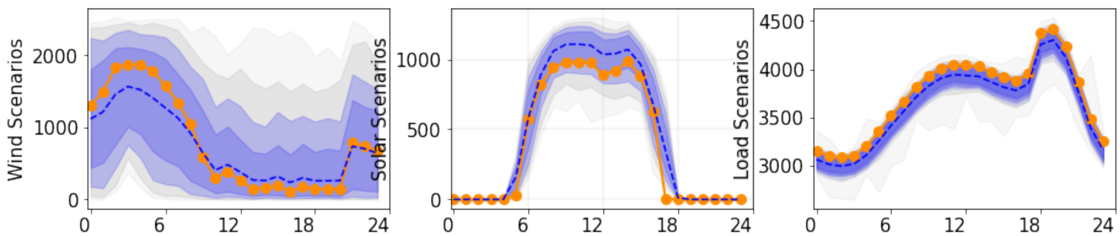
```python
ax.spines['left'].set_visible(False)
plt.xticks(fontsize=14)
plt.yticks(fontsize=12)

ax = fig.add_subplot(1,3,3)
ax.set_ylabel("Renewable Curtailment",fontsize=15)
ax.hist(RenewableCurtailmentAll, bins=20, color='lightblue')
plt.locator_params(axis="x", nbins=4)
plt.grid(linewidth=0.25)
ax.spines['top'].set_visible(False)
ax.spines['right'].set_visible(False)
ax.spines['left'].set_visible(False)
plt.xticks(fontsize=14)
plt.yticks(fontsize=12)
#ax.tick_params(labelsize=15)
from GenCostIntegrationScenario2 import *
from LoadShedHourly import *
DifferenceLoadWindSolar=LoadScenarios-WindScenarios-SolarScenarios
HighGenCost, IntegrationScen=GenCostIntegrationScen2(DifferenceLoadWindSolar,␣
 ↪GenerationCostAll, RenewableCurtailmentAll, LoadSheddingAll, time)
DifferenceLoadWindSolar=WindScenarios
HighGenCost, IntegrationScen=GenCostIntegrationScen2(DifferenceLoadWindSolar,␣
 ↪GenerationCostAll, RenewableCurtailmentAll, LoadSheddingAll, time)
DifferenceLoadWindSolar=SolarScenarios
HighGenCost, IntegrationScen=GenCostIntegrationScen2(DifferenceLoadWindSolar,␣
 ↪GenerationCostAll, RenewableCurtailmentAll, LoadSheddingAll, time)

hours=LoadShedHour['hours']
LoadShed=LoadShedHour['LoadShed']
LoadShedHours(hours, LoadShed)
```

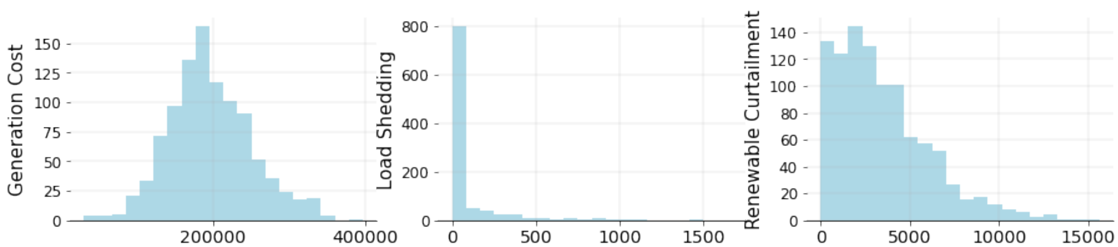
```
The indices of the scenarios which are always above the mean of the scenarios
[10, 99, 156, 634, 655, 700, 846, 910]
58009.53733880001
The number of scenarios for which the integration sum over 24 hrs are bigger
than the integration sum for the mean
```

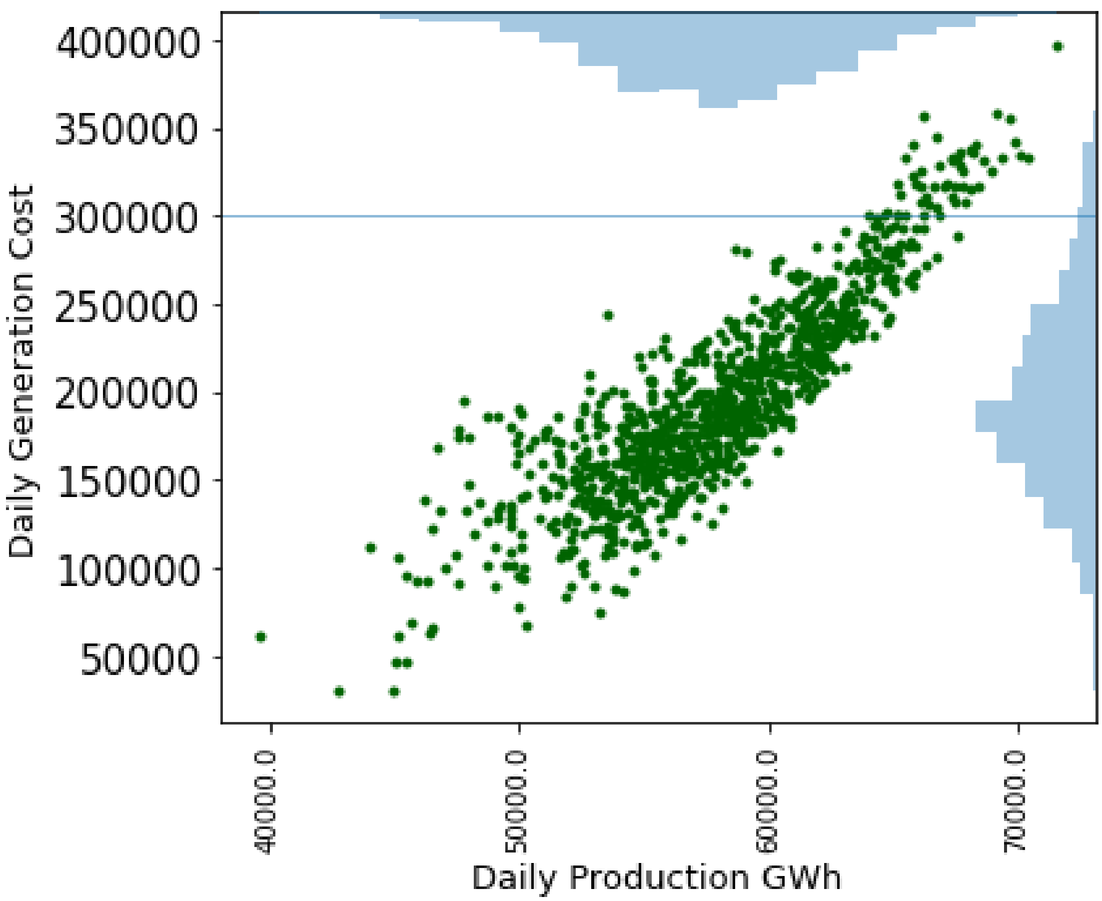
```
C:\Users\Mahashweta Patra\GenCostIntegrationScenario2.py:138: UserWarning:
FixedFormatter should only be used together with FixedLocator
  ax_scatter.set_xticklabels(ax_scatter.get_xticks(), rotation = 90,
fontsize=10)
```

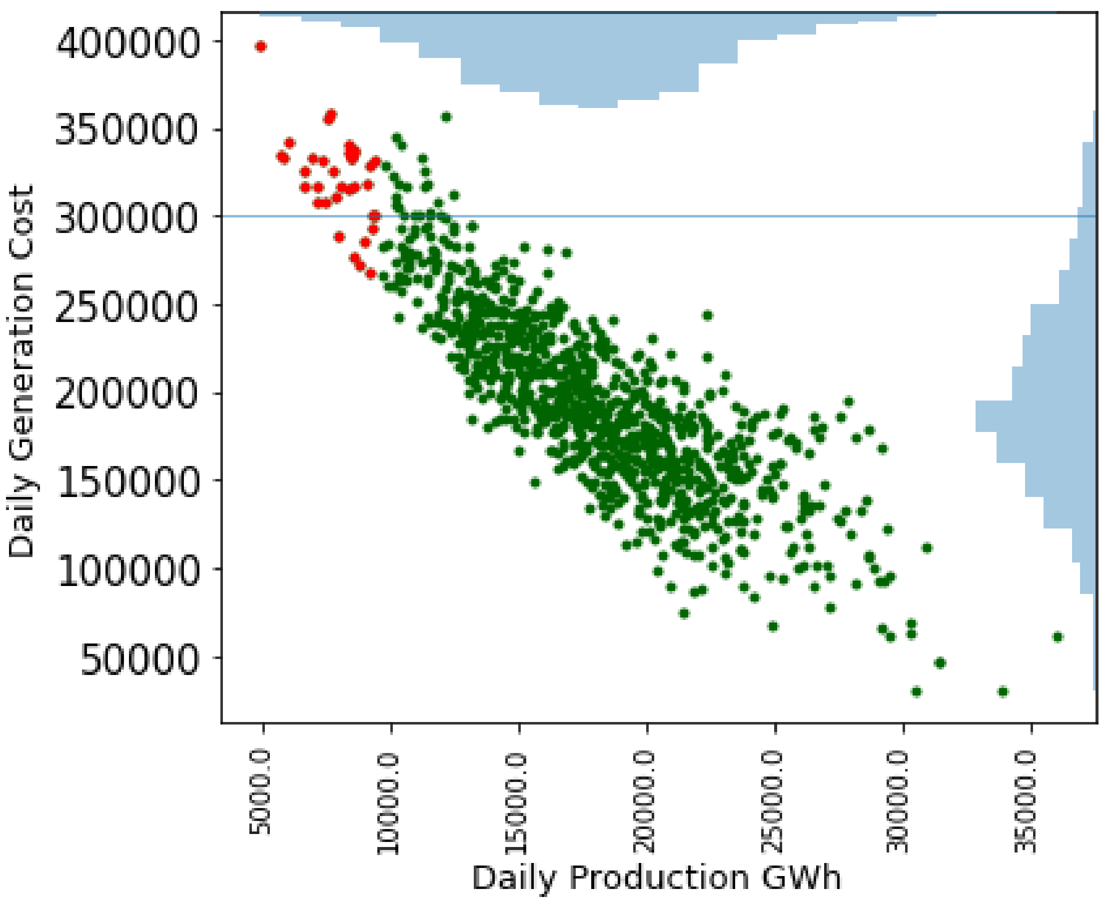
```
The indices of the scenarios which are always above the mean of the scenarios
[389, 794]
17786.862796200003
The number of scenarios for which the integration sum over 24 hrs are bigger
than the integration sum for the mean
The indices of the scenarios which are always above the mean of the scenarios []
```

```
11146.647932400005
The number of scenarios for which the integration sum over 24 hrs are bigger
than the integration sum for the mean
(array([], dtype=int64),)
[184, 119, 34, 5, 34, 77, 20, 1, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0, 1, 0, 0, 0, 0]
```

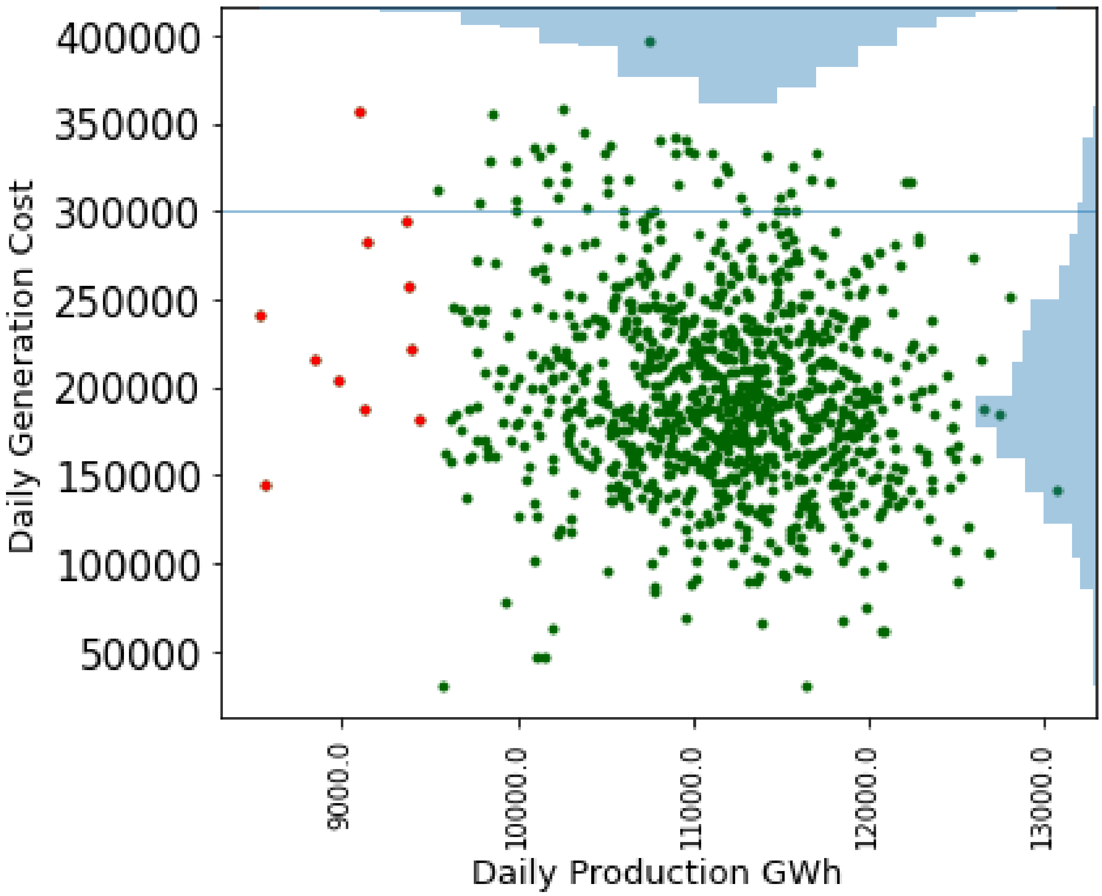


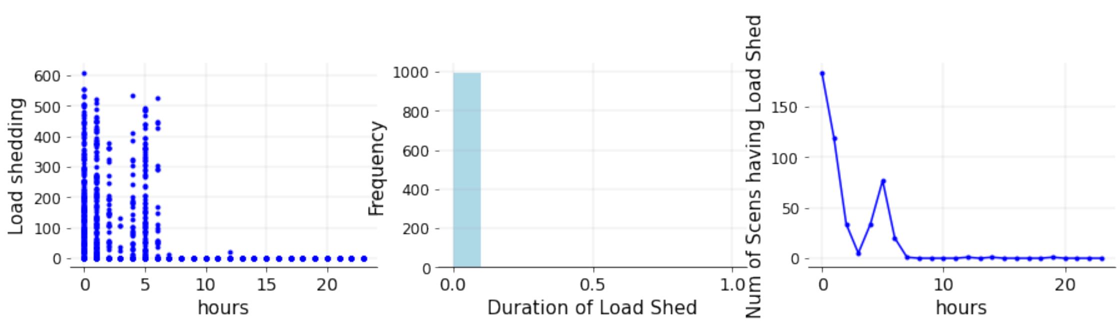



Daily Generation Cost
400000
350000
300000
250000
200000
150000
100000
50000
40000.0
50000.0
60000.0
70000.0
Daily Production GWh



400000
350000
300000
250000
200000
150000
100000
50000
Daily Generation Cost
5000.0
10000.0
15000.0
20000.0
25000.0
30000.0
35000.0
Daily Production GWh





We consider all load, solar and wind to be stochastic and in that case we try to understand the relationship between the scenarios and the vatic output. The scenario causing the high generation cost, for them the integration of energy generation over 24 hrs are high and above the thresold value. We consider only those scenario which has a rapid jump in energy generation from 16th hour to 17th hour. This rapid jump in energy causes the higher generation cost. The scenarios that causes the highest 5% generation cost does not have any connection with the Load shedding or the renewable curtailment though. We consider those scenarios whose integration value is high

(higher than some thresold value)