

```
In [1]: # REFERENCE FUNCTIONS
```

```
In [2]: import pandas as pd
import numpy as np
import Template_GeneralFunctions as GenFun
import Template_CatenaryFlexibleFunctions as Flex
```

```
In [3]: # INPUT DATA
```

```
In [4]: ## CALCULATION AND DESIGN CONSTANTS
### Calculation variables
```

```
In [5]: xRound=1
xStep=1
xMultiplier=1
yMultiplier=1
xStaticMultiplier=0.2
yStaticMultiplier=10
```

```
In [6]: ### Design variables (Base Units [ft, Lbf])
```

```
In [7]: MaxHSpacing=30
minCW_P=0
MinHLength=3/12
HA_Accuracy=1/50/12
SteadyArmLength=3
```

```
In [8]: ## CONDUCTOR PARTICULARS AND LOADING CONDITIONS
```

```
In [9]: Conductors = pd.DataFrame(
    {'Type': ['Messenger Wire', 'Contact Wire', 'Hangers'],
     'Weight': [1.544,1.063,0.2],
     'Tension': [5000,3300,0]})
```

```
In [10]: ## LAYOUT DESIGN
```

```
In [11]: df=pd.read_csv('InputData.csv')
```

```
In [12]: ## DISCRETE SPAN LOADS AND DESIGN CONDITIONS
### Discrete span loads. + weight is in the downward direction
```

```
In [13]: STA_DiscreteLoad_CW = np.array([162298,162612,0])
P_DiscreteLoad_CW = np.array([5,10,0])
STA_DiscreteLoad_MW = np.copy(STA_DiscreteLoad_CW)
P_DiscreteLoad_MW = np.array([0,0,0])
```

```
In [14]: #Steady arms with fixed elevations (applied load calculated by span geometry)
```

```
In [15]: ExpectedSupport_P = 5
STA_FixedSupport_CW=np.array([0,0,0,0])
FixedSupport_EL_Tolerance = 0.1/12
```

```
In [16]: #Critical Clearance Stationing and Elevation
```

```
In [17]: ClearanceSTA = np.array([0,0])  
ClearanceEL = np.array([0,0])
```

```
In [18]: #Stationing of Interest
```

```
In [19]: FocusStation=165250  
FocusNeg:350  
FocusPos=350
```

```
In [20]: # CALCULATIONS
```

```
In [21]: FullWireRun=GenFun.WireRun_df(df,xRound)  
FullWireRun['PreSag']=0  
FullWireRun
```

Out[21]:

	PoleID	STA	Rail EL	MW Height	CW Height	PreSag	Deviation Angle	SpanLength
0	1	162297.0	0	24.00	20.000000	0	0	155.0
1	2	162452.0	0	23.50	19.250000	0	0	160.0
2	3	162612.0	0	23.50	18.500000	0	0	133.0
3	4	162745.0	0	22.50	18.500000	0	0	150.0
4	5	162895.0	0	22.50	18.500000	0	0	173.0
5	6	163068.0	0	22.50	18.500000	0	0	190.0
6	7	163258.0	0	22.50	18.500000	0	0	190.0
7	8	163448.0	0	22.50	18.500000	0	0	190.0
8	9	163638.0	0	22.50	18.500000	0	0	190.0
9	10	163828.0	0	22.25	18.250000	0	0	186.0
10	11	164014.0	0	21.75	17.750000	0	0	170.0
11	12	164184.0	0	21.25	17.250000	0	0	190.0
12	13	164374.0	0	20.75	16.750000	0	0	190.0
13	14	164564.0	0	20.25	16.250000	0	0	191.0
14	15	164755.0	0	19.75	15.750000	0	0	192.0
15	16	164947.0	0	19.25	15.250000	0	0	130.0
16	17	165077.0	0	18.00	15.000000	0	0	130.0
17	18	165207.0	0	17.25	14.750000	0	0	130.0
18	19	165337.0	0	16.50	14.500000	0	0	130.0
19	20	165467.0	0	16.50	14.500000	0	0	126.0
20	21	165593.0	0	16.50	14.500000	0	0	82.0
21	22	165675.0	0	15.75	14.500000	0	0	74.0
22	23	165749.0	0	15.75	14.500000	0	0	120.0
23	24	165869.0	0	16.50	14.500000	0	0	119.0
24	25	165988.0	0	16.50	14.500000	0	0	120.0
25	26	166108.0	0	16.50	14.500000	0	0	119.0
26	27	166227.0	0	15.75	14.500000	0	0	58.0
27	28	166285.0	0	15.50	14.500000	0	0	94.0
28	29	166379.0	0	17.00	14.500000	0	0	95.0
29	30	166474.0	0	17.50	14.500000	0	0	52.0
30	31	166526.0	0	17.50	14.583333	0	0	154.0
31	32	166680.0	0	19.00	14.833333	0	0	135.0
32	33	166815.0	0	20.00	15.000000	0	0	165.0
33	34	166980.0	0	20.00	15.750000	0	0	180.0

	PoleID	STA	Rail EL	MW Height	CW Height	PreSag	Deviation Angle	SpanLength
34	35	167160.0	0	21.00	17.000000	0	0	NaN

```
In [22]: L_DesignBase=[xStep,xRound,xMultiplier,yMultiplier,SteadyArmLength]
L_SpanLoading=[P_DiscreteLoad_CW,STA_DiscreteLoad_CW,P_DiscreteLoad_MW,STA_DiscreteLoad_MW]
L_DesignHA=[MaxHASpacing,minCW_P,MinHALength,HA_Accuracy]
L_StaticCWLoading=[-25,162475]
```

```
In [23]: Nominal = Flex.CatenarySag_Flexible(FullWireRun,Conductors['Weight'],
Conductors['Tension'],L_SpanLoading,L_DesignHA,L_DesignHA)

# Nominal dictionary keys
# Stationing, HA_STA, HA_EL
# LoadedSag, SupportLoad_CW, P_SpanWeight
# LoadedSag_MW, SupportLoad_MW, P_SpanWeight_MW

subloop = 1
```

```
In [24]: Uplift, cloops, NewCWSupportReaction = Flex.CatenarySag_FlexibleHA_Iterative(FullWireRun,Conductors['Weight'],
Conductors['Tension'],L_SpanLoading,L_DesignHA,L_DesignHA)

# Uplift dictionary keys
# Stationing, HA_STA, HA_EL
# LoadedSag, SupportLoad_CW, P_SpanWeight
# LoadedSag_MW, SupportLoad_MW, P_SpanWeight_MW

Main Loops= 4 subLoop2= 0 subLoop1= 0
```

```
In [25]: FocusSPT = 2
StartSPT = FocusSPT-1
EndSPT = FocusSPT+1
Elasticity = Flex.CatenaryElasticity_FlexibleHA(FullWireRun, 0*Conductors['Weight'],
Conductors['Tension'], L_DesignHA, L_DesignHA,
Nominal, StartSPT, EndSPT)

# Elasticity dictionary keys
# STAVaL, DiffMIN, DiffMAX, CycleLoops
```

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

```

Elasticity with uplift at STA= 162722.0
Main Loops= 3 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162723.0
Main Loops= 3 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162724.0
Main Loops= 3 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162725.0
Main Loops= 3 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162726.0
Main Loops= 3 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162727.0
Main Loops= 3 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162728.0
Main Loops= 3 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162729.0
Main Loops= 3 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162730.0
Main Loops= 3 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162731.0
Main Loops= 3 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162732.0
Main Loops= 3 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162733.0
Main Loops= 3 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162734.0
Main Loops= 3 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162735.0
Main Loops= 3 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162736.0
Main Loops= 3 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162737.0
Main Loops= 3 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162738.0
Main Loops= 3 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162739.0
Main Loops= 3 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162740.0
Main Loops= 3 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162741.0
Main Loops= 2 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162742.0
Main Loops= 2 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162743.0
Main Loops= 2 subLoop2= 0 subLoop1= 0
Elasticity with uplift at STA= 162744.0
Main Loops= 2 subLoop2= 0 subLoop1= 0

```

```
In [26]: # OUTPUT
```

```
In [27]: import seaborn as sns
```

```
In [28]: NominalSag = pd.DataFrame({'Stationing': np.append(Nominal.get('Stationing'),Nominal.get('Sag'),
                                                         'Sag': np.append(Nominal.get('LoadedSag'),Nominal.get('LoadedSag_MW')),
                                                         'Cable Type': np.append((Nominal.get('LoadedSag')*0),Nominal.get('LoadedSag_MW'))),
                                NominalSag=NominalSag.pivot(index='Stationing', columns='Cable Type', values='Sag')
                                NominalSag.head()
```

Out[28]: **Cable Type** **0.0** **1.0**

Stationing

162297.0 20.009060 24.000000

162298.0 20.010994 23.948176

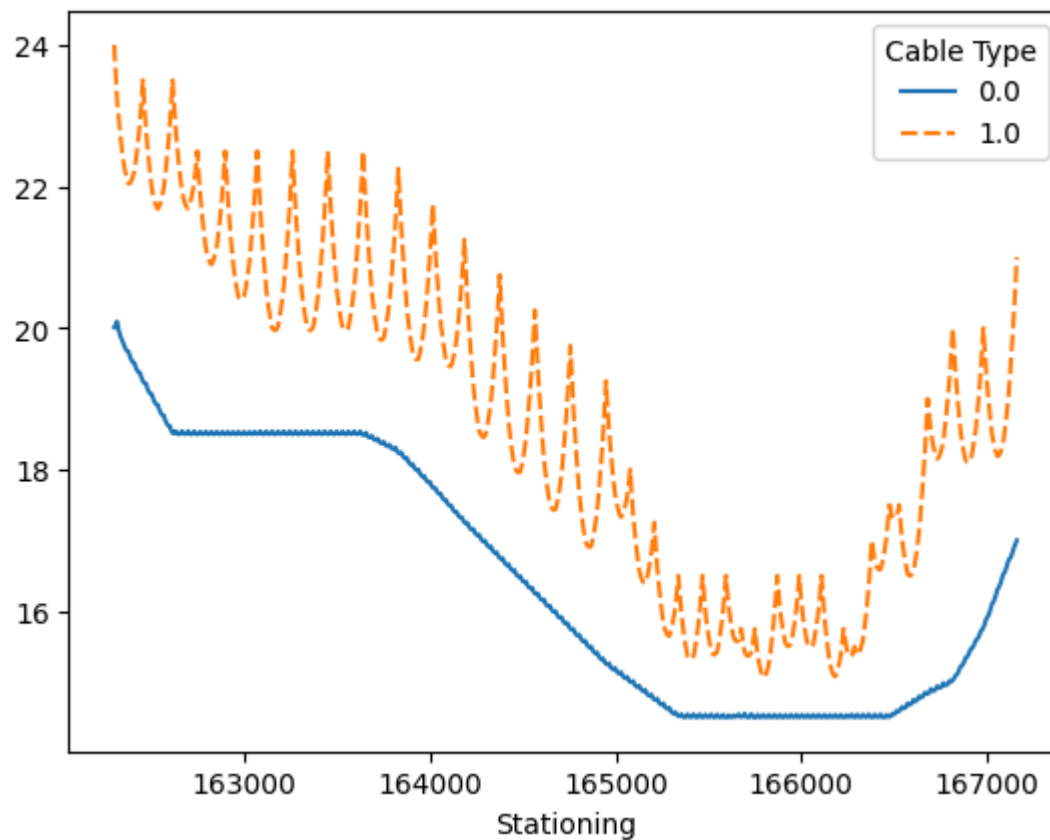
162299.0 20.014007 23.896701

162300.0 20.018100 23.845575

162301.0 20.022516 23.794797

In [29]: `sns.lineplot(data=NominalSag)`

Out[29]: `<Axes: xlabel='Stationing'>`



In [30]: `UpliftSag = pd.DataFrame({'Stationing': np.append(Uplift.get('Stationing'),Uplift.get('Stationing')),
 'Sag': np.append(Uplift.get('LoadedSag'),Uplift.get('LoadedSag_MW')),
 'Cable Type': np.append((Uplift.get('LoadedSag')*0),Uplift.get('LoadedSag_MW'))},
 index=UpliftSag.index, columns=['Stationing', 'Cable Type', 'Sag'])
UpliftSag=UpliftSag.pivot(index='Stationing', columns='Cable Type', values='Sag')
UpliftSag.head()`

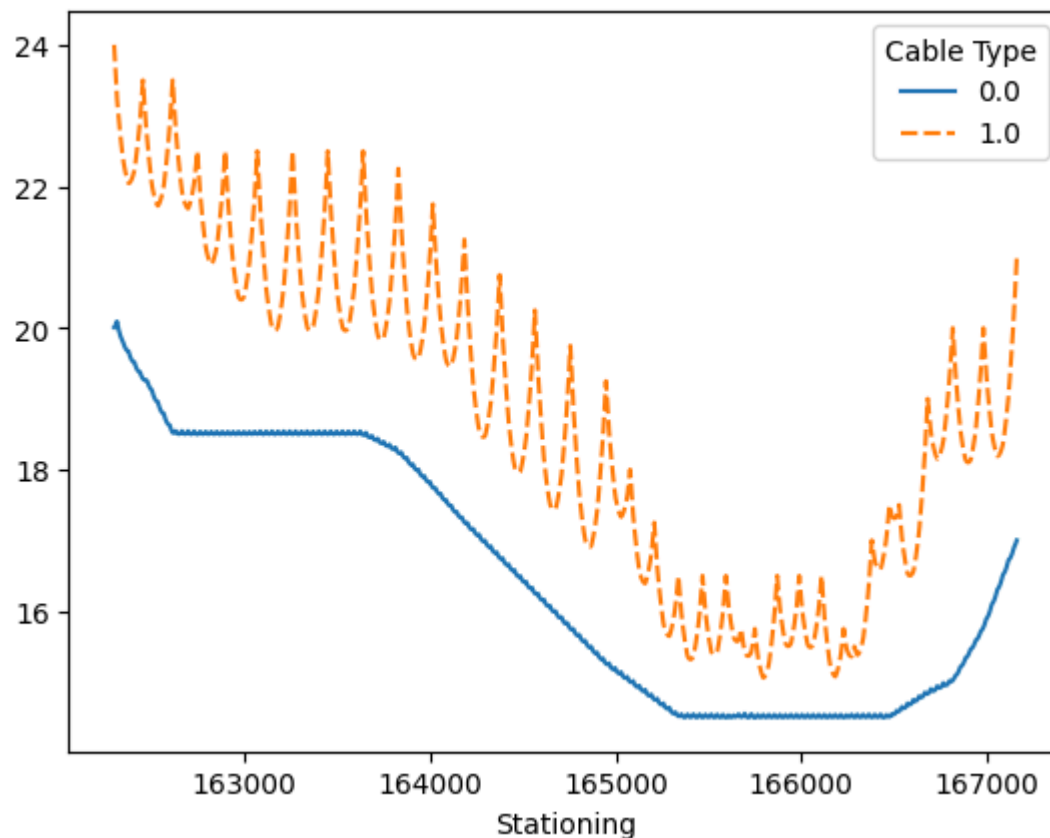
Out[30]: **Cable Type** **0.0** **1.0**

Stationing

162297.0	20.009060	24.000000
162298.0	20.011075	23.948256
162299.0	20.014171	23.896860
162300.0	20.018346	23.845813
162301.0	20.022843	23.795115

In [31]: `sns.lineplot(data=UpliftSag)`

Out[31]: `<Axes: xlabel='Stationing'>`



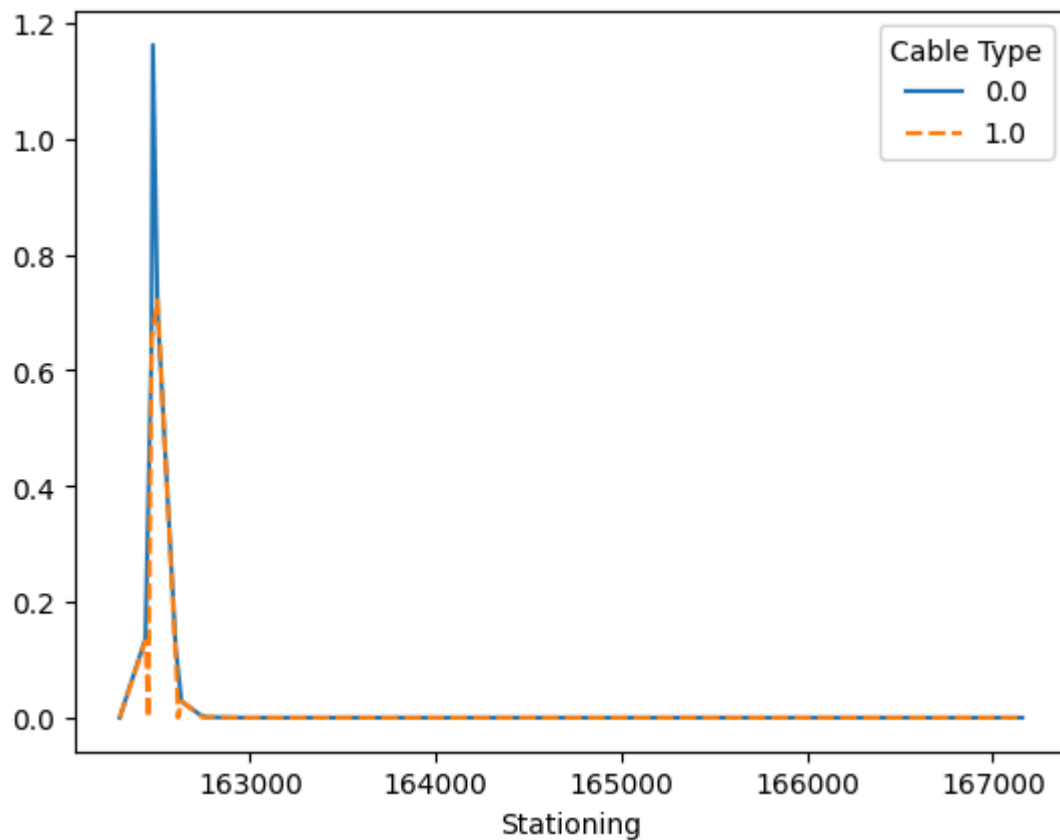
In [32]: `DiffCW = (Uplift.get('LoadedSag')-Nominal.get('LoadedSag'))*12
DiffMW = (Uplift.get('LoadedSag_MW')-Nominal.get('LoadedSag_MW'))*12
DiffSag = pd.DataFrame({'Stationing': np.append(Uplift.get('Stationing'),Uplift.get('S
'Sag': np.append(DiffCW,DiffMW),
'Cable Type': np.append((Uplift.get('LoadedSag')*0),Uplift.get('LoadedS
DiffSag=DiffSag.pivot(index='Stationing', columns='Cable Type', values='Sag')
DiffSag.head()`

Out[32]: **Cable Type** **0.0** **1.0**

Stationing		
162297.0	0.000000	0.000000
162298.0	0.000980	0.000952
162299.0	0.001961	0.001905
162300.0	0.002941	0.002857
162301.0	0.003921	0.003810

In [33]: `sns.lineplot(data=DiffSag)`

Out[33]: `<Axes: xlabel='Stationing'>`



In [34]: `ElasticityGraph = pd.DataFrame({'Stationing': np.append(Elasticity.get('STAVa1'),Elasticity.get('STAVa2')),
'Uplift': np.append(Elasticity.get('DiffMIN')*12,Elasticity.get('DiffMAX')*12),
'Min/Max': np.append((Elasticity.get('DiffMIN')*0),Elasticity.get('DiffMAX')*0)})
ElasticityGraph=ElasticityGraph.pivot(index='Stationing', columns='Min/Max', values='Uplift')
ElasticityGraph.head()`

Out[34]: **Min/Max** 0.0 1.0

Stationing

162452.0 0.0 1.094093

162453.0 0.0 1.091717

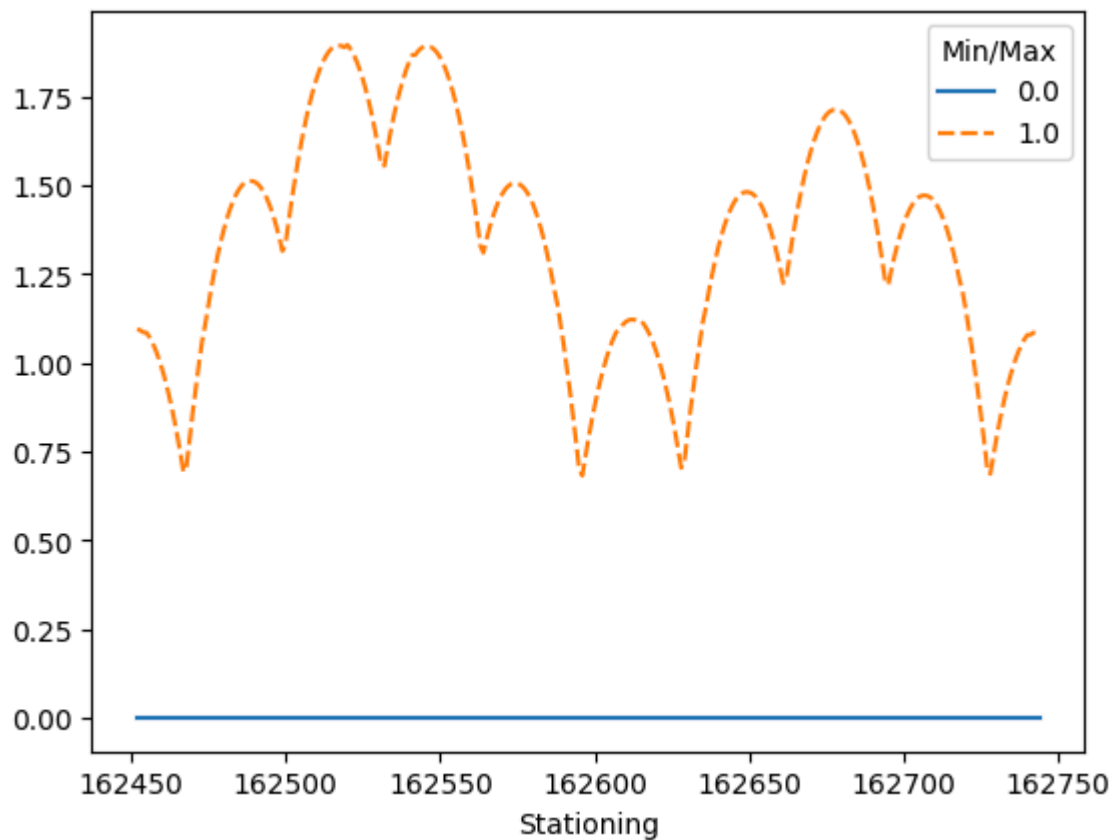
162454.0 0.0 1.085467

162455.0 0.0 1.084777

162456.0 0.0 1.071872

In [35]: `sns.lineplot(data=ElasticityGraph)`

Out[35]: `<Axes: xlabel='Stationing'>`



In [36]: `# SAVE OUTPUT`

In [37]: `NominalSag.to_csv('OutputData.csv')`

In [38]: `FullWireRun['STA'].iloc[3]-FullWireRun['STA'].iloc[1]`

Out[38]: 293.0

In [39]: `Uplift.get('SupportLoad_CW')-Nominal.get('SupportLoad_CW')`

```
In [40]: len(Uplift.get('SupportLoad_CW'))
```

```
In [41]: len(Uplift.get('HA_STA'))
```

In []: