# Import libraries

In [1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from functools import reduce
```

# Import EPRI Data

In [2]:
```
EPRI = 'EPRI.xlsx'

# Extracting Data-frames
df_FES = pd.read_excel(EPRI, sheet_name = 'Fire Event Summaries')
df_FEA = pd.read_excel(EPRI, sheet_name = 'Fire Event Attributes')
df_FSE = pd.read_excel(EPRI, sheet_name = 'Fire Severity Evaluation')
df_FTS = pd.read_excel(EPRI, sheet_name = 'Fire Timeline and Suppression')
df_PR  = pd.read_excel(EPRI, sheet_name = 'Plant Response')

df_epri = [df_FES, df_FEA, df_FSE, df_FTS, df_PR]
```

In [3]:
```
# Set FireID as index

df_FES.set_index('FireID',inplace=True)
df_FEA.set_index('FireID',inplace=True)
df_FSE.set_index('FireID',inplace=True)
df_FTS.set_index('FireID',inplace=True)
df_PR.set_index('FireID', inplace=True)
```

# Merge Dataframes

In [4]:
```
df_epri_merge = reduce(lambda x,y: pd.merge(x,y, on='FireID', how='outer', sort = True), df_epri)
```

In [6]:
```
print(df_epri_merge.columns)
print(df_epri_merge.shape)
```

```
Index(['Event Date_FES', 'Disposition_FES', 'Outside PA', 'Plant Area',
       'Building', 'System', 'Component Group', 'Component', 'Voltage',
       'Current Type', 'Event Date_FEA', 'Disposition_FEA', 'Fire Cause',
       'Group', 'Type', 'Form', 'Fire Type', 'Smoke', 'Temperature',
       'Damage Extent', 'Collated Damage', 'Event Date_FSE', 'Disposition_FSE',
       'Review Status:', 'Automatic Determination', 'Unnamed: 5', 'Unnamed: 6',
       'Event Date_FTS', 'Diposition_FTS', 'Ignition', 'Discovery',
       'Duration Certainty', 'Duration', 'Detection Method',
       'Detection Performance', 'Suppression Method', 'Suppression Agent',
       'Unnamed: 11', 'Unnamed: 12', 'Event Date_PR', 'Diposition_PR',
       'Mode Prior', 'Mode After', 'Power Level Prior', 'Power Level After',
       'Power Effect', 'EAL Declaration'],
      dtype='object')
(2205, 47)
```

# Data Cleanup

**Disposition - Fire Event Summary**

In [8]:
```
dip_fes = df_epri_merge.Disposition_FES.unique()
print(dip_fes)
```

```
['Undetermined' 'Not Challenging' 'Challenging' nan 'Not Evaluated'
 'Potentially Challenging' 'Undetermined (NC-PC) ' 'Undetermined (PC-CH)'
 'Undetermined (NC-PC)' 'Not Challenging ' 'Potentially Challenging '
 ' Not\xa0Challenging' 'Not\xa0Challenging' 'Potentially\xa0Challenging'
 'Undetermined\xa0(NC-PC)' 'Undetermined\xa0(PC-CH)'
 ' Undetermined\xa0(PC-CH)' ' Challenging' ' Undetermined\xa0(NC-PC)'
 ' Potentially\xa0Challenging' 'Undetermined(NC-PC)'
 'Undetermined (PC-CH)' 'Not+D20421:D20432Challenging']
```

In [10]:
```
df_epri_merge['Disposition_FES'] = df_epri_merge['Disposition_FES'].replace(['Potentially\xa0Challenging'
                                                    ' Not\xa0Challenging', 'Not\xa0Challenging',
                                                     'Undetermined\xa0(NC-PC)', 'Undetermined\xa0(PC-CH
                                                    'Undetermined(NC-PC)', 'Not+D20421:D20432Challengir
                                                    ['Potentially Challenging', 'Potentially Challengir
                                                    'Not Challenging', 'Not Challenging',
                                                    'Undetermined (NC-PC)', 'Undetermined (PC-CH)', 'Ur
                                                    'Undetermined (NC-PC)', 'Not Challenging', 'Challer
```

In [11]:
```
df_epri_merge.Disposition_FES.unique()
```

Out[11]:
```
array(['Undetermined', 'Not Challenging', 'Challenging', nan,
       'Not Evaluated', 'Potentially Challenging', 'Undetermined (NC-PC)',
       'Undetermined (PC-CH)', 'Not Challenging ',
       'Potentially Challenging '], dtype=object)
```

**Disposition - Fire Event Attributes**

In [13]:
```
dip_fea = df_epri_merge.Disposition_FEA.unique()
print(dip_fea)
```

```
['Undetermined' 'Not Challenging' 'Challenging' nan 'Not Evaluated'
 'Potentially Challenging' 'Undetermined (NC-PC)' 'Undetermined (PC-CH)'
 'otentially Challenging' 'Undetermined (PC-CH) ' 'Undetermined (PC-CH) '
 'Undetermined(NC-PC)' 'NotChallenging' 'Undetermined(PC-CH)'
 'PotentiallyChallenging' 'Undetermined(NC-PC' ': Not Challenging'
 'Undetermined (NC-PC) FireID: 10614' 'Unknown' 'Undetermined (NC-PC'
 'Undetermined (PC-CH' 'Other electrical or electronic equipment'
 'Not Challengin']
```

In [14]:
```
df_epri_merge['Disposition_FEA'] = df_epri_merge['Disposition_FEA'].replace(['Undetermined\xa0(NC-PC)', '
                                                    'Undetermined\xa0(PC-CH)', 'Potentially\xa0Challer
                                                    'Not\xa0Evaluated ', 'Not\xa0Evaluated', 'Potentia
                                                             ': Not Challenging', 'Undetermined (NC-P
                                                            'NotChallenging', 'otentially Challenging
                                                            'Not Challengin', 'Undetermined (PC-CH',
                                                            'Undetermined (PC-CH) ', 'Undetermined (P
                                                    ['Undetermined (NC-PC)', 'Undetermined (PC-CH)', 'U
                                                     'Undetermined (PC-CH)', 'Potentailly Challenging',
                                                    'Not Evaluated', 'Not Evaluated', 'Potentailly Chal
                                                    'Not Challenging', 'Undetermined (NC-PC)',
                                                    'Not Challenging', 'Potentially Challenging', 'Pote
                                                    'Not Challenging', 'Undetermined (PC-CH)','Undeterm
                                                    'Undetermined (PC-CH)', 'Undetermined (PC-CH)', 'Ur
```

In [15]:
```
df_epri_merge.Disposition_FEA.unique()
```

Out[15]:
```
array(['Undetermined', 'Not Challenging', 'Challenging', nan,
       'Not Evaluated', 'Potentially Challenging', 'Undetermined (NC-PC)',
       'Undetermined (PC-CH)', 'Unknown', 'Undetermined (NC-PC',
       'Other electrical or electronic equipment'], dtype=object)
```

**Disposition - Fire Severity Evaluation**

In [17]:
```
disp_fsebf = df_epri_merge.Disposition_FSE.unique()
disp_fsebf
```

Out[17]:
```
array(['Undetermined', 'Not Challenging', 'Challenging', nan,
       'Not Evaluated', 'Potentially Challenging', 'Undetermined (NC-PC)',
       'Undetermined (PC-CH)', 'Preliminary', 'Undetermined\xa0(NC-PC)',
       'Undetermined\xa0(PC-CH) ', 'Undetermined\xa0(NC-PC) ',
       'Undetermined\xa0(PC-CH)', 'Potentially\xa0Challenging',
       'Not\xa0Evaluated ', 'Not\xa0Evaluated',
       'Potentially\xa0Challenging '], dtype=object)
```

In [18]:
```
df_epri_merge['Disposition_FSE'] = df_epri_merge['Disposition_FSE'].replace(['Undetermined\xa0(NC-PC)', '
                                                                             'Undetermined\xa0(NC-PC) ', 'Undetermined\
                                                                             'Potentially\xa0Challenging', 'Not\xa0Eval
                                                                             'Potentially\xa0Challenging '],
                                                                            ['Undetermined (NC-PC)', 'Undetermined (PC-CH)',
                                                                            'Undetermined (NC-PC)', 'Undetermined (PC-CH)',
                                                                            'Potentially Challenging', 'Not Evaluated', 'Not Ev
                                                                            'Potentially Challenging'])
```

In [19]:
```
df_epri_merge.Disposition_FSE.unique()
```

Out[19]:
```
array(['Undetermined', 'Not Challenging', 'Challenging', nan,
       'Not Evaluated', 'Potentially Challenging', 'Undetermined (NC-PC)',
       'Undetermined (PC-CH)', 'Preliminary'], dtype=object)
```

**Disposition - Fire Timeline and Supression**

In [20]:
```
disp_ftsbf = df_epri_merge.Diposition_FTS.unique()
disp_ftsbf
```

Out[20]:
```
array(['Undetermined', 'Not\xa0Challenging', 'Challenging', nan,
       'Not\xa0Evaluated', 'Potentially\xa0Challenging',
       'Undetermined\xa0(NC-PC)', 'Undetermined\xa0(PC-CH)',
       'Challenging ', 'Undetermined\xa0(NC-PC) ', 'Not\xa0Challenging ',
       'Potentially\xa0Challenging ', 'Not Challenging',
       'Potentially Challenging', 'Undetermined (NC-PC)',
       'Undetermined (PC-CH)',
       'Other plant personnel (in vicinity or passerby)', 'Not Evaluated'],
      dtype=object)
```

In [21]:
```
df_epri_merge['Diposition_FTS'] = df_epri_merge['Diposition_FTS'].replace(['Not\xa0Challenging', 'Not\xa0
                                                                           'Undetermined\xa0(NC-PC)', 'Undetermined\xa
                                                                           'Not\xa0Challenging ', 'Potentially\xa0Chal
                                                                           ['Not Challenging', 'Not Evaluated', 'Poter
                                                                           'Undetermined (NC-PC)', 'Undetermined (PC-C
                                                                           'Not Challenging', 'Potentially Challenging
```

In [22]:
```
df_epri_merge.Diposition_FTS.unique()
```

Out[22]:
```
array(['Undetermined', 'Not Challenging', 'Challenging', nan,
       'Not Evaluated', 'Potentially Challenging', 'Undetermined (NC-PC)',
       'Undetermined (PC-CH)', 'Challenging ',
       'Other plant personnel (in vicinity or passerby)'], dtype=object)
```

**Disposition - Plant Records**

In [25]:
```
disp_prbf = df_epri_merge.Diposition_PR.unique()
disp_prbf
```

Out[25]:
```
array(['Undetermined', 'Not Challenging', 'Challenging', nan,
       'Not Evaluated', 'Potentially Challenging', 'Undetermined (NC-PC)',
       'Undetermined (PC-CH)', 'Unusual Event', 'Cold Shutdown',
       'Not Challenging ', 'Undetermined\xa0(PC-CH) ',
       ' Potentially\xa0Challenging ', 'Not\xa0Challenging',
       ' Undetermined\xa0(NC-PC)', 'Potentially\xa0Challenging',
       ' Not\xa0Challenging ', 'Not\xa0Challenging ',
       'Potentially\xa0Challenging ', 'Undetermined\xa0(NC-PC) ',
       'Undetermined\xa0(PC-CH)', ' Potentially\xa0Challenging',
       'Undetermined\xa0(NC-PC)', 'Challenging ', ' Not\xa0Challenging',
       ' Challenging', '9/7/2006 ', ' Undetermined\xa0(PC-CH)',
       ': Potentially\xa0Challenging', ' Undetermined\xa0(NC-PC) ',
       ': Not\xa0Challenging ', ' Challenging ', ' Not Challenging',
       ' Undetermined (NC-PC)', 'Refueling', 'Undetermined (NC-PC',
       ': Undetermined (NC-PC)', ': Undetermined (PC-CH)',
       'Undetermined (NC-PC) R', '10/11/1991', 'Not Challengin',
       ' Potentially Challenging'], dtype=object)
```

In [27]:
```
df_epri_merge['Diposition_PR'] = df_epri_merge['Diposition_PR'].replace(['Undetermined\xa0(PC-CH) ', ' Po
                                                                         'Not\xa0Challenging', ' Undetermined\xa0(NC-P
                                                                         ' Not\xa0Challenging ', 'Not\xa0Challenging '
                                                                         'Potentially\xa0Challenging ', 'Undetermined\
                                                                          'Undetermined\xa0(PC-CH)', ' Potentially\xa0
                                                                          'Undetermined\xa0(NC-PC)', 'Challenging ', '
                                                                         ' Challenging', ' Undetermined\xa0(PC-CH)',
                                                                         ': Potentially\xa0Challenging', ' Undetermine
                                                                         ': Not\xa0Challenging ', ' Challenging ', ' N
                                                                         ': Undetermined (NC-PC)', ': Undetermined (PC
                                                                         ' Undetermined (NC-PC)', 'Undetermined (NC-PC
                                                                         'Undetermined (NC-PC) R', 'Not Challengin', '
                                                                         'Not Challenging '],
                                                                        ['Undetermined (PC-CH)', 'Potentially Challen
                                                                         'Not Challenging', 'Undetermined (NC-PC)', 'P
                                                                         'Not Challenging', 'Not Challenging',
                                                                         'Potentially Challenging', 'Undetermined (NC-
                                                                         'Undetermined (PC-CH)', 'Potentially Challeng
                                                                         'Undetermined (NC-PC)', 'Challenging', 'Not C
                                                                         'Challenging', 'Undetermined (PC-CH)',
                                                                         'Potentially Challenging', 'Undetermined (NC-
                                                                         'Not Challenging', 'Challenging', 'Not Challe
                                                                         'Undetermined (NC-PC)', 'Undetermined (PC-CH)
                                                                         'Undetermined (NC-PC)', 'Undetermined (NC-PC)
                                                                         'Undetermined (NC-PC)', 'Not Challenging', 'P
                                                                         'Not Challenging'])
```

In [28]:
```
df_epri_merge.Diposition_PR.unique()
```

Out[28]:
```
array(['Undetermined', 'Not Challenging', 'Challenging', nan,
       'Not Evaluated', 'Potentially Challenging', 'Undetermined (NC-PC)',
       'Undetermined (PC-CH)', 'Unusual Event', 'Cold Shutdown',
       '9/7/2006 ', 'Refueling', '10/11/1991'], dtype=object)
```

**Fire Type**

In [29]:
```
df_ftbf = df_epri_merge['Fire Type'].unique()
print(df_ftbf)
```

```
['Arc/electric discharge' 'Flaming combustion – external to component' nan
 'Smoldering combustion – internal to component'
 'Flaming combustion – internal to component' 'Explosion' 'Unknown'
 'laming combustion – external to component' 'Other (specify)'
 'Fire not observed and fire type indeterminate from post-inspectio'
 'Overheating – no smoldering or flaming combustion'
 'No Fire\xa0-\xa0False actuation of detection device'
 'Flamingcombustion–internaltocomponent'
 'Firenotobservedandfiretypeindeterminatefrompost-inspectio'
 'Firenotobservedandfiretypeindeterminatefrompost-inspectio\nFireTypeUnknown:'
 'Smolderingcombustion–internaltocomponent'
 'Flamingcombustion–externaltocomponent'
 'Overheating–nosmolderingorflamingcombustion'
 'Smolderingcombustion–externaltocomponent' 'Arc/electricdischarge'
 'NoFire-Falseactuationofdetectiondevice' 'Other(specify)'
 'Mechanicalequipmentmalfunction/failure'
 'Flaming combustion – internal to componen'
 'Smoldering combustion – external to component' 'Other (specify'
 ': Flaming combustion – internal to component'
 'No Fire - False actuation of detection device'
 'Overheated Material (lube oil, pump packing, thermal insulation, etc.)'
 'Other electrical or electronic equipment'
 'Smoldering combustion – internal to componen'
 'Hot work (cutting/welding/grinding/etc.)'
 'Light smoke coming from ignition source\xa0-\xa0minor or no visibility reduction in vicinity of fire'
 ': Flaming combustion – external to component'
 'Flaming combustion – external to component ' ': Arc/electric discharge'
 'verheating – no smoldering or flaming combustion'
 'Fire not observed and fire type indeterminate from post-inspectio\n'
 'Temporary electrical wiring or equipment'
 ' Fire not observed and fire type indeterminate from post-inspectio'
 ' Arc/electric discharge' 'Overheating – no  or flaming combustion']
```

In [30]:
```
df_epri_merge['Fire Type'].value_counts()
```

Out[30]:
```
Flaming combustion – external to component                                                  594
Smoldering combustion – internal to component                                               217
Flaming combustion – internal to component                                                  213
Overheating – no smoldering or flaming combustion                                           172
Flamingcombustion–externaltocomponent                                                       125
Arc/electric discharge                                                                       93
Smoldering combustion – external to component                                                91
Other (specify)                                                                              91
Flamingcombustion–internaltocomponent                                                        89
Overheating–nosmolderingorflamingcombustion                                                  49
Arc/electricdischarge                                                                        40
Fire not observed and fire type indeterminate from post-inspectio                            32
Unknown                                                                                      32
Smolderingcombustion–externaltocomponent                                                     24
Smolderingcombustion–internaltocomponent                                                     22
Explosion                                                                                    14
Other (specify                                                                                6
Firenotobservedandfiretypeindeterminatefrompost-inspectio                                     6
Firenotobservedandfiretypeindeterminatefrompost-inspectio\nFireTypeUnknown:                   5
NoFire-Falseactuationofdetectiondevice                                                        4
No Fire - False actuation of detection device                                                 4
Smoldering combustion – internal to componen                                                  3
No Fire - False actuation of detection device                                                 3
Other electrical or electronic equipment                                                      2
Other(specify)                                                                                2
Hot work (cutting/welding/grinding/etc.)                                                      2
: Flaming combustion – internal to component                                                  1
 Arc/electric discharge                                                                       1
Flaming combustion – internal to componen                                                     1
: Arc/electric discharge                                                                      1
 Fire not observed and fire type indeterminate from post-inspectio                            1
Flaming combustion – external to component                                                    1
Fire not observed and fire type indeterminate from post-inspectio\n                           1
Overheated Material (lube oil, pump packing, thermal insulation, etc.)                        1
Light smoke coming from ignition source - minor or no visibility reduction in vicinity of fire  1
laming combustion – external to component                                                     1
verheating – no smoldering or flaming combustion                                              1
Overheating – no  or flaming combustion                                                       1
: Flaming combustion – external to component                                                  1
Mechanicalequipmentmalfunction/failure                                                        1
Temporary electrical wiring or equipment                                                      1
Name: Fire Type, dtype: int64
```

In [31]:
```
df_epri_merge['Fire Type'] = df_epri_merge['Fire Type'].replace(['laming combustion – external to compone
                                                 'Flamingcombustion–externaltocomponent',
                                                ': Flaming combustion – external to component',
                                                'Flaming combustion – external to component '], 'Flam
```

In [32]:
```
df_epri_merge['Fire Type'] = df_epri_merge['Fire Type'].replace(['Smolderingcombustion–internaltocomponer
                                                'Smoldering combustion – internal to componen'],
                                                'Smoldering combustion – internal to component')
```

In [33]:
```
df_epri_merge['Fire Type'] = df_epri_merge['Fire Type'].replace(['Smolderingcombustion–externaltocomponer
                                                'Smoldering combustion – external to component')
```

In [34]:
```
df_epri_merge['Fire Type'] = df_epri_merge['Fire Type'].replace(['Flamingcombustion–internaltocomponent',
                                                'Flaming combustion – internal to componen',
                                                ': Flaming combustion – internal to component'],
                                                'Flaming combustion – internal to component')
```

In [35]:
```
df_epri_merge['Fire Type'] = df_epri_merge['Fire Type'].replace(['Fire not observed and fire type indeter
                                                                 'Firenotobservedandfiretypeindeterminatefrompost-insp
                                                                 'Firenotobservedandfiretypeindeterminatefrompost-insp
                                                                 ' Fire not observed and fire type indeterminate from
                                                                 'Fire not observed and fire type indeterminate from p
                                                                 'Fire not observed and fire type indeterminate from p
```

In [36]:
```
df_epri_merge['Fire Type'] = df_epri_merge['Fire Type'].replace(['Arc/electricdischarge',
                                                                 ': Arc/electric discharge',
                                                                 ' Arc/electric discharge'],
                                                                'Arc/electric discharge')
```

In [37]:
```
df_epri_merge['Fire Type'] = df_epri_merge['Fire Type'].replace(['No Fire\xa0-\xa0False actuation of dete
                                                                 'NoFire-Falseactuationofdetectiondevice'],
                                                                'No Fire - False actuation of detection device')
```

In [38]:
```
df_epri_merge['Fire Type'] = df_epri_merge['Fire Type'].replace(['Overheating – no  or flaming combustion
                                                                 'Overheating-nosmolderingorflamingcombustion',
                                                                 'verheating – no smoldering or flaming combustion'],
                                                                 'Overheating – no smoldering or flaming combustion')
```

In [39]:
```
df_epri_merge['Fire Type'] = df_epri_merge['Fire Type'].replace(['Other(specify)',
                                                                 'Other (specify', 'Mechanicalequipmentmalfunction/fai
                                                                ['Other (specify)',
                                                                 'Other (specify)', 'Mechanical equipment malfunction/
```

In [40]:
```
df_epri_merge['Fire Type'] = df_epri_merge['Fire Type'].replace(['Mechanical equipment malfunction/failur
                                                                  'Overheated Material (lube oil, pump packing, therma
                                                                  'Other electrical or electronic equipment',
                                                                  'Hot work (cutting/welding/grinding/etc.)',
                                                                  'Light smoke coming from ignition source\xa0-\xa0mir
                                                                  'Temporary electrical wiring or equipment'],
                                                                 np.nan)
```

In [41]:
```
df_epri_merge['Fire Type'].unique()
```

Out[41]:
```
array(['Arc/electric discharge',
       'Flaming combustion – external to component', nan,
       'Smoldering combustion – internal to component',
       'Flaming combustion – internal to component', 'Explosion',
       'Unknown', 'Other (specify)',
       'Fire not observed and fire type indeterminate from post-inspection',
       'Overheating – no smoldering or flaming combustion',
       'No Fire - False actuation of detection device',
       'Smoldering combustion – external to component'], dtype=object)
```

**Fire Cause**

In [42]:
```
fcbf = df_epri_merge['Fire Cause'].unique()
fcbf
```

Out[42]:
```
array(['High Energy Arc Fault', 'Electrical arcing or sparks (non-HEAF)',
       'Mechanical equipment malfunction/failure', nan,
       'Electrical failure resulting in overheating materials',
       'Hot work (cutting/welding/grinding/etc.)',
       'Overheated Material (lube oil, pump packing, thermal insulation, etc.)',
       'Other (other personnel error, natural effect, etc. specify in comments)',
       'Misuse of heating devices', 'Unknown',
       'Personnel error during test and maintenance activity',
       'Explosion (hydrogen gas ignition, fuel vapor ignition, other volatile fluid vapor ignition)',
       'High Energy Arc Fault (HEAF)', 'Mechanical malfunction/failure',
       'Electrical Failure (overheating, spark, HEAF)',
       'Explosion (hydrogen gas ignition, fuel vapor ignition, other volatile fluid vapor ignition) ',
       'Explosion (hydrogen gas ignition, fuel vapor ignition)',
       'Personnel error: Misuse of heating devices',
       'Electrical malfunction/failure',
       'Personnel error: Misuse of material ignited',
       'False actuation of detector, no ignition or overheat condition',
       'Other(otherpersonnelerror,naturaleffect,etc.specifyincomments)',
       'Electricalfailureresultinginoverheatingmaterials',
       'Mechanicalequipmentmalfunction/failure',
       'Hotwork(cutting/welding/grinding/etc.)',
       'OverheatedMaterial(lubeoil,pumppacking,thermalinsulation,etc.)',
       'Electricalarcingorsparks(non-HEAF)', 'Arc/electricdischarge',
       'Personnelerrorduringtestandmaintenanceactivity', 'Suspicious',
       'Flamingcombustion-externaltocomponent', 'Unkno',
       ':Electricalfailureresultinginoverheatingmaterials',
       'HighEnergyArcFault(HEAF)', 'Not Challenging',
       'vElectrical failure resulting in overheating materials',
       'In-Situ', 'Potentially Challenging',
       ': Electrical failure resulting in overheating materials',
       'Other (personnel error, natural effect, etc. specify in comments)',
       'Transient', 'Trash (i.e., solid refuse collected for disposal)',
       ' Electrical failure resulting in overheating materials',
       'Electrical arcing or sparks (non-HEAF',
       ' Overheated Material (lube oil, pump packing, thermal insulation, etc.)',
       'Electrical failure resulting in overheating materials\n',
       'High Energy Arc Fault (HEAF',
       ' Overheated Material (lube oil, pump packing, thermal insulation, etc',
       'Hot work (cutting/welding/grinding/etc',
       'Other (other personnel error, natural effect, etc. specify in comments',
       'Overheated Material (lube oil, pump packing, thermal insulation, etc.',
       'Hot work (cutting/welding/grinding/etc.',
       'Electrical arcing or sparks (non-HEAF)\n'], dtype=object)
```

In [43]:
```
df_epri_merge['Fire Cause'] = df_epri_merge['Fire Cause'].replace(['High Energy Arc Fault', 'HighEnergyAr
                                                    'High Energy Arc Fault (HEAF'],
                                                   'High Energy Arc Fault (HEAF)')
```

In [44]:
```
df_epri_merge['Fire Cause'] = df_epri_merge['Fire Cause'].replace(['Electricalarcingorsparks(non-HEAF)',
                                                    'Electrical arcing or sparks (non-HEAF)\n'],
                                                   'Electrical arcing or sparks (non-HEAF)')
```

In [45]:
```
df_epri_merge['Fire Cause'] = df_epri_merge['Fire Cause'].replace(['Electricalfailureresultinginoverheati
                                                    ':Electricalfailureresultinginoverheatingmaterials'
                                                    ':Electricalfailureresultinginoverheatingmaterials'
                                                    'vElectrical failure resulting in overheating mater
                                                    ': Electrical failure resulting in overheating mate
                                                    'Electrical failure resulting in overheating materi
                                                    ' Electrical failure resulting in overheating mater
                                                   'Electrical failure resulting in overheating materia
```

In [46]:
```
df_epri_merge['Fire Cause'] = df_epri_merge['Fire Cause'].replace(['OverheatedMaterial(lubeoil,pumppackir
                                                                   ' Overheated Material (lube oil, pump packing, ther
                                                                   ' Overheated Material (lube oil, pump packing, ther
                                                                   'Overheated Material (lube oil, pump packing, therm
                                                                  'Overheated Material (lube oil, pump packing, therma
```

In [47]:
```
df_epri_merge['Fire Cause'] = df_epri_merge['Fire Cause'].replace(['Hotwork(cutting/welding/grinding/etc.
                                                                   'Hot work (cutting/welding/grinding/etc',
                                                                   'Hot work (cutting/welding/grinding/etc.'],
                                                                  'Hot work (cutting/welding/grinding/etc.)')
```

In [48]:
```
df_epri_merge['Fire Cause'] = df_epri_merge['Fire Cause'].replace(['Other(otherpersonnelerror,naturaleffe
                                                                   'Other (personnel error, natural effect, etc. speci
                                                                   'Other (other personnel error, natural effect, etc.
                                                                  'Other (other personnel error, natural effect, etc.
```

In [49]:
```
Cause'] = df_epri_merge['Fire Cause'].replace(['Explosion (hydrogen gas ignition, fuel vapor ignition, ot
                                               'Explosion (hydrogen gas ignition, fuel vapor ignition)'],
                                              'Explosion (hydrogen gas ignition, fuel vapor ignition, other volatile f
```

In [50]:
```
df_epri_merge['Fire Cause'] = df_epri_merge['Fire Cause'].replace(['Personnelerrorduringtestandmaintenanc
                                                                   'Mechanicalequipmentmalfunction/failure', 'Mechani
                                                                   'Misuse of heating devices'],
                                                                  ['Personnel error during test and maintenance activ
                                                                   'Mechanical equipment malfunction/failure', 'Mecha
                                                                   'Personnel error: Misuse of heating devices'])
```

In [51]:
```
df_epri_merge['Fire Cause'] = df_epri_merge['Fire Cause'].replace(['Flamingcombustion-externaltocomponent
                                                                   'In-Situ', 'Potentially Challenging', 'Transient',
                                                                   'Trash (i.e., solid refuse collected for disposal)
                                                                  np.nan)
```

In [52]:
```
df_epri_merge['Fire Cause'].unique()
```

Out[52]:
```
array(['High Energy Arc Fault (HEAF)',
       'Electrical arcing or sparks (non-HEAF)',
       'Mechanical equipment malfunction/failure', nan,
       'Electrical failure resulting in overheating materials',
       'Hot work (cutting/welding/grinding/etc.)',
       'Overheated Material (lube oil, pump packing, thermal insulation, etc.)',
       'Other (other personnel error, natural effect, etc. specify in comments)',
       'Personnel error: Misuse of heating devices', 'Unknown',
       'Personnel error during test and maintenance activity',
       'Explosion (hydrogen gas ignition, fuel vapor ignition, other volatile fluid vapor ignition)',
       'Electrical Failure (overheating, spark, HEAF)',
       'Electrical malfunction/failure',
       'Personnel error: Misuse of material ignited',
       'False actuation of detector, no ignition or overheat condition',
       'Suspicious'], dtype=object)
```

# Saving the cleaned merged data to excel sheet

In [54]:
```
df_epri_merge.to_excel('EPRI_merged.xlsx')
```

In [55]:
```
df_epri_merge.columns
```

Out[55]:
```
Index(['Event Date_FES', 'Disposition_FES', 'Outside PA', 'Plant Area',
       'Building', 'System', 'Component Group', 'Component', 'Voltage',
       'Current Type', 'Event Date_FEA', 'Disposition_FEA', 'Fire Cause',
       'Group', 'Type', 'Form', 'Fire Type', 'Smoke', 'Temperature',
       'Damage Extent', 'Collated Damage', 'Event Date_FSE', 'Disposition_FSE',
       'Review Status:', 'Automatic Determination', 'Unnamed: 5', 'Unnamed: 6',
       'Event Date_FTS', 'Diposition_FTS', 'Ignition', 'Discovery',
       'Duration Certainty', 'Duration', 'Detection Method',
       'Detection Performance', 'Suppression Method', 'Suppression Agent',
       'Unnamed: 11', 'Unnamed: 12', 'Event Date_PR', 'Diposition_PR',
       'Mode Prior', 'Mode After', 'Power Level Prior', 'Power Level After',
       'Power Effect', 'EAL Declaration'],
      dtype='object')
```

# Plots

# Fire Type of different fire events NPP (1990-2009)

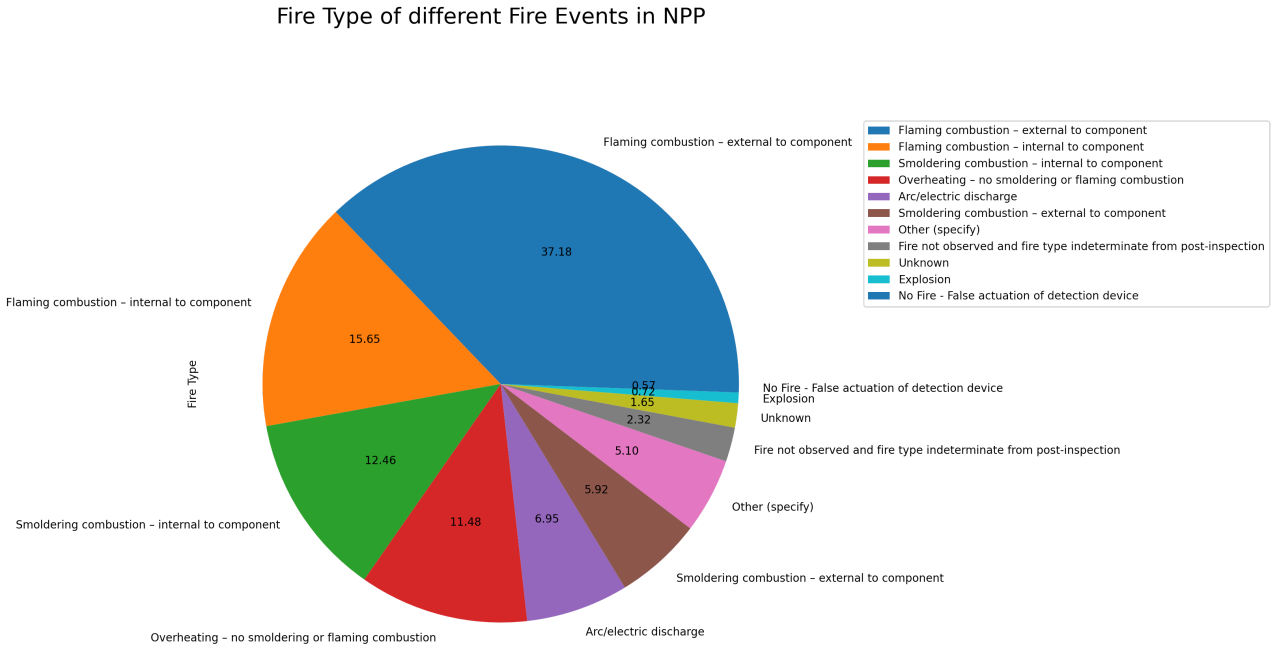
According to [1] the most severe type of combustion between ignition and extinction observed during the fire event. Options are:

a) Flaming combustion – external to component
b) Flaming combustion – internal to component
c) Smoldering combustion – external to component
d) Smoldering combustion – internal to component
e) Overheating – no smoldering or flaming combustion
f) Fully developed compartment fire
g) Explosion
h) Arc/electric discharge
i) No fire – false actuation of detection device
j) Fire not observed and fire type indeterminate from post-inspection
    i. Fire suppressed by fixed suppression
    ii. Fire self-extinguished
    iii. Fire contained within a component
    iv. Room entry not possible before mitigation
    v. Other (specify)
k) Other (specify)
l) Unknown\

In [58]:
```
df_epri_merge['Fire Type'].value_counts()
```

Out[58]:
```
Flaming combustion – external to component                          722
Flaming combustion – internal to component                          304
Smoldering combustion – internal to component                       242
Overheating – no smoldering or flaming combustion                   223
Arc/electric discharge                                              135
Smoldering combustion – external to component                       115
Other (specify)                                                      99
Fire not observed and fire type indeterminate from post-inspection   45
Unknown                                                              32
Explosion                                                            14
No Fire - False actuation of detection device                        11
Name: Fire Type, dtype: int64
```

In [94]:
```
fig1 = plt.figure(figsize=(10,10), dpi=200)
ax = plt.subplot(111)
df_epri_merge['Fire Type'].value_counts().plot(kind = 'pie', autopct='%.2f', legend = True, fontsize=10)
#plt.legend(loc='upper left')
fig1.suptitle('Fire Type of different Fire Events in NPP', fontsize=20)
ax.legend(bbox_to_anchor=(1.1, 0.95))
plt.show()
```




In [95]:
```
fig1.savefig("Fire Type.png", bbox_inches='tight')
```

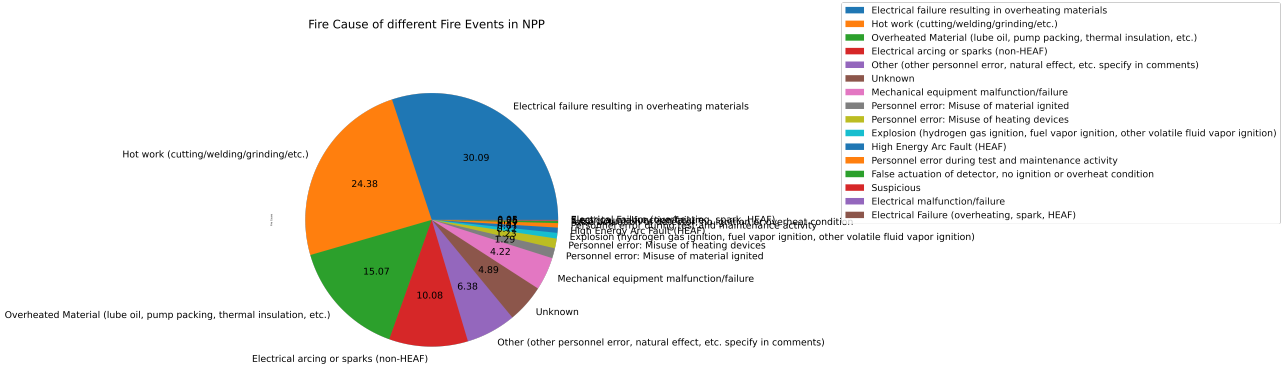
# Fire Cause of different fire events NPP (1990-2009)

According to [1] Fire cause – Options are:
a) Electrical failure resulting in overheating materials
b) Electrical failure resulting in an arcing fault
i. High Energy Arc Fault (HEAF)
ii. Electrical arcing or sparks (non-HEAF)
c) Overheated material (lube oil, pump packing, thermal insulation, etc.)
d) Explosion (hydrogen gas ignition, fuel vapor ignition)
e) Hot work (e.g., sparks or slag from welding, cutting or grinding)
f) Suspicious
g) Other (other personnel error, natural effect, etc. specify in comments)
h) False actuation of detector, no ignition or overheat condition
i) Unknown
j) Personnel error: Misuse of material ignited
k) Personnel error: Misuse of heating devices
l) Mechanical equipment malfunction/failure
m) Personnel error during test and maintenance activity\

In [61]:
```
df_epri_merge['Fire Cause'].value_counts()
```

Out[61]:
```
Electrical failure resulting in overheating materials                                585
Hot work (cutting/welding/grinding/etc.)                                             474
Overheated Material (lube oil, pump packing, thermal insulation, etc.)               293
Electrical arcing or sparks (non-HEAF)                                               196
Other (other personnel error, natural effect, etc. specify in comments)              124
Unknown                                                                               95
Mechanical equipment malfunction/failure                                              82
Personnel error: Misuse of material ignited                                           25
Personnel error: Misuse of heating devices                                            24
Explosion (hydrogen gas ignition, fuel vapor ignition, other volatile fluid vapor ignition)    14
High Energy Arc Fault (HEAF)                                                          13
Personnel error during test and maintenance activity                                  11
False actuation of detector, no ignition or overheat condition                         5
Suspicious                                                                             1
Electrical malfunction/failure                                                         1
Electrical Failure (overheating, spark, HEAF)                                          1
Name: Fire Cause, dtype: int64
```

In [104]:
```
fig2 = plt.figure(figsize=(25,25), dpi=200)
ax = plt.subplot(111)
df_epri_merge['Fire Cause'].value_counts().plot(kind = 'pie', autopct='%.2f', legend = True, fontsize=40)
#plt.legend(loc='upper left')
fig2.suptitle('Fire Cause of different Fire Events in NPP', fontsize=50)
ax.legend(bbox_to_anchor=(3.2, 1.2), fontsize = 40)
plt.show()
```




In [105]:
```
fig2.savefig("Fire Cause.png", bbox_inches='tight')
```

# References

1. Baranowsky, P., & Facemire, J. (2013). The updated fire events database: description of content and fire event classification guidance. Electric Power Research Institute, Palo Alto, CA.

In [ ]:
```
```