In [1]:

```
import osmnx as ox
import geopandas as gpd
import osmium
import time
import pandas as pd
import numpy as np
import shapely.wkb as wkblib
import shapely.wkt
import requests
import os

from PIL import Image, ImageDraw, ImageFont

from shapely import affinity
from shapely.geometry import Point, LineString
from rtree import index
from matplotlib.lines import Line2D

from keplergl import KeplerGl

from utils import add_border

######## CONSTANTS
img_path_temp = 'Berlin_temp.png'
img_path_final = 'Berlin_temp.png'
ALCOHOL_DIST_THRS_M = 500

OSMNx_city_query = 'berlin, germany'

######## FILES
PBF_URL = 'https://download.geofabrik.de/europe/germany/berlin-latest.osm.pbf'
PBF_PATH = 'berlin-latest.osm.pbf'
```

Getting the data

All the information we'll get will be from Open Street Maps - OSM - https://www.openstreetmap.org/ (https://www.openstreetmap.org/)

This is an open source platform containing geographic data and also a source for a variety of open source tools, such as:

- Router: http://project-osrm.org/ (http://project-osrm.org/)
- Geocoder: https://nominatim.org/ (https://nominatim.org/) - https://nominatim.openstreetmap.org/ (https://nominatim.openstreetmap.org/)
- Humanitarian Acts Platform: https://www.hotosm.org/ (https://www.hotosm.org/)

Check the links for more informations :)

For our maps, we need two types of data:

- Street Network: Graph
- Points of interest: Points - Pairs of Latitude/Longitude, together with their metadata.

Street Network

For the street network, we will obtain them from OSMNx - https://geoffboeing.com/2016/11/osmnx-python-street-networks/ (https://geoffboeing.com/2016/11/osmnx-python-street-networks/) (Open Street Maps + NetworkX).

An important detail in the function we're going to use is that it access OSM's geocoder - Nominatin - to convert a string to a polygon, from which OSMNx will extract the roads' network. For some cities, Nominatin just doesn't return a polygon on it's first result, one of the necessary condititions for OSMNx function to work. Give it a test at nominatin between "berlin, germany" and "hamburg, germany".

- The obtained data structure will be a graph (NetworkX) structure, with edges being the street segments and their names and metadata - https://wiki.openstreetmap.org/wiki/Way (https://wiki.openstreetmap.org/wiki/Way).
- For more explanations on the data types from OSM and how OSM represent the world with it, please check https://github.com/caiomiyashiro/geospatial_data_analysis/blob/master/AMLD-2020/Complete_AMLD_2020.ipynb (https://github.com/caiomiyashiro/geospatial_data_analysis/blob/master/AMLD-2020/Complete_AMLD_2020.ipynb) on "OSM Data Representation".

In [2]:

```
# https://nominatim.openstreetmap.org/
G = ox.core.graph_from_place(OSMNx_city_query, simplify=True)
fig, ax = ox.plot_graph(G)

# you can try this out to see the error
# G = ox.core.graph_from_place('hamburg, germany', simplify=True)
# fig, ax = ox.plot_graph(G)
```

Points of Interest - POI

OSMNx helps us by providing an abstraction to easily obtain street networks from Python, but it doesn't retrieve any extra data that we might need, such as POIs for our map.

In order to get OSM data in a complete way, we can access geofabrik's free service on map data - http://download.geofabrik.de/ (http://download.geofabrik.de/).

- They process OSM data in a periodic way in order to aways provide up to date map data.
- Their completeness can be checked on their own manual on what are the things we can find in their data - http://download.geofabrik.de/osm-data-in-gis-formats-free.pdf (http://download.geofabrik.de/osm-data-in-gis-formats-free.pdf)

Lastly, we need some code to extract the data points that are actually relevant for us. For that we'll use pyosmium - https://osmcode.org/pyosmium/ (https://osmcode.org/pyosmium/) - a tool to process the data format that is used by OSM and geofabrik - `osm.pbf` .

Below, we define a class to process the pbf file and process only nodes, which can contain our POIs. For example, the same `ways` that OSMNx processed before hand can also be found on this file, but we choose not to look at them, as OSMNx process them in a better way.

- We'll process the file and save the resulting nodes as a csv, as reading and processing the pbf takes a loooong time.

In [3]:

```
%%time

class Pyosmium(osmium.SimpleHandler):           # class must inherit from osmium.Simp
    def __init__(self, pbf_path):
        osmium.SimpleHandler.__init__(self)        # initialize pyosmium
        self.names = []                            # store points names
        self.amenities = []
        self.wkb_fab = osmium.geom.WKBFactory()    # builds geometry over OSM object
        self.points = []                           # store points geometries
        self.lats = []
        self.longs = []

        print('loading/processing pbf file...')
        self.apply_file(pbf_path, locations=True)  # initialize osm.pbf file process
        self.df = pd.DataFrame({'name': self.names, 'amenity': self.amenities,
                                'point': self.points, 'lat': self.lats, 'long': self


    def node(self, node):
        # TagList can't be converted to dict automatically, see:
        # https://github.com/osmcode/pyosmium/issues/106
        tags_dict = {tag.k: tag.v for tag in node.tags}
        wkb = self.wkb_fab.create_point(node)   # extract Point's hex location data
        points = wkblib.loads(wkb, hex=True)    # convert hex data to WKB geometry f
        self.points.append(points)              # store geometry in list
        self.lats.append(points.xy[1][0])
        self.longs.append(points.xy[0][0])
        self.amenities.append(tags_dict['amenity'] if 'amenity' in tags_dict.keys()
        self.names.append(tags_dict['name'] if 'name' in tags_dict.keys() else '')

if not os.path.isfile(PBF_PATH):
    r = requests.get(PBF_URL)
    with open(PBF_PATH, 'wb') as f:
        f.write(r.content)

berlin_pyosmium = Pyosmium(PBF_PATH)
berlin_pyosmium.df.to_csv('berlin_nodes.csv', index=False)
```

```
loading/processing pbf file...
CPU times: user 12min 8s, sys: 11.1 s, total: 12min 19s
Wall time: 12min 51s
```

Next, we look at all the nodes we collect and only keep the ones who serves our purpose, in this case, that we can obtain ANY kind of alcohol!

- Notice the last 4 commands. As we will play with geographic data, we will work with a geodataframe. Geodataframes are exactly the same as regular Pandas Dataframes, but they have one last column containing a specific type of data called `geometry` that geopandas can play with.

In [4]:

```
%%time
df = pd.read_csv('berlin_nodes.csv')

# list of places that we potentially find alcohol
# list of possible places: https://wiki.openstreetmap.org/wiki/Key:amenity
nice_amenities = ['restaurant', 'fuel', 'fast_food', 'cafe',
                  'pub', 'bar', 'biergarten', 'nightclub', 'brothel',
                  'hookah_lounge']

nice_amenities = df.loc[df['amenity'].isin(nice_amenities)].copy()
# technical step to convert a string containing the lat/long to a geometric object t
nice_amenities['point'] = nice_amenities['point'].apply(lambda elem: shapely.wkt.loa

nice_amenities = gpd.GeoDataFrame(nice_amenities, geometry='point')
nice_amenities.crs = {'init' :'epsg:4326'}

nice_amenities.head()
```

```
CPU times: user 11.3 s, sys: 7.6 s, total: 18.9 s
Wall time: 21.2 s
```

```
/usr/local/lib/python3.7/site-packages/pyproj/crs/crs.py:53: FutureWar
ning: '+init=<authority>:<code>' syntax is deprecated. '<authority>:<c
ode>' is the preferred initialization method. When making the change,
be mindful of axis order changes: https://pyproj4.github.io/pyproj/sta
ble/gotchas.html#axis-order-changes-in-proj-6 (https://pyproj4.github.
io/pyproj/stable/gotchas.html#axis-order-changes-in-proj-6)
  return _prepare_from_string(" ".join(pjargs))
```

Out[4]:

	name	amenity	point	lat	long
367	Aral	fuel	POINT (13.34544 52.54644)	52.546440	13.345439
2907	Aida	restaurant	POINT (13.32282 52.50691)	52.506911	13.322821
2910	Madame Ngo	restaurant	POINT (13.31808 52.50621)	52.506212	13.318081
2911	Thanh Long	restaurant	POINT (13.32078 52.50732)	52.507320	13.320780
4009	Aral	fuel	POINT (13.32819 52.53082)	52.530825	13.328194

Now that we have all our needed data, we can start processing it.

In order to define what color which street is going to have, we will do the following steps:

1. Expand each point of interest in 500 meters of radius - the number 500 is a constant parameter
2. for each street, count how many it intersects with any of the expanded points of interest
3. Define color and street width bins for the counts
4. Plot!

Buffer points to alcohol distance

In [5]:

```
%%time
# projection trick to buffer geometries in 'meters' unit
nice_amenities_s = nice_amenities.to_crs(epsg=3395)

nice_amenities_s['buffered_points'] = nice_amenities_s.buffer(ALCOHOL_DIST_THRS_M).t
nice_amenities_s = nice_amenities_s.to_crs(epsg=4326)

nice_amenities_s = gpd.GeoDataFrame(nice_amenities_s, geometry='buffered_points')

display(nice_amenities_s.head())

# check printed polygon on http://arthur-e.github.io/Wicket/sandbox-gmaps3.html
print('- Original point:')
print(nice_amenities['point'].iloc[0].wkt)
print('\n\n- Buffered point:')
print(nice_amenities_s.iloc[0]['buffered_points'].wkt)
```

	name	amenity	point	lat	long	buffered_points
367	Aral	fuel	POINT (13.34544 52.54644)	52.546440	13.345439	POLYGON ((13.34993 52.54644, 13.34991 52.54617...
2907	Aida	restaurant	POINT (13.32282 52.50691)	52.506911	13.322821	POLYGON ((13.32731 52.50691, 13.32729 52.50664...
2910	Madame Ngo	restaurant	POINT (13.31808 52.50621)	52.506212	13.318081	POLYGON ((13.32257 52.50621, 13.32255 52.50594...
2911	Thanh Long	restaurant	POINT (13.32078 52.50732)	52.507320	13.320780	POLYGON ((13.32527 52.50732, 13.32525 52.50705...
4009	Aral	fuel	POINT (13.32819 52.53082)	52.530825	13.328194	POLYGON ((13.33269 52.53082, 13.33266 52.53056...

```
- Original point:
POINT (13.3454394 52.5464403)


- Buffered point:
POLYGON ((13.3499309764206 52.54644029999288, 13.34990934825246 52.546
17190698269, 13.34984467203913 52.54590609711827, 13.34973757064789 5
2.54564543036426, 13.3495890755237 52.54539241719822, 13.3494006167557
7 52.54514949442895, 13.34917400930506 52.54491900172284, 13.348911435
5252 52.54470315906433, 13.34861542414522 52.54450404536808, 13.348288
82591653 52.54432357844899, 13.34793478615862 52.54416349654328, 13.34
755671446787 52.54402534155908, 13.34715825188137 52.54391044421811, 1
3.34674323581162 52.5438199112319, 13.34631566309026 52.5437546146363,
13.34587965147632 52.54371518338745, 13.3454394 52.54370199730018, 13.
34499914852368 52.54371518338745, 13.34456313690974 52.5437546146363,
13.34413556418838 52.5438199112319, 13.34372054811864 52.5439104442181
1, 13.34332208553213 52.54402534155908, 13.34294401384138 52.544163496
54328, 13.34258997408347 52.54432357844899, 13.34226337585478 52.54450
404536808, 13.3419673644748 52.54470315906433, 13.34170479069494 52.54
491900172284, 13.34147818324423 52.54514949442895, 13.3412897244763 5
2.54539241719822, 13.34114122935211 52.54564543036426, 13.341034127960
87 52.54590609711827, 13.34096945174754 52.54617190698269, 13.34094782
```

```
35794 52.54644029999288, 13.34096945174754 52.5467086913537, 13.341034
12796087 52.54697449633338, 13.34114122935211 52.547235155155, 13.3412
897244763 52.54748815764583, 13.34147818324423 52.54773106740732, 13.3
4170479069494 52.54796154527297, 13.3419673644748 52.54817737182865, 1
3.34226337585478 52.54837646877849, 13.34258997408347 52.5485569189511
8, 13.34294401384138 52.54871698475405, 13.34332208553213 52.548855124
8978, 13.34372054811864 52.54897000923098, 13.34413556418838 52.549060
53154199, 13.34456313690974 52.54912582020519, 13.34499914852368 52.54
91652465693, 13.3454394 52.54917843100719, 13.34587965147632 52.549165
2465693, 13.34631566309026 52.54912582020519, 13.34674323581162 52.549
06053154199, 13.34715825188137 52.54897000923098, 13.34755671446787 5
2.5488551248978, 13.34793478615862 52.54871698475405, 13.3482888259165
3 52.54855691895118, 13.34861542414522 52.54837646877849, 13.348911435
5252 52.54817737182865, 13.34917400930506 52.54796154527297, 13.349400
61675577 52.54773106740732, 13.3495890755237 52.54748815764583, 13.349
73757064789 52.547235155155, 13.34984467203913 52.54697449633338, 13.3
4990934825246 52.5467086913537, 13.3499309764206 52.54644029999288))
CPU times: user 7.88 s, sys: 99.4 ms, total: 7.98 s
Wall time: 8.09 s
```

Check file 1_points_and_buffers.html (1_points_and_buffers.html)

In [6]:

```
# map_1 = KeplerGl(height=500)

# temp_data = gpd.GeoDataFrame(nice_amenities_s['point'], geometry='point')
# map_1.add_data(data=temp_data, name="pois")
# map_1.add_data(data=nice_amenities_s[['buffered_points']], name="buffered_points")
# map_1.save_to_html(file_name="points_and_buffers.html")
```

Count how many alcohol places reach a node given constant ALCOHOL_DIST_THRS_M

In [7]:

```
%%time
segments = []
for uu, vv, kkey, ddata in G.edges(keys=True, data=True):
    uu_data = G.nodes[uu]
    uu_point = Point(uu_data['x'], uu_data['y'])

    vv_data = G.nodes[vv]
    vv_point = Point(vv_data['x'], vv_data['y'])

    longs = [uu_point.xy[0][0], vv_point.xy[0][0]]
    lats = [uu_point.xy[1][0], vv_point.xy[1][0]]
    segments.append(LineString([[lon, lat] for lat, lon in zip(lats, longs)]))
```

```
CPU times: user 1min 2s, sys: 559 ms, total: 1min 2s
Wall time: 1min 2s
```

In [8]:

```
%%time
def create_r_tree(gdf, geometry_col):
    idx = index.Index()
    #Populate R-tree index with bounds of grid cells
    for ix, cell in gdf.iterrows():
        # in GeoPandas, there's always a geometry col and it's always a shapely
        idx.insert(ix, cell[geometry_col].bounds)
    return idx

segments = gpd.GeoDataFrame(segments, columns=['line_segment'], geometry = 'line_seg
geo_idx = create_r_tree(segments, 'line_segment')
```

```
CPU times: user 3min 19s, sys: 624 ms, total: 3min 20s
Wall time: 3min 21s
```

- Spatial Indices:
  - https://automating-gis-processes.github.io/site/notebooks/L3/spatial_index.html (https://automating-gis-processes.github.io/site/notebooks/L3/spatial_index.html)
  - https://www.youtube.com/watch?v=_95bSEqMzUA&t=350s (https://www.youtube.com/watch?v=_95bSEqMzUA&t=350s)

Pay attention that these operations can take quite some time!

In [9]:

```
%%time
segments['count']  = 0
i = 1
for ix, row in nice_amenities_s.iterrows():
    first_filter = list(geo_idx.intersection(row['buffered_points'].bounds))
    if(len(first_filter) > 0):
        second_filter = segments.loc[first_filter].intersection(row['buffered_points
        second_filter_ix = second_filter.index[second_filter.is_empty == False]
        counts = segments.loc[second_filter_ix]['count'].values
        segments.loc[second_filter_ix, 'count'] = counts + 1
```

```
CPU times: user 27min 42s, sys: 4.09 s, total: 27min 46s
Wall time: 27min 54s
```

Check file 2_buffers_and_streets.html (2_buffers_and_streets.html)

In [10]:

```
# map_1 = KeplerGl(height=500)

# most_alcohol = segments.sort_values(by='count', ascending=False).iloc[:500]
# most_alcohol['rank'] = range(1,501)

# map_1.add_data(data=most_alcohol, name="STREET")
# map_1.add_data(data=nice_amenities_s[['buffered_points']], name="buffered_points")
# map_1.add_data(data=gpd.GeoDataFrame({'point': [Point(13.454553, 52.515688)]}, geo
# map_1.save_to_html(file_name="2_buffers_and_streets.html")
```

Assign each segment a color and width based on it's alcohol reach

In [11]:

```
%%time
# List to store colors
roadColors = []
# List to store linewidths
roadWidths = []

# The length is in meters
for ix, item in segments.iterrows():

    if item["count"] >= 1 and item["count"] <= 5:
        color = "#07f507" # Green
        linewidth = 1

    elif item["count"] >= 6 and item["count"] <= 10:
        color = "#e69419" # Orange
        linewidth = 1

    elif item["count"] >= 10 and item["count"] <= 50:
        color = "#fc00e7" # Pink
        linewidth = 1

    elif item["count"] > 50:
        color = "#d40a47" # Red
        linewidth = 1
    else:
        color = "w"
        linewidth = .5

    roadColors.append(color)
    roadWidths.append(linewidth)
```

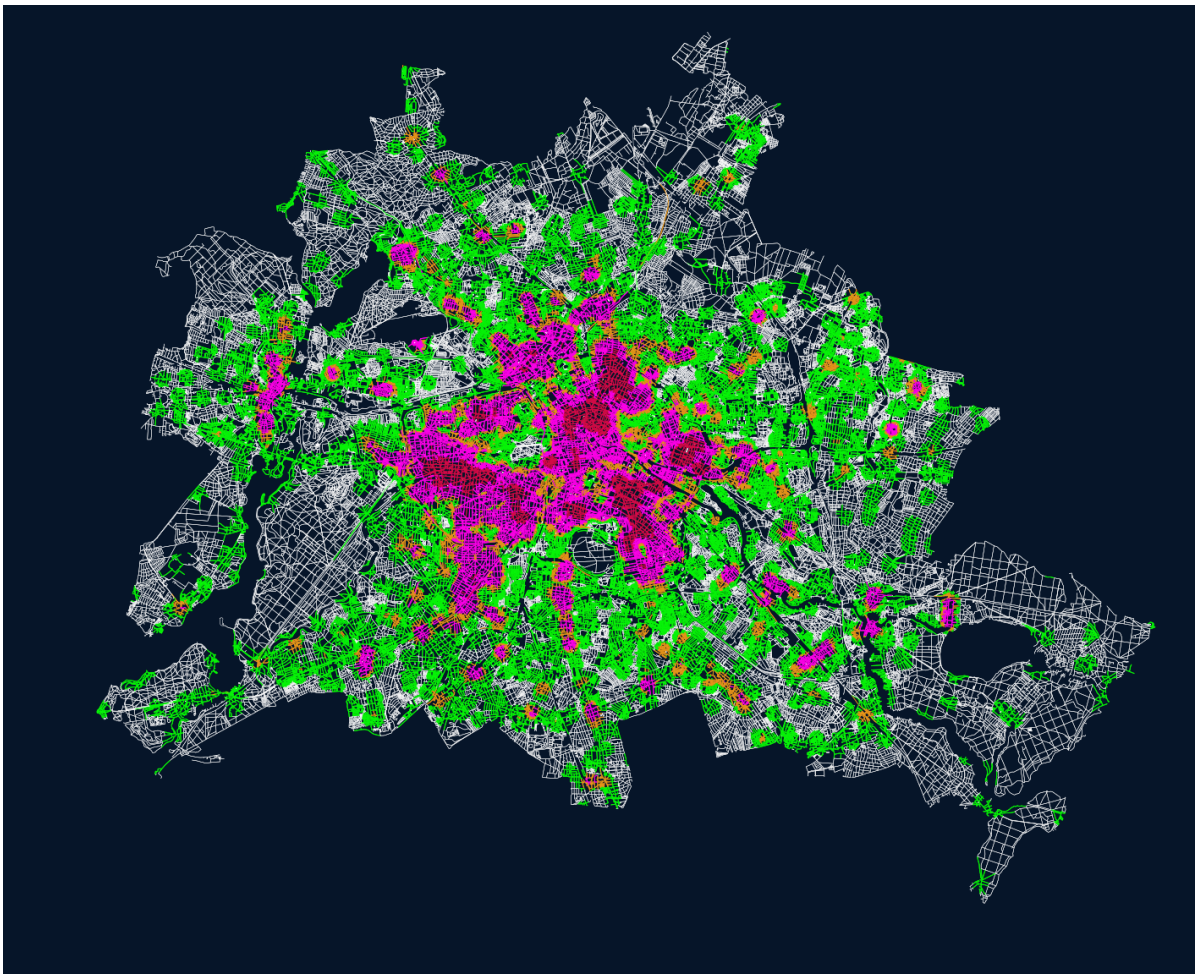
```
CPU times: user 1min 23s, sys: 298 ms, total: 1min 24s
Wall time: 1min 24s
```

Create map

Custom = Custom boring manual adjustements of borders :|

In [12]:

```
%%time

# Center of map
latitude = 52.515720
longitude = 13.406059

# Bbox sides - Custom for each network
north = latitude + 0.17
south = latitude - 0.20
east = longitude + 0.37
west = longitude - 0.37

# Make Map
fig, ax = ox.plot_graph(G, node_size=0, bbox = (north, south, east, west), margin =
                        fig_height=25, fig_width=25, dpi = 300,  bgcolor = "#061529"
                        save = False, edge_color=roadColors,
                        edge_linewidth=roadWidths, edge_alpha=1)


# Text and marker size
markersize = 20
fontsize = 20

# Add legend
legend_elements = [Line2D([0], [0], marker='s', color="#061529", label= 'Alcohol Pot
                          markerfacecolor="#07f507", markersize=markersize),

                   Line2D([0], [0], marker='s', color="#061529", label= 'Alcohol Pote
                          markerfacecolor="#e69419", markersize=markersize),

                   Line2D([0], [0], marker='s', color="#061529", label= 'Alcohol Pote
                          markerfacecolor="#fc00e7", markersize=markersize),

                   Line2D([0], [0], marker='s', color="#061529", label= 'Alcohol Pote
                          markerfacecolor="#d40a47", markersize=markersize)]

l = ax.legend(handles=legend_elements, bbox_to_anchor=(0.0, 0.0), frameon=True, ncol
              facecolor = '#061529', framealpha = 0.9,
              loc='lower left',  fontsize = fontsize, prop={'family':"Georgia", 'siz

# Legend font color
for text in l.get_texts():
    text.set_color("w")

# Save figure
fig.savefig(img_path_temp, dpi=300, bbox_inches='tight', format="png", facecolor=fig
```

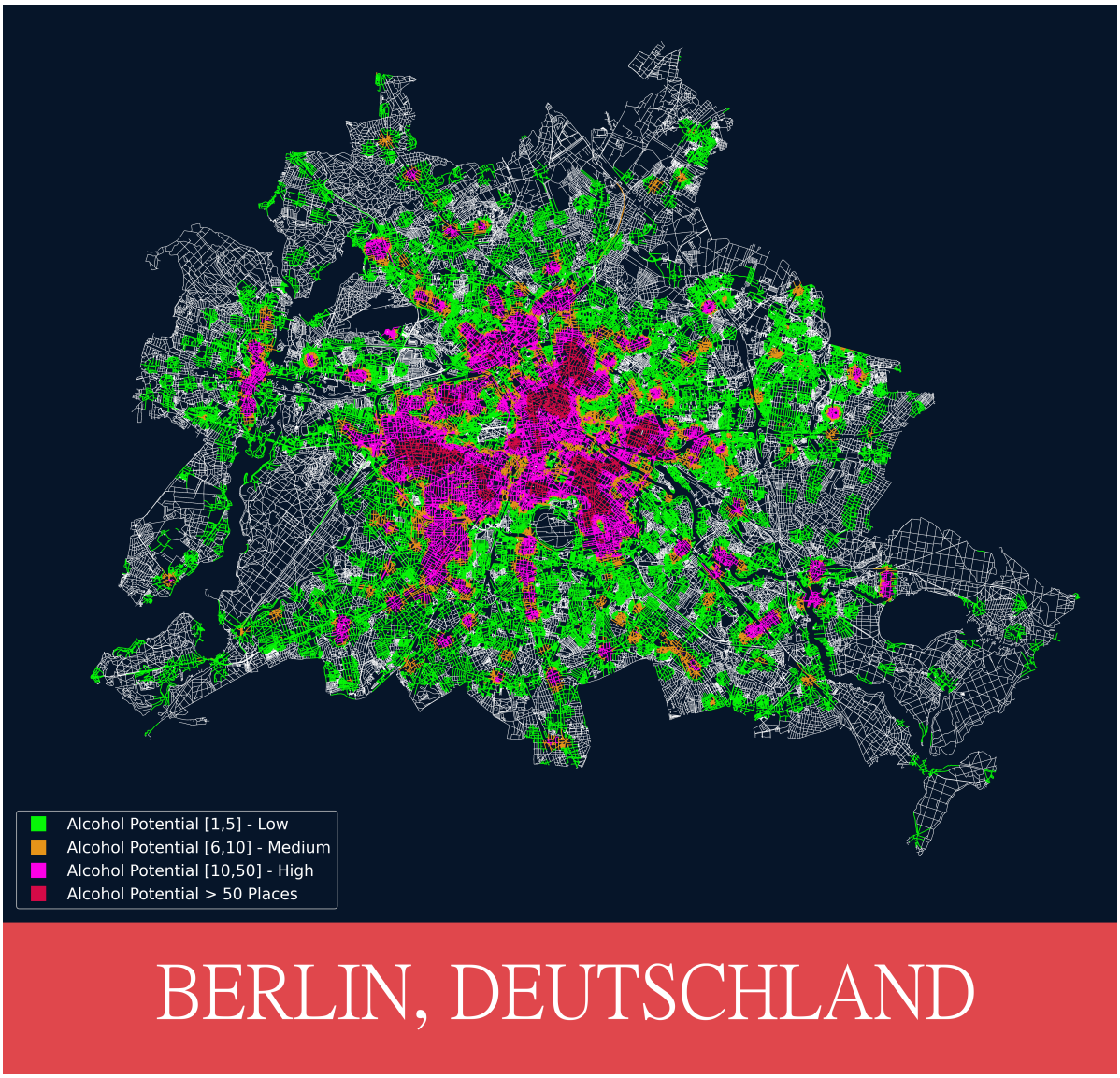


```
findfont: Font family ['Georgia'] not found. Falling back to DejaVu Sa
ns.

CPU times: user 43.2 s, sys: 2.84 s, total: 46 s
Wall time: 48.3 s
```

Add border and text to map - check script utils.add_border

In [13]:

```
%%time
# Output Image
add_border(img_path_temp, output_image=img_path_final, fill = '#e0474c', bottom = 80

# Open Image
img = Image.open(img_path_final)
draw = ImageDraw.Draw(img)

# Get font from working directory. Visit https://www.wfonts.com/search?kwd=pmingliu
font = ImageFont.truetype("PMINGLIU.ttf", 400)

# Add font: position, text, color, font
draw.text((800,5000),"BERLIN, DEUTSCHLAND", (255,255,255), font=font)

# Save image
img.save(img_path_final)

display(img)
```



```
CPU times: user 13.6 s, sys: 335 ms, total: 13.9 s
Wall time: 14.6 s
```

In [ ]:

```
```