EV Power - Lab 4 Project Report

Example Solution 1

Part 0: libraries

```
Attaching package: 'dplyr'
```

```
The following objects are masked from 'package:stats':

    filter, lag
```

```
The following objects are masked from 'package:base':

    intersect, setdiff, setequal, union
```

```
── Attaching core tidyverse packages ──────────────────── tidyverse 2.0.0
──
✔ forcats   1.0.0      ✔ stringr   1.5.2
✔ lubridate 1.9.4      ✔ tibble    3.3.0
✔ purrr     1.1.0      ✔ tidyr     1.3.1
✔ readr     2.1.5
── Conflicts ──────────────────────────────────── tidyverse_conflicts()
──
✖ dplyr::filter() masks stats::filter()
✖ dplyr::lag()    masks stats::lag()
ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all
conflicts to become errors
Linking to GEOS 3.13.0, GDAL 3.8.5, PROJ 9.5.1; sf_use_s2() is TRUE
```

Part 1: Defining Research Question

Chosen Question: How, if at all, does electric vehicle usage impact renewable energy usage? To explore this question, I will compare the electric vehicle registrations by state for 2023 to renewable energy use by state for 2023.

Part 2: Data Preparation and Cleaning

```
  State Count_EVs
1    AL     13047
2    AK      2697
```

```
3    AZ    89798
4    AR     7108
5    CA  1256646
6    CO    90083
```

```
# A tibble: 6 × 2
  State Total_Renew
  <chr>       <int>
1 AK          10088
2 AL         222189
3 AR          87277
4 AZ         108445
5 CA        1065179
6 CO         115062
```

Part 3: Joining / Pivoting Datasets for Analysis

I chose to join the renewable energy usage by state dataset for 2023 with the electric vehicles registration by state dataset for 2023. If electric vehicles are truly powered by clean sources, as asked by the main research question, then renewable energy use by state and year should increase with electric vehicle usage. I joined the two datasets by their "State" column so that each state has a designated row with a column for the number of electric vehicles registered there and a column for the total renewable energy use for the state. I also added a third column, which is the ratio of electric vehicle count to the total renewable energy use for each state to get a baseline at which to compare the states.

```
  State Count_EVs Total_Renew EV_to_Renew
1    AL     13047      222189  0.05872028
2    AK      2697       10088  0.26734734
3    AZ     89798      108445  0.82805109
4    AR      7108       87277  0.08144185
5    CA   1256646     1065179  1.17975101
6    CO     90083      115062  0.78290835
```

Part 4: Mapping Visualization

```
Simple feature collection with 51 features and 2 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: -179.1435 ymin: 18.90612 xmax: 179.7809 ymax: 71.4125
Geodetic CRS:  WGS 84
First 10 features:
            name postal                       geometry
1236   Washington     WA MULTIPOLYGON (((-122.753 48...
1238        Idaho     ID MULTIPOLYGON (((-117.0382 4...
```

```
1239      Montana     MT MULTIPOLYGON (((-116.0482 4...
1242 North Dakota     ND MULTIPOLYGON (((-104.0476 4...
1244    Minnesota     MN MULTIPOLYGON (((-97.22609 4...
1246     Michigan     MI MULTIPOLYGON (((-84.4913 46...
1247        Ohio      OH MULTIPOLYGON (((-80.52023 4...
1248 Pennsylvania     PA MULTIPOLYGON (((-79.76301 4...
1249     New York     NY MULTIPOLYGON (((-79.06523 4...
1251     Vermont      VT MULTIPOLYGON (((-73.35134 4...
```

```
Simple feature collection with 6 features and 124 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: -124.7346 ymin: 41.69681 xmax: -82.4146 ymax: 49.36949
Geodetic CRS:  WGS 84
                      featurecla scalerank adm1_code diss_me iso_3166_2
1 Admin-1 states provinces lakes         2   USA-3519    3519      US-WA
2 Admin-1 states provinces lakes         2   USA-3518    3518      US-ID
3 Admin-1 states provinces lakes         2   USA-3515    3515      US-MT
4 Admin-1 states provinces lakes         2   USA-3516    3516      US-ND
5 Admin-1 states provinces lakes         2   USA-3514    3514      US-MN
6 Admin-1 states provinces lakes         2   USA-3562    3562      US-MI
                                     wikipedia iso_a2 adm0_sr         name
1 http://en.wikipedia.org/wiki/Washington_(state)     US       6   Washington
2             http://en.wikipedia.org/wiki/Idaho     US       1        Idaho
3           http://en.wikipedia.org/wiki/Montana     US       1      Montana
4      http://en.wikipedia.org/wiki/North_Dakota     US       1 North Dakota
5         http://en.wikipedia.org/wiki/Minnesota     US       1    Minnesota
6          http://en.wikipedia.org/wiki/Michigan     US       1     Michigan
  name_alt name_local  type type_en code_local code_hasc note hasc_maybe
1 WA|Wash.       <NA> State   State       US53     US.WA <NA>       <NA>
2 ID|Idaho       <NA> State   State       US16     US.ID <NA>       <NA>
3 MT|Mont.       <NA> State   State       US30     US.MT <NA>       <NA>
4  ND|N.D.       <NA> State   State       US38     US.ND <NA>       <NA>
5 MN|Minn.       <NA> State   State       US27     US.MN <NA>       <NA>
6 MI|Mich.       <NA> State   State       US26     US.MI <NA>       <NA>
   region region_cod provnum_ne gadm_level check_me datarank abbrev postal
1    West       <NA>          0          1       20        1 Wash.     WA
2    West       <NA>          0          1       20        1 Idaho     ID
3    West       <NA>          0          1       20        1 Mont.     MT
4 Midwest       <NA>          0          1       20        1  N.D.     ND
5 Midwest       <NA>          0          1       20        1 Minn.     MN
6 Midwest       <NA>          0          1       20        1 Mich.     MI
  area_sqkm sameascity labelrank name_len mapcolor9 mapcolor13 fips fips_alt
1         0        -99         0       10         1          1 US53     <NA>
2         0        -99         0        5         1          1 US16     <NA>
3         0        -99         0        7         1          1 US30     <NA>
4         0        -99         0       12         1          1 US38     <NA>
```
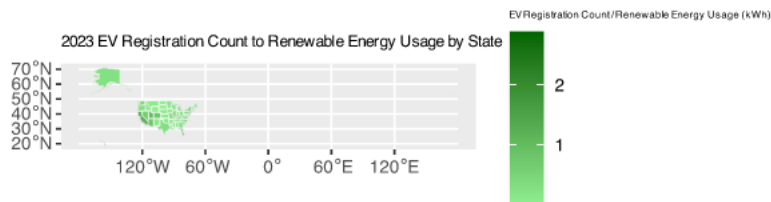
```
5        0      -99        0        9        1        1 US27     <NA>
6        0      -99        0        8        1        1 US26     <NA>
  woe_id                 woe_label    woe_name latitude longitude
1 2347606   Washington, US, United States   Washington  47.4865 -120.3610
2 2347571        Idaho, US, United States        Idaho  43.7825 -114.1330
3 2347585      Montana, US, United States      Montana  46.9965 -110.0440
4 2347593 North Dakota, US, United States North Dakota  47.4675 -100.3020
5 2347582    Minnesota, US, United States    Minnesota  46.0592  -93.3640
6 2347581     Michigan, US, United States     Michigan  43.4343  -84.9479
  sov_a3 adm0_a3 adm0_label                    admin               geonunit
1    US1     USA          2 United States of America United States of America
2    US1     USA          2 United States of America United States of America
3    US1     USA          2 United States of America United States of America
4    US1     USA          2 United States of America United States of America
5    US1     USA          2 United States of America United States of America
6    US1     USA          2 United States of America United States of America
  gu_a3   gn_id     gn_name gns_id gns_name gn_level gn_region gn_a1_code
1   USA 5815135  Washington     -1     <NA>        1      <NA>      US.WA
2   USA 5596512       Idaho     -1     <NA>        1      <NA>      US.ID
3   USA 5667009     Montana     -1     <NA>        1      <NA>      US.MT
4   USA 5690763 North Dakota    -1     <NA>        1      <NA>      US.ND
5   USA 5037779   Minnesota     -1     <NA>        1      <NA>      US.MN
6   USA 5001836    Michigan     -1     <NA>        1      <NA>      US.MI
        region_sub sub_code gns_level gns_lang gns_adm1 gns_region min_label
1          Pacific     <NA>        -1     <NA>     <NA>       <NA>        3.5
2         Mountain     <NA>        -1     <NA>     <NA>       <NA>        3.5
3         Mountain     <NA>        -1     <NA>     <NA>       <NA>        3.5
4 West North Central     <NA>      -1     <NA>     <NA>       <NA>        3.5
5 West North Central     <NA>      -1     <NA>     <NA>       <NA>        3.5
6 East North Central     <NA>      -1     <NA>     <NA>       <NA>        3.5
  max_label min_zoom wikidataid        name_ar        name_bn       name_de
1       7.5        2      Q1223         واشنطن   ওয়াশিংটন   Washington
2       7.5        2      Q1221         أيداهو        আইডাহো         Idaho
3       7.5        2      Q1212         مونتانا        মন্টানা       Montana
4       7.5        2      Q1207 داكوتا الشمالية  নর্থ ডাকোটা North Dakota
5       7.5        2      Q1527        مينيسوتا      মিনেসোটা     Minnesota
6       7.5        2      Q1166         ميشيغان        মিশিগান      Michigan
       name_en         name_es        name_fr        name_el        name_hi
1   Washington      Washington     Washington   Ουάσινγκτον बॉशिंगटन राज्य
2        Idaho           Idaho          Idaho        Άιντάχο        आयडाहो
3      Montana         Montana        Montana       Μοντάνα       मोन्टाना
4 North Dakota Dakota del Norte Dakota du Nord Βόρεια Ντακότα  उत्तर डेकोटा
5    Minnesota       Minnesota      Minnesota      Μινεσότα       मिनेसोटा
6     Michigan         Míchigan       Michigan       Μίσιγκαν       मिशिगन
       name_hu        name_id        name_it    name_ja name_ko
1   Washington     Washington     Washington  ワシントン州    워싱턴
2        Idaho          Idaho          Idaho  アイダホ州   아이다호
3      Montana        Montana        Montana  モンタナ州    몬태나
```

4	Észak-Dakota	Dakota Utara	Dakota del Nord	ノースダコタ州	ㄴㅗㅅ ㄷㅏㅋㅗㅌㅏ
5	Minnesota	Minnesota	Minnesota	ミネソタ州	머네소타
6	Michigan	Michigan	Michigan	ミシガン州	머시간

	name_nl	name_pl	name_pt	name_ru	name_sv
1	Washington	Waszyngton	Washington	Вашингтон	Washington
2	Idaho	Idaho	Idaho	Айдахо	Idaho
3	Montana	Montana	Montana	Монтана	Montana
4	Noord-Dakota	Dakota Północna	Dakota do Norte	Северная Дакота	North Dakota
5	Minnesota	Minnesota	Minnesota	Миннесота	Minnesota
6	Michigan	Michigan	Michigan	Мичиган	Michigan

	name_tr	name_vi	name_zh	ne_id	name_he	name_uk
1	Vaşington	Washington	华盛顿州	1159309547	וושינגטון	Вашингтон
2	Idaho	Idaho	爱达荷州	1159315339	איידהו	Айдахо
3	Montana	Montana	蒙大拿州	1159315333	מונטנה	Монтана
4	Kuzey Dakota	Băć Dakota	北达科他州	1159315337	דקוטה הצפונית	Північна Дакота
5	Minnesota	Minnesota	明尼苏达州	1159315297	מינסוטה	Міннесота
6	Michigan	Michigan	密歇根州	1159314665	מישיגן	Мічиган

	name_ur	name_fa	name_zht	FCLASS_ISO	FCLASS_US	FCLASS_FR
1	ریاست واشنگٹن ایالت واشینگتن		華盛頓州	<NA>	<NA>	<NA>
2	آیداہو	ایڈاہو	愛達荷州	<NA>	<NA>	<NA>
3	مونٹانا ایالت مونتانا		蒙大拿州	<NA>	<NA>	<NA>
4	شمالی ڈکوٹا	داکوتای شمالی	北達科他州	<NA>	<NA>	<NA>
5	مینیسوٹا	مینیسوتا	明尼蘇達州	<NA>	<NA>	<NA>
6	میشیگان	مشی گن	密歇根州	<NA>	<NA>	<NA>

	FCLASS_RU	FCLASS_ES	FCLASS_CN	FCLASS_TW	FCLASS_IN	FCLASS_NP	FCLASS_PK
1	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>
2	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>
3	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>
4	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>
5	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>
6	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>

	FCLASS_DE	FCLASS_GB	FCLASS_BR	FCLASS_IL	FCLASS_PS	FCLASS_SA	FCLASS_EG
1	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>
2	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>
3	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>
4	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>
5	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>
6	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>

	FCLASS_MA	FCLASS_PT	FCLASS_AR	FCLASS_JP	FCLASS_KO	FCLASS_VN	FCLASS_TR
1	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>
2	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>
3	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>
4	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>
5	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>
6	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>

	FCLASS_ID	FCLASS_PL	FCLASS_GR	FCLASS_IT	FCLASS_NL	FCLASS_SE	FCLASS_BD
1	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>
2	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>

```
3      <NA>       <NA>       <NA>       <NA>       <NA>       <NA>       <NA>
4      <NA>       <NA>       <NA>       <NA>       <NA>       <NA>       <NA>
5      <NA>       <NA>       <NA>       <NA>       <NA>       <NA>       <NA>
6      <NA>       <NA>       <NA>       <NA>       <NA>       <NA>       <NA>
  FCLASS_UA FCLASS_TLC Count_EVs Total_Renew EV_to_Renew
1      <NA>       <NA>    152101      365955  0.41562760
2      <NA>       <NA>      8501       77127  0.11022080
3      <NA>       <NA>      4608       58469  0.07881099
4      <NA>       <NA>       959       92154  0.01040649
5      <NA>       <NA>     37050      223864  0.16550227
6      <NA>       <NA>     50284      198458  0.25337351
                    geometry
1 MULTIPOLYGON (((-122.753 48...
2 MULTIPOLYGON (((-117.0382 4...
3 MULTIPOLYGON (((-116.0482 4...
4 MULTIPOLYGON (((-104.0476 4...
5 MULTIPOLYGON (((-97.22609 4...
6 MULTIPOLYGON (((-84.4913 46...
```


Conclusion

The map produced above demonstrates that states along the East and West Coasts, and near the ocean (including D.C., New Jersey, Maryland, Hawaii, California, Delaware, and Utah) have a higher electricle vehicle registration count to renewable energy usage ratio, as demonstrated by their darker coloring along the light green to dark green gradient. This indicates that they use more renewable energy per electric vehicle registered. Contrary to my hypothesis, which was that renewable energy use by state and year should increase with electric vehicle usage, the states with the highest ratio were not also the states with the highest number of electrical vehicle registrations.

A few factors could potentially describe the phenomenon I see in the map above. First, there may be different car regulations in these states that require their electric vehicles to be powered by

truly renewable energy sources, accounting for this difference in the ratio. Another observation is that this difference in ratios is largely along partisan lines - most of the states with the highest ratio are Democratic-leaning, potentially suggesting increased value placed upon the environment and climate-friendly measures and purchasing choices.