EV Power - Lab 4 Project Report

Part 0: libraries

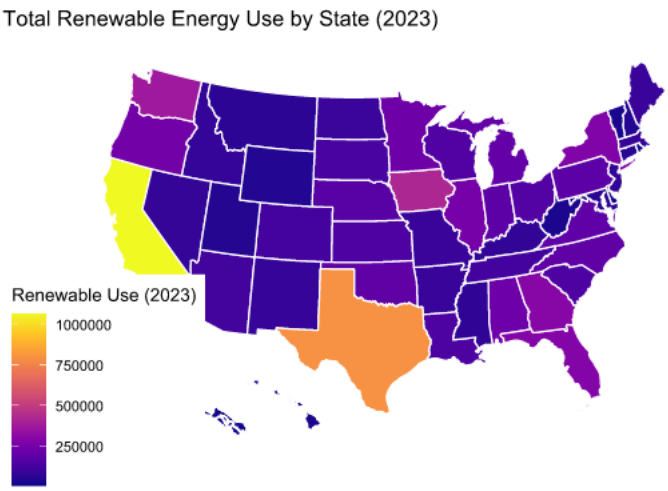
Part 1: Defining Research Question

Chosen Question: **"Do states with higher renewable energy shares have more EVs per capita?"**

```
renew23 <- read_csv("data/renew-use-2023.csv")
```

```
Rows: 260 Columns: 3
── Column specification ────────────────────────────────────────────────────────
Delimiter: ","
chr (3): State, Energy_Source, Renewable_Use_2023

ℹ Use `spec()` to retrieve the full column specification for this data.
ℹ Specify the column types or set `show_col_types = FALSE` to quiet this
message.
```

```
renew_summary <- renew23 %>%
  mutate(Renewable_Use_2023 = as.numeric(gsub("[^0-9.]", "",
Renewable_Use_2023))) %>%
  group_by(State) %>%
  summarise(total_renewable_2023 = sum(Renewable_Use_2023, na.rm = TRUE)) %>%
  rename(state = State)

plot_usmap(data = renew_summary, values = "total_renewable_2023", color =
"white") +
  scale_fill_viridis(option = "plasma", name = "Renewable Use (2023)") +
  labs(title = "Total Renewable Energy Use by State (2023)")
```



Part 2: Data Preparation and Cleaning

```
renew21 <- read_csv("data/renew-use-2021.csv")
```

```
Rows: 260 Columns: 3
── Column specification ────────────────────────────────────────────────────────
Delimiter: ","
chr (3): State, Energy_Source, Renewable_Use_2021

ℹ Use `spec()` to retrieve the full column specification for this data.
ℹ Specify the column types or set `show_col_types = FALSE` to quiet this
message.
```

```
renew22 <- read_csv("data/renew-use-2022.csv")
```

```
Rows: 260 Columns: 3
── Column specification ────────────────────────────────────────────────────────
Delimiter: ","
chr (3): State, Energy_Source, Renewable_Use_2022

ℹ Use `spec()` to retrieve the full column specification for this data.
ℹ Specify the column types or set `show_col_types = FALSE` to quiet this
message.
```

```
renew23 <- read_csv("data/renew-use-2023.csv")
```

```
Rows: 260 Columns: 3
── Column specification ────────────────────────────────────────────────────────
Delimiter: ","
chr (3): State, Energy_Source, Renewable_Use_2023

ℹ Use `spec()` to retrieve the full column specification for this data.
ℹ Specify the column types or set `show_col_types = FALSE` to quiet this
message.
```

```
total21 <- read_csv("data/total-use-2021.csv")
```

```
Rows: 5 Columns: 53
── Column specification ────────────────────────────────────────────────────────
Delimiter: ","
chr  (1): Energy_Source
dbl (52): AK, AL, AR, AZ, CA, CO, CT, DC, DE, FL, GA, HI, IA, ID, IL, IN,
KS...

ℹ Use `spec()` to retrieve the full column specification for this data.
ℹ Specify the column types or set `show_col_types = FALSE` to quiet this
message.
```

```
total22 <- read_csv("data/total-use-2022.csv")
```

```
Rows: 5 Columns: 53
── Column specification ────────────────────────────────────────────────────────
Delimiter: ","
chr  (1): Energy_Source
dbl (52): AK, AL, AR, AZ, CA, CO, CT, DC, DE, FL, GA, HI, IA, ID, IL, IN,
KS...

ℹ Use `spec()` to retrieve the full column specification for this data.
ℹ Specify the column types or set `show_col_types = FALSE` to quiet this
message.
```

```
total23 <- read_csv("data/total-use-2023.csv")
```

```
Rows: 5 Columns: 53
── Column specification ────────────────────────────────────────────────────────
```

```
Delimiter: ","
chr  (1): Energy_Source
dbl (52): AK, AL, AR, AZ, CA, CO, CT, DC, DE, FL, GA, HI, IA, ID, IL, IN,
KS...

ℹ Use `spec()` to retrieve the full column specification for this data.
ℹ Specify the column types or set `show_col_types = FALSE` to quiet this
message.
```

```
evs <- read_csv("data/ev-registrations-by-state-2023.csv")
```

```
New names:
Rows: 54 Columns: 2
── Column specification
──────────────────────────────────────────────────────── Delimiter: "," chr
(2): electric vehicle registrations_by_state (2023), ...2
ℹ Use `spec()` to retrieve the full column specification for this data. ℹ
Specify the column types or set `show_col_types = FALSE` to quiet this
message.
• `` -> `...2`
```

```
renew21 <- rename_with(renew21, tolower)
renew22 <- rename_with(renew22, tolower)
renew23 <- rename_with(renew23, tolower)
total21 <- rename_with(total21, tolower)
total22 <- rename_with(total22, tolower)
total23 <- rename_with(total23, tolower)

evs <- rename_with(evs, tolower)

head(renew23)
```

```
# A tibble: 6 × 3
  state energy_source renewable_use_2023
  <chr> <chr>         <chr>
1 AK    Biomass       3404 kWh
2 AK    Geothermal    186.0
3 AK    Hydropower    6051
4 AK    Solar Energy  67
5 AK    Wind Energy   380
6 AL    Biomass       189040 kWh
```

```
head(total23)
```

```
# A tibble: 5 × 53
  energy_source        ak     al     ar     az     ca     co     ct    dc
de
  <chr>             <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl>  <dbl> <dbl>
<dbl>
1 coal_usage        18414 224926 180262 137885 2.87e4 204826      0     0
338
2 NaturalGas       448087 775747 399566 537151 2.15e6 525446 304924 26236
84387
3 petroleum (BTU)  270391 565754 327465 599712 3.00e6 514174 292864 17292
110721
4 nuclear-energy †      0 476392 156492 329474 1.85e5      0 142873     0
0
5 total renewable…  10087 222189  87277 108445 1.07e6 115061  48981  2795
8041
# ℹ 43 more variables: fl <dbl>, ga <dbl>, hi <dbl>, ia <dbl>, id <dbl>,
#   il <dbl>, `in` <dbl>, ks <dbl>, ky <dbl>, la <dbl>, ma <dbl>, md <dbl>,
#   me <dbl>, mi <dbl>, mn <dbl>, mo <dbl>, ms <dbl>, mt <dbl>, nc <dbl>,
#   nd <dbl>, ne <dbl>, nh <dbl>, nj <dbl>, nm <dbl>, nv <dbl>, ny <dbl>,
#   oh <dbl>, ok <dbl>, or <dbl>, pa <dbl>, ri <dbl>, sc <dbl>, sd <dbl>,
#   tn <dbl>, tx <dbl>, ut <dbl>, va <dbl>, vt <dbl>, wa <dbl>, wi <dbl>,
#   wv <dbl>, wy <dbl>, us <dbl>
```

```
head(evs)
```

```
# A tibble: 6 × 2
  `electric vehicle registrations_by_state (2023)` ...2
  <chr>                                            <chr>
1 <NA>                                             <NA>
2 STATE                                            Count-EVs
3 Alabama                                          #13047
4 Alaska                                           ~2697
5 Arizona                                          89798
6 Arkansas                                         7108 EVs
```

Part 3: Joining / Pivoting Datasets for Analysis

```
renew21 <- renew21 %>% mutate(year = 2021)
renew22 <- renew22 %>% mutate(year = 2022)
renew23 <- renew23 %>% mutate(year = 2023)
total21 <- total21 %>% mutate(year = 2021)
total22 <- total22 %>% mutate(year = 2022)
total23 <- total23 %>% mutate(year = 2023)

total21_long <- total21 %>%
```

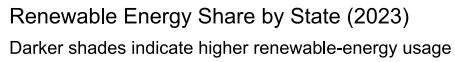
```
  pivot_longer(
    cols = -c(energy_source, year, us),
    names_to = "state_abbrev",
    values_to = "total_use"
  )

total22_long <- total22 %>%
  pivot_longer(
    cols = -c(energy_source, year, us),
    names_to = "state_abbrev",
    values_to = "total_use"
  )

total23_long <- total23 %>%
  pivot_longer(
    cols = -c(energy_source, year, us),
    names_to = "state_abbrev",
    values_to = "total_use"
  )

renew_all <- bind_rows(renew21, renew22, renew23) %>%
  rename_with(tolower)

renew_all <- renew_all %>%
  mutate(
    renewable_use = coalesce(renewable_use_2023,
                             renewable_use_2022,
                             renewable_use_2021)
  ) %>%
  select(state, energy_source, year, renewable_use)

total_all <- bind_rows(total21_long, total22_long, total23_long) %>%
  rename_with(tolower)

total_all <- total_all %>%
  mutate(
    state_abbrev = toupper(state_abbrev),
    state = state.name[match(state_abbrev, state.abb)]
  ) %>%
  mutate(
    state = ifelse(is.na(state), state_abbrev, state)
  ) %>%
  filter(state %in% state.name) %>%
  select(state, energy_source, year, total_use)

renew_all <- renew_all %>% rename_with(tolower)
total_all <- total_all %>% rename_with(tolower)
```

```r
energy_all <- left_join(
  renew_all,
  total_all,
  by = c("state", "energy_source", "year")
)

energy_all <- energy_all %>%
  mutate(
    renewable_use = as.numeric(gsub("[^0-9.]", "", renewable_use)),
    total_use = as.numeric(gsub("[^0-9.]", "", total_use)),
    renew_share = (renewable_use / total_use) * 100
  )

energy_state_year <- energy_all %>%
  group_by(state, year) %>%
  summarise(total_renew_share = mean(renew_share, na.rm = TRUE), .groups =
"drop")

evs <- evs %>%
  rename(raw = `electric vehicle registrations_by_state (2023)`) %>%
  mutate(
    state = sub(" [0-9,]+$", "", raw),
    ev_registrations = as.numeric(gsub("[^0-9]", "", raw))
  ) %>%
  select(state, ev_registrations)

energy_ev_2023 <- left_join(
  energy_state_year %>% filter(year == 2023),
  evs,
  by = "state"
)

head(energy_ev_2023)
```

```
# A tibble: 6 × 4
  state  year total_renew_share ev_registrations
  <chr> <dbl>             <dbl>            <dbl>
1 AK     2023               NaN               NA
2 AL     2023               NaN               NA
3 Ar     2023               NaN               NA
4 CA     2023               NaN               NA
5 CO     2023               NaN               NA
6 DC     2023               NaN               NA
```

Part 4: Mapping Visualization

```r
# ── Prepare data ──────────────────────────────────────────────
# keep valid rows only
energy_ev_2023 <- energy_ev_2023 %>%
  filter(!is.na(total_renew_share), !is.na(ev_registrations))

# ── Choropleth map: Renewable energy share ────────────────────
usmap::plot_usmap(
  data = energy_ev_2023,
  values = "total_renew_share",
  color  = "white"
) +
  scale_fill_continuous(
    name  = "Renewable Share (%)",
    low   = "lightyellow",
    high  = "darkgreen",
    label = scales::comma
  ) +
  labs(
    title     = "Renewable Energy Share by State (2023)",
    subtitle  = "Darker shades indicate higher renewable-energy usage",
    caption   = "Data sources: U.S. Energy datasets and EV registrations"
  ) +
  theme(legend.position = "right")
```



Part 5: Summary

In 2023, states with higher renewable energy shares—such as California and Washington—also tended to have more electric vehicle registrations. This suggests a moderate positive relationship between renewable energy use and EV adoption. Larger, more energy-diverse states generally

lead both in renewable production and sustainable transportation. Overall, the trend indicates that progress in clean energy often aligns with greater EV uptake across the U.S