

# EV Power - Lab 4 Project Report

## Example Solution 1

### Part 0: libraries

```
#install.packages("maps")
#install.packages("sf")
#install.packages("rnaturalearth")

library(dplyr)
```

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

```
library(tidyverse)
```

— Attaching core tidyverse packages — tidyverse 2.0.0

✓ forcats	1.0.0	✓ readr	2.1.5
✓ ggplot2	4.0.0	✓ stringr	1.5.2
✓ lubridate	1.9.4	✓ tibble	3.3.0
✓ purrr	1.1.0	✓ tidyr	1.3.1

— 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

```
library(ggplot2)
library(readr)
library(stringr)
library(maps)
```

Attaching package: 'maps'

The following object is masked from 'package:purrr':

map

```
library(sf)
```

Linking to GEOS 3.13.0, GDAL 3.8.5, PROJ 9.5.1; sf\_use\_s2() is TRUE

```
library(rnaturalearth)

renew_2023 <- read.csv("data/renew-use-2023.csv")
total_2023 <- read.csv("data/total-use-2023.csv")
ev_2023 <- read.csv("data/ev-registrations-by-state-2023.csv")
```

## Part 1: Defining Research Question

Chosen Question: Do states with higher renewable energy use also have more EV registrations in 2023?

## Part 2: Data Preparation and Cleaning

```
#registrations: clean coll, take out firrst two rows, and edit the name of
coll
cleaned_ev <- ev_2023 |>
  rename(state = electric.vehicle.registrations_by_state..2023.) |>
  slice(3:n()) |>
  mutate(count_ev = str_replace_all(X, "\\D+", ""), count_ev =
as.numeric(count_ev)) |>
  select(state, count_ev)
head(cleaned_ev)
```

	state	count_ev
1	Alabama	13047
2	Alaska	2697
3	Arizona	89798
4	Arkansas	7108

```
5 California 1256646
6 Colorado 90083
```

```
#renewable energy use: rename, clean numbers, match state names
cleaned_energy <- renew_2023 |>
  rename(state = State, source = Energy_Source) |>
  mutate(use = str_replace_all(Renewable_Use_2023, "\\D+", ""), use =
as.numeric(use)) |>
  select(state, source, use) |>
  group_by(state) |>
  mutate(total_use = sum(use)) |>
  distinct(state, total_use, .keep_all = TRUE) |>
  select(-source, -use)
head(cleaned_energy)
```

```
# A tibble: 6 × 2
# Groups:   state [6]
  state total_use
<chr>      <dbl>
1 AK         11762
2 AL        223458
3 Ar         87277
4 az        108445
5 CA       1065179
6 CO        115062
```

```
#editing the state values to match
cleaned_energy$state <- toupper(cleaned_energy$state)
#create table to join
state_table <- tibble(
  state = state.abb,
  state_full = state.name
)

pre_combined <- left_join(cleaned_energy, state_table)
```

```
Joining with `by = join_by(state)`
```

```
na_position <- which(is.na(pre_combined$state_full))
pre_combined$state_full[na_position] <- c("District of Columbia", "Total")

cleaned_energy_final <- pre_combined |>
  ungroup() |>
  select(-state) |>
```

```
rename(state = state_full)
head(cleaned_energy_final)
```

```
# A tibble: 6 × 2
  total_use state
  <dbl> <chr>
1    11762 Alaska
2   223458 Alabama
3    87277 Arkansas
4   108445 Arizona
5  1065179 California
6   115062 Colorado
```

```
#cleaned_energy_final
#cleaned_ev
```

### Part 3: Joining / Pivoting Datasets for Analysis

```
new <- left_join(cleaned_ev, cleaned_energy_final)
```

```
Joining with `by = join_by(state)`
```

```
new <- new |>
  mutate(percent_regis = count_ev / count_ev[52] * 100,
         percent_use = total_use / total_use[52] * 100)

new <- slice(new, 1:n()-1)
head(new)
```

	state	count_ev	total_use	percent_regis	percent_use
1	Alabama	13047	223458	0.36695829	2.7293190
2	Alaska	2697	11762	0.07585548	0.1436612
3	Arizona	89798	108445	2.52564728	1.3245487
4	Arkansas	7108	87277	0.19991872	1.0660025
5	California	1256646	1065179	35.34426774	13.0101106
6	Colorado	90083	115062	2.53366316	1.4053688

### Part 4: Mapping Visualization

```
us_states <- ne_states(country = "united states of america", returnclass =
  "sf")

us_joined <- us_states |>
```

```
left_join(new, by = c("name" = "state"))
us_joined
```

Simple feature collection with 51 features and 125 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:

	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
7	Admin-1 states provinces lakes	2	USA-3550	3550	US-OH
8	Admin-1 states provinces lakes	2	USA-3560	3560	US-PA
9	Admin-1 states provinces lakes	2	USA-3559	3559	US-NY
10	Admin-1 states provinces lakes	2	USA-3540	3540	US-VT

	wikipedia	iso_a2	adm0_sr	name
1	<a href="http://en.wikipedia.org/wiki/Washington_(state)">http://en.wikipedia.org/wiki/Washington_(state)</a>	US	6	Washington
2	<a href="http://en.wikipedia.org/wiki/Idaho">http://en.wikipedia.org/wiki/Idaho</a>	US	1	Idaho
3	<a href="http://en.wikipedia.org/wiki/Montana">http://en.wikipedia.org/wiki/Montana</a>	US	1	Montana
4	<a href="http://en.wikipedia.org/wiki/North_Dakota">http://en.wikipedia.org/wiki/North_Dakota</a>	US	1	North Dakota
5	<a href="http://en.wikipedia.org/wiki/Minnesota">http://en.wikipedia.org/wiki/Minnesota</a>	US	1	Minnesota
6	<a href="http://en.wikipedia.org/wiki/Michigan">http://en.wikipedia.org/wiki/Michigan</a>	US	1	Michigan
7	<a href="http://en.wikipedia.org/wiki/Ohio">http://en.wikipedia.org/wiki/Ohio</a>	US	1	Ohio
8	<a href="http://en.wikipedia.org/wiki/Pennsylvania">http://en.wikipedia.org/wiki/Pennsylvania</a>	US	1	Pennsylvania
9	<a href="http://en.wikipedia.org/wiki/New_York">http://en.wikipedia.org/wiki/New_York</a>	US	3	New York
10	<a href="http://en.wikipedia.org/wiki/Vermont">http://en.wikipedia.org/wiki/Vermont</a>	US	1	Vermont

	name_alt	name_local	type	type_en	code_local
1	WA Wash.	<NA>	State	State	US53
2	ID Idaho	<NA>	State	State	US16
3	MT Mont.	<NA>	State	State	US30
4	ND N.D.	<NA>	State	State	US38
5	MN Minn.	<NA>	State	State	US27
6	MI Mich.	<NA>	State	State	US26
7	OH Ohio	<NA>	State	State	US39
8	Commonwealth of Pennsylvania PA	<NA>	State	State	US42
9	NY N.Y.	<NA>	State	State	US36
10	VT	<NA>	State	State	US50

	code_hasc	note	hasc_maybe	region	region_cod	provnum_ne	gadm_level
1	US.WA	<NA>	<NA>	West	<NA>	0	1
2	US.ID	<NA>	<NA>	West	<NA>	0	1
3	US.MT	<NA>	<NA>	West	<NA>	0	1
4	US.ND	<NA>	<NA>	Midwest	<NA>	0	1

5	US.MN	<NA>	<NA>	Midwest	<NA>	0	1		
6	US.MI	<NA>	<NA>	Midwest	<NA>	0	1		
7	US.OH	<NA>	<NA>	Midwest	<NA>	0	1		
8	US.PA	<NA>	<NA>	Northeast	<NA>	0	1		
9	US.NY	<NA>	<NA>	Northeast	<NA>	0	1		
10	US.VT	<NA>	<NA>	Northeast	<NA>	0	1		
	check_me	datarank	abbrev	postal	area_sqkm	sameascity	labelrank name_len		
1	20	1	Wash.	WA	0	-99	0 10		
2	20	1	Idaho	ID	0	-99	0 5		
3	20	1	Mont.	MT	0	-99	0 7		
4	20	1	N.D.	ND	0	-99	0 12		
5	20	1	Minn.	MN	0	-99	0 9		
6	20	1	Mich.	MI	0	-99	0 8		
7	20	1	Ohio	OH	0	-99	0 4		
8	20	1	Pa.	PA	0	-99	0 12		
9	20	1	N.Y.	NY	0	-99	0 8		
10	20	1	Vt.	VT	0	-99	0 7		
	mapcolor9	mapcolor13	fips	fips_alt	woe_id	woe_label			
1	1	1	US53	<NA>	2347606	Washington, US, United States			
2	1	1	US16	<NA>	2347571	Idaho, US, United States			
3	1	1	US30	<NA>	2347585	Montana, US, United States			
4	1	1	US38	<NA>	2347593	North Dakota, US, United States			
5	1	1	US27	<NA>	2347582	Minnesota, US, United States			
6	1	1	US26	<NA>	2347581	Michigan, US, United States			
7	1	1	US39	<NA>	2347594	Ohio, US, United States			
8	1	1	US42	<NA>	2347597	Pennsylvania, US, United States			
9	1	1	US36	<NA>	2347591	New York, US, United States			
10	1	1	US50	<NA>	2347604	Vermont, US, United States			
	woe_name	latitude	longitude	sov_a3	adm0_a3	adm0_label			
1	Washington	47.4865	-120.3610	US1	USA	2			
2	Idaho	43.7825	-114.1330	US1	USA	2			
3	Montana	46.9965	-110.0440	US1	USA	2			
4	North Dakota	47.4675	-100.3020	US1	USA	2			
5	Minnesota	46.0592	-93.3640	US1	USA	2			
6	Michigan	43.4343	-84.9479	US1	USA	2			
7	Ohio	40.0924	-82.6719	US1	USA	2			
8	Pennsylvania	40.8601	-77.6094	US1	USA	2			
9	New York	43.1988	-75.3242	US1	USA	2			
10	Vermont	44.0886	-72.7317	US1	USA	2			
	admin			geonunit	gu_a3	gn_id			
	gn_name								
1	United States of America United States of America					USA	5815135		
Washington									
2	United States of America United States of America					USA	5596512		
Idaho									
3	United States of America United States of America					USA	5667009		
Montana									
4	United States of America United States of America					USA	5690763 North		

Dakota								
5	United States of America	United States of America	USA	5037779				
Minnesota								
6	United States of America	United States of America	USA	5001836				
Michigan								
7	United States of America	United States of America	USA	5165418				
Ohio								
8	United States of America	United States of America	USA	6254927				
Pennsylvania								
9	United States of America	United States of America	USA	5128638			New	
York								
10	United States of America	United States of America	USA	5242283				
Vermont								
	gns_id	gns_name	gn_level	gn_region	gn_al_code	region_sub	sub_code	
1	-1	<NA>	1	<NA>	US.WA	Pacific	<NA>	
2	-1	<NA>	1	<NA>	US.ID	Mountain	<NA>	
3	-1	<NA>	1	<NA>	US.MT	Mountain	<NA>	
4	-1	<NA>	1	<NA>	US.ND	West North Central	<NA>	
5	-1	<NA>	1	<NA>	US.MN	West North Central	<NA>	
6	-1	<NA>	1	<NA>	US.MI	East North Central	<NA>	
7	-1	<NA>	1	<NA>	US.OH	East North Central	<NA>	
8	-1	<NA>	1	<NA>	US.PA	Middle Atlantic	<NA>	
9	-1	<NA>	1	<NA>	US.NY	Middle Atlantic	<NA>	
10	-1	<NA>	1	<NA>	US.VT	New England	<NA>	
	gns_level	gns_lang	gns_adm1	gns_region	min_label	max_label	min_zoom	
1	-1	<NA>	<NA>	<NA>	3.5	7.5	2	
2	-1	<NA>	<NA>	<NA>	3.5	7.5	2	
3	-1	<NA>	<NA>	<NA>	3.5	7.5	2	
4	-1	<NA>	<NA>	<NA>	3.5	7.5	2	
5	-1	<NA>	<NA>	<NA>	3.5	7.5	2	
6	-1	<NA>	<NA>	<NA>	3.5	7.5	2	
7	-1	<NA>	<NA>	<NA>	3.5	7.5	2	
8	-1	<NA>	<NA>	<NA>	3.5	7.5	2	
9	-1	<NA>	<NA>	<NA>	3.5	7.5	2	
10	-1	<NA>	<NA>	<NA>	3.5	7.5	2	
	wikidataid	name_ar	name_bn	name_de	name_en			
1	Q1223	واشنطن	ওয়াশিংটন	Washington	Washington			
2	Q1221	أيداهو	আইডাহো	Idaho	Idaho			
3	Q1212	مونتانا	মন্টানা	Montana	Montana			
4	Q1207	داكوتا الشمالية	নর্থ ডাকোটা	North Dakota	North Dakota			
5	Q1527	مينيسوتا	মিনেসোটা	Minnesota	Minnesota			
6	Q1166	ميشيغان	মিশিগান	Michigan	Michigan			
7	Q1397	أوهايو	ওহাইও	Ohio	Ohio			
8	Q1400	بنسلفانيا	পেনসিলভেনিয়া	Pennsylvania	Pennsylvania			
9	Q1384	نيويورك	নিউ ইয়র্ক	New York	New York			
10	Q16551	فيرمونت	ভার্মন্ট	Vermont	Vermont			
	name_es	name_fr	name_el	name_hi	name_hu			
1	Washington	Washington	Ουάσιγκτον	वाशिंगटन	राज्य	Washington		

2	Idaho	Idaho	Αιδαχο	आयडाहो	Idaho	
3	Montana	Montana	Μοντάνα	मोन्टाना	Montana	
4	Dakota del Norte	Dakota du Nord	Βόρεια Ντακότα	उत्तर डेकोटा	Észak-Dakota	
5	Minnesota	Minnesota	Μινεσότα	मिनेसोटा	Minnesota	
6	Michigan	Michigan	Μίσιγκαν	मिशिगन	Michigan	
7	Ohio	Ohio	Οχάιο	ओहायो	Ohio	
8	Pensilvania	Pennsylvanie	Πενσιλβάνια	पेन्सिलवेनिया	Pennsylvania	
9	Nueva York	État de New York	Νέα Υόρκη	न्यूयॉर्क	New York	
10	Vermont	Vermont	Βερμόντ	वर्मट	Vermont	
	name_id	name_it	name_ja	name_ko	name_nl	
1	Washington	Washington	ワシントン州	워싱턴	Washington	
2	Idaho	Idaho	아이다호州	아이다호	Idaho	
3	Montana	Montana	몬타나州	몬테나	Montana	
4	Dakota Utara	Dakota del Nord	ノースダコタ州	노스다코타	Noord-Dakota	
5	Minnesota	Minnesota	ミネソタ州	미네소타	Minnesota	
6	Michigan	Michigan	미시ガン州	미시건	Michigan	
7	Ohio	Ohio	오하이오州	오하이오	Ohio	
8	Pennsylvania	Pennsylvania	펜실베이니아州	펜실베이니아	Pennsylvania	
9	New York	New York	뉴욕州	뉴욕	New York	
10	Vermont	Vermont	버몬트州	버몬트	Vermont	
	name_pl	name_pt	name_ru	name_sv	name_tr	
1	Waszyngton	Washington	Вашингтон	Washington	Vaşington	
2	Idaho	Idaho	Айдахо	Idaho	Idaho	
3	Montana	Montana	Монтана	Montana	Montana	
4	Dakota Północna	Dakota do Norte	Северная Дакота	North Dakota	Kuzey Dakota	
5	Minnesota	Minnesota	Миннесота	Minnesota	Minnesota	
6	Michigan	Michigan	Мичиган	Michigan	Michigan	
7	Ohio	Ohio	Огайо	Ohio	Ohio	
8	Pensylvania	Pensilvânia	Пенсильвания	Pennsylvania	Pensilvanya	
9	Nowy Jork	Nova Iorque	Нью-Йорк	New York	New York	
10	Vermont	Vermont	Вермонт	Vermont	Vermont	
	name_vi	name_zh	ne_id	name_he	name_uk	
1	Washington	华盛顿州	1159309547	וואשינגטון	Вашингтон	
2	Idaho	爱达荷州	1159315339	איידהו	Айдахо	
3	Montana	蒙大拿州	1159315333	מונטנה	Монтана	
4	Báč Dakota	北达科他州	1159315337	דקוטה הצפונית	Північна Дакота	
5	Minnesota	明尼苏达州	1159315297	מינסוטה	Міннесота	
6	Michigan	密歇根州	1159314665	מישיגן	Мічиган	
7	Ohio	俄亥俄州	1159315315	אוהיו	Огайо	
8	Pennsylvania	宾夕法尼亚州	1159315331	פנסילבניה	Пенсильванія	
9	New York	纽约州	1159312155	ניו יורק	штат Нью-Йорк	
10	Vermont	佛蒙特州	1159315305	ורמונט	Вермонт	
	name_ur	name_fa	name_zht	FCLASS_ISO	FCLASS_US	FCLASS_FR
1	واشنگٹن ایالت	ریاست واشنگٹن	華盛頓州	<NA>	<NA>	<NA>
2	آیڈاہو	ایڈاہو	愛達荷州	<NA>	<NA>	<NA>
3	مونٹانا ایالت	مونٹانا	蒙大拿州	<NA>	<NA>	<NA>
4	داکوتای شمالی	شمالی ڈکوتا	北達科他州	<NA>	<NA>	<NA>
5	مینہسوتا	مینیسوتا	明尼蘇達州	<NA>	<NA>	<NA>



[illegible]

	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>	<NA>
	FCLASS_UA	FCLASS_TLC	count_ev	total_use	percent_regis	percent_use	
1	<NA>	<NA>	152101	365955	4.27797364	4.4697793	
2	<NA>	<NA>	8501	77127	0.23909806	0.9420302	
3	<NA>	<NA>	4608	58469	0.12960403	0.7141412	
4	<NA>	<NA>	959	92154	0.02697271	1.1255702	
5	<NA>	<NA>	37050	223864	1.04206365	2.7342779	
6	<NA>	<NA>	50284	198458	1.41428148	2.4239687	
7	<NA>	<NA>	50393	153084	1.41734720	1.8697700	
8	<NA>	<NA>	70154	178035	1.97314260	2.1745219	
9	<NA>	<NA>	131250	272968	3.69152103	3.3340348	
10	<NA>	<NA>	7816	22209	0.21983184	0.2712610	

geometry

```

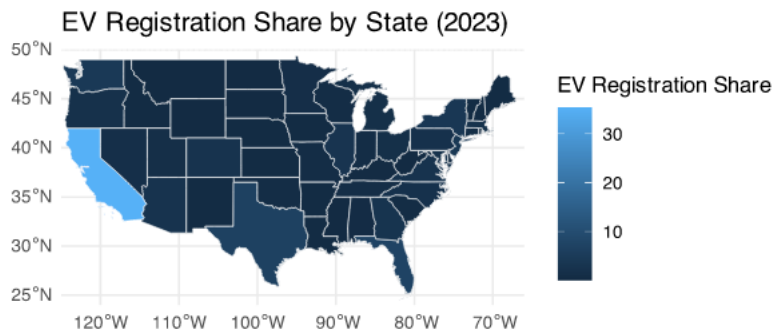
1 MULTIPOLYGON (((-122.753 48...
2 MULTIPOLYGON (((-117.0382 4...
3 MULTIPOLYGON (((-116.0482 4...
4 MULTIPOLYGON (((-104.0476 4...
5 MULTIPOLYGON (((-97.22609 4...
6 MULTIPOLYGON (((-84.4913 46...
7 MULTIPOLYGON (((-80.52023 4...
8 MULTIPOLYGON (((-79.76301 4...
9 MULTIPOLYGON (((-79.06523 4...
10 MULTIPOLYGON (((-73.35134 4...

```

```

#ev plot
ev_map <- ggplot(us_joined) +
  geom_sf(aes(fill = percent_regis), color = "white") +
  scale_fill_continuous(name = "EV Registration Share", na.value = "grey90") +
  labs(title = "EV Registration Share by State (2023)") +
  coord_sf(xlim = c(-125, -66), ylim = c(24, 50), expand = FALSE) +
  theme_minimal()
ev_map

```



```
#energy use plot
use_map <- ggplot(us_joined) +
  geom_sf(aes(fill = percent_use), color = "white") +
  scale_fill_continuous(name = "Renewable Energy Use Share", na.value =
"grey90") +
  labs(title = "Renewable Energy Use Share by State (2023)") +
  coord_sf(xlim = c(-125, -66), ylim = c(24, 50), expand = FALSE) +
  theme_minimal()
use_map
```

