# Packages ----------------------------------------------------------------

library(sf)

library(tidyverse)

library(readxl)

library(writexl)

# Load Data ---------------------------------------------------------------

# 1. stations

stations <-

read\_csv('DataStory/alt\_fuel\_stations.csv')

# 2. EV stocks

# stocks

EV\_registration\_by\_state <-

read\_excel('DataStory/ev-registration-counts-by-state.xlsx') %>%

select(State, `Registration Count`) %>%

filter(State != 'Total')

# registration

LDV\_registration\_2021 <-

read\_excel('DataStory/2021\_LDV\_registration.xlsx') %>%

filter(State != 'United States')

# 3. Housing and other demography data

DMV\_housing\_temp <-

read\_xlsx('DataStory/DMV\_housing.xlsx')

DMV\_housing <-

t(DMV\_housing\_temp[-1])

colnames(DMV\_housing) <- select(DMV\_housing\_temp, `vehicles available`)

# basic states information

data(state)

state <-

cbind(state.name, state.abb, state.area) %>%

as\_tibble() %>%

rename(State = state.name,

abb = state.abb,

area = state.area)

# 4. laws and incentives

EV\_law <-

read\_csv('DataStory/EV\_law.csv') %>%

filter(Recent == TRUE,

State != 'US') %>%

group\_by(State) %>%

summarise(EV\_law = n()) %>%

rename(state.abb = State)

# PHEV\_law is useless since EV\_law overlaps with it

PHEV\_law <-

read\_csv('DataStory/PHEV\_law.csv') %>%

filter(`Recent?` == TRUE,

State != 'US') %>%

group\_by(State) %>%

summarise(PHEV\_law = n()) %>%

rename(state.abb = State)

# states that have incentives or not

state\_w\_incentive <-

cbind(state.abb, state.name) %>%

as\_tibble() %>%

full\_join(EV\_law) %>%

full\_join(PHEV\_law) %>%

rename(State = state.name,

abb = state.abb) %>%

mutate(EV\_law\_B = if\_else(!is.na(EV\_law),

T,

F)) %>%

mutate(PHEV\_law\_B = if\_else(!is.na(PHEV\_law),

T,

F))

# Data preparation --------------------------------------------------------

# 1. charger number by state

charger\_by\_state <-

stations %>%

# the open date is ealier than 2022, so this is the existence of chargers in

# 2021

filter(year(`Open Date`) < 2022) %>%

# 'ON' is in Canada

filter(State != 'ON') %>%

select(`Station Name`, `EV Level1 EVSE Num`, `EV Level2 EVSE Num`,

`EV DC Fast Count`, State) %>%

# 'NA' indicates that there is no this type of EVSE in the station, so there

# is 0 this type of EVSE in the station

replace(is.na(.), 0) %>%

# the total number of charging points in a charging station is the sum of

# 3 types of EVSEs

mutate(EVSE = `EV Level1 EVSE Num` + `EV Level2 EVSE Num` +

`EV DC Fast Count`) %>%

# calculate the total number of EVSE in each state in 2021

group\_by(State) %>%

summarise(EVSE\_state = sum(EVSE))

# 2. increase of EV

# EV count

LDV\_2021 <-

LDV\_registration\_2021 %>%

transmute(

State = State,

EV = `Electric (EV)`,

PHEV = `Plug-In Hybrid Electric (PHEV)`) %>%

mutate(count = EV + PHEV)

# percentage increase

EV\_percentage <-

LDV\_2021 %>%

full\_join(EV\_registration\_by\_state,

by = join\_by(State)) %>%

mutate(percent = `Registration Count` / count)

# Increase & charger count ------------------------------------------------

# An analysis based on 2021 data

increase\_and\_charger <-

charger\_by\_state %>%

rename(abb = State) %>%

full\_join(state,

by = join\_by(abb)) %>%

full\_join(EV\_percentage,

by = join\_by(State)) %>%

# combine the DC values into one row, then discard the previous rows

# containing NA values

rbind(c('DC', 798, 'District of Columbia', 68, 3700, 2500, 6200, 3700,

0.596774193548387)) %>%

na.omit()

# calculate the charger density in each state

increase\_and\_charger$EVSE\_state <- as.numeric(increase\_and\_charger$EVSE\_state)

increase\_and\_charger$area <- as.numeric(increase\_and\_charger$area)

increase\_and\_charger$percent <- as.numeric(increase\_and\_charger$percent)

increase\_and\_charger$count <- as.numeric(increase\_and\_charger$count)

# scatter plot with a fit line

increase\_and\_charger <-

increase\_and\_charger %>%

mutate(charger\_density = EVSE\_state / area)

# 1. charger density by area

p1 <-

increase\_and\_charger %>%

# exclude the outlier for a better visualization

filter(abb != 'DC') %>%

ggplot(aes(x = charger\_density,

y = percent)) +

geom\_point(color = 'gray',

size = 4) +

stat\_smooth(method = 'lm',

formula = y ~ x,

se = F,

color = '#4dac26') +

theme\_bw() +

theme(axis.line = element\_line(colour = '#969696'),

axis.ticks = element\_blank(),

panel.grid.minor = element\_blank(),

panel.grid.major = element\_line(linetype = 'dashed'),

panel.border = element\_blank())

# 2. charger density by EV count

increase\_and\_charger <-

increase\_and\_charger %>%

mutate(charger\_density = EVSE\_state / count)

p2 <-

increase\_and\_charger %>%

# exclude the outlier for a better visualization

filter(abb != 'DC') %>%

ggplot(aes(x = charger\_density,

y = percent)) +

geom\_point(color = 'gray',

size = 4) +

stat\_smooth(method = 'lm',

formula = y ~ x,

se = F,

color = '#4dac26') +

theme\_bw() +

theme(axis.line = element\_line(colour = '#969696'),

axis.ticks = element\_blank(),

panel.grid.minor = element\_blank(),

panel.grid.major = element\_line(linetype = 'dashed'),

panel.border = element\_blank())

# Scatter plot with 2 fit lines -------------------------------------------

# consider incentives for EVs and PHEVs

plot2\_data <-

increase\_and\_charger %>%

left\_join(state\_w\_incentive)

p3 <-

plot2\_data %>%

filter(abb != 'DC') %>%

ggplot() +

geom\_point(aes(x = charger\_density,

y = percent,

color = EV\_law\_B),

size = 4,

alpha = 0.8) +

scale\_color\_manual(values = c('#fc8d59', '#91cf60')) +

geom\_smooth(aes(x = charger\_density,

y = percent,

fill = EV\_law\_B),

method = 'lm',

formula = y ~ x,

se = F,

color = '#969696') +

theme\_bw() +

theme(axis.line = element\_line(colour = '#969696'),

axis.ticks = element\_blank(),

panel.grid.minor = element\_blank(),

panel.grid.major = element\_line(linetype = 'dashed'),

panel.border = element\_blank())

# p4

p4 <-

plot2\_data %>%

filter(abb != 'DC') %>%

ggplot() +

geom\_point(aes(x = charger\_density,

y = percent,

color = EV\_law\_B),

size = 4,

alpha = 0.8) +

scale\_color\_manual(values = c('#fc8d59', '#91cf60')) +

geom\_smooth(aes(x = charger\_density,

y = percent,

fill = EV\_law\_B),

method = 'lm',

formula = y ~ x,

se = F,

color = '#969696') +

theme\_bw() +

theme(axis.line = element\_line(colour = '#969696'),

axis.ticks = element\_blank(),

panel.grid.minor = element\_blank(),

panel.grid.major = element\_line(linetype = 'dashed'),

panel.border = element\_blank())

# Map ---------------------------------------------------------------------

write\_xlsx(plot2\_data, 'DataStory/EV\_map.xlsx')