

Package ‘evsim’

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Title Electric Vehicle Charging Sessions Simulation

Version 1.5.0

Description Simulation of Electric Vehicles charging sessions using Gaussian models, together with time-series power demand calculations. The simulation methodology is published in Cañigueral et al. (2023, ISBN:0957-4174) <[doi:10.1016/j.eswa.2023.120318](https://doi.org/10.1016/j.eswa.2023.120318)>.

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<https://github.com/mcanigueral/evsim/>

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adapt_charging_features

Adapt charging features

Description

Calculate connection and charging times according to energy, power and time resolution

Usage

```
adapt_charging_features(
  sessions,
  time_resolution = 15,
  power_resolution = 0.01
)
```

Arguments

`sessions` tibble, sessions data set in standard format marked by {evprof} package (see [this article](#))

`time_resolution` integer, time resolution (in minutes) of the sessions' datetime variables

`power_resolution` numeric, power resolution (in kW) of the sessions' power

Details

All sessions' Power must be higher than 0, to avoid NaN values from dividing by zero. The ConnectionStartDateTime is first aligned to the desired time resolution, and the ConnectionEndDateTime is calculated according to the ConnectionHours. The ChargingHours is recalculated with the values of Energy and Power, limited by ConnectionHours. Finally, the charging times are also calculated.

Value

tibble

Examples

```
suppressMessages(library(dplyr))

sessions <- head(evsim::california_ev_sessions, 10)

sessions %>%
  select(ConnectionStartDateTime, ConnectionEndDateTime, Power)

adapt_charging_features(
  sessions,
  time_resolution = 60,
  power_resolution = 0.01
) %>%
  select(ConnectionStartDateTime, ConnectionEndDateTime, Power)

adapt_charging_features(
  sessions,
  time_resolution = 15,
  power_resolution = 1
) %>%
  select(ConnectionStartDateTime, ConnectionEndDateTime, Power)
```

add_charging_infrastructure

Assign a charging station to EV charging sessions

Description

Variable ChargingStation and Socket will be assigned to the sessions tibble with a name pattern being: names_prefix + "CHS" + number

Usage

```
add_charging_infrastructure(  
  sessions,  
  resolution = 15,  
  min_stations = 0,  
  names_prefix = NULL,  
  duration_th = 0  
)
```

Arguments

sessions	tibble, sessions data set in standard format marked by {evprof} package (see this article)
resolution	integer, time resolution in minutes
min_stations	integer, minimum number of charging stations to consider
names_prefix	character, prefix of the charging station names (optional)
duration_th	integer between 0 and 100, minimum share of time (in percentage) of the "occupancy duration curve" (see function <code>plot_occupancy_duration_curve</code>). This is used to avoid sizing a charging infrastructure to host for example 100 vehicles when only 5% of time there are more than 80 vehicles connected. Then, setting <code>duration_th = 5</code> will ensure that we don't over-size the charging infrastructure for the 100 vehicles. It is recommended to find this value through multiple iterations.

Value

tibble

Examples

```
# Assign a `ChargingStation` to every session according to the occupancy  
sessions_infrastructure <- add_charging_infrastructure(  
  sessions = head(evsim::california_ev_sessions, 50),  
  resolution = 60  
)  
print(unique(sessions_infrastructure$ChargingStation))  
  
# Now without considering the occupancy values that only represent  
# a 10% of the time  
sessions_infrastructure <- add_charging_infrastructure(  
  sessions = head(evsim::california_ev_sessions, 50),  
  resolution = 60, duration_th = 10  
)  
print(unique(sessions_infrastructure$ChargingStation))
```

expand_sessions	<i>Expand sessions along time slots</i>
-----------------	---

Description

Every session in `sessions` is divided in multiple time slots with the corresponding Power consumption, among other variables.

Usage

```
expand_sessions(sessions, resolution)
```

Arguments

<code>sessions</code>	tibble, sessions data set in standard format marked by <code>evprof</code> package (see this article)
<code>resolution</code>	integer, time resolution (in minutes) of the time slots

Details

The `Power` value is calculated for every time slot according to the original required energy. The columns `NominalPower`, `RequiredEnergy` and `FlexibilityHours` correspond to the values of the original session, and not to the expanded session in every time slot. The column `ID` shows the number of the time slot corresponding to the original session.

Value

tibble

Examples

```
library(dplyr)

sessions <- head(evsim::california_ev_sessions, 10)
expand_sessions(
  sessions,
  resolution = 60
)
```

get_charging_rates_distribution
Charging rates distribution

Description

Get charging rates distribution in percentages from a charging sessions data set

Usage

```
get_charging_rates_distribution(sessions, unit = "year", power_interval = NULL)
```

Arguments

sessions	tibble, sessions data set in standard format marked by {evprof} package (see this article)
unit	character. Valid base units are second, minute, hour, day, week, month, bimonth, quarter, season, halfyear and year. It corresponds to unit parameter in lubridate::floor_date function.
power_interval	numeric, interval of kW between power rates. It is used to round the Power values into this interval resolution. It can also be NULL to use all the original Power values.

Value

tibble

Examples

```
get_charging_rates_distribution(evsim::california_ev_sessions, unit = "year")
```

get_custom_ev_model *Create the custom EV model*

Description

Get the EV model object of class evmodel

Usage

```
get_custom_ev_model(  
  names,  
  months_lst = list(1:12, 1:12),  
  wdays_lst = list(1:5, 6:7),  
  parameters_lst,  
  connection_log,  
  energy_log,  
  data_tz  
)
```

Arguments

names	character vector with the given names of each time-cycle model
months_lst	list of integer vectors with the corresponding months of the year for each time-cycle model
wdays_lst	list of integer vectors with the corresponding days of the week for each time-cycle model (week start = 1)
parameters_lst	list of tibbles corresponding to the GMM parameters of every time-cycle model
connection_log	logical, true if connection models have logarithmic transformations
energy_log	logical, true if energy models have logarithmic transformations
data_tz	character, time zone of the original data (necessary to properly simulate new sessions)

Value

object of class `evmodel`

Examples

```
# For workdays time cycle  
workdays_parameters <- dplyr::tibble(  
  profile = c("Worktime", "Visit"),  
  ratio = c(80, 20),  
  start_mean = c(9, 11),  
  start_sd = c(1, 4),  
  duration_mean = c(8, 4),  
  duration_sd = c(0.5, 2),  
  energy_mean = c(15, 6),  
  energy_sd = c(4, 3)  
)  
  
# For weekends time cycle  
weekends_parameters <- dplyr::tibble(  
  profile = "Visit",  
  ratio = 100,  
  start_mean = 12,
```

```

    start_sd = 4,
    duration_mean = 3,
    duration_sd = 2,
    energy_mean = 4,
    energy_sd = 4
  )

parameters_lst <- list(workdays_parameters, weekends_parameters)

# Get the whole model
ev_model <- get_custom_ev_model(
  names = c("Workdays", "Weekends"),
  months_lst = list(1:12, 1:12),
  wdays_lst = list(1:5, 6:7),
  parameters_lst = parameters_lst,
  connection_log = FALSE,
  energy_log = FALSE,
  data_tz = "Europe/Amsterdam"
)

```

get_demand

Time-series EV demand

Description

Obtain time-series of EV demand from sessions data set

Usage

```

get_demand(
  sessions,
  dtm_seq = NULL,
  by = "Profile",
  resolution = 15,
  align_time = FALSE,
  mc.cores = 1
)

```

Arguments

sessions	tibble, sessions data set in standard format marked by {evprof} package (see this article)
dtm_seq	sequence of datetime values that will be the datetime variable of the returned time-series data frame.
by	character, being 'Profile' or 'Session'. When by='Profile' each column corresponds to an EV user profile.

resolution	integer, time resolution (in minutes) of the sessions datetime variables. If dttm_seq is defined this parameter is ignored.
align_time	logical, whether to align time variables or sessions with the corresponding time resolution
mc.cores	integer, number of cores to use. Must be at least one, and parallelization requires at least two cores.

Details

Note that the time resolution of variables `ConnectionStartDateTime` and `ChargingStartDateTime` must coincide with resolution parameter. For example, if a charging session in `sessions` starts charging at 15:32 and `resolution = 15`, the load of this session won't be computed. To solve this, the parameter `align_time = TRUE` would align charging sessions' start time according to resolution, so following the previous example the session would start at 15:30.

Value

time-series tibble with first column of type `datetime`

Examples

```
suppressMessages(library(lubridate))
suppressMessages(library(dplyr))

# Get demand with the complete datetime sequence from the sessions
sessions <- head(evsim::california_ev_sessions, 100)
demand <- get_demand(
  sessions,
  by = "Session",
  resolution = 60,
  align_time = TRUE
)
demand %>% plot_ts(ylab = "EV demand (kW)")

# Get demand with a custom datetime sequence and resolution of 15 minutes
sessions <- head(evsim::california_ev_sessions_profiles, 100)
dttm_seq <- seq.POSIXt(
  as_datetime(dmy(08102018)) %>% force_tz(tz(sessions$ConnectionStartDateTime)),
  as_datetime(dmy(11102018)) %>% force_tz(tz(sessions$ConnectionStartDateTime)),
  by = "15 mins"
)
demand <- get_demand(
  sessions,
  dttm_seq = dttm_seq,
  by = "Profile",
  resolution = 15,
  align_time = TRUE
)
demand %>% plot_ts(ylab = "EV demand (kW)")
```

get_evmodel_parameters

Get evmodel parameters in a list

Description

Every time cycle is an element of the returned list, containing a list with the user profile as elements, each one containing the ratio and the corresponding tables with the statistic parameters of connection and energy GMM.

Usage

```
get_evmodel_parameters(evmodel)
```

Arguments

evmodel object of class evmodel

Value

list

Examples

```
get_evmodel_parameters(evsim::california_ev_model)
```

get_evmodel_summary

Get evmodel parameters in a list of summary tables

Description

Every time cycle is an element of the returned list, containing a table with a user profile in every row and the mean and standard deviation values of the GMM variables (connection duration, connection start time and energy). If the energy models were built by charging rate, the average mean and sd are provided without taking into account different charging rates (this information is lost in this summary).

Usage

```
get_evmodel_summary(evmodel)
```

Arguments

evmodel object of class evmodel

Value

list

Examples

```
get_evmodel_summary(evsim::california_ev_model)
```

get_occupancy	<i>Time-series EV occupancy</i>
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Description

Obtain time-series of simultaneously connected EVs from sessions data set

Usage

```
get_occupancy(
  sessions,
  dttm_seq = NULL,
  by = "Profile",
  resolution = 15,
  align_time = FALSE,
  mc.cores = 1
)
```

Arguments

sessions	tibble, sessions data set in standard format marked by {evprof} package (see this article)
dttm_seq	sequence of datetime values that will be the datetime variable of the returned time-series data frame.
by	character, being 'Profile' or 'Session'. When by='Profile' each column corresponds to an EV user profile.
resolution	integer, time resolution (in minutes) of the sessions datetime variables. If dttm_seq is defined this parameter is ignored.
align_time	logical, whether to align time variables or sessions with the corresponding time resolution
mc.cores	integer, number of cores to use. Must be at least one, and parallelization requires at least two cores.

Details

Note that the time resolution of variable `ConnectionStartDateTime` must coincide with `resolution` parameter. For example, if a charging session in `sessions` starts charging at 15:32 and `resolution = 15`, the load of this session won't be computed. To solve this, the parameter `align_time = TRUE` would align charging sessions' start time according to `resolution`, so following the previous example the session would start at 15:30.

Value

time-series tibble with first column of type datetime

Examples

```
library(lubridate)
library(dplyr)

# Get occupancy with the complete datetime sequence from the sessions
sessions <- head(evsim::california_ev_sessions, 100)
connections <- get_occupancy(
  sessions,
  by = "ChargingStation",
  resolution = 60,
  align_time = TRUE
)
connections %>% plot_ts(ylab = "Vehicles connected")

# Get occupancy with a custom datetime sequence and resolution of 15 minutes
sessions <- head(evsim::california_ev_sessions_profiles, 100)
dtm_seq <- seq.POSIXt(
  as_datetime(dmy(08102018)) %>% force_tz(tz(sessions$ConnectionStartDateTime)),
  as_datetime(dmy(11102018)) %>% force_tz(tz(sessions$ConnectionStartDateTime)),
  by = "15 mins"
)
connections <- get_occupancy(
  sessions,
  dtm_seq = dtm_seq,
  by = "Profile",
  align_time = TRUE
)
connections %>% plot_ts(ylab = "Vehicles connected")
```

get_user_profiles_distribution

User profiles distribution

Description

Get the user profiles distribution from the original data set used to build the model

Usage

```
get_user_profiles_distribution(evmodel)
```

Arguments

evmodel object of class evmodel

Value

tibble

Examples

```
get_user_profiles_distribution(evsim::california_ev_model)
```

plot_occupancy_duration_curve

Plot the occupancy duration curve

Description

This term is based on the "load duration curve" and is useful to see the behavior of occupancy over the time in your charging installation. The steeper the curve, the shorter the duration that higher number of connections are sustained. Conversely, the flatter the curve, the longer the duration that higher number of connections are sustained. This information is crucial for various purposes, such as infrastructure planning, capacity sizing, and resource allocation.

Usage

```
plot_occupancy_duration_curve(
  sessions,
  dtm_seq = NULL,
  by = "Profile",
  resolution = 15,
  align_time = FALSE,
  mc.cores = 1
)
```

Arguments

sessions	tibble, sessions data set in standard format marked by {evprof} package (see this article)
dtm_seq	sequence of datetime values that will be the datetime variable of the returned time-series data frame.
by	character, being 'Profile' or 'Session'. When by='Profile' each column corresponds to an EV user profile.
resolution	integer, time resolution (in minutes) of the sessions datetime variables. If dtm_seq is defined this parameter is ignored.
align_time	logical, whether to align time variables or sessions with the corresponding time resolution
mc.cores	integer, number of cores to use. Must be at least one, and parallelization requires at least two cores.

Value

ggplot

Examples

```
library(dplyr)

sessions <- head(evsim::california_ev_sessions_profiles, 100)
plot_occupancy_duration_curve(
  sessions,
  by = "Profile",
  resolution = 15,
  align_time = TRUE
)
```

plot_ts

Interactive plot for time-series tibbles

Description

First column of the df tibble must be a datetime or date variable. The rest of columns must be numeric of the same units. This functions makes use of dygraphs package to generate an HTML Dygraphs plot.

Usage

```
plot_ts(df, title = NULL, xlab = NULL, ylab = NULL, legend_width = 250, ...)
```

Arguments

df	data.frame or tibble, first column of name datetime being of class datetime and rest of columns being numeric
title	character, title of the plot (accepts HTML code)
xlab	character, X axis label (accepts HTML code)
ylab	character, Y axis label (accepts HTML code)
legend_width	integer, width (in pixels) of the div which shows the legend.
...	extra arguments to pass to dygraphs::dyOptions function.

Value

dygraph

Examples

```
suppressMessages(library(lubridate))
suppressMessages(library(dplyr))

# Get demand with the complete datetime sequence from the sessions
sessions <- head(evsim::california_ev_sessions, 100)
demand <- get_demand(
  sessions,
  by = "Session",
  resolution = 60,
  align_time = TRUE
)
demand %>% plot_ts()
```

read_ev_model	<i>Read EV model</i>
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Description

Read an EV model JSON file and convert it to object of class `evmodel`

Usage

```
read_ev_model(file)
```

Arguments

`file` path to the JSON file

Value

object of class `evmodel`

Examples

```
ev_model <- california_ev_model # Model of example
save_ev_model(ev_model, file = file.path(tempdir(), "evmodel.json"))
read_ev_model(file = file.path(tempdir(), "evmodel.json"))
```

save_ev_model	<i>Save the EV model</i>
---------------	--------------------------

Description

Save the EV model object of class `evmodel` to a JSON file

Usage

```
save_ev_model(evmodel, file)
```

Arguments

<code>evmodel</code>	object of class <code>evmodel</code> (see this link for more information)
<code>file</code>	character string with the path or name of the file

Value

nothing but saves the `evmodel` object in a JSON file

Examples

```
ev_model <- california_ev_model # Model of example  
save_ev_model(ev_model, file = file.path(tempdir(), "evmodel.json"))
```

simulate_sessions	<i>Simulation of EV sessions</i>
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Description

Simulate EV charging sessions given the `evmodel` object and other contextual parameters.

Usage

```
simulate_sessions(  
  evmodel,  
  sessions_day,  
  user_profiles,  
  charging_powers,  
  dates,  
  resolution  
)
```


Arguments

evmodel	object of class evmodel built with {evprof} (see this link for more information)
sessions_day	tibble with variables time_cycle (names corresponding to evmodel\$models\$time_cycle) and n_sessions (number of daily sessions per day for each time-cycle model)
user_profiles	tibble with variables time_cycle, profile, ratio and optionally power. It can also be NULL to use the evmodel original user profiles distribution. The powers must be in kW and the ratios between 0 and 1. The user profiles with a value of power will be simulated with this specific charging power. If power is NA then it is simulated according to the ratios of next parameter charging_powers.
charging_powers	tibble with variables power and ratio. The powers must be in kW and the ratios between 0 and 1. This is used to simulate the charging power of user profiles without a specific charging power in user_profiles parameter.
dates	date sequence that will set the time frame of the simulated sessions
resolution	integer, time resolution (in minutes) of the sessions datetime variables

Value

tibble

Examples

```
library(dplyr)
library(lubridate)

# Get the example `evmodel`
ev_model <- evsim::california_ev_model

# Simulate EV charging sessions, considering that the Worktime sessions
# during Workdays have 11 kW, while all Visit sessions charge at 3.7kW or
# 11kW, with a distribution of 30% and 70% respectively.

simulate_sessions(
  ev_model,
  sessions_day = tibble(
    time_cycle = c("Workday", "Weekend"),
    n_sessions = c(15, 10)
  ),
  user_profiles = tibble(
    time_cycle = c("Workday", "Workday", "Weekend"),
    profile = c("Visit", "Worktime", "Visit"),
    ratio = c(0.5, 0.5, 1),
    power = c(NA, 11, NA)
  ),
  charging_powers = tibble(
    power = c(3.7, 11),
    ratio = c(0.3, 0.7)
  ),
  dates = seq.Date(today(), today()+days(4), length.out = 4),
```

```
    resolution = 15  
)
```

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