

# Package ‘renpow’

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**Type** Package

**Title** Renewable Power Systems and the Environment

**Version** 0.1-1

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**Description** Supports calculations and visualization for renewable power systems and the environment. Analysis and graphical tools for DC and AC circuits and their use in electric power systems. Analysis and graphical tools for thermodynamic cycles and heat engines, supporting efficiency calculations in coal-fired power plants, gas-fired power plants. Calculations of carbon emissions and atmospheric CO2 dynamics. Analysis of power flow and demand for the grid, as well as power models for microgrids and off-grid systems. Provides resource and power generation for hydro power, wind power, and solar power.

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renpow-package	<i>Renewable Power Systems and the Environment</i>
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## Description

Supports calculations and visualization for renewable power systems and the environment. Analysis and graphical tools for DC and AC circuits and their use in electric power systems. Analysis and graphical tools for thermodynamic cycles and heat engines, supporting efficiency calculations in coal-fired power plants, gas-fired power plants. Supports carbon emissions and atmospheric CO2 dynamics. Grid, microgrids, and off-grid. Hydro power, wind power, and solar power.

## Details

The DESCRIPTION file:

```

Package:    renpow
Type:      Package
Title:     Renewable Power Systems and the Environment
Version:   0.1-1
Date:     2018-05-09
Author:    Miguel F. Acevedo
Maintainer: Miguel F. Acevedo <acevedo@unt.edu>

```

Description: Supports calculations and visualization for renewable power systems and the environment. Analysis and graphs  
 License: GPL ( $\geq 2$ )  
 URL: <https://www.r-project.org/>  
 LazyData: true

#### Index of help topics:

AC.DC.AC	AC-DC and DC-AC in the time domain
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ACharmonics	AC Harmonic Distortion
ACpower	AC power in the time and frequency domain
ASTMG173	Dataset: ASTM G173-03 standard
AirCvCpTK	Dataset: Specific heat of air vs temperature
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CpCvT	Dataset: Specific heat of air vs Temp
Cseq	Carbon Sequestration
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TEODP2017	Dataset: Example of wind speed at two heights
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grid	Electrical Power Grid
hydrology	Hydro Power Hydrology functions
hydropower	Hydroelectric Power Functions
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panels.plots	Plot utilities
pow.work	Mechanical power and work
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tau.bd	Dataset: monthly tau and bd for a location
test100	Dataset: simple example for 100 data points
thermodynamics	Thermodynamic paths and cycles
tidalpower	Tidal Power Functions
transformer	Transformer Circuits
wavepower	Wave Power Functions
windpower	Wind Power calculations and statistics

#### Author(s)

Miguel F. Acevedo

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#### References

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

---

 AC power

*AC power in the time and frequency domain*


---

### Description

Calculates and plots AC power in the domain and phasors. Includes complex number calculations.

### Usage

```
inst.pow.calc(x, freq = 60, nc = 2)
inst.pow.plot(x, rms = FALSE, freq = 60, nc = 2)
inst.pow.leg(ang, lab, ym, w, units, pf)
complex.pow.calc(xc, dig = 2, res = TRUE)
complex.pow.plot(cp)
complex.pow.tri(cp)
pf.corr(P, V, pf, pfc, w = 377, dig = 2)
pf.corr.tri(xpfc)
```

### Arguments

x	list of voltage and current phasors
freq	frequency in Hz
nc	number of cycles to calculate and/or plot
rms	logical to decide to plot the rms value
ang	angles for legend
lab	label for legend
ym	magnitude for legend
w	angular frequency for legend and for pf correction
units	units for legend
pf	power factor for legend of inst.pow.leg or to be corrected by pf.corr
xc	list with voltage, current, and phase angle
dig	number of digits to round complex power
res	logical to print results of complex power
cp	output of complex power; a list
P	real power for pf correction
V	voltage for pf correction
pfc	target power factor
xpfc	output of pf.corr; a list

**Details**

inst.pow.calc calculates time domain instantaneous power given current and voltage phasors. Its output is passed to inst.pow.plot. inst.pow.plot produces time domain plots given current and voltage phasors. It uses inst.pow.legend to display legend

**Value**

w	angular frequency in rad/s
vm	array of magnitude
ang	array of angle
pf	power factor
pavg	average power
t	time sequence
v.i	matrix with voltage and current as a function of time
p	instantaneous power or power as a function of time
units	units for complex power result
S	apparent power
theta	phase angle
P	real power
Q	reactive power
pf	power factor
prnt	string to print results
cp	complex power output of pf.corr
cpc	complex power after correction
y	Voltage,current, and corrected params

**Note**

Functions used in Chapter Chapter 8 of Acevedo (2018)

**Author(s)**

Miguel F. Acevedo <acevedo@unt.edu>

**References**

- Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)
- Irwin, J.D. and R.M. Nelms. 2011. Basic Engineering Circuit Analysis. 11th edition. 2011: Wiley.

**See Also**

Power electronics functions [ac.plot.rect](#), [rectifier](#), [inverter](#)

**Examples**

```

# power resistor
vm=170; R=10
x <- list(c(vm,0),c(vm/R,0))
inst.pow.plot(x)

# power capacitor
w <- 377; v.s <- c(170,0)
C=1000*10^-6
# current response
i.res <- c(v.s[1]*(w*C),v.s[2]+90)
x <- list(v.s,i.res)
inst.pow.plot(x)

# calc complex power
V.s=c(170,10); Z.p=c(10,20)
I.p <- div.polar(V.s,Z.p)
V <- V.s[1]/sqrt(2); I <- I.p[1]/sqrt(2)
theta <- V.s[2]-I.p[2]
cp <- complex.pow.calc(list(V,I,theta))

# pf correction
P=5; V=240; I=40; pfc=0.9
pf <- P*1000/(V*I)
# call pf correction function
pfcorr <- pf.corr(P,V,pf,pfc)
# visualize
pf.corr.tri(pfcorr)

```

---

AC waves and plots      *AC in the time and frequency domain*

---

**Description**

Calculates and plots AC sinusoidal waves in the time domain and phasors. Includes complex number calculations.

**Usage**

```

waves(x, f = 60, nc = 2)
ac.plot(v.t, v.lab = "v(t)", v.units = "V", y.lab = "v(t)[V]", rms = FALSE)
phasor.plot(v.p, v.lab = "V", v.units = "V", lty.p = NULL)
polar(rec)
recta(pol)
mult.polar(x1,x2)
div.polar(x1,x2)
horiz.lab(nw, ym, tmax, ymax, units, yrms, rms)

```

```

wave.leg(nw, ang, lab, ym, w, units)
phas.leg(np, mag, ang, lab, units, lty.p)
gridcir(rmax)
sinplot(xlab, ylab)
arc(mag, ang)
rot.fig(vp, v.lab="wt")
admit(Z.r)
vector.phasor(V, I)

```

### Arguments

x	AC variable given as a list of arrays. Each array contains two entries: magnitude and phase
f	Frequency in Hz, default 60 Hz
nc	Number of cycles to calculate and plot, default 2 cycles
v.t	Values of AC variable at time intervals calculated using waves
v.lab	Label for variable in time domain plot or phasor plot; time domain would typically include (t) and phasor would be upper case; also specifies label for angle in rot.fig
v.units	Units for variable in time domain plot or phasor plot; time domain would typically include (t) and phasor would be upper case
y.lab	Label for y axis composed of variable label and units
rms	Logical for whether the RMS value is added to the plot
v.p	Phasors to plot
lty.p	set of line types for plot and type of line for legend
rec	argument to polar array of rectangular coord
pol	argument to rect: array of magnitude and angle
x1,x2	complex numbers to multiply or divide by mult.polar and div.polar
nw	number of waves to assign horizontal lines
ym	magnitude array
tmax	max x axis value
ymax	max y axis value
units	units for lines and for legend
yrms	rms value to be used in y axis
ang	angle of waves or phasors
lab	label for legend
w	angular frequency for legend
np	number of phasors for legend
mag	magnitude of waves or phasors
rmax	max extent of polar grid for gridcir
xlab	xaxis label for sinplot

yLab	yaxis label for sinplot
vp	voltage for rot fig
Z, r	impedance in rectangular form
V	Voltage
I	Current

### Details

Waves is first used to calculate values for time and the variable. Then the object created by wave is used by ac.plot. Functions polar() and recta() allow polar and rect conversion specifying phasors as arrays. Function mult.polar and div.polar are used for multiplication and division of phasors. Function horiz.lab plots horizontal lines with labels for magnitude and rms. Used mostly by other renpow functions. Function wave.leg and phas.leg write out waves and phasors for legend. Used mostly by other renpow functions. Function gridcir draws a polar grid. Used mostly by other renpow functions. Function arc draws an arc from 0 degrees to a phasor line specified by mag and ang. Used mostly by other renpow functions. Function admit calculates admittance given the impedance in rectangular form. Function vector.phasor specifies voltage and current phasors for plotting.

### Value

Function waves:

w	angular frequency
t	time values
nw	number of waves
ym	magnitude values
ang	ang
y	values
yrms	rms values

### Note

Functions used in Chapter 5, 8, and 10 of Acevedo (2018)

### Author(s)

Miguel F. Acevedo <Acevedo@unt.edu>

### References

- Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)
- Irwin, J.D. and R.M. Nelms. 2011. Basic Engineering Circuit Analysis. 11th edition. 2011: Wiley.



**See Also**

Power electronics functions [ac.plot.rect](#), [rectifier](#), [inverter](#)

**Examples**

```
# from Chapter 5
# one wave show phase angle
x <- list(c(170,30)); v.t <- waves(x); ac.plot(v.t)

# two waves different magnitude and phase
x <- list(c(170,0),c(160,30)); v.t <- waves(x);
v.lab <- c("v1(t)","v2(t)"); v.units <- rep("V",2)
ac.plot(v.t,v.lab,v.units)

# one phasor
v.p <- list(c(170,10)); phasor.plot(v.p)

# phasors phase difference
v.units <- rep("V",2)
v.lab <- c("V1","V2")
# V1 leads V2
v.p <- list(c(170,70),c(170,50))
phasor.plot(v.p,v.lab,v.units)

# rect to polar
polar(c(2,1))
# polar to rect
recta(c(2,45))
# multiplication
x <- polar(c(1,2))
y <- polar(c(2,3))
mult.polar(x,y)

# from Chapter 8
# nodal analysis
Y1 <- 1/(5+5i); Y2 <- 1/(5+5i); Y3 <- 1/(10+10i)
Y <- matrix(c(Y1+Y2,-Y2,-Y2,Y3+Y2),ncol=2,byrow=TRUE)
Is <- c(1+0i,0+0i)
Vn <- solve(Y,Is)
VpIp <- vector.phasor(Vn,Is)
phasor.plot(VpIp$VI, c("V1","V2","Is1","Is2"),
            c("V","V","A","A"),lty.p=c(2,2,1,1))
```

**Description**

Calculates and plots AC sinusoidal waves in the time domain and phasors.

**Usage**

```
rectifier(v.t, full = FALSE)
ac.plot.rect(V.t, v.lab = "v(t)", v.units = "V", y.lab = "v(t)[V]", rms = FALSE)
inverter(x)
```

**Arguments**

<code>v.t</code>	Values of AC variable at time intervals calculated using waves
<code>full</code>	Logical to use full wave rectifier
<code>V.t</code>	output of rectifier
<code>v.lab</code>	Label for variable in time domain plot or phasor plot; time domain would typically include (t) and phasor would be upper case
<code>v.units</code>	Units for variable in time domain plot or phasor plot; time domain would typically include (t) and phasor would be upper case
<code>y.lab</code>	Label for y axis composed of variable label and units
<code>rms</code>	Logical for whether the RMS value is addedd to the plot
<code>x</code>	list(f,vin,nc): frequency, input voltage, number of cycles

**Details**

Calculations of basic power electronics devices

**Value**

<code>V.t</code>	output of rectifier list(w,t,nw,ym,ang,y,yrms,yavg)
<code>vtr</code>	Values of rectified AC variable at time intervals calculated using rectifier

**Note**

Used in Chapter 5 of Acevedo 2018

**Author(s)**

Miguel F. Acevedo <acevedo@unt.edu>

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

Irwin, J.D. and R.M. Nelms. 2011. Basic Engineering Circuit Analysis. 11th edition. 2011: Wiley.

**See Also**

AC functions [ac.plot](#), [phasor.plot](#), [waves](#)

**Examples**

```
# rectified wave
v.AC <- list(c(170,0))
v.t <- waves(v.AC,nc=4)
V.t <- rectifier(v.t)
ac.plot.rect(V.t)

# inverter
x <- list(f=60,vin=170,nc=2)
inverter(x)
```

---

AirCvCpTK

*Dataset: Specific heat of air vs temperature*

---

**Description**

Specific heat of air vs absolute temperature

**Usage**

```
data("AirCvCpTK")
```

**Format**

Three columns text file with header

**Details**

Used to estimate coefficients of  $C_p$  and  $C_v$  vs  $T$

**Source**

data from [https://www.ohio.edu/mechanical/thermo/property\\_tables/air/air\\_Cp\\_Cv.html](https://www.ohio.edu/mechanical/thermo/property_tables/air/air_Cp_Cv.html)

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**Examples**

```
AirCvCpTK
```

---

ASTMG

*Dataset: ASTM G173-03 standard*

---

**Description**

ASTM G173-03 standard

**Usage**

```
data("ASTMG173")
```

**Format**

list with location, lat-long-elev, and two columns for tau (b, d)

**Details**

Optical depth

**Source**

ASTM. ASTM G173 - 03(2012), 2017. Standard Tables for Reference Solar Spectral Irradiances: Direct Normal and Hemispherical on 37 deg Tilted Surface. Accessed November 2017. Available from: <https://www.astm.org/Standards/G173.htm>

Gueymard, C.A., 2004. The sun's total and spectral irradiance for solar energy applications and solar radiation models. *Solar Energy* 76(4):423-453.

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**Examples**

```
X <- ASTMG173
```

---

CO2

*Dataset: CO2 monthly and annualy*

---

**Description**

Atmospheric CO2 monthly and annualy

**Usage**

```
data("CO2monthly")
data("CO2annual")
```

**Format**

CO2 monthly is CO2 expressed as a mole fraction in dry air, micromol/mol, abbreviated as ppm a record has: year, month,decimal-date, average, interpolated, trend-season-corr, days For instance: 1958 3 1958.208 315.71 315.71 314.62 -1 CO2 annual has three values Year, Avg, Uncorrected

**Details**

CO2 monthly and annual

**Source**

NOAA. Trends in Atmospheric Carbon Dioxide. 2017. NOAA, Earth System Research Laboratory, Global Monitoring Division. Accessed June 2017. URL: <http://www.esrl.noaa.gov/gmd/ccgg/trends/>

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**Examples**

```
data(CO2monthly)
```

---

CpCvT

*Dataset: Specific heat of air vs Temp*

---

**Description**

Specific heat of air vs Temp

**Usage**

```
data("CpCvT")
```

**Format**

Three columns text file with header

**Details**

Used to estimate coefficients of  $C_p$  and  $C_v$  vs  $T$

**Source**

data from [https://www.ohio.edu/mechanical/thermo/property\\_tables/air/air\\_Cp\\_Cv.html](https://www.ohio.edu/mechanical/thermo/property_tables/air/air_Cp_Cv.html)

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**Examples**

```
X <- CpCvT
```

---

DC circuits

*DC circuits and power calculations*

---

**Description**

Calculates and plots DC V-I response as well as transient response

**Usage**

```
resistor(V,R)
ivplane(x, x0 = FALSE, y0 = FALSE)
diode(V)
vsource(Voc,Rs)
isource(Isc,Rp)
PVcell(x.PVcell)
PVcell.plot(y.PVcell)
eff.pow(x.eff.pow)
transient(ys, tau, ylabel, ylabel)
fuel.cell(x.fcell)
```

**Arguments**

V	Voltage
R	Resistance
x	Result of function resistor, diode, vsource, or isource
x0	Logical argument to plot2axis

<code>y0</code>	Logical argument to plot2axis
<code>Voc</code>	Open circuit voltage
<code>Rs</code>	Series resistance
<code>Isc</code>	Short circuit current
<code>Rp</code>	Parallel resistance
<code>x.PVcell</code>	list(I0.A, Isc.A, Area, Rs, Rp, Light)
<code>y.PVcell</code>	output of PVcell
<code>x.eff.pow</code>	list(Rth,Voc)
<code>ys</code>	Source for transient calculation
<code>tau</code>	Time constant
<code>ylabel</code>	y axis label for transient plots
<code>yslabel</code>	Source label for transient plots
<code>x.fcell</code>	list(area.cm2,Rload.ohm)

**Details**

Object `x` contains all the calculated values which can be passed to function `ivplane` to plot the graphs.

**Value**

<code>V</code>	Voltage
<code>I</code>	Current
<code>P</code>	Power
<code>txt</code>	labels
<code>Light</code>	Light levels from PVcell

**Note**

Functions used in Chapter 3 and Chapter 5 of Acevedo (2018)

**Author(s)**

Miguel F. Acevedo <acevedo@unt.edu>

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

Irwin, J.D. and R.M. Nelms. 2011. Basic Engineering Circuit Analysis. 11th edition. 2011: Wiley.

**Examples**

```

# from Chapter 3
# resistors
V <- seq(-0.2,1,0.01) # volts
x <- resistor(V,R=1)
ivplane(x)

# diode
V <- seq(-0.1,0.6,0.01) # volts
x <- diode(V)
ivplane(x)

# voltage source
x <- vsource(Voc=24,Rs=1)
ivplane(x)
# current source
x <- isource(Isc=20,Rp=1)
ivplane(x)

# PV cell
x <- list(I0.A=1, Isc.A=40, Area=100, Rs=0.05, Rp=1, Light=1)
# units: I0.A pA/cm2 Isc.A mA/cm2 Area cm2 Rs ohm Rp ohm
X <- PVcell(x)
ivplane(X,x0=TRUE,y0=TRUE)

# efficiency of power transfer
x <- list(Rth=1,Voc=24)
eff.pow(x)

# from Chapter 5
# RC circuit transient
R=0.2;C=1 # Mohm and uF
transient(ys=12,tau=R*C,ylabel="Vc(t) [V]",yslabel="Vs [V]")

# RL circuit transient
R=20;L=1; # kohm and mH
transient(ys=12/R,tau=L/R,ylabel="iL(t) [A]",yslabel="Vs/R [V]")

# Chapter 6 fuel cells
x <- list(area.cm2=15,Rload.ohm=NA)
fuel.cell(x)
x <- list(area.cm2=15,Rload.ohm=0.5)
fuel.cell(x)

```



**Description**

ERCOT load year 2010 by region

**Usage**

```
data("ERCOT2010")  
data("ERCOT2010.01")
```

**Format**

Day and Hour, followed by demand for 8 regions, and demand total ERCOT Header: Hour\_End  
COAST EAST FAR\_WEST NORTH NORTH\_C SOUTHERN SOUTH\_C WEST ERCOT Ex-  
ample of record: 1/1/2010 1:00 7775.679969 1238.21679 1237.781607 950.698047 12406.20808  
2467.652377 5032.076127 1059.772842 32168.08584

**Details**

Example demand grid

**Source**

ERCOT. Hourly Load Data Archives. 2017. Accessed October 2017. Available from: <http://www.ercot.com/gridinfo/load/loa>

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with  
R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**Examples**

```
data(ERCOT2010.01)
```

---

GlobTempAnom

*Dataset: Global Surface Temperature Anomaly*

---

**Description**

Global Surface Annual Temp Anomaly

**Usage**

```
data("GlobTempAnom")
```

**Format**

Year, average, and Five-year Avg For instance: 1880 -0.20 -0.13

**Details**

Global Surface Temp

**Source**

NASA. Global Climate Change. Vital Signs of the Planet. 2017. Accessed June 2017. Available from: <http://climate.nasa.gov/vital-signs/global-temperature/>

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**Examples**

```
data(GlobTempAnom)
```

---

grid

*Electrical Power Grid*

---

**Description**

Electric power systems calculations including buses and loads

**Usage**

```
infinite.bus(x)
seg.ts(Xts,dh0,dhf,var)
series.plot(x.t)
daily.min.max(x.t.y, ylabel, inst.cap, inst.lab)
load.duration(x.t.y, inst.cap, inst.lab)
```

**Arguments**

x	parameters for infinite bus a list(V,X,E,delta):V Voltage, X Reactance, E array of electromotive force, delta array of angle delta
Xts	data frame with ts values
dh0	intial time stamp
dhf	final time stamp
var	variable number to select
x.t	time series to plot
x.t.y	load time series for daily.min.max plots and load-duration curve
ylabel	label for min max
inst.cap	array of installed capacities
inst.lab	array of labels for installed capacities

## Details

`infinite.bus` uses a fixed `V` and `X`, and plots the effect of a set of `E` and `angle` `daily.min.max` draws a plot showing daily maximum and minimum along with horizontal lines for installed capacities `load.duration` builds a load-duration curve and calculate CF for daily load data and a set of generation capacities

## Value

Hours	number of hours for each class
energy	total energy under curve
possible	possible utilization for each class
utilization	actual utilization for each class
CF	capacity factor for each class

## Note

Functions used in Chapter 11 of Acevedo (2018)

## Author(s)

Miguel F. Acevedo <acevedo@unt.edu>

## References

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

## Examples

```
x <- list(V=13.8,X=1,E=seq(14,16,1),delta=seq(6,30,1))
infinite.bus(x)

X <- ERCOT2010
x.t <- seg.ts(X,dh0="1/1/2010 1:00",dhf="1/1/2011 0:00",c(1:9))$x.t

# week day Monday Jan 04 2010
x.t.wd.wt <- seg.ts(X,dh0="1/4/2010 0:00",dhf="1/4/2010 23:00",c(1,5,7))$x.t.seg
series.plot(x.t.wd.wt)

# week Sunday Jan 24 to Saturday Jan 30 2010
x.t.wd.wt <- seg.ts(X,dh0="1/24/2010 0:00",dhf="1/30/2010 23:00",c(1,5,7))$x.t.seg
series.plot(x.t.wd.wt)

# NORTH_C
x.t.y <- x.t[,5]; ylabel <- colnames(x.t)[5]; inst.cap <- c(10000,8000,8000) #MW
inst.lab <- c("Baseload","Intermediate", "Peaking")
daily.min.max(x.t.y,ylabel,inst.cap,inst.lab)

x.t.y <- x.t[,5]
```

```
inst.cap <- c(10000,8000,8000) # MW
inst.lab <- c("Baseload","Intermediate", "Peaking")
load.duration(x.t.y, inst.cap,inst.lab)
```

---

 harmonics

---

*AC Harmonic Distortion*


---

### Description

Calculates harmonic distortion

### Usage

```
harmonic(x, harm.odd, lab.units)
```

### Arguments

x	list of arrays c(mag,phase) with fundamental magnitude and phase
harm.odd	fraction of odd harmonics with respect to the fundamental
lab.units	label for units

### Details

Function harmonic performs calculations and plots, including odd harmonics and THD.

### Value

t	Time sequence
I <sub>tot</sub>	Total currents
I <sub>sum</sub>	Sum of currents in neutral
THD	Total Harmonic Distortion

### Note

Functions used in Chapter 10 of Acevedo (2018)

### Author(s)

Miguel F. Acevedo <acevedo@unt.edu>

### References

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**See Also**

AC waves and plots [ac.plot](#), [phasor.plot](#), [waves](#) three-phase generator

**Examples**

```
# single phase harmonics
x <- list(c(10,0)); harm.odd <- list(c(0.2,0.1,0.05)); lab.units <- "I [A]"
y <- harmonic(x,harm.odd,lab.units)

# three-phase harmonics
x <- list(c(10,0),c(10,-120),c(10,120))
harm.odd <- list(c(0.2,0.1,0.05),c(0.2,0.1,0.05),c(0.2,0.1,0.05))
lab.units <- "I [A]"
y <- harmonic(x,harm.odd,lab.units)
```

---

Hydro Power

*Hydroelectric Power Functions*


---

**Description**

Basic calculations in hydroelectric power generation

**Usage**

```
P.hA(x)
P.Qh(x)
Pmax.Qh(x)
Pe.Pw(x)
Pmax.Qh.plot(x)
turbine.regions(type)
turbine.regions.all()
pipe.loss(pipe)
```

**Arguments**

x	a list with possible h, A, Q, nu, plab: head, cross-area, flow, efficiency,label
type	a turbine type from 'kaplan', 'francis', 'pelton', 'crossflow', 'slh'
pipe	a list Q, d, L, mat: flow, diameter, length, and material. Component mat is one of 'pvc', 'concrete', 'steel', 'galvanized', 'poly'

**Details**

Basic calculations of hydropower

**Value**

X	result of P.hA(x) is array with Head(m), Vel(m/s), Area(m <sup>2</sup> ), Flow(m <sup>3</sup> /s), and Power(in kW or MW)
X	result of P.Qh(x) is array with Head(m), Flow(m <sup>3</sup> /s), and Power(in kW or MW)
X	result of Pmax.Qh(x) is array with Gross head (m), Net head (m), Flow(m <sup>3</sup> /s), and Power(in kW or MW)
X	result of Pe.Pw(x) is array with GrossHead(m), NetHead(m), Flow(m <sup>3</sup> /s), Press(kPa), Eff, PowWater9in kW or MW), and PowGen(in kW or MW)
X	result of pipe.loss(pipe) is array with Head loss(m), and Roughness

**Note**

Functions used in Chapter 12 of Acevedo (2018)

**Author(s)**

Miguel F. Acevedo <acevedo@unt.edu>

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**Examples**

```
# head 3 m and cross-sectional area of 2 m2
x <- list(h=3,A=2); P.hA(x)

x <- list(Q=1000,h=15); Pmax.Qh(x)

x <- list(Q=1000,h=15,nu=0.9); Pe.Pw(x)

x <- list(h=1,Q=100); P.Qh(x)

x <- list(Q=1000,h=15,plab="A"); Pmax.Qh.plot(x)
turbine.regions(type='francis')

x <- list(Q=0.01,d=0.075,L=200,mat='pvc')
hL <- pipe.loss(x)[1,1]
x <- list(h=30-hL,Q=0.01,nu=0.9)
P.Qh(x)
```

**Description**

Hydrological calculations in hydroelectric power generation

**Usage**

```
area.vol(xav)
model.flow(mf)
flow.plot(flow, label)
flow.exc.plot(flow, exc, label)
exceed(flow)
annual.avg(mf, nyrs)
```

**Arguments**

xav	area.vol is a list(H,B,W,L) H pool elevation (m), B bottom elevation (m), W width (km), L tail length (km)
mf	list(base.flow,peak.flow,day.peak,length.season,variab,coef)
flow	flow time series resulting from model.flow
label	label for flow
exc	exceedance levels as a result of exceed
nyrs	number of years

**Details**

Basic hydrological calculations for hydropower

**Value**

X	list(y,proby, prob, Q, Prob.Qmean, prob.Q)
flow	flow time series from model.flow
Xtm	annual avg of flow time series from model.flow

**Note**

Functions used in Chapter 12 of Acevedo (2018)

**Author(s)**

Miguel F. Acevedo <acevedo@unt.edu>

## References

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

## Examples

```
x <- list(H=130,B=100,W=10,L=100)
area.vol(x)

x <- list(base.flow=20,peak.flow=100,day.peak=200,length.season=90,
          variab=c(0.01,2),coef=c(0.4,0.3,0.2,0.1))
flow <- model.flow(x)
flow.plot(flow,label="Simulated flow (m3/s)")
exc <- exceed(flow)
exc$prob.Q
flow.exc.plot(flow,exc,label="Simulated flow (m3/s)")
```

---

magnetic circuits

*Magnetic circuit calculations*

---

## Description

Calculates magnetic elements and circuits

## Usage

```
reluctance(x)
inductor(x)
flux(x)
```

## Arguments

x argument to reluctance or to inductance. For reluctance it is a list of one or more arrays; for instance, one array  $c(\mu, l, A)$  where  $\mu$  is relative permeability,  $l$  is path length, and  $A$  is cross-area. For inductance it is a list(N,rel) where N is number of turns and rel is reluctance For flux it is a list(N,i,rel) where N is number of turns, i is current, and rel is reluctance

## Details

Function reluctance calculates reluctance in MA-turn/Wb from  $\mu$  relative permeability,  $l$  path length, and  $A$  cross-area. Function inductor calculates inductance in mH from number of turns N and reluctance Function flux calculates magnetic flux from number of turns, current, and reluctance



**Value**

rel	reluctance value from reluctance, inductor, or flux functions
prnt	printout of reluctance, inductance, or flux including value and units
L	inductance value from inductor or flux functions
mmf	magnetomotive force or mmf
flux	magnetic flux value

**Note**

Functions used in Chapters 5 and 10 of Acevedo (2018)

**Author(s)**

Miguel F. Acevedo <Acevedo@unt.edu>

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

Irwin, J.D. and R.M. Nelms. 2011. Basic Engineering Circuit Analysis. 11th edition. 2011: Wiley.

**Examples**

```
# Chapter 5 simple inductor
mu=1000; l=1*10^-2; A=pi*(1*10^-3)^2
reluc <- reluctance(x=list(c(mu,l,A)))
reluc$prnt
ind <- inductor(x=list(N=159,rel=reluc$rel))
ind$prnt

# Chapter 10 air gaped inductor
mucore=1000; lcore=6*10^-2; Acore=1*10^-4
mugap=1; lgap=1*10^-3; Agap <- Acore
reluc <- reluctance(x=list(c(mucore,lcore,Acore),c(mugap,lgap,Agap)))
reluc$prnt

rel.eq <- reluc$rel[1]+reluc$rel[2]
ind <- inductor(x=list(N=100,rel=rel.eq))
ind$prnt

magckt <- flux(x=list(N=10,i=1,rel=rel.eq))
magckt$prnt

magckt <- flux(x=list(N=10,i=1,r=reluc$r[2]))
magckt$prnt
```

---

panels plots

*Plot utilities*

---

### Description

Uses layout to plot several graphs on a page and plot on two vertical axis

### Usage

```
panels(wd, ht, rows, cols, pty, int = "r")  
plot2yaxis(x, x0 = FALSE, y0 = FALSE)
```

### Arguments

wd	Width
ht	Height
rows	number of rows
cols	number of columns
pty	type
int	axis intersection
x	Variable x for horizontal axis and variables y1, y2 for vertical axes
x0	Logical to select axis limit
y0	Logical to select axis limit

### Details

Function panels makes more efficient use of space than par(mfrow)

### Note

Util functions used in most chapters of Acevedo (2018)

### Author(s)

Miguel F. Acevedo <Acevedo@unt.edu>

### References

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**Examples**

```
wd=6; ht=3
panels(wd,ht,1,1,pty="m")
t <- seq(0,60,0.1)
x <- pow.work(t,pow="const",p=2)
pow.work.plot(x)
```

```
wd=7; ht=3.5
panels(wd,ht,1,2,pty="m")
# diode
V <- seq(-0.1,0.05,0.01) # volts
x <- diode(V)
ivplane(x)
V <- seq(-0.1,0.6,0.01) # volts
x <- diode(V)
ivplane(x)
```

---

pow.work	<i>Mechanical power and work</i>
----------	----------------------------------

---

**Description**

Calculates and plots mechanical power and work.

**Usage**

```
pow.work(t, pow = "const", p)
pow.work.plot(x)
```

**Arguments**

t	Values of a time sequence for calculation of power
pow	Mode of power calculation, constant or linear
p	Value of power for constant or slope for linear
x	power object calculated from pow.work

**Details**

A call to pow.work requires three arguments: a time sequence, a type of power function such as constant or linear, and a value of power for the parameter of the function.

**Value**

The output of pow.work contains the values of power and work as a function of time. Then we call the plot function using its output as argument to the pow.work.plot function

t	time sequence
p.w	matrix containing with power and work

**Note**

Functions used in Chapter 1 of Acevedo (2018)

**Author(s)**

Miguel F. Acevedo <acevedo@unt.edu>

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**Examples**

```
t <- seq(0,60,0.1)
x <- pow.work(t,pow="const",p=2)
pow.work.plot(x)

x <- pow.work(t,pow="linear",p=0.025)
pow.work.plot(x)
```

---

sequestration

*Carbon Sequestration*

---

**Description**

Simulates carbon sequestration

**Usage**

```
forest.seq(x, y)
```

**Arguments**

x	parameters for forest growth; a list(t,B0,Bmax,nu,r): t time sequence, B0 Biomass at time zero, Bmax Maximum Biomass (parameter of Richards equation), nu Coefficient exponent to adjust shape (parameter of Richards equation), r Growth rate (parameter of Richards equation)
y	Specifications of power plant emissions a list(kgCO2.kWh,P,C): kgCO2.kWh kg of CO2 per kWh produced, P Power produced, C carbon content

**Details**

forest.seq produces rates, area, and a plot of C forest sequestration dynamics

**Value**

yr.max	time in years to achieve biomass for max rate
B.i	required biomass in t/ha to sequester at max rate
max.dCO2	max rate
tCO2.emiss	carbon emission sequestered
area	area required

**Note**

Functions used in Chapter 9 of Acevedo (2018)

**Author(s)**

Miguel F. Acevedo <acevedo@unt.edu>

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**Examples**

```
forest <- list(t=seq(0,100),B0=1,Bmax=150,nu=0.5,r=0.3)
plant <- list(kgCO2.kWh=0.4,P=10^9,C=1.0)
forest.seq(x=forest,y=plant)
```

---

Solar Power

*Solar Power Functions*

---

**Description**

Basic calculations in solar power generation including irradiance and sun path

**Usage**

```
I0.orbit(leap = FALSE, plot = TRUE)
days.mo(day, leap = FALSE)
declination(leap=FALSE,plot=TRUE)
sun.elev(xdec,lat,plot=TRUE)
read.tau(file)
beam.diffuse(dat,plot=TRUE)
I0.blackbody(T.sun, wl.nm, plot = TRUE)
spectral(X, label, wl.lim.nm, T.sun, plot.surf = FALSE)
useful.waste(I0.bb)
sun.path(lat, nday, plot = TRUE)
```

```

sun.diagram(lat)
collector(Ibd, sunpath, tilt, azi.c, fr, label = "")
month.prod(dat)
tilt.adj(lat, days, labels)
one.axis.tracking(dat, mode = "PNS")
two.axis.tracking(dat)

```

### Arguments

leap	logical to use a leap year
plot	logical to plot
day	day of the year for a given day in the month
xdec	result from declination
lat	latitude
file	filename
T.sun	temp sun
wl.nm	wavelength in nm
X	data read from file
label	label for plot
wl.lim.nm	limits for wavelength
plot.surf	logical plot together with surface data
dat	data from file
I0.bb	output from I0.blackbody
nday	day number
Ibd	Irradiance: direct beam and diffuse
sunpath	elev and azimuth from the output of sun.path
tilt	collector tilt angle
azi.c	orientation of collector
fr	fraction reflected
days	days
labels	labels
mode	tracking mode

### Details

Basic calculations of solar power

**Value**

I0	result of I0.orbit: values of daily ET solar irradiance
day.mo	result of day.month: day numbers beginning at day
dec	result of declination: ne equinox day and values of daily declination
elev	result of sun elev: ne equinox day, latitude, and values of daily sun elev
tau	list(loc, lat.long.elev, tau)
Ibd	list(day21.mo,tau,air.mass,lat,Ib,Id,Id.Ib)
I0.bb	list lambda,I.sun.nm,I0
sunpath	list nday, hr.noon, azi, elev
Ic	list(Ib,Id,Ibc,Idc,Irc,Ic,I.h)

**Note**

Functions used in Chapter 14 of Acevedo (2018)

**Author(s)**

Miguel F. Acevedo <acevedo@unt.edu>

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**See Also**

DC circuits [PVcell](#), [PVcell.plot](#)

**Examples**

```
I0.orbit()
declination()

x <- declination(plot=FALSE)
sun.elev(x, lat=32.9)

tau <- tauGolden
# or alternatively
# tau <- read.tau(system.file("extdata", "tauGolden.csv", package="renpow"))
Ibd <- beam.diffuse(tau)

I0.blackbody(T.sun=5800, w1.nm=seq(150, 2500))
```

---

tau and bd

*Dataset: monthly tau and bd for a location*

---

### Description

Optical depth for a location

### Usage

```
data("tauGolden")
data("tauAtlanta")
```

### Format

list with location, lat-long-elev, and two columns for tau (b, d)

### Details

Optical depth

### Source

ASHRAE. ASHRAE Climate Data Center. 2017. Accessed November 2017. Available from: <https://www.ashrae.org/resources-publications/bookstore/climate-data-center#std169>.

### References

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

### Examples

```
tau <- tauGolden$tau
```

---

TEO at DP 2017

*Dataset: Example of wind speed at two heights*

---

### Description

Example summer 2017 TEO station at DP campus. Includes wind speed at two heights, air temp two heights, BP, RH, Wind dir

### Usage

```
data("TEODP2017")
```



**Format**

Text file with header x specifying the variable name

**Details**

Example for wind speed height calibration

**Source**

<http://teo.unt.edu>

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**Examples**

```
v1.v2 <- TEODP2017[,c(1,8,4)]
```

---

test100

*Dataset: simple example for 100 data points*

---

**Description**

Hypothetical Example

**Usage**

```
data("test100")
```

**Format**

Text file with header x specifying the variable name and one field per line with no separator between fields

**Details**

Example for scanning files

**Source**

acevedo

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**Examples**

```
x100 <- test100$x
```

---

thermo paths

*Thermodynamic paths and cycles*


---

**Description**

Functions to calculate thermodynamic paths and cycles

**Usage**

```
cpcv.cal(datafile, plots = FALSE)
RefCoefAir
cp.cv(TC,ref=RefCoefAir)
fcp(TC)
fcpcv(TC)
fcv(TC)
fpv(V,p)
simpson(fun, a, b, pts = 100)
simpson.pv(nRT, a, b, pts = 100)
path.calc(x)
path.summary(y)
isochor(x)
isobar(x)
adiabat(x)
isotherm(x)
phase()
path.lines(x, plane = "Pv", shade.between = FALSE, lab.cycle = FALSE, shade.cycle = FALSE)
path.cycles(x, plane = "Pv", shade.cycle = FALSE)
path.cycles.summary(y)
```

**Arguments**

datafile	name of file for calibration
plots	Logical TRUE for plot
TC	Temp in deg C
ref	Ref and Coef argument to cp.cv; default is RefCoefAir
V	Volume
p	Pressure
fun	function to integrate
a	lower bound of interval
b	upper bound of interval
pts	number of points within the interval

nRT	gas law to calculate pV
x	argument specifying the states for any of isochor, isobar, adiabat, and isotherm path functions. These functions are used internally by path.calc. Argument x of path.calc specifies states for each one of isotherm, adiabat, isochor, isobar: V, P, n, T, M, S or to path.lines shade.under is a logical and part of the x argument specification; it is used by path.lines to shade area under the curve for a given path; default=FALSE or no shade. Argument x is also an argument to path.cycles as list of states in the cycle and cycle type; "carnot", "brayton", "otto", "diesel", "stirling", "box"
y	argument to path.summary or to path.cycles.summary: return from any path function as list(v,V,P,T,s,S,W,Q,cv,cp,gamma,WQtot,call,nM)
shade.between	logical used by path.lines to shade area between to paths; default=FALSE or no shade
lab.cycle	logical used by path.lines to label paths as a thermodynamic cycle; default=FALSE or no cycle
shade.cycle	logical used by path.lines and path.cycles to shade area within a thermodynamic cycle; default=FALSE or no shade
plane	Thermodynamic plane "Ts" or "Pv" to draw cycle. Default is Pv

### Details

Function cpcv.cal calibrates heat capacities as a function of temperature from a datafile. Results for data file AirCvCpTK.csv (same as dataset AirCvCpTK) are stored in RefCoefAir for easy reference. The result of cpcv.cal for other files can be used for the argument ref of cp.cv. Function cp.cv calculates heat capacity at a given temperature. Simpson integrates a function and simpson.pv integrates pv work using gas law. Function path.calc arguments, V is an array with values of V1 and V2, P is array of corresponding pressure values, T can be left unspecified and calculated from P and V. Argument path declares the type of process. argument lab are labels for the initial and final states of the path. Default values are one mole of dry air with  $M = 28.97$  Other calculation modes such as providing T instead of P, to calculate temperature from pressure and volume. The call `y<-path.calc(x)` produces y that contains values of specific volume (m<sup>3</sup>/kg), volume (liters), pressure (bar), temperature (degC), specific heat W and work Q in kJ/kg, heat capacities in kJ/kgK, and gamma. By default there are 1001 points calculated. Function path.summary(y) provides a view of the path.calc results. Function path.lines(x) uses path.calc and helps visualize a paths x; or a list of paths, e.g., list(x1,x2) where x1 and x2 are paths. These paths could be more than 2 and form a thermodynamic cycle. Function path.cycles calculates and plots a thermodynamic cycle Function path.cycles.summary(y) provides a view of the path.cycles results

### Value

TK.ref	T ref in K
cv.ref	cv ref
cpcv.ref	cp to cv ratio ref
cv.coef	cv coefficients
cpcv.coef	cp to cv ratio coefficients
cv	cv per mole

cp	cp per mole
cp.cv	cp to cv ratio
cv.kg	cv per kg
cp.kg	cp per kg
s	integration result by Simpson method
y	return list from path.calc or path.cycles. Used by path.summary and by path.lines as well as by path.cycles.summary
start.end	start and end of path
WQtot	Total work and heat
pts	number of points calculated
call=y\$call	function called
nM	Number of moles

**Note**

Functions used in Chapter 4 of Acevedo (2018)

**Author(s)**

Miguel F. Acevedo <acevedo@unt.edu>

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**Examples**

```
# heat capacities at a given temperature, say 100C
cp.cv(TC=100)

# cv at the middle of a range of temperature
cp.cv(TC=(323+25)/2)$cv

# arguments: V(l), P(bar), T(C), n(mol), M(g/mol)
# default n=1,M=28.9
# example specify V and P
x <- list(V=c(24.78,NA),P=c(1,2),path='isochor',lab=c("1","2"))
y <- path.calc(x)
path.summary(y)

# specify volume and calculate pressure
x <- list(V=c(24.78,34.78),P=c(1,NA),path='isobar',lab=c("3","4"))
y <- path.calc(x)
path.summary(y)

# example specify V and T visualize the path
```

```

x <- list(V=c(10,30),T=c(30,NA),path='isotherm',lab=c("1","2"))
path.lines(x)

# visualize two paths
x1 <- list(V=c(24.78,NA),P=c(1,2),path='isochor',lab=c("1","2"))
x2 <- list(V=c(24.78,34.78),P=c(1,NA),path='isobar',lab=c("3","4"))
path.lines(list(x1,x2))

# visualize two paths and shade in between curves
x1 <- list(V=c(10,30),T=c(200,200),path='isotherm',lab=c("3","4"))
x2 <- list(V=c(10,30),T=c(30,30),path='isotherm',lab=c("1","2"))
x <- list(x1,x2)
path.lines(x,shade.between=TRUE)

# carnot cycle
x <- list(TH=200,TL=30,V1=20,V4=40,cty='carnot')
y <- path.cycles(x,shade.cycle=TRUE)

```

---

three-phase

*Three-phase generator*


---

### Description

Calculates three-phase generator

### Usage

generator(x)

### Arguments

x parameters for generator: list(S3p, V1.rms, pf, lead.lag, Zs.r) where: S3p rated three-phase apparent power, V1.rms line voltage as rms, pf load power factor, lead.lag is -1 or +1, and Zs.r armature impedance in rectangular form

### Details

Function generator produces E, Vp, and Il in polar form and a phasor diagram.

### Value

E.p	electromotive force in polar form
Vp.p	Phase voltage generated in polar form
Il.p	Line current generated in polar form
ys	Source results

**Note**

Functions used in Chapter 10 of Acevedo (2018)

**Author(s)**

Miguel F. Acevedo <acevedo@unt.edu>

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**See Also**

AC functions [ac.plot](#), [phasor.plot](#), [waves](#)

**Examples**

```
x <- list(S3p = 15*10^6, V1.rms = 13.8*10^3, pf=0.85, lead.lag=-1, Zs.r = c(0.1,2))
generator(x)
```

```
x <- list(S3p = 15*10^6, V1.rms = 13.8*10^3, pf=0.85, lead.lag=1, Zs.r = c(0.1,2))
generator(x)
```

---

Tidal Data

*Datasets: Tidal Harmonic Components*

---

**Description**

Harmonic components for tides

**Usage**

```
data("ElevationTide")
data("VelocityTide")
data("EastportTide")
data("CutlerFarrisTide")
data("PortAransasTide")
data("AnchorageTide")
```

**Format**

Harmonic components

**Details**

Tidal calculations

**Source**

National Ocean Service. Currents, Tidal Currents 1. 2017. NOAA, National Oceanic and Atmospheric Administration, Accessed October 2017. Available from: [https://oceanservice.noaa.gov/education/tutorial\\_currents/0](https://oceanservice.noaa.gov/education/tutorial_currents/0)

NOAA. Harmonic Constituents - Station Selection. 2017. NOAA. Accessed October 2017. Available from: <https://tidesandcurrents.noaa.gov/stations.html?type=Harmonic+Constituents>.

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**Examples**

```
data(ElevationTide)
data(VelocityTide)
```

---

Tidal Power

*Tidal Power Functions*


---

**Description**

Calculations in tidal power generation

**Usage**

```
read.tide(file)
harmonics.tide(x, days, ylabel, plot)
power.barrage.cycle(xba)
find.peaks(tz, band)
tide.current.abs(tz, ylabel, plot)
tidal.power(tz, Aflow)
```

**Arguments**

file	filename for tide files in extdata
x	a tidal dataset read from file
days	number of days
ylabel	label for y axis of plot default for harmonics.tide is "Tide wrt MSL (m)" default for tide.current.abs is "Current abs (m/s)"
plot	logical to decide to plot default is TRUE
xba	list(a,Abasin,z,nu): a center of mass at half the tidal range, Abasin tidal basin area, z tidal cycle range, nu efficiency
tz	time and tide height in tidal signal produced by harmonics.tide or rectified by tide.current.abs
band	threshold band to find peaks
Aflow	cross section area for tidal power generation

**Details**

Basic calculations for tidal power

**Value**

X	list(t,z,x) tide time series
X	list(xp,tp,range)
X	list(pow.tide.MW,pow.gen.MW,gen.MWh)

**Note**

Functions used in Chapter 12 of Acevedo (2018)

**Author(s)**

Miguel F. Acevedo <acevedo@unt.edu>

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**Examples**

```
# using extdata
x <- read.tide(system.file("extdata", "AnchorageTide.csv", package = "renpow"))
harmonics.tide(x, days=29)

x <- read.tide(system.file("extdata", "VelocityTide.csv", package="renpow"))
y <- harmonics.tide(x, days=15, ylabel="Velocity m/s")
tide.current.abs(y, ylabel="Velocity (abs val) (m/s)", plot=TRUE)
y <- harmonics.tide(x, days=365, ylabel="Velocity m/s", plot=FALSE)
z <- tide.current.abs(y, ylabel="Current abs (m/s)", plot=TRUE)
tidal.power(z, Aflow=1)

x <- read.tide(system.file("extdata", "ElevationTide.csv", package="renpow"))
y <- harmonics.tide(x, days=29)
y <- harmonics.tide(x, days=365)
z <- find.peaks(y, band=c(0,1))
```



---

transformer	<i>Transformer Circuits</i>
-------------	-----------------------------

---

**Description**

Calculates transformer circuits

**Usage**

```
xformer.ckt(x, dig = 2)
```

**Arguments**

x	list(N,Vs.p,Zs.r,Zo.r,Zl.r): these are N turns ratio, Vs.p Voltage source in polar form, Zs.r Source impedance in rectangular form, Zo.r Output impedance in rectangular form, Zl.r Load impedance in rectangular form.
dig	number of digits for results

**Details**

xformer.ckt transformer circuit calculations using source, impedances, and load,

**Value**

ys	Source results
yx	Transformer results
yl	Load results
prnt	Results of transformer function for printout form

**Note**

Functions used in Chapter 10 of Acevedo (2018)

**Author(s)**

Miguel F. Acevedo <acevedo@unt.edu>

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**See Also**

AC functions [ac.plot](#), [phasor.plot](#), [waves](#)

**Examples**

```
x <- list(N=c(2,1),Vs.p=c(12,30),Zs.r=c(1,0),Zo.r=c(0,0),Zl.r=c(1,0))
xf <- xformer.ckt(x)
```

---

 Wave Power

---

*Wave Power Functions*


---

**Description**

Calculations in wave power generation

**Usage**

```
generate.duration(file)
powflux.wave(Hs, Tp)
wave.contour(X,label,sum, sumlabel)
duration.wave(datafile, file=TRUE)
energy.wave(Pflux, D)
energy.gen(Ew, L, nu)
```

**Arguments**

datafile	either a data file name or a renpow dataset
file	a logical to decide between a data file or a dataset
Hs	height in HsTp matrix
Tp	duration in HsTp matrix
X	Object to plot as contour; can be Pflux, Ew, or Eg
Pflux	Power flux produced by powflux.wave function
Ew	Energy produced by energy.wave function
label	label for plot; the default is ""
sum	logical default TRUE
sumlabel	label for sum; the default is ""
D	duration produced by duration.wave function
L	length of structure or energy conversion device
nu	efficiency

**Details**

Basic calculations for wave power

**Value**

Eg Energy produced by energy.gen function

**Note**

Functions used in Chapter 12 of Acevedo (2018)

**Author(s)**

Miguel F. Acevedo <acevedo@unt.edu>

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**Examples**

```
Pflux <- powflux.wave(Hs=seq(1,10),Tp=seq(5,20))
wave.contour(X=Pflux,label="Power flux (kW/m)")
D <- duration.wave(WaveHsTp,file=FALSE)
# alternatively using file in extdata
# D <- duration.wave(system.file("extdata","WaveHsTp.csv",package="renpow"))
wave.contour(X=D,label="Duration (hrs/yr)")

Ew <- energy.wave(Pflux,D)
wave.contour(X=Ew,label="Energy flux (MWh/yr/m)",sum=TRUE,sumlabel="(MWh/yr/m)")
Eg <- energy.gen(Ew,L=30,nu=0.4)
wave.contour(X=Eg,label="Energy produced (MWh/yr)",sum=TRUE,sumlabel="(MWh/yr)")
```

---

Waves Data

*Dataset: Wave Duration*

---

**Description**

Hypothetical wave duration

**Usage**

```
data("WaveHsTp")
```

**Format**

matrix Hs (rows) and Tp (columns)

**Details**

Hypothetical data for wave power calculations

**Source**

Hypothetical data

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**Examples**

```
data(WaveHsTp)
```

---

Wind Power

*Wind Power calculations and statistics*

---

**Description**

Basic calculations in wind power generation

**Usage**

```
pow.rho.v3.table(x)  
pow.rho.v3(xw)  
rho.pT.air(pT)  
rho.zT.air(zT)  
pow.v3.plot(x)  
pow.wind(pw)  
v.H(vh)  
betz()  
cal.vH(calvh)  
weibull.plot(xmax, scale, shape)  
cdf.plot(rv, xlab, ylab)  
fit.wind(xd, vlabel)  
pow.class(wc)  
power.curve(pc)  
prob.power.curve(pc, avg)  
wind.energy(pc, Pow, avg)
```

**Arguments**

x	a list with possible list(rho= density, v=wind speed and A=cross-section area)
xw	list(rho=array of density values,v=array of wind speed values, A=cross-section area)
pT	a list(p,T,C,punit)
zT	list(z=1000, T.C=20, punit="bar", lapse=6)
pw	list with z, array T.C, array v, punit press unit,lapse,yleg,ylabel
vh	list with array alpha exponent , and array rough of roughness coeffs
calvh	list with list(v1.v2=v1.v2,H1=2,H2=10)
xmax	max x value for Weibull
scale	parameter
shape	parameter
rv	data var for cumulative distribution function
xlab	label x axis
ylab	label y axis
wc	wind speed for wind class chart
xd	wind data object from two anemometers
vlabel	label for graph
pc	a list cutin, vrated, cutout, A, v
avg	avg wind speed for prop.power.curve and wind.energy
Pow	result of power curve and used as argument to wind energy

**Details**

Basic calculations of wind power

**Value**

X1	result of pow.rho.v3.table is list(X,P)
X2	result of pow.rho.v3 is list(rho=,v=,Pow=)
X3	result of rho.pT.air is array with c("Pressure(kPa)", "Temp(C)", "Density(kg/m3)")
X4	result of rho.zT.air is list(X,rho)
X5	result of v.H is v.v0.exp and v.v0.log
X6	result of cal.vH alpha exponent, and array rough of roughness coeffs
X7	result of pow.class is list(Pow.x,class.x)
X8	result of pow.curve is list(Pow, z,P.rated)
X9	result of prob.power.curve is hours in various ranges list(h.cutin,h.cutout,h.rated.nstop, h.run.below.rated)
X10	result of wind.energy is list(energy,unit,CF)

**Note**

Functions used in Chapter 13 of Acevedo (2018)

**Author(s)**

Miguel F. Acevedo <acevedo@unt.edu>

**References**

Acevedo, M.F. 2018. Introduction to Renewable Electric Power Systems and the Environment with R. Boca Raton, FL: CRC Press. (ISBN 9781138197343)

**Examples**

```
x <- list(rho=1.225,v=10,A=1); pow.rho.v3.table(x)

x <- list(rho=c(0.9,1,1.1,1.225,1.3),v=seq(0,10),A=1)
X <- pow.rho.v3(x)

x <- list(v=X$v,y=X$rho,Pow=X$Pow,yleg="rho",ylabel="Density(kg/m3)")
pow.v3.plot(x)

x <- list(z=1000, T.C=10, punit="bar")
rho.zT.air(x)
x <- list(z=100, T.C=30, punit="bar")
rho.zT.air(x)

x <- list(z=1000, T.C=c(10,20,30), v=seq(0,30),punit="bar",
        lapse=6,yleg="T.C",ylabel="Temperature (C)")
pow.wind(x)

x <- list(alpha=c(0.1,0.25,0.4),rough=c(0.1,0.4,1.6))
v.H(x)
```

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