

Storage2 e StorageController2

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2º Encontro do Grupo de Usuários do OpenDSS Brasil
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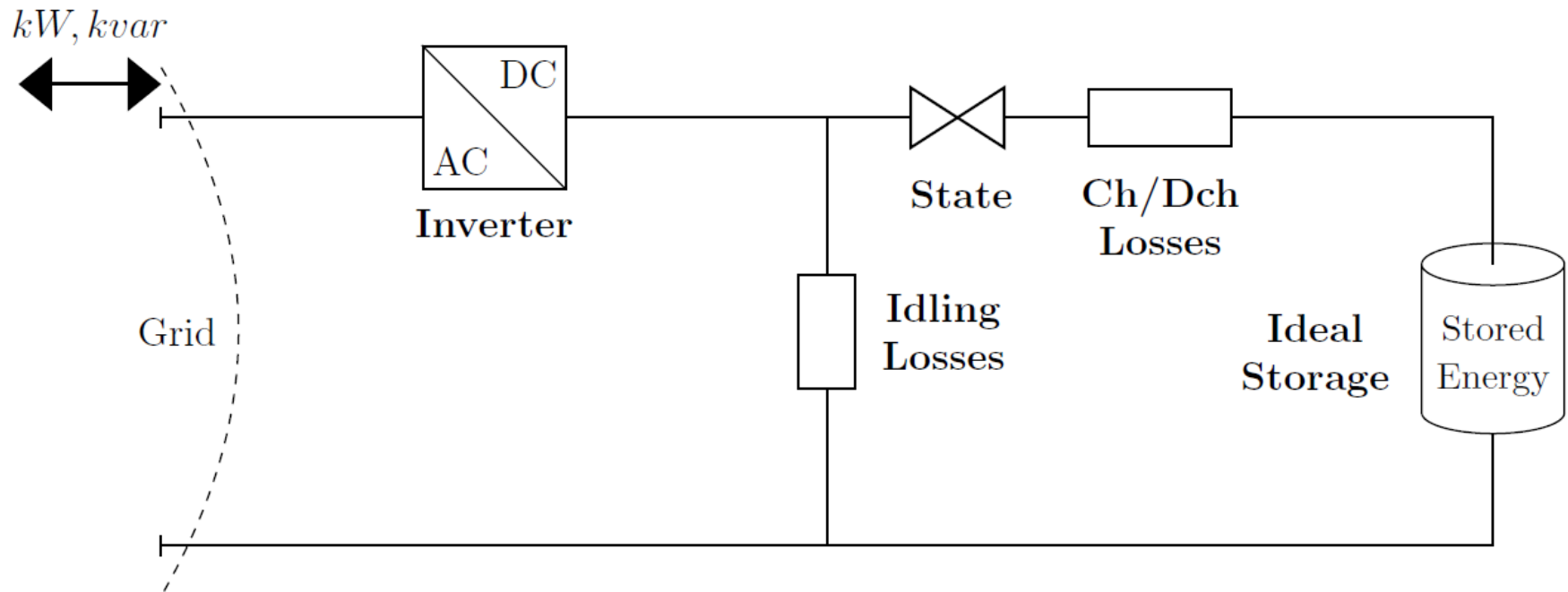


Visão Geral

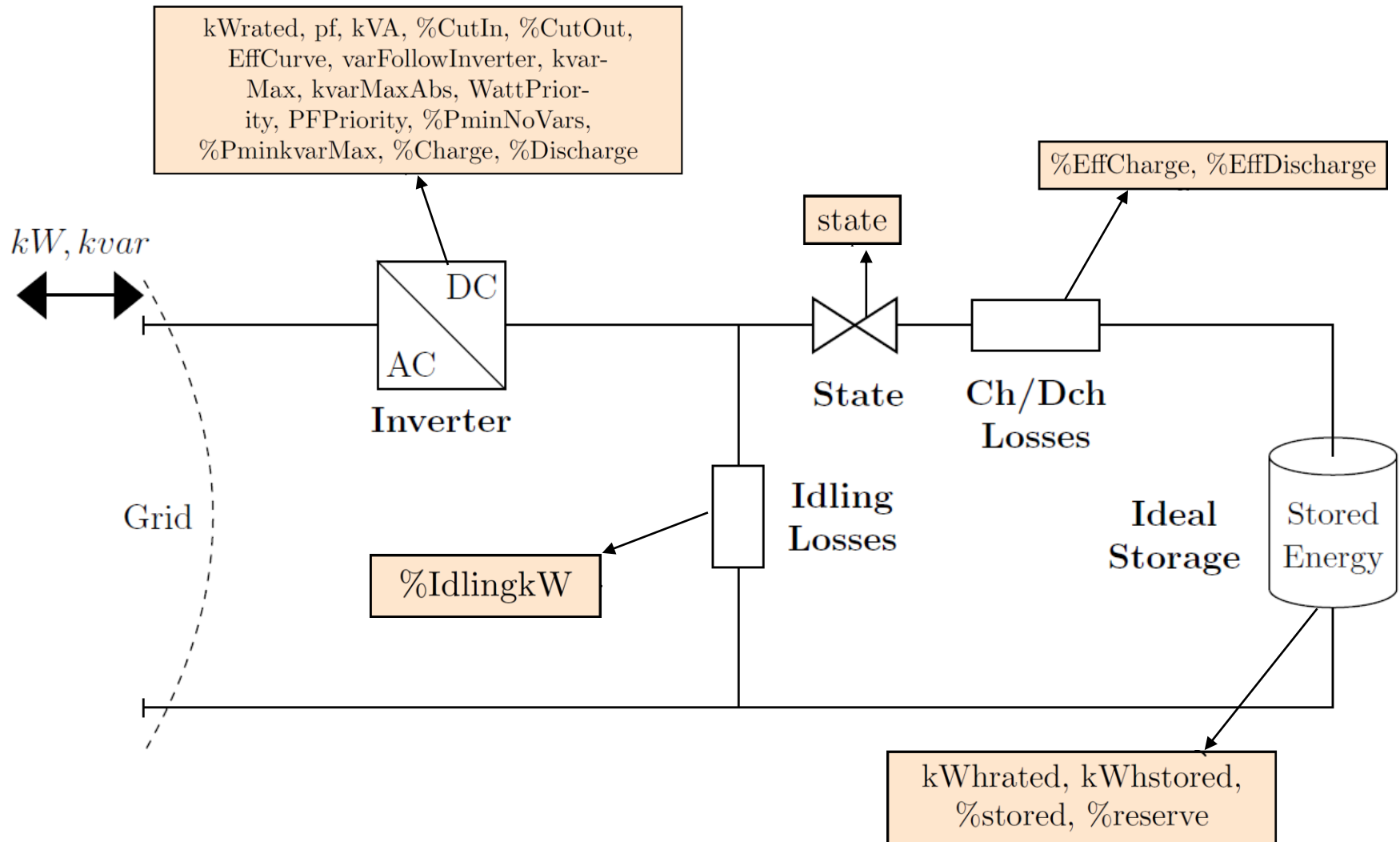
- Storage2
 - Modelagem
 - Modos de Operação
 - Modos de Despacho
 - Variáveis de Estado
 - Atualizações
- StorageController2
 - Modelagem
 - Modos de Despacho
 - Atualizações

Storage2

Modelagem

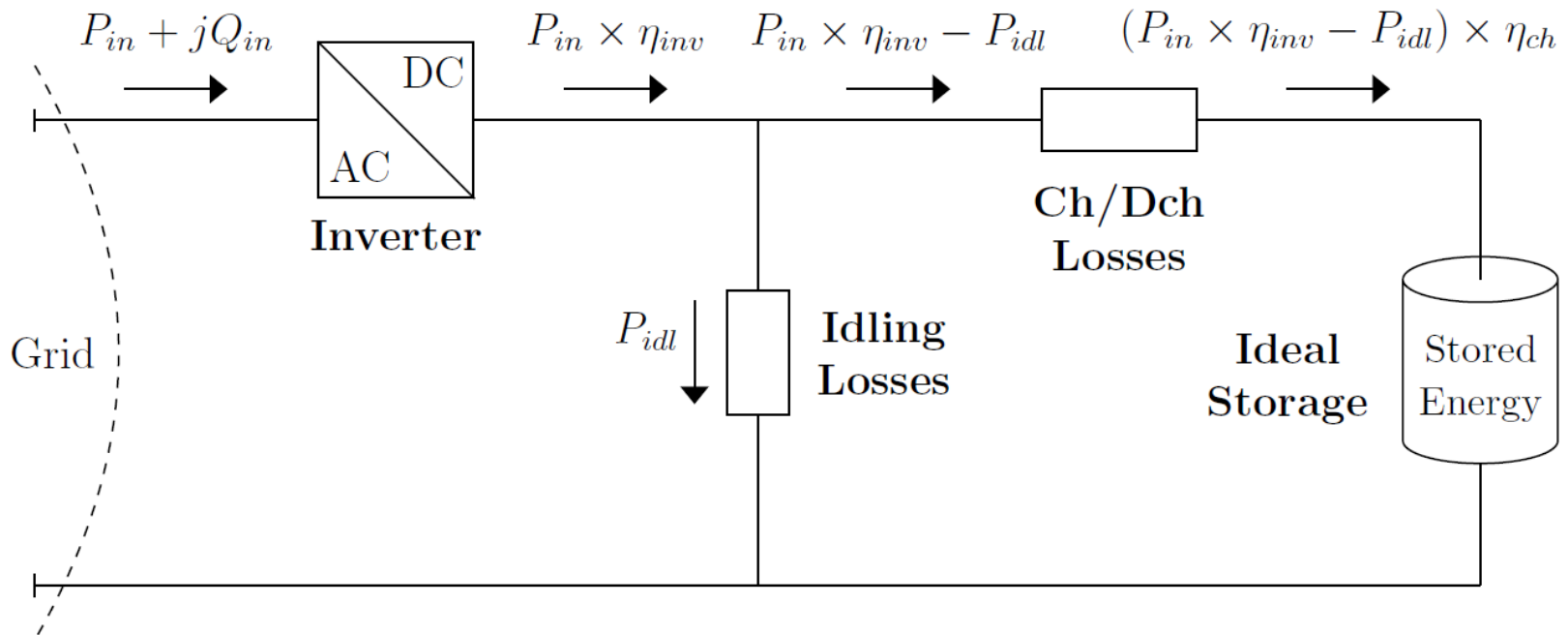


Modelagem



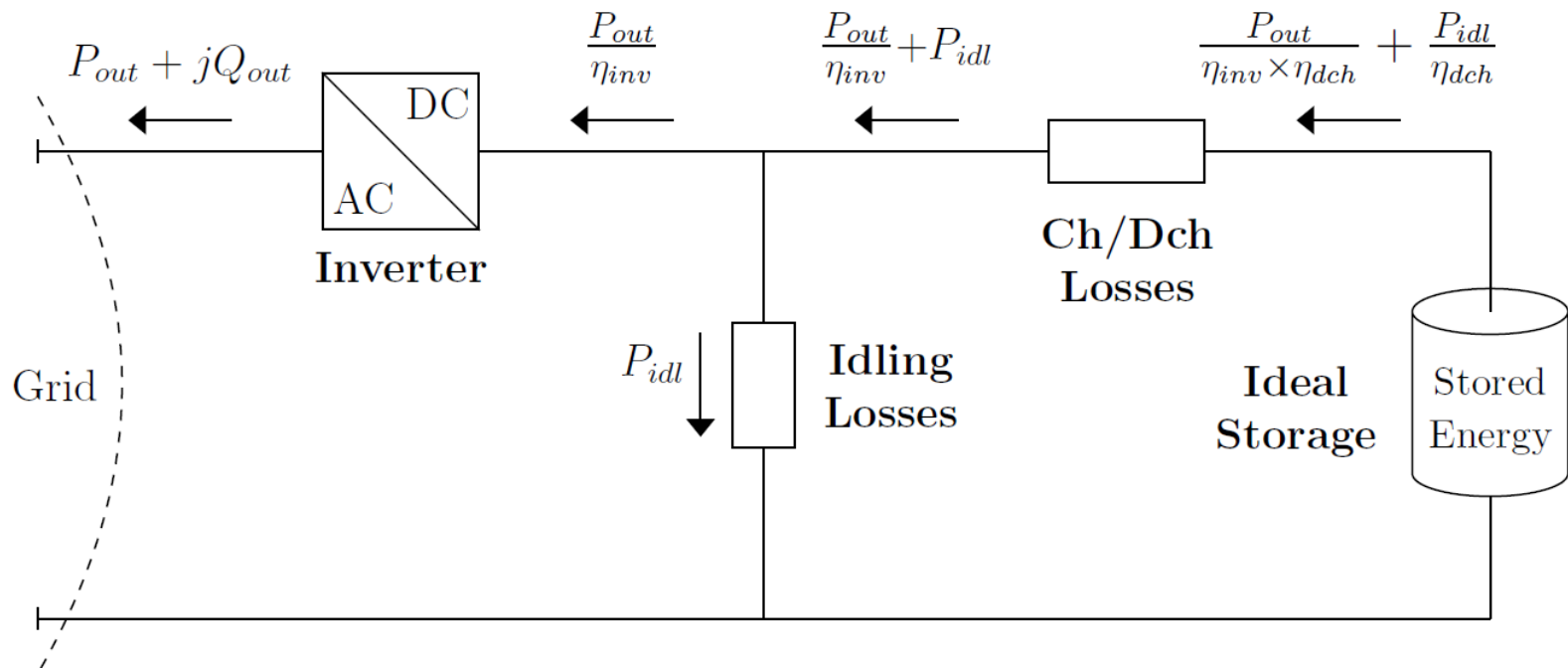
Modos de Operação

- Carga:



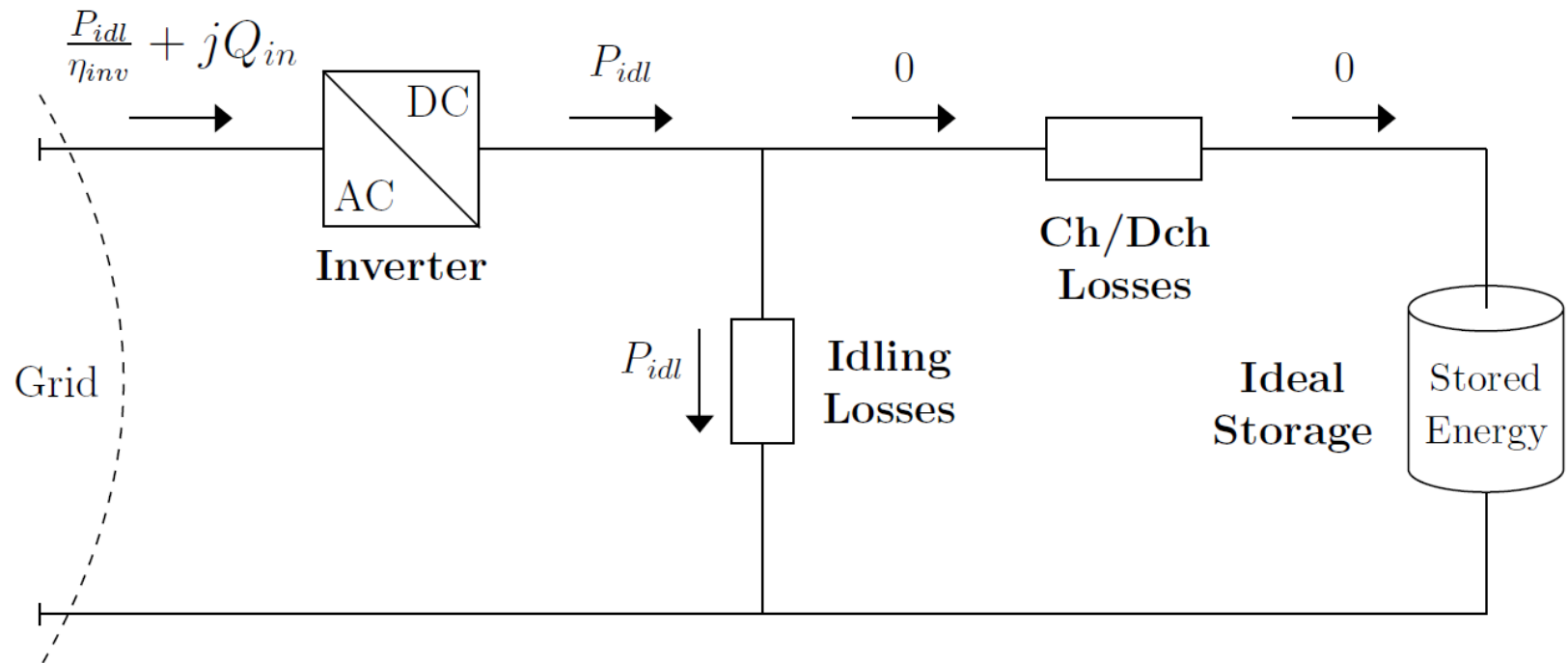
Modos de Operação

- Descarga:



Modos de Operação

- Inativo:



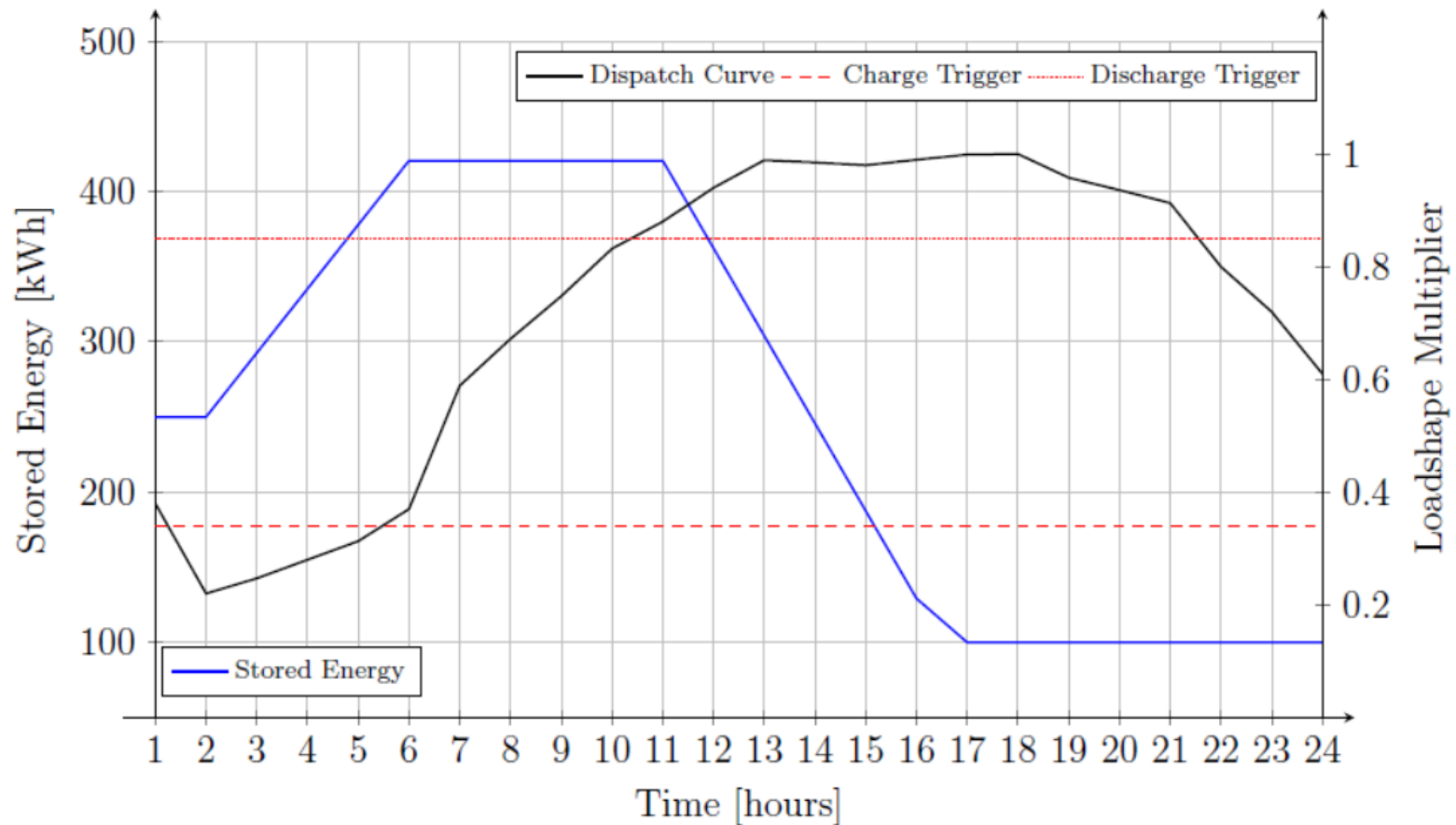
Modos de Despacho

Measure	Means	Mode/Function	
Active Power	Self-Dispatch	Default	<i>Storage.dispmode</i>
		Follow	
		LoadLevel	
		Price	
		External	
		TimeChargeTrigger (Discharge Only)	
	StorageController	PeakShave (Discharge Only)	<i>StorageController.modeCharge/ modeDischarge</i>
		Follow (Discharge Only)	
		Support (Discharge Only)	
		Loadshape	
		PeakShaveLow (Charge Only)	
		Time	
Reactive Power	Self-Dispatch	Constant PF	<i>Storage.pf Storage.kvar</i>
		Constant kvar	
	InvControl	Volt-Var (VV)	<i>InvControl.mode InvControl.com- bimode</i>
		Dynamic Reactive Current (DRC)	
		VV + DRC	
		VV + Volt-Watt (VW)	

Modos de Despacho

Despacho Próprio (Self-Dispatch)

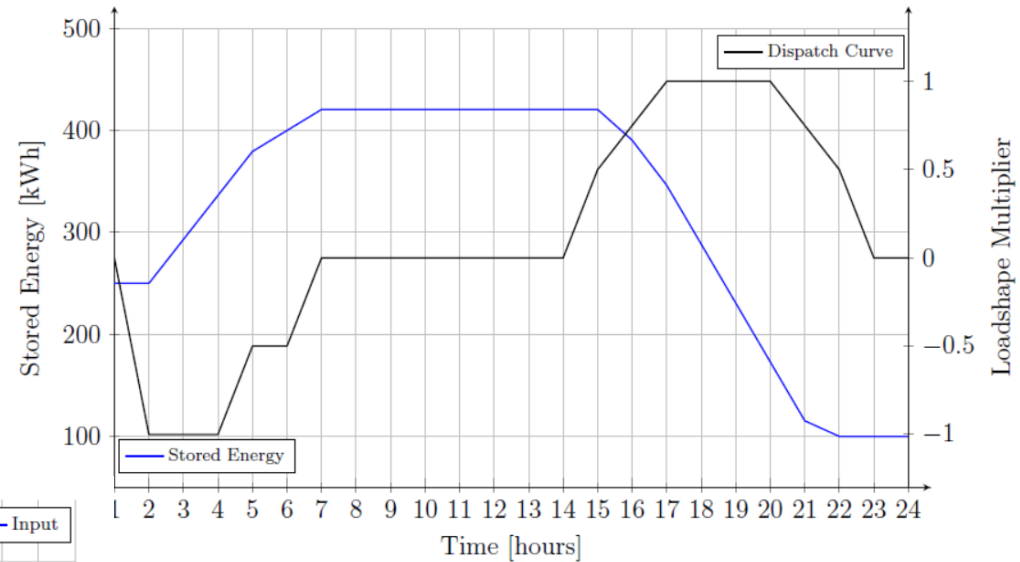
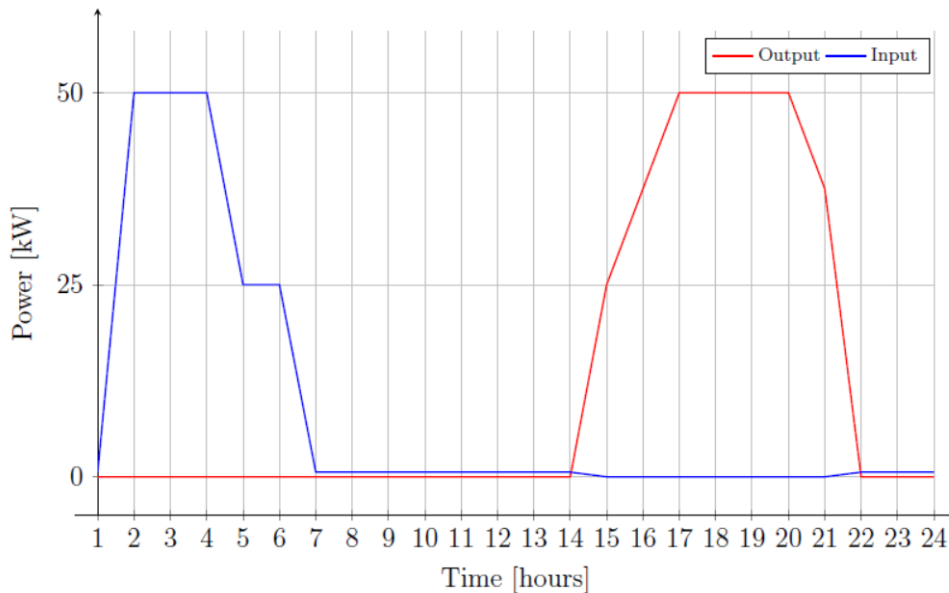
- Default:



Modos de Despacho

Despacho Próprio (Self-Dispatch)

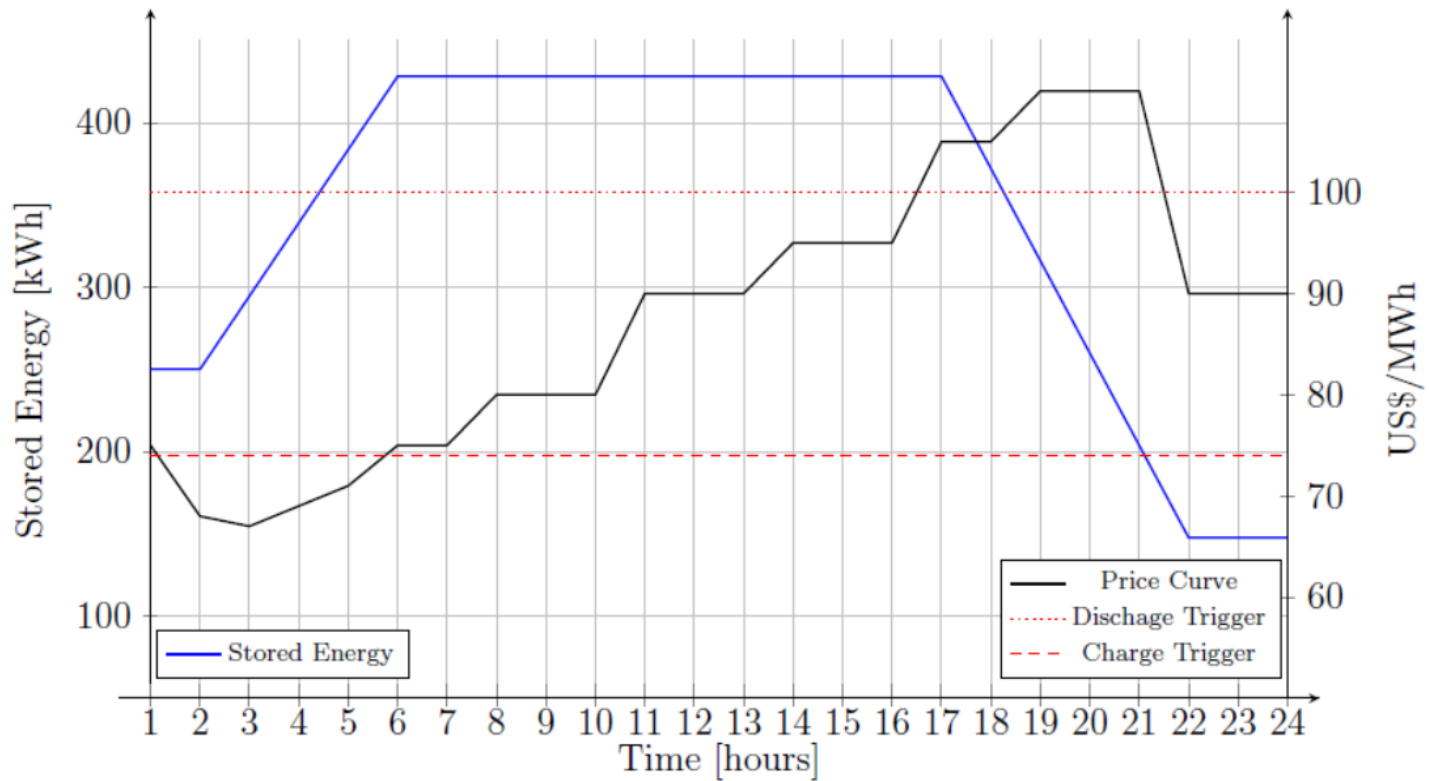
- Follow:



Modos de Despacho

Despacho Próprio (Self-Dispatch)

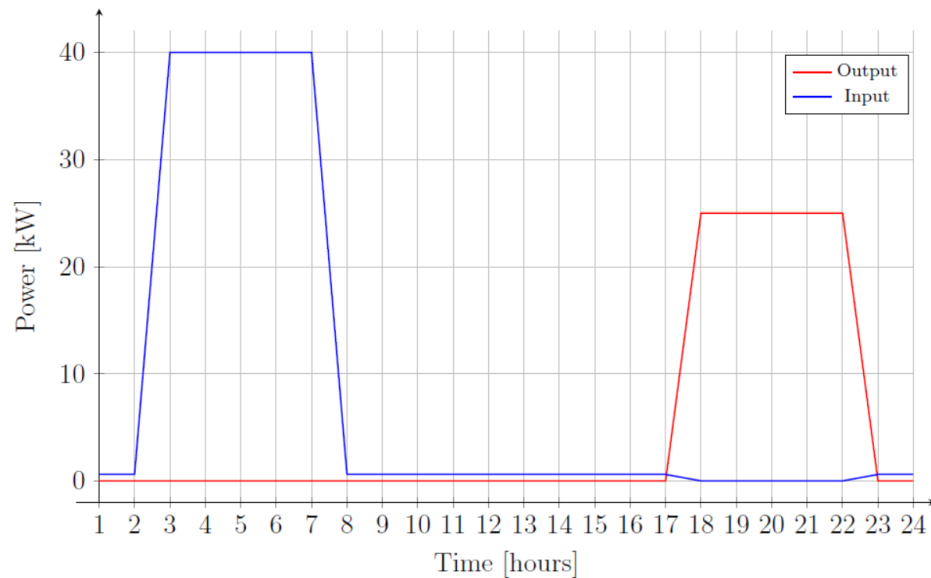
- Price:



Modos de Despacho

Despacho Próprio (Self-Dispatch)

External:



```
! Storage Operation in External Mode
Clear

New Circuit.Source bus1=A basekv=0.48 phases=3 pu=1

! Inverter Efficiency Curve
New XYCurve.Eff npts=4 xarray=[.1 .2 .4 1.0] yarray=[.86 .9 .93 .97]

New Storage2.Storage1 phases=3 bus1=A kv=0.48 pf=1 kWrated=50 %reserve=20
~ effcurve=Eff kWrated= 500 %stored=50 state=idling dispmode=External

New Monitor.Mon.Storage1.State element=Storage2.Storage1 mode=3
New Monitor.Mon.Storage1.Powers element=Storage2.Storage1 mode=1 ppolar=No

Set voltagebases = [0.48]
Calc voltagebases

Set mode=Daily
Set stepsize=1h

// Idles in the first two hours
// 1am-2am
Set number=2
Solve

// Charges for the next 5 hours with 80% of rated power
// 3am-7am
Edit Storage2.Storage1 state=charging %charge=80 ! setting state directly
Set number=5
Solve

// Idles for the next 10 hours
// 8am-5pm
Edit Storage2.Storage1 state=idling
Set number= 10
Solve

// Discharges for the next 5 hours with half of rated power
// 6pm-10pm
! setting state directly through kw (positive means discharging)
Edit Storage2.Storage1 kW=25
Set number=5
Solve

// Idles for the last two hours
// 11pm-12am
Edit Storage2.Storage1 state=idling
Set number= 2
Solve
```

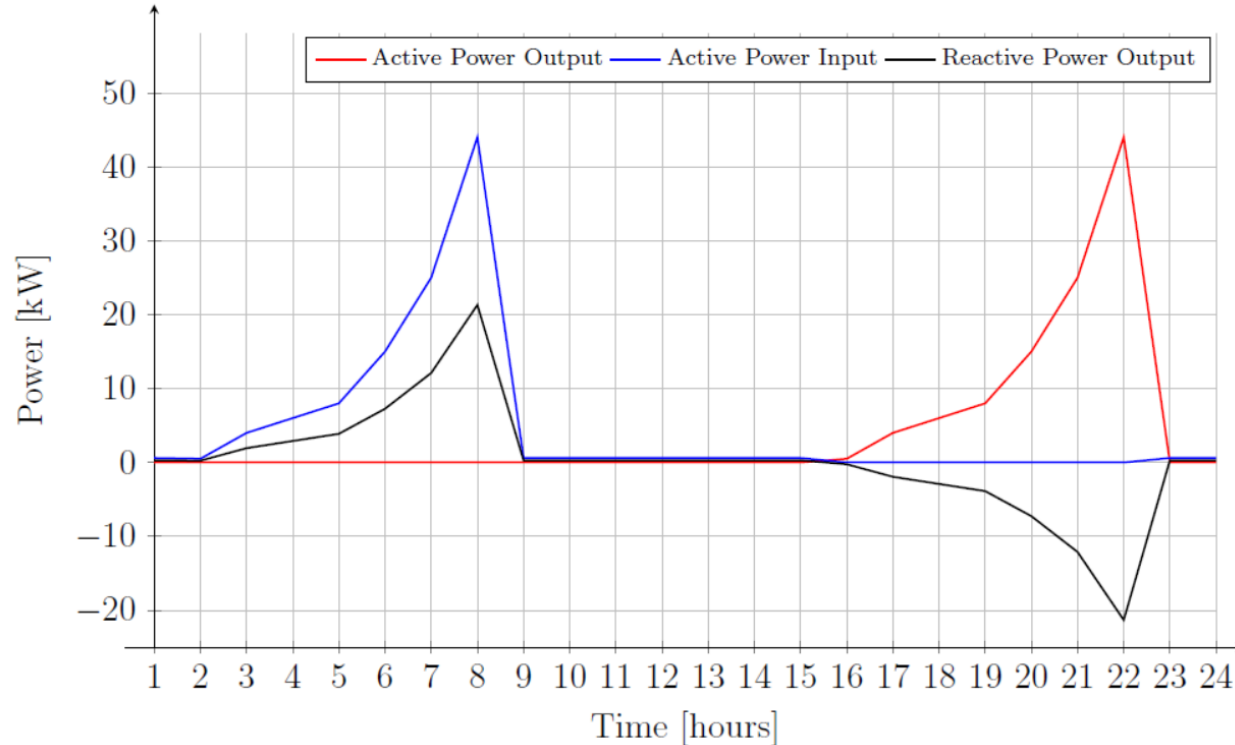
Modos de Despacho

Despacho Próprio (Self-Dispatch)

■ Reativos (FP Fixo):

```
New LoadShape.dispatch_shape interval=1 npts=24
~ mult = [0.0, -0.01, -0.08, -0.12, -0.16, -0.30, -0.50, -0.88, 0.0, 0.0, 0.0,
          0.0, 0.0, 0.0, 0.0, 0.01, 0.08, 0.12, 0.16, 0.30, 0.50, 0.88, 0.0, 0.0]

New Storage2.Storage1 phases=3 bus1=A kv=0.48 pf=1 kWrated=50 %reserve=20
~ effcurve=Eff kWrated= 500 %stored=50 state=idling
~ dispmode=follow pf=-0.90 model=1 daily=dispatch_shape
```



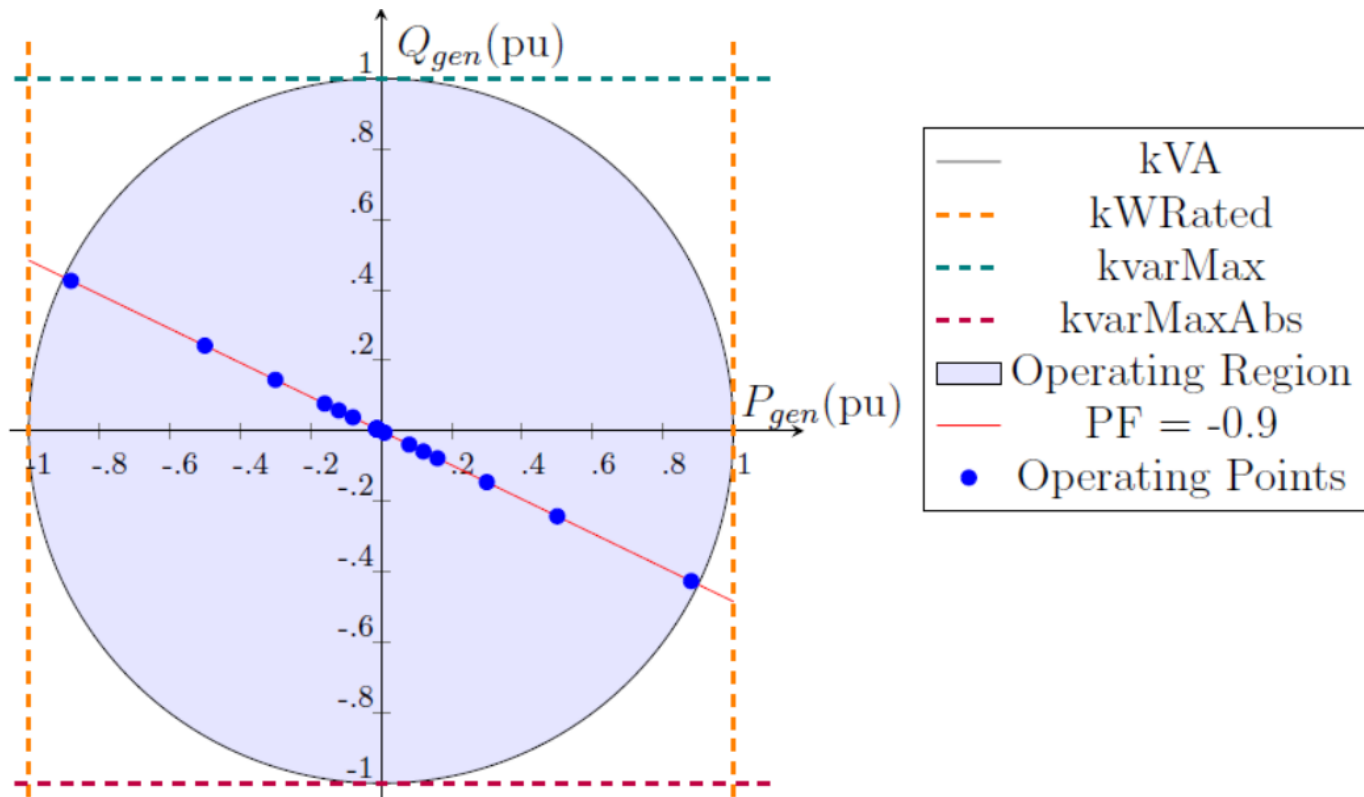
Modos de Despacho

Despacho Próprio (Self-Dispatch)

■ Reativos (FP Fixo):

```
New LoadShape.dispatch_shape interval=1 npts=24
~ mult = [0.0, -0.01, -0.08, -0.12, -0.16, -0.30, -0.50, -0.88, 0.0, 0.0, 0.0,
          0.0, 0.0, 0.0, 0.0, 0.01, 0.08, 0.12, 0.16, 0.30, 0.50, 0.88, 0.0, 0.0]

New Storage2.Storage1 phases=3 bus1=A kv=0.48 pf=1 kWrated=50 %reserve=20
~ effcurve=Eff kWrated= 500 %stored=50 state=idling
~ dispmode=follow pf=-0.90 model=1 daily=dispatch_shape
```

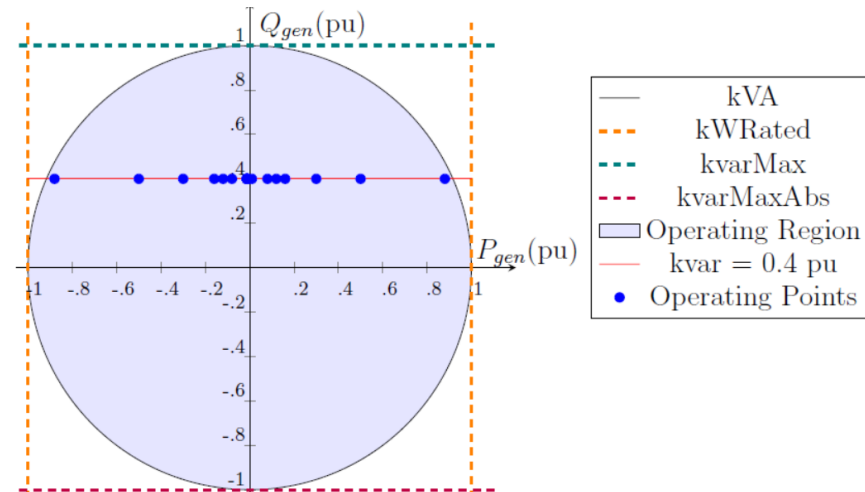
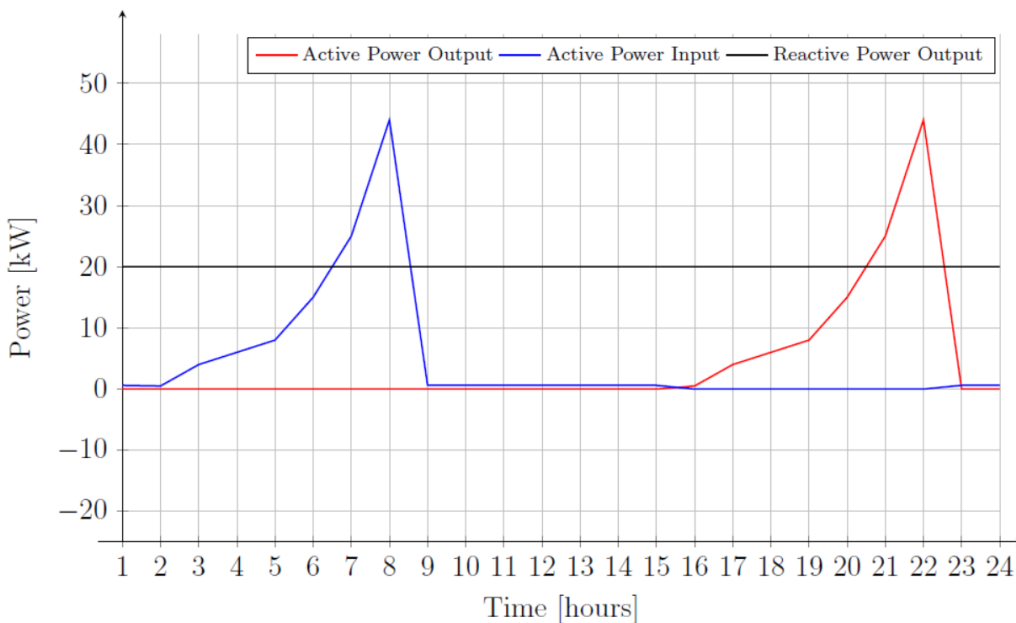


Modos de Despacho

Despacho Próprio (Self-Dispatch)

■ Reativos (Q Fixo):

```
New Storage2.Storage1 phases=3 bus1=A kv=0.48 pf=1 kWrated=50 %reserve=20
~ effcurve=Eff kWhrated= 500 %stored=50 state=idling
~ dispmode=follow kvar=20 model=1 daily=dispatch_shape
```



Variáveis de Estado

State Variable	Description
kWh	Stored Energy in kWh.
State	Storage state. 1 for discharging, -1 for charging and 0 for idling.
kWOut	Power flowing out of the element, in kW. It is a result from the power flow. For discharging state.
kWIn	Power flowing into the element in kW. It is a result from the power flow. For charging and idling states.
kvarOut	Power flowing out of the element in kvar as a signed-value. Positive for vars generation and negative for vars absorption.
DCkW	DC power flowing into the storage inverter in kW at the DC side of the inverter as a signed-value. Positive for power flowing into the grid and negative for power flowing into the Storage element.
kWTotalLosses	Total losses in kW.
kWInvLosses	Inverter losses in kW.

Variáveis de Estado

State Variable	Description
kWIdlingLosses	Idling losses in kW.
kWChDchLosses	Charging and discharging losses in kW.
kWh Chng	Energy variation from the last time step, in kWh. Corresponds to the power that effectively charges/discharges the storage medium/battery multiplied by the time step length.
InvEff	Inverter efficiency.
InverterON	Flag indicating the inverter status. See [3].
Vref	Reference voltage used by the voltage-dependent InvControl functionalities. Equal to 9999 if there is no InvControl controlling the Storage element. See [3].
Vavg (DRC)	Average voltage of the moving window used in InvControl's DRC function. Equal to 9999 if there is no InvControl controlling the element. See [3].
VV Oper	Flag variable that indicates the status of InvControl's Volt-Var function operation. Equal to 9999 if there is no InvControl controlling the element. See [3].
VW Oper	Flag variable that indicates the status of InvControl's Volt-Watt function operation. Equal to 9999 if there is no InvControl controlling the element. See [3].
DRC Oper	Flag variable that indicates the status of InvControl's DRC function operation. Equal to 9999 if there is no InvControl controlling the element. See [3].

Variáveis de Estado

VV_DRC Oper	Flag variable that indicates the status of InvControl's VV + DRC function operation. Equal to 9999 if there is no InvControl controlling the element. See [3].
kWDesired	Nominal power desired or requested by the dispatch mode selected, in kW, if there is enough energy capacity left. Otherwise, it is 0.
kW VW Limit	Active power limit imposed by Volt-Watt function, in kW. See [3]. Equal to 9999 if the function is disabled due to inverter status.
Limit kWOut Function	Active power limit imposed by "Limit DER output function" ($\%kW\ Rated \times kW\ Rated$), in kW. See [3].
kVA Exceeded	Flag indicating if inverter kVA rating has been exceeded. See [3].

Atualizações Storage

- Inclusão do Modelo do Inversor
- Possibilidade de Controle por InvControl
- Função VW para Storage

Possibilidade de Controle por InvControl

```
! Reactive Power Violation (linear region, kvarMax, kVA)
New LoadShape.dispatchFollow interval=(1 3600 /) npts=24 mult = [0, -0.01,
    -0.08, -0.12, -0.14, -0.16, -0.30, -0.50, -0.6, -0.8, -0.95, 0, 0.01, 0.08,
    0.12, 0.14, 0.16, 0.30, 0.50, 0.6, 0.8, 0.95, 0, 0]

Edit Storage2.A dispmode=follow daily=dispatchFollow %cutin=0 %cutout=0
~ %PminNoVars=0 kvarMaxAbs=600 %idlingkW=0

! VV Curve
New XYCurve.vv_curve npts=5 yarray=[1 1 0 -1 -1] xarray=[0.5 0.92 1.0 1.08 1.5]

New InvControl2.InvCtrl combiMode=VV_DRC dbVMin=1 dbVMax=1 arGraLowV=50
~ arGraHiV=50 dynReacAvgWindowLen=2s refReactivePower=VARMAX vvc_curve1=vv_curve
~ varChangeTolerance=0.001

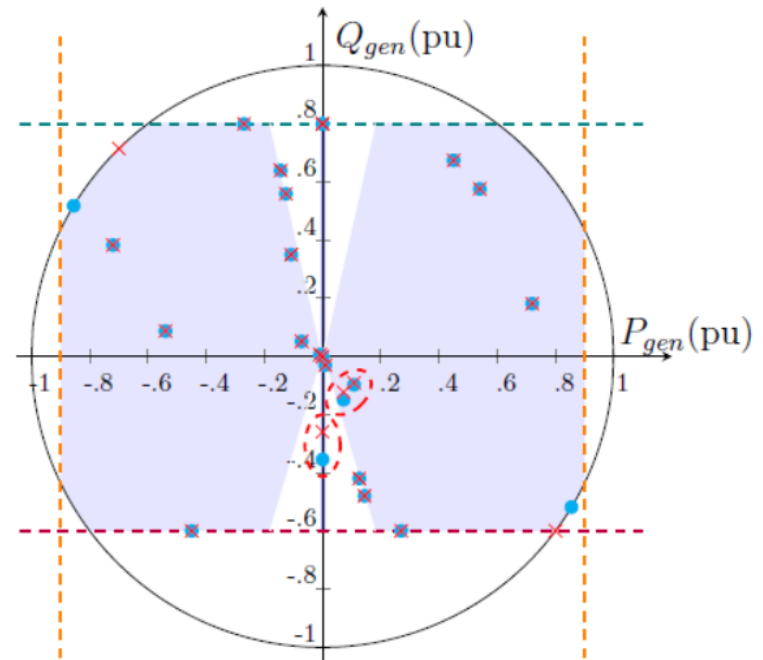
! P Priority
Set casename=Ppriority
Edit Storage2.A wattpriority=true

! Q Priority
!Set casename=Qpriority
!Edit Storage2.A wattpriority=false

Set mode=Daily
Set maxcontroliter=50
Set stepsize=1s

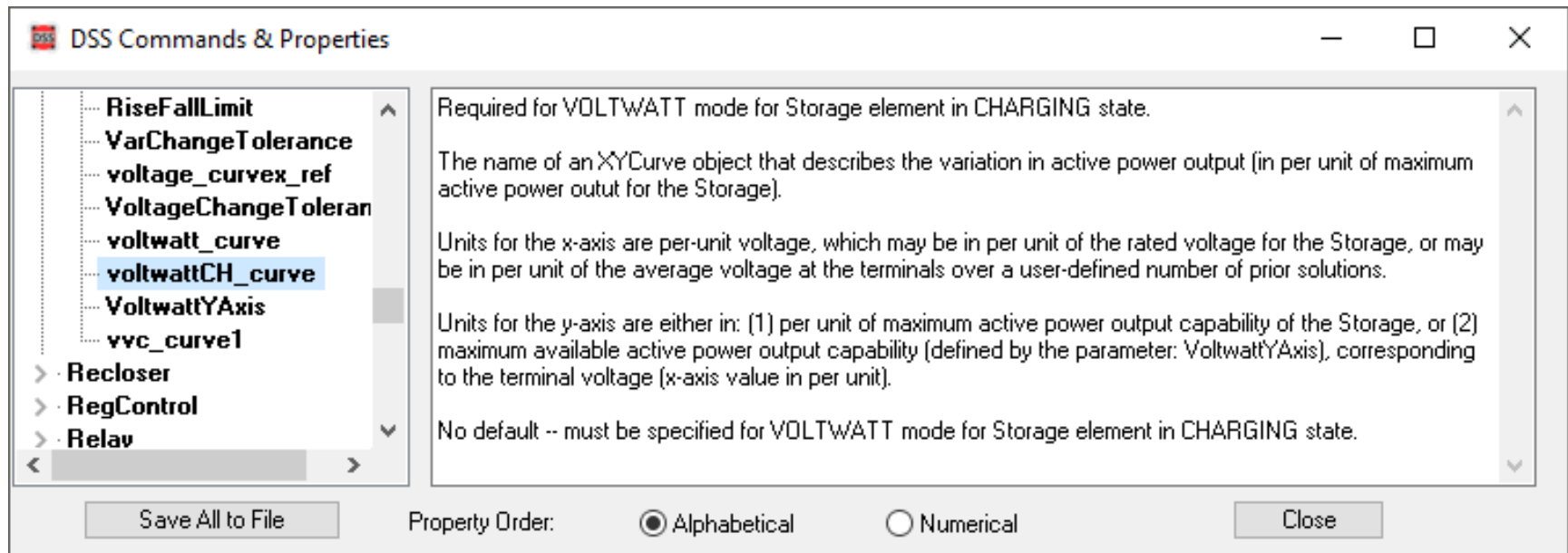
! 1 - 3am
Edit VSource.source pu=1.0
Set number=3
Solve

! 4am
Edit VSource.source pu=0.98
Set number=1
Solve
```



Atualizações Storage

Função VW para Storage

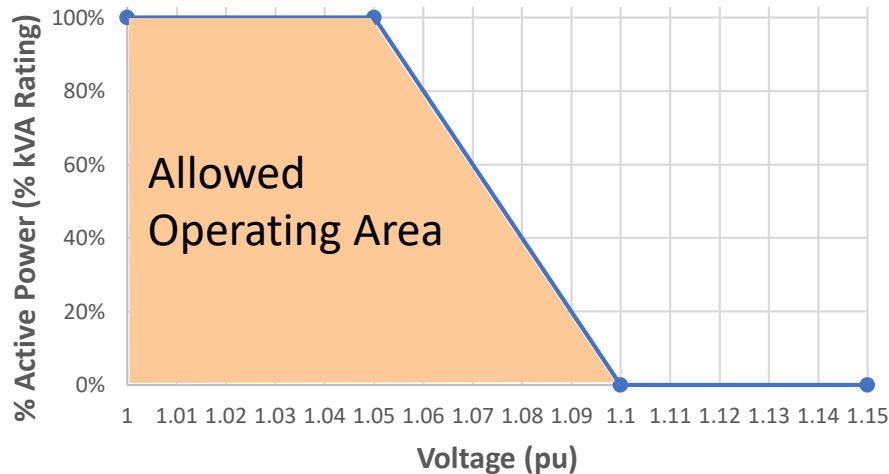


Atualizações Storage

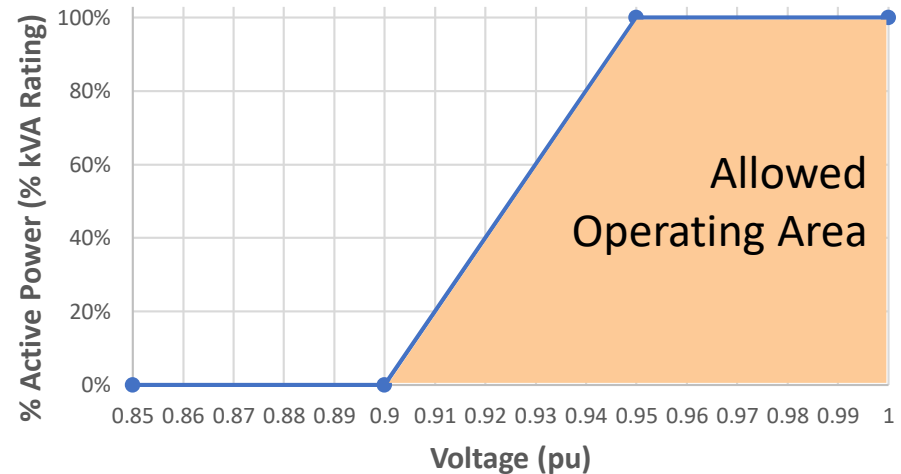
Função VW para Storage

- New XYcurve.vw_curve_dch npts=4 yarray=[1 1 0 0] xarray=[1 1.05 1.1 1.15]
- New XYcurve.vw_curve_ch npts=4 yarray=[0 0 1 1] xarray=[0.85 0.9 0.95 1]

VW - Discharging



VW - Charging



- New InvControl.VoltWatt mode=VOLTWATT voltage_curvex_ref=rated
voltwatt_curve=vw_curve_dch **voltwattCH_curve**=vw_curve_ch

Nota Técnica – Storage2

November 4, 2019

Storage2 Element

Celso Rocha, Jouni Peppanen, Paulo Radatz, Matthew Rylander, Roger Dugan

1 Purpose

This technical note describes the modelling and dispatch modes of the Storage2 element implemented in 2019.

2 Why?

OpenDSS Storage element has passed through a major update in 2019. This technical note has been elaborated mainly to explain the new features, but also to expand the previous Storage documentation [1] with a comprehensive description of the model. The new features are:

- Addition of a built-in inverter model, including losses and capability curve;
- Idling losses block has been moved from the grid interface to the DC side of the inverter;
- Possibility to be controlled by an InvControl2 control element in a similar way to PVSystem2 element, including the possibility of being controlled simultaneously by a StorageController2 and an InvControl2 (see Figure 1);
- Addition of new state variables to aid in the understanding of the operation of the element;

Besides the aforementioned features, it is worth commenting that the Storage2 source code has been formulated for better compatibility with InvControl2 and PVSystem2 implementation, facilitating future implementations of smart inverter functionalities in the InvControl2 source code, which are applicable to both PVSystem2 and Storage2 elements.

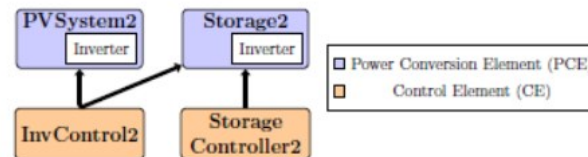
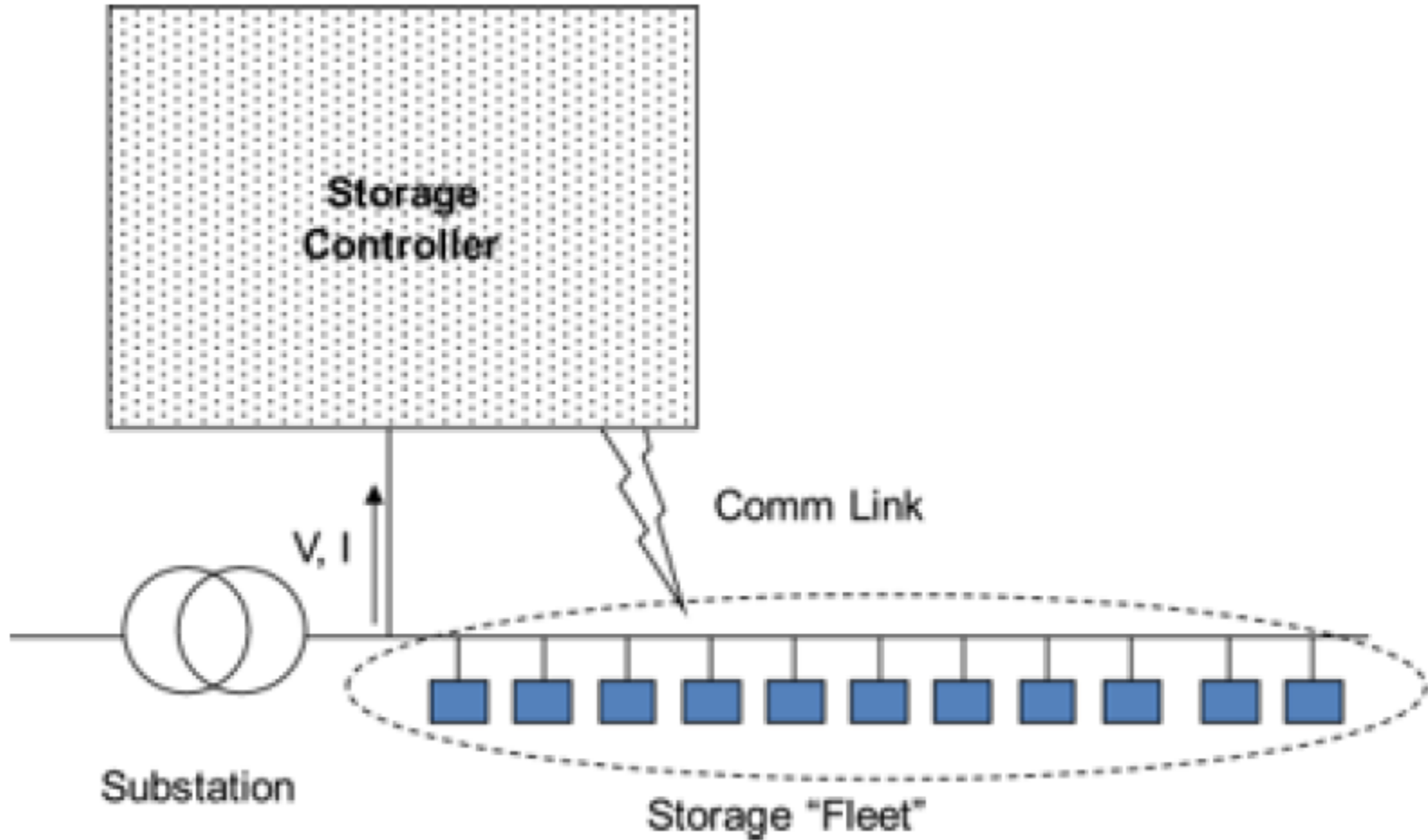


Figure 1: Relation between PVSystem2, Storage2, InvControl2 and StorageController2 elements

StorageController2

Modelagem

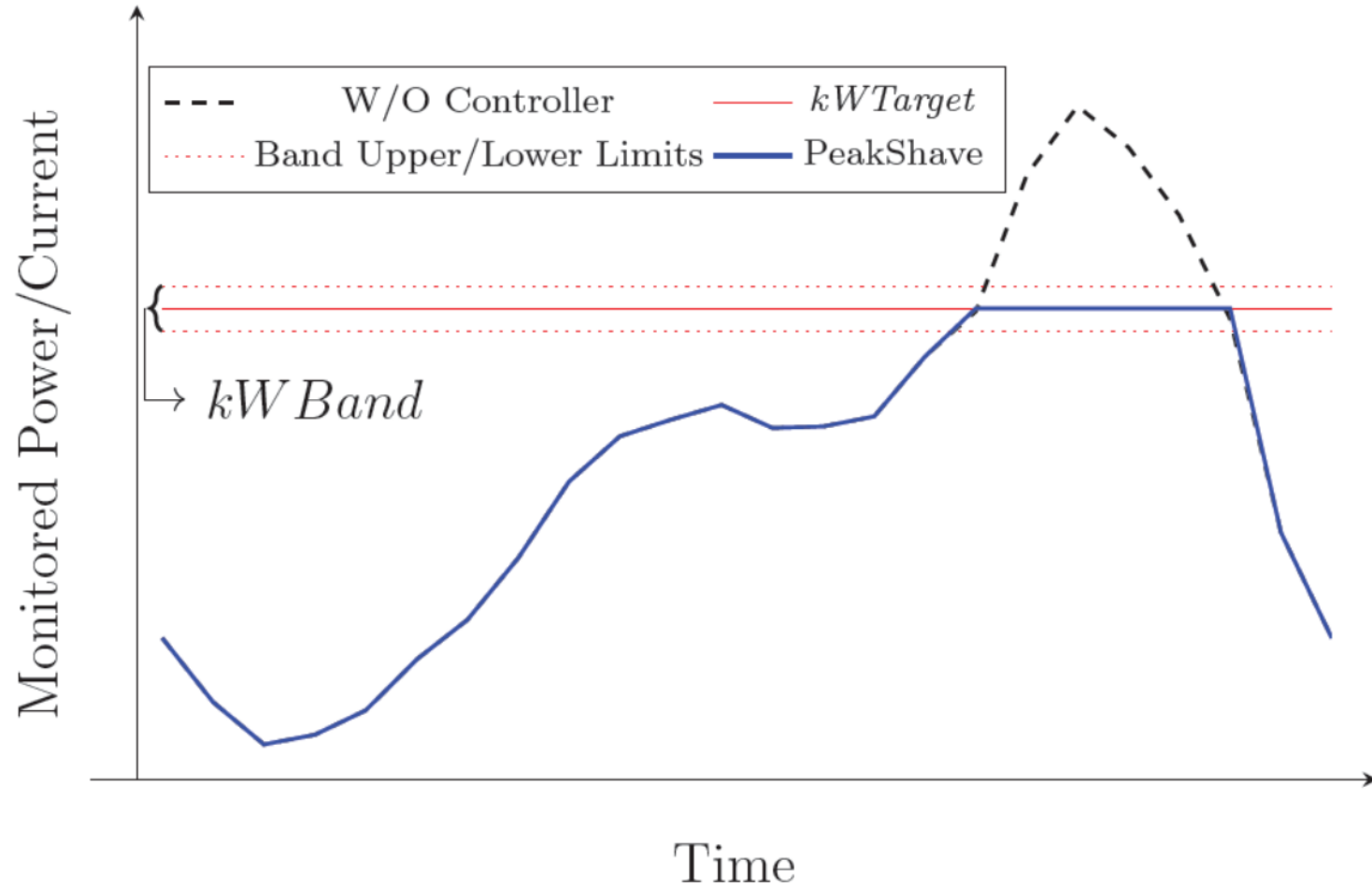


Modos de Despacho

Requested State	Driver	Mode
Discharging Only	Power Flow	PeakShave
		I-PeakShave
		Follow
		Support
	Time	Schedule
Charging Only	Power Flow	PeakShaveLow
		I-PeakShaveLow
Both	Time	Time
		LoadShape

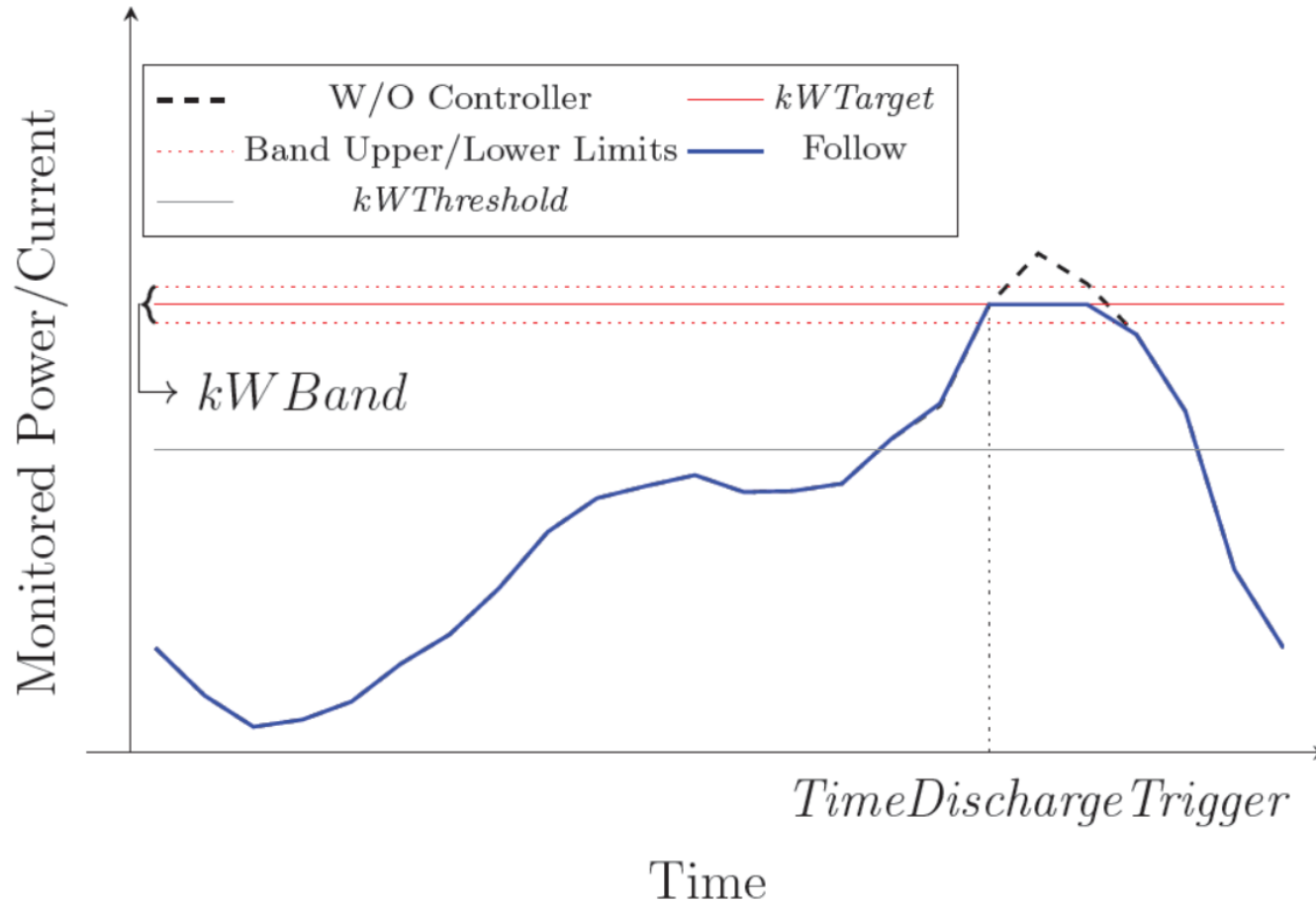
Modos de Despacho

- PeakShave/I-PeakShave (Descarga)



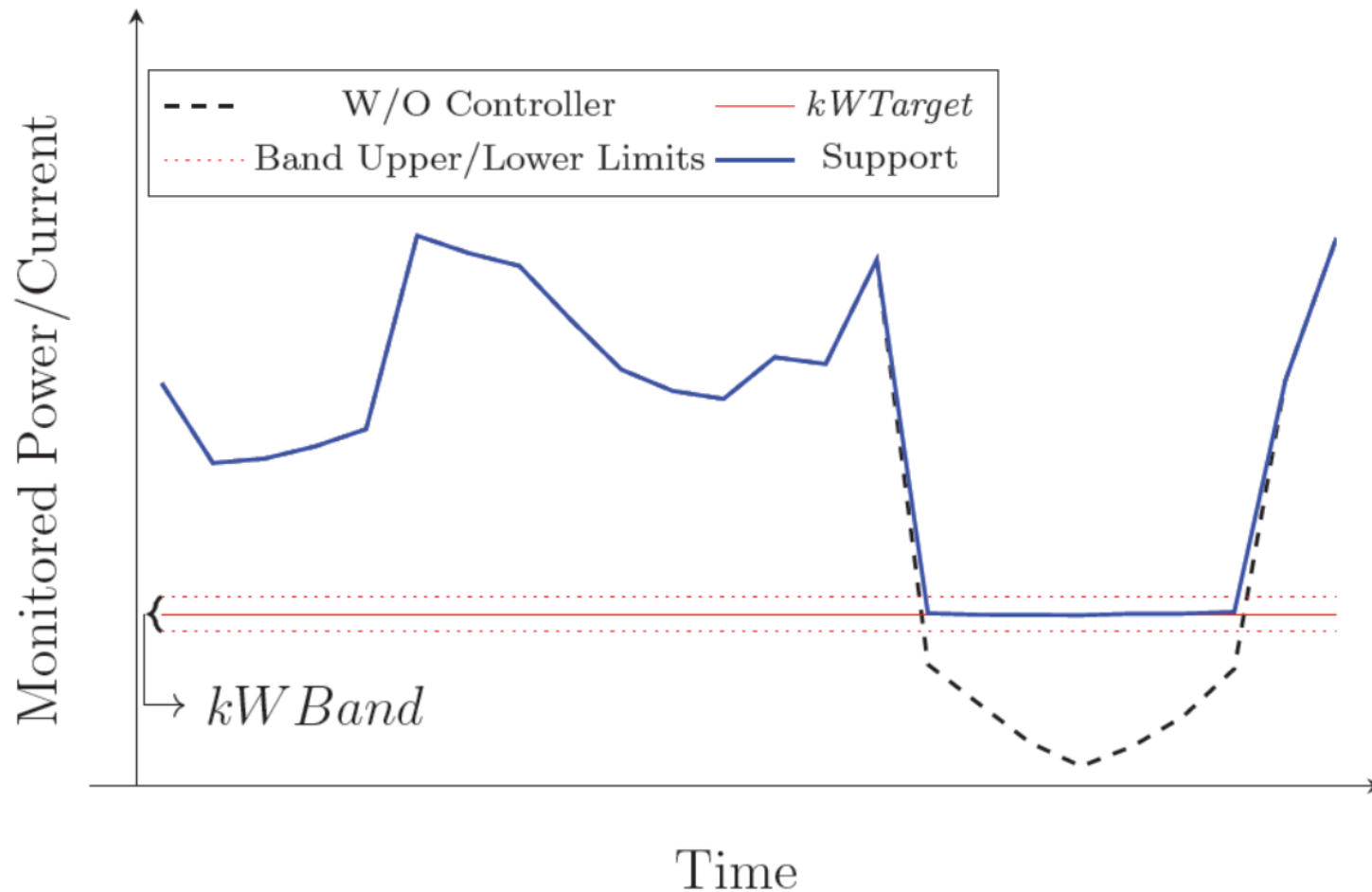
Modos de Despacho

- Follow (Descarga)



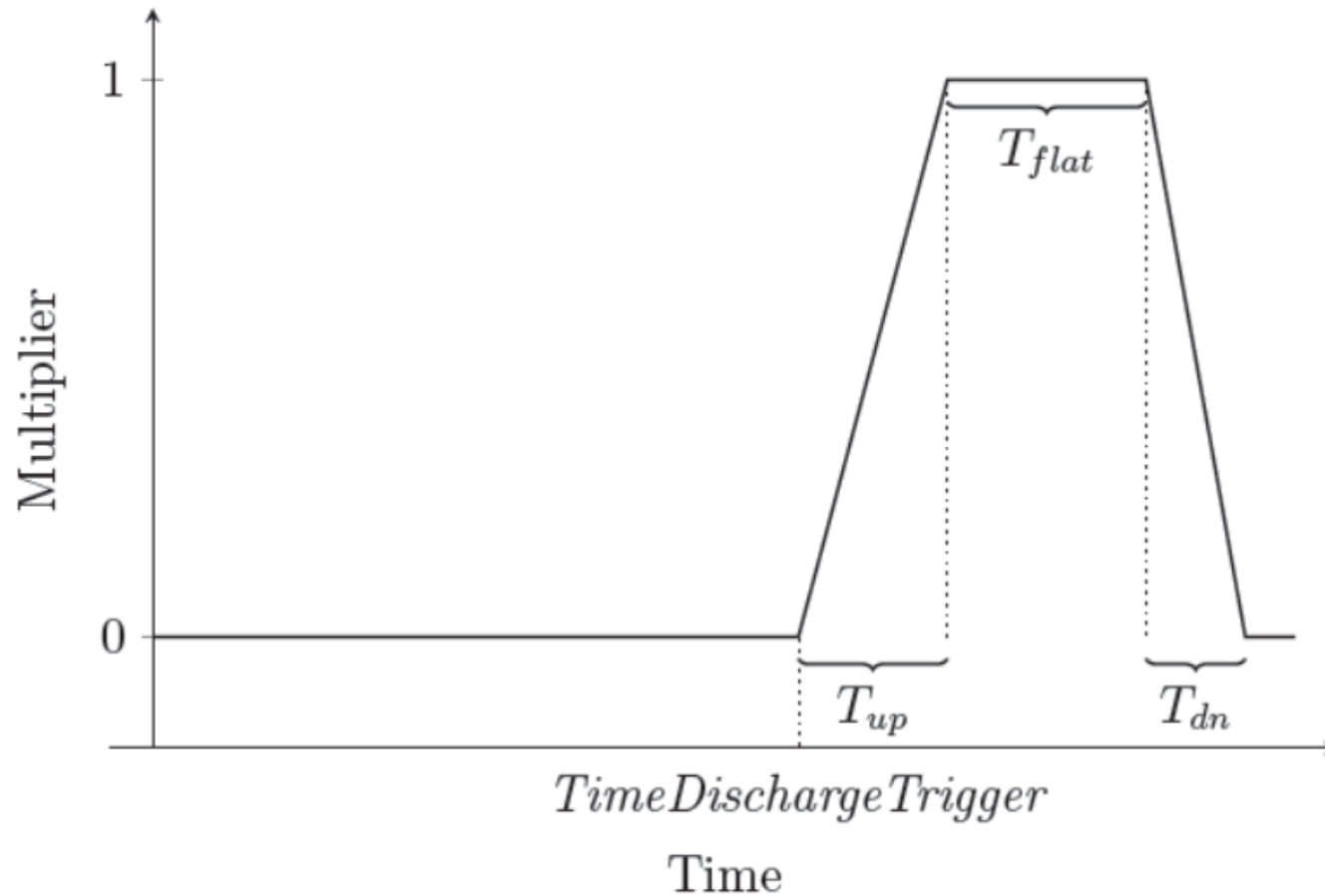
Modos de Despacho

- Support (Descarga)



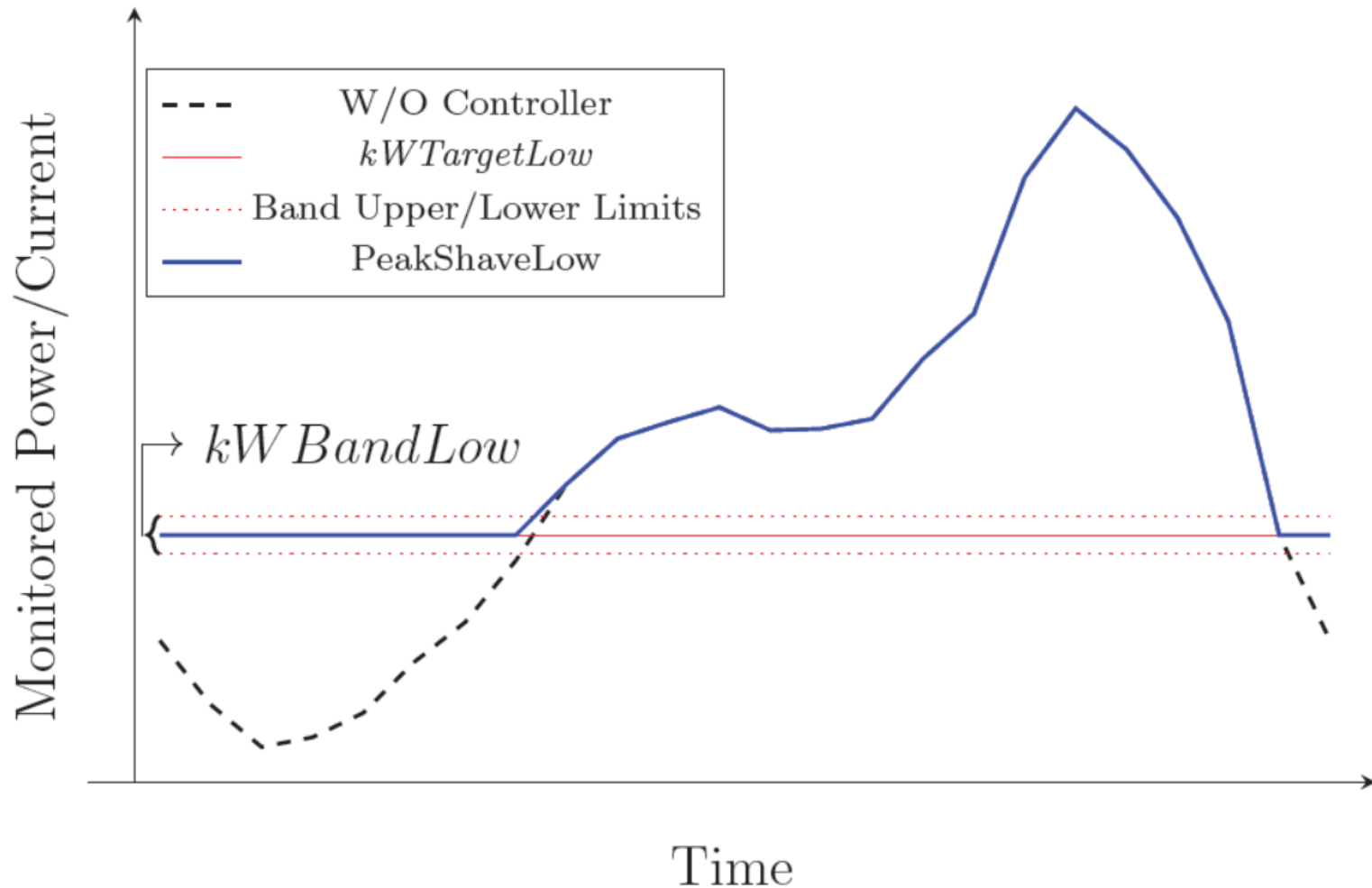
Modos de Despacho

- Schedule (Descarga)



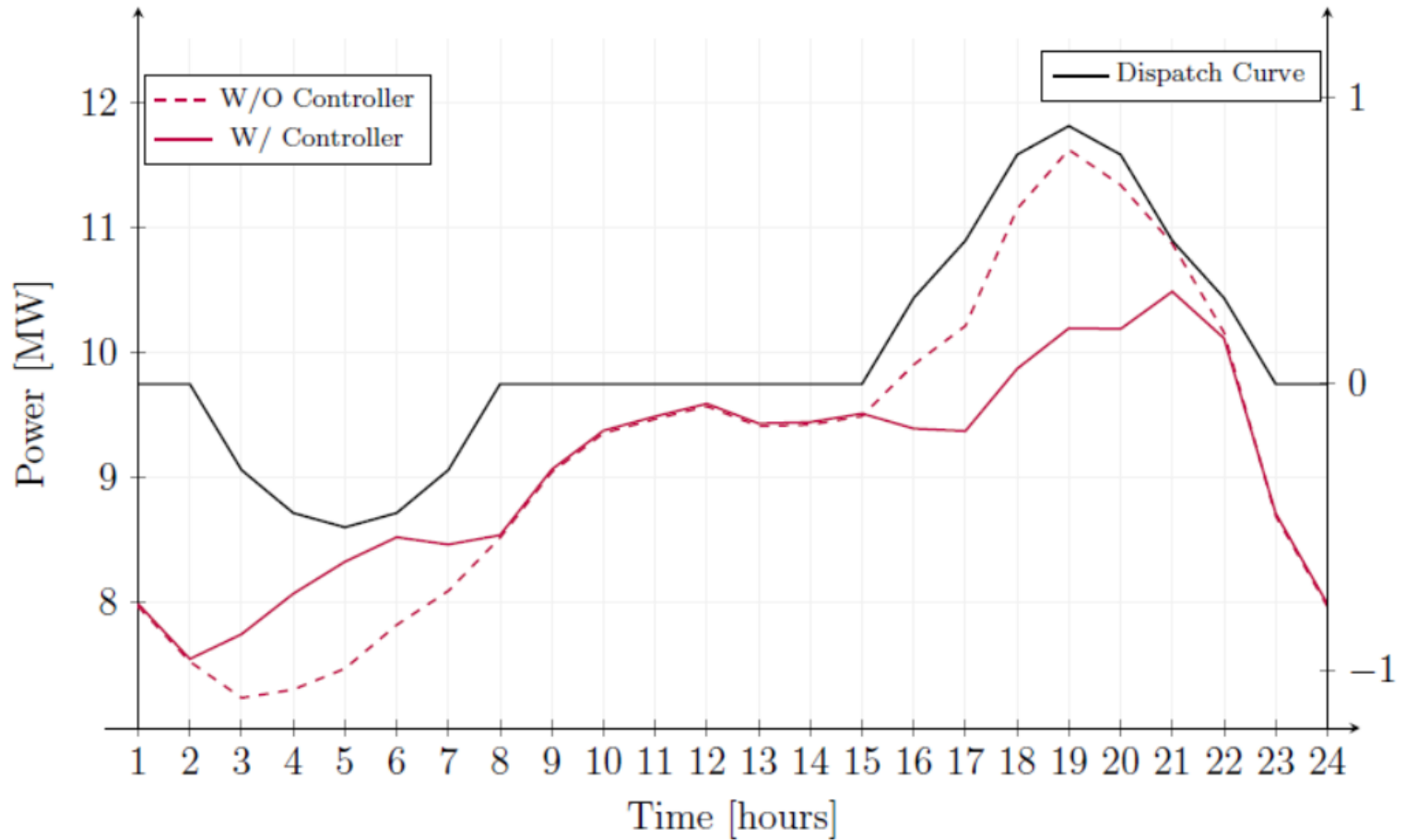
Modos de Despacho

- PeakShaveLow/I-PeakShaveLow (Carga)



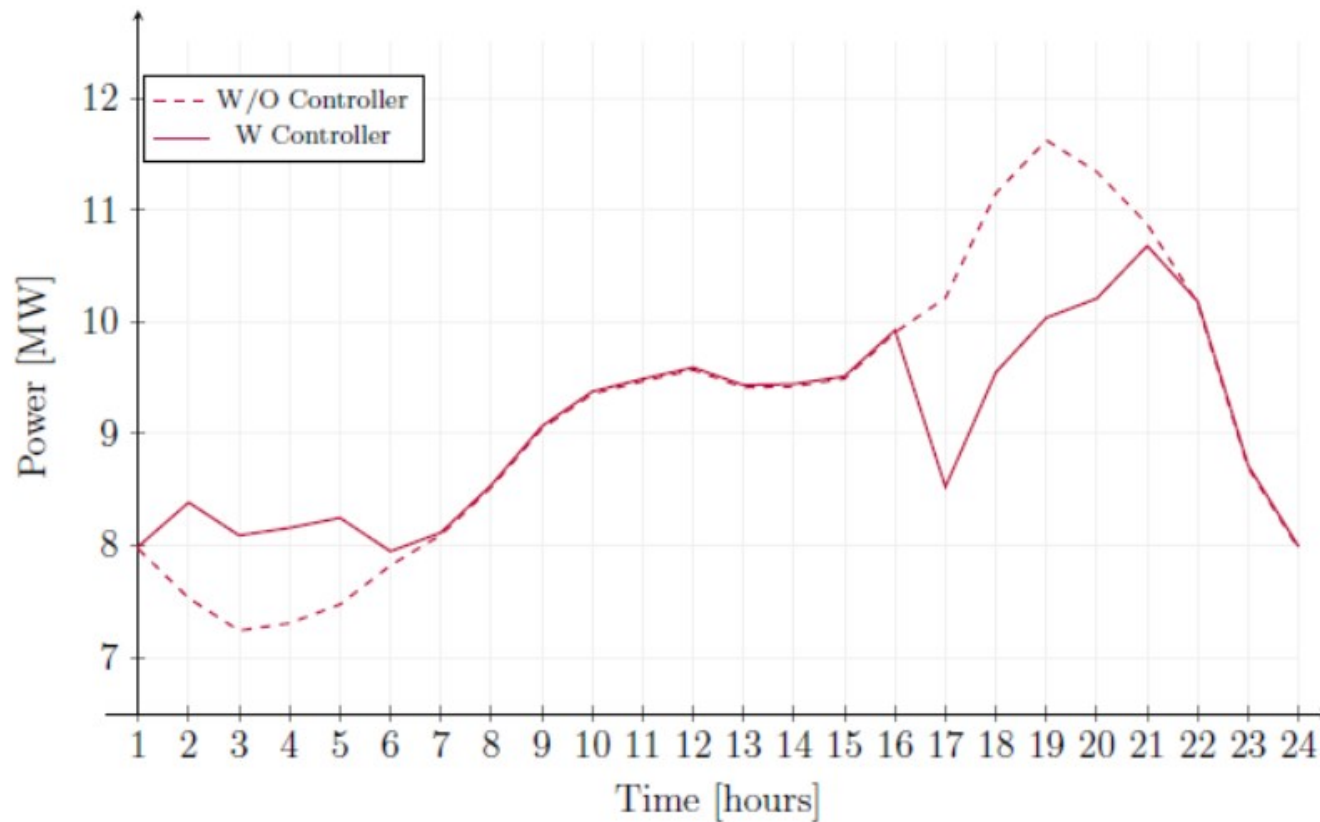
Modos de Despacho

- Loadshape (Carga e Descarga)



Modos de Despacho

- Time (Carga e Descarga)



Atualizações

- Adição de modos PeakShave, PeakShaveLow e I-PeakShaveLow
- Adição de parâmetro MonPhase
- Melhorias no detalhamento das ações no Registro de Eventos
- Adição do parâmetro DispFactor

Nota Técnica – StorageController2

November 25, 2019



StorageController2 Element

Celso Rocha, Jouni Peppanen, Paulo Radatz, Matthew Rylander, Roger Dugan

1 Purpose

This technical note describes the modelling and operation of StorageController2 element, including several demonstration examples.

2 Why?

OpenDSS StorageController element has passed through a major update in 2018/2019. This technical note has been elaborated to detail some of the new features, but also to expand the previous StorageController documentation [1] with a comprehensive description of the model of the controller. The new features are:

- Addition of *I-PeakShave*, *I-PeakShaveLow* and *PeakShaveLow* dispatch modes;
- Possibility to operate simultaneously with InvControl control element controlling the same Storage elements;
- Addition of *DispFactor* property to aid in convergence;
- Possibility to select the regulated measure (power or current) from a specific phase or a combination between different phases of the monitored element through the property *MonPhase*;
- Possibility to specify the deadband as an absolute value. Useful when the desired target value is low. See properties *kWBand* and *kWBandLow*;
- Improved control actions description in Event Log report for better interpretation of operation within each control loop iteration;
- Full compatibility with recently developed Storage2 element;

3 General Remarks

The updated OpenDSS StorageController model has been temporarily named as StorageController2 and it will be the only model supported moving forward. The original StorageController model will be deprecated, but will still be available in the program for a limited time. It will eventually be deleted and the updated model renamed to StorageController.

Thus, it is recommended to use StorageController2. In the remainder of this document, "StorageController" refers to the recently added StorageController2 element.

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