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Final Deliverable – 2

Software Platform Product Description

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Final Deliverable - 2
Software Platform Product Description

Document Purpose

The following report provides information of the software platforms, which are commercialized and deployable by utilities, and include advanced DER control algorithms. Product descriptions describe how each platform and methodology algorithms enhance grid performance and the ability for the grid to host high penetrations of solar generation. Individual control algorithm code and detailed utility performance data will remain proprietary.

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Section 1 Intelligent Controller (DG-IC™)

1.1 General Information and Disclosure

Doosan GridTech (DG) delivers control system software and power system engineering services to help utilities integrate distributed energy resources into the grid. Our control software for energy storage systems runs algorithms and bulk power applications that help utilities maintain power quality on circuits impacted by solar and other renewables, while taking full advantage of energy storage and other distributed energy resources. Powered by DG’s extensive experience in circuit design and ESS integration, our power system engineering services ensure that an ESS is efficiently sized and optimally integrated into the utility infrastructure. For more information on DG products and services, see our website.

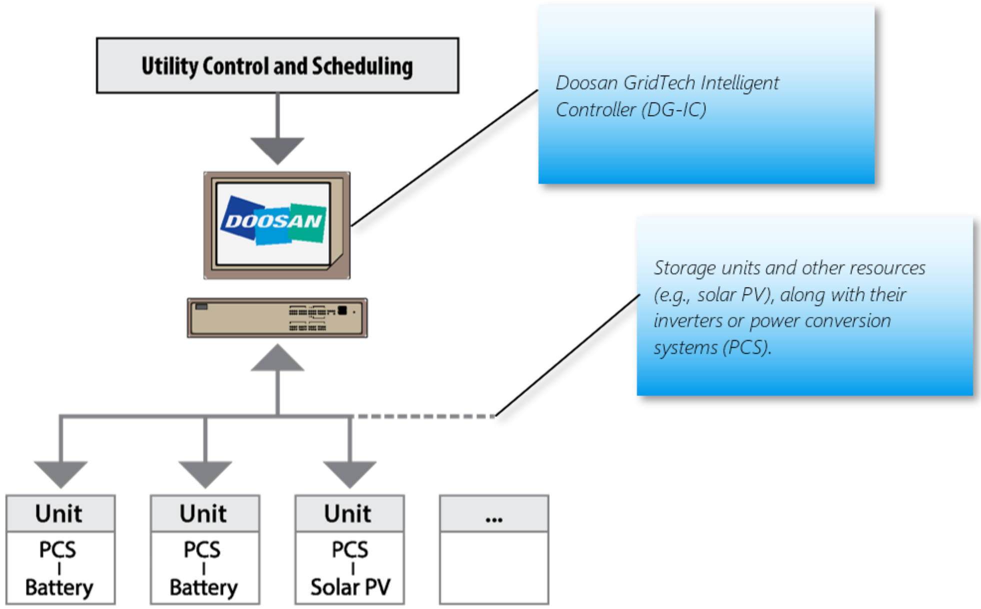
www.DoosanGridTech.com

Doosan GridTech Intelligent Controller (DG-IC™) Product Description
Version 2.0
Rev 07.04 Jul-20

1.2 Introduction

The Doosan GridTech Intelligent Controller (DG-IC™) is a sophisticated site dispatch controller for utility-scale and grid-integrated energy storage systems. It enables the operator to monitor and control any device connected to and configured into the system, including (but not limited to): the control modules and system controllers of storage devices and other energy resources; the inverters and power conversion systems that manage the flow of AC and DC power into and out of the storage system; and, the power and signal meters that provide the real-time data needed for its operating modes to intelligently dispatch power and provide grid-stabilizing services.

The DG-IC also provides the interface for communications between the devices in the system and remote operators and other data collection systems, such as SCADA (Supervisory Control and Data Acquisition). It consists of a substation-hardened computer operating the Doosan GridTech control software and a monitor that displays the human-machine interface (HMI).



The Doosan GridTech software includes the DG Intelligent Controller service and HMI software that can be run on any Windows computer that is connected to the same network.

1.3 Taking Control

At any given time, the system can be under **Local** control of an operator at the site, **Remote** control through a control system such as SCADA or an HMI installed on another computer, or **Automatic** control following one or more predefined schedules.

This section includes:

1.3.1 How Control Works

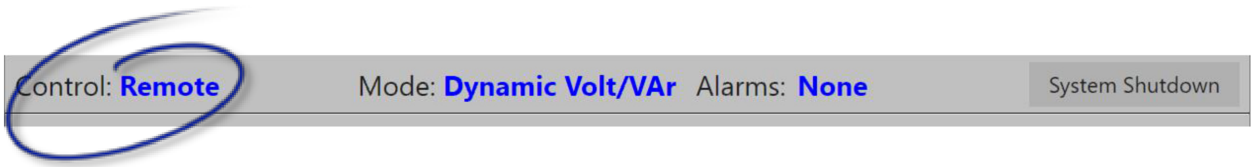
Depending on the circumstances, it may be necessary for exclusive control of the system to rest either in the hands of an operator at the site, an operator at another location, or a predefined schedule of operations that execute automatically.

To safely coordinate control of the system while respecting the physical and electrical constraints of the system, the DG-IC provides three control modes: **Local**, **Remote,** and **Automatic.** You must be logged in with Power User or Administrator privileges to change the control state.

- **Local Control** enables an operator at the site to have direct control of the ESS when performing maintenance or testing. Most configuration settings are available only when the DG-IC control mode has been set to "Local."
- The DG-IC can be placed in Local control, and taken out of Local control, only on the *local instance* of the HMI, which is usually the HMI associated with the on-site computer running the Doosan GridTech Intelligent Controller service; Local control cannot be overridden on a remote computer running a *remote instance* of the HMI.

- **Remote Control** enables offsite operators to control the system in response to conditions in the larger electrical network. For example, if an unplanned event impacts the grid in a significant way, it may be necessary to make timely adjustments to the system's behavior.
- **Automatic Control** Automatic control is an optional feature of the DG-IC that enables power schedulers to schedule automatic system behavior.

The DG-IC toolbar at the top of the screen shows the DG-IC's current control state.



Local and Remote HMIs

The HMI software can be run on any Windows computer that is connected to the DG-IC network. However, Doosan GridTech preconfigures network connections for HMIs as either **Local** (for local instances of the HMI) or **Remote** (for remote instances of the HMI). <u>Only a designated Local HMI can set the DG-IC to Local control, and only a designated Local HMI can remove the DG-IC from Local control.</u>

Once the DG-IC has been removed from Local control and set to either Remote or Automatic control, you can alternate the control state between Remote and Automatic control on any instance of the HMI, or via DNP3 or Modbus commands.

1.3.2 Taking Local Control

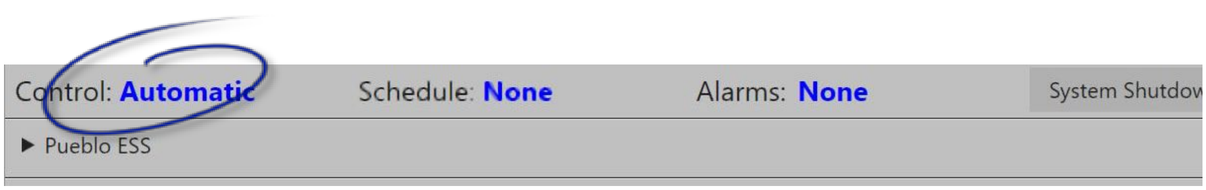
When the DG-IC is set to Local control, the system can be controlled only at the site through a designated Local HMI.

For safety reasons, only an operator at the site using a *local instance* of the HMI can enter or exit Local control. An operator performing maintenance at the site uses the HMI to take Local control of the DG-IC. This locks out remote and scheduled operations, helping to ensure the safety of the on-site personnel and the system. When maintenance work is complete, the operator uses a Local HMI to manually exit Local control, returning exclusive control of the system to remote operators or a schedule.

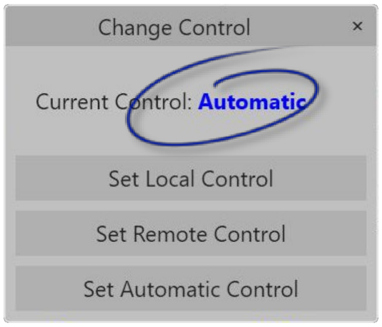
While the system operates in Local control, it is still possible for remote operators to monitor operations through remote HMIs and SCADA. However, no changes will be possible until Local control is exited.

To enter Local control:

1. Using a designated Local HMI at the site, log into the HMI using an account with Control System Power User or Administrator privileges.
2. Click **Control** in the DG-IC toolbar at the top of the screen.



3. On the Change Control popup, click **Set Local Control**.



4 When prompted, confirm the change.

The DG-IC changes to Local control. In Local control, the system can be controlled only through a designated *local instance* of the HMI.

> **!** When you no longer need exclusive local control of the system at the site, be sure to set control back to Remote or Automatic so that remote or scheduled operations can resume.

1.3.3 Setting Remote Control

Unless Local or Automatic control has been enabled, the system operates in Remote control. In Remote control, the system can be controlled by a remote system such as SCADA, or through a designated Remote HMI. This allows a remote operator to reliably control the system's behavior.

To set the DG-IC to Remote control:

1. Click **Control** in the DG-IC toolbar at the top of the screen.
2. If the DG-IC is currently in Local control, you must be using a designated local instance of the HMI to change the control state.
3. On the Change Control popup, click **Set Remote Control.**
4. When prompted, confirm the change.

The DG-IC changes to Remote control. In Remote control, the system can be controlled either via DNP3 or Modbus commands, or through any remote instance of the HMI that is connected to the DG-IC network.

1.3.4 Setting Automatic Control

With the DG-IC set to Automatic control, the system becomes available to respond automatically in accordance with one or more predefined schedules.

- When you set the DG-IC to Automatic control, any presently enabled operating modes are disabled. While in Automatic control, enabled schedules start at their defined Start Times.
- When the DG-IC leaves Automatic control, and returns to Local or Remote control, all running schedules terminate and no operating modes remain enabled.
  For safety reasons, and as a precautionary measure to ensure the system is running as intended by the operator currently in control, *whenever* the Control mode is changed, all enabled operating modes are disabled and will need to be reset.

Up to 50 schedules may be defined and configured in the DG-IC. With the DG-IC in Local or Remote control, you can use the HMI to create, configure, and enable schedules.

The Automatic control mode allows the DG-IC to operate without interference from other functions, such as non-scheduled operating modes. Therefore, while in the Automatic control mode, the DG-IC operator is limited to viewing, pausing, and resuming schedules.

In Automatic mode, you may also use DNP3 and Modbus commands to do the following:

- Select a schedule using its configured index.
- Set the selected schedule's Start Time.
- Enable the selected schedule.

To set the DG-IC to Automatic control:

1. Click **Control** in the DG-IC toolbar at the top of the screen.

   If the DG-IC is currently in Local control, you must be using a designated local instance of the HMI to change the control state.

2. On the Change Control popup, click **Set Automatic Control.**

3. When prompted, confirm the change.

   The DG-IC changes to Automatic control. Any currently enabled operating modes are disabled. In Automatic control, the system is available to respond automatically in accordance with one or more predefined schedules. When an enabled schedule goes into effect, its name appears in the DG-IC toolbar.

1.4 Using Operating Modes

Operating modes enhance and automate how the system operates in relation to the electrical grid. By customizing and enabling operating modes, you can fine-tune your system for efficient, economical operations under changing load, generation, and market conditions.

This section includes:

1.4.1 **How Operating Modes Work**

1.4.2 **Configuring Operating Modes**

1.4.3 **Timing Parameters**

1.4.4 **SOC Recovery**

This section also documents the DG-IC operating modes:

1.4.5 **ESS Power Limit Mode**

1.4.6 **ESS Power Factor Mode**

1.4.7 **ESS Real Power Mode**

1.4.8 **ESS Reactive Power Mode**

1.4.9 **Real Power Response Mode**

1.4.10 **Power Factor Correction Mode**

1.4.11 **Real Power Smoothing Mode**

1.4.12 **Dynamic Volt/Watt Mode**

1.4.13 **Dynamic Volt/VAr Mode**

1.4.14 **Voltage Smoothing Mode**

1.4.15 **Spinning Reserves Mode**

1.4.16 **Automatic Generation Control (AGC) Mode**

1.4.1 How Operating Modes Work

Operating modes determine how the system responds under specified conditions in the electric grid or electricity markets. Once you enable an operating mode, the system responds automatically as conditions change, based on parameters you have set.

You can configure, enable, and disable modes either in the HMI or via utility control systems such as SCADA:

- In the HMI, the Configure Operating Modes popup provides a graphical interface for configuring and enabling modes. This section describes how each mode works and shows how to configure and enable modes in the HMI.
- Some installations enable utility control systems such as SCADA/DMS and power scheduling systems to communicate with the DG-IC using the DG-IC DNP3 interface. The DG-IC DNP3 interface follows the MESA-ESS standard and specifications, which are available for download on the Mesa Standards Alliance web site at www.mesastandards.org.

For more information about how running the DG-IC under Local, Remote, or Automatic control affects operating modes, see 1.3 Taking Control.

The DG-IC provides a variety of modes that address different attributes of system operation. Table 2-1 lists the DG-IC operating modes grouped by the attribute they address and summarizes their behavior.

Table 1-1: Operating Modes in the DG-IC – Grouped by the Attribute They Address

Attribute Addressed	Mode	Behavior
System Settings	ESS Power Limit	Caps the real power input/output of the system while it is charging/discharging.
	ESS Power Factor	Controls the reactive power output of the system by specifying the desired power factor.
	ESS Real Power	Directly sets the real power output of the system by specifying a target value in kilowatts.
	ESS Reactive Power	Directly sets the reactive power output of the system by specifying a target value in kilovars.
Load	Real Power Response	Charges or discharges the system in response to the load or generation at a monitored point on the grid. Parameters can be set to achieve peak power limiting, load following, or generation following. Three instances of this mode enable the DG-IC to perform any combination of Real Power responses in any order of priority.
Power Factor	Power Factor Correction	Controls the reactive power output of the system to achieve the specified power factor at a monitored point on the grid.
Power Volatility	Real Power Smoothing	Charges or discharges the system to compensate for abrupt changes in power at a monitored point on the grid.
Voltage	Dynamic Volt/Watt	Charges or discharges the system when voltage at a monitored point on the grid goes outside of an acceptable range.

	Dynamic Volt/VAr	Applies a curve to the reactive power output of the system in response to changes in voltage at a monitored point on the grid.
	Voltage Smoothing	Changes the reactive power output of the system in response to changes in voltage at a monitored point on the grid.
Frequency	Spinning Reserves	Charges or discharges the system when frequency at a monitored point on the grid goes outside of an acceptable range. Returns batteries to a target state of charge after frequency returns to acceptable range.
	AGC	Charges or discharges real power in response to AGC (Automatic Generation Control) requests.

Use of external signals

Four operating modes directly control the system by applying manual set points. These modes do not respond to external signals:

- ESS Power Limit
- ESS Power Factor
- ESS Real Power
- ESS Reactive Power

All the other modes require an external signal (a remote meter or data source) and apply powerful algorithms to guide the behavior of the system. The external signal can be:

- A physical power meter that is connected to the DG-IC network.
- A virtual meter configured to deliver values via DNP3 from an upstream control system such as SCADA.
- A virtual meter configured to deliver the contents of a time-stamped data file.
- An aggregated power meter which combines the readings from two or more meters, real or virtual.

Note that AGC Mode has its own protocols for accepting SCADA signals or test data files. For details, see 1.4.16 Automatic Generation Control (AGC) Mode.

Power meters for your DG-IC installation were preconfigured according to the requirements and configuration of your system.

Note

Operating modes affect only energy storage/resource units that are in the available pool. Operating modes have no effect on units that have been taken offline for maintenance or testing.

Enabling multiple operating modes

Generally speaking, only one operating mode can be actively telling the system what to do at any given moment. If you enable more than one operating mode at the same time, the DG-IC prioritizes the modes in the order in which you enabled them.

For example, if you first enable Real Power Response to perform peak power limiting, that mode becomes Priority 1. Then if you enable Real Power Smoothing, that mode becomes Priority 2. For information on how to enable and disable operating modes, see 1.4.2 Configuring Operating Modes.

The following figure illustrates how the DG-IC applies multiple operating modes as it responds moment by moment to changing conditions in the electric grid.

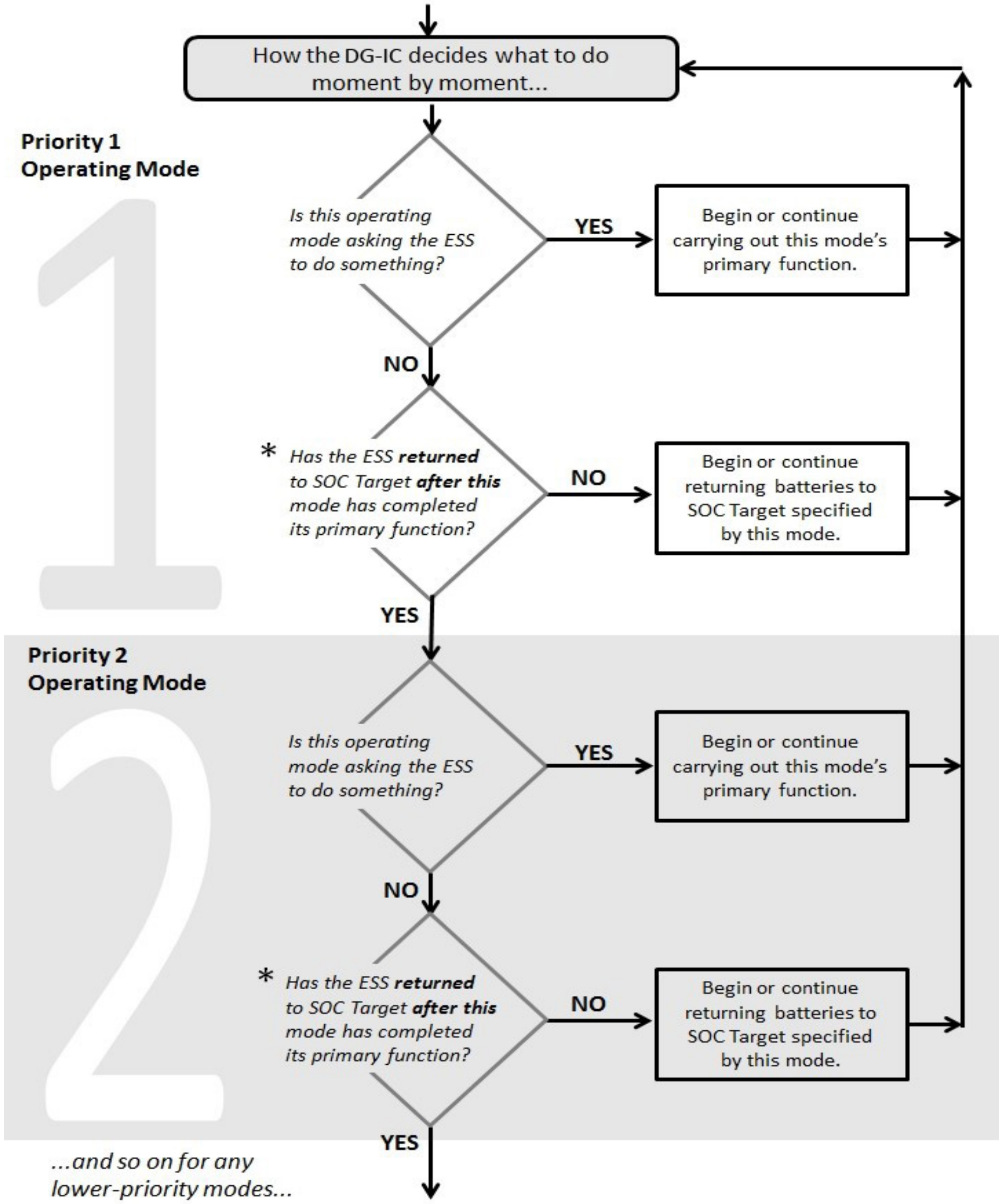


Figure 1-1 How the DG-IC applies multiple operating modes

The figure above represents the core process of the DG-IC. Here are some additional details:

- ESS Power Limit mode is an exception to this logic and is not prioritized. If ESS Power Limit mode is enabled, it is enforcing its limits over all other modes. If ESS Power Limit mode is not enabled, it is not enforcing any limits.
- SOC Recovery. The steps marked * are relevant for only those modes that offer SOC Recovery, and for which the SOC Recovery check box is checked. For more information, see 1.4.4 SOC Recovery.

- **Carrying out this mode's primary function.** Usually, this means the operating mode is actively charging or discharging the system. However, sometimes maintaining zero power output is a valid response to grid conditions. At other times putting the system "on hold" for a specified Violation Response Delay or Healthy Response Delay may be a valid step in the process.
- **Real Power and Reactive Power modes.** If you enable any modes that control the real power output of the system (which is most of the modes) and one of the modes that control the reactive power output of the system (ESS Power Factor, ESS Reactive Power, Power Factor Correction, Dynamic Volt/VAr, Voltage Smoothing, or Adaptive Voltage), the DG-IC will respond to both at the same time. That is, the DG-IC issues commands based on both the highest-priority real power mode and the highest-priority reactive power mode. However, the priorities you set while enabling the modes still determine how power is allocated. That is, the higher priority mode (whether real or reactive) consumes as much available power as it needs, while the lower priority mode (of the opposite power type) gets only what is left over.

If you enable more than one operating mode, how can you prioritize them so that the DG-IC addresses your grid's needs reliably and efficiently? The key is to anticipate *how often* you will need each mode to do its work.

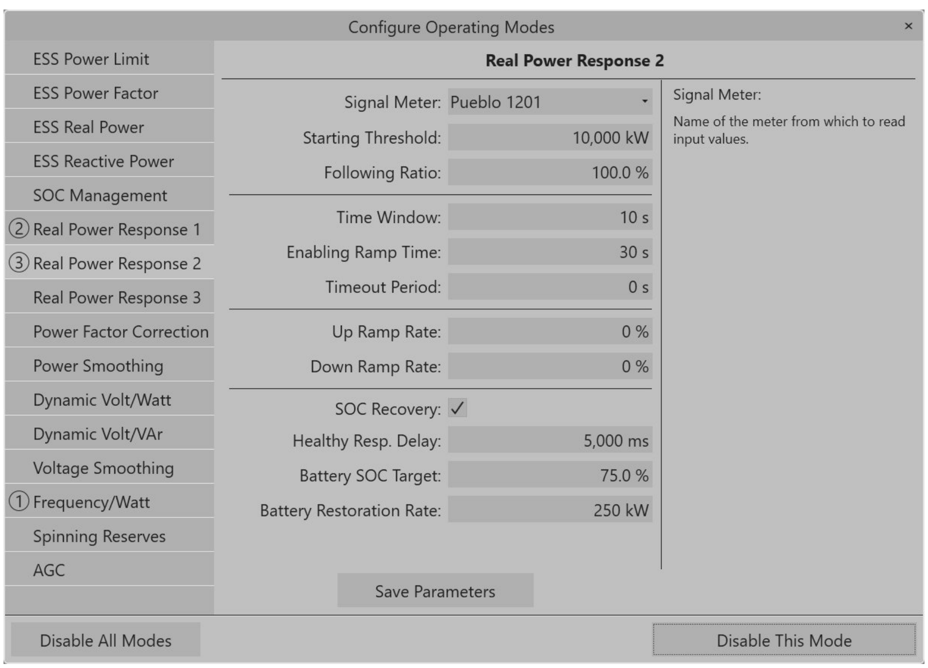
Each operating mode has parameters which you set to specify how – and how often – that mode will be called into action. Parameters can be set so that a mode is triggered very rarely (with a high threshold or wide dead band) – or more continuously (with a low threshold or narrow dead band).

For example, by setting parameters for Real Power Response mode very broadly, it could be triggered on your grid only ten days a year or so. By setting those same parameters more narrowly, the mode could be triggered every afternoon.

In general, it is best to prioritize multiple operating modes by putting them into this order:

- First, the mode you anticipate being triggered *least often* – but most critically needed when it *is* triggered.
- Optionally, one or more mode(s) configured to run *occasionally*.
- Last, the mode you anticipate being needed for the most *continuous* operation.

`Example: Three operating modes enabled at the same time`



In this example:

Frequency/Watt mode is enabled as Priority 1. This mode stands ready to stabilize grid frequency, but the parameters are set so that it will be called upon only rarely. When it is called upon, it supersedes any lower priority modes that may be running.

An instance of **Real Power Response mode** is enabled as Priority 2, with parameters set for load following. This mode performs system-wide peak shaving and is configured to run occasionally. When it is called upon, it supersedes the Priority 3 mode, but not the Priority 1 mode.

Another instance of **Real Power Response mode** is enabled as Priority 3, with parameters set for peak power limiting. This mode is focused on local circuit needs, and – of these three modes – is likely to be called upon most often. It runs as long as no higher priority mode is called upon.

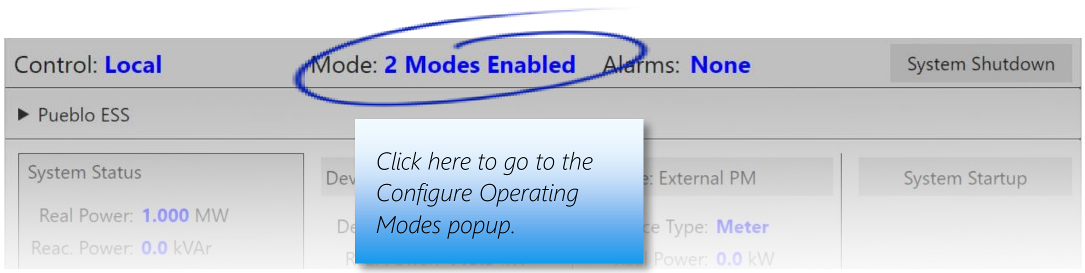
1.4.2 Configuring Operating Modes

To work with modes in the HMI, you must be logged into the HMI with Power User or Administrator privileges.

You enable and disable operating modes and set their parameters on the Configure Operating Modes popup.

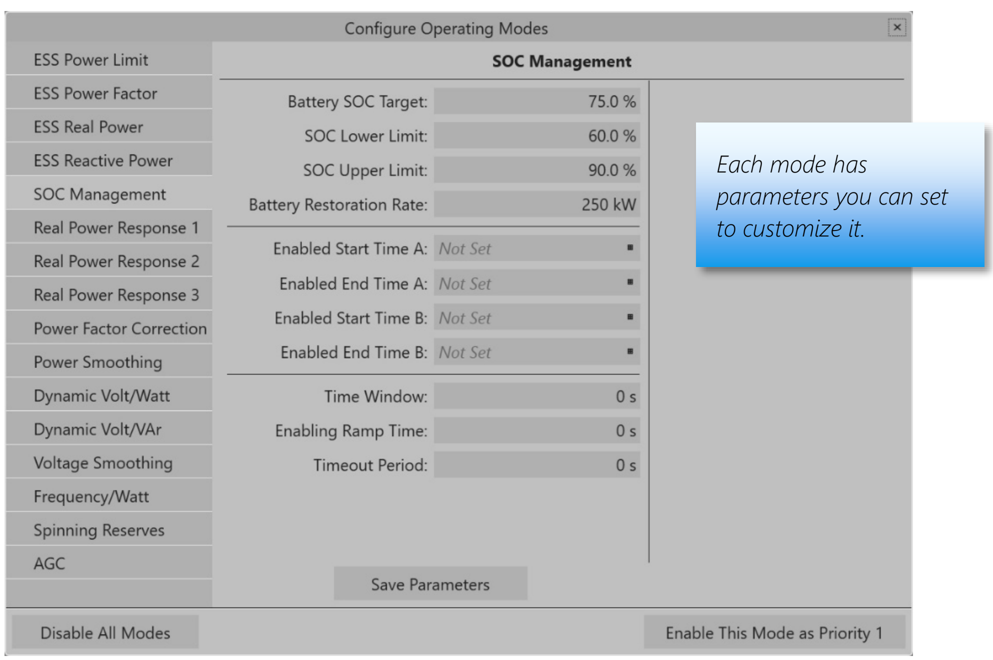
To customize and enable operating modes:

1 In the DG-IC toolbar, click **Mode.**



2 In the Configure Operating Modes popup, use the tabs on the left to choose the mode you want to have top priority.

If your DG-IC installation offers more operating modes, use the up-arrow or down-arrow tabs to see all the operating modes available on your system.



3 Set parameters in the list to the right of the tabs.

For details on how each mode's parameters affect its operation, see the section for that mode later in this section.

4 Click **Enable This Mode as Priority 1.** When prompted, confirm the command. The DG-IC saves all parameter settings and enables the mode.

5 Choose the tab on the left for the mode you want to enable with Priority 2.

6 Set parameters in the list to the right.

7 Click **Enable This Mode as Priority 2.** When prompted, confirm the command. The DG-IC saves all parameter settings and enables the mode.

8 Repeat Steps 5 to 7 above for any additional modes you wish to enable as lower priorities.

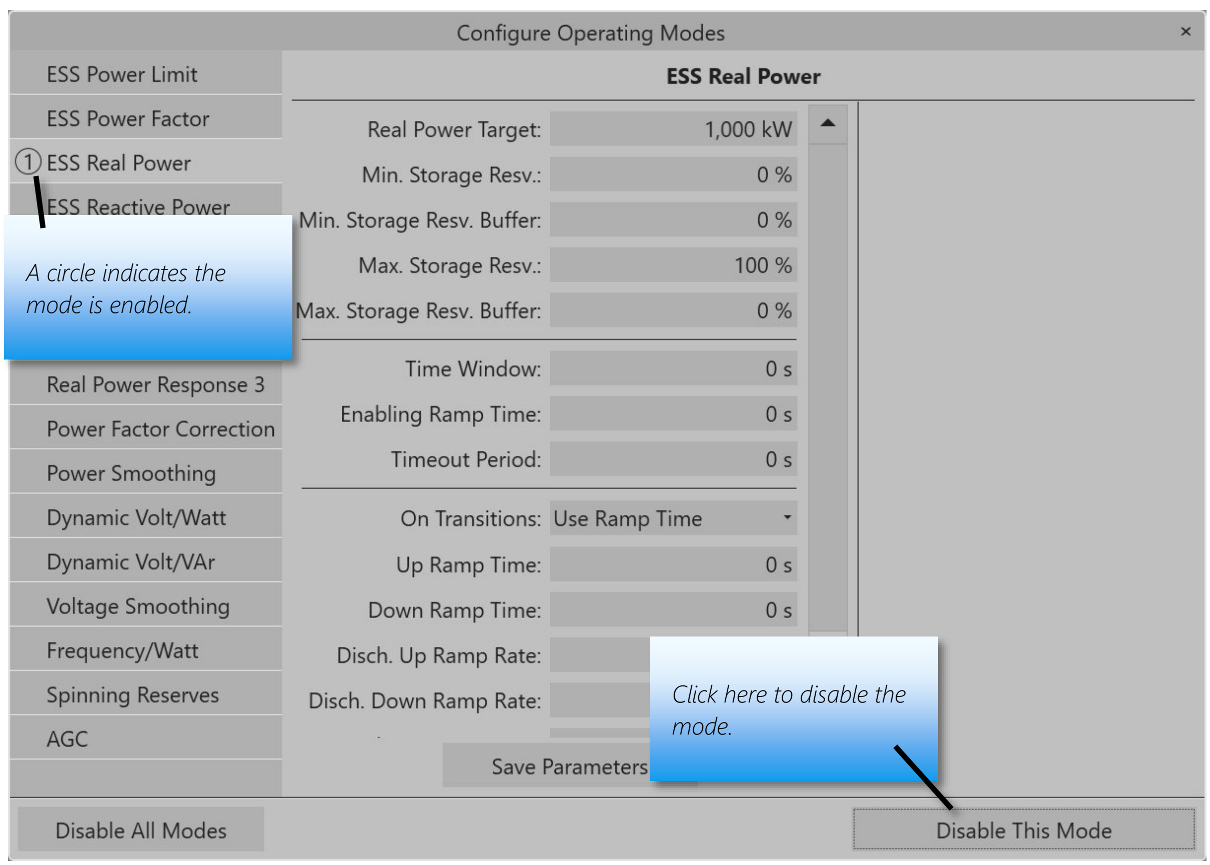
Note

You can also use the Configure Operating Modes popup to customize modes without enabling them. While working with modes on the popup, you can review and change your parameter settings for each mode, then click **Save Parameters** to permanently save those changes whether or not you have enabled that mode. To discard your unsaved settings, close the popup and confirm that you are discarding your changes.

To disable operating modes:

1 In the DG-IC toolbar, click **Mode**.

2 In the Configure Operating Modes popup, use the tabs on the left to choose the mode you want to disable.



3 Click **Disable This Mode.** When prompted, confirm the command.

4 Repeat Steps 2 and 3 above for each additional mode you want to disable.

Note

When you disable one mode at a time, any modes that remain enabled will adjust their priorities accordingly. For example, if you have three modes enabled and you disable the Priority 2 mode, the mode previously enabled as Priority 3 will become Priority 2.

To completely reassign mode priorities, it may be easier to begin by disabling all the modes at once.

To disable all operating modes:

1 In the DG-IC toolbar, click **Mode**.

2 In the Configure Operating Modes popup, click **Disable All Modes**. When prompted, confirm the command.

Now you can enable any modes you want in priority order, as described above in the procedure *To customize and enable operating modes.*

1.4.3 Timing Parameters

Most operating modes use the following timing parameters. Table 2-2 describes how they affect each mode's behavior.

Table 1-2: Timing Parameters for most operating modes

Parameter	Description
Time Window	Range within which to randomly begin executing the requested operation. To execute the operation immediately, enter 0 (zero).
Enabling Ramp Time	The time the system will take switching gradually from its previous settings to the settings initially requested by this operating mode. This time applies as this mode begins execution, as determined by the Time Window parameter. To switch to this mode's initial settings immediately, enter 0 (zero).
Timeout Period	Seconds after which the mode will be disabled. Used to automatically disable an operating mode after a set time period. To never time out (timeout period = infinity), enter 0 (zero).

1.4.4 SOC Recovery

Most operating modes make SOC Recovery available within the mode itself. This enables the mode to return the system batteries to a target state of charge after the mode has completed its primary function.

For example, a primary function of Real Power Response mode can be to discharge real power from the system when load exceeds a specified limit at the monitored point on the grid. After load falls back below that limit, SOC Recovery can return the batteries to the desired state of charge.

Similarly, within Dynamic Volt/Watt mode, SOC Recovery can return the batteries to a healthy state of charge after voltage returns to the acceptable range you have specified.

Note that SOC Recovery can take place only after the operating mode has acted on its primary function. (For example, Dynamic Volt/Watt mode will attempt to return the batteries to a healthy state of charge only *after* that mode has actively used the battery to address voltage fluctuations.) Then, after SOC Recovery has returned the batteries to a healthy state of charge, the mode will not engage SOC Recovery a *second* time until the mode has actively completed its primary function a *second* time.

If you have enabled multiple operating modes, this same logic keeps SOC Recovery within a higher priority mode from abruptly taking control from a lower priority mode.

SOC Recovery Parameters

Most operating modes use the following parameters for SOC Recovery. Table 2-3 describes how each parameter affects the mode's behavior.

Table 1-3: SOC Recovery Parameters

Parameter	Description
SOC Recovery	Turns SOC Recovery on or off for this operating mode. If this check box is checked, the mode will attempt to restore the system to the Battery SOC Target after completing its primary function.
Healthy Response Delay	Milliseconds to wait after the operating mode has completed its primary function and before the system begins restoring the battery SOC. This delay prevents the system from causing oscillations in the electric grid if conditions hover near the operating mode's threshold or limits.
Standby Delay	Milliseconds to wait after Battery SOC Target has been reached before putting the PCSs into Standby mode. This parameter applies only to Spinning Reserves operating mode.
Battery SOC Target	Target state of charge (SOC) for the batteries. When recharging, the system recharges batteries to this target, then stops. When discharging, the system discharges batteries to this target, then stops.
Battery Restoration Rate	Rate (absolute) in real power to return batteries to the SOC Target. Each PCS recharges or discharges its batteries at this rate. Example: Battery Restoration Rate = 1,000.0 kW *When recharging depleted batteries, each PCS pulls 1 MW. A Battery Restoration rate of 1,500.0 kW returns to the SOC Target more quickly. A setting of 500.0 kW returns to the SOC Target more slowly.*

1.4.5 ESS Power Limit Mode

In ESS Power Limit mode, the DG-IC applies a cap to the real power output of the system while it is discharging – and applies a separate cap to the real power input of the system while it is charging. These power limits are specified in kilowatts.

When the batteries are discharging, the Maximum Discharge parameter limits the real power output of the system. When the batteries are charging, the Maximum Charge parameter limits the real power input of the system.

Note

Both Maximum parameters default to zero, which effectively disables system activity. Before enabling ESS Power Limit mode, be sure to set both parameters to non-zero values. To limit either output or input but not the other, set the Maximum you do not want to limit to the nameplate capacity of the system.

For example, to limit output but not input, you could enter 600 kW for Maximum Discharge, then enter any large value, like 9999 kW for Maximum Charge. The DG-IC will validate these values. If you have exceeded the nameplate capacity of the system, a message will remind you what that is.

Unlike all the other operating modes, ESS Power Limit mode is not prioritized. If ESS Power Limit mode is enabled, it is enforcing its limits over all other modes. If ESS Power Limit mode is not enabled, it is not enforcing any limits.

ESS Power Limit Parameters

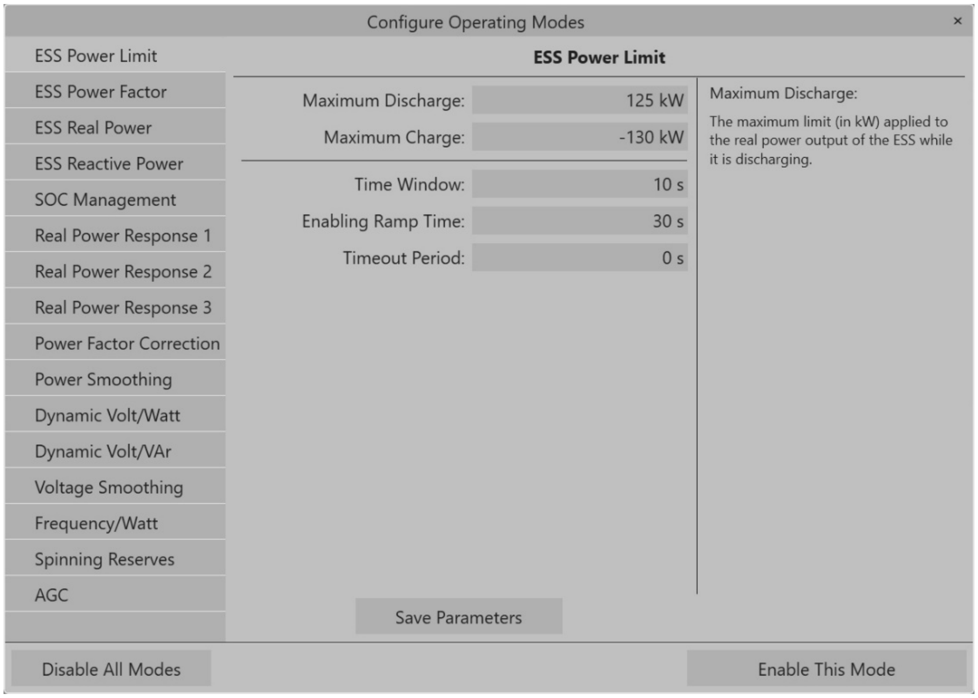
Table 2-4 describes the ESS Power Limit parameters and explains how they affect the mode’s operation.

Table 1-4: ESS Power Limit Parameters

Parameter	Description
Maximum Discharge	The maximum limit (in kW) applied to the real power output of the system. Example: Maximum Discharge = 500.0 kW *No matter what other modes or commands are asking the system to do, its output will never exceed 500 kW while discharging the batteries.*
Maximum Charge	The maximum limit (in kW) applied to the real power input of the system. Example: Maximum Charge = -1000.0 kW *No matter what other modes or commands are asking the system to do, its input will never exceed 1 MW while charging the batteries.*

For information on this mode’s Timing Parameters, see 1.4.3 Timing Parameters.

`Example: ESS Power Limit Mode`



If this mode is enabled with its parameters set as shown:

No matter what other modes are asking the system to do, it will never exceed a real power output of 125 kW or a real power input of 130 kW, beginning 30 to 40 seconds after enabling the mode (Time Window plus Enabling Ramp Time).

With the Timeout Period set to zero (0), ESS Power Limit mode will never time out.

1.4.6 ESS Power Factor Mode

In ESS Power Factor mode, the DG-IC directly controls the reactive power output of the system. This is an internal system setting and does not respond to any external signals. To respond to external power factor readings on the grid, see 1.4.10 Power Factor Correction Mode.

ESS Power Factor Parameters

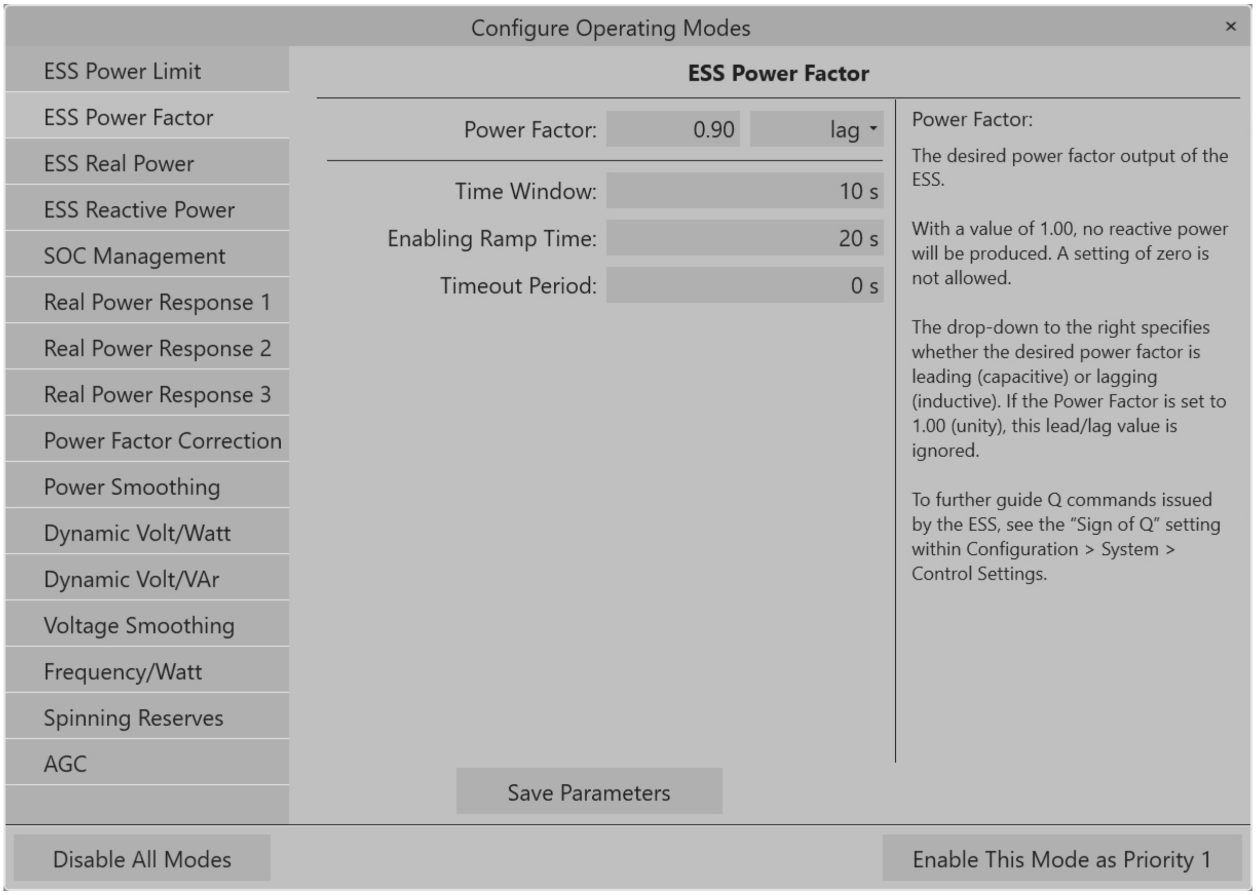
Table 2-5 describes the ESS Power Factor parameters and explains how they affect the mode's operation.

Table 1-5: ESS Power Factor Parameters

Parameter	Description
Power Factor	The desired power factor at the point of common coupling within the system. With a value of 1.00 (unity), no reactive power will be produced. A setting of zero is not allowed. The drop-down to the right specifies whether the desired power factor is leading (capacitive) or lagging (inductive). If the Power Factor is set to 1.00 (unity), this drop-down value is ignored. **Note**: In accordance with EEI signage convention for power factor, the point of reference changes from producer (generator) to consumer (load), and the above description of the lead/lag value applies whether the system is charging or discharging. To specify *how* the ESS Power Factor mode pursues its target power factor, use the system-level setting, **Sign of Q**.

For information on this mode's Timing Parameters, see 1.4.3 Timing Parameters.

`Example: ESS Power Factor Mode`



If this mode is enabled with its parameters set as shown:

The DG-IC controls the reactive power output of the system such that the power factor at the point of common coupling stays as close as possible to 0.90 lagging.

1.4.7 ESS Real Power Mode

In ESS Real Power mode, the DG-IC directly charges or discharges batteries at a specified real power rate. This operation continues until:

- Batteries reach their maximum or minimum state of charge.
- You stop the operation by disabling the mode.
- The operation reaches the specified Timeout Period and automatically disables itself.

ESS Real Power Parameters

Table 2-6 describes the ESS Real Power parameters and explains how they affect the mode's operation.

Table 1-6: ESS Real Power – General Settings

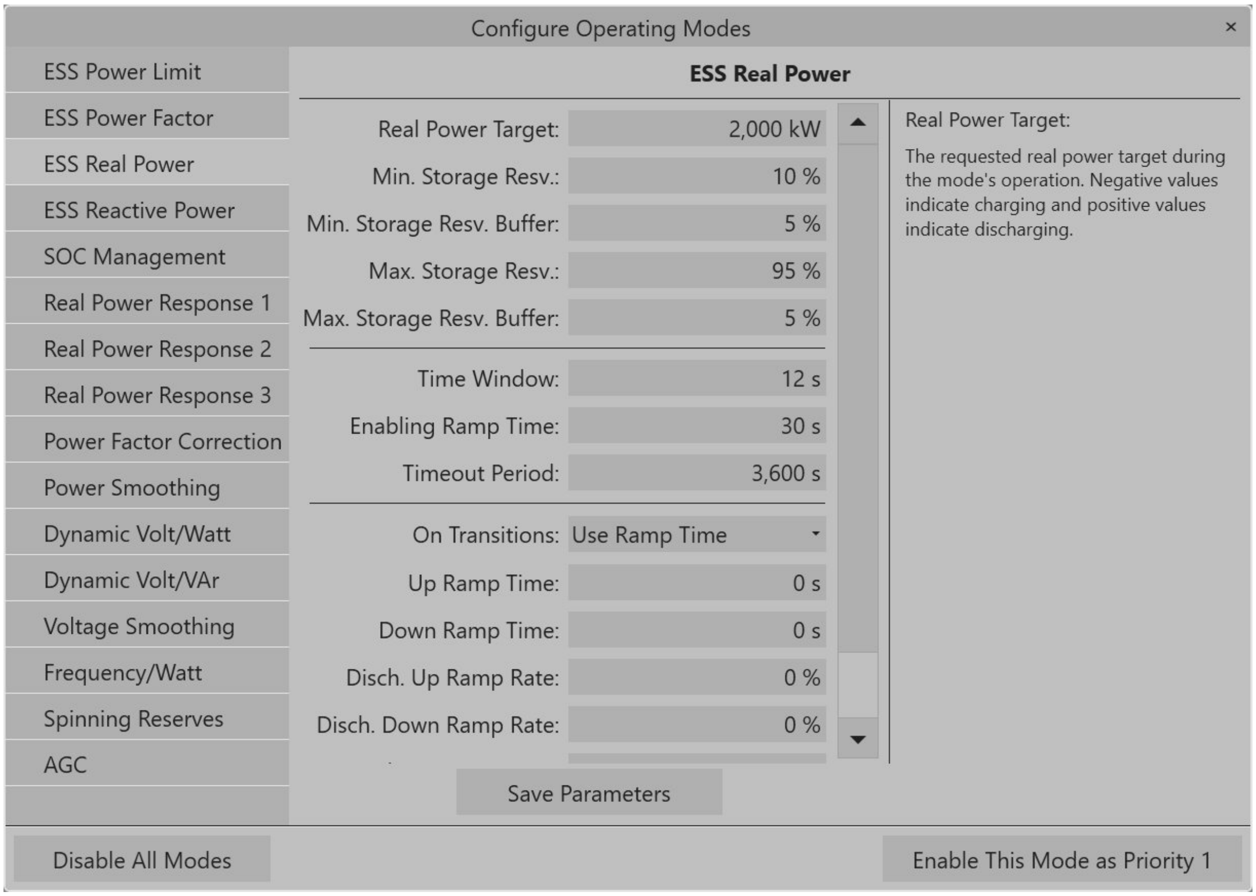
Parameter	Description
Real Power Target	Rate in real power at which to charge or discharge the available batteries. A negative value tells the DG-IC to charge the batteries.

	A positive value tells the DG-IC to discharge the batteries. Example: Real Power Target = -2,500.0 kW *The DG-IC will charge the available batteries, pulling 2,500 kW.*
Minimum Storage Reserve	The battery will not be discharged below this percentage of its usable capacity.
Minimum Storage Reserve Buffer	A delta of state of charge (SOC) that defines a buffer above the Minimum Storage Reserve. While SOC is within this buffer, all discharging commands are tapered. The closer SOC is to the Minimum Storage Reserve, the stronger the taper. If SOC goes below the Minimum Storage Reserve, no more discharging commands are sent until SOC has returned to a point above this buffer.
Maximum Storage Reserve	The battery will not be charged above this percentage of its usable capacity.
Maximum Storage Reserve Buffer	A delta of state of charge (SOC) that defines a buffer below the Maximum Storage Reserve. While SOC is within this buffer, all charging commands are tapered. The closer SOC is to the Maximum Storage Reserve, the stronger the taper. If SOC exceeds the Maximum Storage Reserve, no more charging commands are sent until SOC has returned to a point below this buffer.
On Transitions	Choose the method by which the system can move gradually from setting to setting while this operating mode is executing, or while it is being disabled. Use Ramp Time -- Only the "Ramp Time" parameters below are enabled. The "Ramp Rate" parameters are ignored. Use Ramp Rate -- Only the "Ramp Rate" parameters below are enabled. The "Ramp Time" parameters are ignored.
Up Ramp Time	When a new command requests a higher power setting, this is the time the system will take to move from the previous setting to the new setting. To switch to the new setting immediately, enter 0 (zero).
Down Ramp Time	When a new command requests a lower power setting, this is the time the system will take to move from the previous setting to the new setting. To switch to the new setting immediately, enter 0 (zero).
Discharge Up Ramp Rate	When a new command requests discharging at a greater magnitude, this is the rate at which the system will adjust power until it reaches the new setting. To switch to the new setting immediately, enter 0 (zero).
Discharge Down Ramp Rate	When a new command requests discharging at a lesser magnitude, this is the rate at which the system will adjust power until it reaches the new setting. To switch to the new setting immediately, enter 0 (zero).

Charge Up Ramp Rate	When a new command requests charging at a greater magnitude, this is the rate at which the system will adjust power until it reaches the new setting. To switch to the new setting immediately, enter 0 (zero).
Charge Down Ramp Rate	When a new command requests charging at a lesser magnitude, this is the rate at which the system will adjust power until it reaches the new setting. To switch to the new setting immediately, enter 0 (zero).

For information on this mode's Timing Parameters, see 1.4.3 Timing Parameters

`Example: ESS Real Power Mode`



If this mode is enabled with its parameters set as shown:

- When ESS Real Power is enabled, the system begins discharging power within 12 seconds (Time Window).
- Then the system takes a half-minute (Enabling Ramp Time of 30 seconds) to reach a discharge rate of 2,000 kW (Real Power Target).
- While the mode is enabled, the system continues discharging 2 MW power until (1) batteries approach the Minimum Storage Reserve, or (2) you disable the mode, or (3) with the Timeout Period set to 3,600 seconds, the discharging is automatically disabled after one hour.
- After the batteries' state of charge reaches 15% (the Minimum Storage Reserve plus Minimum Storage Reserve Buffer), discharge commands will begin to be tapered.
- Discharge commands will cease if the batteries' state of charge reaches 10% (the Minimum Storage Reserve).

Note

For safe operations, a bank of batteries should not be discharged when at or below its minimum state of charge or charged when at or above its maximum state of charge. Defined constraints in the DG-IC prevent this from happening.

1.4.8 ESS Reactive Power Mode

In ESS Reactive Power mode, the DG-IC directly sets the reactive power output of the system to meet a specified target. This operation continues until:

- You stop the operation by disabling the mode.
- The operation reaches the specified Timeout Period and automatically disables itself.
- The batteries are drained by the switching losses of the PCS that occur while producing reactive power.

ESS Reactive Power Parameters

Table 2-7 describes the ESS Reactive Power parameters and explains how they affect the mode's operation.

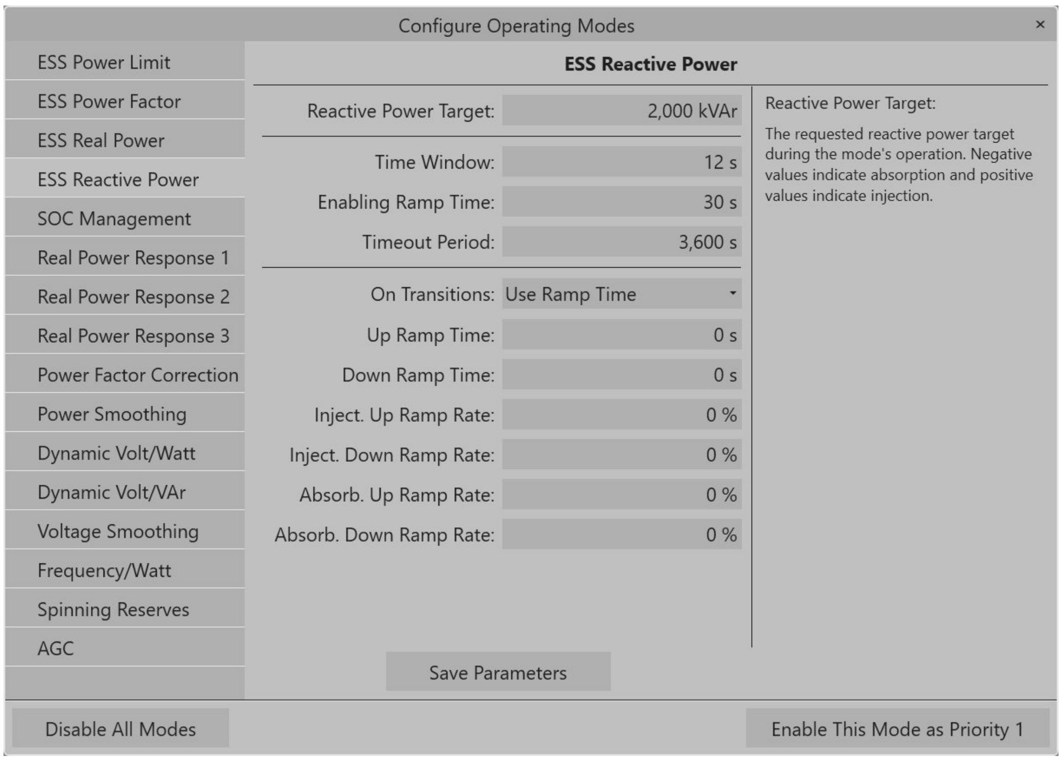
Table 1-7: ESS Reactive Power – General Settings

Parameter	Description
Reactive Power Target	A fixed value (in kVAr) at which the system should output reactive power. A negative value tells the DG-IC to absorb reactive power. A positive value tells the DG-IC to inject reactive power. Example: Reactive Power Target = -1,200.0 kVAr *The DG-IC will set the system to absorb 1,200 kVAr.*
On Transitions	Choose the method by which the system can move gradually from setting to setting while this operating mode is executing, or while it is being disabled. Use Ramp Time -- Only the "Ramp Time" parameters below are enabled. The "Ramp Rate" parameters are ignored. Use Ramp Rate -- Only the "Ramp Rate" parameters below are enabled. The "Ramp Time" parameters are ignored.
Up Ramp Time	When a new command requests greater reactive power output, this is the time the system will take to move from the previous setting to the new setting. To switch to the new setting immediately, enter 0 (zero).
Down Ramp Time	When a new command requests lower reactive power output, this is the time the system will take to move from the previous setting to the new setting. To switch to the new setting immediately, enter 0 (zero).
Injection Up Ramp Rate	When a new command requests the injection of reactive power at a greater magnitude, this is the rate at which the system will adjust output until it reaches the new setting. To switch to the new setting immediately, enter 0 (zero).

Injection Down Ramp Rate	When a new command requests the injection of reactive power at a lesser magnitude, this is the rate at which the system will adjust output until it reaches the new setting. To switch to the new setting immediately, enter 0 (zero).
Absorption Up Ramp Rate	When a new command requests the absorption of reactive power at a greater magnitude, this is the rate at which the system will adjust output until it reaches the new setting. To switch to the new setting immediately, enter 0 (zero).
Absorption Down Ramp Rate	When a new command requests the absorption of reactive power at a lesser magnitude, this is the rate at which the system will adjust output until it reaches the new setting. To switch to the new setting immediately, enter 0 (zero).

For information on this mode's Timing Parameters, see 1.4.3 Timing Parameters.

`Example: ESS Reactive Power Mode`



If this mode is enabled with its parameters set as shown:

- When ESS Reactive Power is enabled, the system begins injecting reactive power within 12 seconds (Time Window).
- Then the system takes a half-minute (Enabling Ramp Time of 30 seconds) to reach the injection target of 2,000 kVAr (Reactive Power Target).
- While the mode is enabled, the system continues injecting 2,000 kVAr until (1) you disable the mode, or (2) with the Timeout Period set to 3,600 seconds, the discharging is automatically disabled after one hour, or (3) the batteries are drained by the switching losses of the PCS that occur while producing reactive power.

Comparing Modes: ESS Power Factor and ESS Reactive Power

Both modes set a fixed and continuous reactive power target, and so are not intended to be enabled at the same time. If both modes are enabled, the higher priority mode would never allow the lower priority mode to operate.

1.4.9 Real Power Response Mode

Real Power Response is a flexible mode in which the DG-IC can charge or discharge the system in response to the load or generation at a monitored point on the grid. Parameters can be set so that the mode performs any of the following:

1.4.9.1 *Peak Power Limiting*

1.4.9.2 *Load Following*

1.4.9.3 *Generation Following*

There are three instances of this mode available in the DG-IC. That is, there are three tabs in the Configure Operating Modes popup devoted to Real Power Response mode settings. Thus, the DG-IC can be set to perform any combination of the behaviors listed above, and in any order of priority.

1.4.9.1 *Peak Power Limiting*

When an instance of Real Power Response mode is set to perform Peak Power Limiting, the DG-IC attempts to limit power flow at a monitored point on the grid by discharging Real Power from the system when the monitored demand exceeds that limit.

The following figure shows how this works.

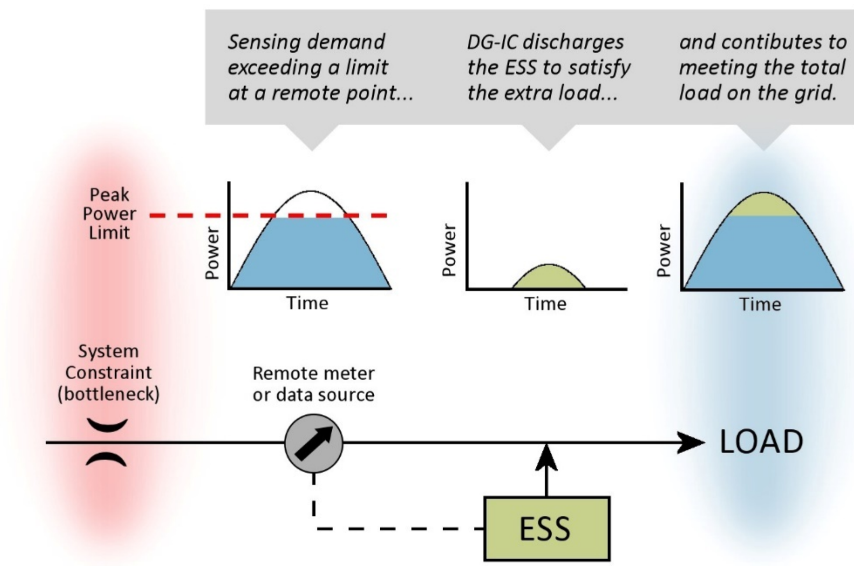


Figure 1-2 How Real Power Response Mode can perform Peak Power Limiting

1.4.9.2 *Load Following*

When an instance of Real Power Response mode is set to perform Load Following, the DG-IC produces Real Power by discharging the batteries in a specified ratio to the measured load when the monitored demand exceeds a specified threshold.

The following figure shows how this works.

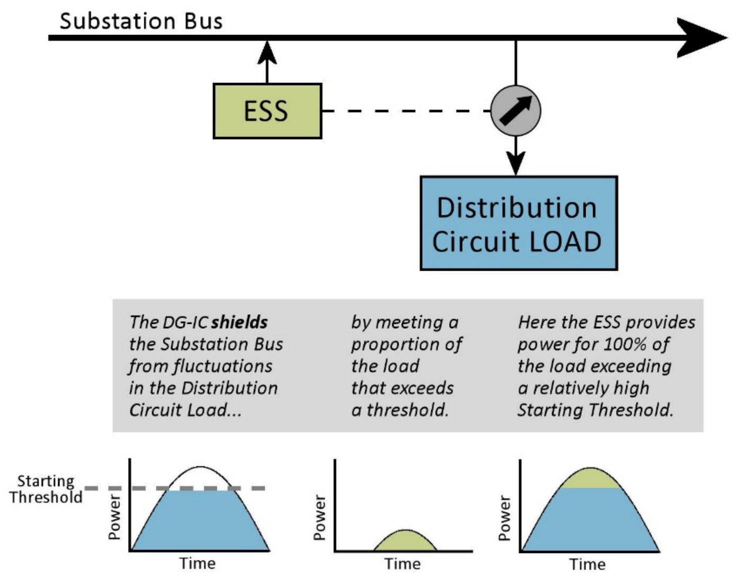


Figure 1-3 How Real Power Response Mode can perform Load Following

1.4.9.3 *Generation Following*

When an instance of Real Power Response mode is set to perform Generation Following, the DG-IC absorbs Real Power by charging the batteries in a specified ratio to the measured generation when the monitored reading goes below a specified threshold.

The following figure shows how this works.

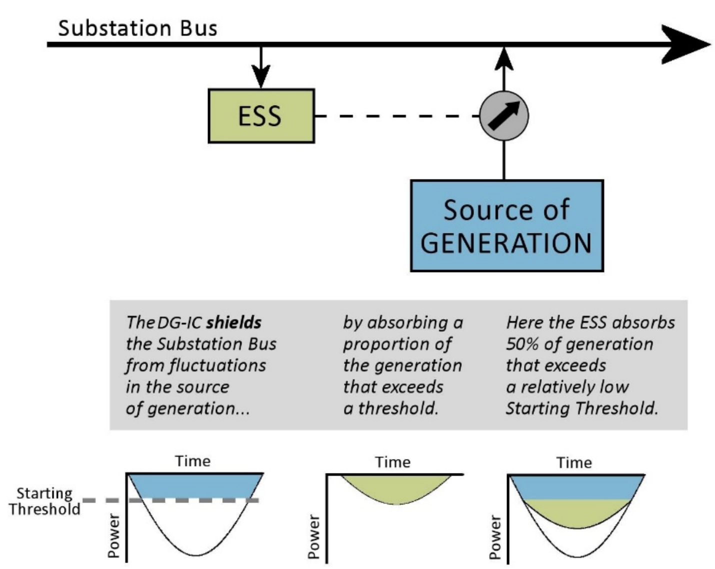


Figure 1-4 How Real Power Response Mode can perform Generation Following Real Power Response Parameters

Table 2-8 describes the Real Power Response parameters and explains how they affect the mode's operation.

Table 1-8: Real Power Response Parameters

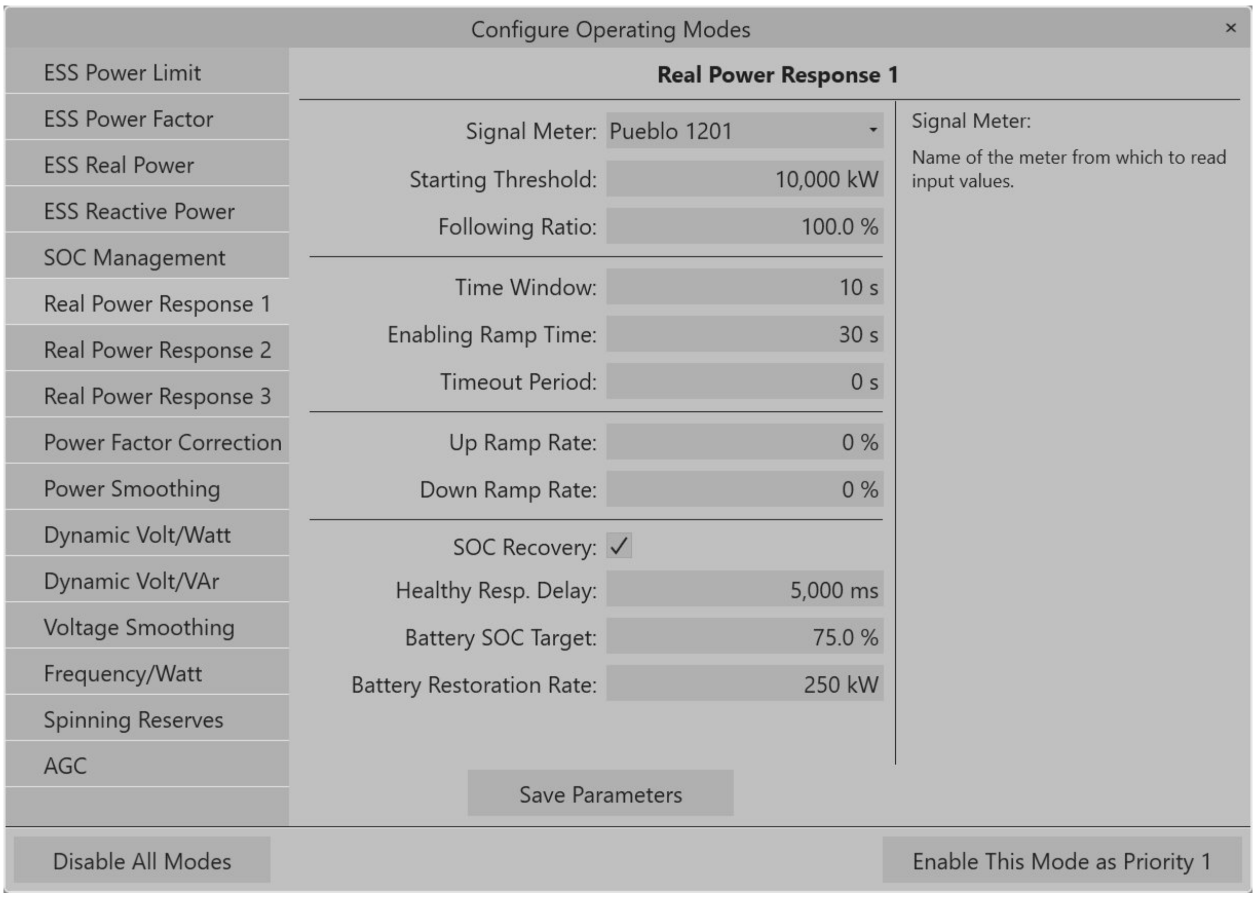
Parameter	Description
Signal Meter	Source of the Real Power readings that the DG-IC monitors and responds to. This can be a physical meter, an aggregated physical meter, or a virtual meter delivering data from SCADA or a data file.
Starting Threshold	The point at which the DG-IC will begin charging or discharging the system. This is a signed value entered in Watts. A positive value tells the DG-IC when to begin discharging the system to meet the increase in load. This behavior is sometimes called Peak Power Limiting or Load Following. A negative value tells the DG-IC when to begin charging the system to absorb the increase in generation. This behavior is often called Generation Following. Example: Starting Threshold = 2,000 kW *If the remote power reading is below 2,000 kW, the DG-IC takes no action. If the remote power reading is above 2,000 kW, the DG-IC begins discharging the system to meet the increased load at the specified Following Ratio.* Example: Starting Threshold = -4,000 kW *If the remote power reading is above -4,000 kW, the DG-IC takes no action. If the remote power reading is below -4,000 kW, the DG-IC begins charging the system to absorb the excess Real Power at the specified Following Ratio.*
Following Ratio	The percentage of the excessive load (or generation) that the system should generate (or absorb). Example: Following Ratio = 100 % *If the Starting Threshold is a positive value, and the remote power reading exceeds the Starting Threshold by 120 kW, the system will discharge 120 kW. This behavior is often called Peak Power Limiting.* Example: Following Ratio = 25 % *If the Starting Threshold is a positive value, and the remote power reading exceeds the Starting Threshold by 120 kW, the system will discharge 30 kW (25% of 120 kW). This is often called Load Following.* *If the Starting Threshold is a negative value, and the remote power exceeds the Starting Threshold by 200 kW, the system will absorb 50 kW (25% of 200 kW). This is often called Generation Following.*
Up Ramp Rate	When a new command requests a higher power setting, this is the rate at which the system will adjust power until it reaches the new setting. To switch to the new setting immediately, enter 0 (zero).

	This parameter applies while the operating mode is executing, and while it is being disabled.
Down Ramp Rate	When a new command requests a lower power setting, this is the rate at which the system will adjust power until it reaches the new setting. To switch to the new setting immediately, enter 0 (zero). This parameter applies while the operating mode is executing, and while it is being disabled.

For information on this mode's Timing Parameters, see 1.4.3 Timing Parameters

For information on this mode's SOC Recovery Parameters, see 1.4.4 SOC Recovery.

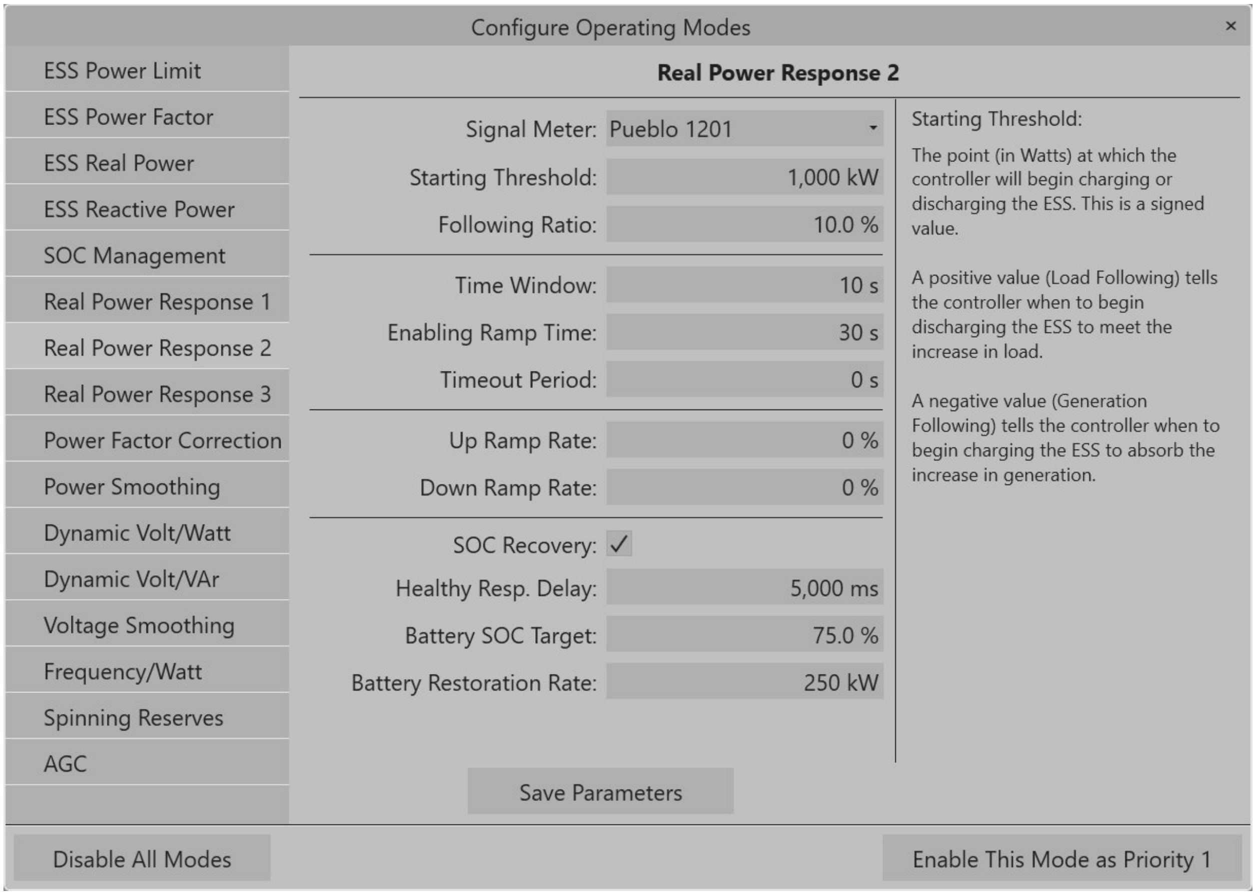
`Example: An instance of Real Power Response Mode set to perform Peak Power Limiting`



If this mode is enabled with its parameters set as shown:

- Real Power will be read from the remote meter named Pueblo 1201.
- The DG-IC will attempt to keep Real Power at the remote meter at or below 10,000 kilowatts.
- Because SOC Recovery has been checked, the mode will be ready to return the system state of charge to 75% after it has performed its primary function of limiting peak power.
- Specifically, after Real Power at the remote meter *returns* to a reading below 10,000 kW and remains there for at least 5 seconds (Healthy Response Delay), each PCS will begin returning its SOC to 75% at a rate of 250 kW.

`Example: An instance of Real Power Response Mode set to perform Load Following`



If this mode is enabled with its parameters set as shown:

- Real Power will be read from the remote meter named Pueblo 1201.
- When the mode is enabled, the system begins following the remote power readings within 10 seconds (Time Window).
- The system takes a half-minute (Enabling Ramp Time = 30 seconds) for the Real Power output of the system to reach the Following Ratio.
- Because Starting Threshold is a positive value, the DG-IC is Load Following, and stands ready to discharge the system when the Starting Threshold is crossed.
- With a Starting Threshold of 1,000 kW, the DG-IC takes no action if the remote power reading is below 1,000 kW.
- With a Following Ratio of 10.0%, the DG-IC will discharge to supply 10% of any excess load above 1,000 kW.
- With the Timeout Period set to 0, this mode will never be automatically disabled.
- Because SOC Recovery has not been checked, the mode will not track or respond to the system state of charge.

1.4.10 Power Factor Correction Mode

In Power Factor Correction mode, the DG-IC adjusts the Reactive Power output of the system to achieve a specified power factor at a monitored point on the grid. (To achieve a specified power factor at the point of common coupling within the system, see 1.4.6 ESS Power Factor Mode)

In Power Factor Correction mode, the DG-IC reads all three phases at the monitored point and compares them to the specified Upper and Lower Limits. If the monitored power factor of any phase exceeds one of these limits, the DG-IC will not drive the power factor in the direction of that limit.

The DG-IC also computes an average power factor from the readings of the three phases. If not prevented from doing so by a phase exceeding one of the limits, the DG-IC compares this average to the specified Average Target. It then adjusts the Reactive Power output of the system to move the monitored power factor closer to this Average Target.

The following figure shows how Power Factor Correction works.

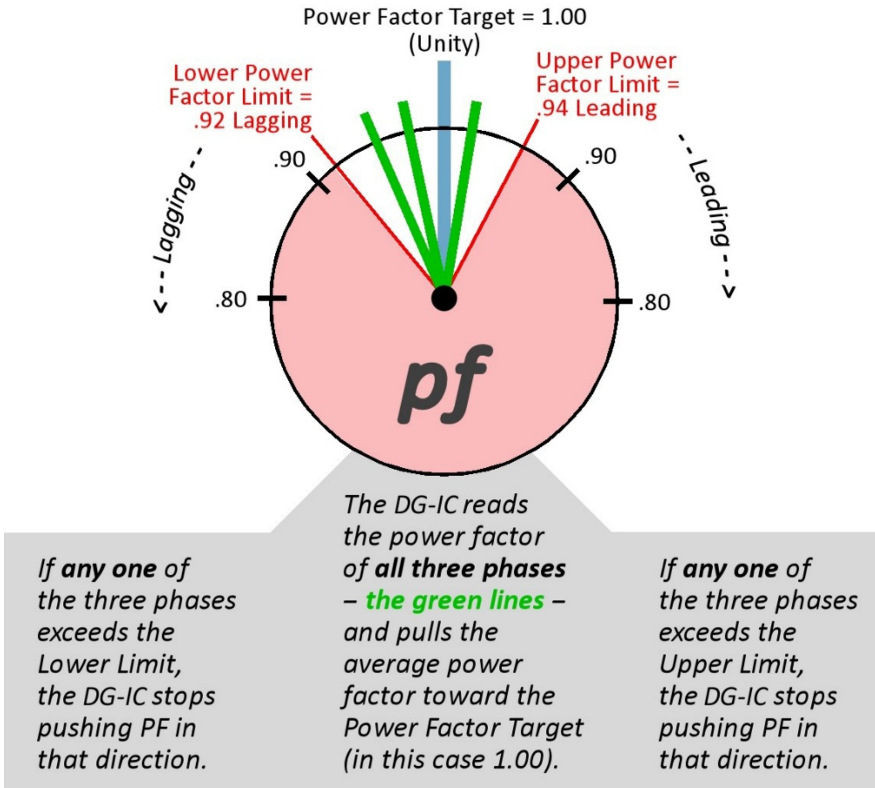


Figure 1-5 How Power Factor Correction Works

Power Factor Correction Parameters

Table 2-9 describes the Power Factor Correction parameters and explains how they affect the mode's operation.

Table 1-9: Power Factor Correction Parameters

Parameter	Description
Signal Meter	Source of the Reactive Power readings that the DG-IC monitors and responds to. This can be a physical meter, or a virtual meter delivering data from SCADA or a data file.
Average Target	The desired power factor for the average of all three phases at the monitored point on the grid. With a value of 1.00 (unity), the DG-IC attempts to achieve no Reactive Power at the monitored point. A setting of zero is not allowed. The drop-down to the right specifies whether the desired power factor is leading (capacitive) or lagging (inductive). If the Power Factor is set to 1.00 (unity), this drop-down value is ignored.

	See the note below for how the DG-IC interprets this parameter.
Upper Limit	A power factor above which the DG-IC stops applying power factor correction in the upper direction. This is typically a leading value. If any one of the three phases exceed this limit, the controller stops driving power factor further in this direction. The drop-down to the right specifies whether this limit is leading (capacitive) or lagging (inductive). If the limit is set to 1.00 (unity), this drop-down value is ignored.
Lower Limit	A power factor below which the DG-IC stops applying power factor correction in the lower direction. This is typically a lagging value. If any one of the three phases exceed this limit, the controller stops driving power factor further in this direction. The drop-down to the right specifies whether this limit is leading (capacitive) or lagging (inductive). If the limit is set to 1.00 (unity), this drop-down value is ignored.

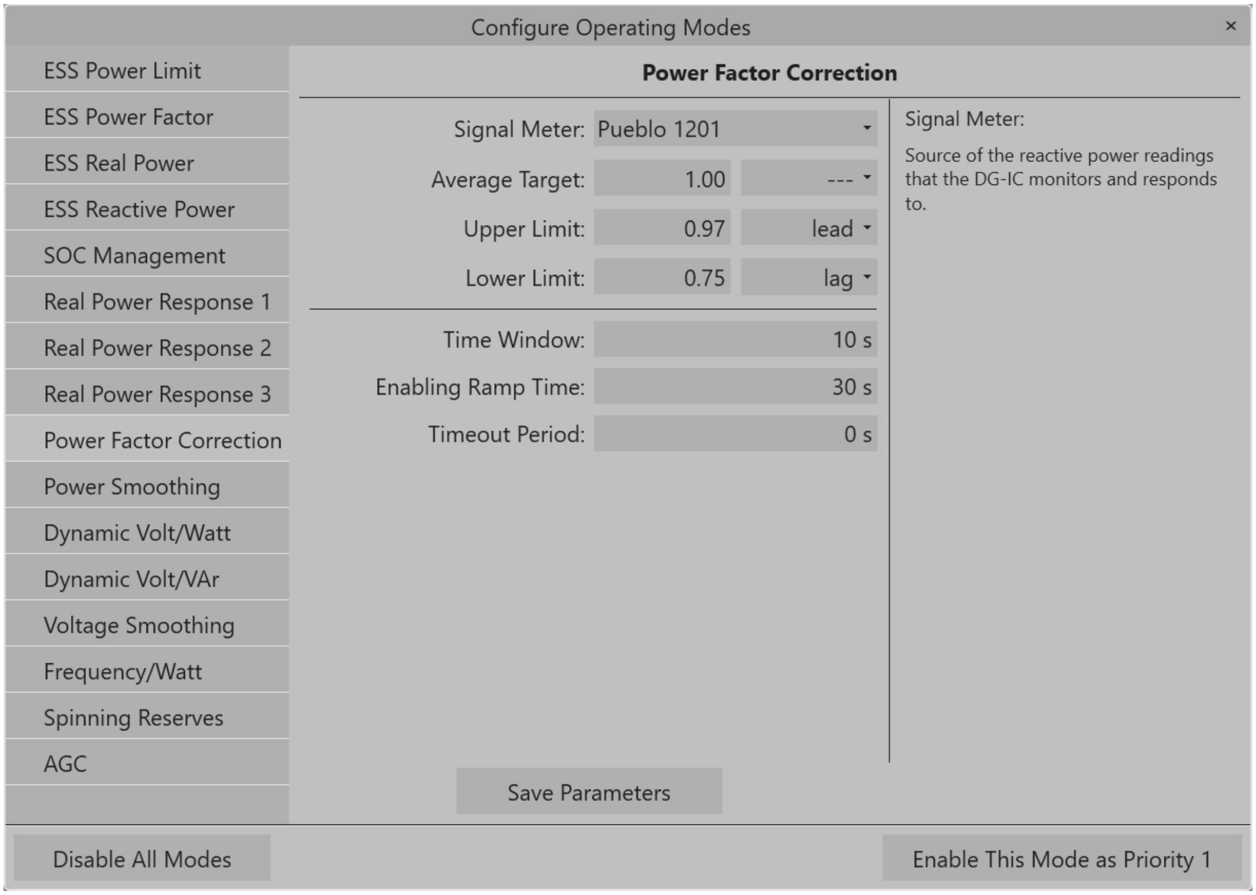
Note

In representing the sign of power factor, the DG-IC follows the convention of the Edison Electric Institute (EEI). Power factor is represented with a single value, the mathematical sign being dropped. The sign is used instead to indicate the injection mode. A positive sign indicates absorbing reactive power (leading, under-excited, capacitive). A negative sign indicates injecting (lagging, over-excited, inductive). This is true regardless of the direction of real power flow.

For information on this mode's Timing Parameters, see 1.4.3 Timing Parameters.

To further guide Reactive Power (Q) commands issued by the ESS, see the "Sign of Q" setting within Configuration > System Configuration > Control Settings.

`Example: Power Factor Correction Mode`



If this mode is enabled with its parameters set as shown:

- Real Power will be read from the remote meter named Pueblo 1201.
- The DG-IC will control the Reactive Power output of the system such that the Power Factor at the remote meter stays as close as possible to 1.00 (Unity).
- If any one of the three phases exceeds 0.97 leading, the DG-IC stops driving power factor further in that direction.
- If any one of the three phases exceeds 0.75 lagging, the DG-IC stops driving power factor further in that direction.
- Note that if **both** limits (Upper and Lower) are exceeded at the same time – that is, if one or more phases of the remote readings exceed the Lower Limit **and** one or more phases exceed the Upper Limit – then the DG-IC keeps driving the average power factor in the direction it was doing so before the second limit was exceeded.

1.4.11 Real Power Smoothing Mode

In Real Power Smoothing Mode, the DG-IC charges or discharges the system to compensate for abrupt changes in Real Power readings at a monitored point on the grid.

Real Power Smoothing requires power readings from an external source, and continuously calculates a moving average of those power readings over a span of time (Filter Time).

By instantly comparing the latest power reading to that moving average, the mode calculates **delta wattage**. In general, the goal of Real Power Smoothing Mode is to minimize delta wattage – that is, to keep the remote power readings as close as possible to its own moving average.

Delta wattage is a signed value:

- A positive delta wattage value indicates the latest power readings are trending higher.
- A negative delta wattage value indicates the latest power readings are trending lower.
- A smaller absolute delta wattage value (closer to zero) indicates a less abrupt change in power readings.
- A higher absolute delta wattage value (farther from zero) indicates a more abrupt change in power readings that might call for smoothing.

Real Power Smoothing Mode responds to delta wattage in the following ways:

- If delta wattage is within a specified dead band (between the Upper Limit and Lower Limit), the DG-IC will not perform any smoothing.
- If delta wattage is above the Upper Limit, the DG-IC applies the specified Smoothing Gradient to delta wattage. For example, it could discharge the system, contributing power to address some of the sudden increase in demand at the monitored point.
- If delta wattage is below the Lower Limit, the DG-IC applies the specified Smoothing Gradient to delta wattage. For example, it could charge the system, absorbing power in response to the sudden dip in demand at the monitored point.

The following figure illustrates how Real Power Smoothing works.

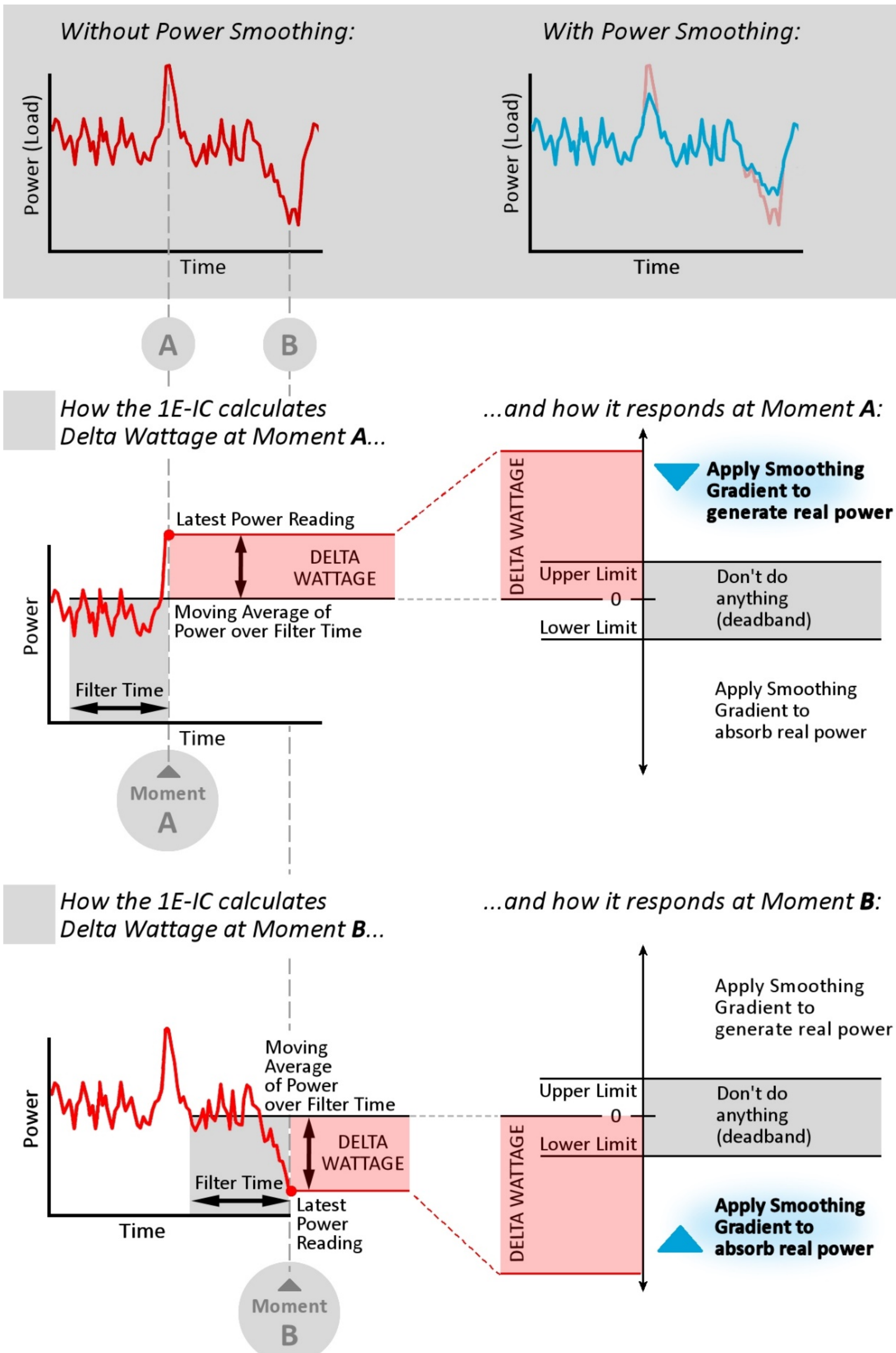


Figure 1-6 How Real Power Smoothing Works

Real Power Smoothing Parameters

Table 2-10 describes the Real Power Smoothing parameters and explains how they affect the mode's operation.

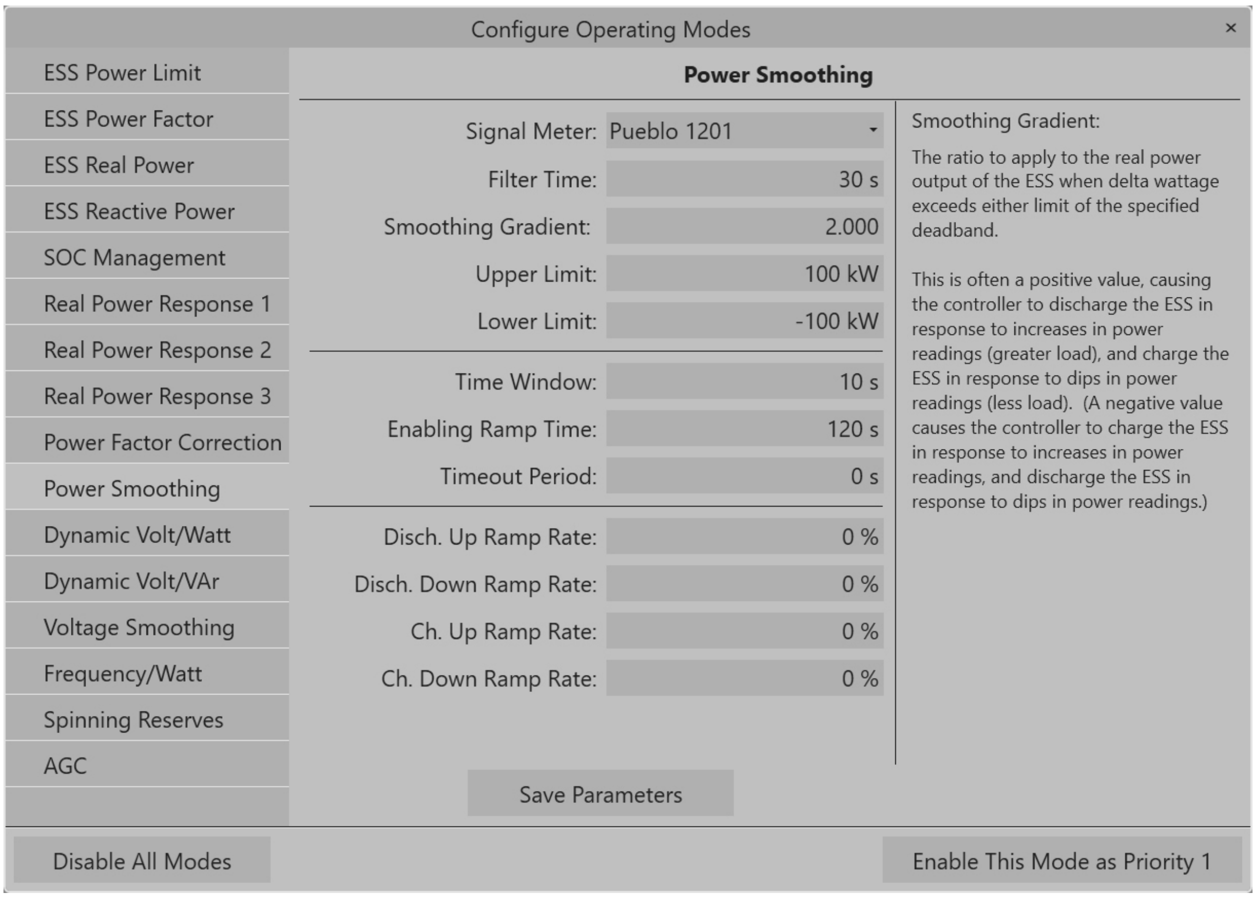
Table 1-10: Real Power Smoothing Parameters

Parameter	Description
Signal Meter	Source of the Real Power readings that the DG-IC monitors and responds to. This can be a physical meter, or a virtual meter delivering data from SCADA or a data file.
Filter Time	The time span (in seconds) over which a continuous moving average of Real Power is calculated.
Smoothing Gradient	The ratio to apply to the Real Power output of the system when delta wattage exceeds either limit of the specified dead band. Tells the DG-IC how much wattage to produce or absorb to soften abrupt changes in Real Power at the monitored point on the grid. Smoothing Gradient is often a positive value, which causes the DG-IC to discharge the system in response to abrupt increases in power readings (greater load), and charge the system in response to abrupt dips in power readings (less load). A negative Smoothing Gradient causes the DG-IC to charge the system in response to increases in power readings, and discharge the system in response to dips in power readings. Example: Smoothing Gradient = 1.5 *For every 1 watt of delta wattage above the Upper Limit, the DG-IC discharges the system 1.5 watts.* *For every 1 watt of delta wattage below the Lower Limit, the DG-IC charges the system 1.5 watts.*
Upper Limit	The upper value of the delta wattage dead band. Specifies how severely Real Power readings need to increase before the DG-IC applies smoothing. Example: Upper Limit = 100 kW *The DG-IC begins to apply smoothing if the latest power reading rises above its own moving average by 100 kilowatts or more.*
Lower Limit	The lower value of the delta wattage dead band. Specifies how severely Real Power readings need to decrease before the DG-IC applies smoothing. Example: Lower Limit = -200 kW *The DG-IC will begin to apply smoothing if the latest power reading dips below its own moving average by 200 kilowatts or more.*
Discharge Up Ramp Rate	When a new command requests discharging at a greater magnitude, this is the rate at which the system will adjust power until it reaches the new setting. To switch to the new setting immediately, enter 0 (zero).

Parameter	Description
Discharge Down Ramp Rate	When a new command requests discharging at a lesser magnitude, this is the rate at which the system will adjust power until it reaches the new setting. To switch to the new setting immediately, enter 0 (zero).
Charge Up Ramp Rate	When a new command requests charging at a greater magnitude, this is the rate at which the system will adjust power until it reaches the new setting. To switch to the new setting immediately, enter 0 (zero).
Charge Down Ramp Rate	When a new command requests charging at a lesser magnitude, this is the rate at which the system will adjust power until it reaches the new setting. To switch to the new setting immediately, enter 0 (zero).

For information on this mode's Timing Parameters, see 1.4.3 Timing Parameters.

`Example: Real Power Smoothing Mode`



If this mode is enabled with its parameters set as shown:

- Real Power will be read from the remote meter named Pueblo 1201.
- With a Filter Time of 30 seconds, the DG-IC continuously calculates a moving average of power readings over the previous half-minute.
- With an Upper Limit of 100 kW and a Lower Limit of -100 kW, the DG-IC will not perform any power smoothing if the latest power readings stay within 100 kW of its moving average in either direction.

- With an Upper Limit of 100 kW, the DG-IC takes action when the latest power readings exceed the moving average by 100 kW or more. Then, with a positive Smoothing Gradient, the DG-IC generates Real Power (discharges the batteries) to soften the increase in power readings. Given a Smoothing Gradient of 2.0, the DG-IC discharges the batteries 2.0 watts for every 1 watt of delta wattage above the Upper Limit.
- With a Lower Limit of -100 kW, the DG-IC takes action when the latest power reading goes below its moving average by 100 kW or more. Then, with a positive Smoothing Gradient, the DG-IC absorbs Real Power (charges the batteries) to soften the decrease in power readings. Given a Smoothing Gradient of 2.0, the DG-IC charges the batteries 2.0 watts for every 1 watt of delta wattage below the Lower Limit.

1.4.12 Dynamic Volt/Watt Mode

In Dynamic Volt/Watt mode, the DG-IC charges or discharges the system to compensate for changes in voltage at a monitored point on the grid. These voltage readings can come from the point of common coupling within the system, or from an external meter or data source.

The DG-IC reads line-to-line voltage at the monitored point, and continuously calculates a moving average of these voltage readings over a span of time (Filter Time).

By instantly comparing the latest power reading to that moving average, the mode calculates **delta voltage**. In general, the goal of Dynamic Volt/Watt Mode is to minimize delta voltage – that is, to keep the remote voltage readings as close as possible to its own moving average.

Delta voltage is a signed value:

- A positive delta voltage value indicates the latest voltage reading is trending higher.
- A negative delta voltage value indicates the latest voltage reading is trending lower.
- A smaller absolute delta voltage value (closer to zero) indicates a more gentle change in voltage.
- A higher absolute delta voltage value (farther from zero) indicates a more abrupt change in voltage that might call for a response by the DG-IC.

Dynamic Volt/Watt mode responds to this delta voltage in the following ways:

- If the delta voltage is within a specified dead band (between the Upper Limit and Lower Limit), the DG-IC takes no action.
- If the delta voltage is above the Upper Limit, the DG-IC applies the specified Watt Gradient to delta voltage to adjust the Real Power output of the system. For example, it could charge the system to respond to the increase in voltage at the monitored point.
- If the delta voltage is below the Lower Limit, the DG-IC applies the specified Watt Gradient to delta voltage. For example, it could discharge the system to produce additional power to respond to the dip in voltage at the monitored point.

The following figure illustrates how Dynamic Volt/Watt Mode works.

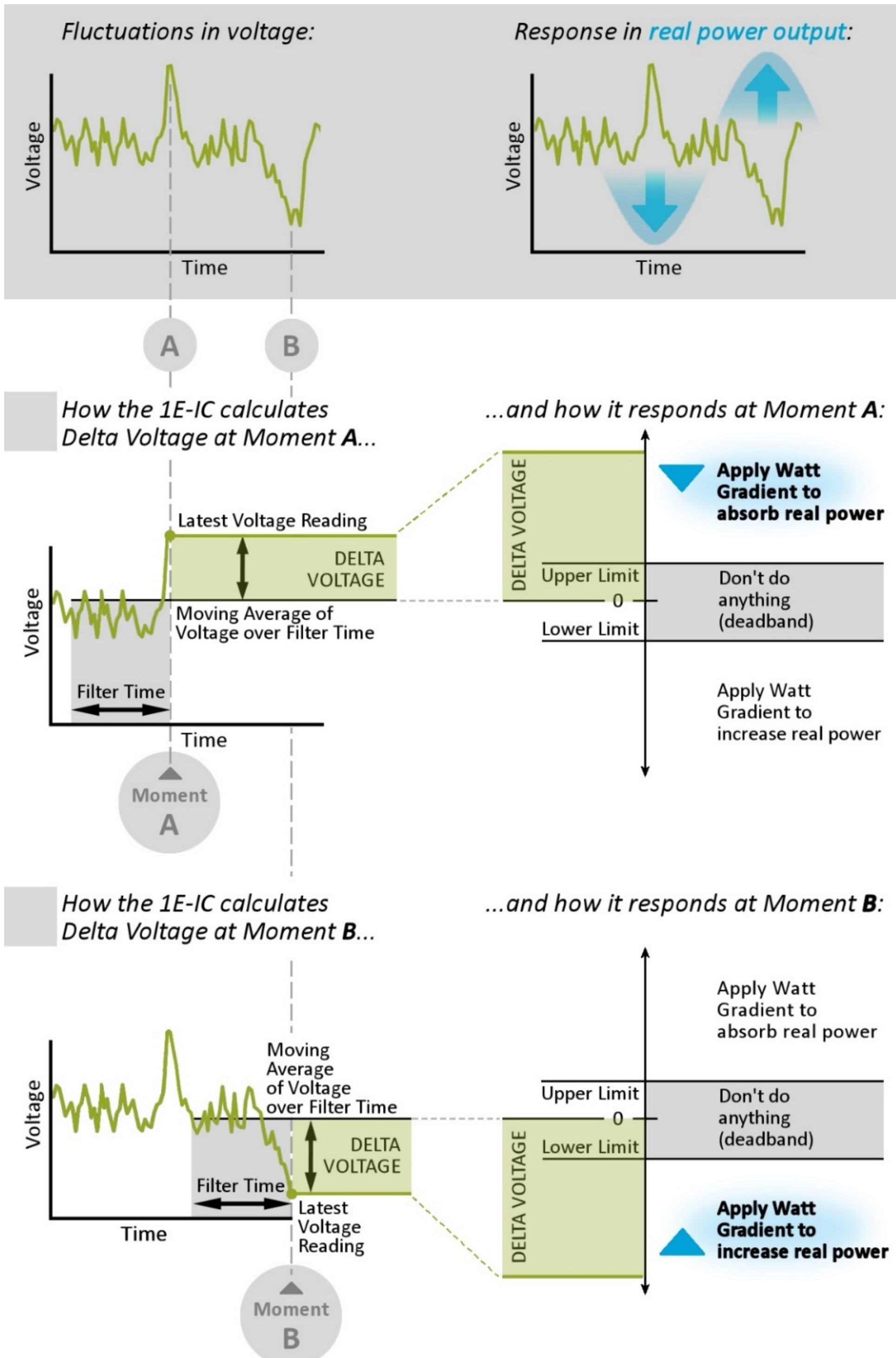


Figure 1-7 How Dynamic Volt/Watt Works

Dynamic Volt/Watt Parameters

Table 2-11 describes the Dynamic Volt/Watt parameters and explains how they affect the mode's operation.

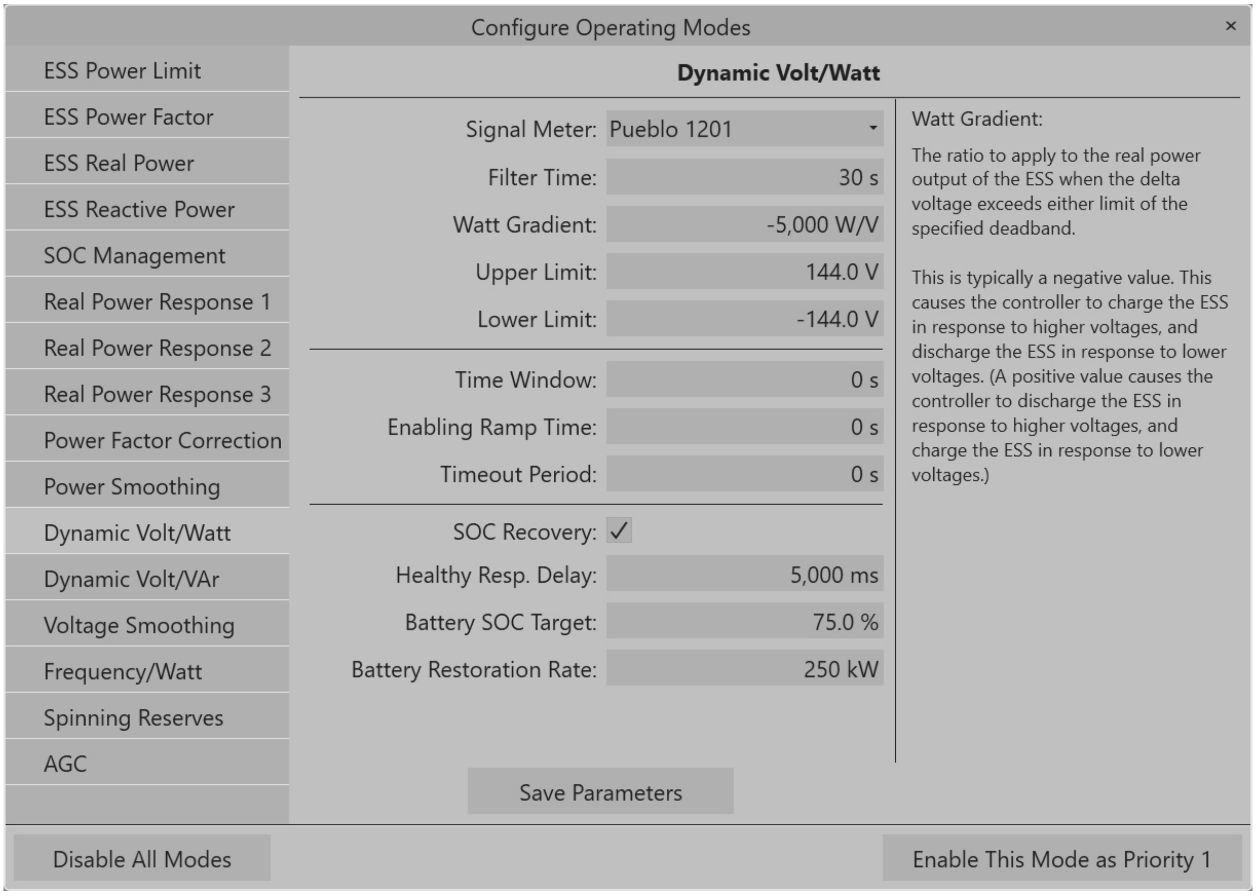
Table 1-11: Dynamic Volt/Watt Parameters

Parameter	Description
Signal Meter	Source of the voltage readings that the DG-IC monitors and responds to. This can be a physical meter, or a virtual meter delivering data from SCADA or a data file.
Filter Time	The time span (in seconds) over which a continuous moving average of voltage is calculated.
Watt Gradient	A ratio that tells the system how much wattage to produce or absorb to soften abrupt changes in voltage at the point on the grid. This is typically a negative value, causing the DG-IC to charge the system in response to higher voltages, and discharge the system in response to lower voltages. A positive value causes the DG-IC to discharge the system in response to higher voltages, and charge the system in response to lower voltages. Example: Watt Gradient = -4500 *For every 1 volt of delta voltage above the Upper Limit, the DG-IC charges the system 4.5 kilowatts.* *For every 1 volt of delta voltage below the Lower Limit, the DG-IC discharges the system 4.5 kilowatts.*
Upper Limit	The upper value of the delta voltage ratio dead band. Specifies how severely voltage readings need to increase before the DG-IC takes action. Example: Upper Limit = 200 Volts *The DG-IC takes action if the latest voltage reading rises above its own moving average by 200 volts or more.*
Lower Limit	The lower value of the delta voltage dead band. Specifies how severely voltage readings need to decrease before the DG-IC takes action. Example: Lower Limit = -300 Volts *The DG-IC takes action if the latest voltage reading dips below its own moving average by 300 volts or more.*

For information on this mode's Timing Parameters, see 1.4.3 Timing Parameters.

For information on this mode's SOC Recovery Parameters, see 1.4.4 SOC Recovery.

`Example: Dynamic Volt/Watt Mode`



If this mode is enabled with its parameters set as shown:

- Voltage readings are taken from the remote meter named Pueblo 1201.
- With a Filter Time of 30 seconds, the DG-IC computes the moving average of remote voltage readings over the previous half-minute.
- With an Upper Limit of 144 volts and a Lower Limit of -144 volts, the DG-IC does not take any action if the latest voltage readings stay within 144 volts of its moving average in either direction.
- With an Upper Limit of 144 volts, the DG-IC takes action when the latest voltage reading exceeds the moving average 144 volts or more. Then, given a Watt Gradient of -5000, the DG-IC reacts by charging the system 5000 watts for each volt the latest reading exceeded the Upper Limit.
- With a Lower Limit of -144 volts, the DG-IC takes action when the latest voltage reading goes below the moving average by 144 volts or more. Then, given a Watt Gradient of -5000, the DG-IC reacts by discharging the system 5000 watts for each volt the latest reading exceeded the Lower Limit.
- With the Timeout Period set to 0, Dynamic Volt/Watt mode will never be automatically disabled.
- Because SOC Recovery has been checked, the mode will be ready to return the system state of charge to 75% after it has performed its primary function of responding to voltage.
- Specifically, after remote voltage readings *returns* to within 144 volts of its moving average and remains there for at least 5 seconds (Healthy Response Delay), each PCS will begin returning its SOC to 75% at a rate of 250 kW.

1.4.13 Dynamic Volt/VAr Mode

In Dynamic Volt/VAr mode, the DG-IC adjusts the Reactive Power output of the system in response to changes in voltage at a monitored point on the grid, which can be either the point of common coupling within the system, or an external meter or data source.

The DG-IC reads line-to-line voltage at the monitored point and compares it to a Reference Voltage that you specify as a system configuration setting. This comparison can be calculated as a percentage or as a delta value.

Comparing voltage as a percentage

The latest voltage reading – divided by the Reference Voltage – yields a percentage of “ideal voltage.” For example, if the Reference Voltage is 12.47 kVolts and the most recent line-to-line voltage reading is 12.35 kVolts, then the resulting Voltage Percentage is 99%.

$$\frac{\text{Latest Voltage Reading}}{\text{Reference Voltage}} = \text{Voltage Percentage} \qquad e.g. \qquad \frac{12.35\ \text{kVolts}}{12.47\ \text{kVolts}} = 99\%$$

Then the DG-IC compares this Voltage Percentage to the values within a user-configured Curve to determine how to the Reactive Power output of the system should respond.

Comparing voltage as a delta

The latest voltage reading – minus the Reference Voltage – yields a delta from “ideal voltage.”

For example, if the Reference Voltage is 12.47 kVolts and the most recent line-to-line voltage reading is 12.35 kVolts, then the resulting Voltage Delta is -0.12 kVolts.

Then the DG-IC compares this Voltage Delta to the values within a user-configured Curve to determine how to the Reactive Power output of the system should respond.

Using Curves

A Curve is a series of Points. Each Point is a pair of values. The first value in each pair is an “If.” The second value in each pair is a “Then.”

In a Dynamic Volt/VAr Curve, each “If” value specifies a voltage percentage or voltage delta, and each “Then” value specifies the appropriate response in kilovars to be output.

Note

Some installations of the DG-IC allow for the use of SCADA-reserved curves which are used for scheduling the Dynamic Volt/VAr operating mode from control center applications such as DERO®. These curves are generally hidden in the DG-IC HMI and override the curve selected for the operating mode.

Dynamic Volt/VAr Parameters

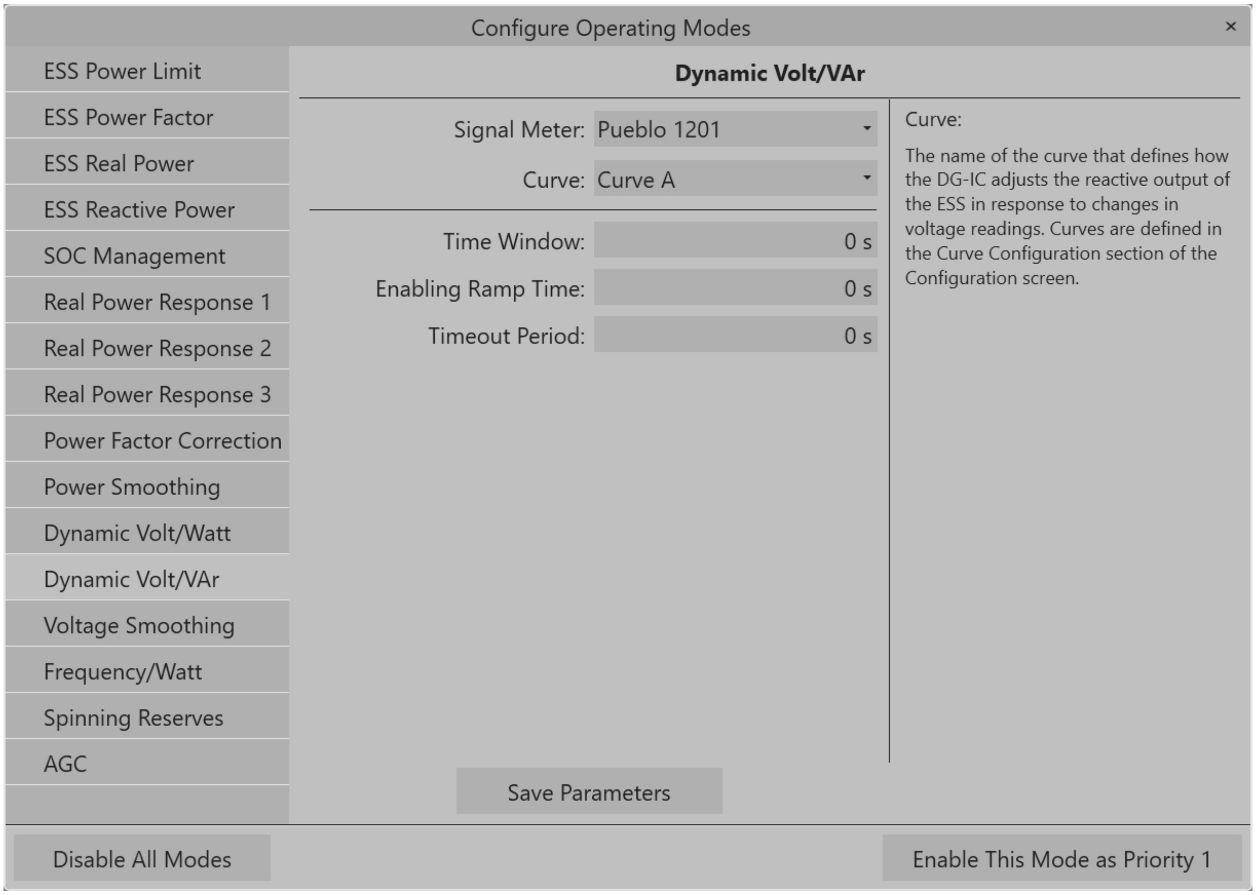
Table 2-12 describes the Dynamic Volt/VAr parameters and explains how they affect the mode’s operation.

Table 1-12: Dynamic Volt/VAr Parameters

Parameter	Description
Signal Meter	Source of the voltage readings that the DG-IC monitors and responds to. This can be a physical meter, or a virtual meter delivering data from SCADA or a data file.
Curve	The name of the Curve that defines how the DG-IC should adjust the reactive output of the system in response to changes in voltage readings.

For information on this mode's Timing Parameters, see 1.4.3 Timing Parameters.

`Example: Dynamic Volt/VAr Mode`



If this mode is enabled with its parameters set as shown:

- Voltage will be read from the remote meter named Pueblo 1201.
- The mode will respond to frequency readings by applying a series of points defined within "Curve A." All Volt/VAr Curves can be reviewed and edited within the Configuration Settings of the DG-IC.
- With the Timeout Period set to zero, this mode will never time out.

1.4.14 Voltage Smoothing Mode

In Voltage Smoothing mode, the DG-IC adjusts the Reactive Power output of the system in response to changes in voltage at a monitored point on the grid. These voltage readings can come from the point of common coupling within the system, or an external meter or data source.

The DG-IC reads line-to-line voltage at the monitored point, and continuously calculates a moving average of these voltage readings over a span of time (Filter Time).

By instantly comparing the latest voltage reading to that moving average, the mode calculates **delta voltage**. In general, the goal of Voltage Smoothing Mode is to minimize delta voltage – that is, to keep the remote voltage readings as close as possible to its own moving average.

Delta voltage is a signed value:

- A positive delta voltage value indicates the latest voltage reading is trending higher.
- A negative delta voltage value indicates the latest voltage reading is trending lower.

- A smaller absolute delta voltage value (closer to zero) indicates a more gentle change in voltage.
- A higher absolute delta voltage value (farther from zero) indicates a more abrupt change in voltage that might call for a response by the DG-IC.

Voltage Smoothing mode responds to this delta voltage in the following ways:

- If the delta voltage is within a specified dead band (between the Upper Limit and Lower Limit), the DG-IC takes no action.
- If the delta voltage is above the Upper Limit, the DG-IC applies the specified Upper Gradient to delta voltage to adjust the Reactive Power output of the system.
- If the delta voltage is below the Lower Limit, the DG-IC applies the specified Lower Gradient to delta voltage to adjust the Reactive Power output of the system.

The following figure illustrates how Voltage Smoothing Mode is typically used.

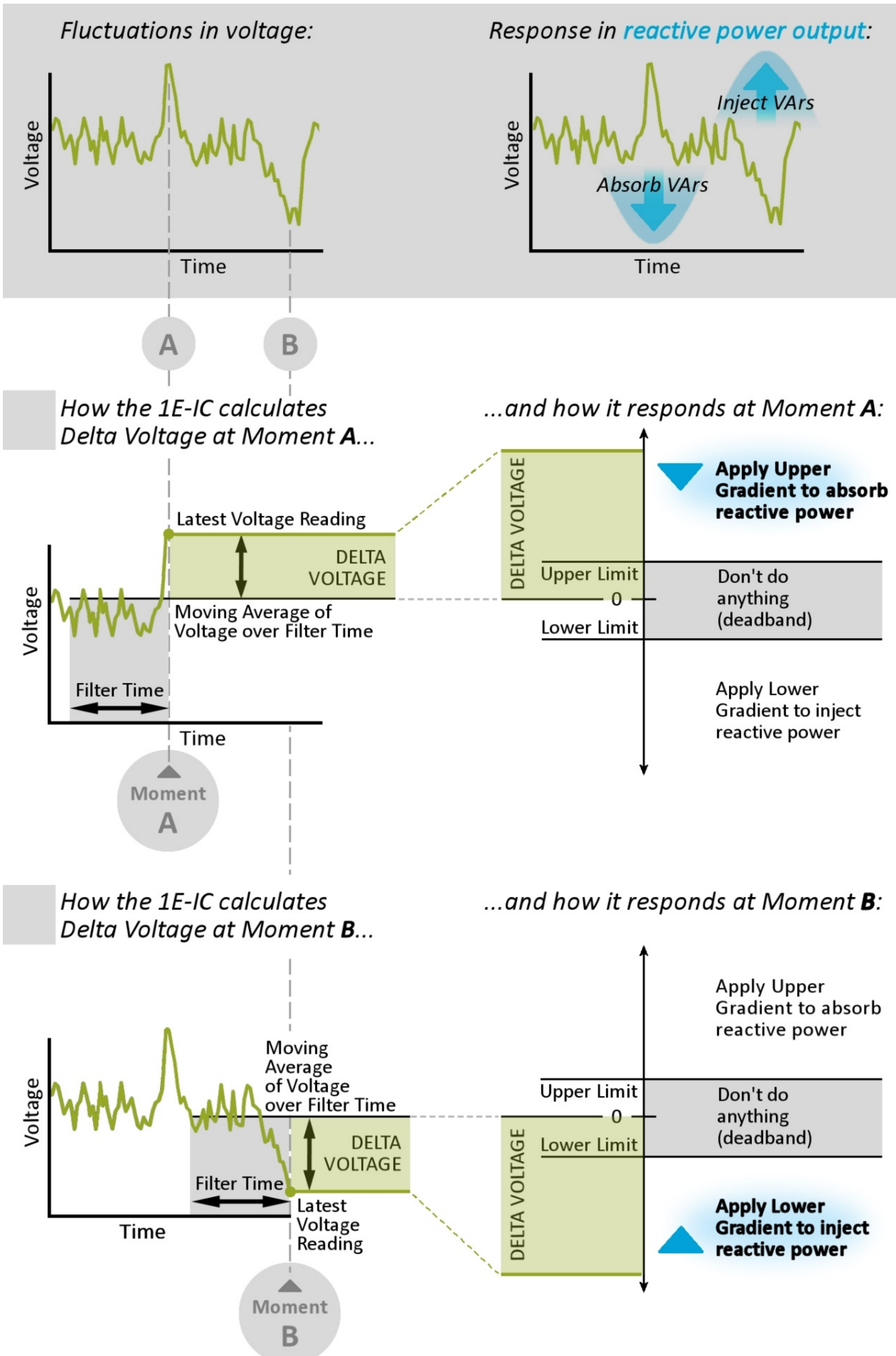


Figure 1-8 How Voltage Smoothing Is Typically Used

Voltage Smoothing Parameters

Table 2-13 describes the Voltage Smoothing parameters and explains how they affect the mode's operation.

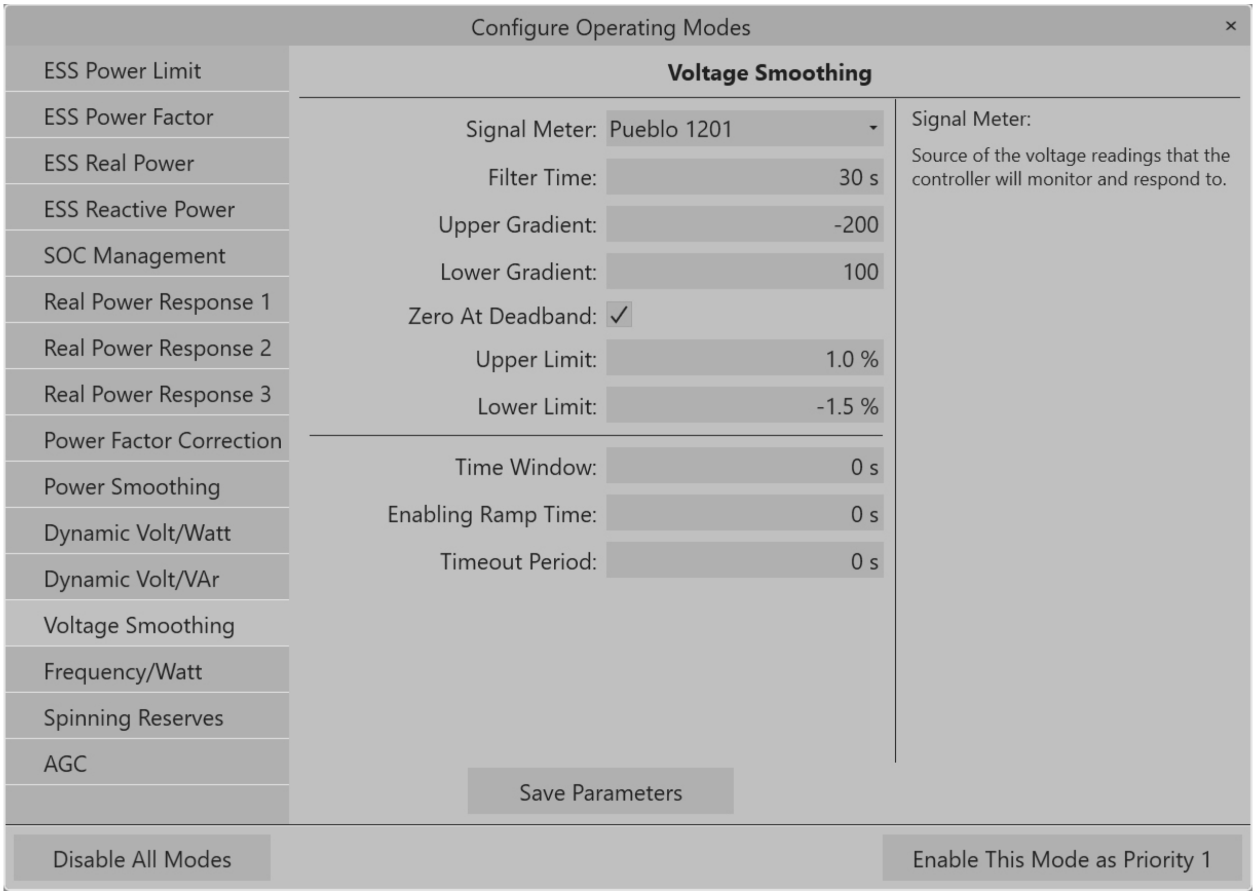
Table 1-13: Voltage Smoothing Parameters

Parameter	Description
Signal Meter	Source of the voltage readings that the DG-IC monitors and responds to. This can be a physical meter, or a virtual meter delivering data from SCADA or a data file.
Filter Time	The time span (in seconds) over which a continuous moving average of voltage is calculated.
Upper Gradient	A percentage of the system's maximum Reactive Power that the DG-IC should apply to each 1% of Reference Voltage that delta voltage goes above the Upper Limit of the dead band. If this gradient is a positive value, the system will inject vars. If this gradient is a negative value, the system will absorb vars. Example: Upper Gradient = -100 *If Reference Voltage is 12,400 V, then for every 1% (124 V) that delta voltage exceeds the Upper Limit of the dead band, the DG-IC responds by absorbing 100% of the system's maximum Reactive Power.* *(This example assumes that Zero At Dead Band is checked.)*
Lower Gradient	A percentage of the system's maximum Reactive Power that the DG-IC should apply to each 1% of Reference Voltage that delta voltage goes below the Lower Limit of the dead band. If this gradient is a positive value, the system will inject vars. If this gradient is a negative value, the system will absorb vars. Example: Lower Gradient = 50 *If Reference Voltage is 12,400 V, then for every 1% (124 V) that delta voltage exceeds the Lower Limit of the dead band, the DG-IC responds by injecting 50% of the system's maximum Reactive Power.* *(This example assumes that Zero At Dead Band is checked.)*

Parameter	Description
Zero At Dead Band	Specifies where the Upper and Lower Gradients reach their zero points (where they intersect the x-axis). This affects how strongly the gradients apply to variations in delta voltage. If this box is checked, the beginning points of the gradients are pegged to the *edges* of the voltage dead band. Thus, the gradients will take smaller (near zero) actions on small, initial excursions of delta voltage beyond the Upper and Lower Limits. If this box is not checked, the beginning points of the gradients are pegged to moving average of voltage *within* the dead band. Thus, the gradients will take larger, immediate actions even on small, initial excursions of delta voltage beyond the Upper and Lower Limits.
Upper Limit	Expressed as a positive percentage of Reference Voltage, this delta is applied to the moving average of voltage to define the upper extent of a dead band. Thus, it specifies how much voltage readings need to increase before the DG-IC responds by injecting or absorbing Reactive Power. Example: Upper Limit = 1.5% *If Reference Voltage is 12,400 V, this defines a delta of +186 V.* *(12,400 times 1.5% = 186.)* *This puts the upper extent of the delta voltage dead band at 186 V above the moving average. The DG-IC will take action if the latest voltage reading rises above its own moving average by 186 V or more.*
Lower Limit	Expressed as a negative percentage of Reference Voltage, this delta is applied to the moving average of voltage to define the lower extent of a dead band. Thus, it specifies how much voltage readings need to decrease before the DG-IC responds by injecting or absorbing Reactive Power. Example: Lower Limit = -0.75% *If Reference Voltage is 12,400 V, this defines a delta of -93 V.* *(12,400 times -0.75% = -93.)* *This puts the lower extent of the delta voltage dead band at 93 V below the moving average. The DG-IC will take action if the latest voltage reading sinks below its own moving average by 93 V or more.*

For information on this mode's Timing Parameters, see 1.4.3 Timing Parameters.

`Example: Voltage Smoothing Mode`



If this mode is enabled with its parameters set as shown:

- Voltage readings are taken from the remote meter named Pueblo 1201.
- With a Filter Time of 30 seconds, the DG-IC computes the moving average of remote voltage readings over the previous half-minute.
- With Zero At Dead Band checked, the Upper and Lower Gradients will be calculated to be zero at the Upper and Lower Limits, that is, at the edges of the dead band.
- With an Upper Limit of 1.0% (assuming the Reference Voltage is 12,400 V), the DG-IC will begin applying the Upper Gradient if the latest voltage reading rises above its own moving average by 124 V or more.
- With an Upper Gradient of -200, the DG-IC would aim to absorb 200% of the system's maximum Reactive Power for every 1% (124 V) that delta voltage exceeds the Upper Limit of the dead band. In practical terms, this means that the DG-IC would absorb 100% of the system's maximum Reactive Power once the delta voltage exceeded the Upper Limit by 0.5% (62 V).
- With a Lower Limit of 1.5%, the DG-IC will begin applying the Lower Gradient if the latest voltage reading sinks below its own moving average by 186 V or more.
- With a Lower Gradient of 100, the DG-IC would aim to inject 100% of the system's maximum Reactive Power for every 1% (124 V) that delta voltage exceeds the Lower Limit of the dead band.
- With the Timeout Period set to 0, Voltage Smoothing mode will never be automatically disabled.

1.4.15 Spinning Reserves Mode

The term **spinning reserves** refers to readily available generation capacity that can be dispatched to maintain system frequency stability in the event of generation or transmission outages. While operating in Spinning Reserves mode, the system can be a source of spinning reserves for the grid.

In Spinning Reserves mode, the DG-IC monitors grid frequency from a signal specified in the mode's configuration and adjusts Real Power output in response to excursions above and below your grid's Reference Frequency, which is typically 50 Hz or 60 Hz. Reference Frequency is a system configuration setting.

- If grid frequency falls below an acceptable range, Spinning Reserves mode can be set to discharge batteries at maximum available power until they are fully depleted, or until frequency returns to a healthy state.
- If grid frequency rises above an acceptable range, Spinning Reserves mode can be set to charge batteries at maximum available power until they are fully charged, or until frequency returns to a healthy state.
- Once frequency returns to a healthy state, batteries can be optionally set to charge or discharge back to a target SOC.
- Smooth transitions between idle, discharging, and charging battery states are supported by two dead bands (Inner and Outer) as well as configurable response delay times.

The following figures show how the system responds to grid frequency excursions while operating in Spinning Reserves mode.

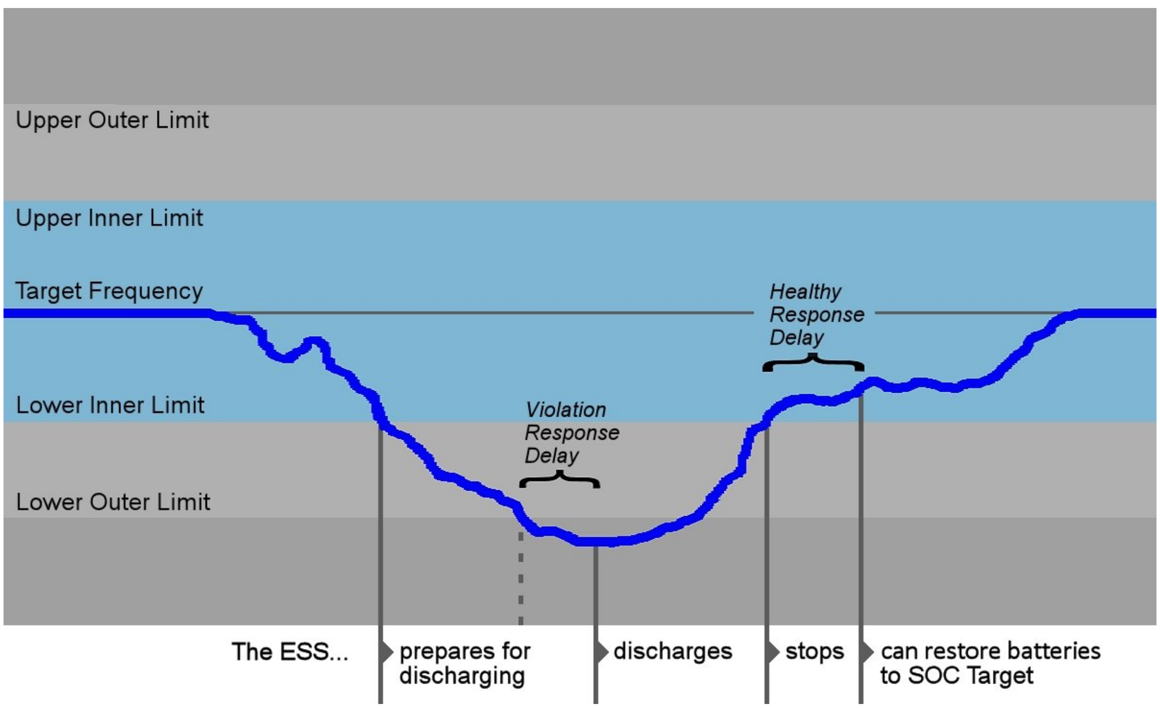


Figure 1-9 Spinning Reserves – Grid Frequency Drops

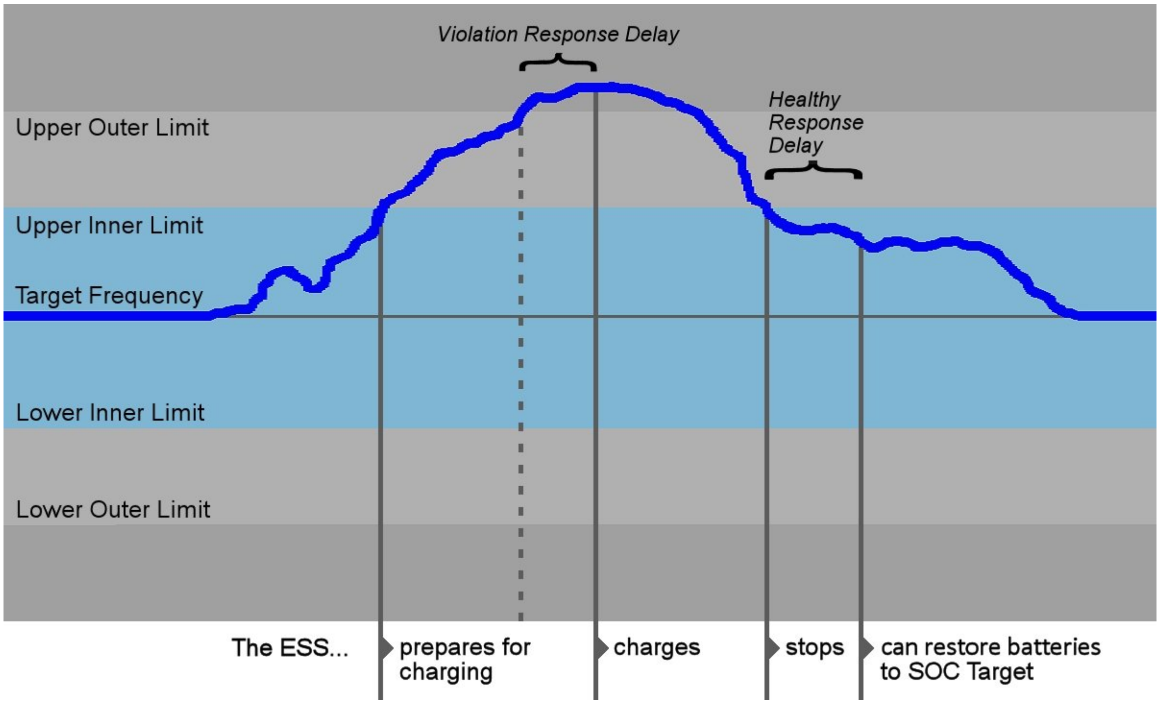


Figure 1-10 Spinning Reserves – Grid Frequency Rises

The Signal Meter, dead band ranges, response delay times, Battery SOC Target and Battery Restoration Rate are all configurable in Spinning Reserves mode.

Spinning Reserves Parameters

The following tables describe the Spinning Reserves parameters and their effect on the mode's operation.

Table 1-14: Spinning Reserves– Frequency Settings

Parameter	Description
Signal Meter	Unique name of the power meter signal that contains the grid frequency to monitor. The signal can come from a physical power meter, a test power meter, or SCADA.

Table 1-15: Spinning Reserves – Outer Limit (Violation Response) Settings

Parameter	Description
Violation Response Delay	Milliseconds to wait after frequency exceeds one of the Outer Limits before the system reacts. This delay prevents the system from causing frequency oscillations near the dead band limit.
Minimum Violation Response Time	Once the system has begun responding to a violation, this is the minimum amount of time that the system will *keep* responding.

Parameter	Description
Upper Outer Limit	Delta above Reference Frequency that triggers the system to charge the batteries (after the Violation Response Delay). To ignore high frequency events, set Upper Outer Limit and Upper Inner Limit to 0 (zero). Example: Reference Frequency = 60.0 Hz Upper Outer Limit = 0.3 Hz *If frequency rises above 60.3 Hz (Reference Frequency plus Upper Outer Limit) and remains there past the Violation Response Delay, batteries begin charging at maximum power and continue to charge until full, or until frequency returns to an acceptable range.*
Lower Outer Limit	Delta below Reference Frequency that triggers the system to discharge the batteries (after the Violation Response Delay). Example: Reference Frequency = 60.0 Hz Lower Outer Limit = 0.3 Hz *If frequency drops below 59.7 Hz (Reference Frequency minus Lower Outer Limit) and remains there past the Violation Response Delay, batteries begin discharging at maximum power and continue to discharge until depleted, or until frequency returns to an acceptable range.*

Table 1-16: Spinning Reserves – Inner Limit (Healthy Response) Settings

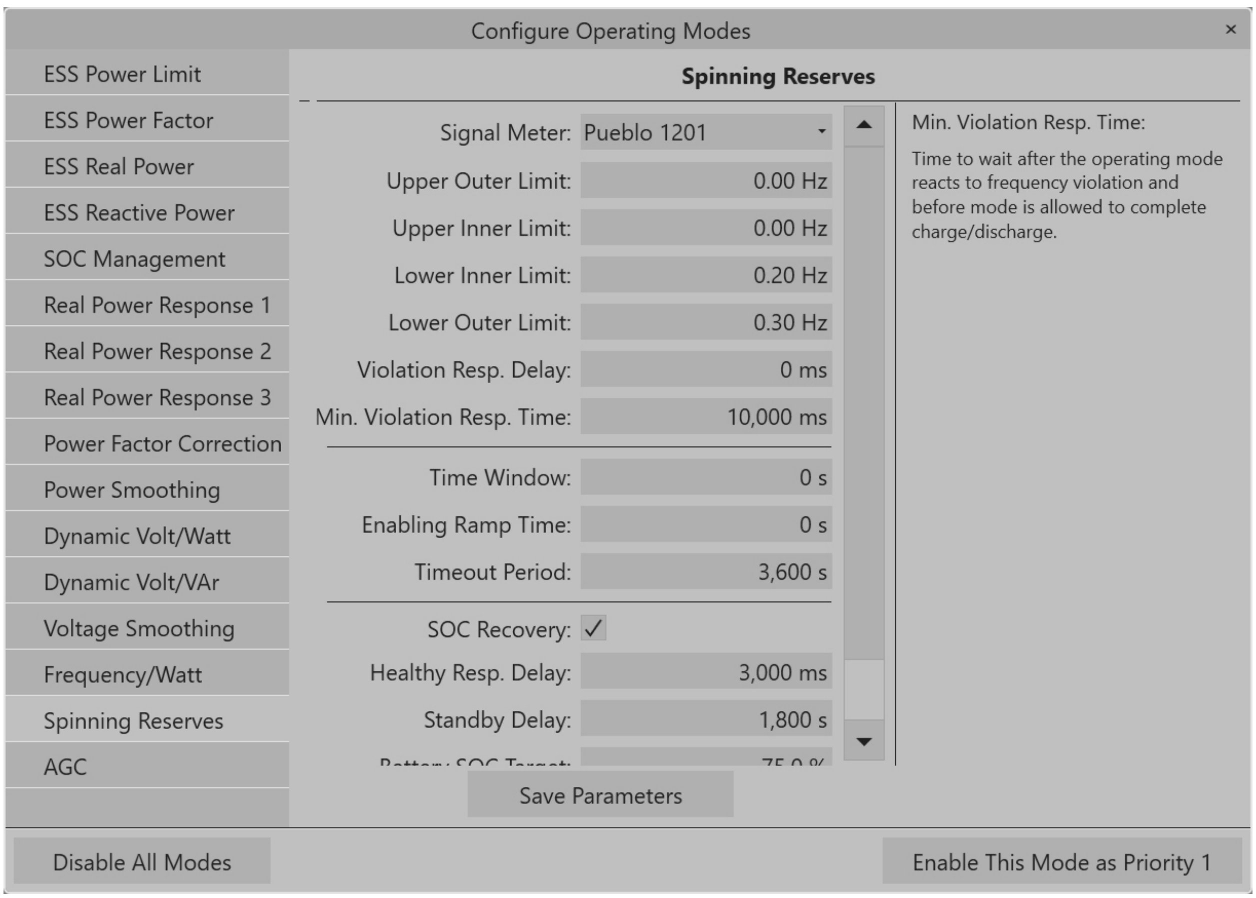
Parameter	Description
Upper Inner Limit	Delta above Reference Frequency considered healthy, or within the optimum range. When this limit is exceeded, the PCS enters a Running state (if not already there) with Real Power set to 0 MW in order to prepare for charging. To ignore high frequency events, set Upper Outer Limit and Upper Inner Limit parameters to 0 (zero). Example: Reference Frequency = 60.0 Hz Upper Inner Limit = 0.2 Hz *If frequency rises above 60.2 Hz (Reference Frequency plus Upper Inner Limit), the PCS enters a ready state to prepare for charging.* *After a frequency rise that triggers the system to charge, if frequency falls back below 60.2 Hz, the system stops charging. If frequency remains below 60.2 Hz past the Healthy Response Delay, the system will discharge to Target SOC at the Battery Restoration Rate if the SOC Recovery parameter is checked.*

Lower Inner Limit	Delta below Reference Frequency considered healthy, or within the optimum range. When this limit is exceeded, the PCS enters a Running state (if not already there) with Real Power set to 0 MW in order to prepare for discharging. Example: Reference Frequency = 60.0 Hz Lower Inner Limit = 0.2 Hz *If frequency drops below 59.8 Hz (Reference Frequency minus Lower Inner Limit), the PCS enters a ready state to prepare for discharging.* *After a frequency drop that triggered the system to discharge, if frequency rises back above 59.8 Hz, the system stops discharging. If frequency remains above 59.8 Hz past the Healthy Response Delay, the system will recharge to Target SOC at the Battery Restoration Rate if the SOC Recovery parameter is checked.*

For information on this mode's Timing Parameters, see 1.4.3 Timing Parameters.

For information on this mode's SOC Recovery parameters, see 1.4.4 SOC Recovery.

`Example: Spinning Reserves Mode`



If this mode is enabled with its parameters set as shown:

- Frequency readings will be taken from the remote meter named Pueblo 1201.
- Your grid's Reference Frequency is defined as 60 Hz.

- The Violation Response Delay is set to 0 (zero), so if frequency falls by more than 0.30 Hz (Lower Outer Limit) to below 59.70 (60.00 – 0.30), the system immediately begins discharging all batteries at full power.
- With a Minimum Violation Response Delay set to 10,000 milliseconds (10 seconds), the system will continue discharging for at least ten seconds.
- After ten seconds, the batteries will continue to discharge until fully depleted, or until frequency rises above the Lower Inner Limit, passing 59.80 Hz (60.00 – 0.20), at which point the system stops discharging.
- Because SOC Recovery is checked, when frequency remains above 59.80 Hz for 1,000 milliseconds (Healthy Response Delay), the system begins charging.
- Each PCS charges at a rate of 500 kW (Battery Restoration Rate).
- With frequency in a healthy range, the system charges until the batteries' state of charge is 75% (Battery SOC Target), at which point it stops charging.
- With a Standby Delay of 1,800 seconds (30 minutes), the system waits 30 minutes after the batteries have been restored to the SOC Target before putting the PCSs into a Standby state.
- With both the Upper Outer Limit and Upper Inner Limit set to 0 (zero), the system ignores frequency rises above the dead band limits and does not respond.
- With the Timeout Period set to 3,600 seconds, Spinning Reserves mode runs for one hour and then is automatically disabled.

1.4.16 Automatic Generation Control (AGC) Mode

Automatic generation control (AGC) is a system for adjusting the power output of multiple power sources in response to changes in load. The AGC operating mode enables the system to participate in AGC.

AGC Parameters

Table 2-17 describes the AGC parameters and explains how they affect the mode's operation.

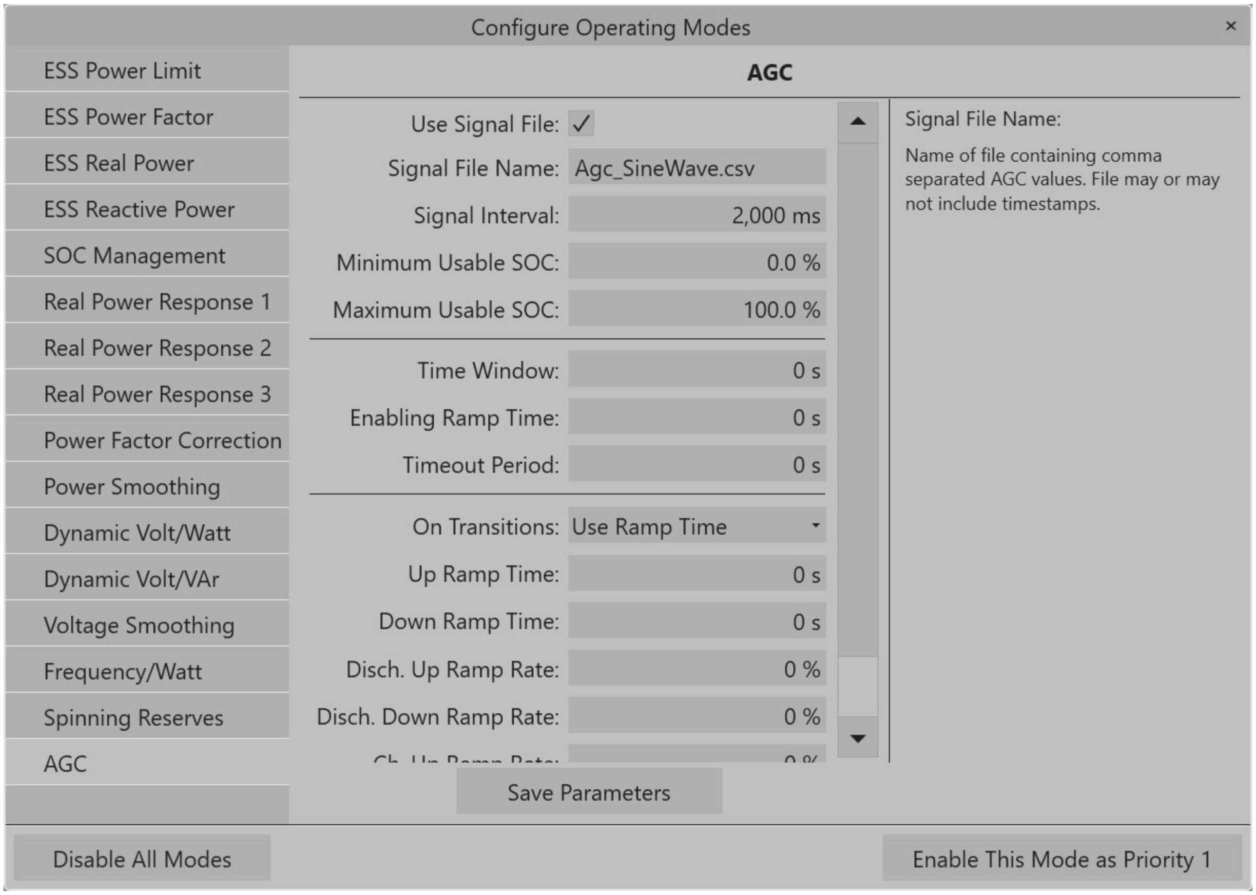
Table 1-17: AGC Parameters

Parameter	Description
Use Signal File	When this checkbox is checked, AGC mode responds to values from the specified data file. This can be done to test AGC mode before letting it respond to live AGC signals. Sample AGC test files are located in: *c:\programdata\Doosan GridTech\Energy Storage Control System\Data Files* AGC test files contain data in CSV (comma-separated values) format. To enable AGC mode to respond to live AGC signals provided by SCADA, uncheck this box.
Signal File Name	Name of data file containing AGC values. The file may or may not include timestamps. This parameter is ignored if the Use Signal File checkbox is unchecked.
Signal Interval	Time interval (milliseconds) between signal values in the data file. If Signal Interval is specified, any timestamps in the specified data file will be ignored. This parameter is ignored if the Use Signal File checkbox is unchecked.
Minimum Usable SOC	A percentage for state of charge (SOC), typically zero or close to it. If the average SOC of all batteries in the system falls below this value, AGC mode remains enabled, but stops discharging the batteries.

Maximum Usable SOC	A percentage for state of charge (SOC), typically 100 or close to it. If the average SOC of all batteries in the system rises above this value, AGC mode remains enabled, but stops charging the batteries.
On Transitions	Choose the method by which the system can move gradually from setting to setting while this operating mode is executing, or while it is being disabled. Use Ramp Times -- Only the "Ramp Time" parameters below are enabled. The "Ramp Rate" parameters are ignored. Use Ramp Rates -- Only the "Ramp Rate" parameters below are enabled. The "Ramp Time" parameters are ignored.
Up Ramp Time	When a new command requests a higher power setting, this is the time the system will take to move from the previous setting to the new setting. To switch to the new setting immediately, enter 0 (zero).
Down Ramp Time	When a new command requests a lower power setting, this is the time the system will take to move from the previous setting to the new setting. To switch to the new setting immediately, enter 0 (zero).
Discharge Up Ramp Rate	When a new command requests discharging at a greater magnitude, this is the rate at which the system will adjust power until it reaches the new setting. To switch to the new setting immediately, enter 0 (zero).
Discharge Down Ramp Rate	When a new command requests discharging at a lesser magnitude, this is the rate at which the system will adjust power until it reaches the new setting. To switch to the new setting immediately, enter 0 (zero).
Charge Up Ramp Rate	When a new command requests charging at a greater magnitude, this is the rate at which the system will adjust power until it reaches the new setting. To switch to the new setting immediately, enter 0 (zero).
Charge Down Ramp Rate	When a new command requests charging at a lesser magnitude, this is the rate at which the system will adjust power until it reaches the new setting. To switch to the new setting immediately, enter 0 (zero).

For information on this mode's Timing Parameters, see 1.4.3 Timing Parameters.

`Examples: AGC Mode`



If this mode is enabled with the **Use Signal File** box checked, and its parameters set as shown:

- While AGC mode is enabled, the system charges or discharges to satisfy AGC requests delivered by the test file Agc_SineWave.csv. More sample test files are located in:
- *c:\programdata\Doosan GridTech\Energy Storage Control System\Data Files*
- To respond to AGC requests from SCADA instead of from the test file, uncheck Use Signal File.

If the **Use Signal File** box is unchecked:

- When AGC mode is enabled, the system charges or discharges to satisfy AGC requests delivered by SCADA.
- With the Timeout Period set to 0.0 seconds, AGC mode does not time out, but continues running until an operator clicks Disable Mode.

Section 2 Distributed Energy Resource Optimizer (DG-DERO™)

2.1 General Information and Disclosure

Information provided in this manual is intended to be accurate and reliable as of the date of publication; however, Doosan GridTech reserves the right to make amendments or correct omissions to this manual at any time.

This manual is provided to you "as is" with no warranties, express, implied or statutory. Your use of this manual is at your own risk, and Doosan GridTech assumes no responsibility for any damage, injury, or expenses resulting from its use. If you find any errors in this manual, please report them to us in writing at GridTechInfo@doosan.com, and we may correct the error in a future version of this manual.

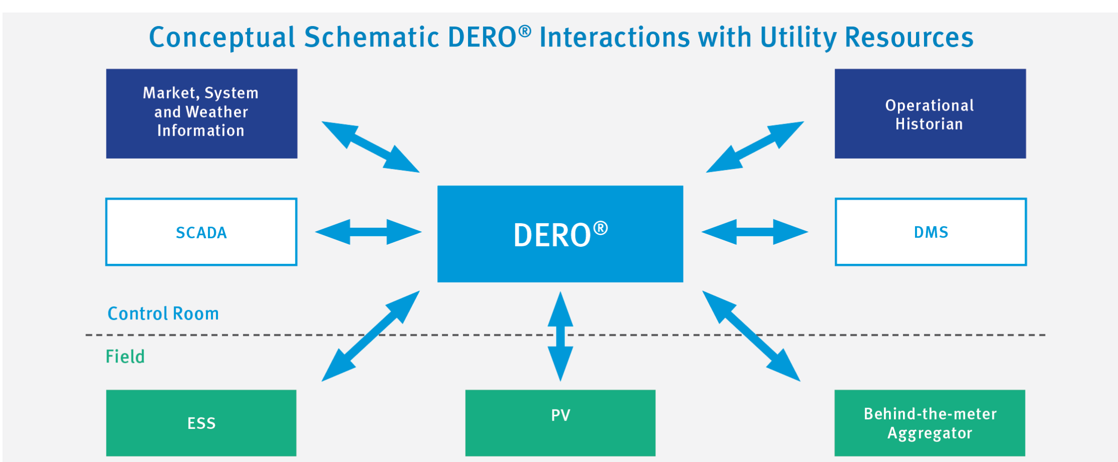
Doosan GridTech provides technology solutions for the digital distributed electric grid. Our control software for energy storage systems runs algorithms and applications that help utilities maintain power quality on circuits impacted by solar and other renewables, while taking full advantage of energy storage and other distributed energy resources. Powered by Doosan GridTech's extensive experience in circuit design and ESS integration, our power system engineering services ensure that an ESS is efficiently sized and optimally integrated into the utility infrastructure. For more information on Doosan GridTech products and services, see our website.

www.DoosanGridTech.com

Doosan GridTech Distributed Energy Resource Optimizer (DG-DERO) Product Description
Version 2.1
Rev 04.06 May-20

2.2 Introduction

The Doosan GridTech® Distributed Energy Resource Optimizer (DG-DERO®) is a software system that securely aggregates and optimizes the economic value of distributed energy resources connected to a distribution grid. Using DG-DERO, you can schedule, optimize, and manage a variety of energy assets in a holistic manner.



DG-DERO works with any MESA-ESS or DNP3-enabled ESS control system and is extensible to other intermediary technologies, such as PV aggregators, meter collars, and demand-response.

Based in the control center of an electrical distribution system, DG-DERO employs standards-based, real-time communication with external services such as a market trading system, and with internal operational technology such as SCADA (Supervisory Control and Data Acquisition) and an operational historian. When combined with the resource-based Doosan GridTech Intelligent Controller (DG-IC™), DG-DERO offers fleet- and circuit-management applications that complement the DG-IC's powerful suite of local operating modes, rounding out the Doosan GridTech platform for control of the energy storage systems and other distributed resources.

2.2.1 About This Manual

This manual describes how to operate DG-DERO. The manual is organized so that content begins with information relevant to all operators, then moves to the information relevant to power schedulers and, finally, to administrators.

The following sections are relevant to any DG-DERO operator or system administrator:

> **2.3 DG-DERO System Overview**, provides an overview of DG-DERO system architecture and requirements.
>
> **2.4 Optimizing with DG-DERO Applications**, provides an overview of the various bulk power and circuit-management applications that issue recommendations or make automatic adjustments to the system schedule in response to changing grid, market and resource conditions.
>
> **2.5 DG-DERO Operations Overview**, shows how to navigate and view information in the HMI and includes an overview of how the system schedule works.

The following sections are relevant to power schedulers (day-ahead and interval-ahead) and system administrators:

> **2.6 Managing the System Schedule**, shows how power schedulers can make adjustments to DERO's dispatch plan. Some installations allow the scheduler to assess the results of one or more DERO applications before they become part of the system schedule, and we show how to accept, reject, or override its day-ahead and interval-ahead recommendations.
>
> **2.7 Managing Energy Resources**, shows how monitor and manage the DERs on your distribution circuits, and how to use DG-DERO to work with individual resource schedules.
>
> **2.8 DERO Reports**, provides an overview of the reports DG-DERO generates on system performance, and the system audits and logs it maintains for administrative purposes and troubleshooting.

The following sections are primarily of interest to system administrators:

> **2.9 Monitoring Circuit Resources**, shows how to monitor circuit congestion, view the real-time voltage profile of circuit branches, and use the circuit schematics to zoom in on individual resources and view their measured parameters in real-time.
>
> **2.10 Configuration Settings**, shows how to access and change configuration settings, including how to configure the DERO applications and to set which resources they control; how to adjust the timing and frequency of DERO recommendations; and how to configure permissions and other administrative parameters.

2.2.2 Release Notes for DG-DERO Version 2.1

2.2.2.1 *System Schedule Page Improvements*

Charge and discharge events may now be broken down by their participating resources. Hovering over a charge/discharge bar on the System Schedule page will now display the resources which were active during the event along with their respective contributions.

Overrides are now tracked by user account. Hovering over any non-null cell in the Overrides row displays the user account name of the operator who submitted the override. Additionally, the User Overrides report now has a Submitted By column showing the same information.

In addition to State of Charge and current/past Deployments, the System Schedule now optionally displays the following:

- The allowable charge and discharge activity based on presently scheduled deployments;
- Historical and forecast Price curve;
- Historical and forecast Load curve.

2.2.2.2 *Resources Page improvements*

For resources which, in addition to supplying information on their **Nameplate Power**, also supply information on their maximum *active* power, a separate parameter for **Maximum Power** is now presented on the Resource summary page . As with Nameplate Power, this parameter is presented as two values: maximum active generation (a positive value); and maximum active charging (a negative value).

When you create a new resource schedule, the preview pane now shows the resource's present state of charge. In previous versions, this value defaulted to 50%. This enables the user to more reliably estimate what the state of charge should be when the schedule is run.

The Types of user schedules available to a resource are now limited to only those types for which the resource has the coinciding operating mode.

Schedule Types now more closely align with the names of their corresponding DG-IC operating modes.

The resource schedules list may now be sorted by any column.

2.2.2.3 *Reports Page Improvements*

On the Optimizer Audit reports, the resource name now appears as a separate column, enabling the user to audit and compare optimizer performance for individual resources.

Some reports now allow you to choose the specific resources and meters from which the data is derived.

The Alert History, Optimizer Audit, and Web Service Audit report all now include an Export option

2.2.2.4 *Help Page Improvements*

In addition to providing access to an online version of this manual, the **Help** page now provides the software version number, the relevant open source and commercial licenses, and contact information for DERO product support.

2.2.2.5 *Other improvements*

If multiple Errors or Warnings (priority 1 and 2 alerts) are active simultaneously, the number presently in the "Abnormal" state is indicated by a small number within the icon displayed on the DERO navigation bar.

Various performance enhancements.

2.3 DG-DERO System Overview

DG-DERO™ is server-based software, typically located in the control center of an electrical distribution utility and connected to one or more distributed energy resources via the utility's control and scheduling systems. DG-DERO synthesizes streams of operational and market-based information to derive a system-wide schedule or dispatch plan for the connected energy resources. DG-DERO then issues ongoing recommendations to power schedulers and makes real-time schedule adjustments in response to changing grid, market, and resource conditions throughout the day.

This section includes:

2.3.1 Architectural Overview

An installation of DG-DERO includes a combination of the following components:

- Doosan GridTech Data Retrieval Service and DERO Database – Collects and merges data from external and operational sources, such as market trading systems (e.g., OATI webTrader), solar and wind forecasts, and the operational historian (e.g., eDNA or Pi), and relays the information to the Optimizer Service.
- Doosan GridTech Distributed Energy Resource Optimizer Service – Runs algorithms on the data and draws on its suite of applications to determine an optimal resource dispatch plan, which it relays either directly to the resources in the field, or to the Scheduling Service.
- Doosan GridTech Scheduling Service – Executes dispatch schedules for energy resources incapable of storing and managing their own schedules.
- Doosan GridTech Schedule Integration Service – An optional service that enables the safe transfer of files between the operational and corporate network across a firewall.
- DG-DERO HMI, a graphical web application using Internet Information Services (IIS) for Windows Server.

The data provided to the Optimizer Service includes the live streams of data coming from power meters and other devices in the field via control systems, such as SCADA or ADMS which DERO uses to make real-time adjustments to the system schedule. DERO may be configured to use forecast data, such as for peak loads, energy prices, and weather forecasts to make automatic adjustments or to issue day-ahead or interval-ahead recommendations to power schedulers who can then make changes to the recommendations before they are integrated into the dispatch plan.

Whether the adjustments are made automatically or via recommendations, the rationale behind each of DERO's decisions is made available to the power scheduler via the HMI, and schedulers are free to override any of its decisions.

Figure 1 on page 61 shows an overview of DG-DERO architecture.

2.3.2 Networking

Networking between DG-DERO components and utility control systems depends on how the utility handles its internal networking, and on requirements for how the particular DG-DERO installation connects to its grid assets. Figure 1 shows one possible configuration of DG-DERO components installed in a typical utility network structure.

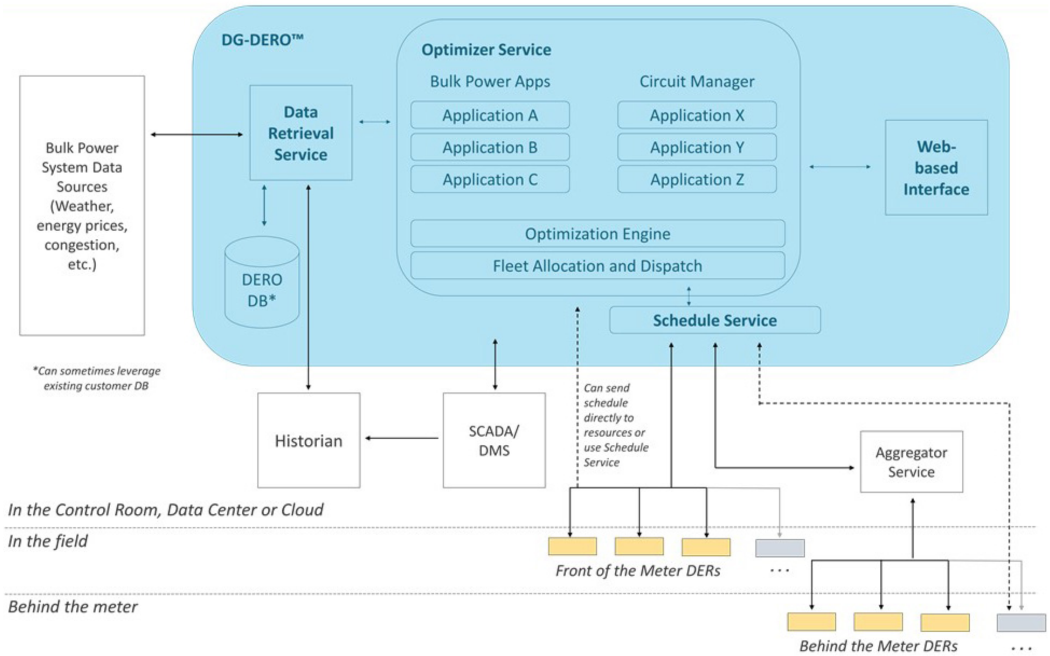


Figure 2-1 DG-DERO Architectural Overview

For detailed information on networking for your DG-DERO installation, see the *Installation Manual* included with your documentation package.

2.3.3 Requirements

DG-DERO software is designed to run on either physical or virtual machines.

DG-DERO requires the following software installations, configurations, and connections to be in place prior to installation. For details on your DG-DERO installation's configurations and connections, see the *DG-DERO Installation Manual* provided with your documentation package.

- Windows Server 2012 R2 Standard (with the latest Windows Updates) installed on each server machine where DG-DERO components will reside.
- A SQL Server 2012 R2 64-bit or newer.
- Minimum hardware requirements include a CPU of 2 GHz or higher (two cores minimum) , at least 8 GB of RAM, and at least 250 GB of storage.
- Two sets of DERO Active Directory security groups, one for DG-DERO HMI access, and one for DG-DERO database access.

2.4 Optimizing with DG-DERO Applications

DG-DERO draws on a suite of bulk power and circuit-management applications to determine an optimal dispatch plan for your distributed energy resources, then presents the plan to power schedulers for acceptance or refinement.

This section includes:

2.4.1 How DG-DERO Applications Work

The DG-DERO applications synthesize streams of operational and market-based information and run algorithms to derive the system schedule for your distributed energy resources. Throughout the day, these applications trigger schedule adjustments, automatically or via appropriately timed recommendations, in response to changing grid, market, and resource conditions. See 2.6 Managing the System Schedule.

DERO Optimization

When each application runs, it calculates a dispatch strategy that best serves its designated goals —to store energy against future price increases, to smooth circuit-level voltage fluctuations, etc.—and submits its calculations as value coefficients and constraints to the optimization engine. These and other constraints, including user-configurable settings, resource capacity, system degradation, operation and maintenance costs, etc. are integrated into the calculations performed by the optimizer engine, which evaluates the inputs and submits real power resource schedules that maximize the economic value of its assets.

Applications and Purposes

Table 2-1 lists all DG-DERO's applications along with their purposes.

Table 2-1: DG-DERO Applications

Application	Purpose
Peak Load Reduction	Makes **five-minutes ahead** adjustments in response to load forecasting to reduce circuit loads during the peak load intervals established by the transmission system operator, with the goal of reducing the distributor's load-ratio share for the following year.
Real Time Price Dispatch	Makes **five-minutes ahead** adjustments in response to price forecasting, taking advantage of the volatility of real-time energy prices. The adjustments account for the forecast LMP as well as their effect on battery life and performance.
Energy Arbitrage	Constitutes the basis for DERO's **Day-ahead** adjustments or recommendations based on load and price forecasting. The Energy Arbitrage recommendation forms the initial system schedule for the following day. Local circuit factors, such as resource limits, maintenance events, and expected SOC at start of day are also considered in formulating the recommended schedule.
Voltage Support	Makes **five-minutes ahead** adjustments to the reactive power output of the circuit's DERs in response to voltage fluctuations on a given circuit.
Congestion Management	Makes **five-minutes ahead** adjustments to the real power output of the circuit's DERs in response to unexpected circuit-level congestion.
Resource Maintenance	Responds to a sudden drop in the system's state of charge or available power (such as when a resource fails or is temporarily excluded from the system for maintenance purposes) and, in the absence of a pending optimization-run from another application, instructs DERO to re-optimize the System Schedule. **Note:** Because it responds to exigent system-level constraints, the Resource Maintenance application takes precedence in DERO optimization and cannot be disabled.

To determine which applications are enabled for a given resource, see 2.10.3 'Resources Per Application' Settings. To monitor the performance of the DERO applications over a given time, see 2.8.3 Application Reports.

Nimble Responses to Changing Conditions

Based on forecasts for anticipated market and environmental conditions, the deployed system schedule maps out optimal operations (charge or discharge real power, inject or absorb reactive power) to serve utility priorities. As conditions change, the DG-DERO applications respond, either by making automatic adjustments to the system schedule, or by submitting recommendations for approval by the system operator.

For example, if a price spike is forecast for the following day, the Energy Arbitrage application's day-ahead recommendation will be to adjust charge/discharge timing and power over that period. More immediately, unexpected circuit level congestion will trigger the Congestion Management application to respond by making five-minutes ahead adjustments to the output of the circuit's distributed assets.

And, to keep the whole system running smoothly, DERO will make automatic corrections to the state of charge of its energy storage assets so that energy is available when needed without causing undue stress on energy assets or the local circuit.

Figure 2-1 shows how the various DG-DERO applications operate on day-ahead, hour-ahead, and within-hour scheduled operations.

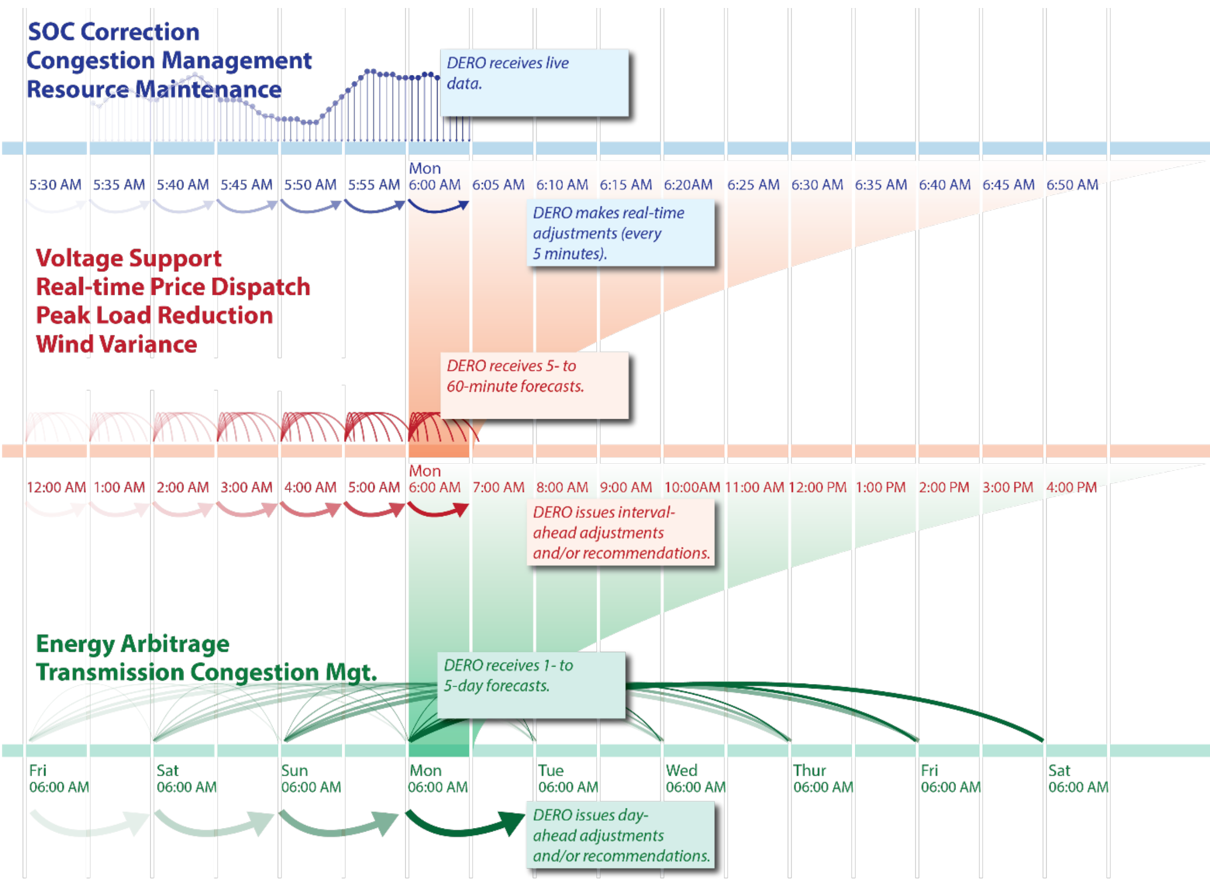


Figure 2-2 DG-DERO Applications Related to Power Schedule Periods

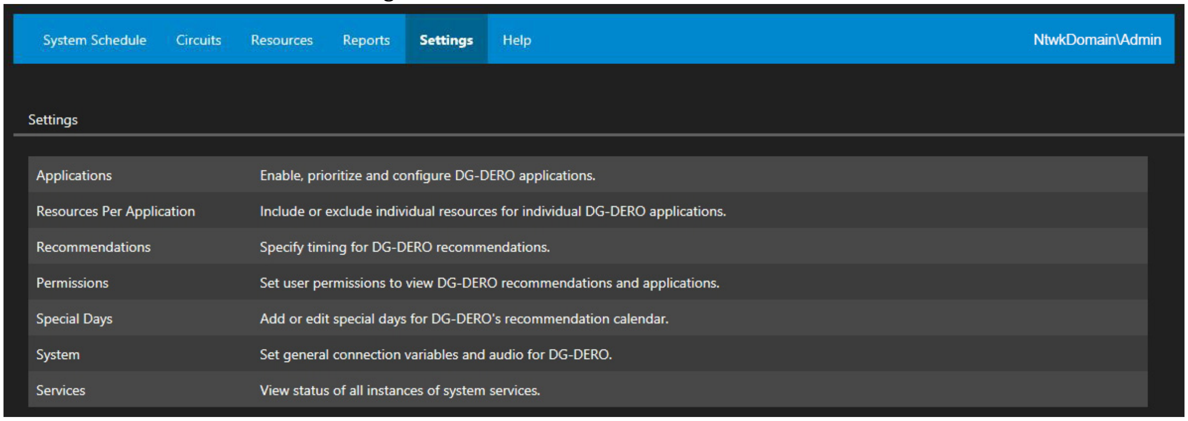
Power schedulers who use DG-DERO to monitor and adjust the deployed system schedule are granted permissions to view either Day-head or Interval-ahead Recommendations, or both. For more about how power schedules monitor and manage recommendations on the system schedule, see 2.5 DG-DERO Operations Overview, and 2.6 Managing the System Schedule.

2.4.2 Accessing Settings for Applications

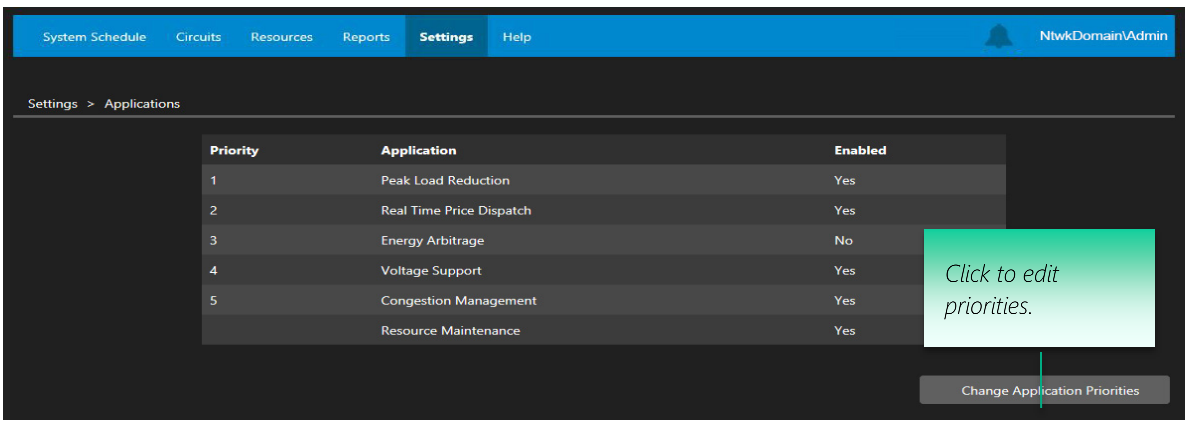
To edit configuration settings, you must be logged in with DG-DERO Administrator privileges.

To edit settings for applications:

1 Log into DG-DERO using an account with DG-DERO Administrator privileges. For more on logging in, see 2.5.2 Authorization and User Privileges

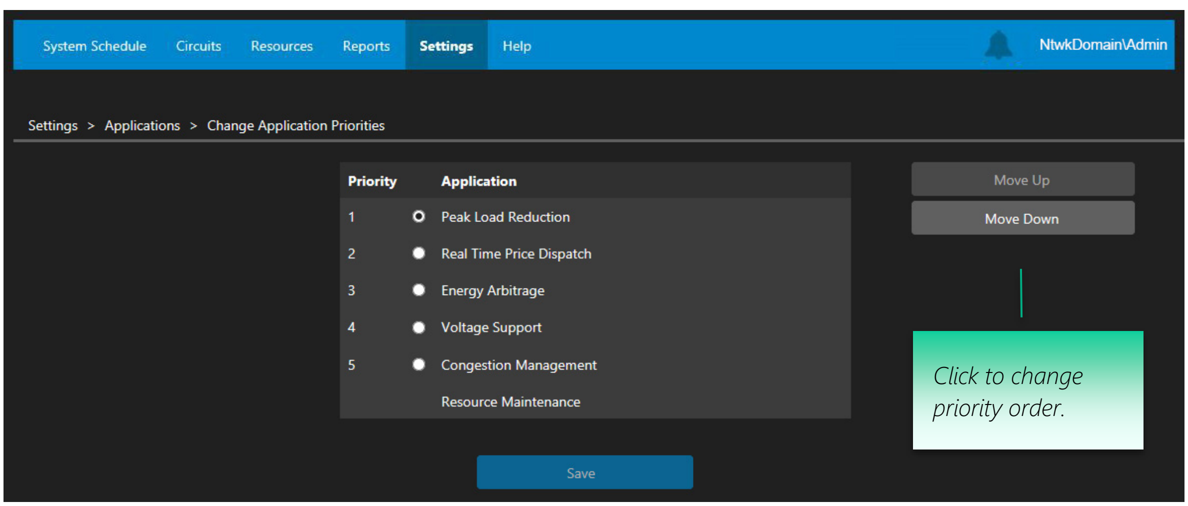


2 Click the **Settings** tab, then click the row for **Applications** settings.
DG-DERO displays the Applications settings page. The applications with configurable settings are listed in order of priority.



To configure an application's settings, click the row for the application.

To adjust the priority order, click **Change Application Priorities**.



For details on each application's settings, and more about adjusting the order of priority, see 2.10.2 'Applications' Settings.

2.5 DG-DERO Operations Overview

DG-DERO operations are monitored, configured and executed through the DG-DERO HMI, a graphical web-based application using Internet Information Services (IIS) for Windows Server.

This section includes:

- 2.5.1 **Starting and Closing the DG-DERO HMI**
- 2.5.2 **Authorization and User Privileges**
- 2.5.3 **Getting Around DG-DERO**
- 2.5.4 **The System Schedule Page**
- 2.5.5 **The Circuits Page**
- 2.5.6 **The Resources Page**
- 2.5.7 **The Reports Page**
- 2.5.8 **The Settings Page**
- 2.5.9 **Notifications and Alerts**
- 2.5.10 **Getting Help**

The DG-DERO HMI is a graphical web application hosted on Internet Information Services (IIS) for Windows Server. Web-based applications have many advantages, including the ability to run on any platform, and of faster development cycles that adapt more quickly to user requirements. The ability to run a variety of browsers on multiple platforms also means that DG-DERO may look and feel slightly different in different contexts. Note that all the screen images in this manual were taken using Internet Explorer.

> **!** As with all browser-based applications, navigating away from a DG-DERO page that contains unsaved edits (or un-submitted overrides) will result in those changes being lost. Depending on your browser, a message will usually be displayed alerting you to that fact. *In all cases, leaving a page in DG-DERO without first* ***saving*** *or* ***submitting*** *any changes you've made will result in those changes being discarded.*

2.5.1 Starting and Closing the DG-DERO HMI

Aside from restrictions set by your network administrator, the DG-DERO HMI can be accessed through any machine on your corporate network.

To access the DG-DERO HMI:

1. Open a browser and point it to the host name or IP address that was established for the site on installation.
2. If prompted, enter your DG-DERO user credentials.
3. Once logged in, your network domain and DG-DERO user name appear in the upper right of the DG-DERO navigation bar.

4. Your access to DG-DERO operations is limited according to the User Group restrictions outlined below.

2.5.2 Authorization and User Privileges

Each DG-DERO user, identified by their login credentials, belongs to one of the following three Active Directory security groups which provide varying levels of access to the DERO HMI:

Doosan GridTech DERO Read-only Users: Members of this group have read-only access to all pages and views in DERO. They can monitor all operations in DG-DERO and export Reports but cannot approve schedules, submit overrides, or reset system alerts and notifications.
Doosan GridTech DERO Users: Members of this group may submit overrides to the System Schedule, approve or reject day-ahead or interval-ahead recommendations, respond to and reset system alerts and notifications, and/or access the Circuits page.
Doosan GridTech DERO Administrators: The Administrator has full access to the DG-DERO HMI, including Resources and resource scheduling, Circuits, Reports, Settings, and all operations in the System Schedule.

DG-DERO Administrators assign the following permissions to members of the first two security groups:

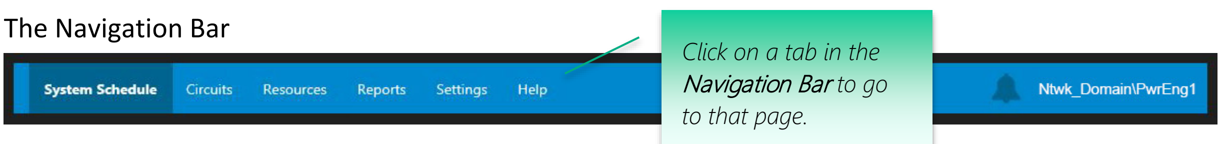
Interval-Ahead Permission: Allows the user to view *Interval-Ahead* recommendations for the system schedule. Enables users with write access to approve, reject, submit and override *Interval-Ahead* recommendations, and to reset relevant system alerts and notifications.
Day-Ahead Permission: Allows the user to view *Day-Ahead* recommendations for the system schedule. Enables users with write access to approve, reject, submit, and override *Day-Ahead* recommendations, and to reset relevant system alerts and notifications.
Energy Control Center Permission: Allows the user to access to the Circuits page where they can monitor individual resources by their relative location and connections with other resources on the same circuit.

DG-DERO works with most enterprise authorization strategies and offers robust authentication and identity management where needed.

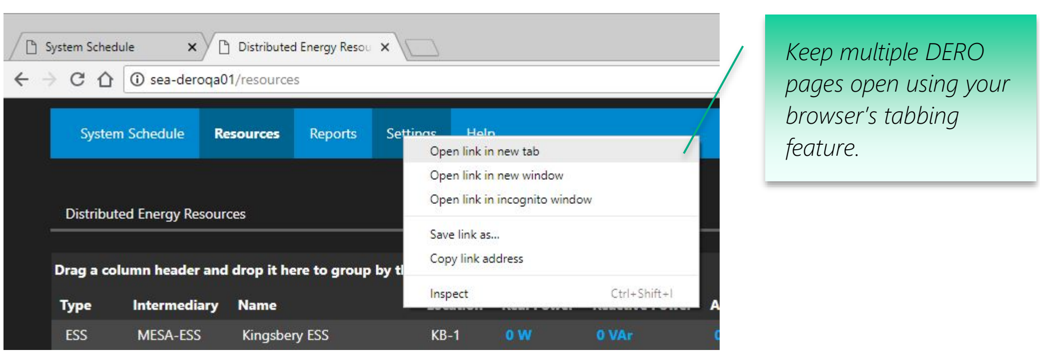
2.5.3 Getting Around DG-DERO

There are five primary views, or pages, in the DG-DERO HMI, and these are laid out as tabs across the Navigation Bar at the top of the screen: System Schedule; Circuits; Resources; Reports; and Settings.

The Navigation Bar

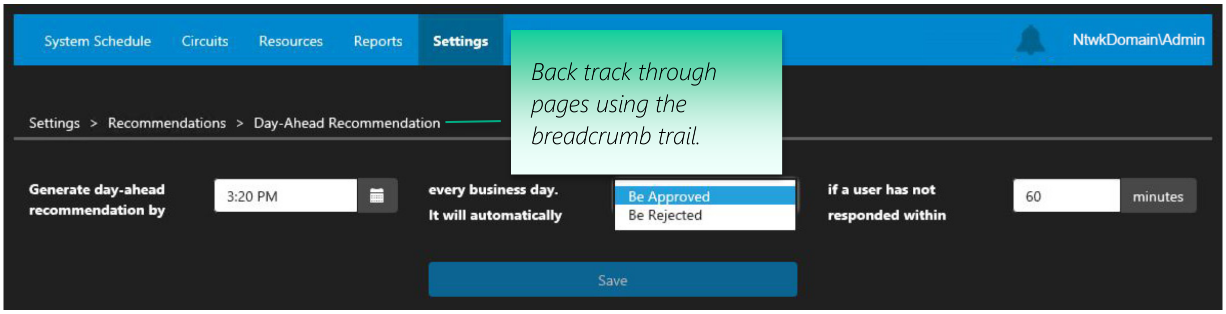


Most browsers allow for multiple pages to be displayed simultaneously, either as separate windows or as tabs. This enables you to view and compare two or more DERO pages without having to navigate between them.



The Breadcrumb Trail

When navigating deeper into the interface, the path you followed is displayed just under the Navigation Bar on the left side of the screen. This "breadcrumb trail" provides a means of quickly returning to a previous page.



2.5.4 The System Schedule Page

The DG-DERO home page is the **System Schedule**, where the DG-DERO's system deployments are monitored and tracked in relation to the utility's actual, forecast and scheduled loads. The **DG-DERO control panel** at the bottom of the System Schedule page enables power schedulers to view and refine the daily, hourly and real-time recommendations and adjustments generated by DERO's fleet- and circuit-management applications.

Graphically represented in the upper two-thirds of the page is the system's **State of Charge,** tracked over time, with scheduled and past **Deployments** represented by vertical gray bars spanning the interval in the current view. Power or Energy that is scheduled to be dispatched by the end of the interval is represented by a light gray bar, which changes to a dark gray bar as deployments move into the past. The **allowable range of charge/discharge activity** is indicated by a shade of gray just lighter than the background color.

The **Forecast** row shows the load forecast (in megawatts or megawatt-hours) from the start of the current day, and the loads forecast for the next five days. System **Load** is also tracked on the chart concurrent with the **State of Charge** and **Price** forecast.

The **Actual/Adj. Forecast** row shows the actual loads (in megawatts or megawatt-hours) from the last 24 hours, and the loads forecast for the next five days as adjusted by the DG-DERO recommendations and operator overrides.

The four rows labeled **DERO** are where DG-DERO recommendations (Day-Ahead and Interval-Ahead adjustments) are assessed, and overrides are executed by the power schedulers. The values are in megawatts (MW) or megawatt hours (MWh)—depending on whether Power or Energy is selected in the current view—with negative values representing power or energy from the grid (charging the system) and positive values representing power or energy made available to the grid (discharging the system).

- The **Deployed** row displays the current schedule of system deployments accepted by DG-DERO.
- The **Recommendations** row is where recommended adjustments coming from DG-DERO are made available for review by the power schedulers.
- The **Override** row is where power schedulers can enter any overrides to the recommended adjustments or currently deployed values.
- The **Effective** row displays the actual adjustments which DERO determines can be made given the currently active schedule and any overrides suggested by the power scheduler.

Across the bottom of the System schedule page are buttons to **Submit** or **Reject** DERO recommendations and user overrides.

The **Notes** field provides space for comments the operator may wish to be logged along with their submission or rejection.

Viewing Contributing Factors to Recommended or Deployed Values

Each enabled application participating in DERO optimization will have goals that contribute either positively or negatively to the results. Applications which push the result in the direction determined by optimization, i.e. to charge or discharge real power, or to absorb or inject reactive power, “Agree” with the result; dissenting applications “Disagree” with the result.

Other influences include the following”

> <u>Future Needs (High/Medium/Low)</u>– Future requirements for system capability rated on a scale from low, to medium, to high;
>
> <u>User overrides</u> – Operator-initiated deployments or overrides to DERO’s recommended and scheduled deployments;
>
> <u>System Constraints</u> – System-level constraints, such as state of charge.
>
> <u>Resource Maintenance</u> – Influences include: Resource outages; Resources switching from Automatic to Local Mode, and; Resources excluded from DERO optimization.

To view a summary of the factors contributing to a DERO action

In the DERO control panel in the lower portion of the System Schedule page, hover the mouse pointer over any value in the Recommendations or Deployed rows.

Applications are grouped by their agreement or disagreement with the optimized result’s direction, and then sorted by the degree to which their goals harmonize with the result. Other influences are sorted by the degree of their influence over the result.

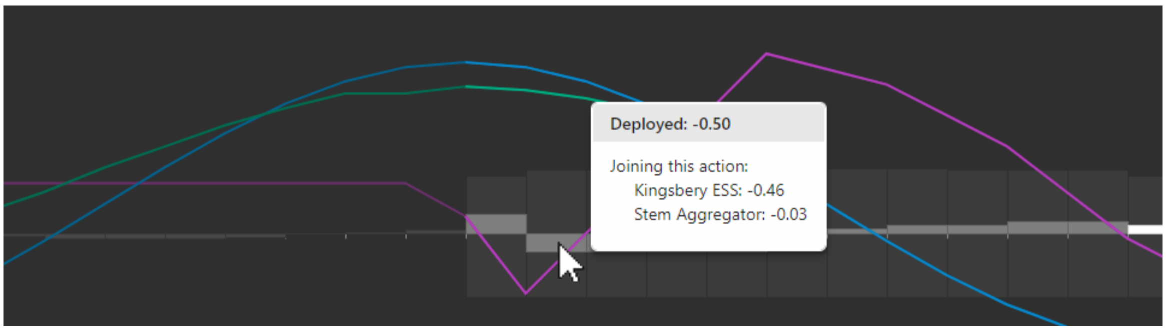
Note: If there has been no DERO activity, no summary popup will appear for that block of time. Activity not initiated by DERO, such as the charging and discharging from user-generated resource schedules, is not included in the summary popup.

For more detailed information about how DERO arrived at its decisions, see 2.8 DERO Reports. For more information on system scheduling, see 2.6 Managing the System Schedule

To view the resources contributing to a DERO action

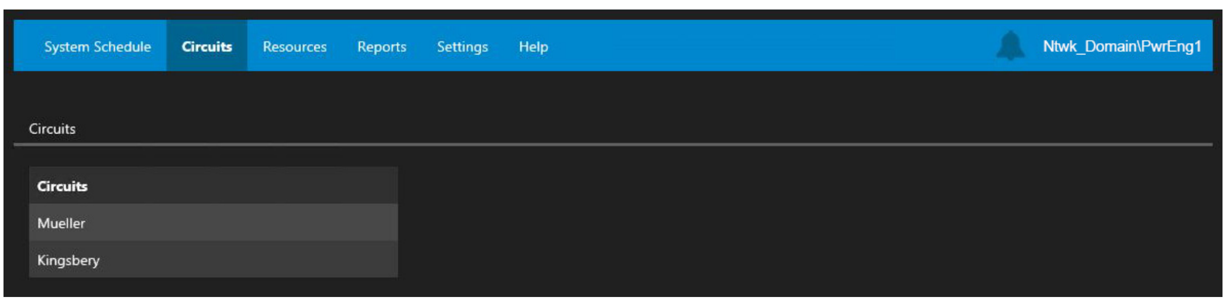
In chart portion of the System Schedule, hover the mouse pointer over any deployment (light gray box)

Resources contributing to or mitigating the action are listed along with the values of their contribution.



2.5.5 The Circuits Page

The Circuits page lists the circuits on which DERO's resources are distributed.

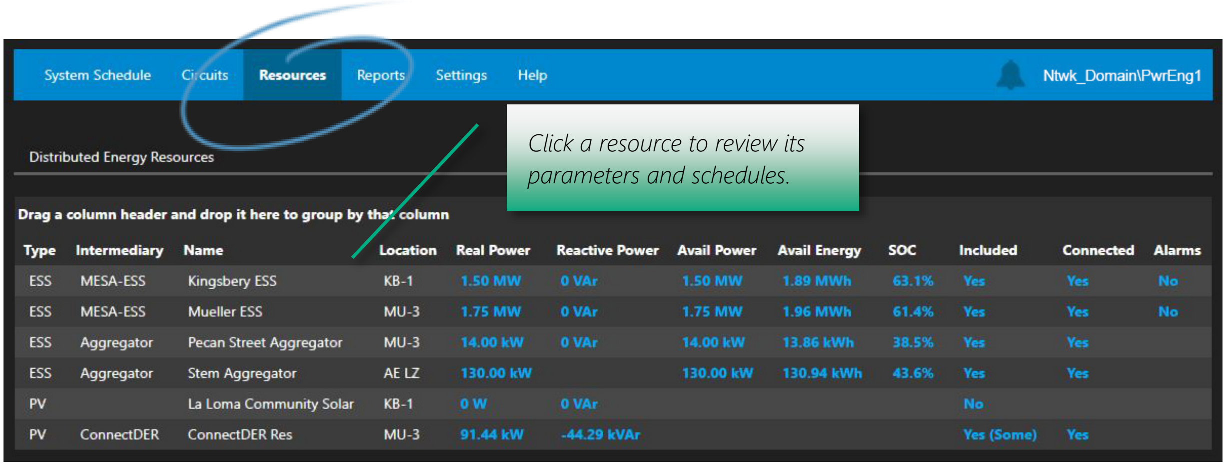


Clicking on a circuit opens its Circuit Details page with several **View** options, including a schematic view of the entire circuit showing the distribution and interconnections of all of its devices and resources, along with their real-time measured values.

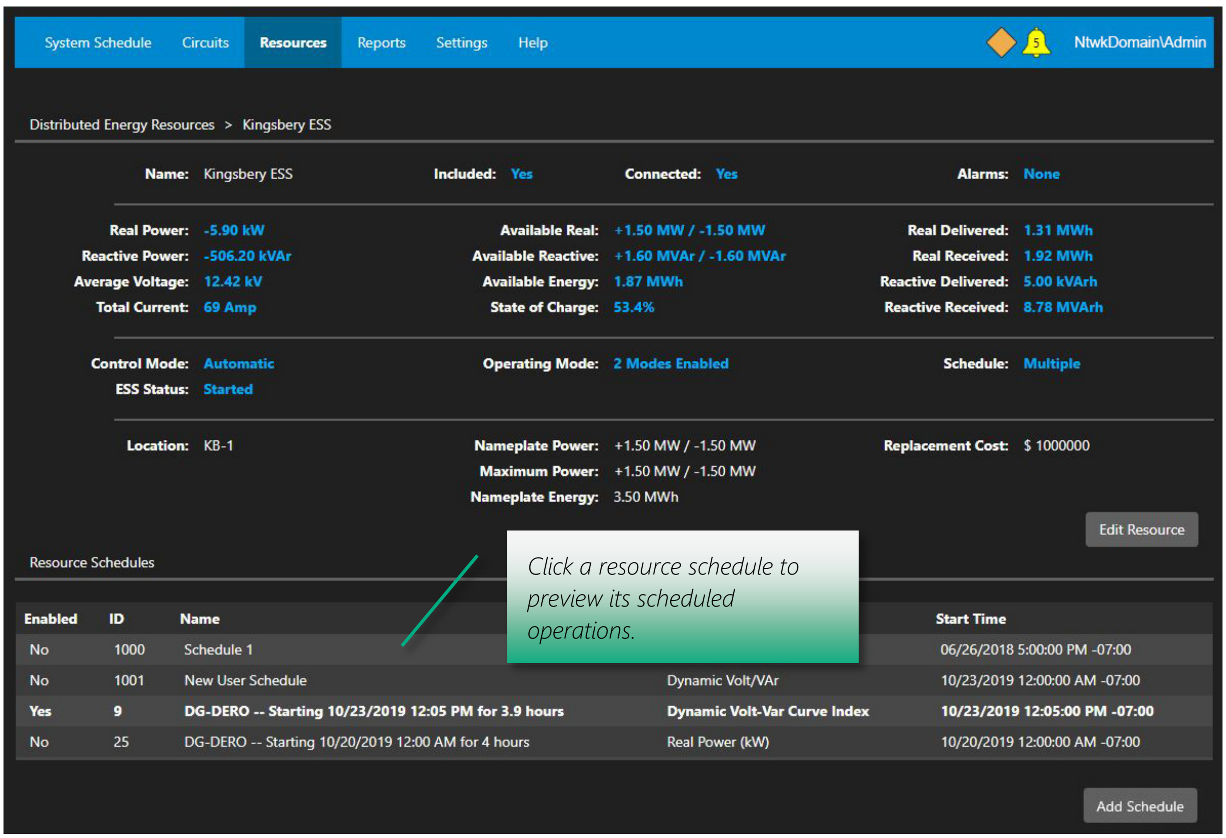
For more information, see 2.9 Monitoring Circuit Resources.

2.5.6 The Resources Page

The Resources page lists the energy resources (e.g., energy storage systems, and distributed energy resources) available to DG-DERO. Each resource is listed by name and location along with its relevant parameters and whether it is currently included or excluded from DG-DERO optimization.



Clicking an individual resource brings up the resource details page where administrators can include or exclude the selected resource from DERO optimization, and power schedulers can review DERO's reserved schedules, both as charts and as tabular data, and create and modify user-generated resource schedules that run independently of the DG-DERO optimizer.



Clicking a resource schedule displays the schedule's operational parameters and set points. Administrators and power schedulers can adjust these settings and graphically preview the schedule's operations.

For more detailed information, see 2.7 Managing Energy Resources.

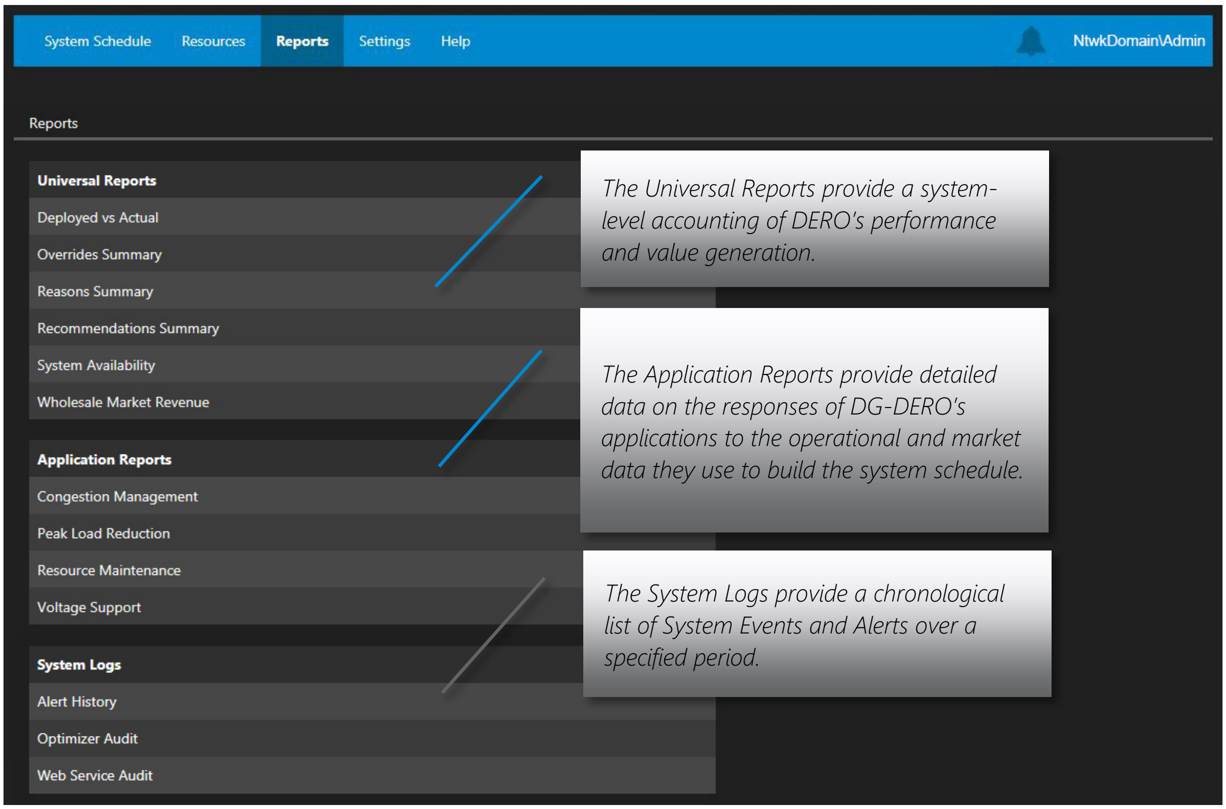
2.5.7 The Reports Page

DG-DERO provides built in reports with exportable data to inform the users about its performance. The reports are broadly divided into three categories: **Universal Reports**, **Application Reports** and **System Logs**.

The **Universal Reports** provide a system-level accounting of DERO's performance and value generation.

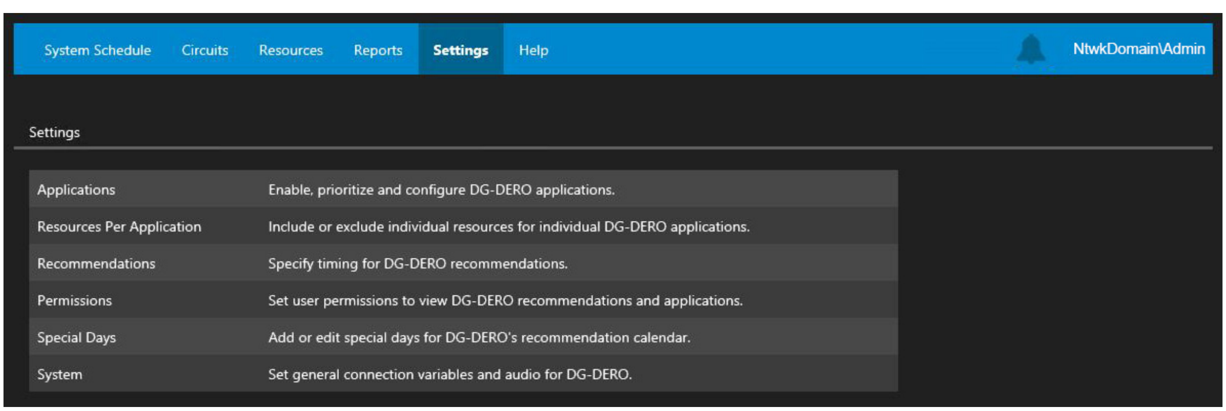
The **Application Reports** provide detailed data on the responses of DG-DERO's fleet- and circuit-management applications to the operational and market data they use to build the system schedule.

The **System Logs** provide a chronological list of System Events and Alerts over a specified period. The System Audit report (available to Administrators only) includes user log-ins, setting updates, recommendations, schedule submittals/rejections, resource status, report requests, etc. Both the System Audit and the Alert History reports default to the previous full day.



2.5.8 The Settings Page

Members of the DG-DERO Administrators security group can use the Settings page to configure DG-DERO to the specific needs of their utility and power schedulers.

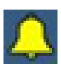


These settings are grouped into the following categories:

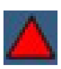
- **Applications**: Enable, disable, prioritize, and configure the DG-DERO applications. See 2.4 Optimizing with DG-DERO Applications, and 2.10.2 'Applications' Settings
- **Resources Per Application**: Include or exclude individual resources for individual DG-DERO applications. See 2.10.3 'Resources Per Application' Settings.
- **Recommendations**: Specify the frequency and timing of DG-DERO recommendations. See 2.10.4 'Recommendations' Settings.
- **Permissions**: Assign user permissions for approving or rejecting DERO's day-ahead or interval-ahead recommendations, and for access to the Circuits page. See 2.10.5 'Permissions' Settings.
- **Special Days:** Add or edit holidays for DG-DERO's Recommendations calendar. See 2.10.6 'Special Days' Settings.
- **System**: Set the general connection variables associated with DG-DERO's external data sources. See 2.10.7 'System' Settings.
- **Services**: For DG-DERO installations where one of or more of its services is set up with redundancy and failover, administrators can view the status and current rank of each component. See 2.10.8 'Services' Settings.

2.5.9 Notifications and Alerts

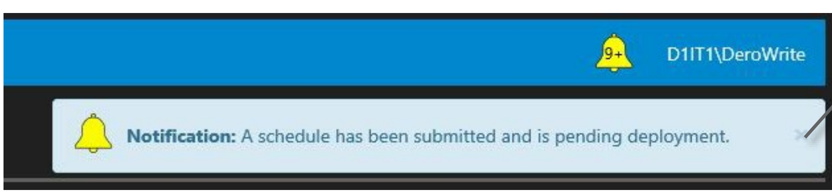
System events that may require attention are communicated through notifications and alerts. Their severity is indicated by a symbol, which appears as a clickable icon on the navigation bar.


Notifications. Identified by a yellow bell icon; indicate such things as the availability of new recommendations, schedule submissions, and overrides.


Warnings. Identified by an orange diamond icon; require acknowledgment by the operator; indicate non-system-critical events, such as a delay in receiving a load forecast. Also referred to as **Priority 2 (P2)** alerts

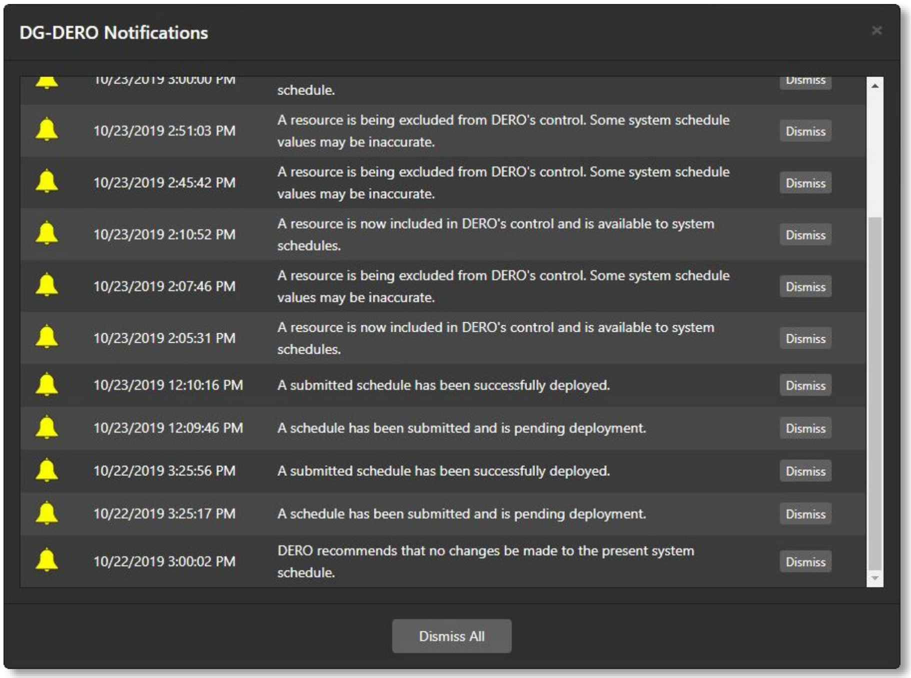

Errors. Identified by a red triangle icon; indicate system errors that often require immediate attention from the operator. These are events critical to the system's operation, such as the loss of communication with an external service. Also referred to as **Priority 1 (P1)** alerts.

Any new alert or notification will be signaled with a tone (configurable in Settings, see 2.10.7 'System' Settings) and will initially appear as banner below the icons in the upper right of the navigation bar. The banner can be closed, and will otherwise disappear after a few minutes, but the notification or alert can still be reviewed by clicking its icon on the navigation bar.

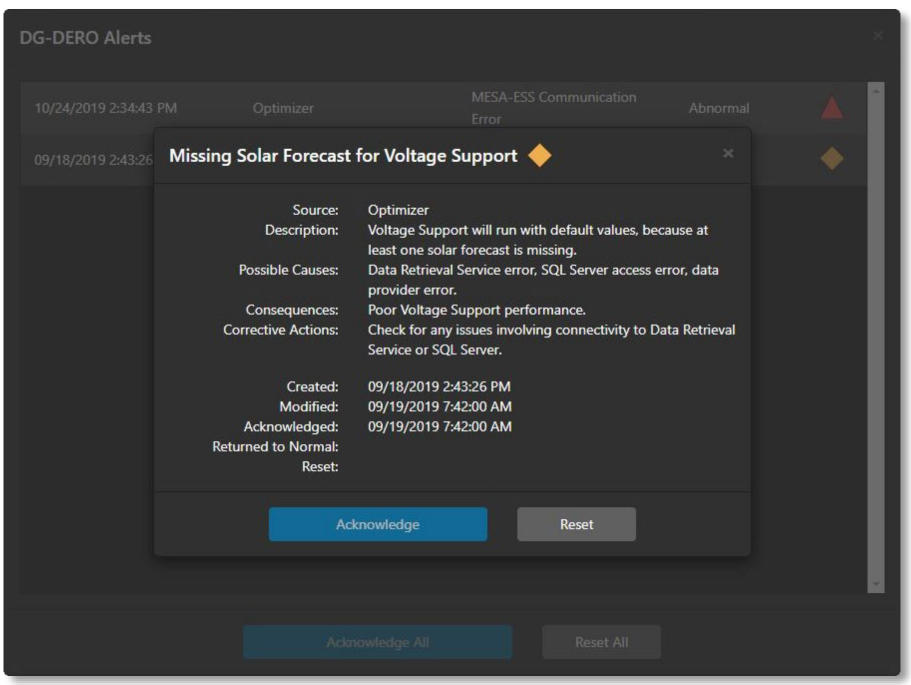


Banners alert you to new system events. Click the X to close.

- To view all active alerts or notifications, click the corresponding icon in the navigation bar. A list of all active notifications or alerts is displayed.



- In the notifications list, click **Dismiss All**, or in alerts list, click **Acknowledge All** to stop the icon from flashing.
- Additional details are provided from Warnings and Errors. Clicking a line on the alerts list displays a popup with information to help you isolate its cause to take corrective action.



- In the details window, you can **Acknowledge** or **Reset** individual alerts. Errors that require operator intervention cannot be reset until the underlying problem is addressed.
- To reset all active alerts, click **Reset All** in the alerts list.

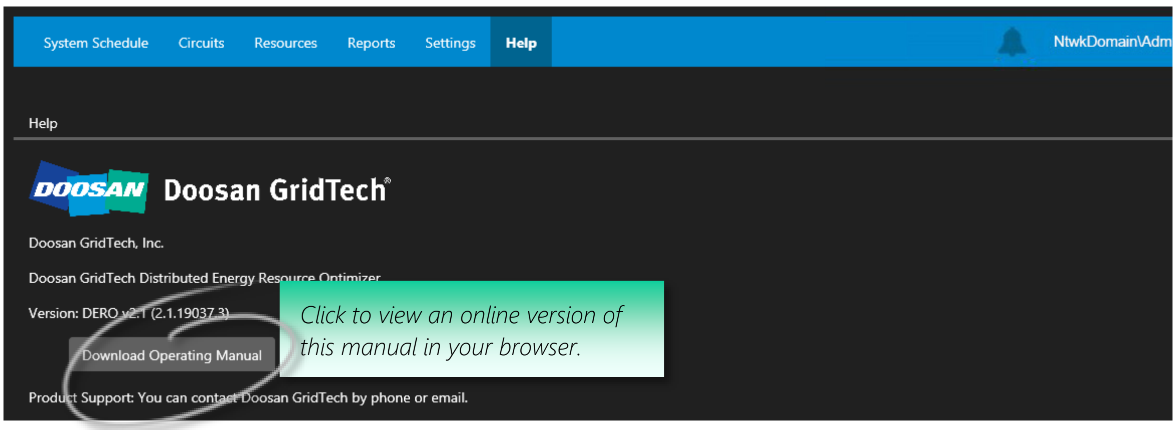
Alerts that have been reset can be reviewed in the **Alert History** report, and Recommendations that have been rejected or approved can be reviewed in the **Recommendations Summary**, both accessible from the **Reports** page.

2.5.10 Getting Help

The **Help** page provides the version number, licensing, and contact information for product support. There is also a link which opens the online version of this manual, which you can view in a tab or a separate browser window concurrently with DERO.

To open this operating manual in your browser

1. Click the **Help** tab and, near the top of Help page,
2. Click the button labeled **Download Operating Manual.**

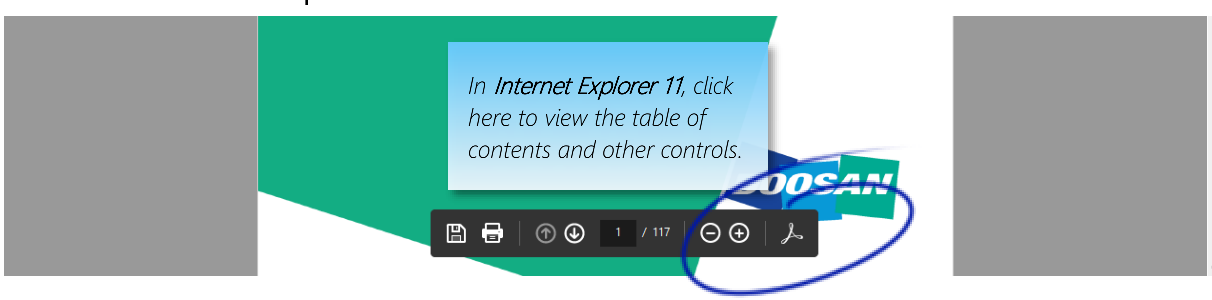


The operating manual is a 10MB PDF. If this is the first time you've accessed the manual through the DERO HMI, there will be a delay while the file downloads. Once the file has been downloaded to your local machine, it will open in separate tab in your browser.

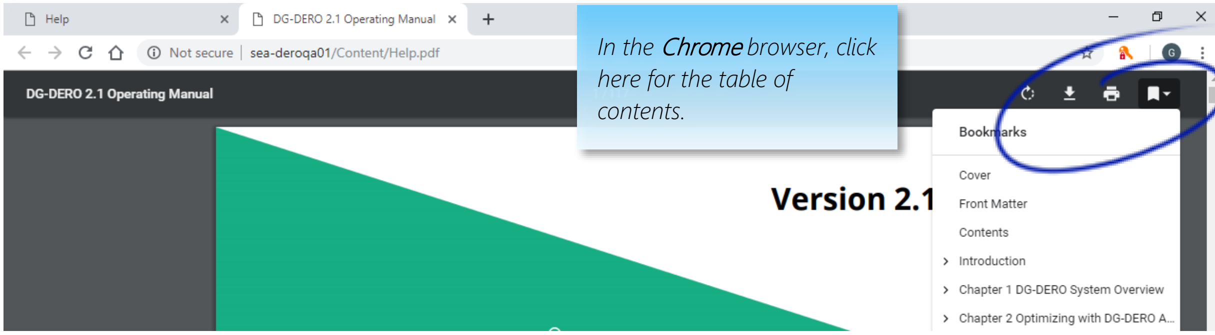
Help Viewing Options

Browsers differ in the way they display PDF files, but all should provide the same navigation controls you'd get with a standalone PDF reader, such as Adobe Reader or Acrobat.

View a PDF in Internet Explorer 11



View a PDF in Chrome



View a PDF in Edge

2.6 Managing the System Schedule

The **System Schedule** page tracks system loads and DG-DERO's system deployments from start of the current day to 120 hours into the future. As load, generation, and market conditions change throughout the day, DG-DERO makes real-time adjustments, and issues recommendations that power schedulers can accept, reject, or fine-tune to suit local circuit needs.

This section includes:

To view the system schedule:

- Click the **System Schedule** tab in the navigation bar.

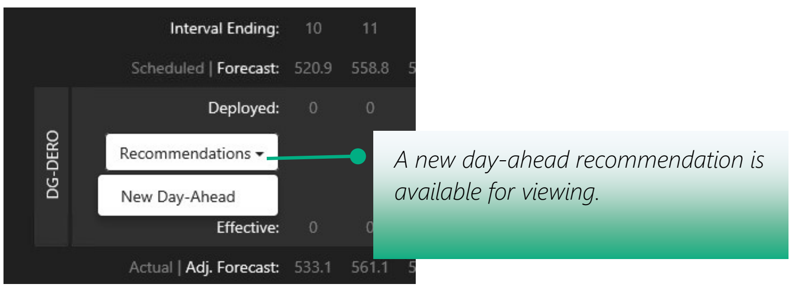
2.6.1 How Recommendations Work

Throughout the day, DG-DERO makes automatic adjustments to the system schedule, or issues appropriately timed recommendations, in response to changing conditions as tracked by DG-DERO's applications. Each application has its own purpose and focuses on the conditions that affect its particular goals. For a list of all the applications and their purposes, see 2.4 Optimizing with DG-DERO Applications.

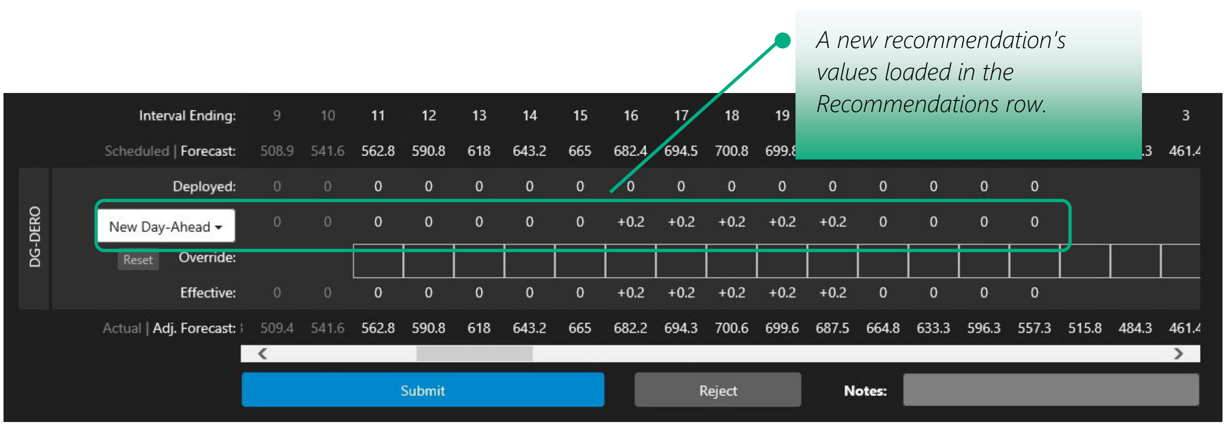
Recommendations are initiated by individual applications, each of which are categorized by the frequency with which they issue requests for changes to the system schedule. All day-ahead applications, for example, contribute to DERO's issuing of a single day-ahead recommendation, rather than a separate recommendation for each of them. When called upon to adjust the schedule, DERO considers the input of all currently-enabled applications, as well as other factors, including: future needs for system capability, operator-initiated deployments or overrides to DERO's previously recommended and scheduled deployments; system-level constraints; previously approved recommendations, and; resource availability. DERO then reconciles these various inputs to make automatic adjustments to the system schedule or to formulate a **recommendation** for approval by an operator.

Some applications, singularly or in combination, issue **day-ahead recommendations** for deployments spanning the next one-to-five days. Day-ahead recommendations are displayed to power schedulers with privileges to view day-ahead schedules. Other applications issue **interval-ahead recommendations** that apply to scheduling within the current day and are displayed to interval-ahead schedulers. (see 2.5.2 Authorization and User Privileges)

After the appropriate applications have issued their individual requests, DERO formulates a recommendation that consolidates their differences and reconciles the results with various other constraints. DERO then displays, in the System Schedule's Recommendations row, a notification indicating that a recommendation is available.



To view the recommendation, the power scheduler selects it from the drop-down. The recommended new values for deployment appear in the Recommendations row.



The power scheduler can then submit the recommendation unchanged, reject it, or fine-tune the recommendation by entering preferred values in the Override row.

To handle cases in which a recommendation approaches present time without receiving a response from a power scheduler, DG-DERO is configured to either automatically accept or reject a recommendation after a timeout period. For information on configuration settings for recommendations, see 2.10.4 'Recommendations' Settings.

To accept a recommendation without changing it:

With the recommendation's values loaded in the Recommendations row, click the **Submit** button. While the submission is in process, the Submit button displays "**Submitted and Pending…**" and the DERO control panel is disabled. A submission can take a several minutes to deploy.

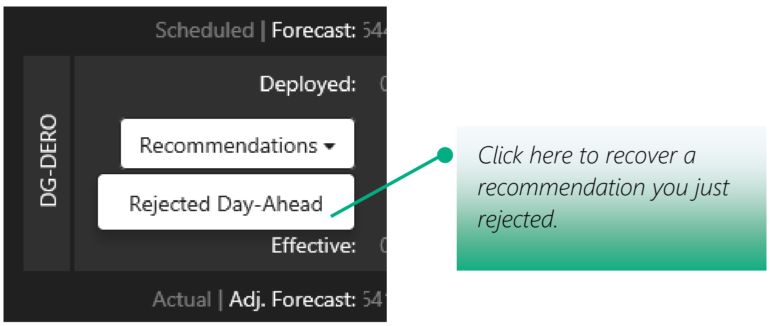
> **!** **Any values in the Override row will always take precedence over values in the Recommendations row.** If you mean to approve a recommendation that came in while you were entering overrides, first clear the values from the Override row by clicking **Reset**. (see below for details.)

To reject a recommendation:

- Click the **Reject** button.

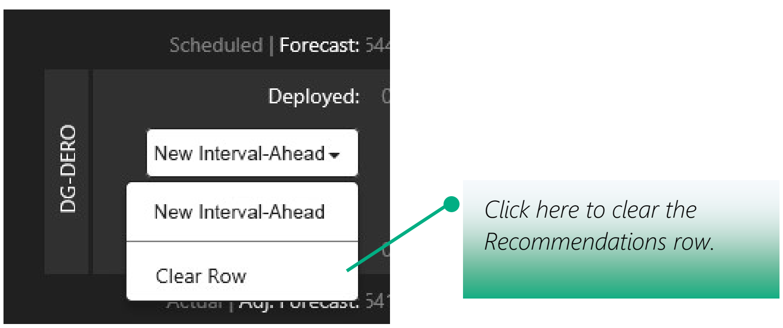
To recover rejected recommendation

- In case you change your mind and want to review it again, a rejected recommendation remains available in the Recommendations drop-down within its timeout period.



To clear the Recommendations row without taking other action:

- In the Recommendations drop-down, select **Clear Row**. This has no effect on the Recommendation.

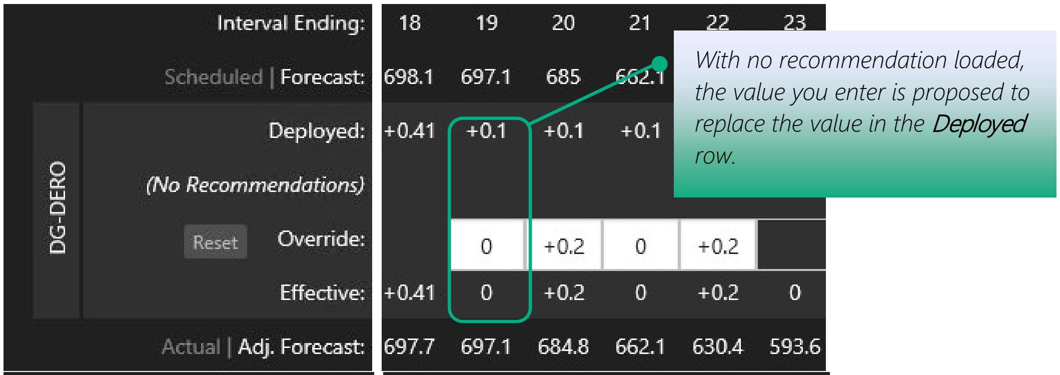


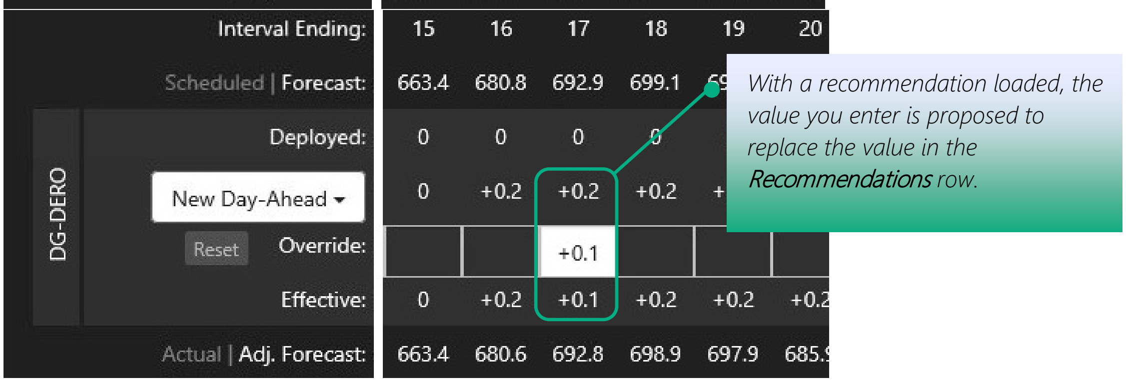
2.6.2 Entering Overrides

Entering overrides works the same whether you are fine-tuning a deployed system schedule, a day-ahead recommendation, or an interval-ahead recommendation. Most examples and graphics in this section show overrides on a day-ahead recommendation; however, the process is the same in each context.

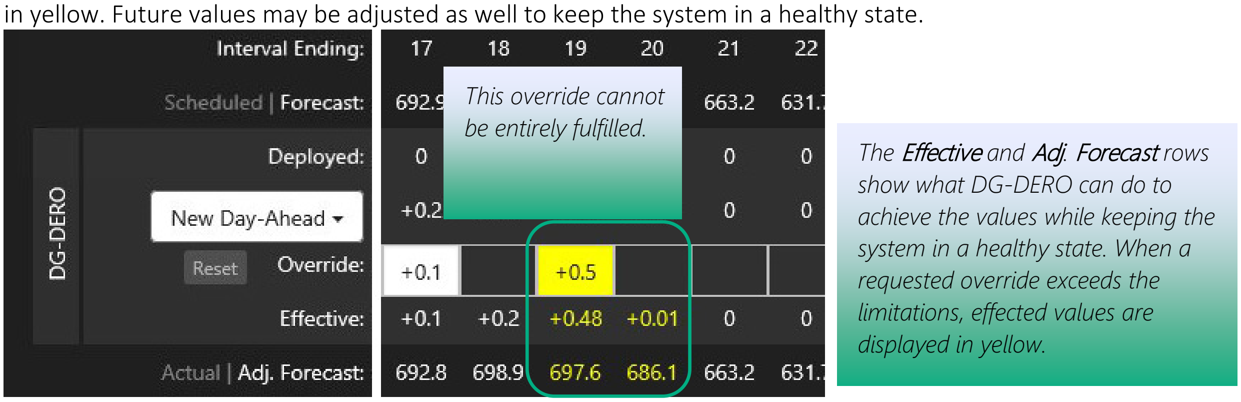
To override a deployed system schedule or new recommendation:

1. In the **Override** row, enter the new values directly below those in the Deployed or Recommendations row that you intend to replace.
2. Click **Validate** to confirm the values entered.
   Note: Edits to each time block in the Override row must be validated before submission. When entering overrides, the **Submit** button changes to the **Validate** button.





3 Check the **Effective** row, which shows the actual, effective adjustments DG-DERO determines can be made, given the currently active system. If the effective adjustment differs from your override, the values display in yellow. Future values may be adjusted as well to keep the system in a healthy state.

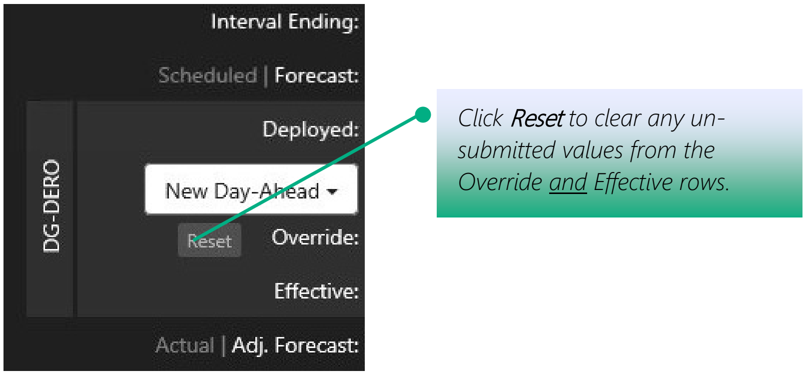


4 Check for possible future effects of your overrides by scrolling ahead to review the entire System Schedule.

5 Continue fine-tuning until you are ready to submit your changes.

To clear any values in the Override which you have not yet submitted, click **Reset**. Override values already submitted will _not_ be cleared. They can, however, still be edited.

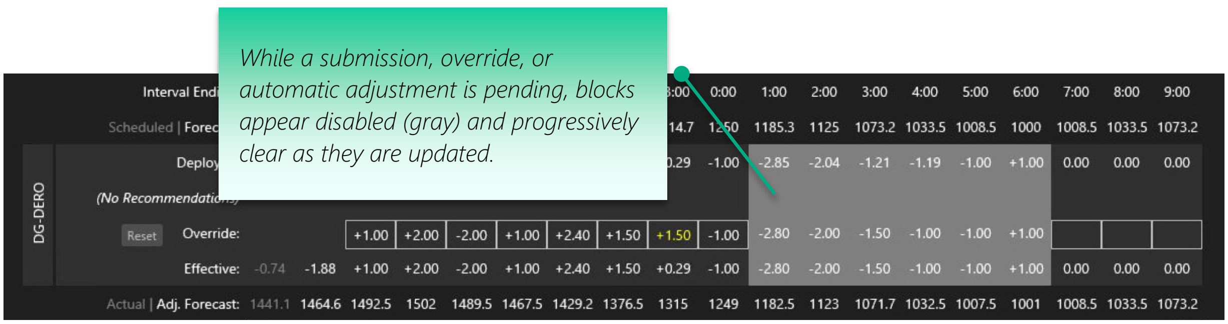
Note: Clicking **Reset** will reset *both* the Override *and* the Effective rows of any unsubmitted overrides, returning them to their original, un-validated state. Validation results will be cleared, and discrepancies between the Override and Effective values will no longer be highlighted.



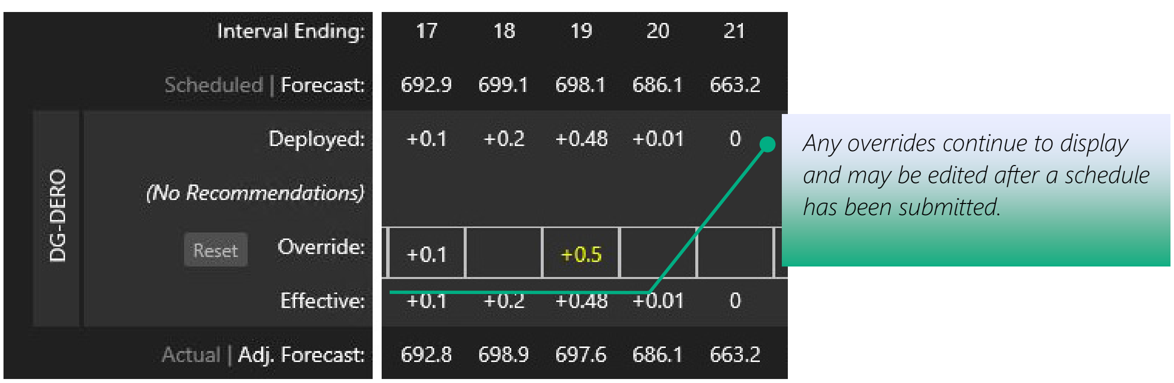
6 To submit your changes, click **Submit**.

You can still make changes after an override has been submitted. However, parts of the DG-DERO control panel are disabled while a submission is pending deployment, and the process can take several minutes to complete.

While DERO processes any user submission, override, or automatic adjustment to the System Schedule, the affected intervals are disabled and appear as gray blocks which progressively clear as each interval's scheduled deployment, moving from present to future, is optimized, dispatched, and made available for editing.



After completion, DG-DERO shows the new values in the **Deployed** row, matching the values from the **Effective** row.



Once submitted, the recommendation disappears from the Recommendations row. However, any operator overrides continue to display in the Override row and may still be edited.

Switching views to expose time intervals of finer or coarser granularity will collapse or expand the values in the Override correspondingly. A collapsed time block is indicated by a grey bar *below* the cell, and an expanded time block is indicated by a grey bar *above* a range of cells.

2.6.3 Logging and Auditing Deployments

Augmented data on past and future deployments can be accessed by hovering the mouse over their corresponding screen regions on the System Schedule page:

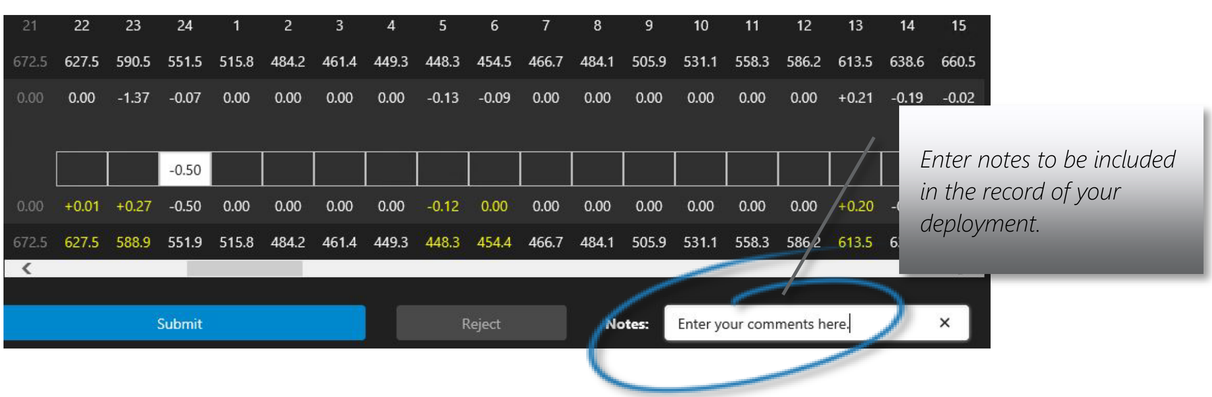
<u>To view the applications and influences which factored into a deployed value</u>, hover the mouse pointer over its cell in the Deployed row

<u>To view the participating resources along with their contributions to the deployed value</u>, hover the mouse pointer over its Charge or Discharge block in the chart.

<u>To view the user account responsible for submitting an override</u>, hover the mouse pointer over its cell in the Override row.

DERO activity is recorded in the **System Logs** accessible from the **Reports** page. For more information, see 2.8.4 System Logs.

The **Notes** field at the bottom of the System Schedule page is enabled whenever values have been entered in the **Override** row of the DERO control panel. When the override is submitted, a record of the deployment is saved in the **Optimizer Audit** report along with the contents of the Notes field.



To append Notes to an override action

1. On the System Schedule page, enter your overrides in the Override row of the DERO control panel.
2. In the **Notes** field, enter the text you wish to be included in the record of the deployment.

3 Click the **Submit** button.

2.7 Managing Energy Resources

A DG-DERO **energy resource** is a distributed energy resource, such as an energy storage system (ESS) or generation source (PV, wind, etc.), that has been brought under the scope and influence of DG-DERO. A **resource schedule** is a pre-defined series of controller operations upon a single resource at specified time points. The **system schedule** shows the aggregated scheduled charge and discharge actions of all energy resources that are currently included in DERO operations.

This section includes:

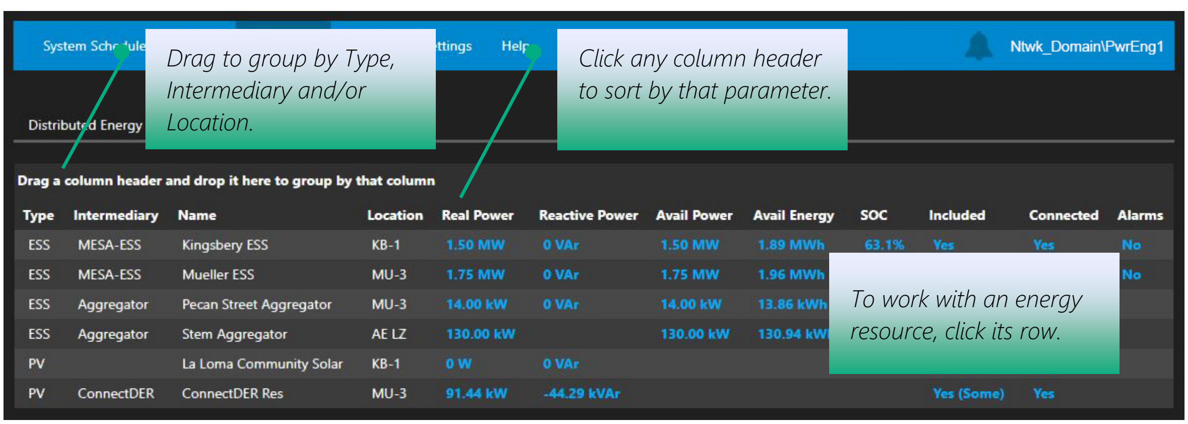
2.7.1 Monitoring Energy Resources

Live data from a signal meters and other devices on a circuit bus or feeder can be monitored on the **Circuits** page, which shows individual resources in relation to their circuit geography and voltage profiles. For more information, see 2.9 Monitoring Circuit Resources.

Resource parameters and specifications are monitored and managed from the **Resources** page.

To view energy resources:

1 Click the **Resources** tab in the navigation bar.
DG-DERO displays the Resources page, which lists all the energy storage and generation resources under DERO's purview.

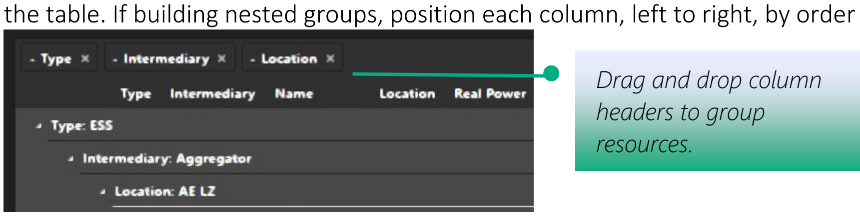


All the resources currently under the scope and influence of DERO are displayed, either individually or as groups of small, constituent resources. Some resources may be grouped. In the image above, clicking the last row (ConnectDER Res) will open a screen listing the ConnectDER service meters on that circuit.

Persistent (unchanging) parameter values are displayed as normal text. Dynamic values are displayed as blue text. Hovering the mouse pointer over any dynamic value will report the date and time of its most recent update.

Resource lists can be grouped and sorted by any column.

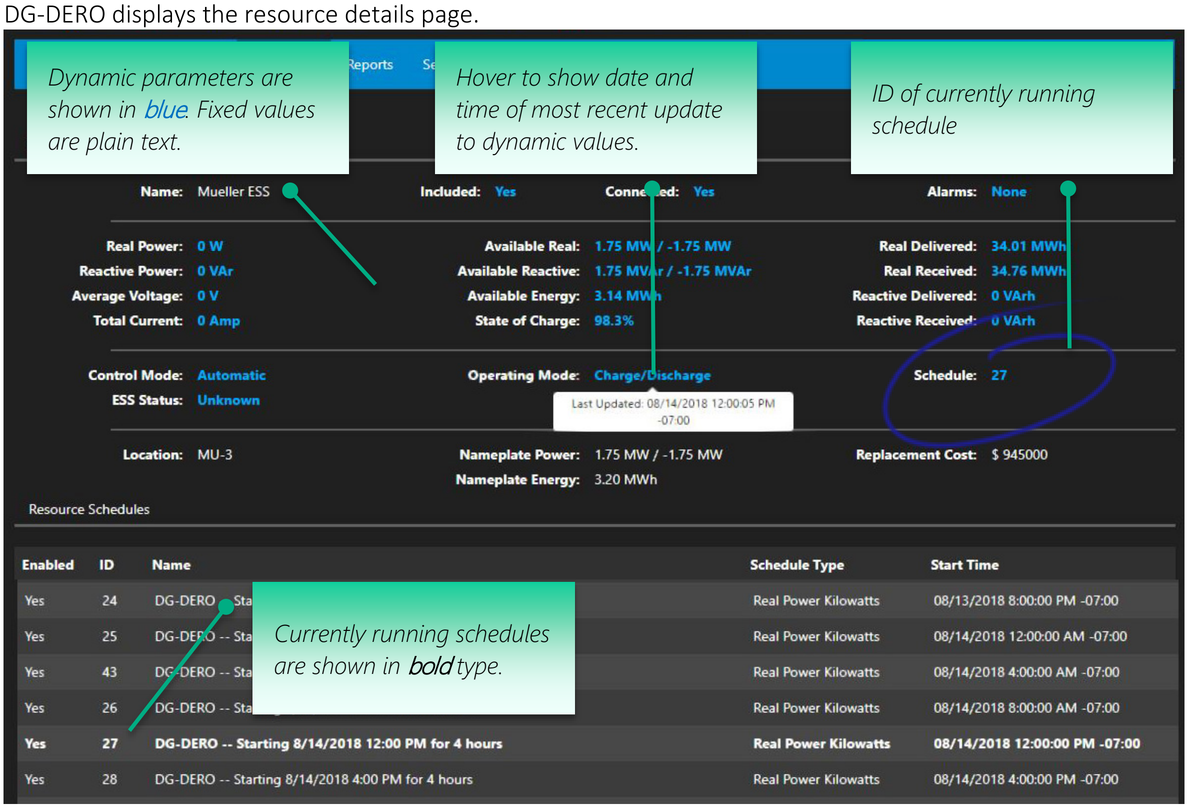
- To sort resources, click any column header. Subsequent clicking cycles sort ordering, i.e., sort, reverse-sort, and default sort.
- To group resources by parameter, drag any column header upward and drop it into the region just above the table. If building nested groups, position each column, left to right, by order of their grouping.



- To sort or reverse-sort on a grouped parameter, click its Group By header.
- To un-group resources, click the 'x' beside the Group By parameters you no longer want the resources grouped by.

2 Click on one of the listed system resources.

DG-DERO displays the resource details page.



The resource's configuration and capabilities are listed, along with its reserved and user-generated schedules. The information displayed for a given resource depends on its Type and its Intermediary.

Resource Parameters

The following is a comprehensive list of the parameters that may be displayed on the resource details page:

- Name – The name given the resource when it was brought into DERO.

- Included – Yes/No. Indicates whether the resource is currently included in DERO optimization.
- Connected – Yes/No. Indicates whether the resource is connected and in communication with DERO. A disconnected resource will show '0' available real and reactive power.
- Alarms – Any unresolved alarm conditions being reported by the resource's Intermediary controller.
- Real Power – The instantaneous real power, as measured by the meter, flowing to/from the resource.
- Reactive Power – The instantaneous reactive power, as measured by the meter, flowing to/from the resource.
- SOC – The present state of charge of the energy storage system, as a percentage of the nameplate energy. Not all energy storage systems report their SOC to DERO.
- Total Current – The real-time current across all phases.
- Avg. Voltage – The real-time voltage across all phases
- Avail Real – The real power capacity of the resource.
- Avail Reactive – The reactive power capacity of the resource.
- Avail Energy – The energy capacity of the resource, adjusted for its current state of charge, and for any de-rating factors such as temperature.
- Real Delivered – Total energy delivered by the resource over a period relevant to the resource. For a battery storage system, the value is accumulative since inception. For aggregators the value may reset every 24 hours.
- Real Received – Total energy received by the resource over a period relevant to the resource. For a battery storage system, the value is accumulative since inception. For aggregators, the value may reset every 24 hours.
- Reactive Delivered – Total reactive energy delivered by the resource over a period relevant to the resource. For a battery storage system, the value is accumulative since inception. For aggregators, the value may reset every 24 hours.
- Reactive Received – Total reactive energy received by the resource over a period relevant to the resource. For a battery storage system, the value is accumulative since inception. For aggregators, the value may reset every 24 hours.
- Location – The named, physical location of the resource.
- Nameplate Power – The resource's rated or installed capacity for full-load sustained output in megawatts.
- Nameplate Energy – The resource's rated or installed capacity for full-load sustained output in megawatt-hours.
- Replacement Cost – The cost to replace the resource.
- Power Factor – The currently measured Power Factor for the resource.
- Nameplate PCS Power – The power conversion system's rated or installed capacity for full-load sustained output in mega-volt-amperes.
- Nameplate PV Power – The solar array's rated or installed capacity for full-load sustained output in megawatts.
- Control Mode – A system resource may be set to Local, Remote, or Automatic control. To be included in DERO optimization, its control mode must be set to Automatic.
- Operating Mode – Intermediary controllers may have certain modes of operation that determine how a resource responds to various metered or internal conditions. An ESS, for example, operating in a **Charge/Discharge** mode, will continue charging until it reaches a target value, or discharging until it reaches its minimum storage reserve.
- Schedule – The Schedule ID of any currently running schedule. If no schedule is running, zero (0) is displayed. If two or more schedules are running concurrently, "Multiple" is displayed.

2.7.2 Editing Energy Resources

Including and Excluding Resources from DERO Optimization

When formulating recommendations for the system schedule, the DG-DERO applications account for the capabilities of all "included" energy resources. An "excluded" energy resource is not available for consideration in the system schedule.

You exclude an energy resource to reserve its use for a specific purpose, such as scheduled maintenance, to run a test, or to run a schedule that conflicts with one or more of the DG-DERO reserved schedules. For a list of Schedule Types, see “Schedule Types and Interoperability” on page 85.

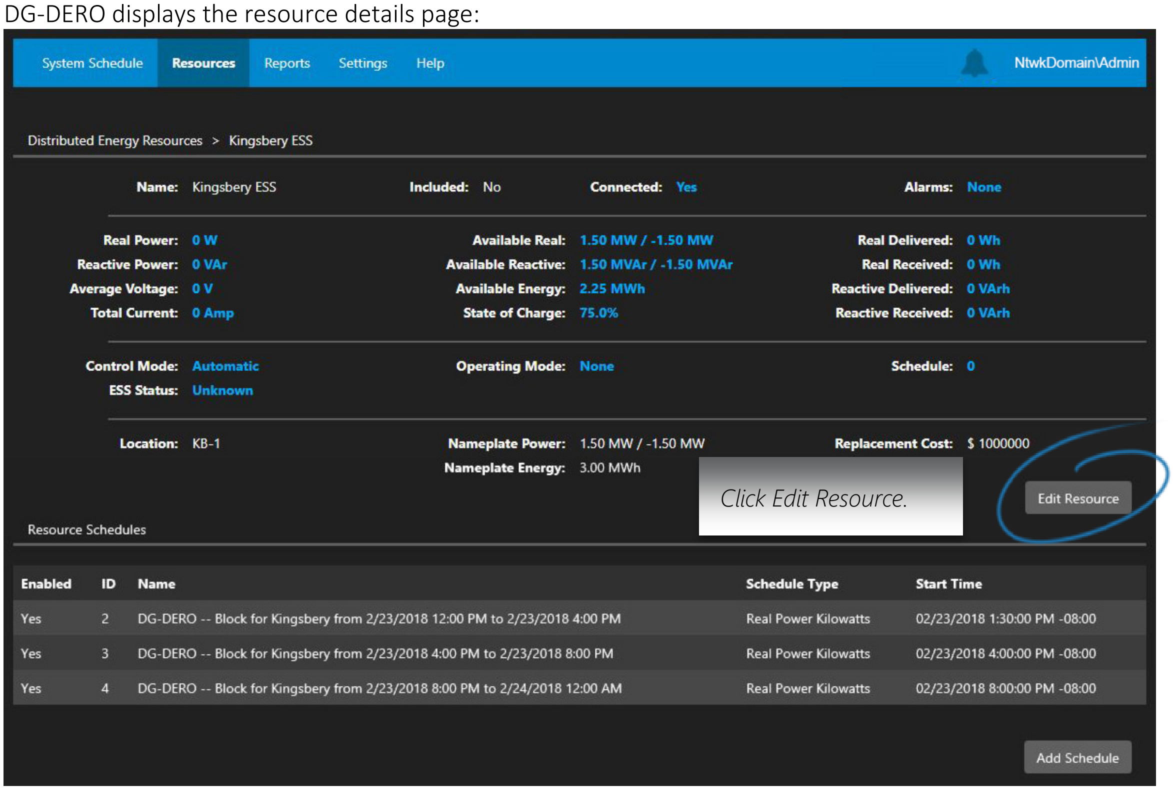
Excluding an energy resource will automatically disable the DERO-generated schedules for that resource. While the resource is excluded, these otherwise read-only schedules can be edited. Though it isn’t recommended, you may want to adjust Start Times and other parameters in the DERO-reserved schedules to compensate for the time the resource was excluded. You should manually re-enable any schedules you edit before the resource is re-included in DERO optimization.

To edit an energy resource, you must be logged in with DG-DERO Administrator privileges.

To include or exclude an energy resource:

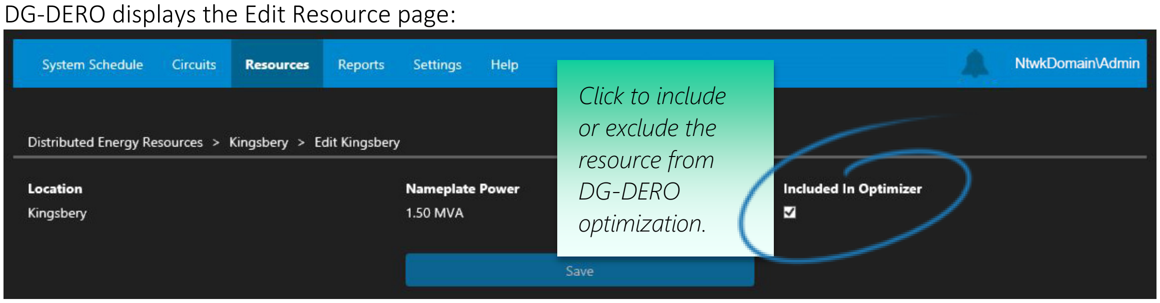
1 On the Resources page, click the row for the system resource you want to edit.

DG-DERO displays the resource details page:



2 On the resource details page, click the **Edit Resource** button.

DG-DERO displays the Edit Resource page:



3 Set whether the resource is **Included in Optimizer** consideration when formulating recommendations (checked) or **Excluded** (unchecked).

- **Excluding** a resource disables its DERO-reserved schedules, leaving the system schedule unaffected by what may be only a short-term exclusion of the resource from DERO optimization. The system schedule will, however, be revalidated, and its currently deployed values lost, if the operator submits any overrides, or a new recommendation is approved.
- To avoid potential conflict with the DERO-reserved schedules, all user-generated resource schedules are disabled when that resource is **Included** in DERO optimization. After re-including a resource that has been excluded from DERO optimization, you should manually re-enable, as necessary, its user-generated resource schedules.
- When a resource is re-included, its DERO-reserved schedules will remain disabled until the next time the system schedule is optimized or manually updated. See 2.7.6 Configuring Resource Schedules.

4 Click **Save.**

2.7.3 How Resource Schedules Work

A **resource schedule** specifies the action of an operating mode for a resource over a series of recurring time intervals. When you create, or modify a resource schedule, you determine the operating mode's action over time by setting a value for the mode's operation at each of the schedule's time points.

For example, you can schedule an ESS to charge its batteries at a specified rate in the middle of the day, storing energy from solar sources when generation is high. The same schedule can be used to discharge power back to the grid in the late afternoon and early evening, providing power when solar generation is low, and demand is high.

When working with the DG-IC, DERO supports up to 50 schedules for each energy resource but reserves 43 for its own use in formulating the aggregated system schedule. For each resource you can create up to 7 schedules that are not part of the DG-DERO system schedule. Any additional schedules may be overwritten by DERO.

This section describes how to use DG-DERO to create and edit resource schedules. For information on using the DG-IC to create and edit schedules for energy storage resources, see the *Doosan GridTech Intelligent Controller Operating Manual*.

Running a Resource Schedule

In configuring a resource schedule, you set it to start running at a date and time. You can also configure a schedule to run again (Repeat) at regular intervals, such as every day, every other week, or on specific days of the week or month.

A resource schedule starts running when these conditions are true:

- **The schedule is Enabled.** For details on enabling schedules, see 2.7.6 Configuring Resource Schedules.
- **The resource is in communication with DERO** when the schedule's initial Start Time, or the Start Time for its next repetition, has occurred.
- **The DG-IC (if applicable) is set to Automatic control** when the schedule's initial Start Time, or the Start Time for its next repetition, has occurred. (For details on how Automatic control works for an ESS controlled by the DG-IC, see 1.3 Taking Control)

If the resource is unavailable while a schedule is running, the schedule, and any scheduled operations, stop. If the resource is unavailable and is later made available, an enabled schedule that is configured to repeat returns to its repeat cycle, starting at the Start Time of its next repetition. To restart a schedule that is not configured to repeat, the operator sets a new Start Time for when the resource will be available.

Schedule Types and Interoperability

The DG-IC prioritizes each resource's scheduled operations. When scheduled real-power or reactive-power operations are in conflict; the resource schedule with the lower index value (i.e., higher on the list) takes precedence.

Note: While a resource is included in DERO optimization, all user-generated schedules take precedence over those generated for that resource by DERO. Excluding a resource from DERO optimization should automatically disable all its DERO-generated schedules.

Before running a user-defined resource schedule, it is usually prudent to first **Exclude** its resources from DG-DERO consideration to avoid conflict with reserved schedules that serve the system schedule. For more about including and excluding energy resources, see 2.7.2 Editing Energy Resources.

Table 2-2 lists the types of schedules supported by DG-DERO.

Table 2-2: Types of Schedules

Schedule Type	Purpose	DG-IC Operating Mode
AGC (Automatic Generation Control)	Enable or disable the AGC operating mode. When enabled, the mode runs as configured in the DG-IC Configure Operating Mode popup.	AGC
Dynamic Volt/VAr	Enable or disable the Volt-VAr operating mode. When enabled, the mode runs as configured in the DG-IC Configure Operating Mode popup.	Dynamic Volt/VAr
Dynamic Volt-Watt	Enable or disable the Dynamic Volt-Watt operating mode. When enabled, the mode runs as configured in the DG-IC Configure Operating Mode popup.	Dynamic Volt/Watt
Frequency/Watt	Enable or disable the Frequency/Watt operating mode. When enabled, the mode runs as configured in the DG-IC Configure Operating Mode popup.	Frequency/Watt
Power Factor	Directly control the reactive power output of the ESS by setting the desired power factor (PF).	ESS Power Factor
Power Factor Correction	Enable or disable the Power Factor Correction operating mode. When enabled, the mode runs as configured in the DG-IC Configure Operating Mode popup.	Power Factor Correction
Power Limit	When discharging or charging, limit the real power output or input of the ESS to a specified kilowatt rate.	ESS Power Limit
Reactive Power (%)	Absorb or inject reactive power at a specified percentage of maximum available reactive power.	ESS Reactive Power
Reactive Power (kVAr)	Absorb or inject reactive power at a specified kilovar rate.	ESS Reactive Power
Real Power (%)	Charge or discharge the ESS at a specified percentage of maximum available power.	ESS Real Power
Real Power (kW)	Charge or discharge the ESS at a specified kilowatt rate.	ESS Real Power
Real Power Response 1, 2, 3	Enable or disable the Real Power Response operating mode. When enabled, the mode runs as configured in the DG-IC Configure Operating Mode popup.	Real Power Response 1, 2, 3

Real Power Smoothing	Enable or disable the Power Smoothing operating mode. When enabled, the mode runs as configured in the DG-IC Configure Operating Mode popup.	Power Smoothing
SOC Management	Enable or disable the SOC Management operating mode. When enabled, the mode runs as configured in the DG-IC Configure Operating Mode popup.	SOC Management
Voltage Smoothing	Enable or disable the Voltage Smoothing operating mode. When enabled, the mode runs as configured in the DG-IC Configure Operating Mode popup.	Voltage Smoothing
Dynamic Volt/VAr Curve Index	Enable or disable the Dynamic Volt/VAr operating mode but use SCADA-reserved curves rather than the curves configured in the DG-IC. Otherwise, when enabled, the mode runs as configured in the DG-IC Configure Operating Mode popup.	Dynamic Volt/VAr
PV Output Maximum (%)	Draws power from a PV resource up to the specified percentage of its maximum available power.	n/a

You can program your resources to automatically perform a variety of energy storage tasks throughout the day, some operating simultaneously, others in sequence. Compatible schedule types can be running simultaneously.

Factors that limit simultaneous operations include:

- Operations that charge or discharge real power require exclusive control over the flow of real power. For that reason, a Real Power Kilowatt or Real Power Percentage schedule cannot be running at the same time as another Real Power Kilowatt or Real Power Percentage schedule.
- Any resource schedule that operates on real or reactive power may potentially conflict with the DG-DERO reserved schedules and should be run only while the resource is **Excluded** from DG-DERO consideration.
- Operations that control the reactive power output of the ESS require exclusive control of the flow of reactive power. For that reason, an ESS Power Factor or Power Factor Correction schedule cannot be running at the same time as another ESS Power Factor or Power Factor Correction schedule.

The compatibility of a schedule type is based on its associated operating mode. For more about combining operating modes, see 1.4.1 How Operating Modes Work.

Scheduling Capacity, Recurrence, and Duration

For each resource, you can create up to 7 schedules that operate outside the DG-DERO system schedule.

Each resource schedule can contain up to 100 set points. A **set point** is a target value the resource attempts to reach at a point in time, or **time point.**

When you create a resource schedule, you specify the rate of **Recurrence** (sometimes called the “granularity”) of the schedule’s time points. A schedule’s time points can recur at regular intervals of 15 minutes, 30 minutes, or one hour. You also specify the schedule’s **Duration**, which is the total number of hours the schedule runs.

Because each resource schedule is limited to 100 set points, and each set point occurs at a single time point, a schedule’s maximum Duration is determined by its rate of Recurrence. For example, a schedule with 1-hour Recurrence contains 1 set point per hour. Its Duration can range from 1 to 100 hours. A schedule with 15-minute Recurrence contains four set points per hour. Its Duration can range from 1 to 25 hours.

Table 2-3 lists each schedule Recurrence rate with its acceptable range of Duration.

Table 2-3: Recurrence Rates with Acceptable Ranges of Duration

Recurrence (Granularity)	Duration Range
15-minute	1 - 25 hours
30-minute	1 - 50 hours
1 hour	1 - 100 hours

2.7.4 Accessing Resource Schedules

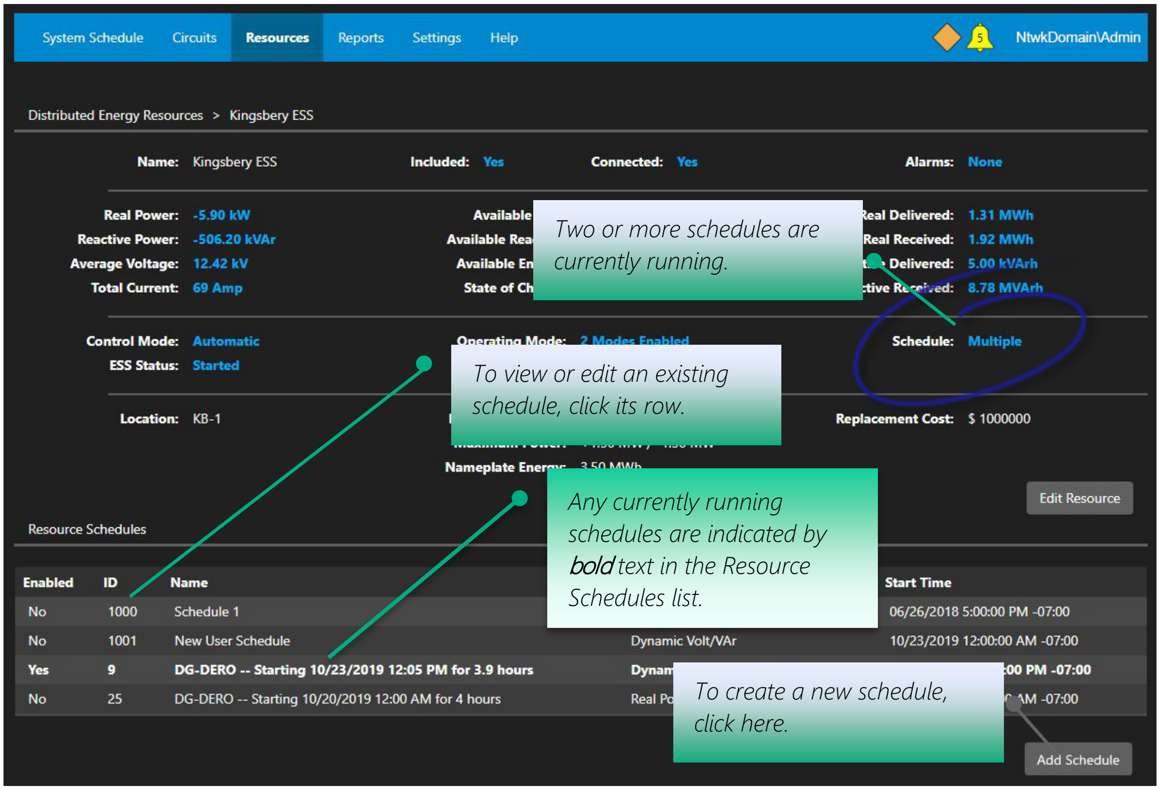
You can view, create, and edit resource schedules from the resource details page of the distributed energy resource you want to schedule. To create or edit a resource schedule, you must be logged in with DG-DERO Power Scheduler or Administrator privileges.

To create or modify a resource schedule for a resource controlled by the DG-IC, the control state of the DG-IC must be Automatic. You cannot use DG-DERO to configure a resource schedule while the DG-IC is in Local or Remote control. For more about setting control states, see 1.3 Taking Control.

To go to a resource schedule page:

1. From the **Resources** tab in the navigation bar, click the resource you want to schedule.
   DG-DERO displays the resource details page, which displays status information about the resource and lists its schedules. On this page, you can review each schedule's Type, Start Time, and whether the schedule is Enabled.

Note: The list of resource schedules shows both reserved schedules generated by DG-DERO to serve the system schedule, and operator-created schedules that run independently of the system schedule. *DG-DERO's reserved schedules cannot be modified unless the resource has first been excluded from DERO optimization.*



2 Click the schedule you want to work with.
DG-DERO opens the resource schedule page, where you can review the schedule's settings and edit schedules you have created. For more about editing a resource schedule, see 2.7.6 Configuring Resource Schedules.

2.7.5 Adding and Deleting Resource Schedules

When you create a new schedule, you set its unique ID number, Name, rate of Recurrence, and Duration.

To create a schedule:

1 On the resource details page of the distributed energy resource you want to schedule, click **Add Schedule.**
DG-DERO displays the Add Schedule page.
Set the parameters you want to define the schedule.

- **ID** is a unique ID number (Integer).
- **Name** is the name that appears on the page for the resource.

For more information on Type, Recurrence, Duration, and Start Time, see 2.7.3 How Resource Schedules Work.

2 Click **Add.**
DG-DERO creates the new schedule and displays its schedule configuration page.

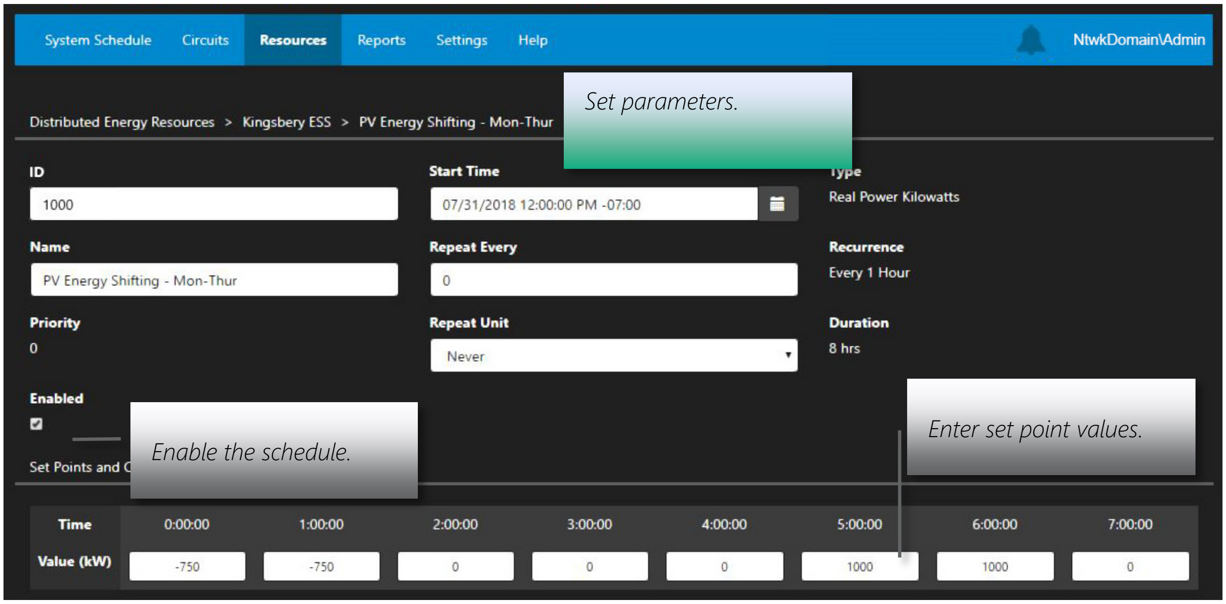
3 Set the parameters you want and click **Save** to save the schedule. For details on the settings, see 2.7.6 Configuring Resource Schedules.

To delete a schedule:

- Click **Delete** in the lower area of the resource schedule page and confirm the deletion when prompted.

2.7.6 Configuring Resource Schedules

When you first create a resource schedule, DG-DERO displays its configuration page automatically. To edit an existing schedule, click in the schedule's row on its resource details page. On the resource schedule page, you can set parameters that affect the schedule's overall operations, determine its set points, and view a chart to preview the schedule's operations.



The Resource Schedule page shows time intervals that are offset from the start time of the schedule. Note that this is different from the system schedule page, which shows time offset from "hour-ending."

To change configuration settings:

1. In the upper area of the page, set or change parameters for the schedule's overall operation. For more on setting Start Time, Repeat Every, Repeat Unit, and Enabled, see Table 5-3, "Schedule Parameters for Overall Schedule Operations." A schedule's Type, Recurrence, and Duration cannot be changed once the schedule has been created. To change these settings, create a new schedule with the settings and configuration you want.
2. Under **Set Points**, set the target value for the resource to reach at each time point.
   For more on these parameters, see Table 5-4, "Value Parameter Settings."
   A chart below the schedules parameters and set points previews the schedule's operations, showing how well the resource meets its target set points at a given state when the schedule starts.

In this Real Power (kW) schedule for an ESS, DG-DERO shows the schedule's operations with a starting state of charge (SOC) of 22%.

- Set the slider at the left of the page to the resource's expected starting state. For example, if you expect an ESS's state of charge to be closer to 75% when the schedule starts, move the slider up to 75%. The chart changes to reflect the new value.
- Hover the mouse pointer over the chart for a description of the underlying element.

3 When you are finished, click **Save** in the lower area to save your changes. The process of validating and saving schedule changes may take a few moments to complete.

Parameter Settings for Resource Schedules

Table 2-4 describes the configurable parameters that affect the schedule's overall operation.

Table 2-4: Schedule Parameters for Overall Schedule Operations

Parameter	Description
Start Time	Date and time the schedule next starts running. For the schedule to run, it must be Enabled, and the resource must be in Automatic control at the Start Time. A repeating schedule's Start Time updates to the next Start Time when one of the following events occur: • The schedule is presently Enabled, and the resource is put in Automatic control. • The control state of the resource is presently Automatic, and the schedule's state is changed to Enabled. • The schedule begins execution.
Repeat Every	Number (integer) that sets the pattern of repetitions. Examples: • Repeat Every = 0. The schedule does not repeat. • Repeat Every = 1. The schedule repeats at every Repeat Unit. If the Repeat Unit is Hour(s), the schedule repeats every hour. • Repeat Every = 2. The Schedule repeats at every 2nd Repeat Unit. If the Start Time is on a Friday and the Repeat Unit is Week(s), the schedule repeats every other Friday.

Repeat Unit	Time interval between repetitions. Time interval can be Second(s), Minute(s), Hour(s), Day(s), or one of the following: • Week(s). Weekly on the same day of the week as the Start Time. • Week(s), Mon/Tues/Wed/Thurs. Weekly on Monday, Tuesday, Wednesday, and Thursday. • Weeks(s), Sat/Sun. Weekly on Saturday and Sunday. • Month(s), Same Date. Monthly on the same numbered day as the Start Time. *For example, the fifth day of the month.* • Mo(s), Same Day/Week from Start. Monthly on the same day and week as the Start Time, counting from the start of the month. *For example, the second Monday from the start of the month.* • Mo(s), Same Day/Week from End. Monthly on the same day and week as the Start Time, counting from the end of the month. *For example, the last Friday of the month.* • Never. The schedule does not repeat.
Enabled	Check to enable the schedule. • When checked, the schedule starts running at the Start Time. The resource must be in Automatic control at the Start Time for the schedule to run. • When unchecked, the schedule does not start running.

Value determines the target set point value that the resource attempts to reach at the associated time point. Table 5-4 describes the Value parameters for each schedule type.

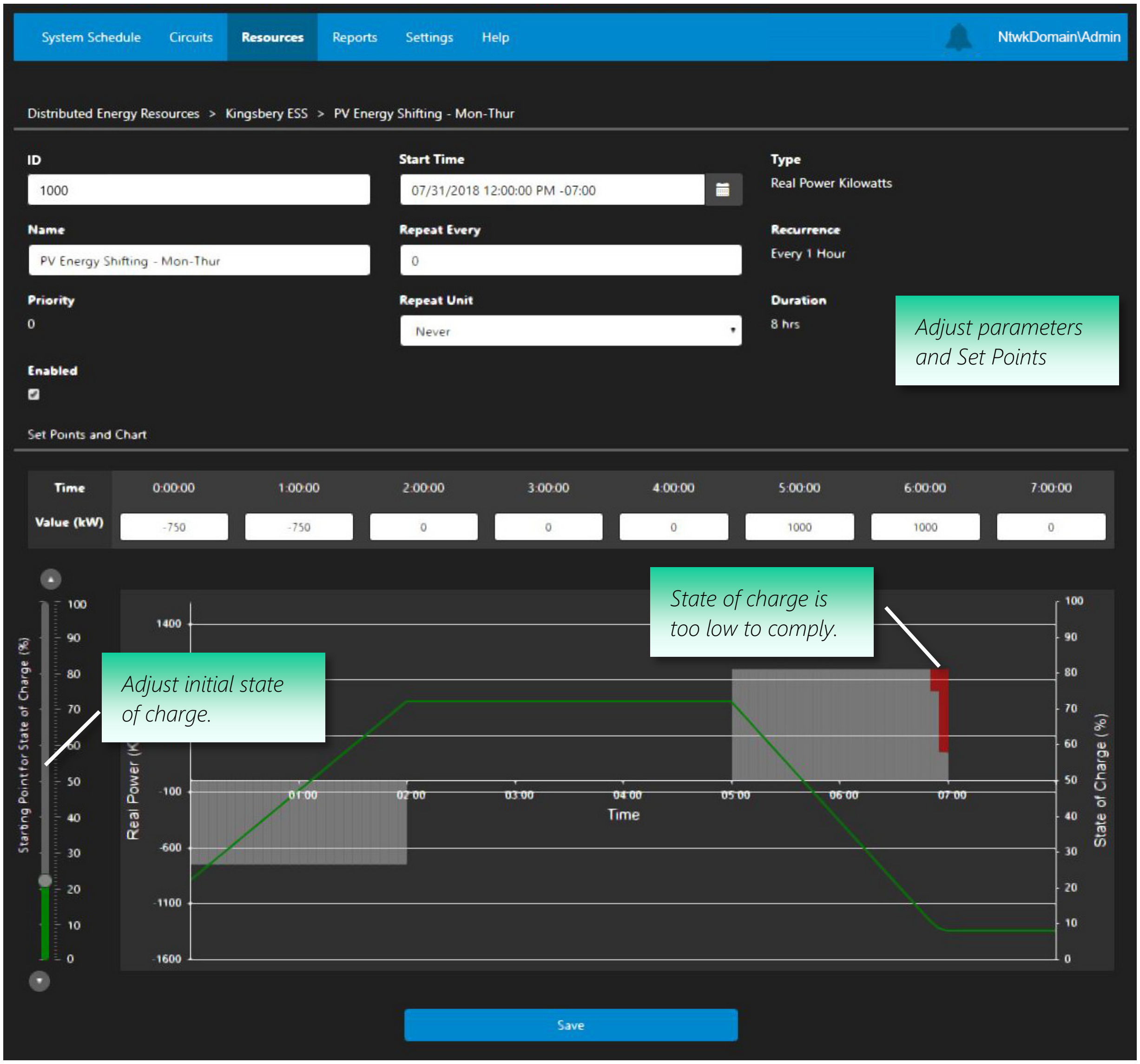
Table 2-5: Value Parameter Settings

Schedule Type	Description of Value Setting	Range
AGC (Automatic Generation Control)	Enables (1) or disables (0) the AGC operating mode. When enabled, the mode runs as configured in the DG-IC. Unit: Integer	0 (zero) or 1
Dynamic Volt/VAr	Enables (1) or disables (0) the Dynamic Volt/VAr operating mode. When enabled, the mode runs as configured in the DG-IC. Unit: Integer	0 (zero) or 1
Dynamic Volt/Watt	Enables (1) or disables (0) the Dynamic Volt-Watt operating mode. When enabled, the mode runs as configured in the DG-IC. Unit: Integer	0 (zero) or 1
Power Factor	Desired power factor output of the ESS. Unit: Power factor as a decimal Note: While pursuing the desired power factor, the ESS always produces positive reactive power to support voltage (i.e., the sign of Q is always positive).	0.1 to .99 (leading) -0.1 to -.99 (lagging) 1.0 (Unity) Zero is not allowed.
Power Factor Correction	Enables (1) or disables (0) the Power Factor Correction operating mode. When enabled, the mode runs as configured in the DG-IC. Unit: Integer	0 (zero) or 1

Power Limit	The maximum limit applied to real power output of the ESS when discharging, and the maximum limit applied to real power input to the ESS when charging. Unit: Kilowatts Note: If two or more ESS Power Limit schedules are running at the same time, the most conservative (closer to zero) setting is applied.	Within the nameplate capacity of the ESS.
Reactive Power (%)	Percentage of available reactive power to be absorbed by (negative) or injected into (positive) the system. Unit: Percentage as an integer	-100 to 100
Reactive Power (kVAr)	Rate at which reactive power is to be absorbed by (negative) or injected into (positive) the system. Unit: Kilovars	Within limits of available reactive power.
Real Power (%)	Percentage of available real power to charge (negative) or discharge (positive) batteries. Unit: Percentage as an integer	-100 to 100 (inclusive)
Real Power (kW)	Rate of real power to charge (negative) or discharge (positive) batteries. Unit: Kilowatts	Greater than the battery's configured minimum state of charge (SOC) and less than maximum SOC.
Real Power Response 1, 2, 3	Enables (1) or disables (0) the Real Power Response operating mode. When enabled, the mode runs as configured in the DG-IC. Unit: Integer	0 (zero) or 1
Real Power Smoothing	Enables (1) or disables (0) the Real Power Smoothing operating mode. When enabled, the mode runs as configured in the DG-IC. Unit: Integer	0 (zero) or 1
Dynamic Volt/VAr Curve Index	Enables (1) or disables (0) the Dynamic Volt/VAr operating mode. When enabled, the mode runs as configured in the DG-IC but uses SCADA-reserved curves rather than those configured in the DG-IC. Unit: Integer	0 (zero) or 1
PV Output Maximum (%)	Percentage of maximum available PV power. Unit: Percentage as an integer	0 to 100 (inclusive)

For details on the DG-IC operating mode associated with each schedule type and its parameter settings, see 1.4 Using Operating Modes.

Example: Photovoltaic Energy Shifting

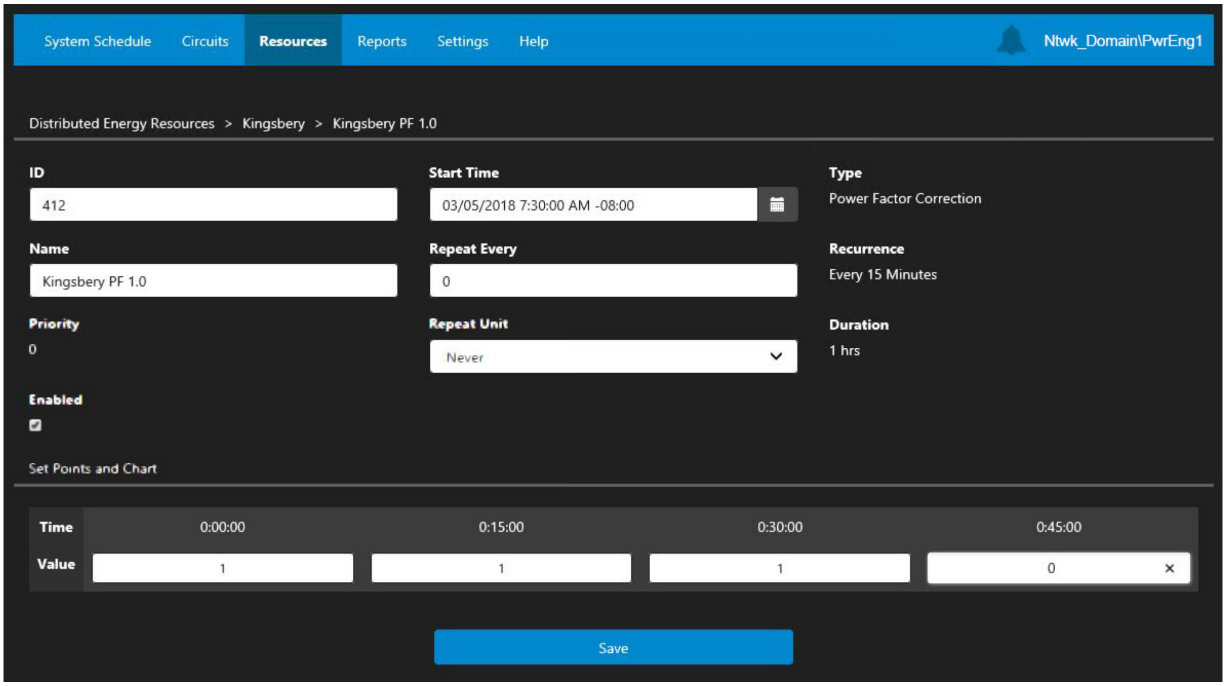


In this example:

- The anticipated state of charge at the schedule's Start Time is about 22%.
- The schedule sets a rate of real power to charge or discharge the ESS every hour for eight hours.
- Because the schedule operates on real power, its resource should be **Excluded** from DG-DERO operations before the schedule runs, to avoid affecting the system schedule. For more information, see 2.7.2 Editing Energy Resources.
- The schedule is **Enabled**. With the ESS in Automatic control, the schedule starts running at 12:00 PM (noon) on July 31, 2018. If the ESS is not under Automatic control at that time, the schedule starts running at noon on the following Monday, Tuesday, Wednesday, or Thursday.
- The schedule is set to charge ESS batteries from noon until 3:00 PM, taking the first hour to ramp from 0 (zero) to charge at a target Value of -750 kW, staying fixed at the target value for the second hour, and taking the third hour to ramp from -750 to 0 kW.
- The schedule is set to discharge batteries from 5:00 PM until 8:00 PM, taking the first hour to ramp from 0 kW to 1000 kW, staying fixed at the target value for the second hour, and taking the final hour to ramp from 1000 kW to 0 kW.

- The schedule repeats (starts running again) at noon every Monday, Tuesday, Wednesday, and Thursday in the following weeks.
- If the ESS is taken out of Automatic control while the schedule is running, the schedule stops running. Any scheduled operations in process also stop.
- If the ESS is taken out of Automatic control and later returned to Automatic control, the schedule restarts at the beginning of the next repetition. For example, if the ESS is taken out of Automatic control at 2:00 PM on Monday afternoon, the schedule stops at that time. If the ESS is then returned to Automatic control at 4:00 PM on Monday afternoon, the schedule starts again on Tuesday at 12:00 PM.

`Example: Power Factor Correction`



In this example:

- The schedule enables (1) or disables (0) the Power Factor Correction operating mode. When Power Factor Correction is enabled, the mode runs as configured in the DG-IC Configure Operating Mode popup.
- Because the schedule operates on reactive power, it can run while its resource is **Included** in DG-DERO operations without affecting the system schedule. For more information, see 2.7.2 Editing Energy Resources.
- The schedule is **Enabled**. With the ESS in Automatic control, the schedule starts running at 7:30 AM on July 31, 2018 and repeats every fifteen minutes for one hour, then stops.
- The schedule is set to enable (1) the Power Factor Correction operating mode from 7:30 AM until 8:15 AM, then disable (0) the mode for the last fifteen minutes of the hour.
- The schedule does not repeat.
- If the ESS is taken out of Automatic control while the schedule is running, the schedule stops running. Any scheduled operations in process also stop.

2.7.7 Daylight-Saving Time

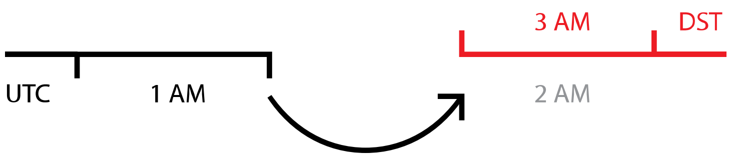
DG-DERO uses, internally, Universal Time Coordinated (UTC). UTC is the local time at the Prime Meridian – '0' degrees longitude – which passes through Greenwich, England and is often still referred to as Greenwich Mean Time. The time displayed to the user, however, is always local time with respect to the time zone of the user's computer. All times will be adjusted from UTC to the time zone of your computer regardless of the time zone in which the event occurred.

UTC is consistent and does not have the seasonal variations that many standard times do. Most of North America and Europe, as well as several other regions in the world, currently turn their clocks forward an hour in the summer ("Summer" or "Daylight Saving Time") and back to standard time again in the winter. The times and dates for the transition vary from region to region and are reversed between the northern and southern hemispheres.

This can impact the Resource and System Schedules as discussed below.

Standard Time to Daylight-Saving Time

In the transition from Standard to Daylight Saving Time, one hour (typically the 2 AM hour) is skipped, resulting in a one-hour gap on the clock and the truncation of the 24-hour day to 23.



In the transition from Standard to Daylight Saving Time, times from 02:00:00 to 02:59:59 do not exist.

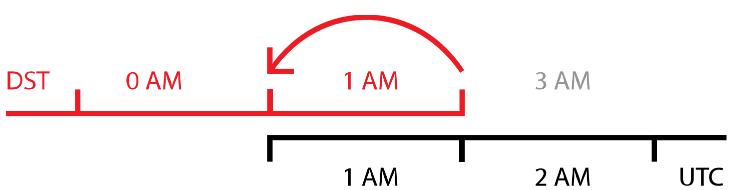
For user-generated Resource schedules that overlap the transition from Standard to Daylight Saving Time, DG-DERO makes the following adjustments:

- Start times within the 2 AM hour (i.e., the hour *ending* at 3 AM) will adjust to their corresponding times within the 3 AM hour (i.e., the hour *ending* at 4 AM).
- If the schedule's Repeat Unit is set to hours, minutes and seconds, the duration is unaffected, but the schedule will complete its cycle (and begin its next iteration) one hour later by the clock.
- If the schedule's Repeat Unit is set to hours, minutes and seconds, its Start and End times will continue to be offset to one hour later by the clock until the next transition to standard time.
- If a schedule's Repeat Unit is set to days, weeks or months, it will complete the cycle that overlaps the transition one hour later by the clock, but its next iteration will begin at the Start Time specified, by the clock.

Note: Once a year, there will be one less hour between the end of the first cycle and the beginning of its next iteration. If a schedule completes its cycle after its next iteration is scheduled to begin, priority, unless otherwise specified, is given to the currently running schedule. The next iteration will start one hour later by the clock and will continue to start one hour later by the clock until the return to Standard Time.

2.7.8 Daylight-Saving Time to Standard Time

In the transition from Daylight Saving to Standard Time, one hour (typically the 1 AM hour) is repeated, which makes any reference to that hour ambiguous, and, the 24-hour day is extended to 25.



In the transition from Daylight Saving to Standard Time, times from 01:00:00 to 01:59:59 repeat.

For user-generated Resource schedules that overlap the transition from Daylight Saving to Standard Time, DG-DERO makes the following adjustments:

- Start times within the 1 AM (i.e., the hour *ending* at 2 AM) hour will adjust to their corresponding times within the *second* occurrence of the hour.
- If the schedule's Repeat Unit is set to hours, minutes and seconds, the duration is unaffected, but the schedule will complete its cycle (and begin its next iteration) one hour earlier by the clock.
- If the schedule's Repeat Unit is set to hours, minutes and seconds, its Start and End times will continue to be offset to one hour earlier by the clock until the next transition to DST.

- If a schedule's Repeat Unit is set to days, weeks or months, it will complete the cycle that overlaps the transition one hour earlier by the clock, but its next iteration will begin at the Start Time specified, by the clock.

Note: Once a year, there will be one additional hour between the end of the first cycle and the beginning of its next iteration. For schedules meant to iterate continuously, there will be one hour before the beginning of its next iteration in which the schedule is not running.

Scheduling Around Daylight-Saving Time

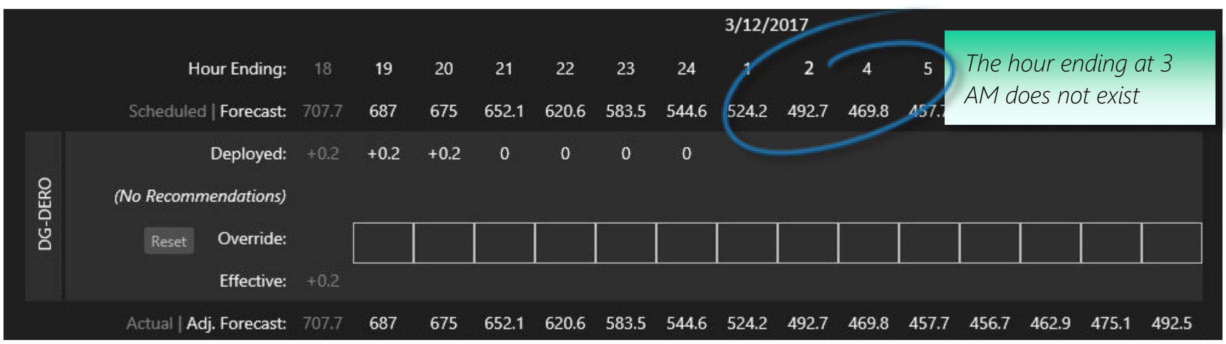
The adjustments DG-DERO automatically makes to the user-generated Resource schedules at the transitions between Standard Time and Daylight-Saving Time may sometimes require adjustment.

Basically, the operator may want to create two additional Resource schedules that will each be run once – before, during or after the transition between DST and Standard Time. These would consist of a schedule for a 23-hour day, and a schedule for a 25-hour day.

The 23-hour day

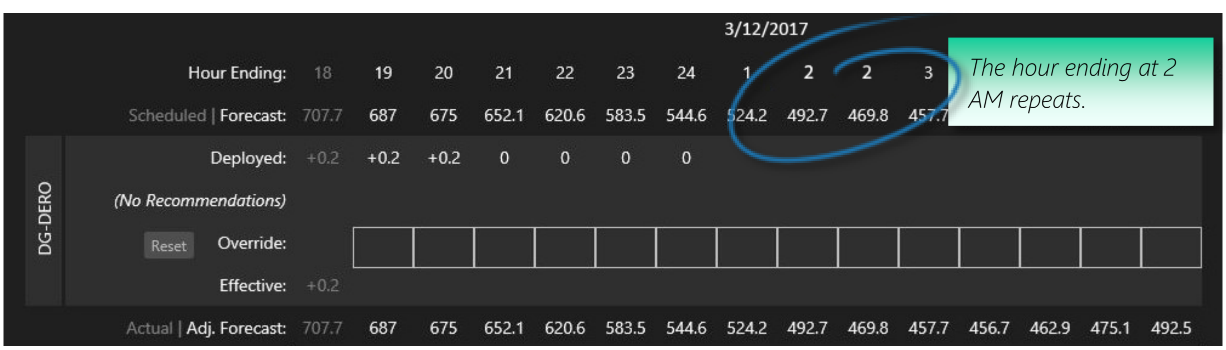
It may be necessary to address overlaps in user-generated Resource schedules that iterate continuously after the transition to DST. Even where Start Time is specified, the one-hour overlap may force a repeating schedule to start as much as one hour later by the clock until the return to Standard Time, or until corrected by the operator.

It is optional to address the one time a year in which the next iteration of a repeating schedule comes one hour earlier than usual, but which does not otherwise affect the schedule.



The 25-hour day

It is optional to address the one time a year in which the next iteration of a repeating schedule comes one hour later than usual. This may be of special concern for schedules meant to iterate continuously.



2.8 DERO Reports

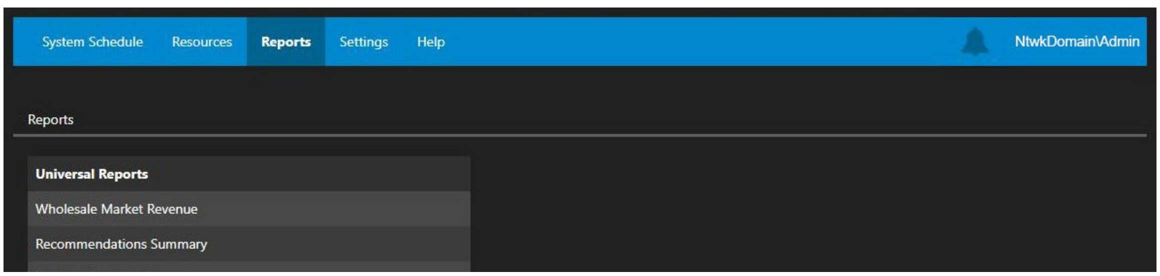
DG-DERO provides built in reports with exportable data to inform the users about its performance. The reports are broadly divided into three categories: Universal Reports; Application Reports; and System Logs.

This section includes:

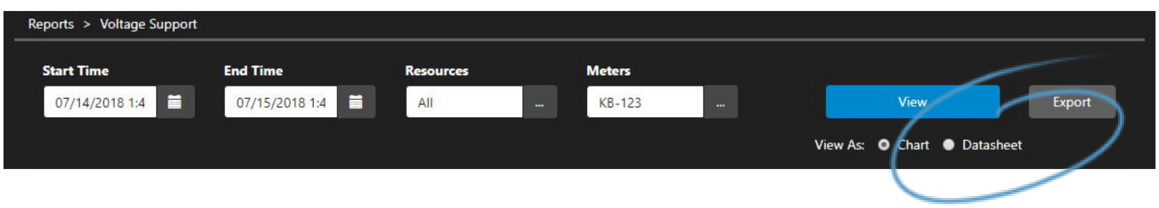
2.8.1 Running and Viewing the DERO Reports

To view reports

- From the **Reports** tab, click the name of the report you wish to view.



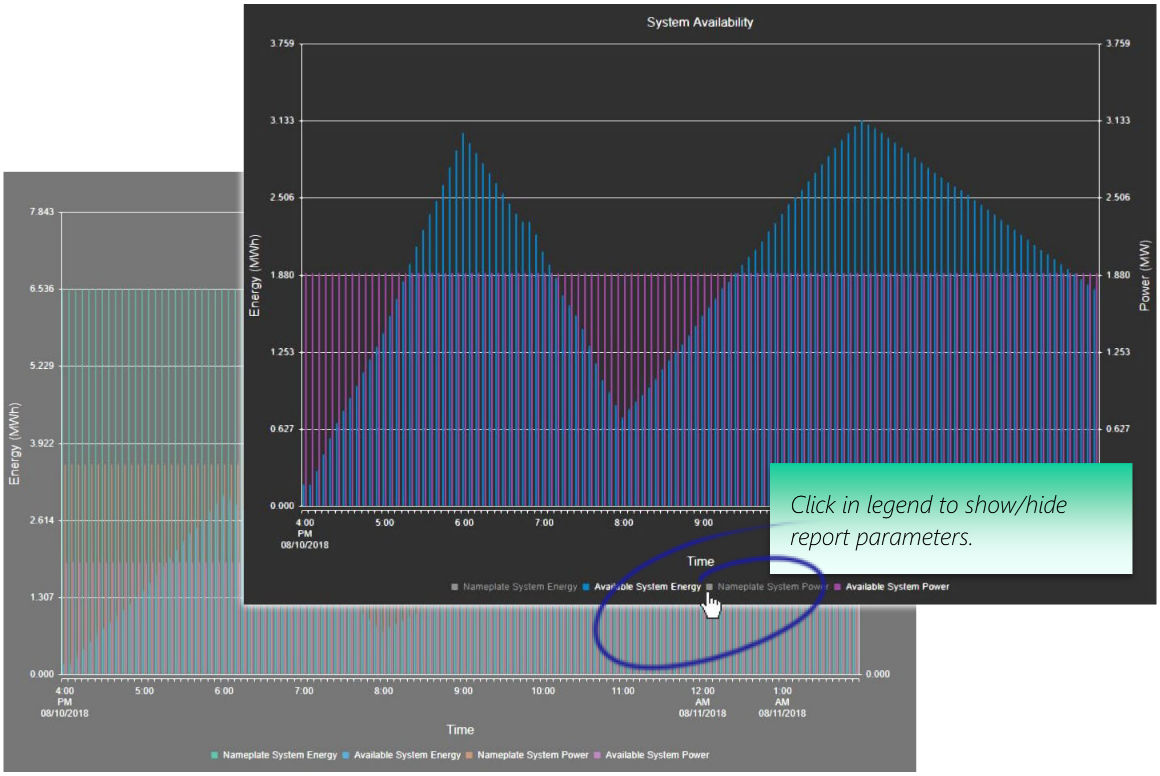
The report opens in its default view and default time range. Most reports can be viewed either as tabular data (**Datasheet** view), or graphically (**Chart** view). Click the radio buttons in the upper right portion of the screen to switch between alternate views.



To adjust other view options, or to Export the report to Excel, see the following procedures.

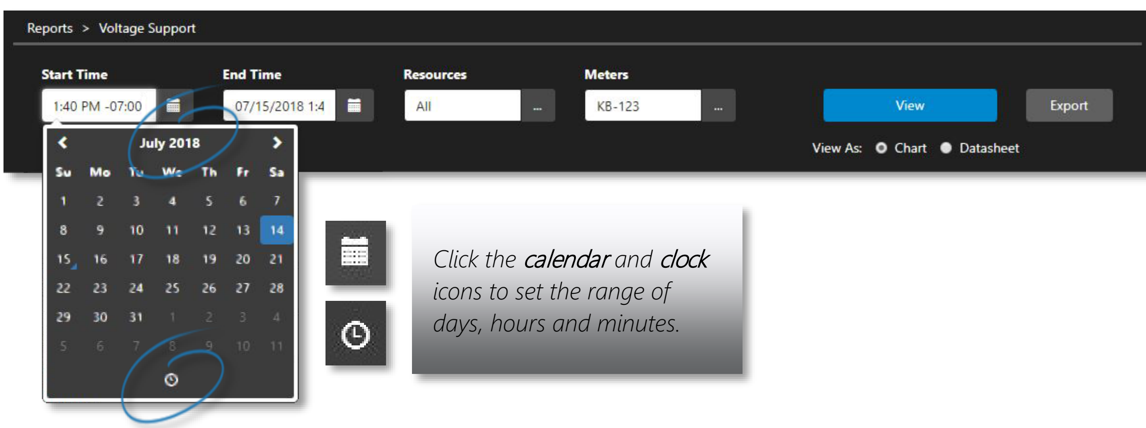
To show/hide report parameters in Chart view

- Click the parameter name in the report legend at the bottom of the chart.



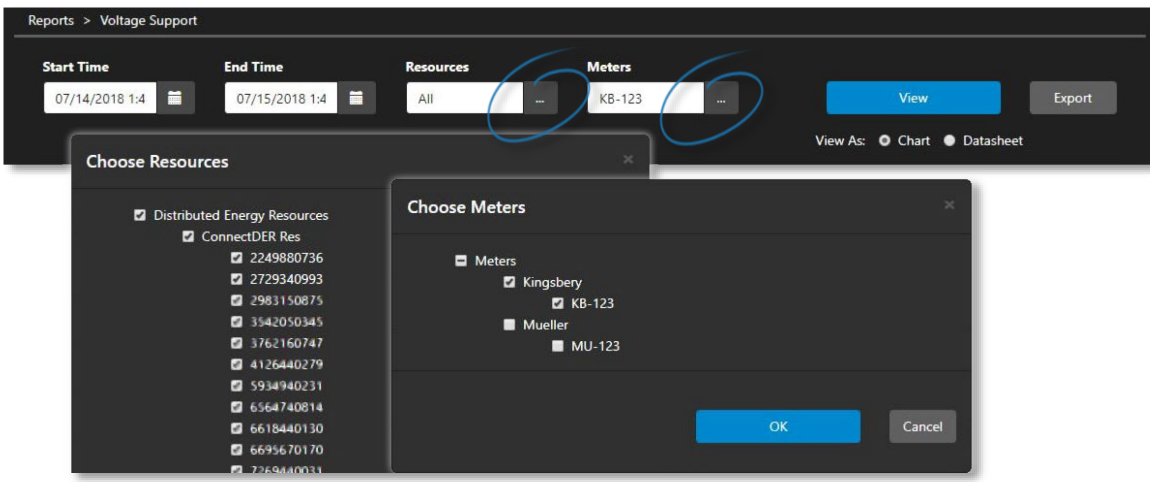
To set the time range, resources, and meters for a report

1 To set the range of days to be included in the report, click the calendar icon beside **Start Time** and **End Time.**



2 To set the range of hours to be included in the report, in the pop-up calendar, click the clock icon.

3 Some reports allow you to choose the specific resources and meters from which the data is derived. Click the ellipses icon (...) to select the **Resources** and/or **Meters** to be included in your report.



When selecting the resources to include in the report, you have the option of including activity from their user-generated schedules, i.e. activity that generally occurs only while the resources were excluded from DERO optimization. To view this activity, check the box, "Include activity while resources were excluded from Optimization," at the bottom of the Choose Resources popup:

4 Click **View** to view the report with the options you selected.

To export reports to Microsoft Excel format

- Open and configure the report you want, then click **Export**. The report will be saved in your default downloads folder as an Excel file with the name, [report name].xlsx.

2.8.2 Universal Reports

The Universal Reports provide a system-level accounting of DERO's performance and value generation over a specified time range.

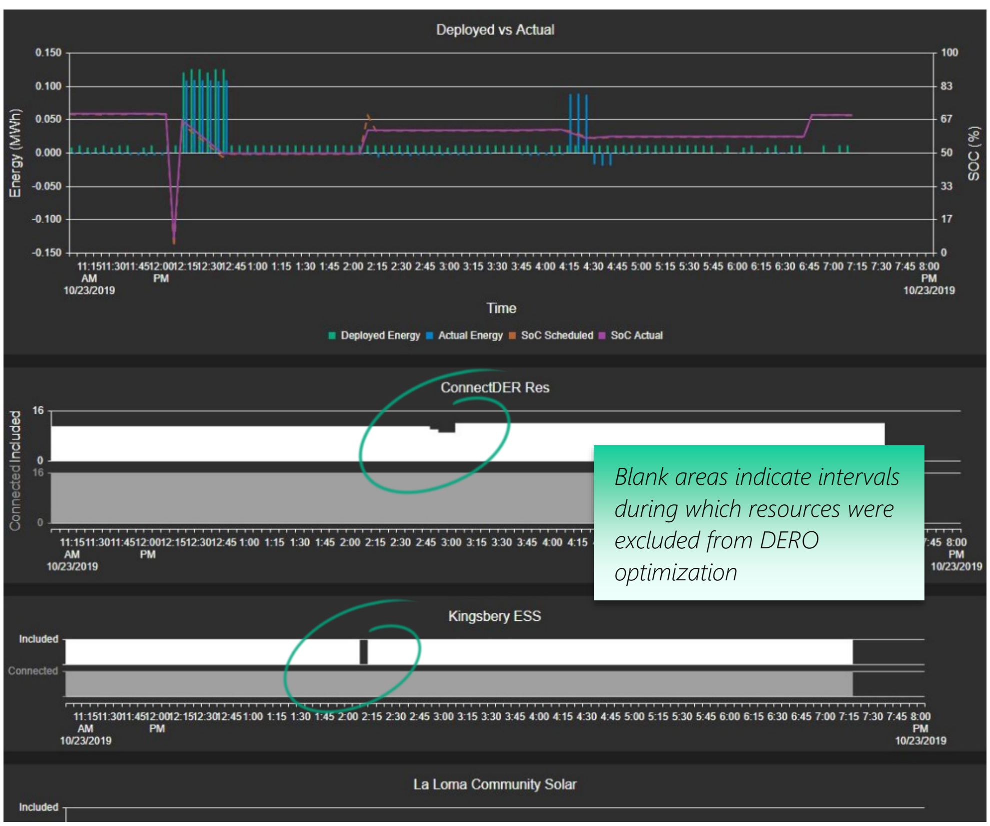
For the **fields marked with an asterisk (*)** below, you may see null values for the last hour ending. Because of their reliance on external sources, their data may be delayed one to three minutes from the hour's end. If a report is run too soon after the hour's end, you may need to refresh the report (i.e., click the **View** button) to see the most recent data.

2.8.2.1 *Deployed versus Actual*

Indicates what DERO did in relation to the last scheduled value over a specified period. The data can be viewed as a bar chart, or as a datasheet with the following values:

Date and Interval Start – The time interval to which the values correspond.
Deployed Energy (MWh) – The energy scheduled to be delivered (positive) or received (negative) in the given hour.
Actual Energy (MWh)* – The metered energy the system delivered (positive) or received (negative) in the given hour. Note that due to auxiliary power, the actual energy may be slightly lower than the deployed value if the system is discharging and will have a non-zero value even if the ESS is idle.
SoC Scheduled (%) – The target state of charge in the system schedule for the end of the given hour.
SoC Actual (%) – The actual state of charge of the system at the end of the given hour.

Viewed as a chart, the values for Deployed Energy (MWh) and Actual Energy (MWh) are represented by vertical bars – positive for energy received for charging the system, negative for energy delivered and discharging the system, and SoC Scheduled and SoC Actual are represented by lines – tracked over time on the horizontal axis.

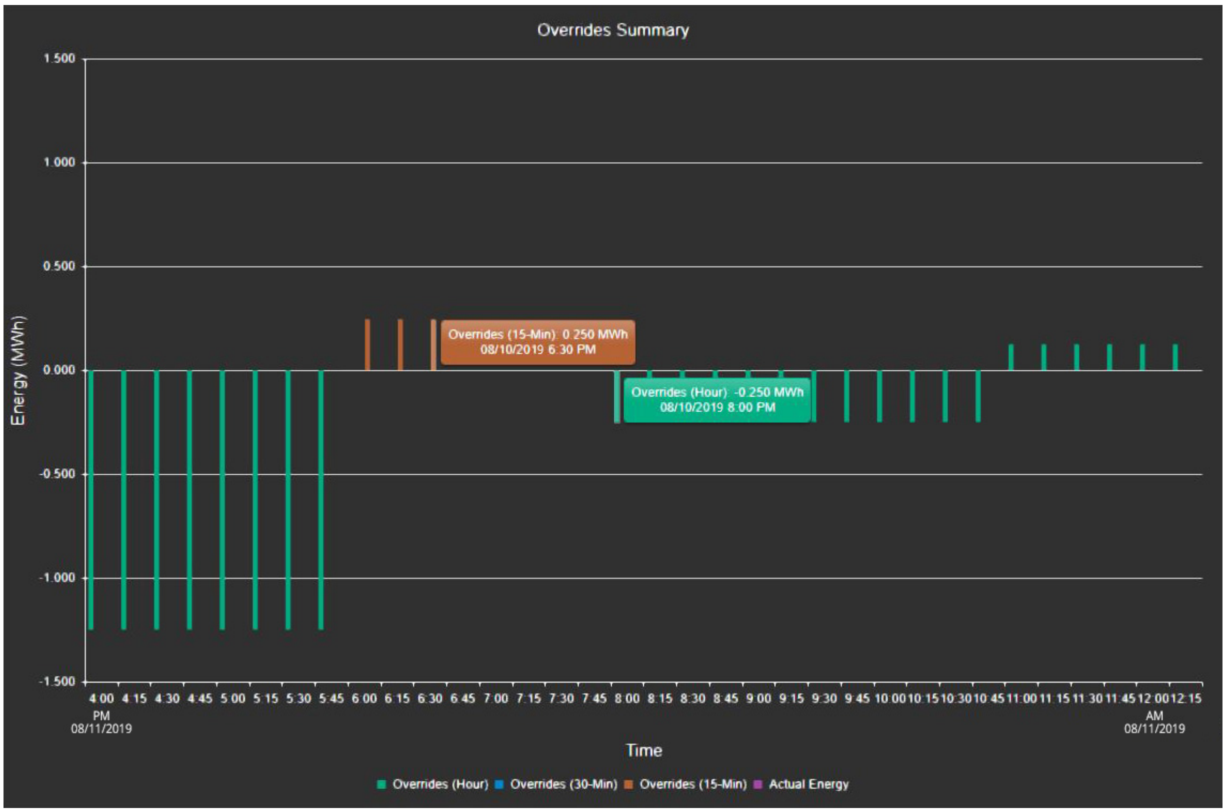


2.8.2.2 *Overrides Summary*

Shows the frequency of user overrides and compares their deployed values to the actual values that DERO was able to achieve, while keeping the system in a healthy state.

> Date and Interval Start – The time interval to which the values correspond.
> Override (Hour/30-Min/15-Min) (MWh) – The last user override that was submitted for the given interval.
> Actual Energy (MWh) – The metered energy that the system supplied to (negative) or delivered to (positive) the grid over the interval. Note that due to auxiliary power, the Actual Energy may have a non-zero value even if the ESS was neither charging nor discharging over the interval.
> Submitted By – The username of the operator who submitted the override.

Viewed as a chart, the most recent user override for each given block of time (in 15-min, 30-min, and 1-hr increments) is compared against the actual deployed energy. Values are represented as vertical bars, with time on the horizontal axis:



2.8.2.3 *Recommendations Summary*

Lists each DERO recommendation over a specified period with the following data:

> Recommendations Type – Day Ahead; Hour Ahead; Real Time.
> Recommendation Status – Rejected; Approved.
> Deployed – Yes/No.
> Created On – The date and time the recommendation was generated.
> Modified On – If overrides were deployed, the date and time of its execution.
> Modified By – User who overrode and deployed the modified recommendation.

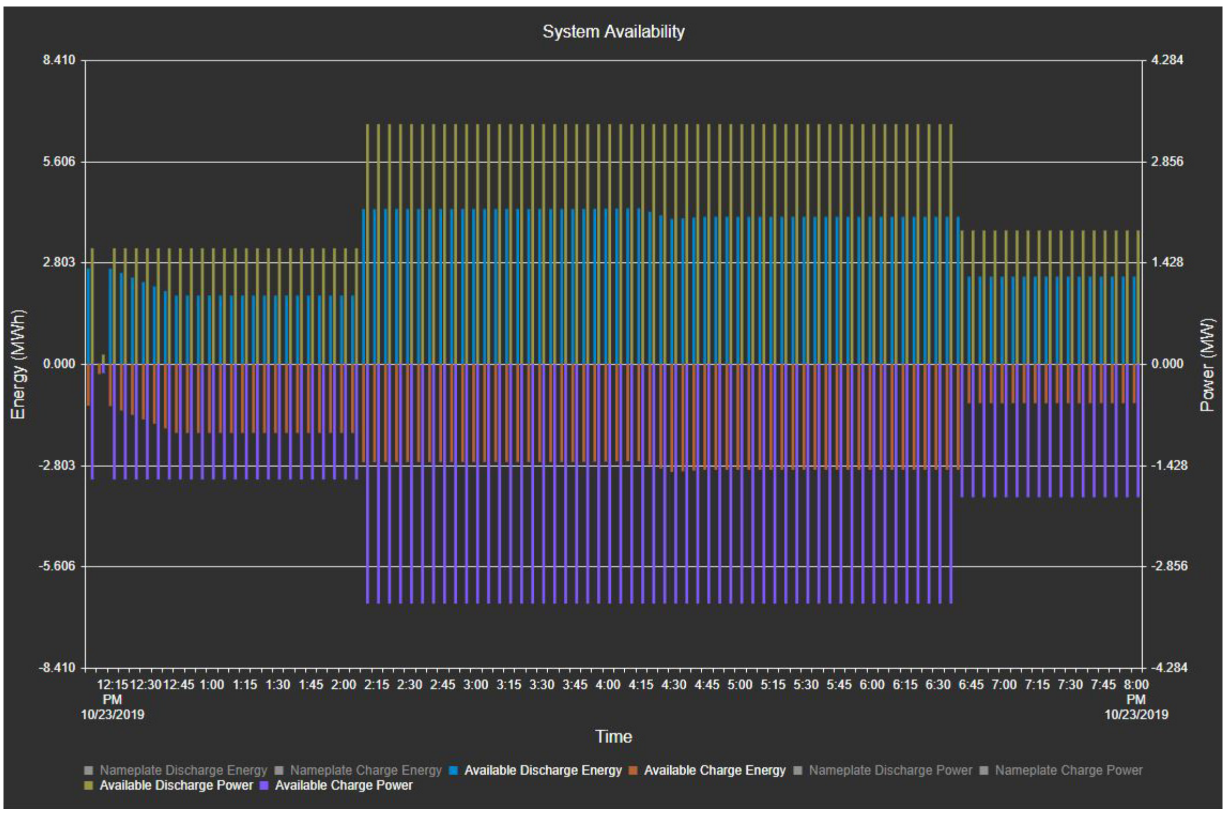
Exported Recommendations Summaries are saved in Microsoft Excel's XLSX format.

2.8.2.4 *System Availability*

Provides details of available system capacity grouped by hours for the specified period. The data can be viewed graphically, or as a datasheet with the following values:

> Date and Interval Start – The time interval to which the values correspond.
> Nameplate Charge/Discharge Power (MW) – The rated power of the system.
> Available Charge/Discharge Power (MW) – The power available from the system measured over 5-minute intervals. The available power can differ from rated power when one or more components are taken offline, excluded from DERO optimization, or de-rated due to factors such as temperature.
> Nameplate Charge/Discharge Energy (MWh) – The rated capability of the system at the beginning of battery life, and at the optimal charge or discharge rate.
> Available Charge/Discharge Energy (MWh) – Energy available from the system averaged over the given interval. The available energy can vary due to the system's state of charge, or when one of more components are taken offline, excluded from DERO optimization, or de-rated due to factors such as temperature.

Viewed as a chart, the rated and actual values for power and energy are represented as vertical bars with time as the horizontal axis:



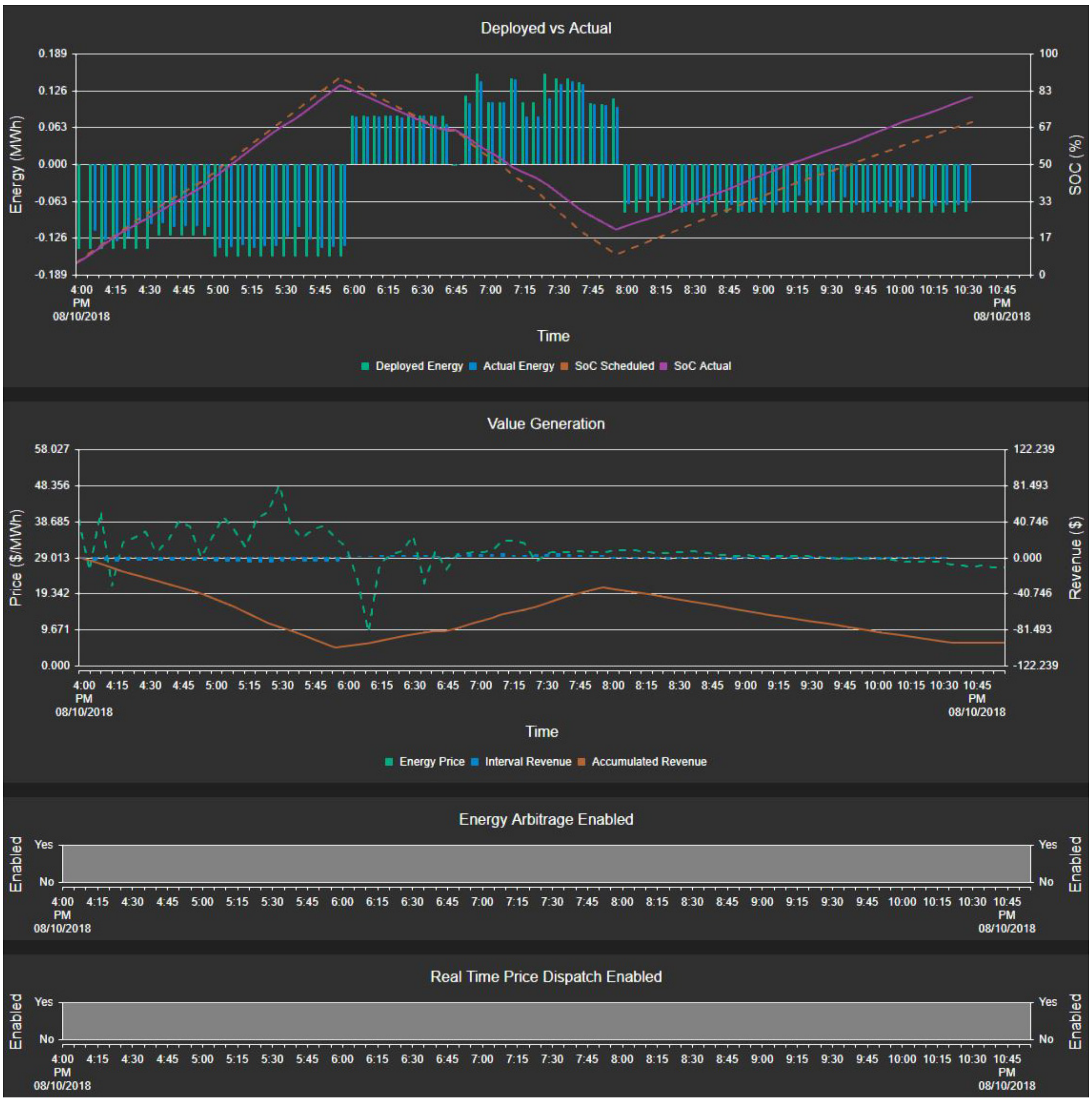
2.8.2.5 *Wholesale Market Revenue*

Compares the results of DG-DERO's market-based applications (Real Time Price Dispatch, and Energy Arbitrage), i.e., the actual and deployed energy, with the revenue achieved during the period. The data can be viewed graphically, or as a datasheet with the following values:

> Date and Interval Start – The time interval to which the values correspond.
> Deployed Energy (MWh) – The energy scheduled to be delivered (positive) or received (negative) in the given hour.

Actual Energy (MWh)* – The metered energy the system delivered (positive) or received (negative) in the given hour.
SoC Scheduled (percentage) – The target state of charge in the system schedule for the end of the given hour.
SoC Actual (percentage) – The actual state of charge of the system at the end of the given hour.
Energy Price – The price of energy measured over the interval. Depending on the market, this could be the Locational Marginal Price (LMP) or the Settlement Price Point (SPP).
Interval Revenue – Actual Energy × Energy Price.
Accumulated Revenue – The revenue accumulated during the report's time window.

Viewed as a chart, the **Deployed versus Actual** chart is compared with the **Value Generation** chart which tracks the energy price, internal revenue, and accumulated revenue over the period. The status (Enabled: Yes/No) of the wholesale market applications is tracked in separate charts below the value generation curves.



2.8.3 Application Reports

The Application Reports provide detailed data on the responses of DG-DERO's applications to the operational and market data they use to build the system schedule. The data is presented graphically and as tabular data that may be exported in aggregate form.

> The charts and aggregate data capture information on overall performance, but the individual application reports are most informative when only that application is enabled. Under normal operation, multiple applications will be enabled, and the performance of the application may be less obvious in the report.

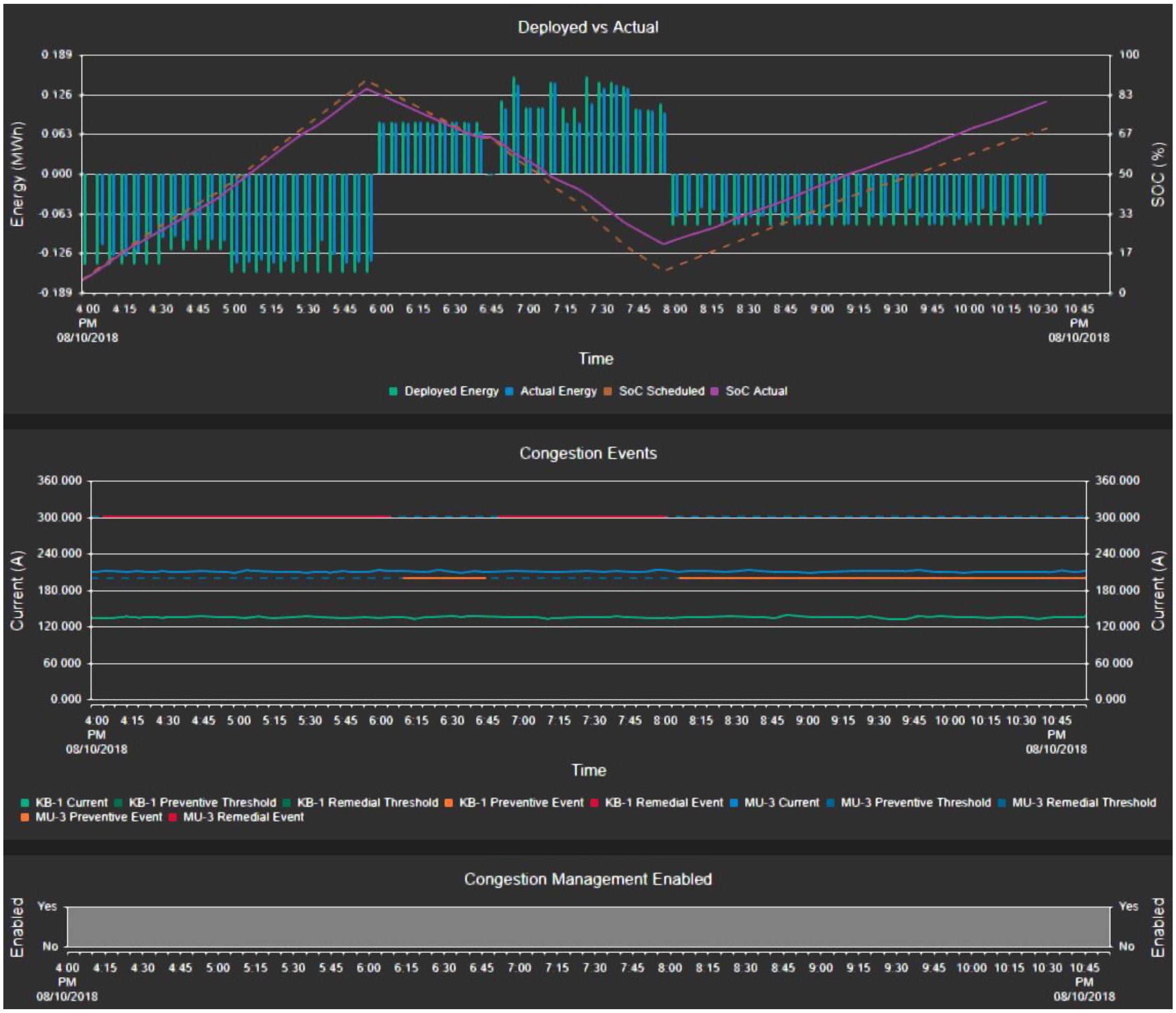
For the **fields marked with an asterisk (*)** below, you may see null values for the last hour ending. Because of their reliance on external sources, their data may be delayed one to three minutes from the hour's end. If a report is run too soon after the hour's end, you may need to refresh the report (i.e., click the **View** button) to see the most recent data.

2.8.3.1 *Congestion Management*

Responds in real time to relieve unexpected circuit-level congestion by adjusting the output of the circuit's distributed assets. Inputs include a cost coefficient which is calculated based on two pre-defined settings for each meter: The Base Cost ($ per MWh) and the Incremental Cost ($ per MWh×A).

Circuit/Meter – The ID of the signal meter reporting congestion on its circuit.
Type – Indicates whether the congestion event was addressed as Preventative or Remedial by the application. (For information on the preventative and remedial thresholds and how to adjust them, see "Configuring Congestion Management" in 2.10.2 'Applications' Settings)
Time Start/End – The start and end time of the congestion event.
Thresholds Preventative (A) / Remedial (A) – The threshold parameters for this meter. The Preventative Threshold parameter (in amperes), and the Remedial Threshold parameter (in amperes).
Base Cost ($/MWh) / Incremental ($/MWh×A)) – The cost-based parameters for this meter. The Base Cost parameter (in $ per MWh), and the Incremental Cost parameter (in $ per MWh×A).
Current Min (A) / Max (A) – The minimum current (in amperes) measured during the congestion event and the maximum current (in amperes) measured during the congestion event.
Mean Current Weighted (A) / Standard (A) – The mean weighted, and the non-weighted standard averages of the currents measured during the congestion event. The mean weighted average determines if the congestion event is recognized as Preventative or Remedial.

Viewed as a chart, the **Deployed versus Actual** chart is compared with the **Congestion Events** per circuit, tracked linearly as current (A) over time. The status (Enabled: Yes/No) of the Congestion Management applications is tracked in a separate chart below the congestion events curves.



2.8.3.2 *Peak Load Reduction*

Responds in real time to reduce circuit loads during the peak load intervals established by the transmission system operator, with the goal of reducing the distributor's load-ratio share for the current year.

> <u>Date and Interval Start</u> – The time interval to which the values correspond.
> <u>Deployed Energy (MWh)</u> – The energy scheduled to be delivered (positive) or received (negative) in the given hour.
> <u>Actual Energy (MWh)*</u> – The metered energy the system delivered (positive) or received (negative) in the given hour.
> <u>SoC Scheduled (percentage)</u> – The target state of charge in the system schedule for the end of the given hour.
> <u>SoC Actual (percentage)</u> – The actual state of charge of the system at the end of the given hour.
> <u>ERCOT System Load (GW)</u> – The system load for the interval as forecast by ERCOT.
> <u>Current Peak (GW)</u> – The peak load on the system as metered during the previous calendar month.

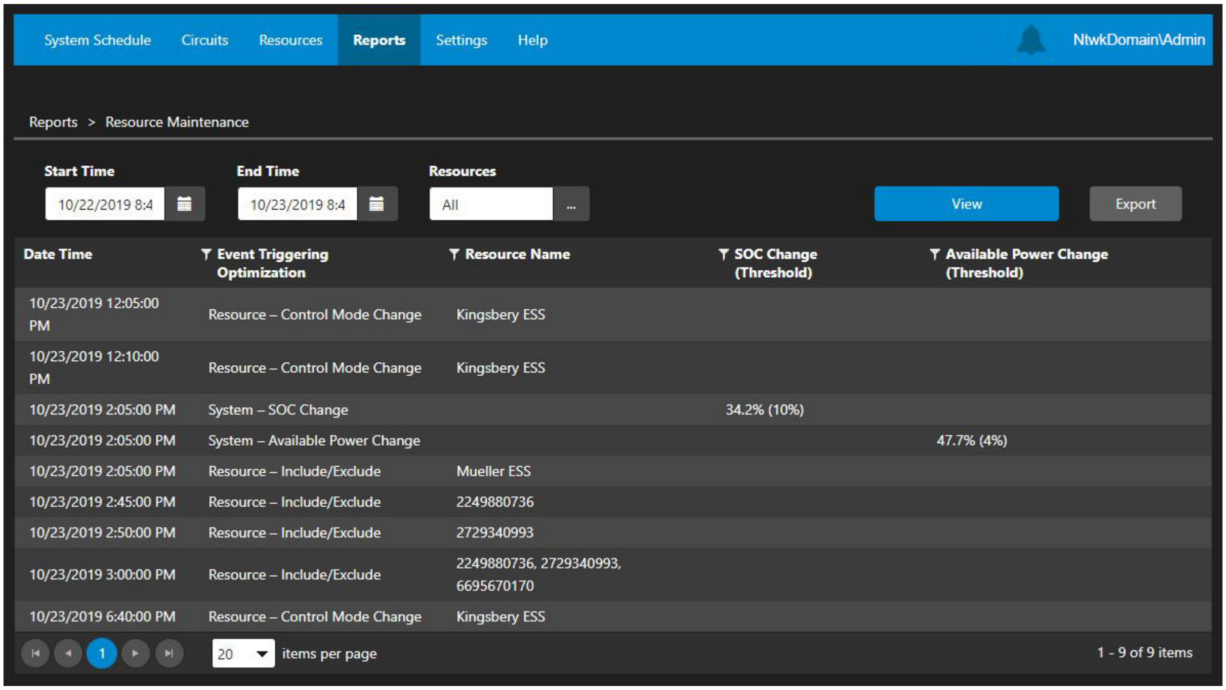
Viewed as a chart, the **Deployed versus Actual** data is compared with the **ERCOT System Load** chart, which compares the current peak with the ERCOT system load as horizontal lines across time on the horizontal axis. The status (Enabled: Yes/No) of the Peak Load Reduction applications is tracked in a separate chart below the ERCOT system load curves.

2.8.3.3 *Resource Maintenance*

The Resource Maintenance application is triggered whenever the system's state of charge or available power decreases by a configured amount. If no optimization-run is pending, Resource Maintenance instructs DERO to reoptimize the System Schedule.

This report catalogs each triggering event over the specified time period.

> Date Time – The response interval, which occurs every 5 minutes until the issue is resolved.
> Event Triggering Optimization – The triggering event, as reported by the system, which resulted in the outage or derating.
> Available Power Change (Threshold) – The amount by which the configured threshold for system available power was exceeded by the outage or derating; and (in parentheses) the configured threshold for the allowable decrease in the system's available power before the Resource Maintenance application is triggered.
> SOC Change (Threshold) – The amount by which the configured threshold for systems SoC changes was exceeded by the outage or derating; and, (in parentheses) the configured threshold for the allowable decrease of the system's state of charge (i.e. "potential energy") before the Resource Maintenance application is triggered.



2.8.3.4 *Voltage Support*

Responds in 5-minute intervals to voltage fluctuations on a given circuit and (by selecting a Volt/VAr curve or changing the power factor) makes automatic within-hour adjustments to the reactive power output of the circuit's DERs. The data can be viewed graphically, or as a datasheet with the following values:

- Date and Interval Start – The time interval to which the values correspond.
- Deployed (MVAr) – The reactive power deployed during the interval.
- Actual (MVAr) – The actual reactive power absorbed or injected during the interval.
- User Limit High (p.u.) – High Voltage Limit (in per-unit) as configured.
- User Limit Low (p.u.) – Low Voltage Limit (in per-unit) as configured.
- VS Enabled – Indicates (Yes/No) whether Voltage Support was enabled during the interval.
- Voltage Deviation [Circuit Name] (p.u.) – Standard voltage deviation (in per-unit) on this circuit.
- Voltage Deviation [Circuit Name] (p.u.) – Standard voltage deviation (in per-unit) on this circuit.

Viewed as a chart, the **Actual Reactive Power** dispatched by the system is compared with the **Average Voltage** and user limits tracked over time, both with and without Voltage Support enabled. The status (Enabled: Yes/No) of the Voltage Support applications is tracked in a separate chart below the voltage curves.

2.8.4 System Logs

The Event Logs provide a chronological list of System Events and Alerts over a specified period. The System Audit report includes user logins, setting updates, recommendations, schedule submittals/rejections, resource status, report requests, etc. Both the System Audit and the Alert History reports default to the previous full day.

The system event logs include the following:

Alert History: archives Warnings and Alerts that have been acknowledged and reset.

Optimizer Audit: archives optimizer engine events, both automatic and user-initiated. Requires Administrator privileges.

Web Service Audit: archives DERO user sessions, reporting pages accessed and user actions during the session. Requires Administrator privileges.

2.9 Monitoring Circuit Resources

The Circuits page is the primary interface for DERO's circuit-level applications, such as Voltage Support and Congestion Management. Utilizing DERO's knowledge of the power systems' physics, topology, devices, and distributed resources, the Circuits page enables the operator to better manage distribution feeders and improve reliability and power quality.

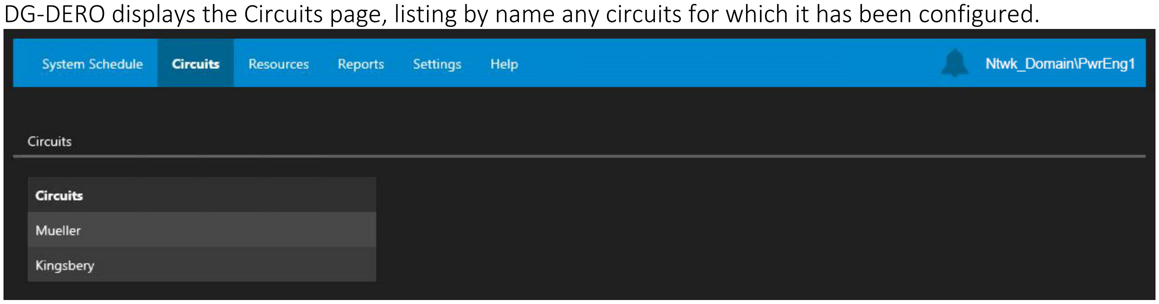
This section includes:

2.9.1 Accessing the Circuits Page

Only members of the DERO Administrators security group and users with the **Energy Control Center permission** can view the Circuits page. (see 2.10.5'Permissions' Settings)

To view a circuit:

1. Log into DG-DERO using an account with DG-DERO User privileges, and Energy Control Center permissions. For more on logging in, see 2.5.2 Authorization and User Privileges.
2. Click the **Circuits** tab on the Navigation bar.
   DG-DERO displays the Circuits page, listing by name any circuits for which it has been configured.



3. Click on a circuit.

DG-DERO displays the current user's most recently chosen **View** of the selected circuit.

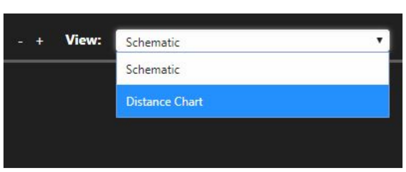
Circuit View Options

Circuits can be viewed as a conventional one-line schematic, with "live" data showing the current state of its loads and resources, including real-time measured values from its meters and other devices.

Schematic views – The default view when you first open a circuit shows a schematic view of the substation bus with feeder meters displaying live data (with amperage as its headline value) at each of its circuit branches. Clicking on a circuit's Device Group, represented by a stack of white rectangles, opens a schematic view of that feeder circuit, displaying live data (with voltage as its headline value) from each of its monitored devices.

To switch between circuit views

- From the **View** list in the upper right corner of the circuit page, choose any available alternate view.

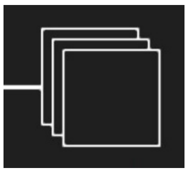


2.9.2 Navigating the Circuit Diagrams

Circuits in DG-DERO are displayed as one-line diagrams with conventional representations of circuit branches, connections, and circuit elements, and enables the user to monitor in real-time the status and measured values of its smart devices and distributed resources.

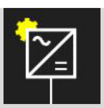
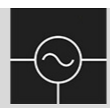
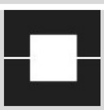
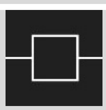
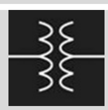
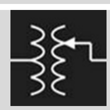
To navigate a circuit diagram:

- To zoom in or out, click the **+/-** buttons in the upper right of the screen, or, if your mouse has a scroll wheel, roll forward to zoom in, and roll back to zoom out.
- To move around the circuit, left-click and drag.
- If the feeder circuit view is available, sub-circuits and sub-branches may be viewed by clicking their **Device Group** icon:



Symbols and Conventions

Conventional electrical symbols are used in the circuit schematics. The table below shows some of the more common devices:

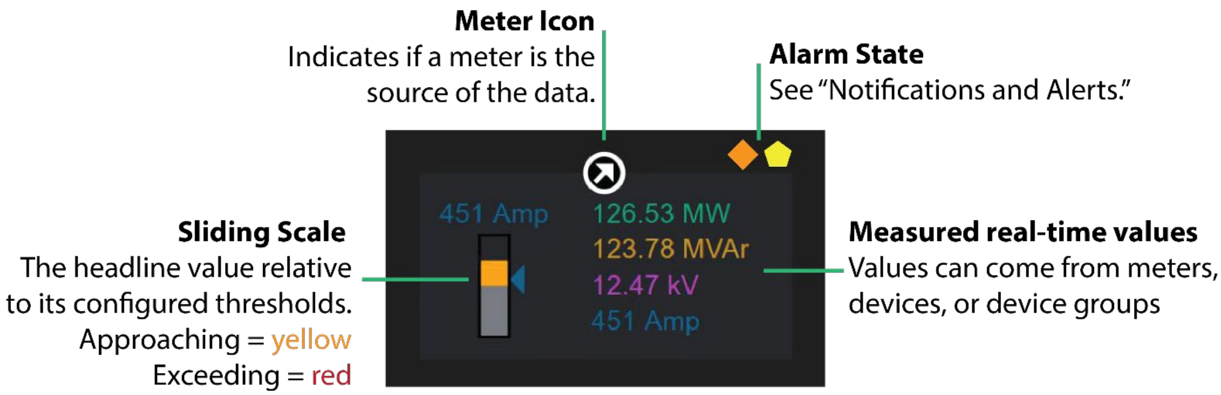
				
Battery	PV Inverter	Load	Generator	Capacitor
				
Circuit Breaker Closed	Circuit Breaker, Open	Transformer	Transformer with Tap Changer	Voltage Regulator

2.9.3 Reading Live Data

Most circuits will contain smart meters and other devices capable of measuring the flow of power along one branch of the circuit, or monitoring the status of one or more of its resources, and communicating the information back to the control center network. DERO reads these values and presents them, live, on the circuit schematic.

In the circuit's Schematic view, the live data from meters and smart devices appears in a **Headline Panel** along the branch of the circuit where the values are being measured – e.g., where circuit branches to a device group, or at the location of a primary meter.

The figure below identifies the elements of the Headline Panel:



Additional characteristics of Headline Panels include the following:

- Some Headline Panels may represent Device Groups. Click to view a schematic of its resources and/or devices.
- Some devices (such as transformers and PCSs) may have more than one Headline panel.

The Circuits page serves primarily as view onto the working of DERO's circuit management applications: Congestion Management, and; Voltage Support. The Headline Panel communicates its live values with reference to these applications' configured limits and thresholds.

Live Data for Substation Bus View

The Congestion Management application monitors the amperage at each of the signal meters along the main bus where a primary circuit branches off to its sub-circuits. Where possible, the application adjusts the generation output and load demands of the sub-circuit's resources.

In the Headline Panel for meters in the Substation Bus view, amperage is shown both numerically (on the right), and relative to its threshold value along a sliding scale (on the left). When amperage is low, or falls within a normal range, the index points on the sliding scale remain gray. When the amperage approaches or exceeds the configured threshold for that sub-circuit, the associated index point turns yellow or red.

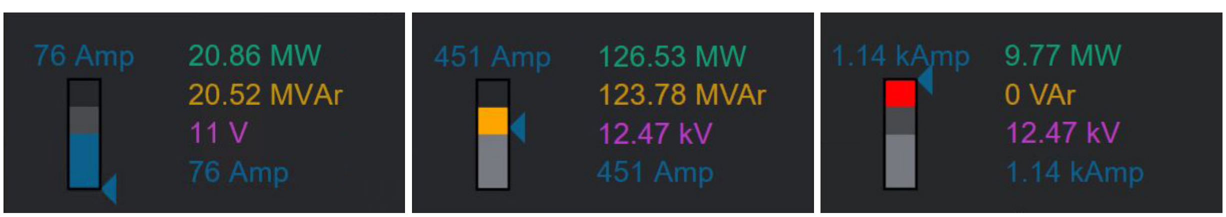


Figure 2-3 Panels showing amperage in relation to its configured thresholds

For information on configuring threshold amperages on selected circuits, see Congestion Management in 2.10.2 'Applications' Settings.

Live Data for Feeder Circuit View

In the Headline Panels for the Feeder Circuit views, voltage is shown both numerically (on the right), and relative to its acceptable range along a sliding scale (on the left). When voltage falls within a normal range, the index points on the sliding scale remain gray. When the voltage approaches the limits of its configured range the associated index points turn yellow. If voltage drops below or rises above the configured percentages, the associated index points turn red.

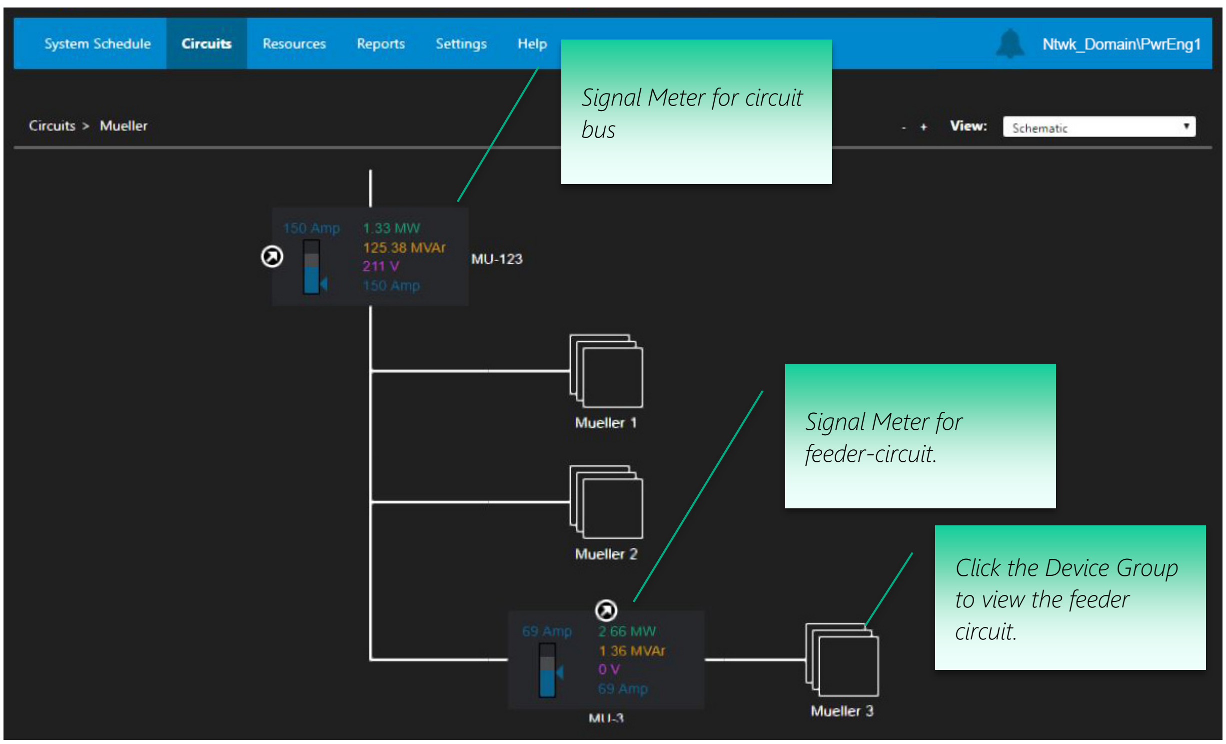
Figure 2-4 Headline Panels showing voltage in relation to its configured range

For more information, see Voltage Support in 2.10.2 'Applications' Settings.

2.9.4 Schematic Views

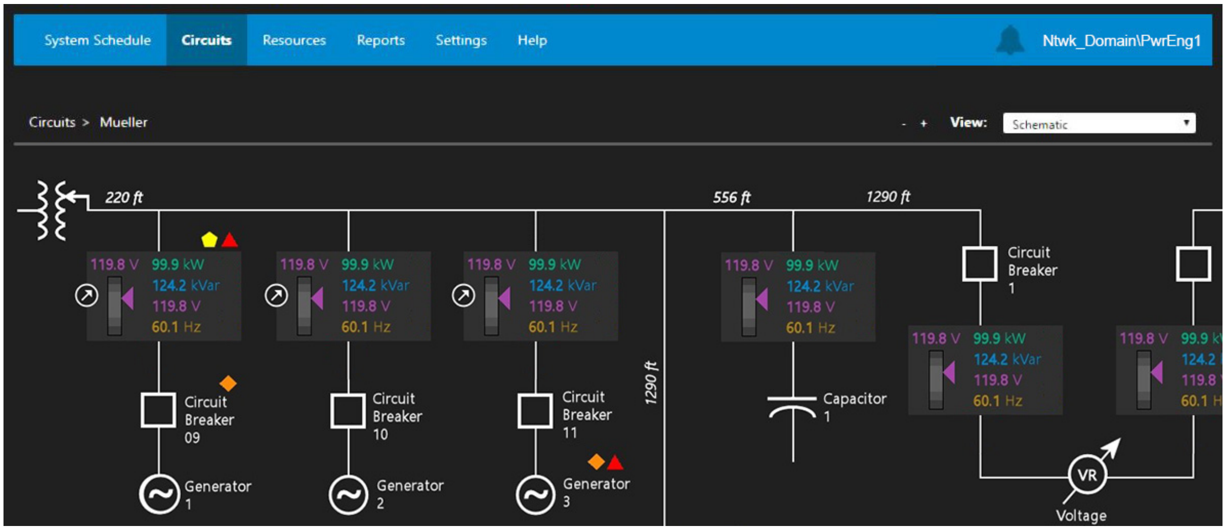
Substation Bus views

A circuit diagram of the primary circuit bus and sub-circuits branching at signal meters, with Amperage as the headline value.



Feeder Circuit views

The Feeder Circuit view is a full circuit diagram displayed as a conventional one-line, with Voltage as the headline value.



2.10 Configuration Settings

As system administrator, you can view and edit configuration settings for DG-DERO. These include settings to configure DG-DERO applications and recommendations, settings to define holidays for the Recommendations calendar, and other system-wide settings.

Many configuration options are specified only once, on installation. Though a critical system requirement, configuring DG-DERO is not likely to be a frequent task.

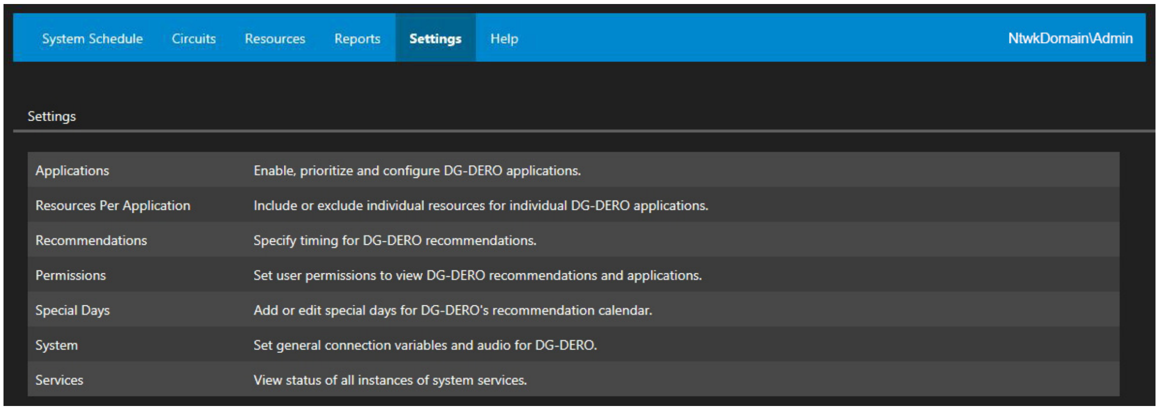
This section includes:

2.10.1 Accessing Configuration Settings

Any user can view configuration settings from the Settings screen. To edit configuration settings, you must be logged in with DG-DERO Administrator privileges.

To edit configuration settings:

1. Log into DG-DERO using an account with DG-DERO Administrator privileges. For more on logging in, see 2.5.2 Authorization and User Privileges.
2. Click the **Settings** tab on the Navigation bar.
   DG-DERO displays the Settings page.



3. On the Settings screen, click the row for the category of settings you want to configure. DG-DERO displays the category's settings.
4. View, change, and save the settings you want. For details on an application's settings, see 2.10.2.

2.10.2 'Applications' Settings

The "Applications" pages allow an administrator to enable or disable DG-DERO applications, prioritize between them, and configure their parameters.

Each DG-DERO application will typically be running alongside numerous other applications, each with its own goals, and the urgencies of each application are reconciled during optimization runs. In the rare event of a tie, i.e., when two or more applications' conflicting goals are weighted evenly by the optimization engine, DERO refers to their order of priority in the Application Settings. Additionally, certain parameters to DERO's algorithms can be configured for each application, providing an administrator with the tools necessary to fine tune its optimization.

Application priorities are considered by the DG-DERO optimization engine only as a tie breaker. When two or more application's urgencies are calculated to be of equal importance to the system schedule, the application with the higher priority will take precedence.

Prioritizing Applications

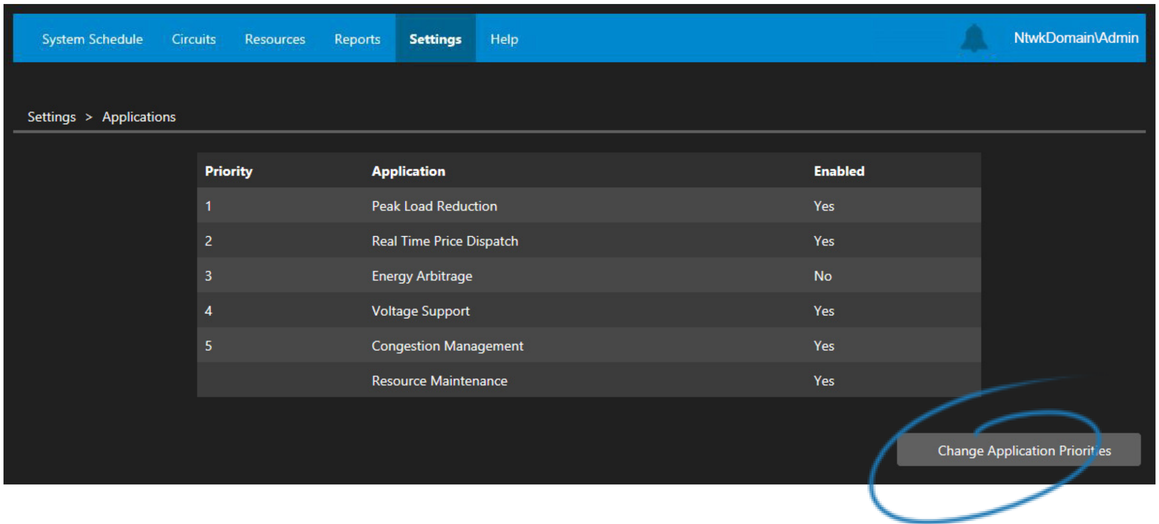
DG-DERO's fleet management and circuit-based applications might be prioritized as follows:

1. **Peak Load Reduction**
2. **Real Time Price Dispatch**
3. **Energy Arbitrage**
4. **Voltage Support**
5. **Congestion Management**
7. **Resource Maintenance**

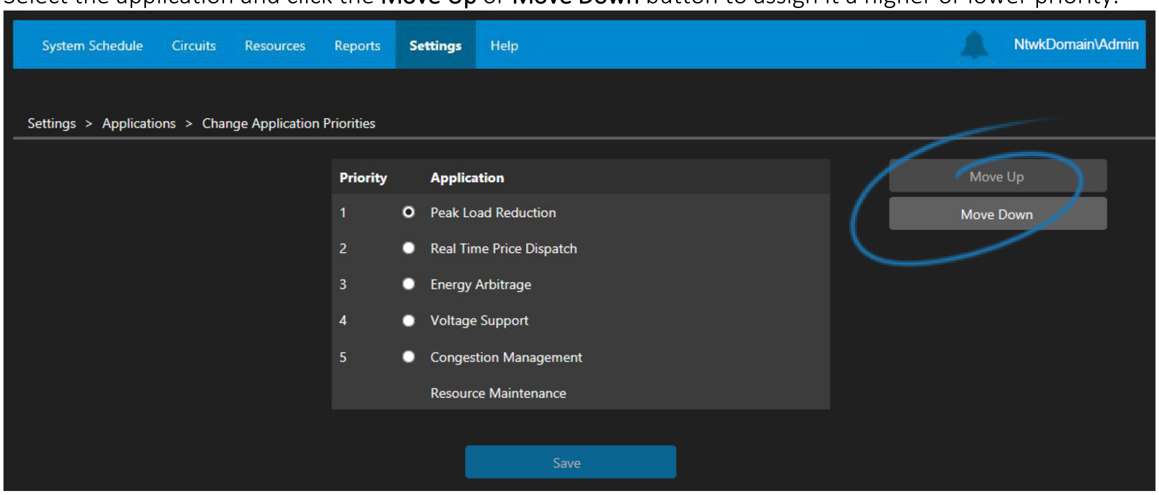
Resource Maintenance is a system-critical application that responds to sudden drops in the system's state of charge or available power, such as when a resource fails or is temporarily excluded from the system for maintenance purposes. Because it responds to exigent system-level constraints, the Resource Maintenance application takes precedence in DERO optimization and cannot be disabled.

To change application priorities:

1. Logged in as an administrator, on the **Settings** page for **Applications**, click **Change Application Priorities**.



2 Select the application and click the **Move Up** or **Move Down** button to assign it a higher or lower priority.



3 Click **Save**.

Note: Changing application priorities can affect the system schedule. Please monitor schedules over the next few hours to make sure DG-DERO applications are behaving as you intend.

Enabling, and Disabling Applications

If necessary, most applications can be disabled and excluded from DERO optimization.

To enable or disable an application:

1 On the **Settings** page for **Applications**, click the application to open its configuration page.
2 Check (or un-check) the **Enabled** box to enable (or disable) the application.
3 Click **Save**.

Some circuit-based applications, like Congestion Management can be enabled and disabled separately for each circuit, sub-circuit, or meter. To disable the application entirely, clear the **Enabled** box at the top of application's configuration.

2.10.2.1 *Configuring SOC Recovery*

SOC Recovery is an option within the application's settings that applies pressure on the application's participating resources to maintain their state of charge within prescribed bounds. You establish the target range and set cost parameters for straying above and below that range. Whenever the host application is idle, SOC Recovery checks the state of charge of its resources and applies the appropriate pressure to raise the state of charge to a prescribed minimum or lower it to a prescribed maximum.

The host application's ability to respond to exigencies is not affected by SOC Recovery; if conditions call for a response from the host application, SOC Recovery remains idle until the conditions have been addressed.

However, because it is separately enabled and configured for each application that supports it, SOC Recovery can apply indirect pressure on another application's ability to respond and should therefore be evaluated along with all the other factors that contribute to the optimized system schedule.

2.10.2.2 *Configuring Resource Maintenance*

Sudden drops in the system's available power or state charge are typically indicative of one or more resources being disconnected or partially shut down for maintenance purposes. The Resource Maintenance application compensates for the resultant loss of available power or energy by making real-time adjustments to its allocation of scheduled deployments across its fleet of distributed assets.

All system resources participate in Resource Maintenance. No resource can be exempted from Resource Maintenance without being excluded from DERO optimization altogether.

Note: Because Resource Maintenance is hard-coded as the highest-priority application in DERO optimization, it cannot be disabled.

2.10.2.3 *Configuring Real Time Price Dispatch*

Real Time Price Dispatch responds to price forecasting, making automatic within-hour adjustments to take advantage of the volatility of real-time energy prices. The adjustments account for the forecast Settlement Point Price (SPP) and LMP as well as their effect on battery life and performance.

2.10.2.4 *Configuring Energy Arbitrage*

Each day at the time configured in the Recommendations Settings, the Energy Arbitrage recommendation forms the initial system schedule for the following day. It is based on load and/or price forecasting, but local circuit factors, such as resource limits, maintenance events, and expected SoC at start of day are also considered in formulating the recommended schedule. Its purpose is to buy (charge the system) when energy prices are low and sell (discharge the system) when energy prices are high.

2.10.2.5 *Configuring Voltage Support*

Voltage Support responds in real time to voltage fluctuations on a given circuit and makes automatic within-hour adjustments to the power factor and Volt/VAr curves, affecting the reactive power output of the circuit's DERs.

2.10.2.6 *Configuring Peak Load Reduction*

The Peak Load Reduction application attempts to reduce the utility's load and hence its load ratio share during the peak load months established by its regional transmission organization or independent system operator. In some regions, for example, each MW of load that can be reduced during the peak intervals each month can help reduce the utility's payments to its transmission system operator for the entire following year.

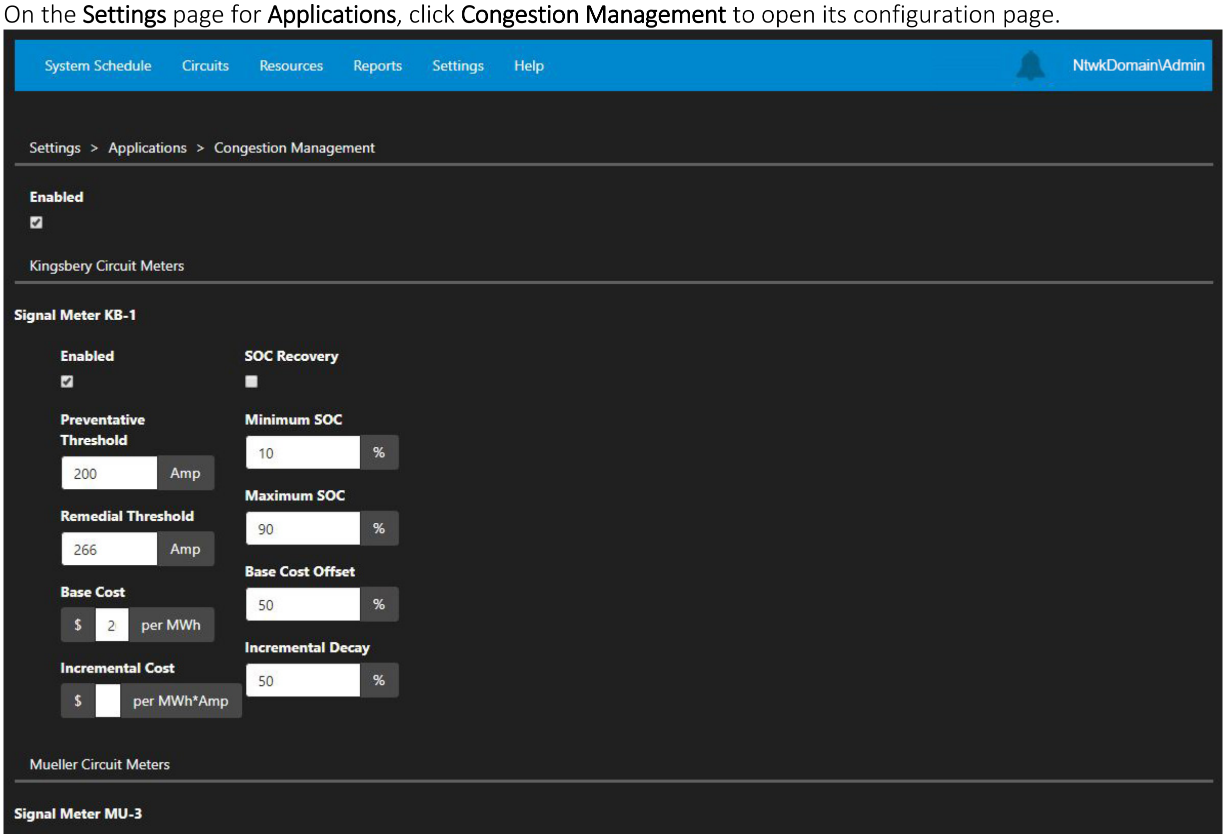
2.10.2.7 *Configuring Congestion Management*

The goal of this application is to use the active power capability of the distributed resources on a circuit to relieve congestion problems on, and upstream of, its sub-circuit. Every five minutes, Congestion Management takes the measured amperages from each meter and compares them to the configured threshold values. A Congestion event is detected when the per-phase amperage (the calculated average of all phases) exceeds either the Preventative or Remedial thresholds.

The app considers the total current (sum of all phases) and acts if that total, divided by the number of phases, exceeds the preventative or remedial thresholds.

To configure the Congestion Management application

1 On the **Settings** page for **Applications**, click **Congestion Management** to open its configuration page.



2 For each meter, make any necessary changes to the parameters (described above).

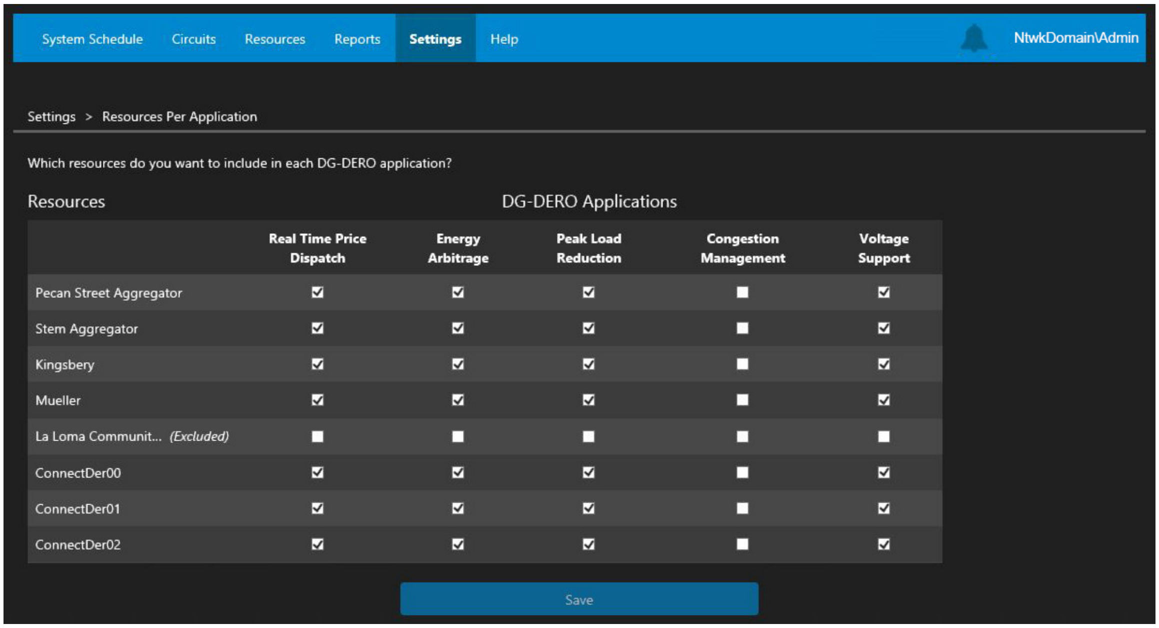
3 Click **Save**.

2.10.3 'Resources Per Application' Settings

The "Resources Per Application" page allows an administrator to selectively designate which resources are available to act on the urgencies of each DG-DERO application, and which are not. For example, only certain assets may have the capacity to participate in Peak Load Reduction. Or, you may wish to dedicate certain assets to voltage support or congestion management when their feeder circuits are experiencing serious congestion or voltage fluctuations.

To associate Applications with Resources:

1 From the Settings page, click Resources Per Application.



	Real Time Price Dispatch	Energy Arbitrage	Peak Load Reduction	Congestion Management	Voltage Support
Pecan Street Aggregator	☑	☑	☑	☐	☑
Stem Aggregator	☑	☑	☑	☐	☑
Kingsbery	☑	☑	☑	☐	☑
Mueller	☑	☑	☑	☐	☑
La Loma Communit... *(Excluded)*	☐	☐	☐	☐	☐
ConnectDer00	☑	☑	☑	☐	☑
ConnectDer01	☑	☑	☑	☐	☑
ConnectDer02	☑	☑	☑	☐	☑

2 For each Resource (ESS, aggregated PV, etc.) listed in the left column, check or uncheck the box associated with each DG-DERO application.

Checked – The Resource will participate in the application's optimization strategies.

Un-checked – The Resource will not participate in the application's optimization strategies.

3 Click Save.

2.10.4 'Recommendations' Settings

The "Recommendations" pages allow an Administrator to set the time and frequency of the day-ahead and interval-ahead recommendations generated by DG-DERO and, in the absence of operator intervention, whether DERO recommendations are automatically approved or rejected after a specified lapse of time.

To set parameters for Recommendations.

- On the **Settings** page, click **Recommendations**, and choose the **Application Group** and adjust the parameters as discussed below.

Day Ahead Applications

The settings for day-ahead applications are as follows:

Generate day-ahead recommendation by...
Enter the time of day or click the calendar icon and select the time of day that you want future recommendations to be generated. Subsequent Day-Ahead recommendations will be generated each business day at the time you choose.

...every business day. It will automatically...
In the absence of operator intervention, choose whether you want the schedule to be automatically approved or rejected.

...if user has not responded within...
Enter the number of minutes that will elapse before a recommendation is automatically approved or rejected in the absence of operator intervention.

Note: Day-Ahead recommendation may be configured to sometimes span more than 24 hours. For more information, see 2.10.6 'Special Days' Settings.

Interval-Ahead Applications:

The settings for Hour-Ahead applications are as follows:

Generate hour-ahead recommendation by…
Enter number of minutes past the hour that you want future hour-ahead recommendations to be generated.
…minutes after every hour. It will automatically…
In the absence of operator intervention, choose whether you want the schedule to be automatically approved or rejected.
…if user has not responded within…
Enter the number of minutes that will elapse before a recommendation is automatically approved or rejected in the absence of operator intervention.

2.10.5 'Permissions' Settings

Permissions settings enables administrators to designate which member of the DG-DERO Users security group may approve or reject DERO recommendations and/or access the Circuits page.

To grant permissions to power schedulers and control center circuit managers

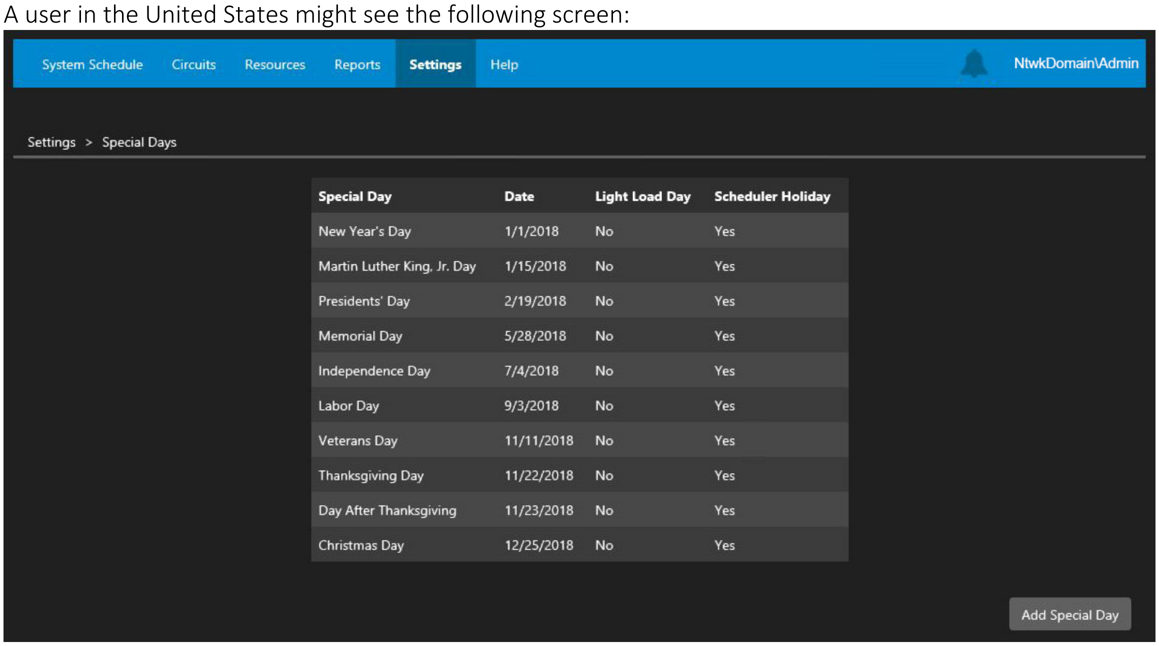
1. On the **Settings** page, click **Permissions.**
   Set the permissions for each user:
   a. The **Day-Ahead Permission** box grants permission to view and override Day-Ahead recommendations.
   b. The **Interval-Ahead Permission** box grants permission to view and override Interval-Ahead recommendations.
   c. The **Energy Control Center Permission** box grants permission to view the Circuits page.
2. When you are finished setting permissions, click **Save.**

2.10.6 'Special Days' Settings

DG-DERO enables administrators to account for regional differences that may affect the system and resource schedules. The default list of national holidays will vary depending on the country in which your installation has been deployed.

To add, edit, or delete a special day:

1. From the Settings page, click **Special Days**.
   A user in the United States might see the following screen:



Special Day	Date	Light Load Day	Scheduler Holiday
New Year's Day	1/1/2018	No	Yes
Martin Luther King, Jr. Day	1/15/2018	No	Yes
Presidents' Day	2/19/2018	No	Yes
Memorial Day	5/28/2018	No	Yes
Independence Day	7/4/2018	No	Yes
Labor Day	9/3/2018	No	Yes
Veterans Day	11/11/2018	No	Yes
Thanksgiving Day	11/22/2018	No	Yes
Day After Thanksgiving	11/23/2018	No	Yes
Christmas Day	12/25/2018	No	Yes

2. Click on the special day you wish to edit or delete
   – Or –
   Click the **Add Special Day** button.

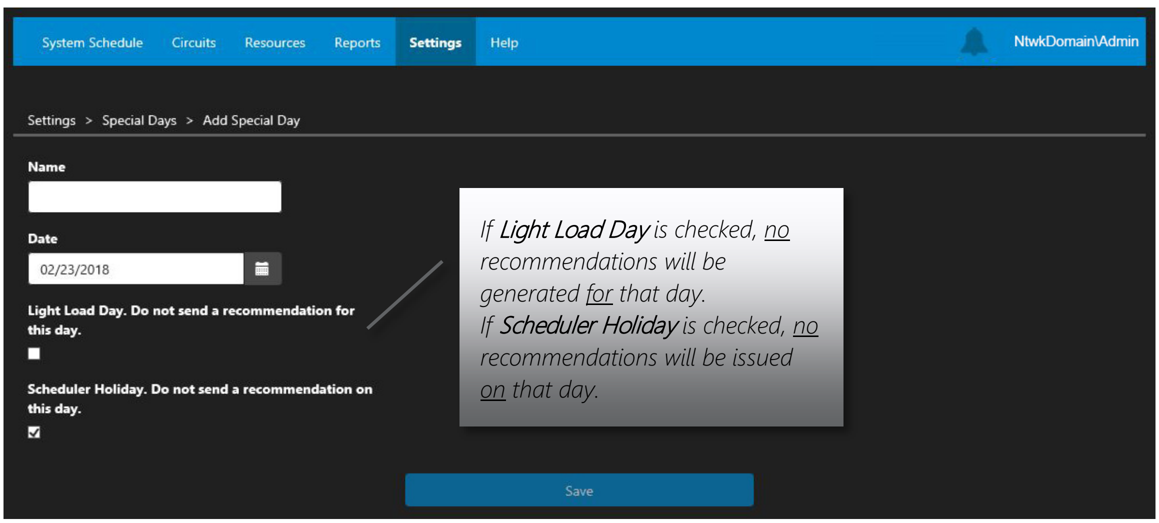
3 Enter changes:

a. **Name / Date** – Enter or edit the **Name** of the special day and the **Date** on which it occurs. Repeating dates, such as the first Monday of every month, must be entered as separate special days.

b. **Light Load Day** – If left *un-checked*, DERO will perform Energy Arbitrage and generate a Day Ahead recommendation for the special day, just as it would for any other day. If *checked*, DERO will *not* perform Energy Arbitrage and will *not* generate a Day Ahead recommendation for the special day. Un-checked by default.

c. **Scheduler Holiday** – If checked (default), DERO will issue no recommendations on that day. DERO will, instead, issue the recommendation on the nearest day prior to the Scheduler Holiday that allows for recommendations to be issued. Day Ahead recommendations issued before a Scheduler Holiday will span therefore more than 24 hours.

DERO defines a Scheduler Holiday as *unstaffed*, and will not, therefore, send a recommendation out for approval on that day. However, unless the **Light Load Day** box is checked, DERO *will* perform Energy Arbitrage and generate its Day-Ahead recommendations, as usual, for the day.



4 Click **Save**

–Or–

To delete the Special Day, click **Delete**.

2.10.7 'System' Settings

System settings specify system-wide connections, such as the Optimizer Service's http address and the directory path where resource schedules are stored.

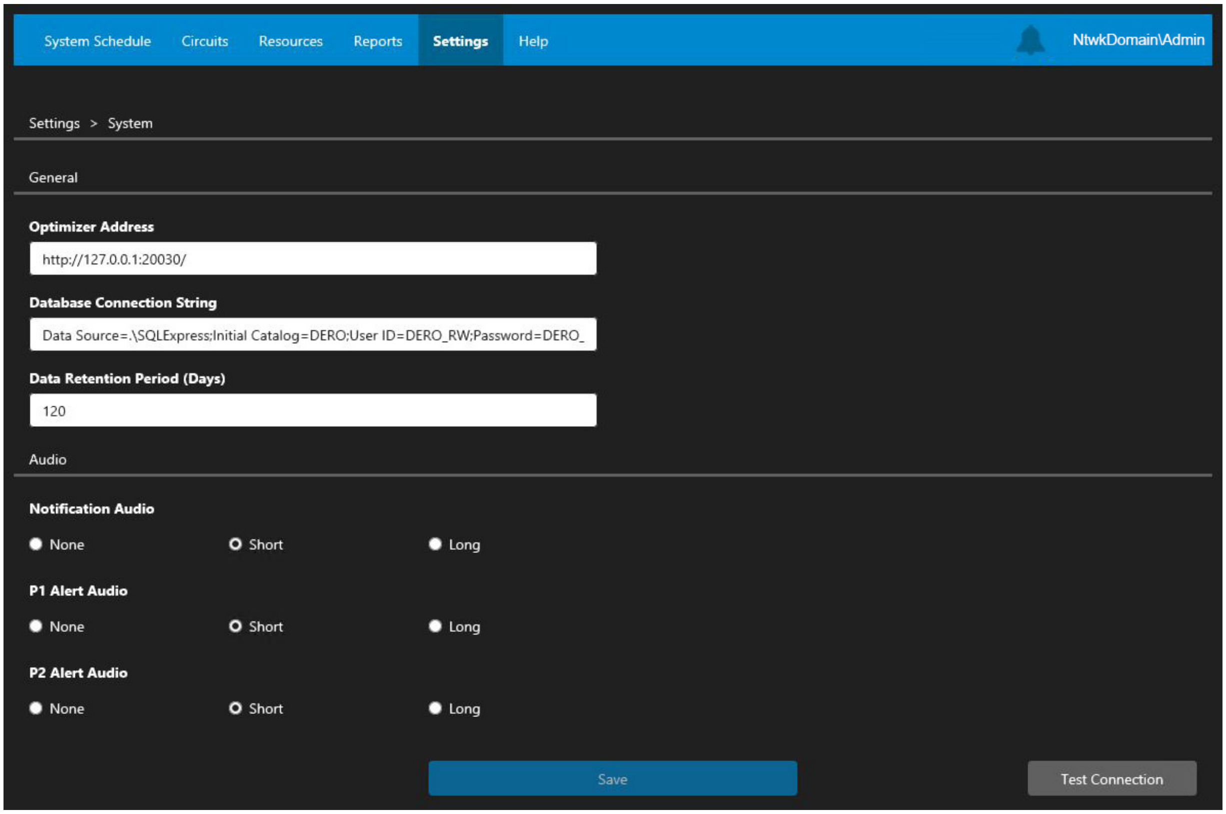


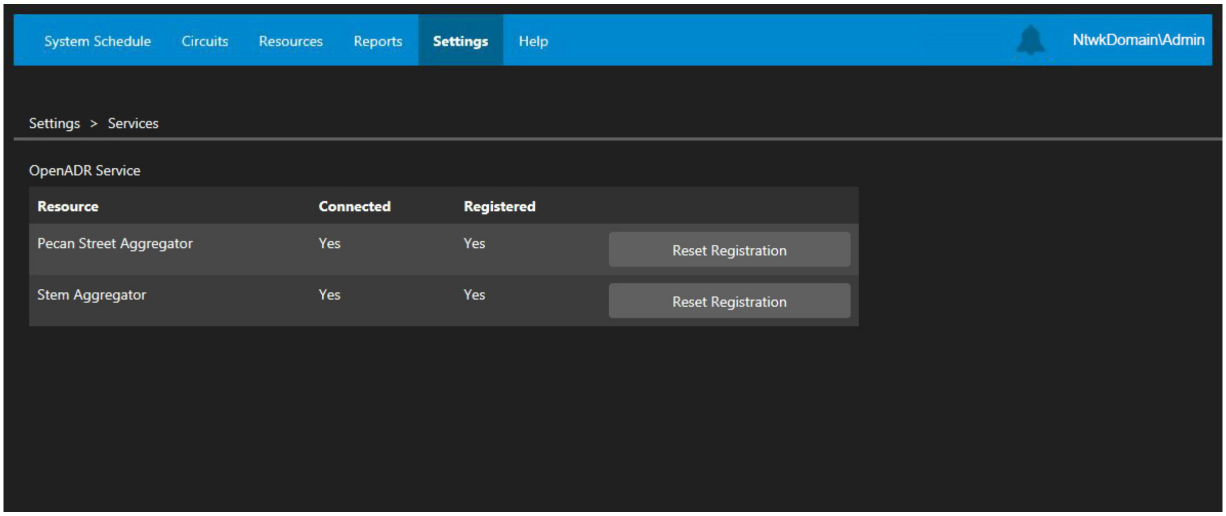
Table 1-1 lists the system configuration settings you can change.

Table 2-6: System Settings

Setting	Purpose
Optimizer Address	The IP address and Port of the Optimizer Service. Must be set before setting the Database Connection String and Schedule Directory Path.
Schedule Directory Path	For installations that include the DG-DERO Schedule Integration Service, the folder where resource schedules are stored.
Database Connection String	Specifies the server that contains the DERO Database, which is a SQL Server database configured to be the Optimizer service's data source. **Example**: Data Source=(localdb)\...\DERODatabase
Data Retention Period	Event log data will be retained, and accessible via the System Audit and Alert History reports, for the number of days entered here.
Audio for Notifications and Alerts	A long or short tone can be configured to accompany any newly issued Notification, Warning (P2 alert), or Error (P1 alert). This tone will sound with the appearance of the banner, providing an audio cue along with the visual.

2.10.8 'Services' Settings

Services settings enable administrators to view that status of DERO services as well as the registration status of any OpenADR aggregators on its circuits.



Registration is a process that enables DERO to schedule its OpenADR aggregators. The OpenADR Service reports the connection and registration status of each aggregator in the system. Unregistered aggregators can be reset on this page by clicking the resource's **Reset Registration** button.

For installations which include Redundancy and Failover protection, the Services Settings page allows an administrator to view the status of all instances of the DERO services, including the Optimizer Service, the Schedule Service, the Data Retrieval Service and, if applicable, the Schedule Integration Service.

Each instance of the service is identified with the following attributes

Name	Description
Rank	Primary/Secondary
Name of Machine	The name of the machine as identified through the Windows UI. For example, VM #1 or Greg's-PC.
Status	Available/Unavailable