Electrical Safety Authority

# Guideline for
# Distributed Energy Resources (DER)
## (Energy Storage and Generation)
### Version 2.1

## Ontario Regulation 22/04

## Electrical Distribution Safety

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# 1.0 General

## 1.1 Purpose of Guideline

This Guideline has been prepared to primarily provide guidance to distributors on how to comply with Ontario Regulation 22/04 Electrical Distribution Safety. Specifically, this Guideline addresses whether distributed energy resource installations are deemed part of a distribution system by being a distribution asset.

This Guideline along with the Regulation and other appropriate Codes and Standards form the basis on which ESA will assess the safety of the electrical distribution installations within the Province of Ontario.

## 1.2 Reference

Appendix B relies heavily on the work in the Sandia Report, SAND2010-0815, printed February 2010, and entitled Energy Storage for the Electric Grid: Benefits and Market Potential Assessment Guide.

## 1.3 Definitions

- "**Authority**" means the Electrical Safety Authority;
- **"distribution asset"** means electrical equipment used to distribute electricity, by conveying electricity at voltages of 50 kilovolts or less, or may include such other assets that have been deemed to be *distribution assets* by the Ontario Energy Board;
- **"distributed energy resource" or "DER"** means a source of electric power that is not directly connected to a bulk power transmission system. This includes terms such as distributed resources (DR), energy storage and generation from synchronous machines, induction machines and inverter based.
- **"distributed energy resource system"** means the DERs, interconnection systems, control systems, sensing devices or functions, and protection devices or functions up to the point of the DER connection.
- **"distribution system"** means a system for distributing electricity, and includes any structures, equipment or other things used by an owner for that purpose;
- **"distributor"** means a person or company who is licensed to own or operate a *distribution system* under Part V of the *Ontario Energy Board Act*, 1998;
- **"electrical equipment"** means any apparatus, appliance, device, instrument, fitting, fixture, machinery, material or thing used in or for, or capable of being used in or for, the distribution, supply or utilization of electric power or energy, and, without restricting the generality of the foregoing, includes any assemblage or combination of materials or things which is used, or is capable of being used or adapted, to serve or perform any particular purpose or function when connected to an electrical installation, notwithstanding that any of such materials or things may be mechanical, metallic or non-electric in origin;

- **“ownership demarcation point”** means the point,

  (a) at which the distributor’s ownership of a *distribution system*, including connection assets, ends at the customer, and

  (b) that is not located beyond,

    i. the first set of terminals located on or in any building, or
    ii. an electrical room or vault in a building where the electrical room or vault is of tamperproof construction, bears a sign to indicate that it is an electrical room or vault and is accessible only to authorized persons;

- **“Regulation”** means the Ontario Regulation 22/04 – Electrical Distribution Safety;

## 2.0 What types of *Distributed Energy Resources* are deemed part of a *distribution system* under Regulation 22/04?

To be deemed part of a *distribution system* under Regulation 22/04 a *distributed energy resource system* shall meet the following criteria:

a. The *distributed energy resource system* is deemed a *distribution asset* by the Ontario Energy Board (OEB) or if the *distribution asset* status has not been established, the *distributed energy resource system* is to primarily exist for such purposes as equipment upgrade deferrals or improved reliability of the *distribution system* (see Appendix A for more examples).*
b. The *distributed energy resource system* is connected to the distributor's side of an *ownership demarcation point*; and
c. Regulation 22/04 Sections 4 & 5 are satisfied.

* Note: In the event that the OEB has determined the status to <u>not</u> be a *distribution asset*, at any point in time, then ESA will automatically harmonize with the OEB decision and will also consider the equipment to "not be part of the *distribution system*".

In the event the *distribution energy resource system* is not considered part of the *distribution system* and the *distribution energy resource system* is connected on the distributor's side of the *ownership demarcation point*, all Ontario Electrical Safety Code requirements are applicable.

**See <u>Appendix A</u> for more examples of what is considered**

- **"Typically covered under Regulation 22/04"; and**
- **"Typically not covered under Regulation 22/04".**

## Appendix A

The following information relies heavily on the work in the Sandia Report, SAND2010-0815, printed February 2010, and entitled Energy Storage for the Electric Grid: Benefits and Market Potential Assessment Guide.

**Typically Covered Under Regulation 22/04**

**Application #1 —Congestion Relief**
**Description** – Congestion relief would be installed at locations that are electrically downstream from the congested portion of the distribution system.
**Typically Covered by Regulation 22/04** - Yes

**Application #2 —Upgrade Deferrals**
**Description** - Upgrade deferral involves delaying or avoiding investments in distribution system upgrades using relatively small amounts of energy storage. A small amount of energy storage can be used to provide enough incremental capacity to defer the need for a large investment in equipment.
**Typically Covered by Regulation 22/04** - Yes

**Application #3 — Area Regulation**
**Description** – Area regulation is used to reconcile momentary differences between supply and demand. This is not Load Following as the energy and durations addressed are much smaller.
**Typically Covered by Regulation 22/04** - Yes

**Application #4 — Voltage Support**
**Description** - Voltage support is to offset reactive effects so that grid system voltage can be restored or maintained.
**Typically Covered by Regulation 22/04** – Yes

**Application #5 — Substation On-site Power**
**Description** – Substation on-site power provides power to switching components and to substation communication and control equipment when the grid is not energized.
**Typically Covered by Regulation 22/04** – Yes

**Application #6 — Electric Service Reliability**

**Description** – Electric service reliability involves using equipment to provide highly reliable electric service, such as:

a) In the event of a complete power outage lasting more than a few seconds, the equipment provides enough energy to ride through outages of extended duration to complete an orderly shutdown of processes and/or to transfer to on-site generation resources; or
b) In areas with a high penetration of wind and/or solar the energy output to the grid can vary, and this equipment can provide enough energy to ride through the variability as the demand will not have changed.

**Typically Covered by Regulation 22/04** – Yes

**Application #7 — Electric Service Power Quality**

**Description** – Electric service power quality involves using energy storage to protect on-site loads downstream from energy storage against short-duration events that affect the quality of power delivered to the load.

**Typically Covered by Regulation 22/04** – Yes

**Application #8 — Emergency Power**

**Description** – Emergency equipment primarily installed for emergency power is defined as equipment used to supply emergency power as a result of loss of utility power supply and is not expected to exceed 300 operating hours at one time. The 300 operating hours at one time harmonizes with the CSA definition of an “emergency generator”.

**Typically Covered by Regulation 22/04** – Yes

**Not Typically Covered Under Regulation 22/04**

**Application #9 — Electric Energy Time-Shift**
**Description** - Electric energy time-shift (time-shift) involves purchasing inexpensive electric energy, available during periods when price is low, to charge the energy storage unit so that the stored energy can be used or sold at a later time when the price is high.
**Typically Covered by Regulation 22/04** - No

**Application #10 — Time-of-Use Energy Cost & Demand Management**
**Description** - Time-of-use (TOU) energy cost & demand management involves equipment used by energy end users (utility customers) to reduce their overall costs for electricity.
**Typically Covered by Regulation 22/04** - No

**Application #11 — Electric Supply Capacity**
**Description** - Electric supply capacity involves using equipment to defer and/or to reduce the need to buy new central station generation capacity and/or to 'rent' generation capacity in the wholesale electricity marketplace.
**Typically Covered by Regulation 22/04** - No

**Application #12 — Load Following**
**Description** – Load following capacity is characterized by power output that changes as frequently as every several minutes. The output changes in response to the changing balance between electric supply (primarily generation) and end user demand (load) within a specific region or area.
**Typically Covered by Regulation 22/04** - No

**Application #13 — Electric Supply Reserve Capacity**
**Description** - Electric supply reserve capacity involves a portion of the normal electric supply resources that can be called upon when the normal electric supply becomes unavailable unexpectedly. Generally, reserve capacity is equivalent to 15% to 20% of the normal electric supply capacity.
**Typically Covered by Regulation 22/04** - No

**<u>Appendix B</u>**

The following information relies heavily on the work in the Sandia Report, SAND2010-0815, printed February 2010, and entitled Energy Storage for the Electric Grid: Benefits and Market Potential Assessment Guide.

## Application #1 — Congestion Relief

### *Application Overview*

In areas, distribution capacity additions are not keeping pace with the growth in peak electric demand. Consequently, distribution systems may become congested during periods of peak demand, driving the need and cost for more distribution capacity.

Storage could be used to avoid congestion-related costs. In this application, storage systems would be installed at locations that are electrically downstream from the congested portion of the distribution system. Energy would be stored when there is no distribution congestion, and it would be discharged (during peak demand periods) to reduce distribution capacity requirements.

### *Technical Considerations*

The discharge duration needed for distribution congestion relief cannot be generalized easily, given all the possible manifestations. There may be a few occurrences during a year when there are several consecutive hours of distribution congestion.

The standard discharge duration assumed for this application is four hours.

### *Application Synergies*

Depending on location, the owner, the discharge duration, and other circumstances, storage used for distribution congestion relief may be compatible with most if not all applications described in this report, especially electric energy time-shift, electric supply capacity (peaking), ancillary services and possibly renewable energy time-shift.

## Application #2 — Upgrade Deferral

### *Application Overview*

Distribution upgrade deferral involves delaying – and in some cases avoiding entirely – utility investments in distribution system upgrades, using relatively small amounts of energy storage. Consider a distribution system whose peak electric loading is approaching the system's load carrying capacity (design rating). In some cases, installing a small amount of energy storage downstream from the nearly overloaded point will defer the need for an upgrade.

Consider a more specific example: A 15-MW substation is operating at 3% below its rating and load growth is about 2% per year. In response, engineers plan to upgrade the substation next year by adding 5 MVA of additional capacity. As an alternative, engineers could consider installing enough storage to meet the expected load growth for next year, plus any appropriate engineering contingencies (i.e., it may not be prudent to install 'just enough' storage, especially if there is uncertainty about load growth).

The key theme is that a small amount of storage can be used to provide enough incremental capacity to defer the need for a large 'lump' investment in distribution equipment.

Notably, for most nodes within a T&D system, the highest loads occur on just a few days per year, for just a few hours per year. Often, the highest annual load occurs on one specific day whose peak is somewhat higher than any other day. One important implication is that storage used for this application can provide a lot of benefit with limited or no need to discharge.

Although the emphasis for this application is on distribution upgrade deferral, a similar rationale applies to distribution equipment life extension. That is, if energy storage use reduces loading on existing equipment that is nearing its expected life, the result could be to extend the life of the existing equipment. This may be especially compelling for distribution equipment that includes aging transformers and underground power cables.

### *Technical Considerations*

Energy storage must serve sufficient load, for as long as needed, to keep loading on the distribution equipment below a specified maximum. The standard discharge duration is assumed to range from three to six hours.

### *Application Synergies*

Utility-owned storage used for distribution deferral is also likely to be well-suited for several other applications, especially electric energy time-shift, electric supply capacity (peaking), and electric supply reserve capacity. Depending on location and circumstances, the same utility-owned storage could also be used for voltage support, congestion relief, electric service reliability, electric service power quality, and renewable energy time-shift.

## Application #3 — Area Regulation

### *Application Overview*

Area regulation (regulation) is one of the ancillary services for which energy storage may be especially well-suited. Regulation is used to reconcile momentary differences between supply and demand. That is, at any given moment, the amount of electric supply capacity that is operating may exceed or may be less than load. Regulation is used for damping of that difference. Consider the example shown in the figure below. In that figure, the thin (red) plot with numerous fluctuations depicts total system demand without regulation. The thicker (black) plot shows system load after damping of the short-duration fluctuations with regulation.

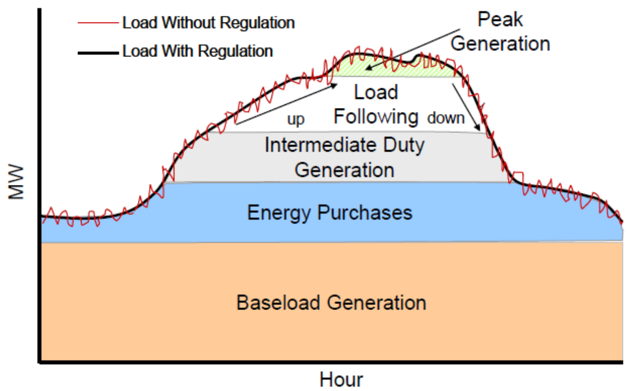


**Figure 4. System load without and with area regulation.**

### *Technical Considerations*

The rapid-response characteristic (i.e., fast ramp rate) of some types of storage makes that storage especially valuable as a regulation resource. In fact, the benefit of regulation from energy storage with a fast ramp rate (e.g., flywheels, capacitors, and some battery types) is on the order of two times that of regulation provided by generation.

### *Application Synergies*

In most cases, storage used to provide area regulation cannot be used simultaneously for another application. However, at any given time, storage could be used for another more beneficial application instead of using it for regulation (e.g., electric energy time-shift, electric supply capacity, electric supply reserve capacity, or upgrade deferral).

## Application #4 — Voltage Support

### *Application Overview*

An important technical challenge for electric grid system operators is to maintain necessary voltage levels with the required stability. In most cases, meeting that challenge requires management of 'reactance'. Reactance occurs because equipment that generates, transmits, or uses electricity often has or exhibits characteristics like those of inductors and capacitors in an electric circuit.

To manage reactance at the grid system level, grid system operators rely on an ancillary service called 'voltage support'. The purpose of voltage support is to offset reactive effects so that grid system voltage can be restored or maintained. Historically, voltage support has been provided by generation resources. Those resources are used to generate reactive power (VAR) that offsets reactance in the grid. Technologies (e.g., modular energy storage, modular generation, power electronics, and communications and control systems) can be used for voltage support. Conventional 'power factor correction' capacitors are good for managing localized reactance that occurs during normal operating conditions. Capacitors do not perform well as a voltage support resource, however, because they draw an increasing amount of current as voltage drops – to maintain power – which adds to voltage-related problems affecting the greater grid system.

One especially notable load type for this application is smaller air conditioning (A/C) equipment like that used for residences and for small businesses. The reactance from motors used for A/C compressors poses a significant voltage-related challenge because, as grid voltage drops – during localized or region-wide grid emergencies – the motors draw an increasing amount of current to maintain power. That exacerbates the voltage problem, in part because air conditioners are most likely to be turned on when the grid is most heavily loaded and possibly when the grid is especially prone to voltage-related problems.

### *Technical Considerations*

Storage systems used for voltage support must have VAR support capability if they will be used to inject reactive power. Also, storage used for voltage support must receive and respond quickly to appropriate control signals. The standard value for discharge duration is assumed to be 30 minutes — time for the grid system to stabilize and, if necessary, to begin orderly load shedding.

### *Application Synergies*

In general, storage used for voltage support must be available within a few seconds to serve load for a few minutes to perhaps as much as an hour. Thus, storage serving another application could also provide voltage support if the storage can be available within a few seconds to provide voltage support and if the storage has enough stored energy to discharge for durations ranging from a few minutes to an hour.

If the same storage is used for voltage support and for another ‘must-run’ application (e.g., distribution upgrade deferral), then the worst case is that the storage is completely dedicated to serving local demand during the few dozen too few hundred hours per year when the distribution equipment is most heavily loaded, leaving storage available during 95%+ of the year to serve other applications. If the storage is used primarily for non-voltage support, such as in the example above, then ESA would consider that the primary application would not be voltage support.

## Application #5 — Substation On-site Power

### *Application Overview*

There are over 100,000 battery storage systems at utility substations in North America. They provide power to switching components and to substation communication and control equipment when the grid is not energized.

### *Technical Considerations*

The standard discharge duration is assumed to range from 8 to 16 hours.

### *Application Synergies*

Conceptually, the same storage used for substation on-site power could be used for other applications. Key considerations include a) use of the storage for other applications cannot degrade reliability and b) the storage must have sufficient discharge duration to serve the substation on-site power application plus other applications (i.e., enough energy must be stored to serve the substation on-site power application and the other applications). For example, if 8 hours of discharge duration is required for substation on-site power and 5 hours are required for another application then the total discharge duration must be 8 + 5 = 13 hours. Given the high incremental cost for most types of storage that would be used for substation on-site power, use of the same storage system for other applications may be impractical in most circumstances.

## Application #6 — Electric Service Reliability

### *Application Overview*

The electric service reliability application entails using energy storage to provide highly reliable electric service. In the event of a complete power outage lasting more than a few seconds, the storage system provides enough energy to ride through outages of extended duration; to complete an orderly shutdown of processes; and/or to transfer to on-site generation resources. In areas with a high penetration of wind and/or solar the energy output can vary, the equipment can provide enough energy to ride through the variability as the demand will not have changed.

### *Technical Considerations*

The discharge duration required is based on situation-specific criteria. If an orderly shutdown is the objective, then discharge duration may be an hour or more. If an orderly transfer to a generation device is the objective, then no more than a few minutes of discharge duration are needed. The standard value for discharge duration is 15 minutes. Similar discharge durations are applicable to energy ride through for the variability produced for areas of high penetration of wind and/or solar.

### *Application Synergies*

The electric service reliability application may be compatible with most applications described in this report except area regulation and transmission support. It is especially compatible with the electric service power quality application.

If a storage system has sufficient discharge duration to serve the electric service reliability application plus other applications, it could be especially well-suited to serving the TOU energy cost and demand charge management applications as well as renewable (co-located distributed PV) capacity firming.

Depending on circumstances, the same storage system could also be used for electric energy time-shift, electric supply capacity (peaking), ancillary services, voltage support, transmission congestion relief, distribution upgrade deferral, electric service reliability, electric service power quality, and renewables energy time-shift applications.

## Application #7 — Electric Service Power Quality

### *Application Overview*

The electric service power quality application involves using energy storage to protect on-site loads downstream (from storage) against short-duration events that affect the quality of power delivered to the load. Some manifestations of poor power quality include the following:

- Variations in voltage magnitude (e.g., short-term spikes or dips, longer term surges, or sags).
- Variations in the primary 60-Hz frequency at which power is delivered.
- Low power factor (voltage and current excessively out of phase with each other).
- Harmonics (i.e., the presence of currents or voltages at frequencies other than the primary frequency).
- Interruptions in service, of any duration, ranging from a fraction of a second to several or even many minutes.

### *Technical Considerations*

Storage used for power quality should produce high-quality power output and should not adversely affect the grid. Typically, the discharge duration required for the power quality application ranges from a few seconds to about one minute.

### *Application Synergies*

Given the short discharge duration and distributed deployment of storage for electric service power quality, few if any applications are compatible with storage designed specifically for that application. Nevertheless, the electric service power quality application may be compatible with several other applications if storage is designed for those other applications (i.e., with longer discharge duration), especially time-of-use energy cost management, demand charge management, and electric service reliability.

## Application #8 — Emergency Power

### *Application Overview*

Emergency power may be portable generation or portable energy storage, for either planned or unplanned outages.

### *Technical Considerations*

The emergency power supply is not expected to exceed 300 operating hours at any one time. This 300 operating hour limit harmonizes with the CSA definition of an “Emergency generator”.

### *Application Synergies*

None.

## Application #9 — Electric Energy Time-shift

### *Application Overview*

Electric energy time-shift (time-shift) involves purchasing inexpensive electric energy, available during periods when price is low, to charge the storage plant so that the stored energy can be used or sold at a later time when the price is high.

This application tends to involve purchase of inexpensive energy from the wholesale electric energy market for storage charging. When the energy is discharged, it could be resold via the wholesale market, or it may offset the need to purchase wholesale energy and/or to generate energy to serve end users' needs.

### *Technical Considerations*

For the time-shift application, the plant storage discharge duration is determined based on the incremental benefit associated with being able to make additional buy-low/sell high transactions during the year versus the incremental cost for additional energy storage (discharge duration).

The standard assumption value for storage minimum discharge duration for this application is two hours. The upper boundary for discharge duration is defined by potential CAES or pumped hydroelectric facilities. For storage types that have a high incremental cost to increase the amount of energy that can be stored (i.e., to increase discharge duration), the upper boundary is probably five or six hours — the typical duration of a utility's daily peak demand period.

### *Application Synergies*

Although each case is unique, if a plant used for electric energy time-shift is in the right location and if it is discharged at the right times, it could also serve the following applications: electric supply capacity, distribution upgrade deferral, transmission congestion relief, electric service reliability, electric service power quality, and ancillary services.

## Application #10 — Time-of-use Energy Cost Management

### *Application Overview*

Time-of-use (TOU) energy cost management involves storage used by energy end users (utility customers) to reduce their overall costs for electricity. The energy storage charges during off-peak time periods when the electric energy price is low, then discharge the energy during times when on-peak TOU energy prices apply. This application is similar to electric energy time-shift.

### *Technical Considerations*

The standard value assumed for this application is five hours of discharge duration.

### *Application Synergies*

Depending on overlaps between on-peak energy prices and times when peak demand charges apply, the same storage system can be used for time-of-use energy cost management might also be compatible with the demand charge management application. It could also provide benefits associated with improved electric service power quality and improved electric service reliability. Similarly, depending on a plant’s discharge duration and when discharge occurs, it may be compatible with the distribution upgrade deferral application.

## Application #11 — Electric Supply Capacity

### *Application Overview*

Depending on the circumstances in a given electric supply system, energy storage could be used to defer and/or to reduce the need to buy new central station generation capacity and/or to 'rent' generation capacity in the wholesale electricity marketplace.

### *Technical Considerations*

The operating profile for storage used as supply capacity (characterized by annual hours of operation, frequency of operation, and duration of operation for each use) is circumstance-specific. Consequently, it is challenging to make generalizations about storage discharge duration for this application.

### *Application Synergies*

Depending on location and other circumstances, storage used for this application may be compatible with the following applications: electric energy time-shift, electric supply reserve capacity, area regulation, voltage support, distribution upgrade deferral, transmission support and congestion relief, electric service power quality, and electric service reliability.

## Application #12 — Load Following

### *Application Overview*

Load following is one of the ancillary services required to operate the electricity grid. Load following capacity is characterized by power output that changes as frequently as every several minutes. The output changes in response to the changing balance between electric supply (primarily generation) and end user demand (load) within a specific region or area.

Conventional generation-based load following resources' output increases to follow demand up as system load increases. Conversely, load following resources' output decreases to follow demand down as system load decreases. Typically, the amount of load following needed in the up direction (load following up) increases each day as load increases during the morning. In the evening, the amount of load following needed in the down direction (load following down) increases as aggregate load on the grid drops. A simple depiction of load following is shown in the figure below.

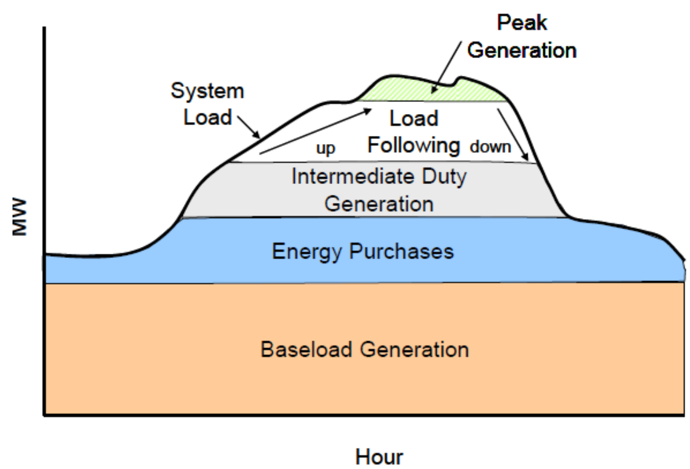


**Figure 3. Electric supply resource stack.**

### *Technical Considerations*

Storage used for load following should be somewhat-to-very reliable. For this application, storage could provide up to two service hours of discharge duration.

### *Application Synergies*

Load following could have good synergies with renewable capacity firming, electric energy time-shift, and possibly electric supply reserve capacity applications. If storage is distributed, then that same storage could also be used for most of the distributed applications and for voltage support.

## Application #13 — Electric Supply Reserve Capacity

### *Application Overview*

Prudent operation of an electric grid includes use of electric supply reserve capacity (reserve capacity) that can be called upon when some portion of the normal electric supply resources become unavailable unexpectedly.

At minimum, reserves should be at least as large as the single largest resource (e.g., the single largest generation unit) serving the system. Generally, reserve capacity is equivalent to 15% to 20% of the normal electric supply capacity, although specific reserve margins are designated in rules and/or regulations.

The three generic types of reserve capacity are:

- **Spinning Reserve** – Generation capacity that is online but unloaded and that can respond within 10 minutes to compensate for generation or transmission outages. ‘Frequency responsive’ spinning reserve responds within 10 seconds to maintain system frequency. Spinning reserves are the first type used when a shortfall occurs.
- **Supplemental Reserve** – Generation capacity that may be offline, or that comprises a block of curtailable and/or interruptible loads, and that can be available within 10 minutes. Unlike spinning reserve capacity, supplemental reserve capacity is not synchronized with the grid (frequency). Supplemental reserves are used after all spinning reserves are online.
- **Backup Supply** – Generation that can pick up load within one hour. Its role is, essentially, a backup for spinning and supplemental reserves. Backup supply may also be used as backup for commercial energy sales.

### *Technical Considerations*

Storage used for reserve capacity must have enough stored energy to discharge for the required amount of time (usually at least one hour).

### *Application Synergies*

In most cases, storage cannot serve any other applications while it is providing electric supply reserve capacity. Nevertheless, when storage is not used as electric supply reserve capacity, it could be used for electric energy time-shift, electric supply capacity, other ancillary services, renewable energy time-shift, renewable capacity firming, and wind generation grid integration. Depending on location, it could also be used for distribution upgrade deferral.