CLAIMS

1. A power management system comprising:

an energy storage device; and

a control system coupled to the energy storage device, wherein the control system is configured to:

execute a control routine to determine whether to charge or discharge the energy storage device, including determining a difference between a current state of charge of the energy storage device and a target state of charge of the energy storage device, receiving an output signal characterizing the output of a power generator, and determining to charge or discharge the energy storage device based on the difference and the output signal;

determine that the output signal is outside of a specified range; and

modify the target state of charge of the energy storage device in response to determining that the output signal is outside of the specified range.

2. The power management system of claim 1, wherein the control system is configured to:

determine that the output signal is below a first threshold and, in response, reduce the target state of charge of the energy storage device; and

determine that the output signal is above a second threshold and, in response, increase the target state of charge of the energy storage device.

3. The power management system of claim 1, wherein the control system is configured to:

determine that the output signal is outside of a specified range for a specified period of time; and

modify the target state of charge of the energy storage device in response to determining that the output signal is outside of the specified range for the specified period of time.

4. The power management system of claim 1, wherein the power generator is configured to provide intermittent power to a load, and wherein the energy storage device is configured to source power to the load when discharging and sink power from the power generator when charging.

5. The power management system of claim 4, wherein the power generator comprises one or more wind turbines, the load is an electrical grid, and the energy storage device comprises one or more batteries, each battery coupled to a respective bidirectional power conversion system.

6. The power management system of claim 5, wherein receiving the output signal comprises receiving a value from the power generator or a measurement device coupled to the power generator indicating an average or instantaneous power output from the wind turbines.

7. The power management system of claim 1, wherein determining to charge or discharge the energy storage device based on the difference and the output signal comprises:

determining that the output signal indicates that the power generator is generating power at an increasing rate above a first threshold rate and, in response, charging the energy storage device; and

determining that the output signal indicates that the power generator is generating power at a decreasing rate below a second threshold rate and, in response, discharging the energy storage device.

8. The power management system of claim 7, wherein the control system is configured to, in executing the control routine, decrease the first threshold rate or the second threshold rate or both when the current state of charge of the energy storage device is below the target state of charge of the energy storage device.

9. The power management system of claim 7, wherein the control system is configured to, in executing the control routine, increase the first threshold rate or the second threshold rate or both when the current state of charge of the energy storage device is above the target state of charge of the energy storage device.

10. The power management system of claim 1, wherein the control system comprises a real-time processing system to execute the control routine.

11. A method performed by a control system of a power management system, the method comprising:

executing a control routine to determine whether to charge or discharge an energy storage device coupled to a load, including:

determining a difference between a current state of charge of the energy storage device and a target state of charge of the energy storage device;

receiving an output signal characterizing the output of a power generator coupled to the load; and

determining to charge or discharge the energy storage device based on the difference and the output signal;

determining that the output signal is outside of a specified range; and

modifying the target state of charge of the energy storage device in response to determining that the output signal is outside of the specified range.

12. The method of claim 11, wherein determining that the output signal is outside of the specified range and modifying the target state of charge of the energy storage device comprises:

determining that the output signal is below a first threshold and, in response, reducing the target state of charge of the energy storage device; and

determining that the output signal is above a second threshold and, in response, increasing the target state of charge of the energy storage device.

13. The method of claim 11, wherein determining that the output signal is outside of the specified range comprises determining that the output signal is outside of a specified range for a specified period of time.

14. The method of claim 11, wherein the power generator is configured to provide intermittent power to the load, and wherein the energy storage device is configured to source power to the load when discharging and sink power from the power generator when charging.

15. The method of claim 14, wherein the power generator comprises one or more wind turbines, the load is an electrical grid, and the energy storage device comprises one or more batteries, each battery coupled to a respective bidirectional power conversion system.

16. The method of claim 15, wherein receiving the output signal from the power generator comprises receiving a value indicating an average or instantaneous power output from the wind turbines.

17. The method of claim 11, wherein determining to charge or discharge the energy storage device based on the difference and the output signal comprises:

determining that the output signal indicates that the power generator is generating power at an increasing rate above a first threshold rate and, in response, charging the energy storage device; and

determining that the output signal indicates that the power generator is generating power at a decreasing rate below a second threshold rate and, in response, discharging the energy storage device.

18. The method of claim 17, further comprising decreasing the first threshold rate or the second threshold rate or both when the current state of charge of the energy storage device is below the target state of charge of the energy storage device.

19. The method of claim 17, further comprising increasing the first threshold rate or the second threshold rate or both when the current state of charge of the energy storage device is above the target state of charge of the energy storage device.

20. A method performed by a first control system of a power management system, the method comprising:

receiving an output signal characterizing the output of a power generator coupled to a load;

determining that the output signal is outside of a specified range; and

sending a modified target state of charge to a second control system for an energy storage device in response to determining that the output signal is outside of the specified range, wherein the second control system is executing a control routine to determine whether to charge or discharge the energy storage device coupled to the load, including:

determining a difference between a current state of charge of the energy storage device and the modified target state of charge of the energy storage device;

receiving an output signal from a power generator coupled to the load; and

determining to charge or discharge the energy storage device based on the difference and the output signal.

1. A power management system comprising:

an energy storage device; and

a control system coupled to the energy storage device, wherein the control system is configured to:

execute a control routine to determine whether to charge or discharge the energy storage device, including determining a difference between a current state of charge of the energy storage device and a target state of charge of the energy storage device, receiving an output signal characterizing the output of a power generator, and determining to charge or discharge the energy storage device based on the difference and the output signal;

determine that the output signal is outside of a specified range; and

modify the target state of charge of the energy storage device in response to determining that the output signal is outside of the specified range.

2. The power management system of claim 1, wherein the control system is configured to:

determine that the output signal is below a first threshold and, in response, reduce the target state of charge of the energy storage device; and

determine that the output signal is above a second threshold and, in response, increase the target state of charge of the energy storage device.

3. The power management system of claim 1, wherein the control system is configured to:

determine that the output signal is outside of a specified range for a specified period of time; and

modify the target state of charge of the energy storage device in response to determining that the output signal is outside of the specified range for the specified period of time.

4. The power management system of any one of claims 1-3, wherein the power generator is configured to provide intermittent power to a load.

5. The power management system of claim 4, wherein the energy storage device is configured to source power to the load when discharging and sink power from the power generator when charging.

6. The power management system of claim 4 or 5, wherein the power generator comprises one or more wind turbines.

7. The power management system of any one of claims 4-6, wherein the load is an electrical grid, and the energy storage device comprises one or more batteries, each battery coupled to a respective bidirectional power conversion system.

8. The power management system of claim 7, wherein receiving the output signal comprises receiving a value from the power generator or a measurement device coupled to the power generator indicating an average or instantaneous power output from the wind turbines.

9. The power management system of any one of the preceding claims, wherein determining to charge the energy storage device based on the difference and the output signal comprises determining that the output signal indicates that the power generator is generating power at an increasing rate above a first threshold rate and, in response, charging the energy storage device.

10. The power management system of any one of the preceding claims, wherein determining to discharge the energy storage device based on the difference and the output signal comprises determining that the output signal indicates that the power generator is generating power at a decreasing rate below a second threshold rate and, in response, discharging the energy storage device.

11. The power management system of claim 9 or 10, wherein the control system is configured to, in executing the control routine, decrease the first threshold rate or the second threshold rate or both when the current state of charge of the energy storage device is below the target state of charge of the energy storage device.

12. The power management system of claim 9 or 10, wherein the control system is configured to, in executing the control routine, increase the first threshold rate or the second threshold rate or both when the current state of charge of the energy storage device is above the target state of charge of the energy storage device.

13. The power management system of any one of the preceding claims, wherein the control system comprises a real-time processing system to execute the control routine.

14. A method performed by the control system of the power management system of any one of the preceding claims, the method comprising:

executing a control routine to determine whether to charge or discharge an energy storage device coupled to a load, including:

determining a difference between a current state of charge of the energy storage device and a target state of charge of the energy storage device;

receiving an output signal characterizing the output of a power generator coupled to the load; and

determining to charge or discharge the energy storage device based on the difference and the output signal;

determining that the output signal is outside of a specified range; and

modifying the target state of charge of the energy storage device in response to determining that the output signal is outside of the specified range.

15. A method performed by a first control system of the power management system of any one of claims 1-13, the method comprising:

receiving an output signal characterizing the output of a power generator coupled to a load;

determining that the output signal is outside of a specified range; and

sending a modified target state of charge to a second control system for an energy storage device in response to determining that the output signal is outside of the specified range, wherein the second control system is executing a control routine to determine whether to charge or discharge the energy storage device coupled to the load, including:

determining a difference between a current state of charge of the energy storage device and the modified target state of charge of the energy storage device;

receiving an output signal from a power generator coupled to the load; and

determining to charge or discharge the energy storage device based on the difference and the output signal.