CLAIMS

1. A system comprising:

an energy storage device coupled to an electrical grid;

a plurality of sensors coupled to the electrical grid, the electrical grid comprising a plurality of metering nodes at different geographic locations, each sensor being coupled to a metering node;

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

receive a measurement from each of the sensors;

determine, based on the received measurements, whether a grid event is a local event or a distributed event; and

select a response mode for controlling the energy storage device based on whether the grid event is determined to be a local event or a distributed event.

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

determine that a first grid event is a local event, and in response, cause the energy storage device to inject or absorb active power at a first rate to compensate for the first grid event; and

determine that a second grid event is a distributed event, and in response, cause the energy storage device to inject or absorb active power at a second rate greater than the first rate to compensate for the second grid event.

3. The system of claim 1, wherein determining whether the grid event is a local event or a distributed event comprises calculating a difference between a first phase angle at a first sensor and a second phase angle at a second sensor, and, if the difference exceeds a threshold, determine that the grid event is a distributed event.

4. The system of claim 1, wherein determining whether the grid event is a local event or a distributed event comprises:

determining a first power flow from a first sensor to a second sensor;

comparing the first power flow with a recorded power flow from the first sensor to the second sensor, and, if the first power flow is oscillating more than a threshold oscillation amount from the recorded power flow or a rate of change of the power flow relative to the recorded power flow exceeds a rate of change threshold, determine that the grid event is a distributed event.

5. The system of claim 1, wherein determining whether the grid event is a local event or a distributed event comprises counting a number of sensors reporting the grid event, and, if the number of sensors is greater than a threshold number of sensors, determining that the grid event is a distributed event.

6. The system of claim 1, wherein the grid comprises first and second levels of grid components and a first plurality of sensors are located in the first level of grid components and a second plurality of sensors are located in the second level of grid components, and wherein determining whether the grid event is a local event or a distributed event comprises counting a first number of sensors reporting the grid event in the first level and a second number of sensors reporting the grid event in the second level and determining whether the grid event is a local event or a distributed event based on the first number of sensors and the second number of sensors.

7. The system of claim 6, wherein determining whether the grid event is a local event or a distributed event based on the first number of sensors and the second number of sensors comprises:

determining a difference between the first number of sensors and the second number of sensors; and

if the difference is greater than a threshold difference, determining that the grid event is a local event, and if the difference is less than or equal to the threshold difference, determining that the grid event is a distributed event.

8. The system of claim 1, wherein determining whether the grid event is a local event or a distributed event comprises:

receiving location information from each of the sensors; and

determining whether the grid event is a local event or a distributed event based on the location information.

9. The system of claim 8, wherein determining whether the grid event is a local event or a distributed event based on the location information comprises:

counting a first number of sensors of a first location reporting the grid event;

counting a second number of sensors of a second location reporting the grid event;

determining a difference between the first number of sensors and the second number of sensors; and

determining that the grid event is a local event if the difference is less than or equal to a threshold difference and determining that the grid event is a distributed event if the difference is greater than the threshold difference.

10. The system of claim 1, wherein the system is configured to determine that the grid event has occurred by determining that at least a first sensor has reported a reduction in a measured electrical parameter of the grid.

11. The system of claim 10, wherein determining that at least a first sensor has reported the reduction in the measure electrical parameter comprises determining that the first sensor has reported the reduction in the measured electrical parameter for at least a threshold period of time.

12. A method comprising:

receiving a measurement from each of a plurality of sensors coupled to an electrical grid, the electrical grid comprising a plurality of metering nodes at different geographic locations, each sensor being coupled to a metering node;

determining, based on the received measurements, whether a grid event is a local event or a distributed event; and

selecting a response mode for controlling an energy storage device coupled to the electrical grid based on whether the grid event is determined to be a local event or a distributed event.

13. The method of claim 12, comprising:

determining that a first grid event is a local event, and in response, causing the energy storage device to inject or absorb active or reactive power at a first rate to compensate for the first grid event; and

determine that a second grid event is a distributed event, and in response, cause the energy storage device to inject or absorb active or reactive power at a second rate greater than the first rate to compensate for the second grid event.

14. The method of claim 12, wherein determining whether the grid event is a local event or a distributed event comprises counting a number of sensors reporting the grid event, and, if the number of sensors is greater than a threshold number of sensors, determining that the grid event is a distributed event.

15. The method of claim 12, wherein the grid comprises first and second levels of grid components and a first plurality of sensors are located in the first level of grid components and a second plurality of sensors are located in the second level of grid components, and wherein determining whether the grid event is a local event or a distributed event comprises counting a first number of sensors reporting the grid event in the first level and a second number of sensors reporting the grid event in the second level and determining whether the grid event is a local event or a distributed event based on the first number of sensors and the second number of sensors.

16. The method of claim 15, wherein determining whether the grid event is a local event or a distributed event based on the first number of sensors and the second number of sensors comprises:

determining a difference between the first number of sensors and the second number of sensors; and

if the difference is greater than a threshold difference, determining that the grid event is a local event, and if the difference is less than or equal to the threshold difference, determining that the grid event is a distributed event.

17. The method of claim 10, wherein determining whether the grid event is a local event or a distributed event comprises:

receiving location information from each of the sensors; and

determining whether the grid event is a local event or a distributed event based on the location information.

18. The method of claim 15, wherein determining whether the grid event is a local event or a distributed event based on the location information comprises:

counting a first number of sensors of a first location reporting the grid event;

counting a second number of sensors of a second location reporting the grid event;

determining a difference between the first number of sensors and the second number of sensors; and

determining that the grid event is a local event if the difference is less than or equal to a threshold difference and determining that the grid event is a distributed event if the difference is greater than the threshold difference.

19. The method of claim 12, comprising determining that the grid event has occurred by determining that at least a first sensor has reported a reduction in a measured electrical parameter of the grid.

20. The method of claim 19, wherein determining that at least a first sensor has reported the reduction in the measured electrical parameter comprises determining that the first sensor has reported the reduction in the measured electrical parameter for at least a threshold period of time.

Claims

1. A system comprising:

an energy storage device coupled to an electrical grid;

a plurality of sensors coupled to the electrical grid, the electrical grid comprising a plurality of metering nodes at different geographic locations, each sensor being coupled to a metering node;

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

receive a measurement from each of the sensors;

determine, based on the received measurements, whether a grid event is a local event or a distributed event; and

select a response mode for controlling the energy storage device based on whether the grid event is determined to be a local event or a distributed event.

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

determine that a first grid event is a local event, and in response, cause the energy storage device to inject or absorb active power at a first rate to compensate for the first grid event; and

determine that a second grid event is a distributed event, and in response, cause the energy storage device to inject or absorb active power at a second rate greater than the first rate to compensate for the second grid event.

3. The system of claim 1 or 2, wherein determining whether the grid event is a local event or a distributed event comprises calculating a difference between a first phase angle at a first sensor and a second phase angle at a second sensor, and, if the difference exceeds a threshold, determine that the grid event is a distributed event.

4. The system of claim 1 or 2, wherein determining whether the grid event is a local event or a distributed event comprises:

determining a first power flow from a first sensor to a second sensor;

comparing the first power flow with a recorded power flow from the first sensor to the second sensor, and, if the first power flow is oscillating more than a threshold oscillation amount from the recorded power flow, determine that the grid event is a distributed event.

5. The system of claim 1 or 2, wherein determining whether the grid event is a local event or a distributed event comprises:

determining a first power flow from a first sensor to a second sensor;

comparing the first power flow with a recorded power flow from the first sensor to the second sensor, and if a rate of change of the first power flow relative to the recorded power flow exceeds a rate of change threshold, determine that the grid event is a distributed event.

6. The system of claim 1 or 2, wherein determining whether the grid event is a local event or a distributed event comprises counting a number of sensors reporting the grid event, and, if the number of sensors is greater than a threshold number of sensors, determining that the grid event is a distributed event.

7. The system of any one of the preceding claims, wherein the grid comprises first and second levels of grid components and a first plurality of sensors are located in the first level of grid components and a second plurality of sensors are located in the second level of grid components.

8. The system of claim 7, wherein determining whether the grid event is a local event or a distributed event comprises counting a first number of sensors reporting the grid event in the first level and a second number of sensors reporting the grid event in the second level and determining whether the grid event is a local event or a distributed event based on the first number of sensors and the second number of sensors.

9. The system of claim 8, wherein determining whether the grid event is a local event or a distributed event based on the first number of sensors and the second number of sensors comprises:

determining a difference between the first number of sensors and the second number of sensors; and

if the difference is greater than a threshold difference, determining that the grid event is a local event, and if the difference is less than or equal to the threshold difference, determining that the grid event is a distributed event.

10. The system of any one of the preceding claims, wherein determining whether the grid event is a local event or a distributed event comprises:

receiving location information from each of the sensors; and

determining whether the grid event is a local event or a distributed event based on the location information.

11. The system of claim 10, wherein determining whether the grid event is a local event or a distributed event based on the location information comprises:

counting a first number of sensors of a first location reporting the grid event;

counting a second number of sensors of a second location reporting the grid event;

determining a difference between the first number of sensors and the second number of sensors; and

determining that the grid event is a local event if the difference is less than or equal to a threshold difference and determining that the grid event is a distributed event if the difference is greater than the threshold difference.

12. The system of any one of the preceding claims, wherein the system is configured to determine that the grid event has occurred by determining that at least a first sensor has reported a reduction in a measured electrical parameter of the grid.

13. The system of claim 12, wherein determining that at least a first sensor has reported the reduction in the measure electrical parameter comprises determining that the first sensor has reported the reduction in the measured electrical parameter for at least a threshold period of time.

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

receiving a measurement from each of the plurality of sensors coupled to the electrical grid;

determining, based on the received measurements, whether the grid event is a local event or a distributed event; and

selecting a response mode for controlling the energy storage device based on whether the grid event is determined to be a local event or a distributed event.