CLAIMS

1. A building management system (BMS) optimization system for optimizing a pre-existing BMS of a building to reduce energy consumption by equipment instances in the building, the pre-existing BMS executing native control logic to control the behaviour of the equipment instances in the building via BMS-generated set point commands, the system comprising:

a cloud platform that is configured to:

generate, receive and/or retrieve a digital building model of the building that at least identifies the equipment instances in the building; and

analyse existing behaviour of the equipment instances in the building and recommend one or more optimized control strategies from a strategy library to improve one or more aspects of the operation of specific equipment instances in the building;

an onsite controller that is in data communication with the pre-existing BMS of a building, and which is configured to implement the recommended optimized control strategies from the cloud platform by overriding set points of the native control logic of the pre-existing BMS in real-time by generating higher-priority set point commands than the BMS-generated set point commands to thereby optimize the operation of the specific equipment instances in the building; and

a data network or data communication link between cloud platform and onsite controller.

2. A BMS optimization system according to claim 1 wherein the cloud platform comprises a model builder that is configured or operable to generate, receive and/or retrieve the digital building model of the building, the digital building model being generated based on extracting meta data and set points from the BMS relating to the equipment instances of the building.

3. A BMS optimization system according to claim 1 or claim 2 wherein the cloud platform comprises a fault detection and diagnostic (FDD) engine that is configured to process the digital building model, incoming BMS time-series data streams representing operation of the equipment instances of the building, and control

strategies from the strategy library to generate recommendation data identifying recommended optimized control strategies for the specific equipment instances and/or specific categories of equipment instances.

4. A BMS optimization system according to claim 3 wherein the FDD engine comprises a comparator that is configured or operable to compare nominal control strategy curves or functions to the incoming BMS time-series data streams to generate one or more deviation parameters representing or indicative of the current operation of the equipment instances in the building relative to the nominal control strategy curves or functions, and which generates diagnosis time-series data streams comprising at least the deviation parameters generated by the comparison.

5. A BMS optimization system according to claim 4 wherein the comparator of the FDD engine receives or retrieves incoming BMS time-series data provided by the BMS that represents, for each equipment instance being analysed, an actual controlled output set point value for the equipment instance, a process variable set point value associated with the equipment instance, and an actual process variable value associated with the equipment instance, and wherein the diagnosis time-series data streams comprise one or more deviation parameters generated based on or as a function of one or more of: a nominal controlled output value derived from the nominal control strategy curves or functions, the actual controlled output set point value, the process variable set point value, and/or the actual process variable value.

6. A BMS optimization system according to claim 5 wherein the diagnosis time-series data streams comprises any one or more of the following deviation parameter values:

a controlled output deviation value representing the difference between the nominal controlled output value and the actual controlled output set point value;

a controlled output Euclidian distance value representing the Euclidian distance between the nominal controlled output value and the actual controlled output set point value;

a process variable deviation value representing the difference between the process variable set point value and the actual process variable value; and/or

a process variable Euclidian distance value representing the Euclidian distance between the process variable set point value and the actual process variable value.

7. A BMS optimization system according to any one of claims 4-6 wherein the FDD engine comprises a recommendation engine that is configured or operable to generate the recommendation data identifying the recommended optimized control strategies for each equipment instance and/or category of equipment instance based at least partly on or as a function of the diagnosis time-series data streams and a recommendation threshold parameter or parameters.

8. A BMS optimization system according to any one of claims 3-7 wherein the FDD engine further comprises:

an augmentation engine that is configured or operable to identify and augment the recommendation data for equipment instances with any existing override data associated with the one or more respective equipment instances, the override data being indicative of any overrides or modifications required to the recommendation data for any applicable equipment instances; and/or

a rollout planner process that is configured to: identify which equipment instances are designated for which stage of a progressive optimization rollout; determine which optimized control strategies are applicable for each equipment instances identified for each stage based on the recommendation data and any applicable override data; and generate rollout plan data indicative of the optimized control strategies applicable to the equipment instances at each stage of the rollout.

9. A BMS optimization system according to claim 8 wherein the FDD engine further comprises a rollout implementer engine that is configured to spawn and/or configure an optimizer process in the onsite controller for each equipment instance in accordance with the rollout plan data for each stage of the rollout, each optimizer process being configured to override one or more set points of its associated equipment instance generated by the pre-existing BMS in accordance with its linked optimized control strategy.

10. A BMS optimization system according to any one of claims 1-9 wherein the onsite controller comprises one or more optimizer processes executing in an optimizer engine, each optimizer process being configured to override set points generated by the pre-existing BMS associated with the control of a respective equipment instance of the building in accordance with the recommended optimized control strategy for that equipment instance, and wherein each optimizer process of the onsite controller for an equipment instance is configured to:

access or retrieve BMS time-series data representing the process variable set point value and actual process variable value; and

override or configure the controlled output set point value in the pre-existing BMS for the equipment instance to the nominal controlled output value extracted from the nominal control strategy curve or function associated with the recommended optimized control strategy for the equipment instance based at least partly on the BMS time-series data.

11. A BMS optimization system according to claim 9 or claim 10 wherein the FDD engine further comprises a verifier engine that is configured to process the digital building model, incoming BMS time-series data streams representing operation of the equipment instances of the building, and a nominal control strategy curve or function of the optimized control strategy being implemented by the optimizer process for each equipment instance to generate deviation parameters representing or indicative of the current operation of the equipment instances relative to their associated optimized control strategy, and wherein the verifier engine is configured to generate fault data for one or more of the equipment instances based on comparing the deviation parameters to a verification threshold parameter or parameters.

12. A BMS optimization system according to any one of claims 9-11 wherein the FDD engine further comprises a monitoring engine that is configured to process the digital building model, incoming BMS time-series data streams representing operation of the equipment instances of the building, and the nominal control strategy curve or function of the optimized control strategy being implemented by the optimizer

process for each equipment instance to generate deviation parameters representing or indicative of the current operation of the equipment instances relative to their associated optimized control strategy, and wherein the monitoring engine is configured to generate fault data for one or more of the equipment instances based on comparing the deviation parameters to a monitoring threshold parameter or parameters, and wherein the verification threshold(s) are configured with a higher sensitivity to error compared to the monitoring threshold(s).

13. A BMS optimization system according to any one of claims 1-12 wherein the onsite controller is an edge computer that is in data communication with the pre-existing BMS via a BMS communication protocol, and wherein the BMS communication protocol is BACnet.

14. A BMS optimization system according to any one of claims 1-13 wherein the onsite controller is configured to override the set points of the pre-existing BMS via a command priority mechanism or system of a BMS communication protocol.

15. A BMS optimization system according to any one of claims 1-14 wherein the onsite controller is configured to generate commands having an associated configured priority level for execution, the commands comprising set points for controlling equipment instances of the building and which are generated in accordance with the optimized control strategies, and wherein the commands generated by the onsite controller have a configured priority level for execution that is higher than commands generated by the pre-existing BMS such that the set points generated by the onsite controller override the set points generated by the pre-existing BMS.

16. A BMS optimization system according to claim 15 wherein commands generated by the onsite controller have a configured priority level for execution that is higher than commands generated by the pre-existing BMS and lower than a predetermined or configurable safety priority level; and/or wherein the onsite controller is in data communication with the pre-existing BMS via a BMS communication protocol comprising BACnet, and commands to control set points of equipment instances of

the building are executed in accordance with a command priority array based on the priority level configured for generated commands.

17. A BMS optimization system according to any one of claims 1-16 wherein the pre-existing BMS is agnostic to the overriding control of specific equipment instances of the building exerted by the onsite controller; and/or wherein the onsite controller is configured to override control of one or more aspects of the operation of specific equipment instances of the building in accordance with the optimized control strategies without requiring modification of the native control logic of the pre-existing BMS.

18. A BMS optimization system according to any one of claims 1-17 wherein the pre-existing BMS continues to attempt to exert control over the equipment instances of the building in accordance with its native control logic by generating commands to control set points of one or more equipment instances, but wherein at least a portion of the BMS-generated set point commands are overridden by higher-priority commands generated by the onsite controller in accordance with the optimized control strategies.

19. A BMS optimization system according to any one of claims 1-18 wherein the onsite controller is configured to exert overriding control over one or more aspects of the operation of specific equipment instances of the building based on the optimized control strategies, while any remaining aspects of the operation of equipment instances of the building remain controlled by the native control logic of the pre-existing BMS; and wherein the one or more aspects of the operation of specific equipment instances of the building overridden by the onsite controller comprises controlling specific sets or groups or areas of equipment instances of the building.

20. A BMS optimization system according to any one of claims 1-19 wherein the pre-existing BMS seamlessly resumes full control of the operation of the specific equipment instances if the onsite controller goes offline, or wherein the pre-existing BMS resumes full control of the operation of the specific equipment instances by

virtue of BMS-generated set point commands to control operation of the specific equipment instances becoming effective again once any overriding higher-priority set point commands from the offline onsite controller cease to override the BMS-generated set point commands.

21. A system for optimizing building behavior of a building to reduce energy consumption by equipment instances in the building comprising:

an optimization engine;

an analysis system that is configured to:

generate, receive and/or retrieve a digital building model of the building that at least identifies the equipment instances in the building;

analyse existing behaviour of the equipment instances in the building and generate or select one or more optimized control strategies from a strategy library for execution by the optimization engine to improve one or more aspects of the operation of specific equipment instances in the building; and

a pre-existing building management system (BMS) executing native control logic to control the behaviour of the equipment instances in the building via BMS-generated set point commands, and

wherein the optimization engine that receives and executes the optimized control strategies to override set points of the native control logic of the pre-existing BMS by generating higher-priority set point commands than the BMS-generated set point commands to improve the one or more aspects of the operation of the specific equipment instances in the building.

22. A system according to claim 21 wherein the commands comprise set points for controlling equipment instances of the building; and/or wherein the commands are generated and executed in accordance with a BMS communication protocol to control equipment instances of the building.

23. A system according to claim 21 or claim 22 wherein the commands are executed in accordance with a command prioritization mechanism or system of the BMS communication protocol; and/or wherein the BMS communication protocol is BACnet

and the equipment instances are BACnet devices, and wherein the commands are executed in accordance with a command prioritization mechanism or system comprising a command priority array in BACnet.

24. A system according to any one of claims 21-23 wherein each generated command comprises a configurable command priority level that determines its priority of execution relative to other competing commands.

25. A system according to any one of claims 21-24 wherein the analysis system is a remote or cloud-based system or platform, and wherein the analysis system is in data communication with the optimization engine over a data network.

26. A system according to any one of claims 21-25 wherein the optimization engine is a separate device, interface or controller that connects or interfaces with the pre-existing BMS; and/or wherein the optimization engine is retrofittable to or with the pre-existing BMS; and/or wherein the optimization engine is provided in an edge computer that interfaces or is in data communication with the pre-existing BMS.

27. A system according to any one of claims 21-26 wherein the optimization engine is in data communication with the pre-existing BMS via a BACnet communication protocol.

28. A system according to any one of claims 21-27 wherein the optimization engine is installed onsite at the building; and/or wherein the optimization engine and pre-existing BMS are virtual machines or software applications which operate within the same or different computing systems; and/or wherein the optimization engine is remote or installed offsite from the building.

29. An optimization engine for optimizing a pre-existing building management system (BMS) of a building, the pre-existing BMS executing native control logic to control building behaviour via BMS-generated set point commands, the optimization engine comprising:

an interface for data communication with the pre-existing BMS of a building and/or equipment instances of the building;

memory for storing one or more optimized control strategies selected from a strategy library that are configured to improve one or more aspects of the operation of specific equipment instances in the building; and

a processor or application configured to execute the one or more optimized control strategies to override set points of the native control logic of the pre-existing BMS by generating higher-priority set point commands than the BMS-generated set point commands to thereby improve the one or more aspects of the operation of specific equipment instances in the building.

30. An optimization engine according to claim 29 wherein the optimization engine comprises or is in the form of an edge computer that is in data communication with the pre-existing BMS; or wherein the optimization engine is a virtual machine or software application.