**[4]** A need therefore exists to provide systems and methods for adaptively maximising cost savings or profits that addresses one or more of the above problems.

**[5]** Furthermore, other desirable features and characteristics will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and this background of the disclosure.

## SUMMARY

**[6]** According to the first aspect of the invention, a system for adaptively maximizing cost savings or profits over a period of time in response to a time-bound variable is provided, comprising: a limited capacity energy storage device configured to provide energy to or receive energy from an electrical consumer, or a producer or an electrical grid; a bilateral flow link operatively coupled to the energy storage device and configured to control a direction and an adjustable magnitude of a flow of the energy from or to the energy storage device, the adjustable magnitude of the energy being within an operating range comprising a maximum possible flow of energy to the energy storage device (in-flow limit) and a maximum possible flow of energy from the energy storage device (out-flow limit); and a control device operatively coupled to the bilateral flow link; and a bi-directional energy flow measurement device operatively coupled to the control device and the bilateral flow link, wherein the control device controls an energy flow via the bilateral flow link in response to the time-bound variable used to adaptively maximize the cost savings or profits based on an estimated quantity of energy required by or provided by the electrical consumer and/or producer, the fill level of the storage device resulting from a rate of in-flow to the energy storage device or a rate of out-flow from the energy storage device over the period of time and wherein the control device is further configured to calculate an optimal net metered energy (O) to be received from or provided to the electrical grid based on a quantity of energy provided to or received from the energy storage device via the bilateral flow link and the estimated quantity of energy required by or provided by the electrical consumer or the producer, the quantity of energy received from or provided to the electrical grid being measured by the bi-directional energy flow measurement device.

**[12]** In an embodiment, the control device determines the level difference based on at least one of (i) a long-term optimization of the average fill level of the energy storage device and (ii) losses to be incurred by system.

**[13]** In an embodiment, wherein the energy storage device is a battery.

**[14]** In an embodiment, the bilateral flow link comprises a bi-directional converter and a charger, the bi-directional converter and the charger being operatively coupled to the control device.

**[15]** In an embodiment, the bi-directional energy flow measurement device is a bi-directional electrical meter.

**[16]** According to the second aspect of the invention, a method for adaptively maximizing cost savings or profits in response to a time-bound variable in a system is provided. The system comprises a limited capacity energy storage device configured to provide energy to or receive energy from an electrical consumer, a producer or an electrical grid; a bilateral flow link operatively coupled to the energy storage device and configured to control a direction and an adjustable magnitude of a flow of the energy from or to the energy storage device, the adjustable magnitude of the energy being within an operating range comprising a maximum possible flow of energy to the energy storage device (in-flow limit) and a maximum possible flow of energy from the energy storage device (out-flow limit); a bi-directional energy flow management device operatively coupled to the control device and the bilateral flow link; and a control device operatively coupled to the bilateral flow link, the method comprising: controlling, by the control device, an energy flow via the bilateral flow link in response to the time-bound variable used to adaptively maximize the cost savings or profits based on an estimated quantity of energy required by or provided by the electrical consumer and/or producer, the fill level of the storage device resulting from a rate of in-flow to the energy storage device or a rate of out-flow from the energy storage device over the period of time; and

calculating, by the control device, an optimal net metered energy (O) to be received from or provided to the electrical grid based on a quantity of energy provided to or received from the energy storage device via the bilateral flow link and the estimated quantity of energy required by or provided by the electrical consumer or the producer.

**[22]** In an embodiment, the method further comprises determining the level difference based on at least one of (i) a long-term optimization of the average fill level of the energy storage device and (ii) losses to be incurred by system.

**[23]** According to the third aspect of the invention, a system for adaptively maximizing cost savings or profits over a period of time in response to a time-bound variable is provided, comprising: a limited capacity energy storage device configured to provide energy to or receive energy from an electrical consumer, a producer or an electrical grid; a bilateral flow link coupled to the energy storage device and configured to control a direction and an adjustable magnitude of a flow of the energy from or to the energy storage device, the adjustable magnitude of the energy being within an operating range comprising a maximum possible flow of energy to the energy storage device (in-flow limit) and a maximum possible flow of energy from the energy storage device (out-flow limit); and a bi-directional energy flow measurement device operatively coupled to the control device and the bilateral flow link, wherein the energy flow via the bilateral flow link is controlled in response to the time-bound variable used to adaptively maximize the cost savings or profits based on an estimated quantity of energy required by or provided by the electrical consumer or the producer, a fill level of the storage device resulting from a rate of in-flow to the energy storage device or a rate of out-flow from the energy storage device over a period of time, and an optimal net metered energy (O), to be received from or provided to the electrical grid, is calculated based on a quantity of energy provided to or received from the energy storage device via the bilateral flow link and the estimated quantity of energy required by or provided by the electrical consumer or producer, the quantity of energy received from or provided to the electrical grid being measured by the bi-directional energy flow measurement device.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[24]** Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

**[25]** Figure 1 shows a block diagram of a system 100 within which energy can be provided to or received from according to a first embodiment.

**CLAIMS:**

1. A system for adaptively maximizing cost savings or profits over a period of time in response to a time-bound variable, comprising:

a limited capacity energy storage device configured to provide energy to or receive energy from an electrical consumer, a producer or an electrical grid;

a bilateral flow link operatively coupled to the energy storage device and configured to control a direction and an adjustable magnitude of a flow of the energy from or to the energy storage device, the adjustable magnitude of the energy being within an operating range comprising a maximum possible flow of energy to the energy storage device (in-flow limit) and a maximum possible flow of energy from the energy storage device (out-flow limit);

a control device operatively coupled to the bilateral flow link; and

a bi-directional energy flow measurement device operatively coupled to the control device and the bilateral flow link,

wherein the control device controls an energy flow via the bilateral flow link in response to the time-bound variable used to adaptively maximize the cost savings or profits based on an estimated quantity of energy required by or provided by the electrical consumer or the producer, the fill level of the storage device resulting from a rate of in-flow to the energy storage device or a rate of out-flow from the energy storage device over the period of time, and

wherein the control device is further configured to calculate an optimal net metered energy (O) to be received from or provided to the electrical grid based on a quantity of energy provided to or received from the energy storage device via the bilateral flow link and the estimated quantity of energy required by or provided by the electrical consumer or the producer, the quantity of energy received from or provided to the electrical grid being measured by the bi-directional energy flow measurement device.

2. The system according to claim 1, wherein the control device is further configured to:

identify a multi-dimensional search space within which the optimal net metered energy (O) over an identified time period can be found; and

reduce the multi-dimensional search space to a first reduced search space (C*) within which the optimal net metered energy (O) can be found based on a maximum rate of in-flow or a maximum rate of out-flow, controllable via the bilateral flow link.

3. The system according to claim 2, wherein the control device is further configured to:

identify a sub-space (H*) within which the optimal net metered energy (O) can be found, so that an initial fill level and a targeted final fill level of the energy storage device are met, the sub-space (H*) being within the multi-dimensional search space; and

reduce the multi-dimensional search space to a second reduced search space (CH*) within which the optimal net metered energy (O) can be found based on the maximum rate of in-flow or the maximum rate of out-flow controllable via the bilateral flow link and the initial fill level and the targeted final fill level of the energy storage device, the second reduced search space being an intersection between the sub-space (H*) and the first reduced search space (C*) within the multi-dimensional search space.

4. The system according to claim 3, wherein the control device is further configured to reduce the second reduced search space (CH*) to a third reduced search space (CH**) based on a limited capacity of the energy storage device.

5. The system according to any one of claims 1-4, wherein the control device controls a fill level of the energy storage device via the bilateral flow link based on the difference between the initial fill level and the targeted final fill level of the energy storage device over the period of time, the level difference being used to compensate a drift of an average fill level of the energy storage device over the period of time.

6. The system according to claim 5, wherein the control device determines the level difference based on at least one of (i) a long-term optimization of the average fill level of the energy storage device and (ii) losses to be incurred by system.

7. The system according to any one of the preceding claims, wherein the energy storage device is a battery.

8. The system according to claim 7, wherein the bilateral flow link comprises a bi-directional converter and a charger, the bi-directional converter and the charger being operatively coupled to the control device.

9. The system according to any one of claims 1-8, wherein the bi-directional energy flow measurement device is a bi-directional electrical meter.

10. A method for adaptively maximizing cost savings or profits in response to a time-bound variable in a system, the system comprising:

a limited capacity energy storage device configured to provide energy to or receive energy from an electrical consumer, a producer or an electrical grid;

a bilateral flow link operatively coupled to the energy storage device and configured to control a direction and an adjustable magnitude of a flow of the energy from or to the energy storage device, the adjustable magnitude of the energy being within an operating range comprising a maximum possible flow of energy to the energy storage device (in-flow limit) and a maximum possible flow of energy from the energy storage device (out-flow limit);

a bi-directional energy flow measurement device operatively coupled to the control device and the bilateral flow link; and

a control device operatively coupled to the bilateral flow link, the method comprising:

controlling, by the control device, an energy flow via the bilateral flow link in response to the time-bound variable used to adaptively maximize the cost savings or profits based on an estimated quantity of energy required by or provided by the electrical consumer and/or producer, the fill level of the storage device resulting from a rate of in-flow to the energy storage device or a rate of out-flow from the energy storage device over the period of time; and

calculating, by the control device, an optimal net metered energy (O) to be received from or provided to the electrical grid based on a quantity of energy provided to or received from the energy storage device via the bilateral flow link and the estimated quantity of energy required by or provided by the electrical consumer or the producer.

11. The method according to claim 10, wherein the step of adaptively maximizing the cost savings or profits further comprises:

identifying, by the control device, a multi-dimensional search space within which the optimal net metered energy (O) over an identified time period can be found; and

reducing, by the control device, the multi-dimensional search space to a first reduced search space (C*) within which the optimal net metered energy (O) can be found based on a maximum rate of in-flow or the maximum rate of out-flow controllable via the bilateral flow link.

12. The method according to claim 11, wherein the step of adaptively maximizing the cost savings or profits further comprises:

identifying, by the control device, a sub-space (H*) within which the optimal net metered energy (O) can be found, so that an initial fill level and a targeted final fill level of the energy storage device are met, the sub-space (H*) being within the multi-dimensional search space; and

reducing, by the control device, the multi-dimensional search space to a second reduced search space (CH*) within which the optimal net metered energy (O) can be found based on the maximum rate of in-flow or the maximum rate of out-flow controllable via the bilateral flow link and the initial fill level and a targeted final fill level of the energy storage device, the second reduced search space being an intersection between the sub-space (H*) and the first reduced search space (C*) within the multi-dimensional search space.

13. The method according to claim 12, wherein the step of adaptively maximizing the cost savings or profits further comprises reducing the second reduced search space (CH*) to a third reduced search space (CH**) based on a limited capacity of the energy storage device.

14. The method according to any one of claims 10-13, wherein the step of adaptively maximizing the cost savings or profits is further based on the difference between the initial fill level of the energy storage device and the targeted final fill level of the energy storage device over the period of time, the level difference being used to compensate a drift of an average fill level of the energy storage device over the period of time.

15. The method according to claim 14, further comprising determining the level difference based on at least one of (i) a long-term optimization of the average fill level of the energy storage device and (ii) losses to be incurred by system.

16. A system for adaptively maximizing cost savings or profits over a period of time in response to a time-bound variable, comprising:

a limited capacity energy storage device configured to provide energy to or receive energy from an electrical consumer, a producer or an electrical grid;

a bilateral flow link coupled to the energy storage device and configured to control a direction and an adjustable magnitude of a flow of the energy from or to the energy storage device, the

adjustable magnitude of the energy being within an operating range comprising a maximum possible flow of energy to the energy storage device (in-flow limit) and a maximum possible flow of energy from the energy storage device (out-flow limit); and

a bi-directional energy flow measurement device operatively coupled to the control device and the bilateral flow link,

wherein the energy flow via the bilateral flow link is controlled in response to the time-bound variable used to adaptively maximize the cost savings or profits based on an estimated quantity of energy required by or provided by the electrical consumer or the producer, a fill level of the storage device resulting from on a rate of in-flow to the energy storage device or a rate of out-flow from the energy storage device over a period of time, and an optimal net metered energy (O), to be received from or provided to the electrical grid, is calculated based on a quantity of energy provided to or received from the energy storage device via the bilateral flow link and the estimated quantity of energy required by or provided by the electrical consumer or producer, the quantity of energy received from or provided to the electrical grid being measured by the bi-directional energy flow measurement device.