

CLAIMS

1. An energy storage system for efficiently storing electrical energy from an electrical energy source into two or more batteries, comprising the steps of:

providing an input voltage detector electrically connected to the energy source, a number of energy storage devices electrically connected to the energy source and a charge controller electrically connected to the energy storage devices, wherein each energy storage device comprises a charging circuit with a voltage detector and one or more batteries, the charge controller communicably coupled to the energy storage devices and the input voltage detector, and the charging circuits are initially disabled preventing the flow of electrical energy from the energy source to the batteries;

determining connection utility values of the energy storage devices based on one or more battery and energy source parameters using the charge controller and the input voltage detectors, wherein the connection utility values are based on the input power voltage, the states of charge of the batteries of the energy storage devices, and the minimum voltage requirements of the energy storage devices for charging the batteries attached to the energy storage devices;

connecting zero or more storage devices based on the connection utility values of the selected energy storage devices to the energy source by enabling the charging circuits of the selected energy storage devices, thereby allowing electrical energy to flow into the batteries;

determining disconnection utility functions of the energy storage devices based on one or more battery and energy source parameters using the charge controller and the input voltage detector, wherein the disconnection utility values are based on the input power voltage, the states of charge of the batteries of the energy storage devices, and the minimum voltage requirements of the energy storage devices for charging the batteries attached to the energy storage devices;

disconnecting zero or more energy storage devices from the energy source based on the disconnection utility values by disabling the charging circuits of the selected energy storage devices, thereby stopping the flow of electrical energy into the batteries;

repeating the determining steps, the connection step, and the disconnection step until all batteries are substantially charged, a specified charge level is obtained, a specified charging time period has elapsed. or until the input power voltage drops to a predefined value.

2. The energy storage system of statement 1, the steps of determining connection utility values and connecting zero or more energy storage devices are executed only when the input

voltage is above a predefined value $l_{vm} + \alpha$ wherein l_{vm} is the minimum of the charging voltage requirements of the energy storage devices and $\alpha > 0$ is a predefined value.

3. The energy storage system of statement 1 wherein the steps of determining disconnection utility values and disconnecting zero or more energy storage devices are executed only when the input voltage is below a predefined value l_{vm} .
4. The energy storage system of statement 2, the value α is the maximum amount of the input voltage that will drop if an energy storage device is connected.

5. The energy storage system of statement 1 wherein the connection utility values C_j are calculated using the following equation for each of the j -th energy storage device:

$$C_j = 0, \text{ if } V_i \leq (l_{vm_j} + \alpha_j)$$

$$C_j = 1/(V_i - (l_{vm_j} + \alpha_j)), \text{ if } V_i > (l_{vm_j} + \alpha_j)$$

where V_i is the current input voltage, l_{vm_j} is the required charging voltage of the j -th energy storage device, and α_j is the estimated amount of the input voltage that will drop if the j -th energy storage device is connected;

6. The energy storage system of statement 1 wherein the disconnection utility values D_j are calculated using the following equation for each of the j -th energy storage device:

$$D_j = 1/\beta_j$$

where β_j is the estimated amount of the input voltage that will be increased if the j -th energy storage device is disconnected;

7. The energy storage system of statement 1, further comprising the step of adjusting the charge currents of one or more of the connected energy storage devices until the charge currents of the energy storage devices reach the maximum charge rates of the batteries attached to the storage devices or until the input power voltage drops below any of the minimum voltage requirements of the energy storage devices for charging the batteries attached to the energy storage devices.
8. The energy storage system of statement 1 wherein the energy storage system is a portable system that can be detached from the energy source and the fitness equipment, wherein the system continues to function as a power source for electrical equipment.
9. The energy storage system of statement 1, further comprising the step of selecting an energy storage device for discharging, wherein an energy storage device with the highest state of charge is selected for discharging.

10. The energy storage system of statement 1 wherein the electrical energy source is connected to at least one fitness equipment to generate electricity using a dynamo generator which converts physical energy of users to electrical energy.
11. The energy storage system of statement 1, further comprising the step of measuring the one or more parameters for the two or more energy storage devices, wherein the one or more parameters comprise at least one of a parallel resistance, a series resistance, a parallel capacitance, a phase angle, a battery temperature, a battery internal pressure, a battery internal resistance, a battery terminal voltage and a voltage derivative with time.