CLAIMS:

1. An electrochemical desalination system comprising:

a first and a second electrochemical devices each comprising an electrochemical desalination module comprising at least one pair of electrodes and a compartment between each pair of electrodes for receiving an electrolyte solution, each of the first and second electrochemical desalination devices comprising a plurality of successive operation cycles, each cycle comprising a charging mode of operation for charging each pair of electrodes and for adsorbing ions in the electrolyte solution on the electrodes, and a discharging mode of operation for discharging the pair of electrodes and for desorbing ions from the pair of electrodes; and

a controller configured to control the system that the first and second electrochemical desalination devices have interleaved charging and discharging modes of operation, wherein one of the first and second electrochemical desalination devices is in a discharging mode and the at least one pair of electrodes release electrical current, while the other of the first and second electrochemical desalination devices is in a charging mode of operation and receives the electrical current released from said one of the first and second electrochemical desalination device.

2. The system of claim 1, wherein the controller is configured to control the system such that each of the first and second electrochemical desalination devices has an equal cycle time.

3. The system of claim 1, wherein the controller is configured to control the system such that a charging time for the charging mode of operation equals a discharging time for the discharging mode of operation for each of the first and second electrochemical desalination devices.

4. The system of claim 1, wherein the controller is configured to control the system such that the charging mode of operation of each of the first and second electrochemical desalination devices comprises a normal discharging mode of operation and a compulsory discharging mode of operation.

5. The system of claim 1, wherein the first and second electrochemical desalination devices comprise at least one bi-directional converter electrically connected between the electrochemical desalination module and a power supply.

6. The system of claim 5, wherein each of the bi-directional converters comprises a bi-directional DC/DC converter for transmitting a direct current to the electrochemical desalination module of one of the first and second electrochemical desalination devices during the charging mode of operation, and transmitting a direct current to the other of the first and second electrochemical desalination devices.

7. The system of claim 1, comprises at least two first electrochemical desalination devices connected in series and at least two second electrochemical desalination devices connected in series for respectively continuous removal of ions.

8. The system of claim 7, wherein the controller is configured to control one of the at least two electrochemical desalination devices to have interleaved charging and discharging modes of operation with at least one of the at least two second electrochemical desalination device.

9. An electrochemical desalination method comprising:

operating a first electrochemical desalination device in a charging mode of operation comprising:

charging at least one pair of electrodes of the first electrochemical desalination device with opposite polarities;

passing an electrolyte solution through a compartment between each pair of electrodes of the first electrochemical desalination device;

adsorbing ions in the electrolyte solution on the at least one pair of electrodes; and

exiting a dilute solution out of the first electrochemical desalination device; and

operating the first electrochemical desalination device in a discharging mode of operation comprising:

releasing electric energy stored in the at least one pair of electrodes of the first electrochemical desalination device to a second electrochemical desalination device, and charging at least one pair of electrodes of the second electrochemical desalination device using the electric energy released by the at least one pair of electrodes of the first electrochemical desalination device; and

desorbing ions accumulated on the at least one pair of electrodes of the first electrochemical desalination device into the electrolyte solution in the compartment.

10. The method of claim 9, wherein charging the at least one pair of electrodes of a first electrochemical desalination device comprises receiving a direct current released during a discharging mode of operation of the at least one pair of electrodes of the second electrochemical desalination device.

11. The method of claim 10 further comprising obtaining charging/discharging current profiles for the first and second electrochemical desalination devices, and controlling a converter to output currents for charging/discharging the pairs of electrodes respectively according to the charging/discharging current profiles.

12. The method of claim 9, wherein the discharging mode of operation comprises a normal discharging mode of operation for a normal discharging time and releasing a direct current driven by the electric energy stored in the at least one pair of electrodes in the first electrochemical desalination device during the normal discharging time.

13. The method of claim 12, wherein the normal discharging mode of operation comprises comparing if an instantaneous discharging energy released from the pair of electrodes of the first electrochemical desalination device meet an

instantaneous energy requirement for charging the pair of electrodes of the second electrochemical desalination device.

14. The method of claim 13, wherein comparing comprises comparing an instantaneous discharging electric power of the first electrochemical desalination device with an instantaneous charging electric power of the second electrochemical desalination device.

15. The method of claim 12, wherein the discharging mode of operation further comprises a compulsory discharging mode of operation for a compulsory discharging time by transmitting a direct current to the at least one pair of electrodes of the first electrochemical desalination device with reversed polarities.

16. The method of claim 15 further comprising calculating and determining a normal discharging current, normal discharging time, compulsory discharging current and compulsory discharging time based on a previous operation cycle or the average of several previous operation cycles.

17. The method of claim 16, wherein the calculating and determining of the normal discharging time and compulsory discharging time is repeated at a certain time interval.

18. The method of claim 17, wherein the normal charging time and compulsory discharging time are determined such that a difference of an energy output from the first electrochemical desalination device and an energy input to the first electrochemical desalination device is maximized.

The invention claimed is:

1. An electrochemical desalination system comprising:

a first and a second electrochemical desalination devices each comprising an electrochemical desalination module comprising at least one pair of electrodes and a compartment between each pair of electrodes for receiving an electrolyte solution, each of the first and second electrochemical desalination devices comprising a plurality of successive operation cycles, each cycle comprising a charging mode of operation for charging each pair of electrodes and for adsorbing ions in the electrolyte solution on the electrodes, and a discharging mode of operation for discharging the pair of electrodes and for desorbing ions from the pair of electrodes; and

a controller programmed to control the system such that the first and second electrochemical desalination devices have interleaved charging and discharging modes of operation, wherein one of the first and second electrochemical desalination devices is in a discharging mode and the at least one pair of electrodes release electrical current, while the other of the first and second electrochemical desalination devices is in a charging mode of operation and receives the electrical current released from said one of the first and second electrochemical desalination device,

wherein the controller is programmed to control the system such that the discharging mode of operation of each of the first and second electrochemical desalination devices comprises a normal discharging mode of operation and a compulsory discharging mode of operation,

wherein the controller is further programmed to calculate and determine a normal discharge current, normal discharging time, compulsory discharging current and compulsory discharging time based on a previous operation cycle or the average of several previous operation cycles.

2. The system of claim 1, wherein the controller is programmed to control the system such that each of the first and second electrochemical desalination devices has an equal cycle time.

3. The system of claim 1, wherein the controller is programmed to control the system such that a charging time for the charging mode of operation equals a discharging time for the discharging mode of operation for each of the first and second electrochemical desalination devices.

4. The system of claim 1, wherein the first and second electrochemical desalination devices comprise at least one bi-directional converter electrically connected between the electrochemical desalination module and a power supply.

5. The system of claim 4, wherein each of the bi-directional converters comprises a bi-directional DC/DC converter for transmitting a direct current to the electrochemical desalination module of one of the first and second electrochemical desalination devices during the charging mode of operation, and transmitting a direct current to the other of the first and second electrochemical desalination devices.

6. The system of claim 1, comprising at least two first electrochemical desalination devices connected in series and at least two second electrochemical desalination devices connected in series for respectively continuous removal of ions.

7. The system of claim 1, wherein the controller is programmed to calculate and store charging current profiles and charging time for the first and second electrochemical desalination devices, according to electric charge needed for charging the pairs of electrodes.

8. The system of claim 1, wherein the controller is programmed to compare if an instantaneous discharging energy released from the pair of electrodes of the first electrochemical desalination device meets an instantaneous energy requirement for charging the pair of electrodes of the second electrochemical desalination device, at the normal discharging mode of operation.

9. The system of claim 1, wherein the controller is programmed to determine the normal charging time and compulsory discharging time such that a difference between energy released and an energy input during the discharging time is maximized.

10. The system of claim 1, wherein the controller is programmed to repeat the calculating and determining the normal discharging time and compulsory discharging time at a certain time interval.

11. The system of claim 1, wherein the controller is programmed to control the system such that at the end of the compulsory discharging mode of operation, a voltage across the at least one pair of electrodes of the electrochemical desalination device in the discharging mode is substantially equal to zero, and a voltage across the electrochemical desalination device in the discharging mode is below zero.