Li-Ion battery BMS system:

To safely use a Lithium Ion battery a Battery Management System (BMS) is used. This is the case even in cordless tool. The BMS protects the battery, provides cell balancing, and optimizes the power to be delivered to the electrical load. The best way to think about a BMS is to recognize that it is a part of the battery. Historically speaking, lithium Ion batteries applications are fairly recent compared to the use of lead acid batteries. If lead acid battery where newly invented they too would have a BMS.

Here are some common functions for a BMS:
Charging: maximum allowed battery voltage, restart charge level, balance cells
Load: short circuit protection, over discharge protection, over current protection

Specification vary and tend to be specific for each application.

BMS methods:
Charging:
The charger is connected to the BMS and the BMS sends the charge to the battery. It also monitors the series batteries cell voltage. It will allow any current to the battery within its Maximum continuous current specification of the BMS board. If the battery voltage reaches the maximum voltage specification it will switch off the connection from the charger to the battery.

As a battery is being used the battery voltage will drop based on the change in charge. When the voltage reaches a certain value the BMS would allow the charger to top off the battery.

Using a smart charger the last 20% of charge is accomplish with very low current. The BMS during this charging period will balance the cell so that the maximum amount of power can be delivered. Without the balancing a low cell will continue to be low and actually increase this difference. This is an issue with higher series cell counts or for cells that poorly made or the mixing of cells from different manufactures. It should not be much of an issue with this implementation, however it is part of the system so it come for free.

Smart Charging: Just like lead acid batteries the charge needs to be controlled. A constant current to 80% charge and then diminishing current to zero at the full charge set point. These charger will charge lead acid or Li-Ion. The trick is to have the correct set point. Li-Ion will accept or deliver a very large current, each battery manufacture lists the batteries ability to accept or deliver charge. This is one of the reasons Li-Ion is so popular. In many cases the battery can deliver all the power at 3 to 5 times its Amp Hour (AH) rated current with no ill effects. Think of those cordless drills that use such small batteries. However, and RV mass storage battery is about small loads for long run time, this 40 pound, 8X8X10” in size, and 12 cells Li battery will deliver 200 AH of charge (2.2kW/11.5VDC = 200 AH), as well as four 100 AH lead acid batteries.

Some users have suggested using the BMS to allow the use of any charger. The BMS's charging protection circuit for maximum battery charge voltage will switch off the charger when the battery reaches near full charge. I did test this idea out and it does work, there would be no balancing, the battery would have an elevated temperature and it may overload the charger. Smart chargers can be purchased for a reasonable price, there is no reason not to have one. If you already have one, it would likely be applicable for this solution.

Claims and Theory of Operation:
Difference between Lithium Ion and Lead Acid Batteries:
Li-Ion does not need to be fully charged to stay healthy, they don't have the Lead Sulphate issue
Much higher energy density, a lot smaller in size
Lighter weight, 40 pounds for 200AH
They can be discharged to 10% without damaging, Lead Acid should not be discharged below 50%
Sealed battery
Requires a management system to safely use the battery, which makes it more complex
Same smart charging profile
Undercharging lengthens the battery life, Lead Acid undercharging shortens the battery capacity/life
Predictable longevity, errant cells can be replaced
Some manufactures make crappy batteries
Cost per Watt comparable to Lead Acid
Possible to have thermal runaway, most common is from over charging

Theory of Operation:
This pertains to the circuit presented in this implementation
The battery ground connection is controlled by the BMS. This management circuit, monitors a whole host of dynamic characteristic in order to protect the battery and also the load. Such as over current to the load, it will shut the load off, over voltage from the charger, it will switch the charger circuit off.

The battery positive is connected to a 100 amp circuit breaker through a shunt resistor. The resistor provides a voltage proportional to the battery current which is used by the panel meter to show the value of the current, and also to calculate the instantaneous power and it store the accumulated energy used. If desired the user can reset the energy value between charges to monitor the state of charge (SOC). The meter also measured the battery voltage; four variables are displayed at any given time.

A smart charger is connected to the BMS and will charge then balance and top off the battery anytime the trailer is on shore power. It does this by measuring the series cell voltage and determining the SOC for each cell, it then uses a balancing current to bring up any low cell. The balancing can take up to a day; this is much like a trickle charger used on Lead Acid batteries. The smart charger will also support a load if the battery capacity falls below 90%. The charger provides 10amps of current up to the 80% charge point and then the current reduces linearly to zero at full charge. The10amp charger was selected to simplify the system connection with the realization that charging takes time no matter how big the charger is even though the BMS can handle up to 100 amp charger. However, the higher current smart chargers can be expensive. Even upgrading to a 20 amp charger would be double the cost of the 10 amp charger.

Gaps or changes:
Elimination of the Lead Acid batteries, battery box, battery compartment and AS linear power supply.
To maintain a connection to the tow vehicle alternator a 2 ohm 20 watt resistor or three series diodes are used.