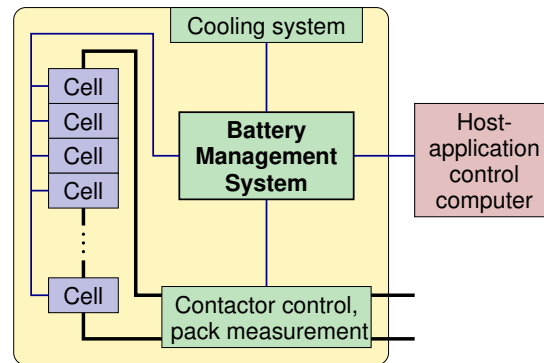




BMS requirement 4: Performance management

- So far, we have now looked at requirements 1 through 3 of a BMS
- We now consider requirement 4, **performance management**
 - State-of-charge (SOC) estimation, power-limit computation, balance/equalize cells



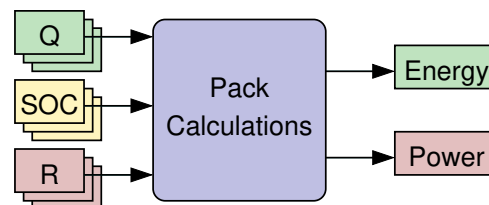
What needs to be estimated, and why?

- Battery applications need to know two battery quantities:
 - How much energy is available in the battery pack
 - How much power is available in the immediate future
- Knowing energy is most important for applications such as EV:
 - Tells me how far I can drive
- Knowing power is most important for applications such as HEV:
 - Tells me whether I can accelerate or accept braking charge
- Both are important for applications such as E-REV/PHEV



Why must we estimate energy, power?

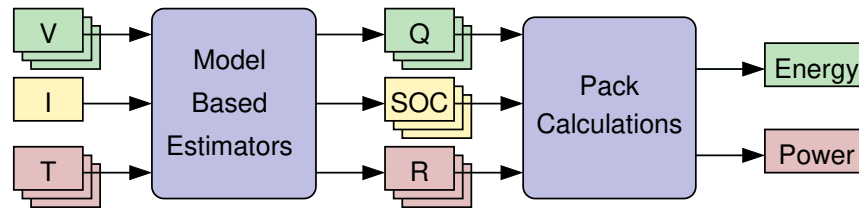
- Can't measure available energy or available power
- Instead, must estimate these values
 - To estimate energy, we must know (at least) all cell states-of-charge z_k and capacities Q_k
 - To estimate power, we must know (at least) all cell states-of-charge z_k and resistances R_k





Why must we estimate SOC, SOH?

- But, cannot directly measure these parameters either!
- Therefore, must estimate SOC, SOH



- Available inputs include all cell voltages, pack current, and temperatures of cells or modules.



Quality of estimates

- There are both good and poor methods to produce estimates:
 - Poor methods are generally simpler to understand, code, and validate, but yield less-accurate results
- Impacts of a poor estimator can be:
 - Abrupt corrections when voltage or current limits exceeded, leading to customer perception of poor drivability, or
 - Overcharge or overdischarge, which damages cells, or
 - Compensating for uncertainty by overdesigning pack
- All of these have costs in dollars, weight and/or volume



Summary

- Applications need to know battery available energy and power
- Can't measure; must estimate based on z_k , Q_k , R_k
- These also must be estimated using measured voltage, current, and temperature
- Major premise of this specialization: investing in good BMS electronics and algorithms can reduce pack size and result in considerable net savings
 - Course 2: How to model cells, needed by algorithms
 - Course 3: Advanced methods for SOC estimation
 - Course 4: SOH estimation
 - Course 5: Balancing and power-limits estimation
- Preview of these next



Credits

Credits for photos in this lesson

- Lemonade on slide 2: CC0 public domain, cropped from <https://pixabay.com/en/drinks-juice-fruit-juice-summer-1430739/>
- Photo of Rudolph Kalman (pioneer of estimation theory and inventor of the “Kalman filter” we will study in Course 3) on slide 5, By Greuel, Gert-Martin [CC BY-SA 2.0 de (<http://creativecommons.org/licenses/by-sa/2.0/de/deed.en>)], via Wikimedia Commons, https://commons.wikimedia.org/wiki/File:Rudolf_Kalman.jpg (cropped)