Tyler Lewis Clean Energy Research Foundation

2017 Grant Recipients

Lithium-Ion Batteries and Off-Shore Wind Energy

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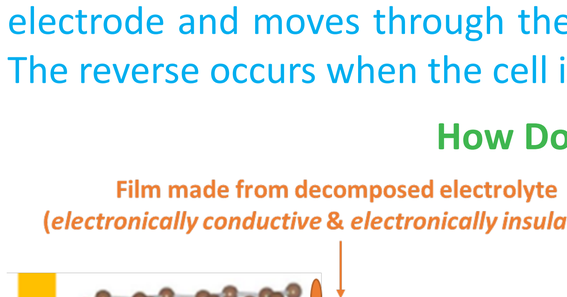
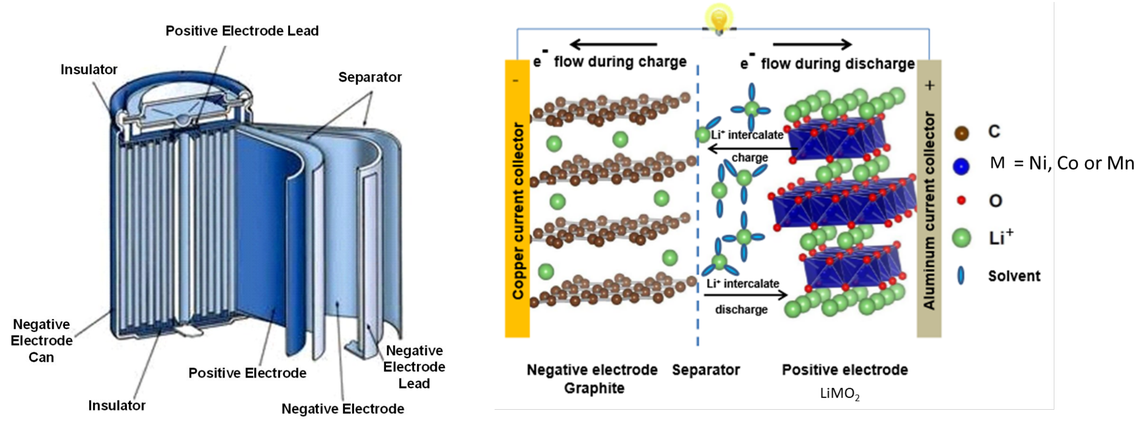
*Improving the Lifetime of Lithium-Ion Cells

Why are Lithium-Ion Cells Important?



Lithium-ion cells are used as energy storage devices for clean energy technologies, such as electric vehicles. Improving the lifetime of lithium-ion cells will make clean energy technologies less costly and more competitive.

How Does a Lithium-Ion Cell Work?



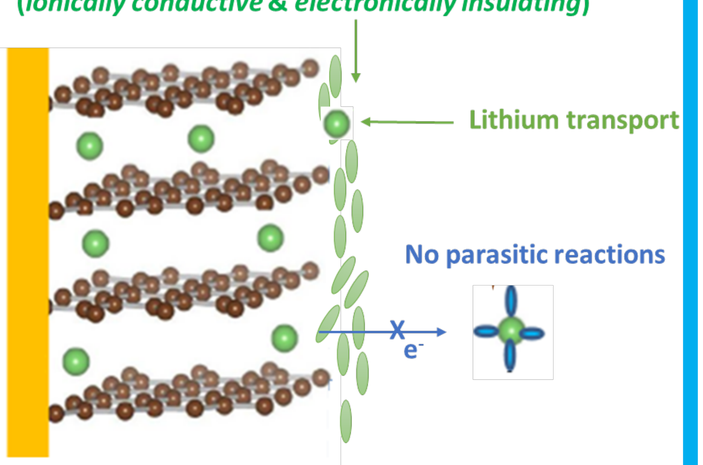
Lithium-ion cells contain a negative electrode, a positive electrode, and an electrolyte. As the cell is discharged, lithium leaves the negative electrode and moves through the electrolyte to the positive electrode. The reverse occurs when the cell is charged.

How Does a Cell Fail?

Parasitic reactions between the electrolyte and charged electrodes causes films of decomposed electrolyte to build up on the electrode surfaces over time. These films can block lithium-ions from entering the electrodes.

How to Prevent Cell Failure?

Electrolyte additives are chemicals added in very small amounts to the cell. They act like preservatives, and prevent the decomposition of electrolyte at the electrodes. For example, electrolyte additives can polymerize, forming a protective layer on the electrodes.

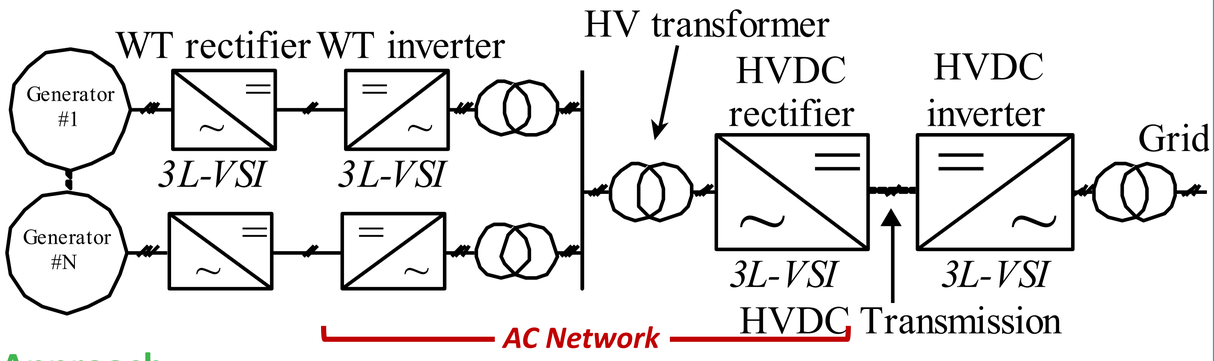


My PhD research is focused on: identifying parasitic reaction pathways, developing the best additives, and creating new techniques for analysing changes in electrolyte.

†Partial Power Processing Converters in Offshore Wind Farms with DC Collection Systems

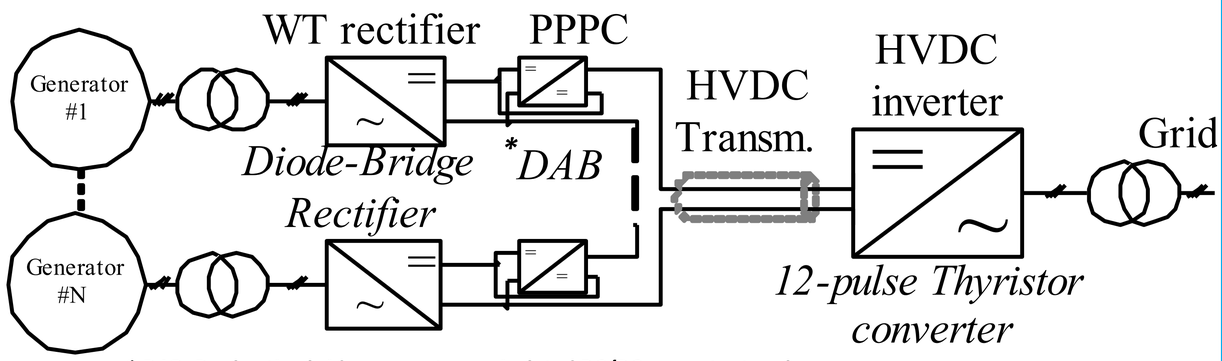
Current State of the Art

- Rapidly growing offshore wind markets in Europe, E. Asia, N. America
- First tender awarded at regular electricity market rates in 2017
- Size of farms significantly larger than onshore farms
- Farms located far from shore employ High-Voltage DC transmission (HVDC) in an "add-on" configuration, resulting in:
  - Many energy conversion stages needed (approx. 7 back-to-back)
  - High losses and investment cost



Approach

- Eliminate offshore ***AC network***
- Replace wind turbine power converters (voltage-source inverters; VSI) with efficient and robust Diode-Bridge Rectifiers
- Use partial power processing converters (PPPCs) to maintain wind turbine operation for maximum energy extraction
- Series-connection of wind turbines enables operation of the farm's electrical components based on local wind speed differences, rather than absolute wind speeds
  - PPPCs allow electrical equipment to operate closer to its 'natural' operating points, resulting in better conversion efficiency and potentially smaller converter sizes than previous research studies



** DAB=Dual-active bridge converter, an isolated DC/DC converter topology.*

Preliminary results

- Studies have shown a potential to improve conversion efficiency by 3% points compared to commercial implementations and 2% points compared to other research-stage concepts at rated power – and more than that at partial output power.

Future work

- Improve understanding on sizing converters and how to best operate series-connected turbines in different farm configurations, as this works fundamentally different from currently used technology
- Estimate the economically optimal wind farm configuration for different kinds of wind farm sites