What is Battery Scale-up?
You may think battery making is a simple process at first sight; two electrodes with different potentials use an electrolyte to transfer electricity. Practically, however, battery production is extremely sensitive to material choice, temperature, electrode thickness, mixing method, and many more variables.

Thermally produced research on small temperature, with You Large

Interesting Result from Welding Test
- Ultrasonic welding is used to weld the large scale battery current collector foils to tabs. This is the main point of connection between the battery and whatever is being powered.
- Scanning Electron Microscopy (SEM) was used to characterise the efficacy of the welds.
- The left image shows a “good” weld with no gaps between the 27 foils. The right image has a large gap that increases resistance.

Small-Scale Battery Making Process
1. Material Selection:
   - Choose a suitable cathode or anode material.
   - This is based on electrochemistry and materials science.
   - This project researched sodium oxides that form biphasic P2/O3 structures when used as a cathode.

2. Electrode Synthesis:
   - Two methods: Sol-Gel or Solid State.
   - Synthesis is highly sensitive to variables such as temperature and particle size.
   - X-Ray diffraction tests are performed to see if the predicted structures were formed.
   - This is Na0.77Mn0.4Fe0.4O2.0810%." 

3. Make & Test the cell:
   - Must be done in a glove box as electrode materials react with water. That’s me in there!
   - Electrode is made into a slurry and coated onto aluminium or copper.
   - The cell is filled with electrolyte.
   - The cell undergoes formation and aging cycles that characterise performance and life.

Large-Scale Assembly Line
Once a material has been proven to have satisfactory performance and life, it can move into larger scale production. The electrode slurry that was previously manufactured in milliliters is now scaled up to liters, a 3 order of magnitude increase! This gives an idea of how much added complexity there is at large scale production. The images below are from the university of St Andrews’ scale up facility at the Eden campus.

Engineering Challenges of Large-Scale Production
- **Dry Room**: Battery electrodes, particularly sodium-based cathodes, are highly sensitive to moisture. Thus, a large portion of the process is done in a “dry lab”, where the relative humidity is under 1%!
- **Machine Tolerances**: large scale production is a “real-to-reel” process, meaning lots of rollers are used. Thus, concentricity tolerance should be minimised, and the surface should be machined in a roughness to maintain homogeneity in the coat.
- **Mixing Method**: Planetary mixing, or spiral mixing? – that is the question. Different mixing methods will result in differing viscosities for the same slurry. This will affect the coating process and hence performance through volumetric efficiency and solid content.

References
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- https://www.interlith.com/blog/2018-06-12-
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- Hamza Al-Aqqad is studying Mechanical Engineering at Imperial College London. He is interested in working in the battery industry. He believes it his responsibility as an engineer to provide society with sustainable energy solutions.
- Hamza is interested in large scale battery manufacture projects, as well as battery pack design and thermal management. Aside from engineering, he enjoys photography & football.

Click the icon for Hamza’s LinkedIn!