BT1 Fundamentals of Battery Supply Chain Systems

BY THE FARADAY INSTITUTION AS A DELIVERY PARTNER OF THE FARADAY BATTERY CHALLENGE BY INNOVATE UK

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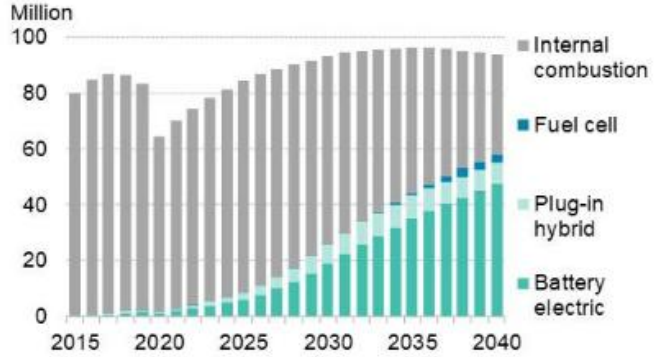
BEV Outlook (2022)

Figure 1: Global annual passenger vehicle sales by drivetrain



Source: BNEF

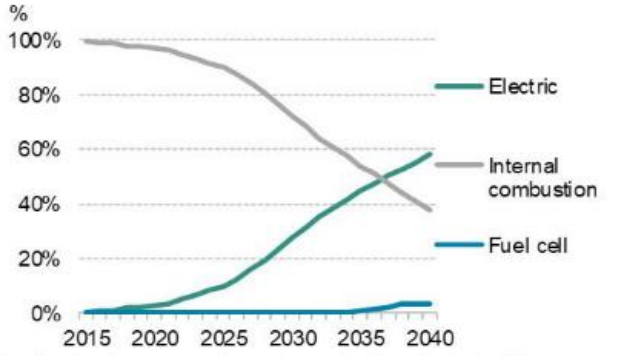
Figure 1 shows global passenger vehicle sales since 2015 (in millions) with a prediction up to 2040.

You can clearly see the predicted growth in both battery electric and plug-in hybrid between now and 2040, with battery electric selling more units.

Fuel cells begin to make an appearance but not in any large volume. However, this is only a prediction and will undoubtably be driven by technology.

Notes:

Figure 2: Global share of total annual passenger vehicle sales by drivetrain



Source: BNEF
Note: Electric share of annual sales includes battery electric and plug-in hybrid

Figure 2 shows the data above as a percentage of global vehicle sales.

Looking at the data it is predicted that by 2040, electric vehicle sales will make up approx. 60% of all passenger vehicle sales globally, with the internal combustion engine dropping just below 40%.

Notes:

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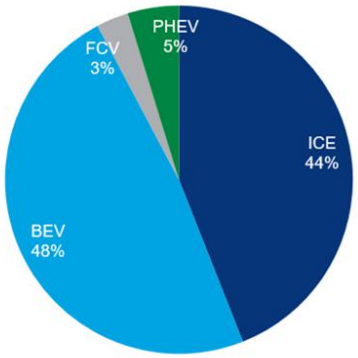
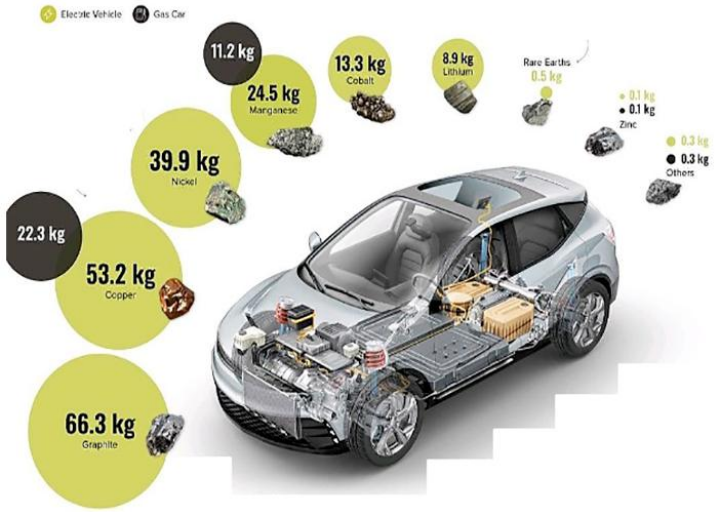


Source: Wood Mackenzie

It is predicted that by 2050 there will be approx. 700 million electric vehicles on the road (BEV and PHEV), making up approx. 53% of all vehicles.

Fuel cell vehicles (FCV) are predicted to make up approx. 3% of all vehicles in 2050 with the remaining 44% still being internal combustion engines (ICE).

Notes:



Materials Used in Production (2022)
This image is only a general representation. You can see the total weight of the various materials used in an electric vehicle.

The black circles represent the materials used in an internal combustion engine vehicle as a comparison.

Graphite makes up the largest proportion of material (by weight), mainly due to it being the anode material in a lithium-ion battery. Copper is a close second due to an electric vehicle's stator winding being made up of more than a mile of copper wire, to convert electric energy into mechanical energy.

Notes:

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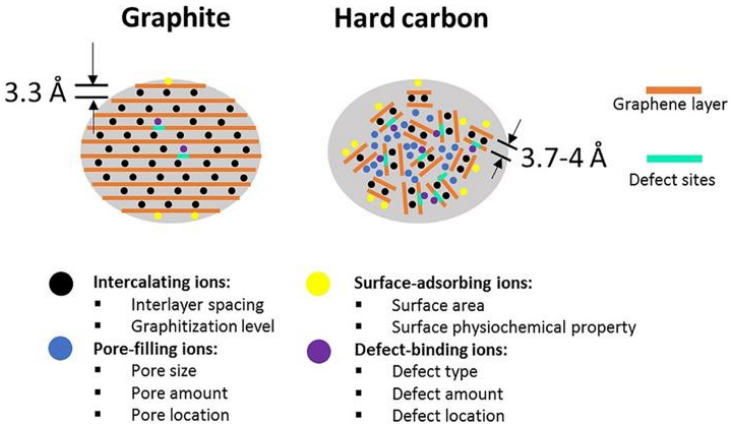
Graphite (powder)
Graphite makes up the vast bulk of the anode (95%) of a typical Li-ion battery fitted to a battery electric vehicle (BEV) and approximately 1kg of graphite is needed per kWh of battery energy. This makes it, by weight, the most significant element of the battery cell.

Graphite is used in the production of the anode side of the battery **– alternative uses to graphite are hard carbon (PVDC).**

Notes:



Hard Carbon is essentially industrial charcoal. Charcoal is lightweight and 'hard' because it forms open crystal lattices.
Those 3-D lattices can handle the larger sodium ions.

Graphite is dense and 'soft' because it forms in sheets of 2-D lattices which are densely stacked together. The sheets are not connected to each other. So a lump of graphite is like a stack of paper - heavy and flexible and the sheets can be separated. Those sheets are called graphene.

Hard Carbon is more like wood: lighter and rigid and full of holes.

Notes:

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Copper

Principal sulfidic ores are **chalcocite** (Cu_2S) and **chalcopyrite** ($CuFeS_2$, yellow copper ore), whereas **cuprite is the major oxidic ore** (Cu_2O, red copper ore). **Malachite** ($Cu_2(OH)_2CO_3$, green copper ore) and **azurite** ($Cu_3(OH)_2(CO_3)_2$, blue carbonite copper) are other ores of importance.

Copper strips (insulated) are commonly used to make and form the series / parallel links in a battery packs (commonly known as **busbars**). Copper is also the key component in the battery pack High Voltage **cabling**.

Notes:

Nickel / Nickel Oxide (powder)

Ni-O makes up around **70 or 80%** of the blend to produce the cathode, in **8**11 or **7**12 - NMC cells.

Nickel plated steel strips are commonly used to make and form the series / parallel links in a battery module between the cells.

Notes:

Cobalt
Is a hard, lustrous, blue and silver-grey ore. Cobalt is primarily used in lithium-ion batteries, and in the manufacture of magnetic, wear-resistant and high-strength alloys.

In NMC (Nickel Manganese Cobalt) cells (81**1** or 71**2**) Cobalt Oxide makes up **10 or 20%** of the blend to produce the cathode.

Notes:

Manganese
Is a hard, brittle, silvery metal, often found in minerals in combination with iron. Manganese is a transition metal with a multifaceted array of industrial alloy uses.

Manganese Oxide makes up **10%** of the blend to produce the cathode, in 8**1**1 or 7**1**2 - NMC cells.

Notes:

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Lithium Carbonate
Is an inorganic compound,
the lithium salt of carbonic acid with
the formula Li_2CO_3

This white salt is **widely used in the processing of metal oxides.**

Lithium Carbonate's main use is as a precursor for compounds used in lithium-ion batteries.

Notes:

Sulphur
The bright yellow or orangish colour of Sulphur makes the mineral easy to identify. It forms pyramidal or tabular crystals, encrustations, powdery coatings, and granular or massive aggregates.

Sulphur is a common **deposition product from volcanic gases** associated with realgar, cinnabar and other minerals.

It is used in **Li-S** batteries, currently being developed.

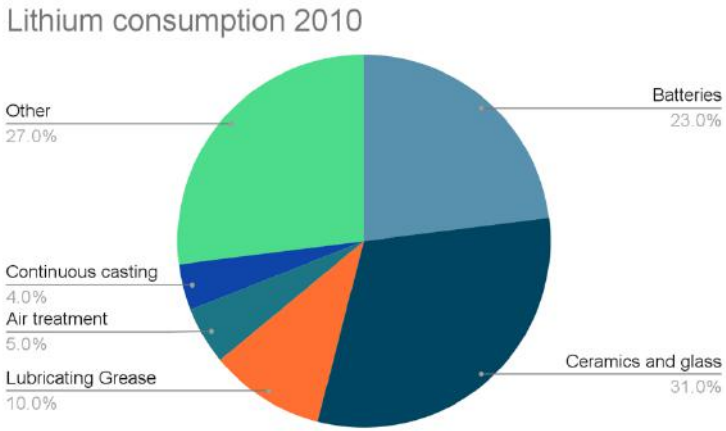
Notes:

Sodium

Sodium (Na) is a very soft silvery-white metal. Sodium is the most common alkali metal and the sixth most **abundant element** on Earth, comprising 2.8 percent of Earth's crust.

Sodium-ion batteries are a potential alternative to lithium-based battery technologies, largely due to sodium's lower cost and greater availability.

Notes:



Lithium Consumption (2010)

The pie chart to the right shows the levels and areas of Lithium consumption in 2010. You can see from this that in 2010 the overall amount of Lithium used for batteries was 23%.

Notes:

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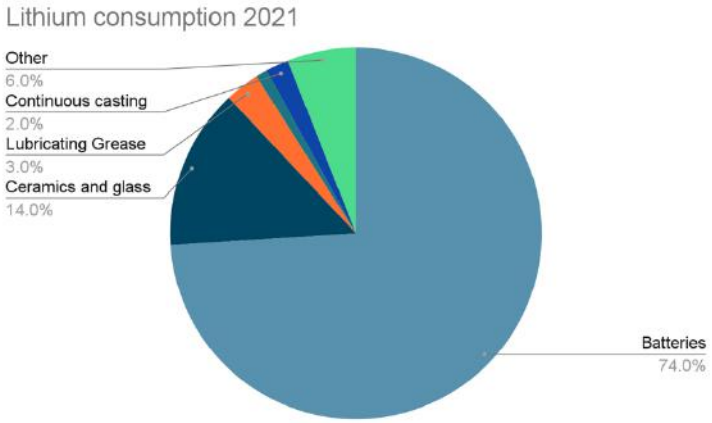

Lithium Consumption (2021)

This pie chart shows the Lithium consumption levels and areas in 2021. You can see form this that Lithium used in battery manufacture has increased from 23% in 2010 to 74% in 2021.

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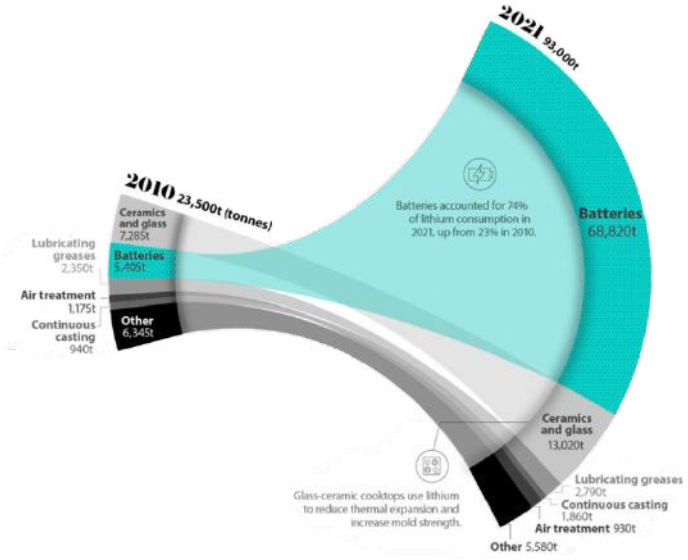

Change in Battery Use

The diagram on the left shows the volume of Lithium used in battery manufacture from 2010 to 2021 and how this has increased. In 2010 approx. 5,405 tonnes of Lithium were used in battery manufacture, compared with 68,820 tonnes in 2021. This is an overall increase of 1173%, over an 11 year period.

Notes:

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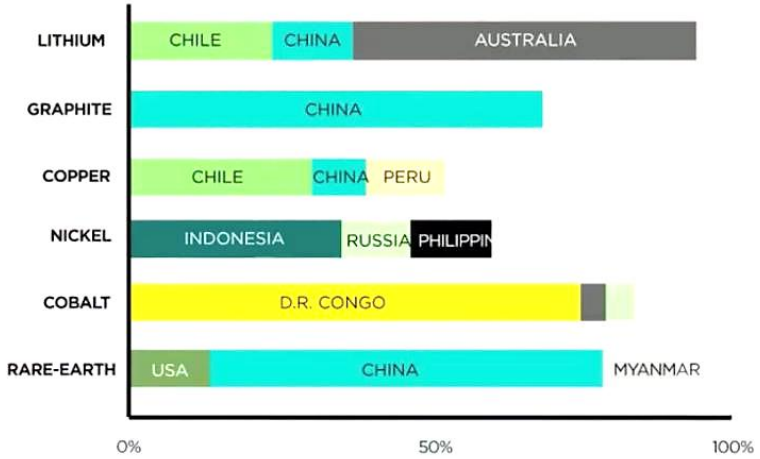

Notes:

Global Demand on Supply

We are going to need by 2035, 4 million tons of Lithium carbonate to satisfy production consumption demand.

Currently (2022), the world is producing 678,000 tons with a need of 3.3Million tons in the upstream demand.

Rank	Country	2021 Production (tonnes)	% of Total
#1	Australia	55,416	52%
#2	Chile	26,000	25%
#3	China	14,000	13%
#4	Argentina	5,967	6%
#5	Brazil	1,500	1%
#6	Zimbabwe	1,200	1%
#7	Portugal	900	1%
#8	United States	900	1%
	Rest of World	102	0.1%
	Total	**105,984**	**100%**

Notes:

Lithium Carbonate Production (2021)

The table on the left shows the Lithium production, in tonnes, across the globe in 2021. You can see that 90% of the overall Lithium produced comes from just three countries, Australia, Chile and China.

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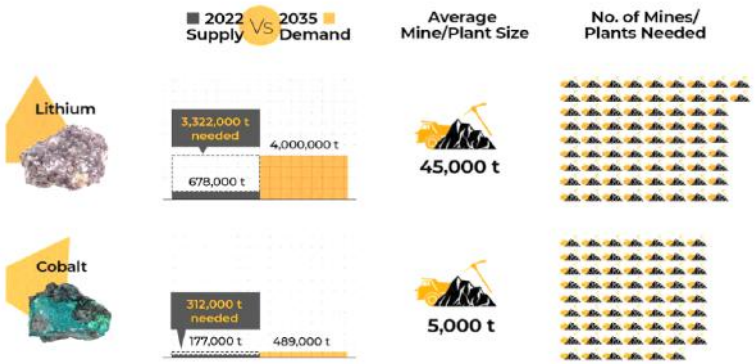
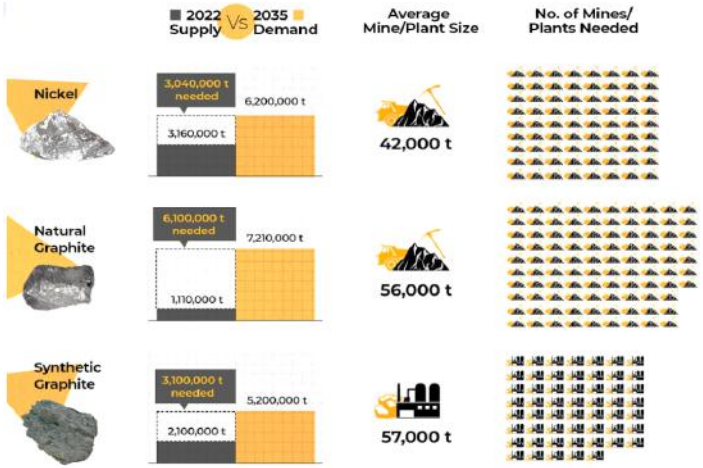


Lithium and Cobalt Supply vs Demand

By 2035, the world will need to be extracting 6-7 times the Lithium Carbonate that it is now, to keep up with global demand. Reclaiming and the re-use of materials will be key to solving this problem.

By 2035, the Cobalt supply, will need to triple. Again, reclaiming and the re-use of materials will be key, as cobalt only comes from certain parts of the world (raw materials extraction).

Notes:



Nickel, Natural Graphite and Synthetic Graphite Supply vs Demand

As batteries develop the use of nickel, graphite, hard carbons and SiC materials will all need follow up solutions. By 2035, to simply extract 6-7 times the graphite needed globally would be a difficult task.

Notes:

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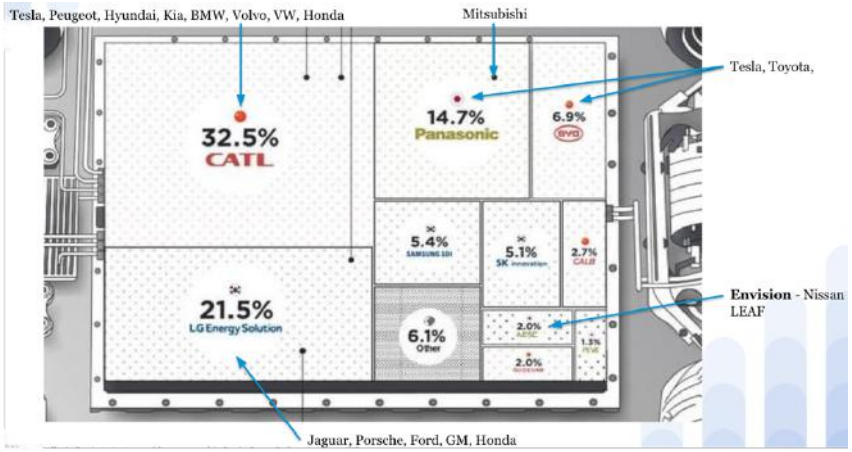
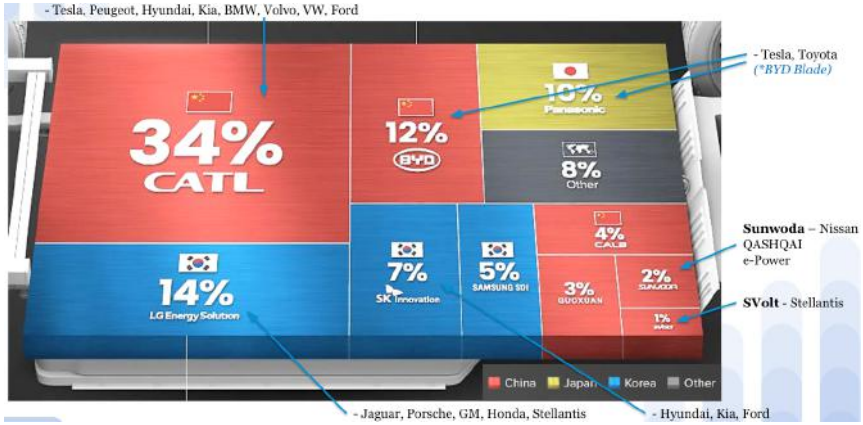


EV Battery Manufacturers – Market Share (2021)

This diagram shows the top 10 manufacturers in 2021, along with their market share. CATL was the clear leader with 32.5% of the market.

Notes:



EV Battery Manufacturers – Market Share (2022)

This diagram shows the top 10 manufacturers in 2022, along with their market share. CATL was again the clear leader with 34% of the market (an increase of 1.5% on 2021) This due to the increased demand for EVs globally - largely led by Tesla's production numbers. BYD almost doubled its market presence with a 12% share (6.9% in 2021) - Due mainly to the production of their new blade batteries.

Notes:

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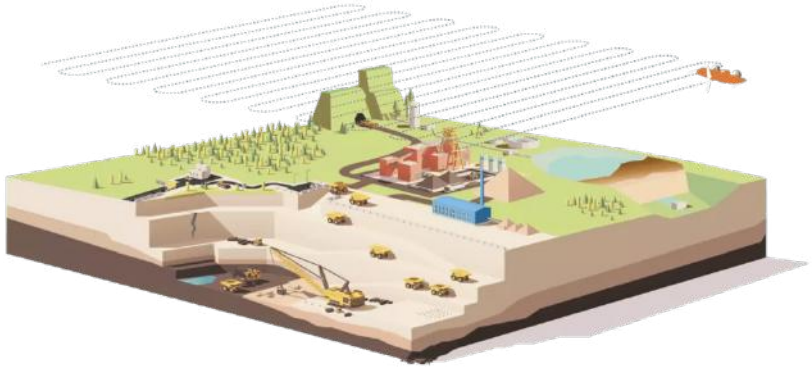

Source: wingtra.com

Types of Mining in Battery Supply Chain

Within the battery supply chain types of mining include:

- Underground mining
- Surface mining
- Salars extraction/evaporation
- Deep bore-hole extraction
- Osmosis – forced evaporation extraction

Notes:

Underground Mining – Manganese in Hard Rock

About **80% of the known world manganese resources are in South Africa**; other important manganese deposits are in Ukraine, Australia, India, China, Gabon and Brazil.

Notes:

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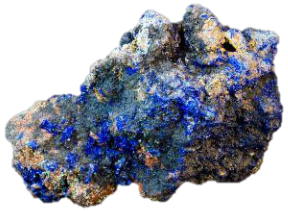
Underground Mining – Lithium in Hard Rock
The granite rock which underlies Cornwall and West Devon is enriched in lithium, which is contained within mica minerals such as zinnwaldite and lepidolite.

Notes:

Open Pit/Cast (Surface mining)
98% of Cobalt production is mined as a by-product.

Technologies include both underground and surface mining. Various nickel and copper ores are processed by both pyrometallurgical and hydro-metallurgical techniques.



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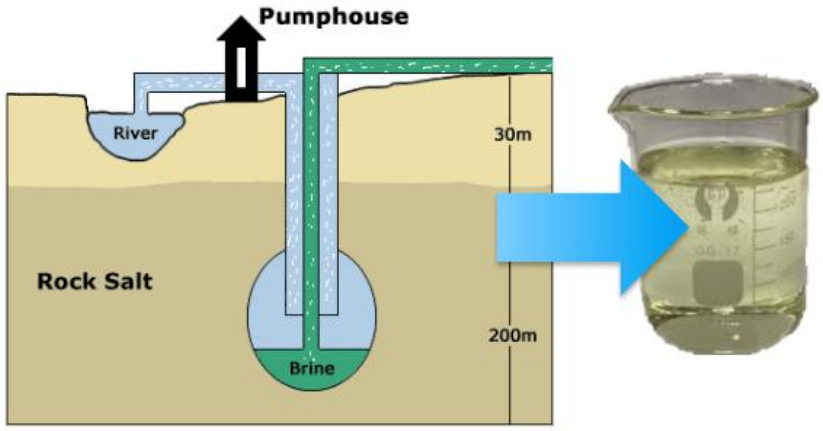
Salars (Evaporation Pond) Extraction

Saltwater from underground lakes is brought to the surface and evaporates in large basins (Salars). The remaining saline solution is further processed in several stages until the lithium carbonate remaining is suitable for use in the manufacturing process.

Notes:

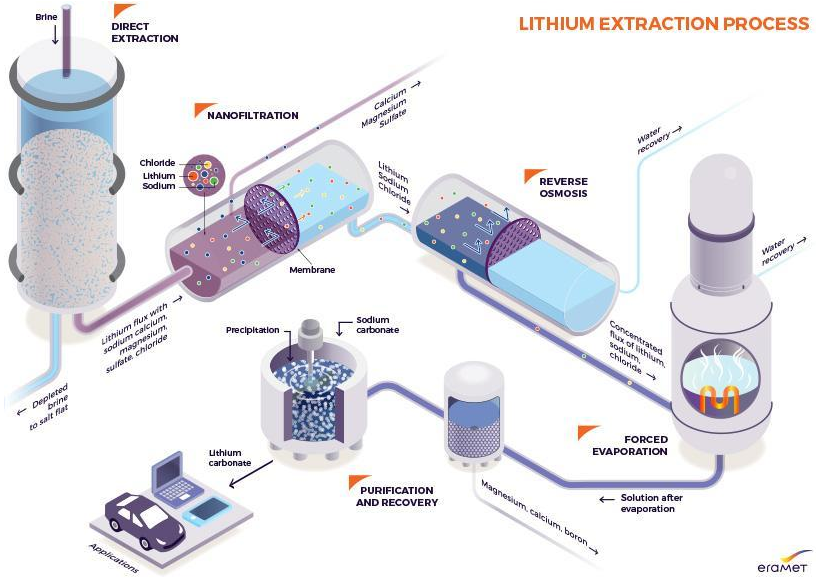


Deep Bore-hole (Rock Basin) Extraction

Brine from underground natural rock basin formation is brought to the surface and then processed.

Commonly this is done in 'Salars' (through evaporation – heat, in the natural environment) however, nano filtration and osmosis purification methods have also been developed to perform forced evaporation, to extract and process lithium carbonate.

Notes:



Nano Filtration & Osmosis Purification/Forced Evaporation

Nanofiltration removes these microbes, as well as most natural organic matter and some natural minerals, especially divalent ions which cause hard water. Nanofiltration, however, does not remove dissolved compounds.

Osmosis uses a semipermeable membrane which has small pores that block contaminants but allow water molecules to flow through. In osmosis, water becomes more concentrated as it passes through the membrane to obtain equilibrium on both sides.

Notes:

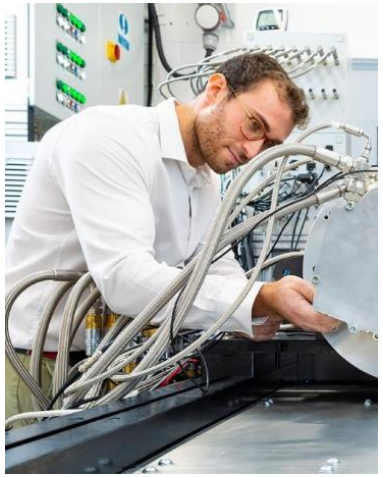
Grade, Identity and Purity Testing

Testing is the determination of one or more characteristics of an object in quality and quantity level according to standardised and accredited handling procedure.

An object may consist of different properties / characteristics which can be classified as follows:

- **Physical** – the structural part of the object
- **Chemical** – the presence of any harmful substances inside the object, or the possibility of migration of harmful substances
- **Flammability** – refers to the ease to fire hazard/fire burn
- **Functionality** – refers to the performance claim of an object

Notes:



Grade, Identity and Purity Testing cont.

- **Directive - a legal act** (of the European Union for example) It requires member states to achieve a particular result without dictating the means of achieving that result
- **Regulation - self-executing** and do not require any implementing measures
- **Standard - the standardised testing method & procedure** to verify if the testing sample comply with regulation requirements
- **Buyer requirement** refers to the tailor-made requirements set out by the buyer to align with the internal company objective, policy and specific product line

Notes:

Grade, Identity and Purity Testing cont.

Every manufacturer, retailer and buyer have an obligation to ensure their products, which are ready to be launched onto the market, are fulfilled with the quality, safety and performance requirements according to standard, directive, regulation or even buyer's needs.

Therefore, a third-party test in an accredited laboratory plays an important role in fostering quality assurance for a global trade.

Notes:

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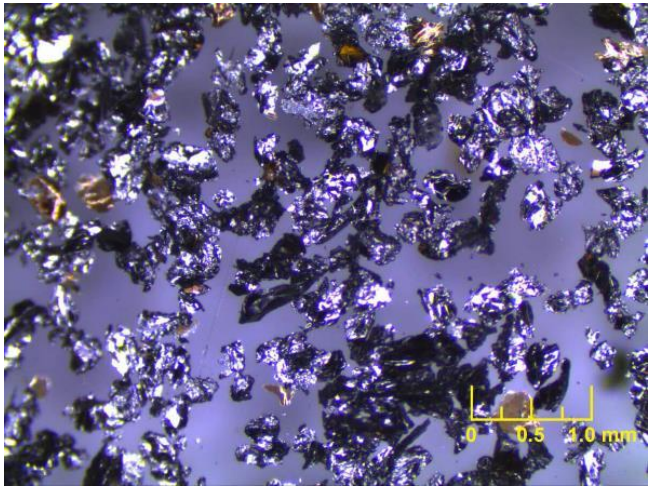
Materials – Physical Testing

Testing can include flotation, gravity concentration, leaching, scrubber testing, flake size characterisation, and assaying for graphite.

Notes:



Flake Size Characterisation

The key for this procedure is to quickly identify the flake size of the easy to recovery graphite as well as to understand the challenges of recovering and upgrading the remaining graphite.

1. A sample of approximately 10Kg is crushed and ground to a coarse size (0.8-1.0mm)
2. A materials 'super-panner' is used for gravity separation of the crushed material. Froth flotation can also be used at this stage
3. The graphite concentrate is then sieved for accurate flake sizing

Notes:

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Froth Floatation

Froth flotation can be used for flake size characterisation of graphite.

This test gives us a clear indication of the size distribution and liberation of the graphite, along with revealing which factor(s) would have a direct effect on the recovery and purity of the graphite concentrate.

Notes:

Sonicating

Sonication - the process of applying sound energy to agitate particles in a liquid.

Ultrasonication - Ultrasonic frequencies (>20 kHz) are often used.

Sonication can be conducted using either an ultrasonic bath or an ultrasonic probe (sonicator).

Notes:

Powder Testing for Cohesion

A transparent drum cylinder is rotating around its axis half-filled with a sample of powder.

The testing can produce the following information:

- Flowability
- Cohesion
- Thixotropy – agglomeration, segregation, and attrition.
- Caking
- Aeration

Notes:

Powder Testing for Cohesion cont.

The rotation starts and the drum will rotate at different velocities. A camera takes a snapshot during the rotation then software can analyse the pictures stacked per speed.

The analyses give the measurements for the cohesive index and flowing angle per speed.

The cohesive index is only related to the cohesive forces between the grains.

Notes:

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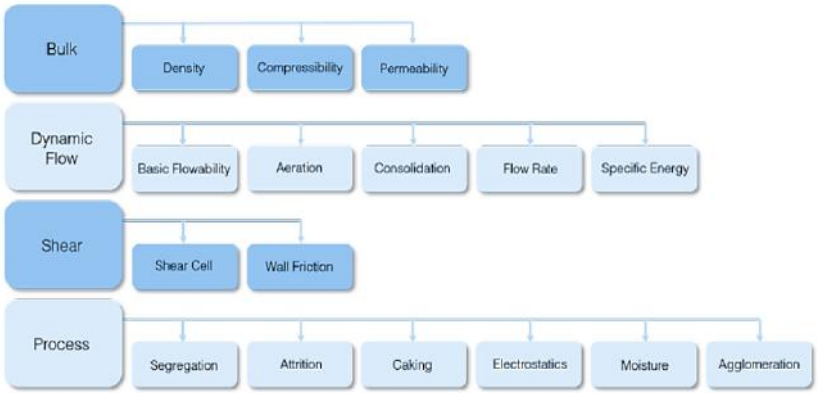


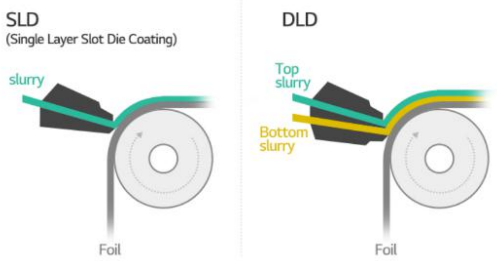
Granular Material Flow Analyser

Agglomeration is a particle formation process in which at least two primary particles are combined to form a new one. This principle is often used in many industries, e.g. pharmaceutical manufacturing, food processing and fertilizer production.

Notes:

Granular Material Flow Analyser cont.

The flow of the particles which make up the slurry is important to provide a consistent layer during manufacturing.



Notes:

3rd Party/Independent Testing – Certification of Analysis

This stage of the certification includes an assessment by an appropriate person of the following:

- Quality systems and audits
- Staff training in relation to materials contamination prevention
- The handling of materials and processing
- Raw Materials supplier assessment procedures
- Traceability and recall procedures
- Quality Control (in-house) materials verification / testing

Notes:

3rd Party/Independent Testing – Certification of Analysis cont.

- Pre-certification involves testing a minimum of three pre-certification samples using EN / ISO standards.
- For standardisation all samples must consist of a minimum material weight.
- Testing will be carried out in parallel with the material and manufacturing review (Stage 1).

Notes:

Certification Completion

3rd Party/Independent Testing – Certification of Analysis cont.

On successful completion of stages 1 and 2 a Certificate of Analysis will be issued.

This can then be used to inform on a product's quality or for the information on the Safety Data Sheet Document.

Notes:

Securing Supply of Raw Materials in the (Upstream) Supply Chain

The trading of raw materials is also known as the commodities market. Commodities can be traded, in the same manner as stocks and shares.

Notes:

Securing Supply of Raw Materials in the (Upstream) Supply Chain cont.

The main functions are:

- Researching and sourcing of supplies
- Enquiries and receiving quotations
- Negotiating terms and delivery times
- Placing contracts and orders
- Expediting delivery
- Monitoring quality and delivery performance

Notes:

Researching and Sourcing of Supplies

Source Locally – This makes it easier to determine whether your materials are ethically sourced. It's often easier to get local materials to you, with fewer delays. You may be able to bring them in faster when your inventory needs change suddenly.

Notes:

Researching and Sourcing of Supplies **Notes:**

Build in Diversity - Sole sourcing may be less expensive, but you are entirely reliant on that source. If there are shortages and challenges that impact that supplier, you may find it impossible to overcome them for your own sourcing needs. If you have diversity in your sourcing, you can bring in raw materials you need even when challenges impact other areas of your supply chain.

Researching and Sourcing of Supplies **Notes:**

Increase your inventory - If you've struggled to provide supplies your customers need, consider ways that you can increase your own available inventory.

Work with your distributors - Distributors often can help find additional resources when you are struggling with your primary supply source. Often, they buy and sell on a global level, which means they can keep up with current trends and provide you with the most cost-effective solution to your current supply chain needs.

Notes:

Enquiries and Receiving Quotations

An enquiry is a request from the customer, for you to provide them with a sales quotation.

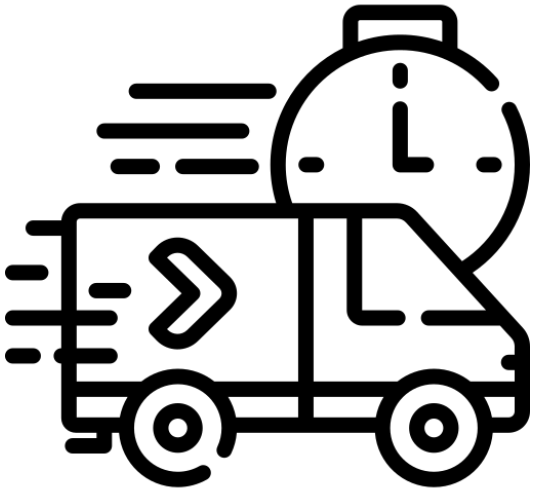
A quotation presents the customer with a legally binding offer for delivering a product or providing a service within certain fixed conditions.

Notes:

Negotiating Terms

6 principles for effective negotiations:

- Know what you are trying to accomplish.
- Develop a strategy plan before negotiations start.
- Study and understand your seller.
- Work towards a win-win (reward for all parties involved).
- Be prepared to walk away.



Delivery Times

Delivery times:

- A lead time is the time between when an order is placed and when it is delivered.
- A company can use that information and its knowledge of when it needs to receive something, to work out when to place an order.
- All the processes that enable an order to be delivered affect delivery lead time, including design work, production, quality control, packaging and shipping.

Notes:

Contracts and Placing Orders

Purchase orders are commercial documents while contracts are legally binding documents.

Purchase orders do not become legally binding documents until they are accepted by the seller whereas a contract is a legal document from the start.

Notes:

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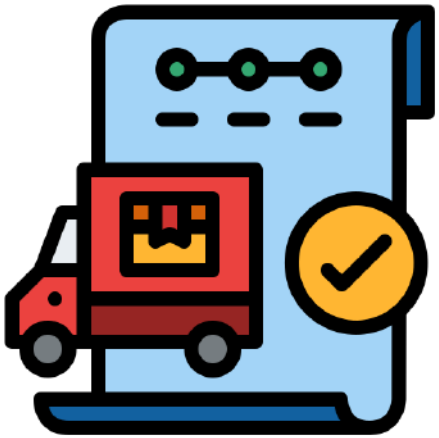
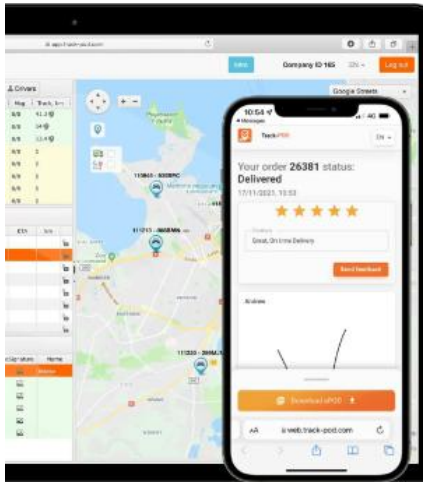


Notes:

Expected Delivery

Expedited delivery is usually the fastest delivery service, where parcels are delivered to your recipient much quicker than a normal standard delivery service offers.

It is used when a customer needs a shipment quicker than usual.



Notes:

Monitoring Quality and Delivery Performance

- Shipping status tools. (Real time tracking, where is the air freight or ship)
- Order processing tools. (Customer order tracking tools / database)
- Lean inventory platforms. (JIT / MRP – flow of supplied materials)
- Warehouse management. (Digital systems such as MRP / SAP / ERP)
- Bidding and spending analysis. (Cash flow and buying)
- Supplier management. (Talking to your suppliers / tracking their figures out to you)
- Demand forecasting.
- Analytics and reporting. (ERP / SAP)

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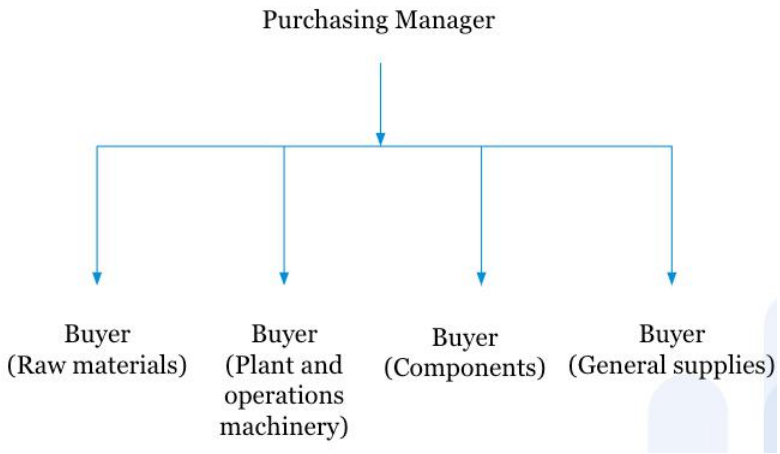


Purchasing

A typical large, purchasing department, would be shown in a company's 'visual management' chart.

It is common for there to be a purchasing manager and buyers who will specialise in particular types of commodities. The products being purchased would require the buyer to be technically qualified.

Notes:

Legal Contracts

- **Negotiating terms and delivery times -** As with any business transaction there will be terms and conditions, these could also include expected delivery dates.
- **Placing contracts and orders -** Once all parties within the transaction agree the terms a legally binding contract will be drawn up and signed.
- **Expediting delivery -** Ensure that delivery of materials is timely and within the contracted terms.
- **Monitoring quality and delivery performance -** Monitoring of progress will always be part of a good logistically system and will give early warning of problems.

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

What does the future hold?

Questions to ask yourself:

1. What are the dangers if I don't invest and plan now for current/future technology?
2. Will I see a return on investment (ROI) for our production facility?
3. If I invest money now, will the processes still be current in five years?
4. What if the chemistries change?
5. What if the battery shape changes?

Notes:

Beyond Li-ion Batteries

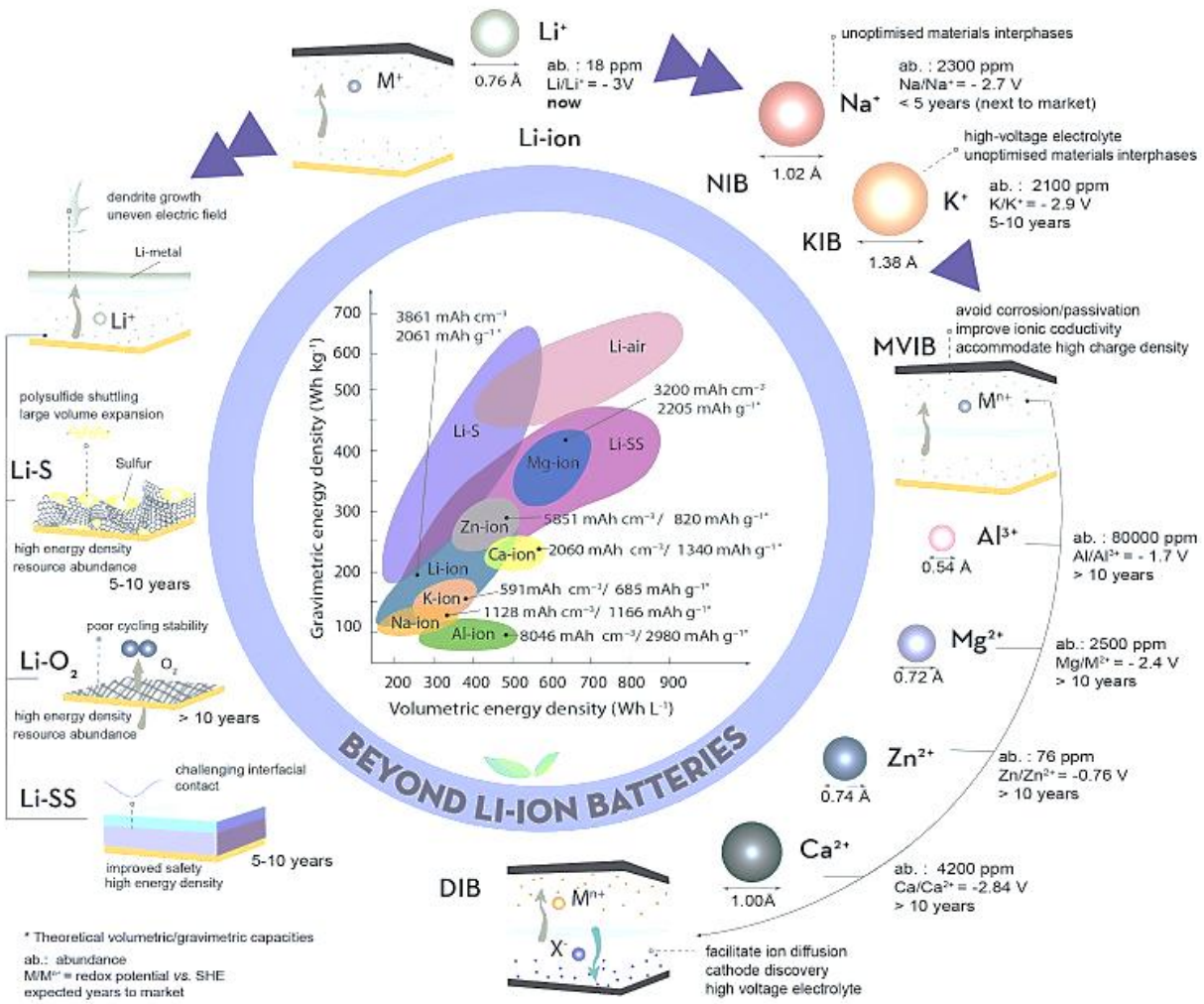
Questions to consider:

1. What are blade batteries?
2. Is sulphur safe to use in batteries?
3. What about Lithium-air batteries?
4. When will solid state batteries be available?
5. Should we use Lithium Ferro Phosphate (LFP) or Nickel Manganese Cobalt (NMC)?
6. Lithium vs Sodium?

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Beyond Lithium-ion Batteries – Emerging Technologies



Notes:

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Beyond Lithium-ion Batteries – The Next 10 Years

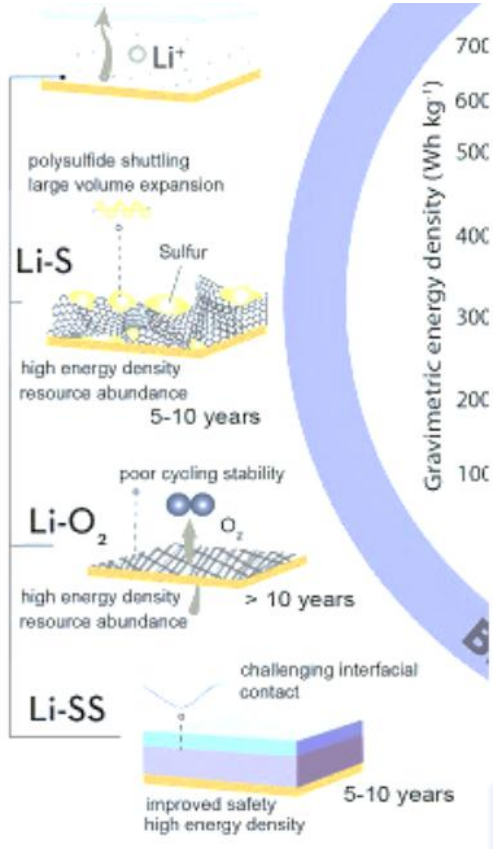
Li-FP replace Li-NMC Batteries ☐ (Now)

Li / Na Sulphur Batteries ☐

Air Batteries ☐

Solid State Batteries ☐ (5-10 Years)

GUESS O METER



Notes:

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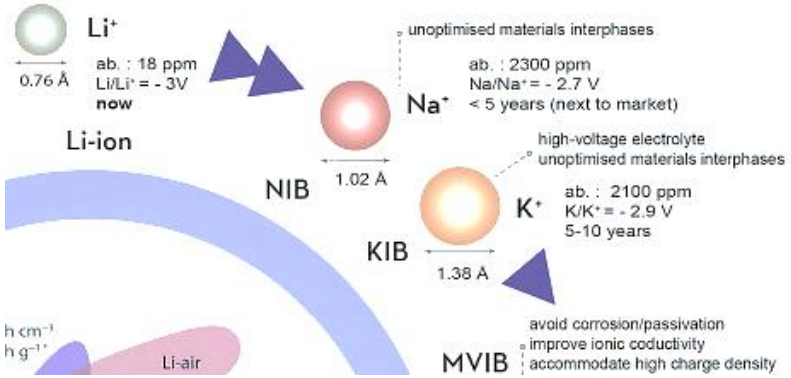


The Next Compositions/Blends

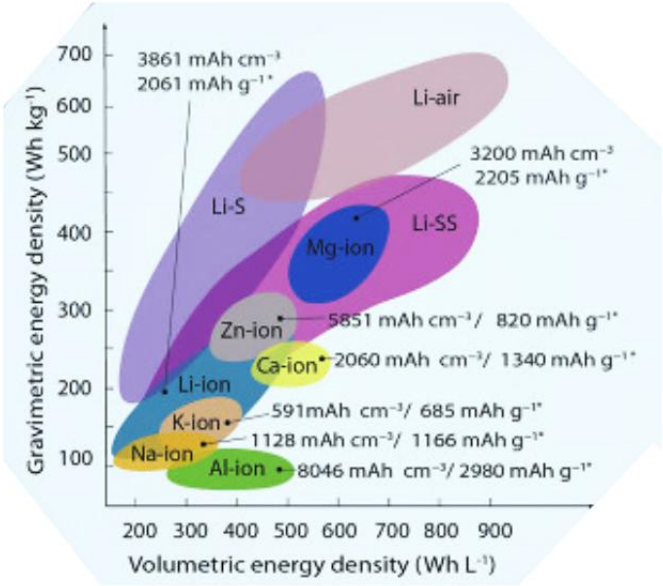
Li = Lithium (Currently used) known as LIBs

Na = Sodium (within the next 5 years) known as SIBs

K = Potassium (possibly seen, within the next 5 – 10 years) know as KIBs

Notes:

The Performance Scale



Notes:

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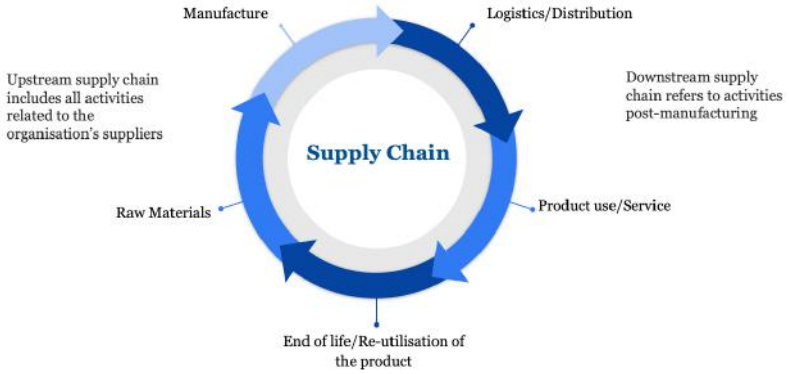


Upstream and Downstream in the Supply Chain

Downstream supply chain can also be thought of as the "demand" while Upstream supply chain is the "supply."

Supply chain managers seek to balance demand and supply to make sure that there are no lost sales, inventory shortages, or over-ordering.

Supply chain inefficiencies can waste money in operational costs, so matching the supply and demand is of high importance.

Notes:

Understand the Supply Chain

For a supply chain to achieve its maximum level of effectiveness and efficiency, material flows, money flows and information flows throughout the entire chain, it must be managed in an integrated and holistic manner, driven by the overall service and cost objectives.

- Overall supply chain policies and targets
- Demand planning and management
- Supply planning and management
- Inventory policies and standards

Notes:

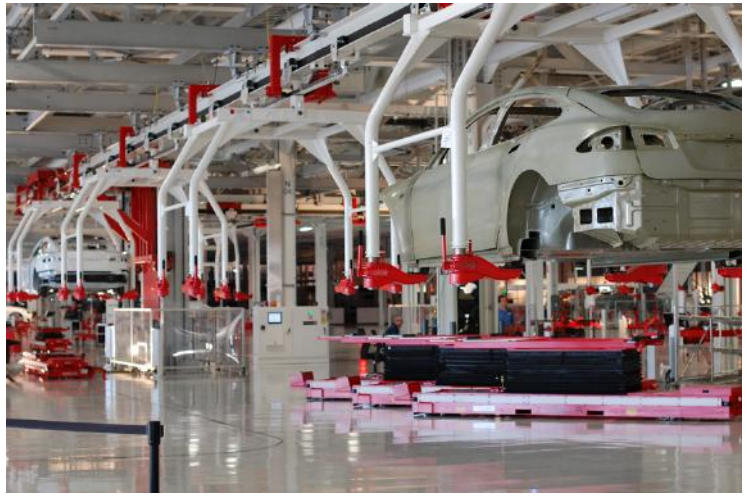
BT1 - Fundamentals of Battery Supply Chain Systems

Understand the Supply Chain

Buy

- Global and domestic sourcing
- Supplier management
- Purchasing/materials planning and management

Notes:



Understand the Supply Chain

Make

- Production Planning and Scheduling
- Capacity Planning and Optimisation
- Manufacturing Layout and Practices
- Product Development and Introduction

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Understand the Supply Chain

Move

- Trade Agreements
- Import / Export Regulations and Customs
- Free Trade Ports / Zones
- Transport Management
- Carrier Evaluation
- Inbound Transportation
- Inter-facility and Outbound Transportation

Notes:

Understand the Supply Chain

Sell

- Order Management
- Return Processing
- Reverse Logistics
- After-Sales Services and Spares
- Customer Service Policies

Notes:

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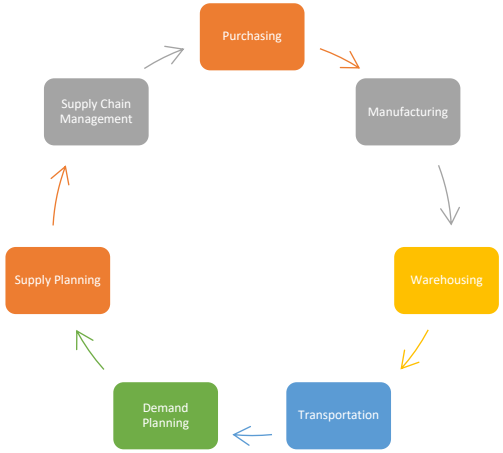

Supply Chain Functions

The 7 main supply chain functions are:

- Purchasing
- Manufacturing
- Warehousing
- Transportation
- Demand Planning
- Supply Planning
- Supply Chain Management

Notes:

Objectives of an affective Supply Chain

- Improving Flexibility / Efficiency
- Improving Quality
- Optimising Transportation and logistics
- Reducing Costs
- Enhancing Customer satisfaction
- Improving Distribution
- Monitoring for better coordination

Notes:

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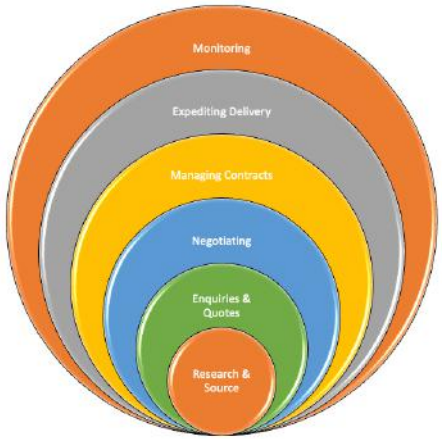
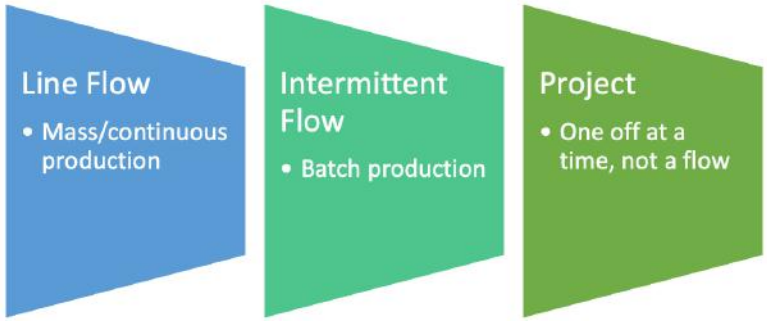


Notes:

Purchasing – Upstream Supply Chain

The main functions are:

- Researching and sourcing of supplies
- Enquiries and receiving quotations
- Negotiating terms and delivery times
- Placing / managing contracts and orders
- Expediting delivery
- Monitoring quality and delivery performance



Notes:

Plant and Operations Machinery – Battery Supply Chain

Decisions have to be made in relation to location of the factory and the design layout of production facilities.

Selecting the processes of production is important and is strategic in nature. This means that it has an impact on the whole business.

There are three basic methods for a production process:

- **Line flow** (Mass / Continuous production)
- **Intermittent flow** (Batch production)
- **Project** *(One off at a time, not a flow)*

BT1 - Fundamentals of Battery Supply Chain Systems

Manufacture Methods and Processes

	One off production	**Batch Production**	**Mass Production**
Number made	1 - 10	10 - 1000	1000's -
Designed by	Designer/Craftsperson		Management Structure
Made by	Labour intensive	Mechanisation (jigs/fixtures)	Automation
Risk v reward	Risk throughout the project	Risks are reduced	Risks are concentrated
Personal involvement	High personal Interest		Low personal interest
Manufacturing processes	Variety of working approaches		Approaches must be defined
Flexibility once designed	Total versatility from one piece to the next	Some versatility	Very difficult to modify
Accuracy	Variable from piece to piece	Interchangeable	Precise likeness from one to another
Market availability	Exclusivity	Limited availability	Widely available
Development process	Development during manufacturing	Some modifications done during manufacturing	All development done prior to manufacturing
Capital investment	Low capital investment		High capital Investment
Production overheads	Low overheads		High overheads
Ability to recoup costs	All costs absorbed in 1 item		Costs divided into 1000's

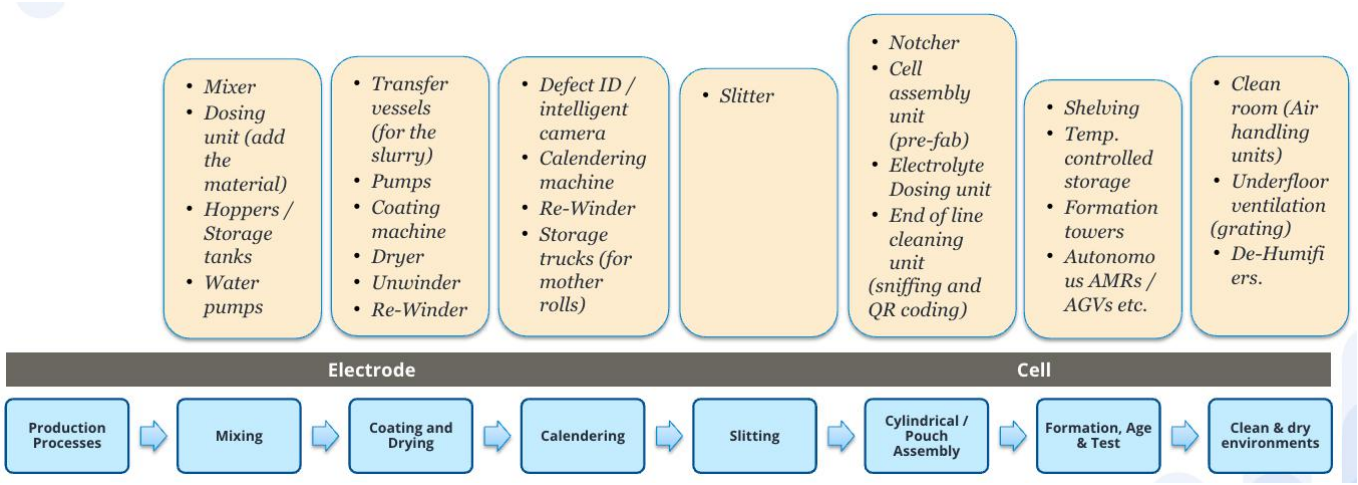
Notes:

Plant and Operations Machinery

Other important factors to consider include:

- **Capacity planning** (Size of facility)
- **Stock / Inventory Control** (Warehousing)
- **Workforce Management** (Trained operators)
- **Quality Control and Quality Management** (QA / QC / TQM)

Notes:



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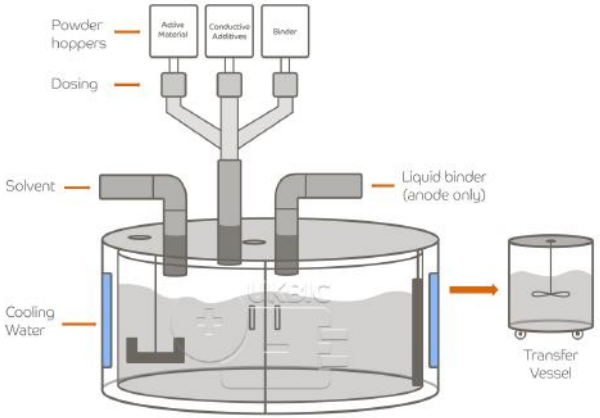

Image source: UKBIC

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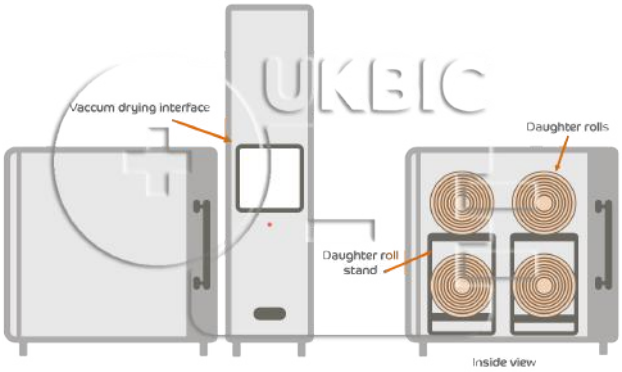

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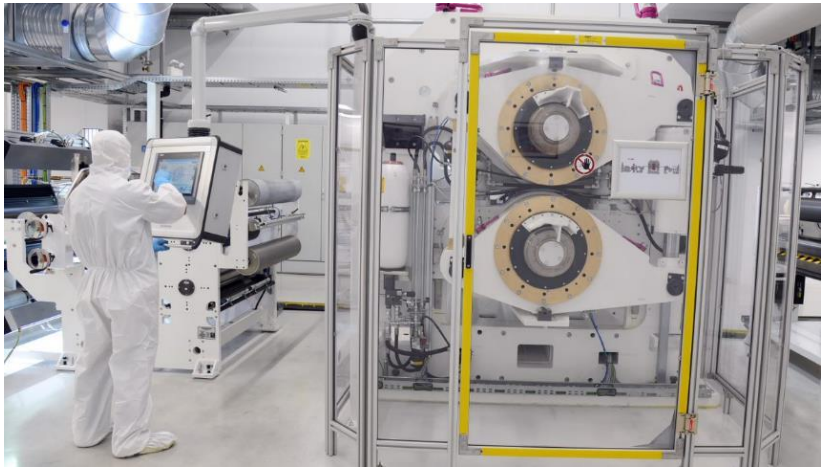


Calandering

Calendering, process of smoothing and compressing a material (notably paper) during production by passing a single continuous sheet through a number of pairs of heated rolls. The rolls in combination are called calenders.


Slitter

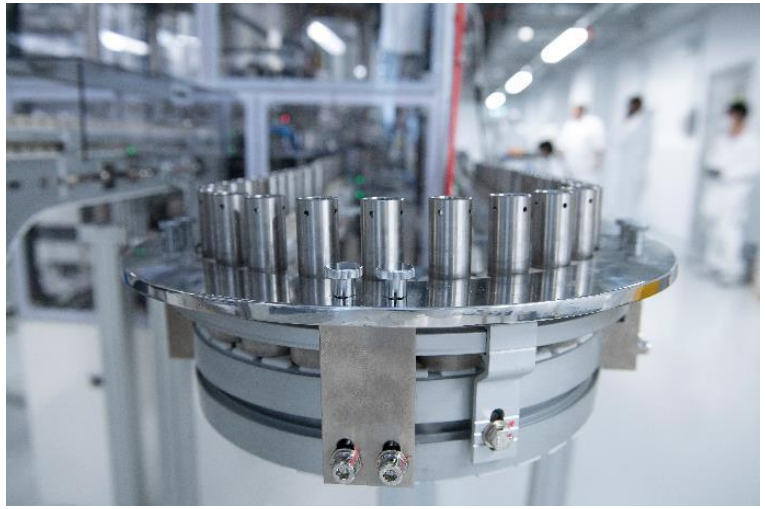
Notes:

Dosing Machine

The dosing machine is used to control the quantity of ingredients/compounds used in the production process. The dosing machine is used to continually monitor this and adjust levels automatically, based on pre-determined settings.

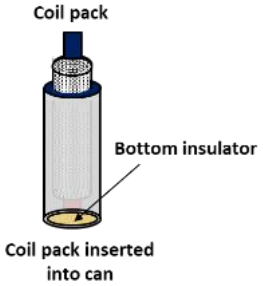
Notes:

BT1 - Fundamentals of Battery Supply Chain Systems



Winding and Packing Unit (automated)

The coiled materials are then inserted into the ‘can’ which is the protective shell around the active materials. The can is the part many of us see as being a ‘battery’.



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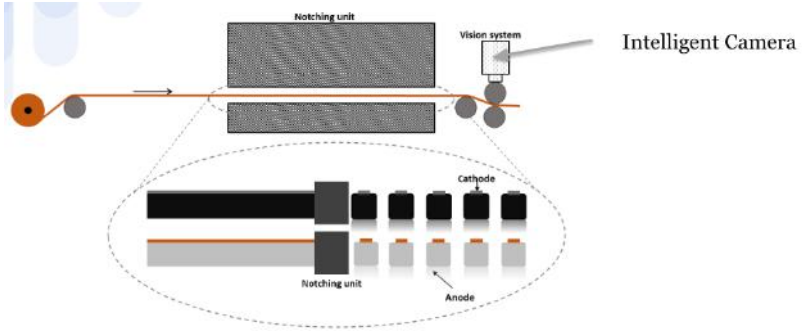

Notching Machine (Nothcer)

The daughter rolls are unwound and passed through a notching unit where they are cut to size ready for insertion into the pouch cell.

A vision system is present at the end of the line to confirm dimensions.

Two machines are used one for anode and one for cathode to prevent cross contamination.

Notes:

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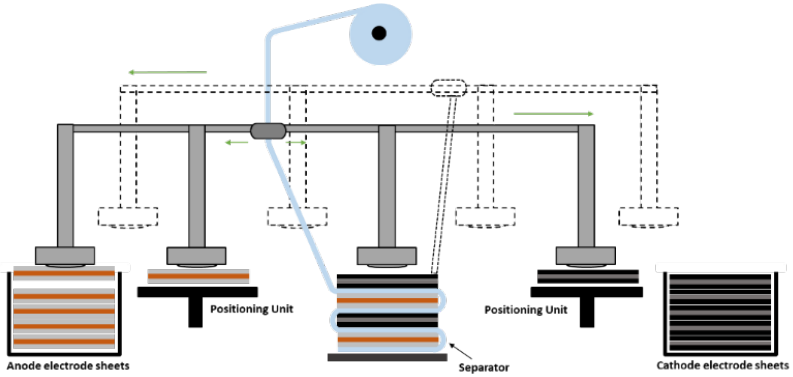


Stacker

Stacking is where the cathode and anode electrode sheets are stacked using a technique known as Z-folding.

The anode and cathode sheets are stacked and separated by a continuous roll of separator to form the pouch stack.

Notes:

Ageing Area (Warehousing)

The aging process consists of repeated cycles at different rates as well as a period of rest time for the batteries. During this portion of the process, several quality related parameters are monitored.

At the end of the entire process, a few end of line (EOL) tests are conducted to characterise the cell and then it is ready to be integrated into packs or other applications.

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Formation Tower (Warehousing)

The formation part of the process involves charging and discharging the battery slowly to build up the solid electrolyte interphase (SEI) layer.

This layer on the electrodes is crucial to battery performance and incorrectly formed batteries can suffer from short lifespans and lower capacity.

Notes:

Cell Assembly Unit

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Warehousing and Storage

Warehousing and materials handling activities, take around 20% of total logistics distribution costs.

The storage function of a warehouse is about inventory accumulation over a period of time. The storage of this stock may take place in different locations and for different lengths of time in warehouses, depending on the storage purpose and movements.

Notes:

Receiving

Receiving includes the physical unloading of goods from the transportation carrier as well as verifying their count and specifications against (PO) purchase order records, inspecting them for damage, and updating warehouse inventory / stock records.

Receiving also includes sorting and classification of products and pre-packaging bulk shipments into smaller ones before moving them to their warehouse storage location.

Finally, the physical movements of products to storage areas, locations for specialised services (such as consolidation areas).

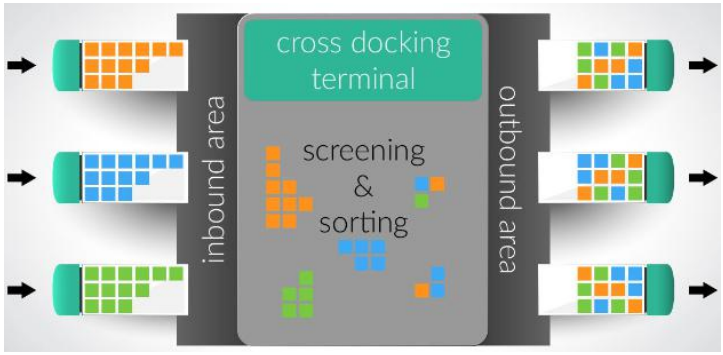
Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Order Pick-Up

This is a fundamental movement activity in warehousing and involves identifying and retrieving products from storage areas according to customer orders.
Order filling also includes accumulating, regrouping, and packaging the products into customers' desired assortments. Moreover, generating packing slips or delivery lists may also take place at this point.
Order-picking activities are time consuming and labour intensive. A study in the UK revealed that around 63% of warehouse operating costs are the result of order picking.

Notes:



Cross Docking

In this process, receiving products from one source are occasionally consolidated with products from other sources with the same destination and immediately sent to customers, without moving to long-term storage.
A pure cross-docking operation only organises the transfer of materials from inbound receiving dock to the outbound dock, eliminating nonvalue-adding activities such as put away, storage, and order filling.
In practice, there might be some delay, and the items may remain in the facility between 1 and 3 days.

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Shipping

Shipping involves physically moving and loading assembled orders onto transportation carriers, checking the content and sequence of orders, and updating stock records. It may also include sorting and packaging the products for specific customers or bracing and packing the items to prevent them from damage.

Notes:

Source: Image by biancoblue on Freepik

Systems Used in a Warehouse

ASRS

Automated Storage and Retrieval gantry Systems, eliminate a lot of order-picking activities wastes.

Shelving / Racking

These are found in most medium size operational warehouses. A number or letter system is commonly used for locations.

Stock Rotation

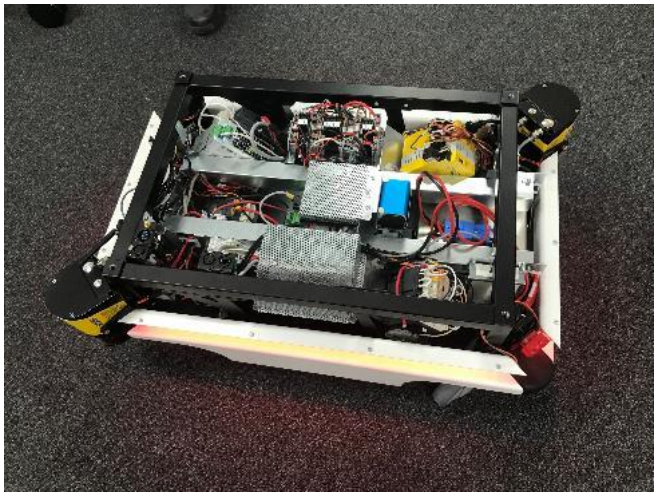
Used for inventory with ‘use by’ dates. All batteries from the day of manufacture suffer from ‘self-discharge’ and ‘degradation’ year on year.

Notes:

Robotics and Automation - Advantages

- Reduced operating costs
- Improved product quality
- Increased production output
- Increased manufacturing flexibility – ease of reuse
- Reduced waste
- Improved health and safety
- Reduced labour turnover
- Reduced capital costs
- Saving on space

Notes:



Autonomous Mobile Robots (AMR)

Autonomous Mobile Robots (AMR) navigate via maps that software constructs on-site or via pre-loaded facility drawings. This capability can be compared to GPS and a pre-loaded set of maps.

When the space has been programmed or learned, it will generate the most direct path based on simple positions on the map.

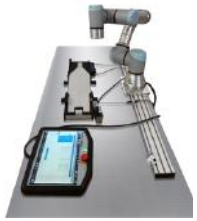
The AMR uses data from cameras, built-in sensors and laser scanners. Sophisticated software enables it to detect its surroundings and choose the most efficient route to the target.

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Cobots 'Robotics' - Automation
A Cobot is a Collaborative Robot. This means that the robot is able to work alongside people.

They differ from industrial robots, which tend to be large robots that work for example in the car manufacturing industry.



They require less safety protocols and are interactive / safe for people to touch, move or manipulate.

Notes:

End Effectors – Basic Hand Gripper

- Simplistic design, makes it perfect for precision assembly tasks
- Grip force 60 to 185 N
- Payload up to 5 kg

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

End Effectors – Three Finger Gripper

Ideal for advanced manufacturing and robotic research, the 3-Finger Gripper is the best option for maximum versatility and flexibility.

- Four grip types: Pinch, Wide, Scissor and Basic Mode
- Control each of the fingers separately, plus feedback from each
- End effector is compatible with all major industrial robots
- Payload up to 10kg

Notes:

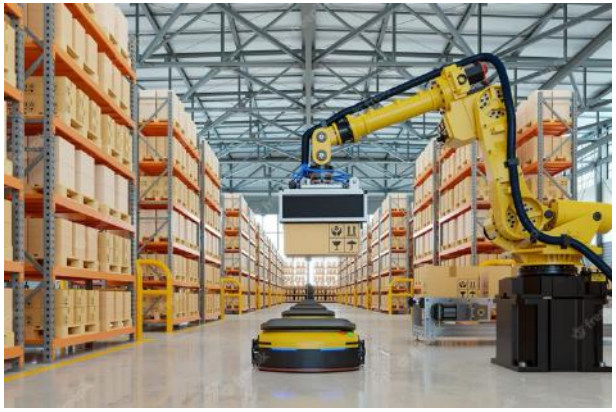
End Effectors – Vacuum Picker

Vacuum Grippers are ideal for picking a wide range of different materials, those with either even or uneven surfaces such as cardboard, glass, metal sheet (dry) and plastic / polymer sheet.

- Energy source: Compressed air or electricity
- Picker mass: around 340g *(per suction cup)*
- Powerful vacuum flow
- Low Noise

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems



Source: Image by vanitjan on Freepik

Robotics and Automation – Risks and Barriers

With any new process, it brings with it both risks and barriers, which need to be overcome. These include:

- Technical risk
- High variability
- Health & safety
- Initial cost and return on investment
- Skill levels
- Floor space
- Company culture
- Working environment

Notes:

Source: Image by macrovector on Freepik

Technical Risk

There needs to be a thorough analysis of the risks, which is particularly important for complex technical tasks. This analysis will test the feasibility of adopting robotics to automate processes.

High Variability

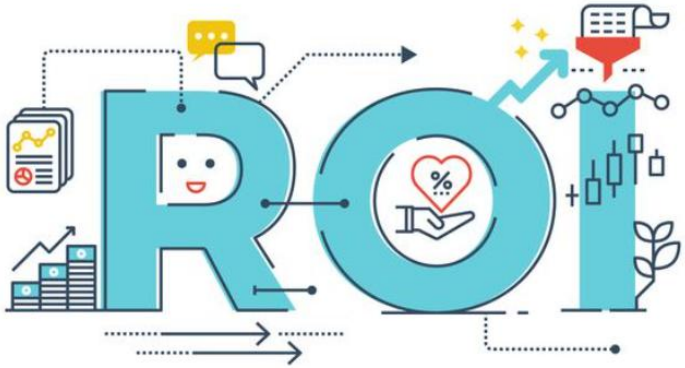
Usually, robotics and automation systems are deployed in industries with low variability and high volumes. Increasingly the advances in robotics are enabling organisations with product variability to consider automating processes.

Notes:

Health & Safety

Robotics and automation improve the levels of health and safety of manual operations as they remove manual handling. Robots do have their own safety hazards, but fatalities and injuries are low compared to those caused by manual handling.

Notes:



Initial Cost and Return on Investment

A longer-term view needs to be taken of this. Ordinarily payback might be calculated over two years, but a well maintained robotic and automation system should provide a minimum payback of 5 years, with some system payback extending to 10 years.

Skill Levels

The skill needs of personnel to operate robotic and automation systems could be a barrier. Investment in training and recruitment will be needed.

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Source: Image by macrovector on Freepik

Floor Space
Robotics and automation in some instances may require more floor space than manual operations, although in many instances they save on space.

Company Culture
Resistance to change and a fear of robots taking jobs is often mentioned as reasons not to install automation**.** In the long-term automation has created more jobs than have been lost and at a higher skill level.

Notes:

Source: Image by vectorpouch on Freepik

Working Environment
The working environment needs to be carefully considered when thinking about automation. Automation systems are generally tolerant of working environments, however there may be some extreme working environments that do not lend themselves to automation.

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Inbound Logistics
Inbound Logistics includes the physical unloading of goods from the transportation carrier as well as verifying their count and specifications against (PO) purchase order records, inspecting them for damage, and updating warehouse inventory / stock records.

Notes:

Inbound Logistics cont.
Receiving also includes sorting and classification of products and repackaging bulk shipments into smaller ones before moving them to their warehouse storage location.

Finally, the products are moved to a location for storage. These storage locations are recorded to reduce time looking for an item.

Notes:

Source: Image by biancoblue on Freepik

Inbound Logistics cont.

In order to optimise inbound logistics all items, large or small will be recorded when entering the manufacturing facility. This information could include:

- **Size** - will have an effect on the location it is stored at
- Weight - has repercussions for the way the item is handled
- **Location** - sometimes using GPS to locate an item will speed up recovery and use
- **Use by date** - some battery materials have a shelf life which needs to be understood
- **Goods in date** - when the item was received, can relate to planning (Just in Time)
- **Purchase order number** or 'job' allocated to the item

Notes:

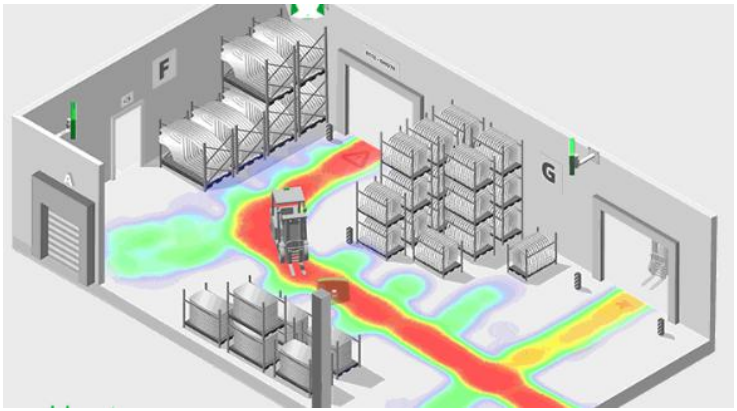
Source: Image by macrovector on Freepik

Inbound Logistics – Automation

There is more and more automation being used in logistics:

- Robots unloading transportation.
- Automatic movers stacking shelves or racking
- GPS location devices for tracking a component around a factory
- RFID (Radio Frequency identification) labels to speed up scanning and data transfer

Notes:



Heatmap

Inbound Logistics – Technology Improvements

Real-time tracking of forklifts or other vehicles, helps your logistics and production managers achieve greater -

- Efficiency
- Profitability
- Safety

By making better use of your fleet, cutting down on wasted man hours and, more importantly, preventing accidents.

Notes:

Spaghetti flow

Inbound Logistics – Technology Improvements cont.

As well as the routes of each forklift, advanced visualisation can bring an understanding of processes to streamline the traffic and remove bottlenecks. These include heatmaps showing how the density of the traffic is distributed within the facility.

These commonly understandable visualisation methods help to onboard and get the agreement of all stakeholders for increasing the ‘efficiency’ and cutting time wasted costs.

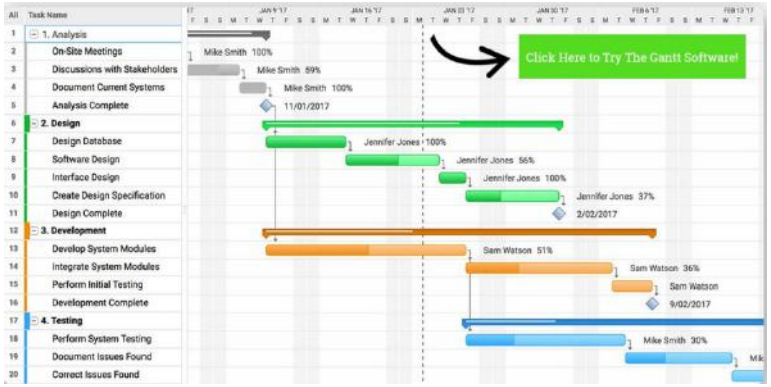
Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Types of Production Planning, Scheduling and Control

- Gantt Chart / Digital Timeline
- MRP - Materials Requisition Planning
- SAP / ERP - Systems Applications and Products planner / enterprise resource planning

Notes:



Gantt Chart/Digital Timeline

A Gantt chart is a project management tool assisting in the planning and scheduling of projects of all sizes, although they are particularly useful for simplifying complex projects.

You can easily see:

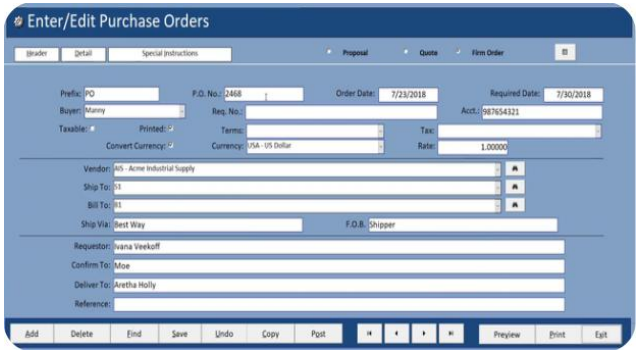
- A visual display of the whole project
- Timelines and deadlines of all tasks
- Relationships and dependencies between the various activities
- Project phases

Notes:

Gantt Chart/Digital Timeline cont.

Project management timelines and tasks are converted into a horizontal bar chart, showing the start and end dates, as well as dependencies, scheduling and deadlines, including how much of the task is completed per stage and who is the task owner. This is useful to keep tasks on track when there is a large team and multiple stakeholders when the scope changes.

Notes:



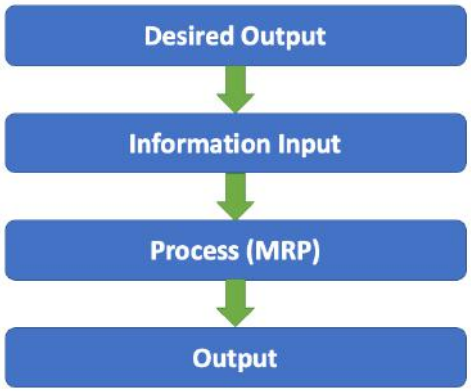
MRP – Materials Requisition Tier 1

Material Requirement Planning includes:

- Plan the needs for materials
- Comprises only the manufacturing area.
- Open loop system
- Responds to what, how much and when to acquire materials
- Improves the materials production scheduling.

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems



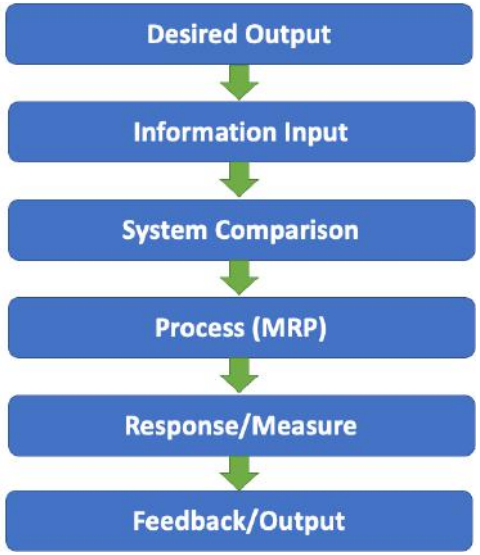
Notes:

Open Loop System

Desired output > Information input > Process (MRP) > Output

Simple MRP is often open loop.

The user has a goal and selects an input to a system to try to achieve this.



Notes:

Closed Loop System

Desired output > Information input > System comparison (how much / when) > Process (MRP) > Response / Measure (what is available) > Feedback (in loop) or Output

More sophisticated MRP systems are closed loop

The user inputs the goal to the system

BT1 - Fundamentals of Battery Supply Chain Systems

Notes:

MRP – Resource Planning Tier 2

- Plan the needs for resources
- Includes the whole business
- Closed loop system
- Responds the same as MRP - Tier 1, includes also how much and when it will be produced, and what are the available resources
- Improves productivity

Commodity Market Trading

Trade has happened for thousands of years, be it food or land or resources.

Commodities are raw materials or agricultural products and are now traded globally.

Because commodities are physical items, they are subject to the following influences:

- **Rarity** - eg Gold or Diamonds are not commonly found.
- **Land ownership** - where are the minerals from.
- **Dispute/war** - Disruption can change availability.
- **Natural disaster** - Can affect supply chains

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

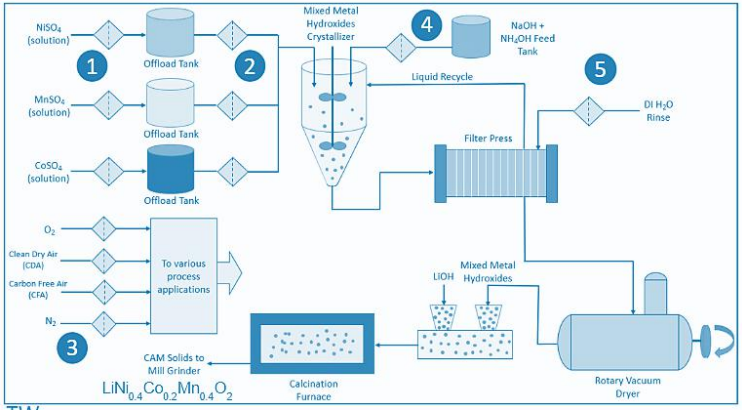
SAP/ERP

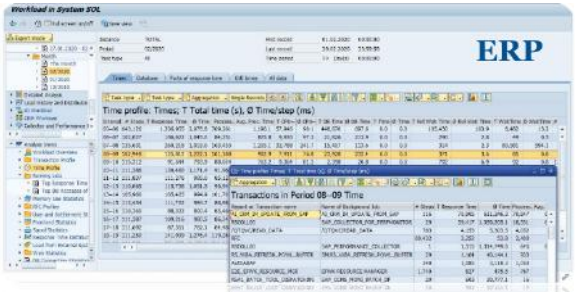
Systems Applications and Products (SAP) planner, is a widely-used Enterprise Resource Planning (ERP) software.

It creates a centralised system for organisations that enables every department to access and share common data to create a more streamlined work environment for every employee in the company.

Facilitates effective data processing and information flow across a business.

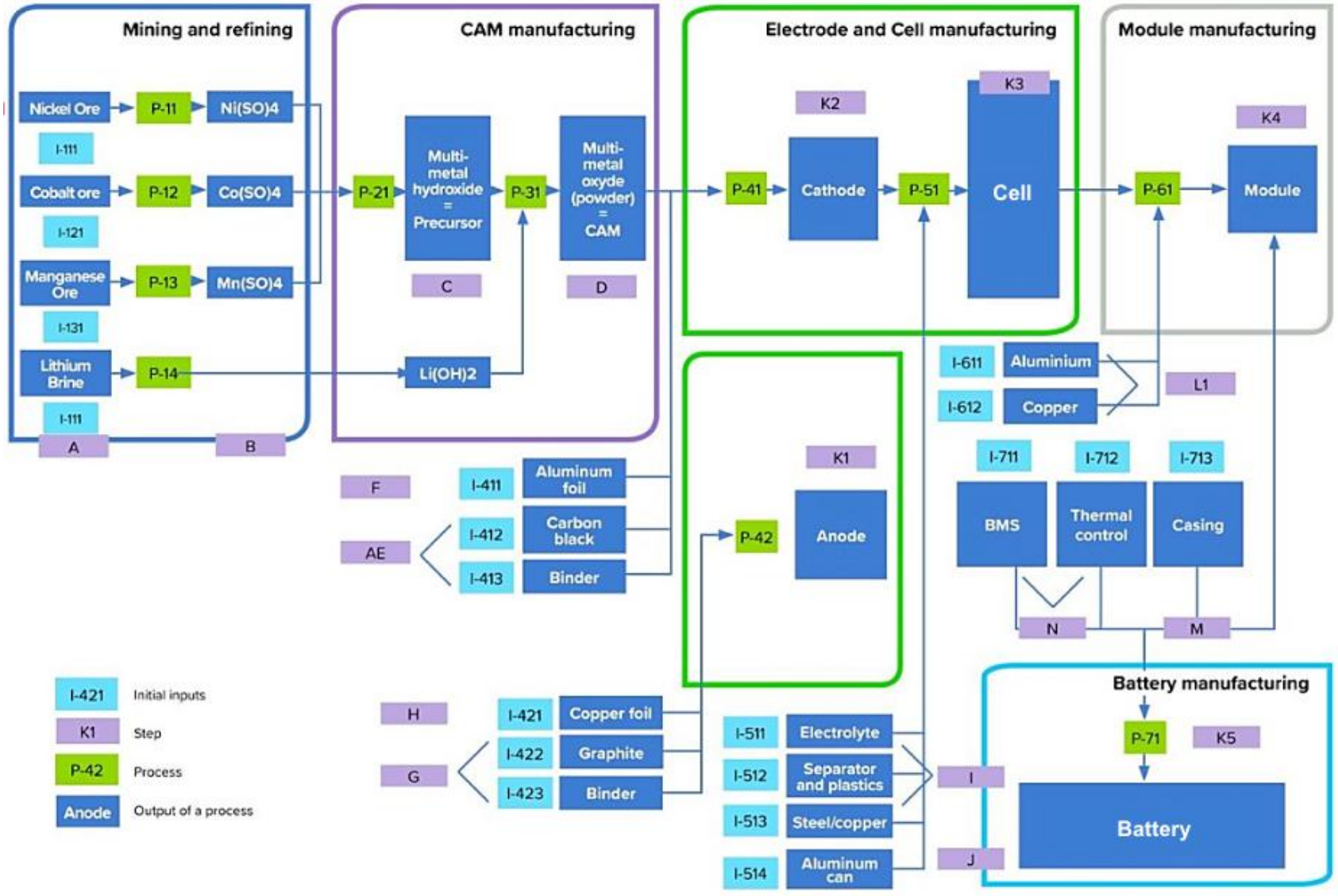
Notes:





Notes:

Process Flow – NMC Li-ion Battery Production



BT1 - Fundamentals of Battery Supply Chain Systems

Business issue	How ISO 9001 helps	Benefits
Client expectation	• It helps you to identify present customer needs and identify and assess future requirement • It helps you to measure client satisfaction	• You focus on planing ahead to make sure you have the right resources and knowledge in your organization • Helps you to build a resilient organization for the long term • Helps you to deliver better products and services • Increase in customer satisfaction and repeat business
Compliance	• Helps you ensure all regulatory requirements are met for your products and services • Requires you to communicate regulatory requirements to your employees and interested parties	• Gives confidence to interested parties that relevant regulations and compliance obligations are being met • Protects your reputation • Reduces likelihood of fines and prosecutions which allows you to focus on winning business
Improvement	• It makes you assess risks and identify opportunities for your business • It makes you continually examine opportunities for improvement • You need to put in place the operational controls to effectively manage and measure your performance	• Lower operational costs • Reduce waste and increase efficiency • Improve your bottom line
Reputation	• Demonstrates your commitment to quality products and services • It is the most widely recognized international management system standard • Helps safeguard the quality of your products and services	• Improved reputation and stakeholder satisfaction • A competitive advantage to grow your business • Win more high-value customers, and achieve improved customer retention with better customer service
Engagement	• Requires you to identify all internal and external stakeholders relevant to your Quality Management System and their needs • Requires you to communicate the quality policy and ensure that the workforce understands how they contribute to it • You are expected to show how you meet customer requirements and regulatory and statutory requirements	• Internal and external communication is improved • Business with a motivated and engaged workforce are more likely to remain compliant and avoid penalties or fines

Notes:

Conforming to ISO Standards (ISO 9001:2015)

The seven principles of ISO 9001 include:

- Engagement of people
- Customer focus
- Leadership
- Process approach
- Improvement
- Evidence-based decision making
- Relationship management

Notes:

Conforming to IATF (International Automotive Task force) Standards

- IATF 16949:2016 is the Automotive Quality Management System (QMS) standard.
- It enables harmonisation of the various supplier assessment and certification systems across an entire automotive supply chain.
- Common automotive quality system requirement based on ISO 9001 and customer specific requirements from the automotive sector.
- IATF 16949 certification emphasises the development of a process oriented quality management system that:-
  - provides for continual improvement, defect prevention and reduction of variation and waste in the supply chain.
- The goal is to meet customer requirements efficiently and effectively.

BT1 - Fundamentals of Battery Supply Chain Systems

Material safety data sheets (MSDS) are an older format and could vary from source to source within a country, depending on national requirements. However, the newer SDS format is internationally standardised.

Battery Data Sheets/SDS Sheets

Safety data sheets (SDS) are documents that list information relating to occupational safety and health for the use of various substances and products. SDSs are a widely used system for cataloguing information on chemicals, chemical compounds, and chemical mixtures. SDS information may include instructions for the safe use and potential hazards associated with a particular material or product, along with spill-handling procedures.

Notes:

2.3 Other hazards :

Appearance, Color and Odor: Solid object with no odor.

Primary Routes(s) of Exposure: These chemicals are contained in a sealed enclosure. Risk of exposure occurs only if the cell or pack is mechanically, thermally, electrically or physically abused to the point of compromising the enclosure.
If this occurs, exposure to the electrolyte solution contained within can occur by inhalation, ingestion, eye contact and skin contact.

Potential Health Effect(s):

Acute (short term): see Section 8 for exposure controls.
In the event that this cell or pack has been ruptured, the electrolyte solution contained within the cell would be corrosive and can cause burns to skin and eyes.
Inhalation: Inhalation of materials from a sealed cell is not an expected route of exposure. Vapors or mists from a ruptured cell may cause respiratory irritation.
Ingestion: Swallowing of materials from a sealed cell is not an expected route of exposure. Swallowing the contents of an open cell can cause serious chemical burns to mouth, esophagus, and gastrointestinal tract.
Skin: Contact between the cell and skin will not cause any harm. Skin contact with the contents of an open cell can cause severe irritation or burns to the skin.
Eye: Contact between the cell and the eye will not cause any harm. Eye contact with the contents of an open cell can cause severe irritation or burns to the eye.
CHRONIC (long term): see Section 11 for additional toxicological data.

Interactions with other chemicals: Immersion in high conductivity liquids may cause corrosion and breaching of the cell or battery enclosure. The electrolyte solution inside of the cells may react with alkaline (basic) materials and present a flammability hazard.

Potential Environmental Effects: Not Available.

Section III – COMPOSITION/INFORMATION ON INGREDIENTS

3.1 Mixture

CAS No.	EC No.	REACH Registration No.	%[weight]	Name	Common Name (Synonyms)	Classification according to Regulation(EC) No 1272/2008/(CLP)
12325-84-7	Not available	-	25~35	Lithium Nickel Oxide	Not available	Not classified
7782-42-5	231-955-3	-	20~30	Graphite	Not available	Not classified
7439-89-6	231-096-4	-	10~20	Iron	Not available	Not classified
7440-50-8	231-159-6	-	5~15	Copper	Not available	Not classified

Notes:

Section IV – FIRST-AID MEASURES

4.1 Description of first aid measures

Following eye contact :
- Rinse eyes with plenty of water for at least 15 minutes and seek medical attention.

Following skin contact :
- Remove contaminated clothing and wash before reuse.
- Immediately rinse contact area with plenty of clean water.
- Provide first aid to contacted area to prevent infection.
- Get medical attention.

Following inhalation :
- In case of inhalation of organic electrolyte mist, remove from exposure to fresh air.
- If necessary give oxygen. Get medical attention.

Following ingestion :
- In case of ingestion of electrolyte don't induce vomiting.
- If patient is conscious and alert give 2~4 cupfuls of milk or water.
- Never give anything by mouth to an unconscious person.
- Get medical attention immediately.

Further Information :
- The following first aid measures are required only in case of exposure to interior battery components after damage of the external battery casing.
- Undamaged, closed cells do not represent a danger to the health.

4.2 Most important symptoms and effects, both acute and delayed

Acute effects : Not available
Delayed effects : Not available

4.3 Indication of immediate medical attention and special treatment needed

- Ensure that medical personnel are aware of the material(s) involved and take precautions to protect themselves.

Health & Safety and the Battery Supply Chain

As with any manufacturing process, battery manufacturing has its own health and safety risks:

- Manual handling - often heavier than their size suggests
- Materials used - can be toxic due to the materials used
- Potential for fumes
- Potential for fire - if cells are damaged in transit/warehousing

Notes:

Compliance: Labelling and Packaging

A hazard statement is a phrase that describes the nature of the hazard in the substance or mixture. A hazard statement will be determined by the application of the classification criteria.

Examples of battery hazard statements include:

- Hazardous voltage inside - A battery may have several protective layers
- Toxic if swallowed - Common sense isn't always common
- Corrosive, if the battery is leaking - Care in handling required
- Explosive, risk of explosion if damaged, punctured or pierced

Notes:

Compliance: Labelling and Packaging cont.

- The UKCA marking is the product marking used for products being placed on the market in Great Britain (England, Scotland and Wales).
- The UKCA marking applies to most products for which the CE marking could be used.
- The technical requirements (sometimes referred to as 'essential requirements') you must meet for the UKCA marking will depend on the product specific legislation for your product.
- By following designated standards, manufacturers can claim 'presumption of conformity' with the corresponding essential requirements that apply to their product.

Notes:

Battery packs,
Modules or cells.

WEEE

Compliance: Labelling and Packaging cont.

Electronics waste should never be placed in the general waste by the end user.

WEEE labelling needs to be clear on products and separated into:

- Waste batteries
- Waste electrical and electronic devices

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems


Accompanying Lithium Battery Document

Reference Number (optional):

WARNING: LITHIUM BATTERIES THAT HAVE BEEN RECALLED BY THE MANUFACTURER FOR SAFETY REASONS MUST NOT BE SHIPPED BY AIR.

Terminology
- Cell – electrochemical unit, consisting of an anode and a cathode, capable of producing electrical current
- Battery – assembly of cells
- Lithium ion cells/batteries – rechargeable – includes lithium polymer cells/batteries
- Lithium metal cells/batteries – generally non-rechargeable

This package contains lithium cells or batteries in the following configuration (check applicable box):

Lithium Ion – Maximum of • 20 Watt-hours per cell; and • 100 Watt-hours per battery	Lithium Metal – Maximum of • 1 grams of lithium metal per cell; and • 2 grams of lithium metal per battery
X Cells or batteries only (ICAO/IATA Packing Instruction 965, Section II) Cells or batteries in a package, without electronic equipment Package Limit: ≤ 7.7Wh or ≤ 2.0 kg; or > 2.7 Wh but ≤ 20 Wh = 2 cells; or > 7.7Wh but ≤ 100 Wh = 2 batteries	Cells or batteries only (ICAO/IATA Packing Instruction 969, Section II) Cells or batteries in a package, without electronic equipment Package Limit: ≤ 1 g = 2.5 kg; or > 0.3 g but ≤ 1 g = 2 cells; or ≤ 0.3 g but ≤ 1 g = 2 batteries
Cells or batteries only (ICAO/IATA Packing Instruction 966, Section III) Cells or packs not in a package, without electronic equipment	Cells or batteries only (ICAO/IATA Packing Instruction 968, Section III) Cells or batteries not in package, without electronic equipment
Packed with equipment (ICAO/IATA Packing Instruction 967, Section II) Cells or batteries packed with associated electronic equipment	Packed with equipment (ICAO/IATA Packing Instruction 969, Section II) Cells or batteries contained in package with associated battery-powered equipment – only the batteries not installed in the equipment
Contained in equipment (ICAO/IATA Packing Instruction 967, Section III) Cells or batteries installed in equipment	Contained in equipment (ICAO/IATA Packing Instruction 970, Section II) Cells or batteries installed in equipment

Package shall be labelled with cells, a handling hazard event if the package is damaged, if the package is in transit, it must be quarantined, evaluated and repaired. For more information call +49 7190 92 000.

List telephone number here, including area code and any applicable country code

Name/Address of shipper: Technische Industries E.E GmbH, Max-Eyth-Strasse 19, D-71364 Winnenden

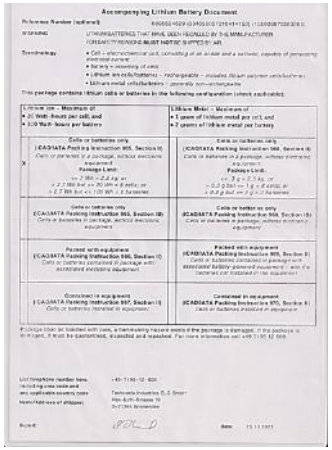
Signed: [signature] Date: 15.11.2021

Supply Chain Labelling/Traceability

Traceability information across the supply chain will include the country of origin of the raw materials as well as the quantities present in the battery placed on the market.

There are environmental considerations that relate to the mining of battery materials. The extraction of lithium from salars can divert hundreds of thousands of gallons of water from agricultural operations. Also, chemicals can find their way into the water supply, harming wildlife.

Notes:


Accompanying Lithium Battery Document

Supply Chain Labelling/Traceability cont.

EU legislation will require batteries to have minimum amounts of recycled content, lowering the environmental burden, but also reducing Europe's dependence on raw materials.

By 2035, EV battery recycling could provide at least 22% of the lithium and nickel and 65% of the cobalt necessary for European production.

Notes:

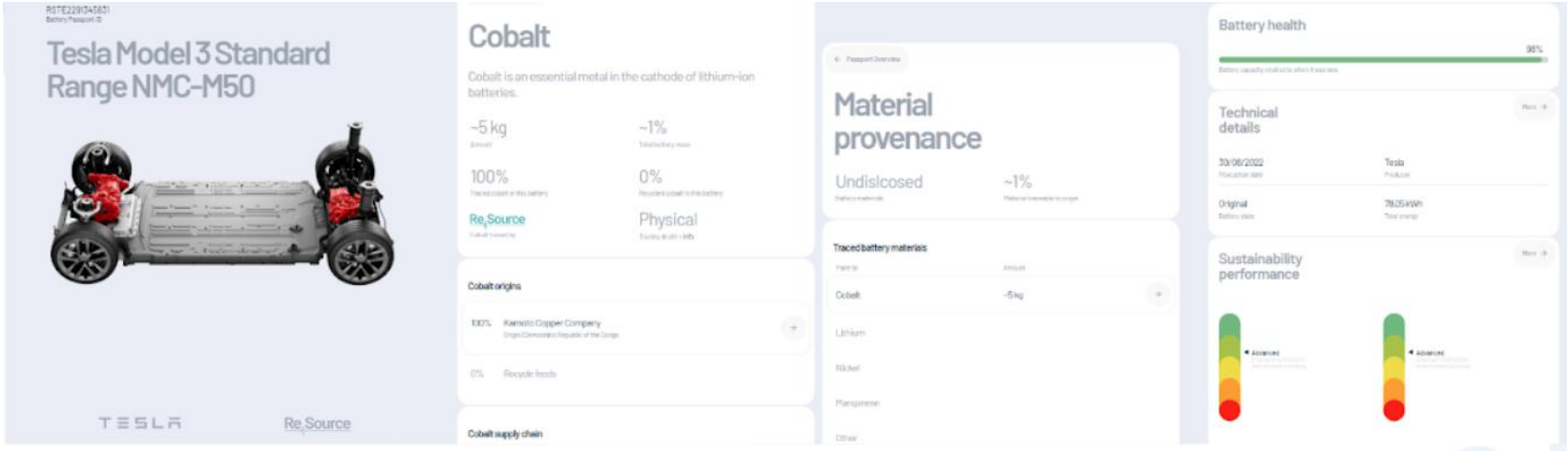
BT1 - Fundamentals of Battery Supply Chain Systems

Notes:

Supply Chain Labelling/Traceability cont.
Most car manufacturers offer eight-year, 100,000 mile battery warranties, which in simple terms, would mean that batteries recycled today first hit the road in 2010.

Tesla and Nissan being pathfinder's in EVs have been selling vehicles in Europe for more than a decade, but it's clear that one of the current limitations on EV battery recycling is availability.

Tesla's Proposed Digital Battery Passport



BT1 - Fundamentals of Battery Supply Chain Systems

Customer Charter

A customer service charter is a document that outlines how an organisation promises to work with its customers along with providing insights into how a business operates.

It should help a customer to:

- Understand how a company will work with a customer to fulfil the contract.
- It can include the policies and procedures an organisation will follow when working with partners.

Notes:

Source: Image by Freepik

Customer Charter cont.

Statements used should be clear and simple:

The 'Business' will…

- Correct issues promptly when they have gone wrong and learn from the problem.
- Consult customers regularly and take account of their comments and feedback.

The 'Business' will strive to…

- Offer value for money
- Make sure our staff are fully equipped to help you.

Notes:

Returns Policy

There are 5 steps to 'Good' reverse logistics, which are:

- Process the return
- Deal with returns
- Keep returns moving
- Repair
- Recycle

Notes:

Process the Return

The return process starts when the consumer signals they want to return a product. This step should include return authorization and identify the product's condition. This process also involves scheduling return shipments, approving refunds and replacing faulty goods.

Notes:

Source: Image by storyset on Freepik

Dealing with Returns

Once a returned product arrives at your location or centralized processing centre, inspect it and determine its return category.
(Note: If you have optimized reverse logistics, you should know where the product should go before it arrives.)
Sort products into the disposition options: fix, resell as new, resell as a return, recycle, scrap or refurbish.

Notes:

Source: Image by juicy_fish on Freepik

Keep Returns Moving

Reduce your daily waste by sending repairable items to the repair department.

Repair

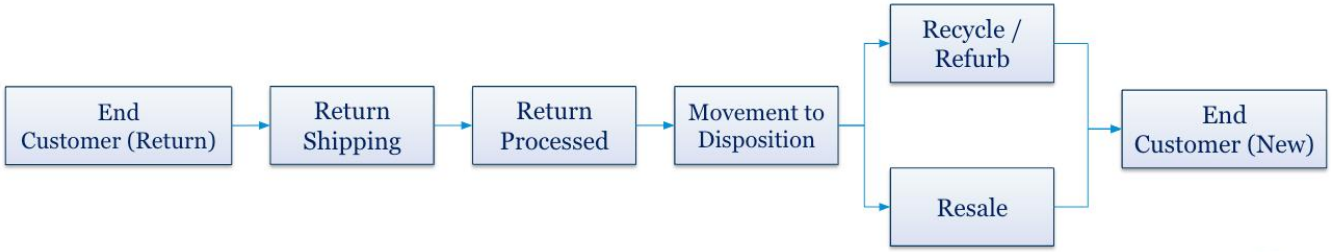
After reviewing the returned item/equipment and determining whether it can be repaired, move it to the repair area. If not possible, sell any sellable parts.

Recycle

Any parts or products that you cannot fix, reuse or resell should be sent to the area for recycling.

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems



Notes:

	Quality Control	Quality Assurance
Raw Materials	- Site inspections. - Lab tests of purity (Scientists) materials.	- Regular sample reports - Legal contracts to provide on time.
Pre-Production (Delivery / JIT)	- Quality of stock material visually inspected. - Destructive tests of random sample pieces.	- JIT deliveries (only what is needed for the day/ week).
Manufacturing	- Visual checks - Go / No-go gauges (poke-a-yoke) - JIGs - Intelligent cameras - Probe measuring CMM or PUGs	- Checked against CAD / blueprint drawings. - Trained workshop technicians. - Checked against customer specifications (**KANBANs**).
Quality Inspection / Testing	- Destructive tests (longevity) - Tensile, torsion, drop tests. - Weather testing (Environmental elements tank)	- BETA tests (riders) - 1 in 1,000 tested etc. (continuity)

ISO 9001:2015 Quality Management Systems (Sub – contractor relations)

[**MRP**] Materials Requisition Planning / [**SAP**] System Applications and Products

ISO 9001:2015 Total Quality Management (QC inspection/testing)

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

	Quality Control	Quality Assurance
Sales (What do sales offer?)	- Pre-delivery inspection note (dealer to customer) - Aftercare / (mandatory) factory warranty / plua extended warranty agreements offered.	- Check of the specification / order. - User manual (details and **serial no.** / label added.)
Use / When the bike is with the user	- Nut / bolt checks - Tyre checks - Brake checks	- User manual (print or digital)
Aftercare / Post-Sales	- Service program (preventative maintenance) - Care instructions	- Service record / **log book**.
Disposal / Recycling	- Component parts are separated (disassembly instructions for processors) - Recycling – tyres for remould. - Electronics / lights – batteries removed. (WEEE)	- Manufacturers to report on how much of the bike can be recycled (EU directive) - Companies responsible for safe disposal of own product.

ISO 9001:2015 – No replacements, should be no defective products.
*Has to be a Repair: It is not acceptable to just replace with new.

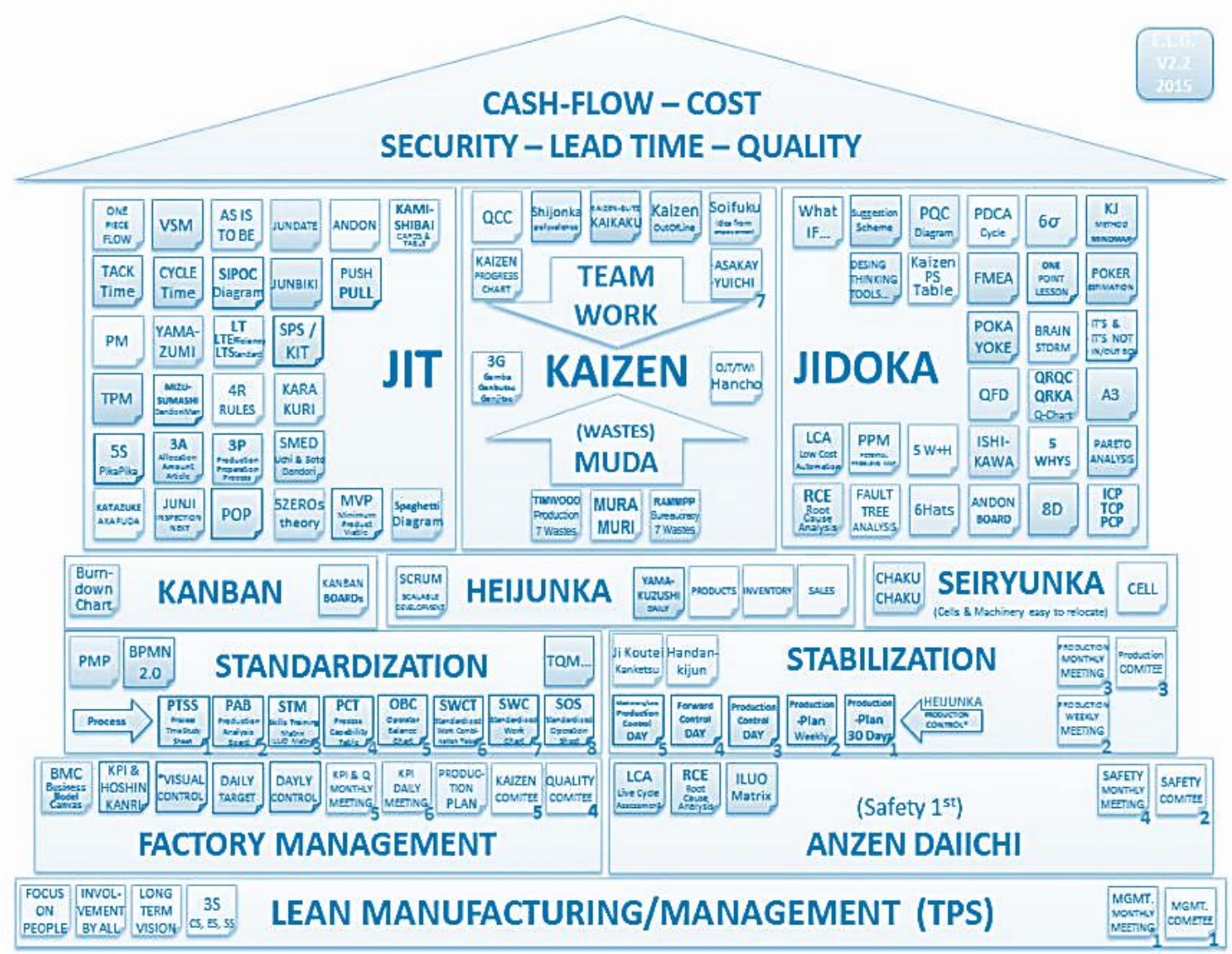
All Parts OEM traceable to manufacturing / production line. From original KANBAN system – factory records. Specific intervals – servicing by the manufacturer.

EU Waste Framework Directive
Batteries would be handled by an (ABTO) Approved battery treatment operator.

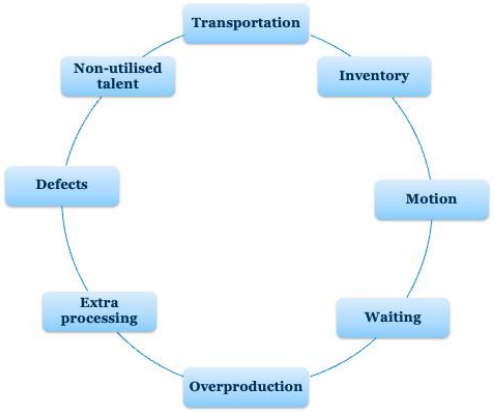
Notes:

Notes:

House of Supply Chain



BT1 - Fundamentals of Battery Supply Chain Systems



Lean Manufacturing – 8 Wastes

Taiichi Ohno - a Japanese Industrial Engineer, was known as the father of the Toyota Production System. While searching for better ways for process improvement and to optimise resources, 'Ohno' identified 7 lean wastes (Muda in Japanese) of lean manufacturing (the 8th waste was added in the 90s).

Notes:

The 8 wastes of Lean Manufacturing are known as '**DOWNTIME**':

- Defects
- Overproduction
- Waiting
- Non-utilised talent
- Transportation
- Inventory
- Motion
- Extra processing

Originally developed for the automotive sector, other industries have started utilising it to add value to the business processes.

Defects

The production of a defective product or delivery of service will require either a rework or a scraping of the product. The customer will not pay for either.

Overproduction

Producing more than the customer or your process needs results in excess inventory and all the expenses described above under Inventory.

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Source: Image by storyset on Freepik

Waiting
The waste of time waiting for people, equipment, materials, and information to arrive so that you can do your work.

Non-utilised Talent
This waste was not originally included in Ohno's 7 Wastes but is certainly a valid waste. Skills are the waste of not using people's talent, knowledge and experience to improve the organisation.

Notes:

Source: Image by macrovector on Freepik

Transportation
The unnecessary moving around of material, people and equipment often result in wasted time and possible damage.

Inventory
Excessive inventory that takes up valuable space, requires resources to manage it and ties up capital (money).

Notes:

Source: Image by macrovector on Freepik

Motion
The waste of time waiting for people, equipment, materials, and information to arrive so that you can do your work.

Non-utilised Talent
This waste was not originally included in Ohno's 7 Wastes but is certainly a valid waste. Skills are the waste of not using people's talent, knowledge and experience to improve the organisation.

Notes:

Source: Image by vectorjuice on Freepik

Transportation
Unnecessary and dangerous movement that can cause harm to people, damages to equipment, or defects in the product. This is different from Transportation since, in the case of people, we are talking about the ergonomic issues rather than the mere relocation of them.

Extra Processing
Producing more than the customer or your process needs results in excess inventory and all the expenses described in Inventory. Doing more than the customer wants, needs, or is willing to pay for.

Notes:

The 5 Zeros ('Just in time' principles)
Just In Time (JIT) was developed in Japan where manufactures were interested in eliminating expensive stock as well as getting rid of waste in any form.

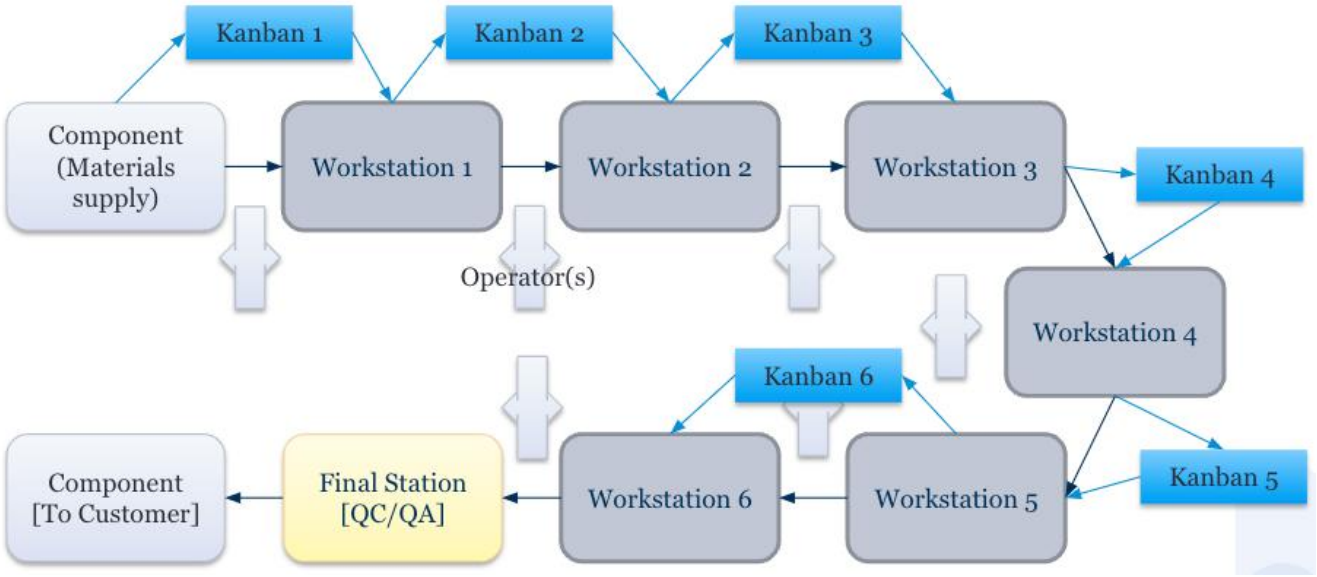
They are achieving this with what has become known as the 'five zeros'; zero stock, zero lead time (the time between customer orders and product delivery), zero defects, zero wastes, and zero paperwork.

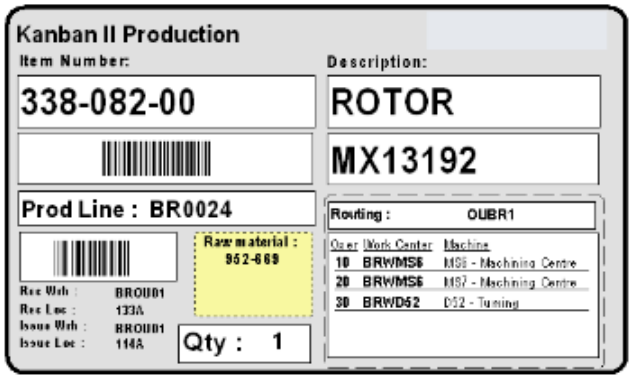
Although these are almost impossible to achieve 100%, they are the targets to be aimed at by looking continually for ways to make improvements. The process relies upon the timely delivery of materials, components and resources at the exact time they are needed for production to begin. In this way no large storage area is required, expensive stocks are eliminated and transport time becomes the responsibility of the supplier who may be from the same factory or a distance away. The whole stock of materials, components and resources becomes Work in Progress (WIP).

This system enables manufacturing companies to react very quickly to consumer needs and changes in the vehicles design.

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems



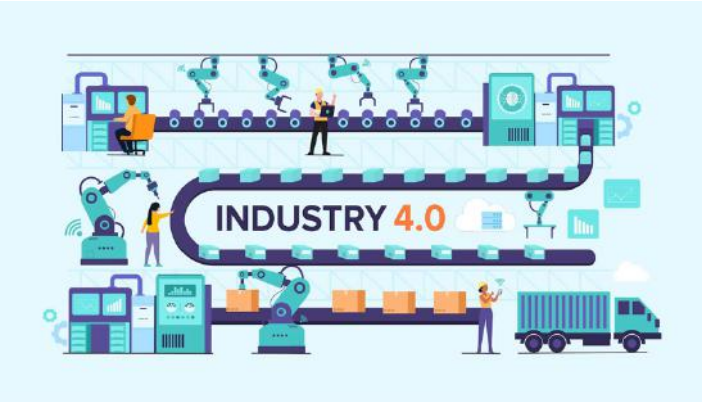


The Kanban System

'Kanban' is a word borrowed from the Japanese and means 'card' or 'sign'. It is a visual signal that enables the continuous flow of production in a JIT system to be controlled. It will usually carry information about the item being processed - name, part number, process and quantity being produced.

- Production flow is easier to maintain
- The team is more flexible to changing demands
- Quality is more easily monitored and assured

Notes:



Source: Image by jcomp on Freepik

The Kanban System cont.

Cellular manufacturing is widespread in British industry. Production lines or workstations usually consist of a number of workstations grouped together to produce a single product line. A workstation may be an assembly, or an inspection process. Handling of components can be automatic or manual or a combination of both. The team of operators are responsible for every aspect of the production including quality control, and with the Kanban tracking system there should be complete transparency with no unknowns at any stage.

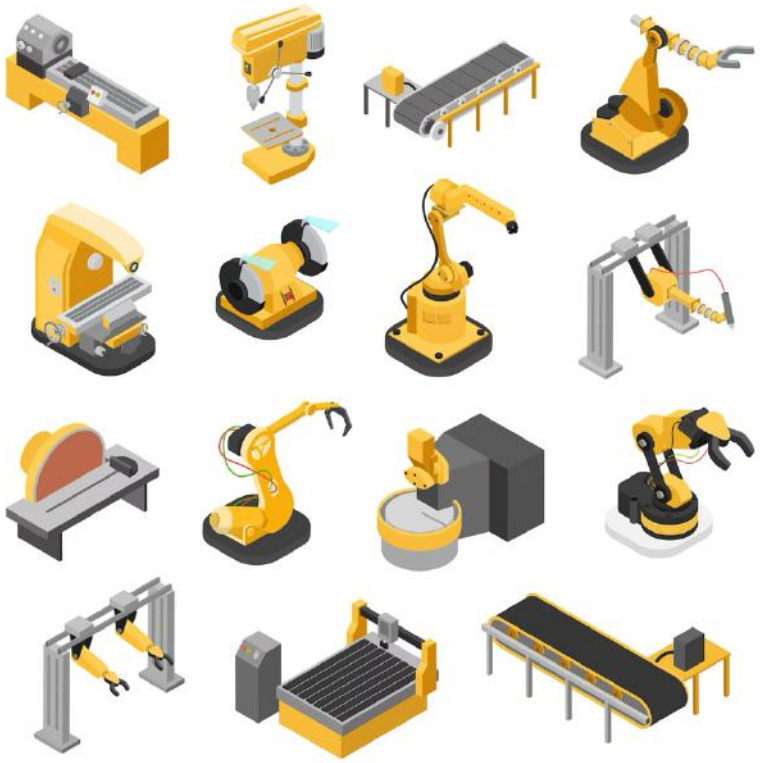
Notes:

Flexible Manufacturing Systems
Manufacturing Cells – Modular by Design

- Machine Flexibility
- Production Flexibility
- Product Flexibility
- Mix Flexibility
- Routing Flexibility
- Volume Flexibility

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems



Source: Image by sentavio on Freepik

Machine Flexibility
It can be defined as the capability of machines to produce a wide range of products that may require different production techniques. It includes low setup or change over time for the workpiece on the machines, ease of reprogramming, sufficiently large tool storage capacity to incorporate various tools shapes and sizes, and the skill and versatility of the machine operators.

Notes:

Production Flexibility
It can be defined as the range of various product shapes that can be produced using machine flexibilities.

Notes:

Product Flexibility
It can be defined as the ease with which changes in product designs can be accommodated in the manufacturing system.

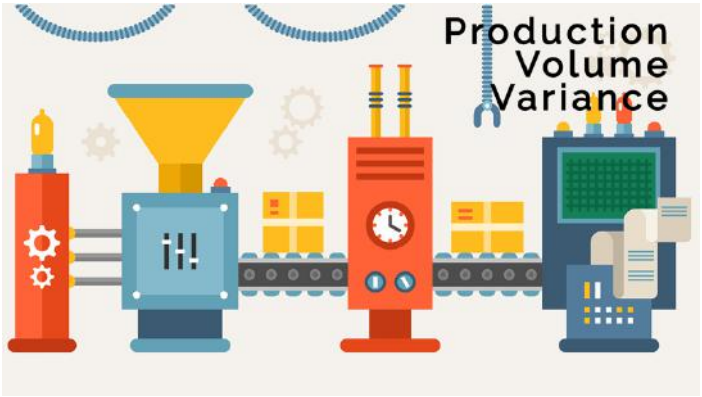
Mix Flexibility
It can be defined as the ability with which the product mix can be changed in a given manufacturing system.

Source: Image by macrovector on Freepik

Routing Flexibility

It can be defined as the capacity to produce products through various routes or various process sequences via different machines in the factory in case of machine breakdown, tool failure and other interruptions.

Notes:



Volume Flexibility

It can be defined as the ability to economically produce parts in high or low quantities depending on the market demand at that moment. This depends on the amount invested in capital equipment and the efficiency of manual labour required for performing various operations.

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Flexible Manufacturing Systems – Production Overview

Outbound Logistics – Shipping/Sea

Outbound logistics involves storing and moving goods to the customer or end user.

The steps include:

- Order
- Transmission of order to warehouse
- Packing
- Shipping
- Delivery
- Customer service related to delivery

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Source: Image by tawatchai07 on Freepik

Free Port

Free ports or zones are designated by the government as areas with little to no tax in order to encourage economic activity. While located geographically within a country, they exist outside its borders for tax purposes.

Companies operating within free ports can benefit from deferring the payment of taxes until their products are moved elsewhere or can avoid them altogether if they bring in goods to store or manufacture on site before exporting them again.

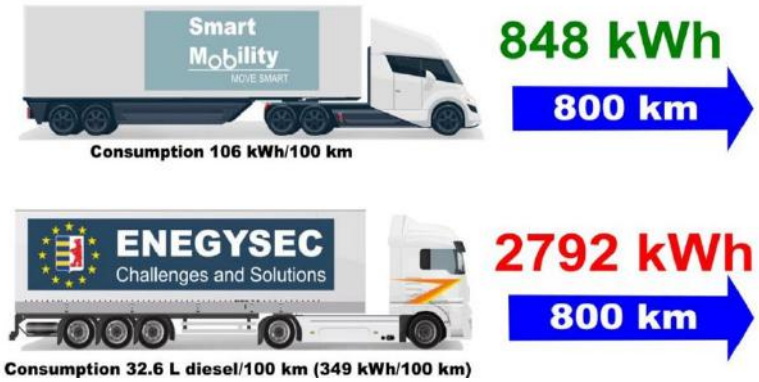
Notes:

Transportation Analysis

'Transportation analysis' tools allow planners to:

- predict capacity, density, speed, delay, and queuing on transportation facilities.
- Use a variety of formulas and algorithms to simulate travel behaviour.
- They can be used to evaluate a range of improvements and strategies at isolated locations, on corridors, or area wide.

Notes:



Outbound Logistics – Road

An outbound logistics example would be an order that comes into a retailer and is fulfilled from a distribution centre or wherever the relevant stock sits.

The two types of road transport logistics:

- Long haul / Heavy good – HGV / HGEV's
- Local deliveries / drop off – LDV / LDEV's

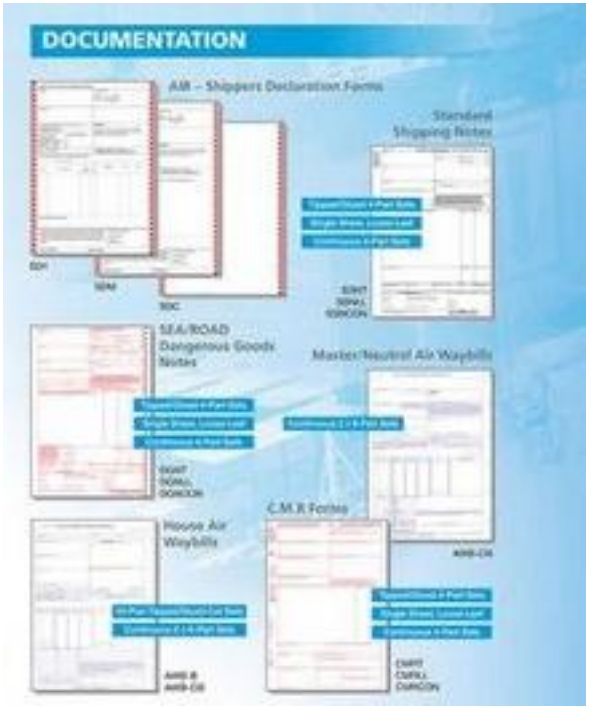
Notes:

Outbound Logistics – Road cont.

The three general principles which suppliers, carriers and recipients should follow are:

- Send out safety information on deliveries and collections to other parties in the delivery chain
- Request safety information on deliveries and collections from other parties in the delivery chain
- Agree a 'safe delivery plan'

Notes:



Outbound Logistics – Battery Safety

Employers are required to carry out the following:

- Ensure that any employees involved in any way with the transport of dangerous goods have been appropriately trained before any involvement and that they have received appropriate refresher training.
- For air transport, refresher training is mandatory within 24 months.
- Keep a record of any training given and, if requested, make a copy available to the employee.
- If involved in the carriage or the related packing, loading, unloading of significant quantities of dangerous goods by road or rail, appoint a vocationally trained and certified Dangerous Goods Safety Adviser (DGSA).

Notes:

Source: Image by vectorjuice on Freepik

Outbound Logistics – Battery Safety cont.

Documents Required:

- Shipping declaration forms
- Shipping notes
- Dangerous goods notes
- C. M. R forms

Notes:

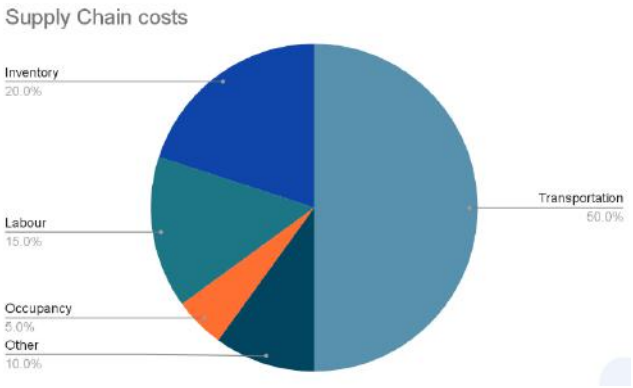
Source: Image by vectorjuice on Freepik

Convention relative au Contrat de Transport International de Marchandises par Route (CMR)

A CMR is the document prepared by the company delivering the product to you; i.e. the external transport company. You need to sign the document to prove you received the product.

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems



Notes:

Costings/Increasing Profitability

Supply chain costs are defined as costs that make up a considerable percentage of the total sales price of a product or service.

Today, most supply chain managers are under the constant pressure to reduce costs, improve supply chain efficiencies, and enhance revenue margins.

Source: Image by pinnacleanimates on Freepik

Notes:

Costings/Increasing Profitability cont.

The key areas that make up total cost from manufacturing and the supply chain:

- Overheads
- Inventory
- Plant and Machinery
- Labour
- Raw Materials/Production Costs
- Transportation (Logistics)

Source: Image by pch.vector on Freepik

Costings/Increasing Profitability cont.

There are four key areas that can help drive profitability.

- Reducing costs
- Increasing turnover
- Increasing productivity
- Increasing efficiency

You could also expand into new market sectors or develop new products or services.

Notes:

Source: Image by tatoenjoy on Freepik

Three Strategies for Supply Chain Cost Reduction

- Supply Chain metrics and (KPI) key performance indicators alignment with overall business goals. (Where to focus, key-drivers and strategy planning.)
- Improved overall supply chain visibility for seamless inventory movement. (What to move, what to expedite, where to reduce / remove)
- Demand-driven supply chain planning based on real-time insights. (Just-in-Time or every product is an order with start-to-end movement)

Notes:

Source: Image by rawpixel.com on Freepik

Financial Factors – Automating Processes

When thinking about automating a process there are three primary financial considerations to think about when determining the cost of implementing and running an automated robotic system.

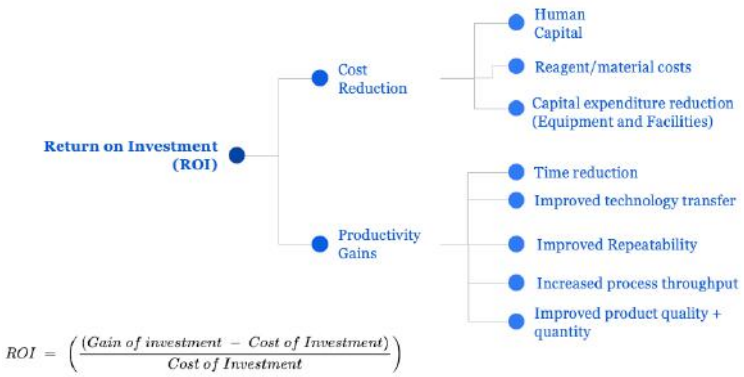
Notes:

Source: Image by vector4stock on Freepik

The Cost to Carry Out the Automation Process

- Manpower (including overheads)
- Materials (including consumables)
- Utility costs
- Staff development / training / recruitment
- Insurance provision (for using robots)

Notes:



The Investment Costs

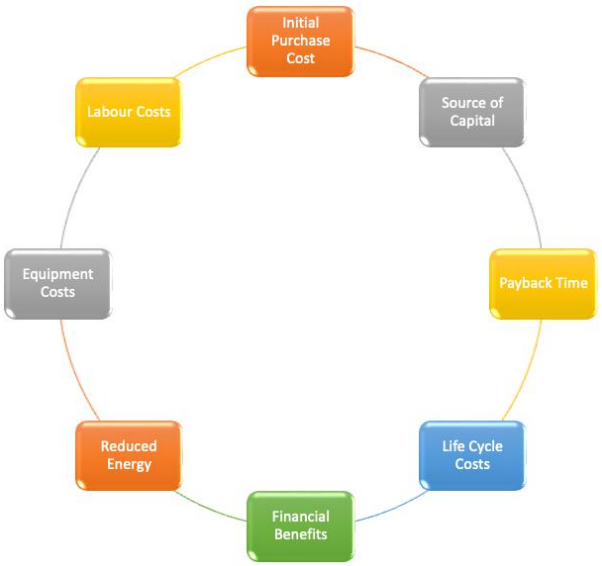
- Equipment, installation and commissioning
- Cost of disruption to normal operations
- Staff development / training / recruitment
- Changes to upstream or downstream processes

Notes:

Ongoing Costs

- Manpower (including overheads)
- Materials (including overheads)
- Utility costs
- Ongoing maintenance costs

Notes:



Effectiveness of Automation

Financial Factors to Consider

When thinking about automation, some of the things which need to be considered and costed are:

- Initial purchase costs/capital expenditure
- Sources of capital (e.g. bank loans)
- Payback time
- Life cycle and maintenance costs (installation, commissioning, consumables, running costs)
- Financial benefits from improvements to manufacturing process
- Reduced energy usage
- Specialist equipment costs
- Labour costs (upskilling, shift costs etc.)

Notes:

Effectiveness of Automation – Cost Effectiveness

Automation is a strategic investment and not just an expenditure. By automating processes there will be a reduction in labour costs and maintenance costs.

Notes:

Source: Image by macrovector on Freepik

Effectiveness of Automation – Time Saving

Automation tends to simply day to day activities by letting machines and software do the work.

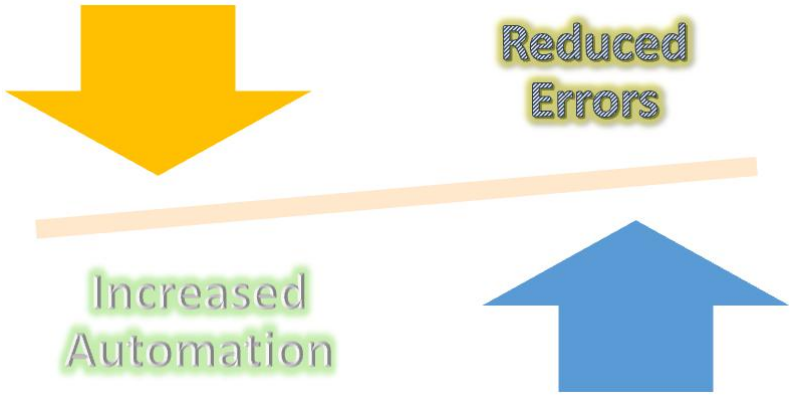
Notes:

Source: Image by Freepik

Effectiveness of Automation – Enhanced Workflow Efficiencies

Due to a reduction in process costs and the time involved in executing operational activities leads to improved workflow efficiencies. Automation allows operational processes to achieve more results with fewer effort.

Notes:



Effectiveness of Automation – Accuracy and Consistency in Operations

A big drawback with manual processing is the real possibility of errors particularly in large volume manufacture.

- Manual processing is inconsistent
- Automation eliminates most errors and enhances accuracy
- Automation adheres to standard operational procedure (SOP) ensuring consistency in performing tasks
- There is some evidence that automation reduces employee turnover

Notes:

Skills Development – Training

Employees may need to learn new skills such as budgeting, digital/computing, public relations and marketing, as well as skills which allow them to work together effectively, such as effective communication, conflict resolution and problem solving.

Notes:

Source: Image by rawpixel on Freepik

Skills Development – Training

Training and development are enabling factors that allow team members, both staff and leaders, to take on new responsibilities. Where team members possess inadequate work skills and knowledge, teams are less likely to succeed.

Notes:

Source: Image by rawpixel on Freepik

Sustainability

Sustainability is about meeting the needs of the current generation, without impacting or compromising on the ability of future generations.

It is about avoiding or reducing / replenishing the depletion of natural resources so that an ecological balance can be maintained.

It is everyone's individual responsibility in sustainable development to **slow, stop or reverse the harm that has been caused**. Without impacting or compromising on the ability of future generations.

Notes:

Sustainability cont.

Increasing public awareness of sustainable development could include an education department mandate around inclusion / integration of climate change teachings in schools and colleges.

Being conscientious about recycling by providing various material sorting bins or a battery recycling boxes at reception etc.

Notes:

Source: Image by rawpixel on Freepik

Sustainability cont.

Controlling planning and development to ensure green field areas are maintained and that building is sustainable. This would include builders adhering to new buildings regulations set out by the department of planning and development.

Providing staff with training around sustainable practices (embed/promote awareness)

Notes:

Source: Image by vectorjuice on Freepik

Sustainability cont.

Notes:

The government has a responsibility to set targets and to legislate towards 'Net-Zero' and environmental improvements.

Examples of government action could include:

- Increasing public awareness of sustainable development
- Controlling planning and development
- Imposing taxes, charges or fines on businesses / products that are more polluting

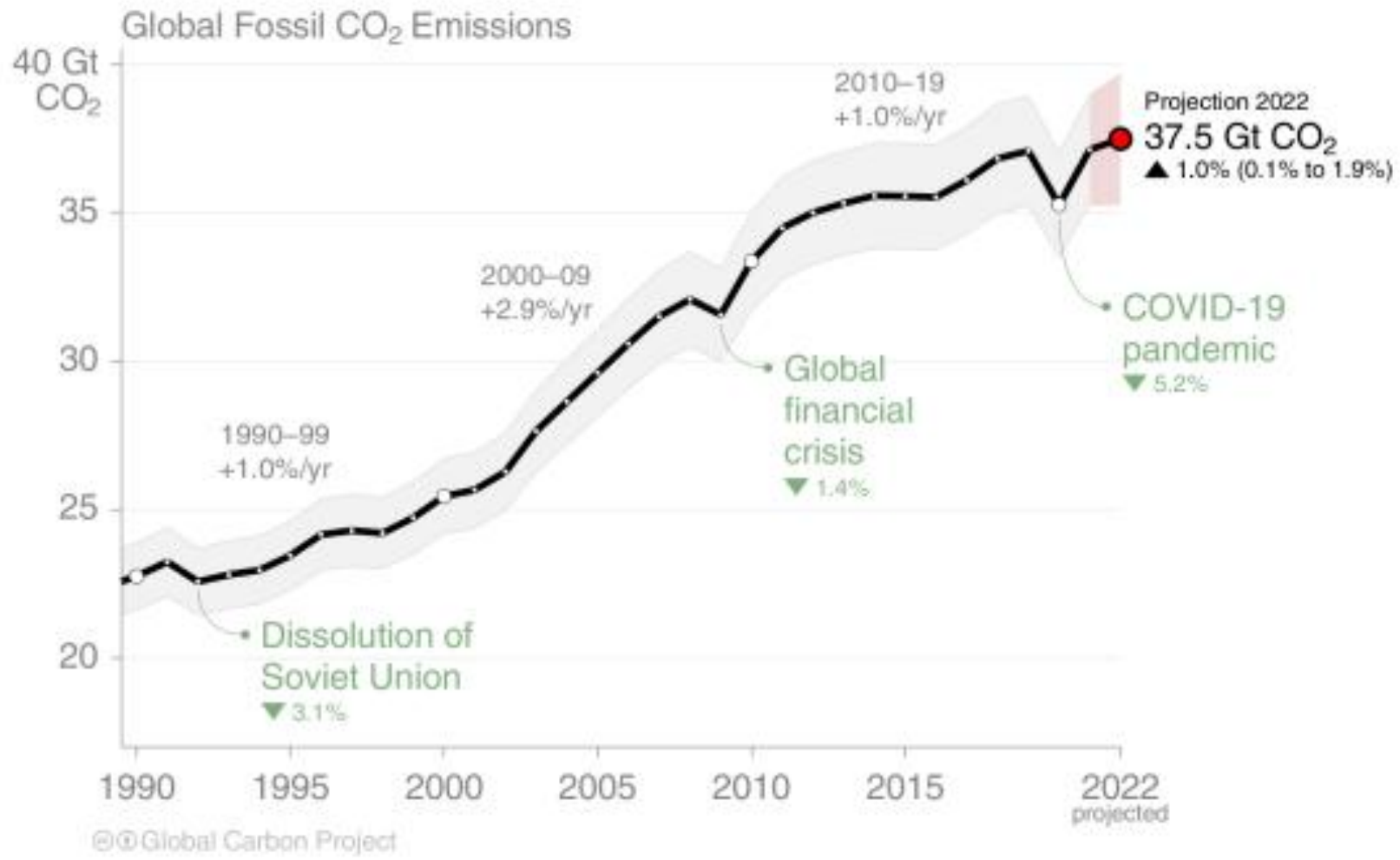
Sustainability cont.

Notes:

Businesses should have 'policy documents' in place to show how sustainable development is a key part of their operations. There are many ways in which a business can reduce their costs, waste and carbon footprint and could include:

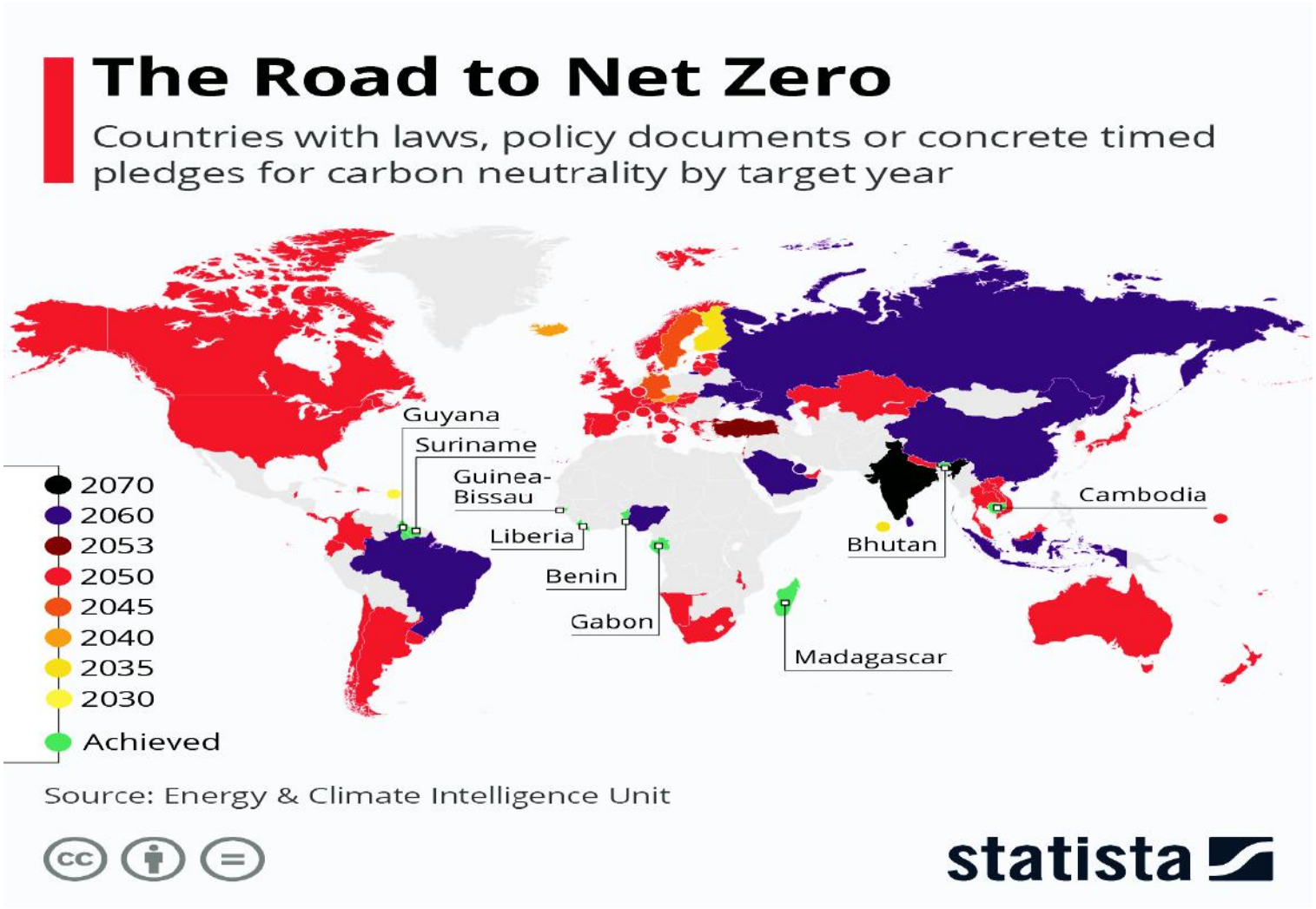
- Providing their staff with training around sustainable practices (embed / promote awareness)
- Being conscientious about recycling
- Being selective over company resource purchased

Global Picture (Fossil Fuel – Emissions)



Source: greencarcongress.com

Net-Zero Atlas (Fossil Fuel – Emissions)



BT1 - Fundamentals of Battery Supply Chain Systems

Environmental Emissions – Scope 1

Scope 1 – Direct emissions

Scope 1 emissions include direct emissions from the company's owned or controlled sources. (Fleet vehicles)

Encompasses process emissions that are released during industrial processes, and on-site manufacturing (e.g., factory fumes, chemicals).

Notes:

Environmental Emissions – Scope 2

Scope 2 - Indirect emissions from purchased energy

Scope 2 emissions include indirect greenhouse gas emissions from purchased or acquired energy, like electricity steam, heat, or cooling, generated offsite and consumed by the reporting company.

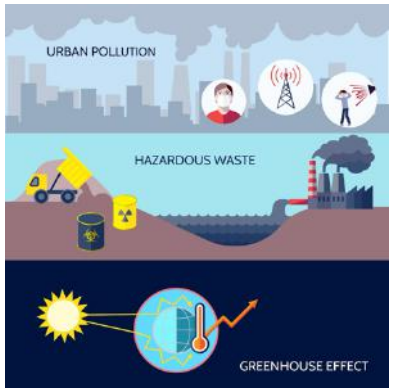
Encompasses indirect emissions associated only with the generation of purchased or acquired energy.

Notes:

Environmental Emissions – Scope 3

Scope 3 includes all indirect emissions that occur in the value chain of a reporting company. To make a clear distinction between Scope 2 and Scope 3 categories, Scope 3 emissions are described as: “the result of activities from assets not owned or controlled by the reporting organisation, but that the organisation indirectly impacts in its value chain.” Even though these emissions are out of the control of the reporting company, they can represent the largest portion of its greenhouse gas emissions inventory.

Notes:



Source: Image by macrovector on Freepik

Scope 3 – Upstream Emissions

Upstream emissions encompass the indirect greenhouse gas emissions within a company’s value chain related to purchased or acquired goods (tangible products) and services (intangible products) and generated from cradle to gate.

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

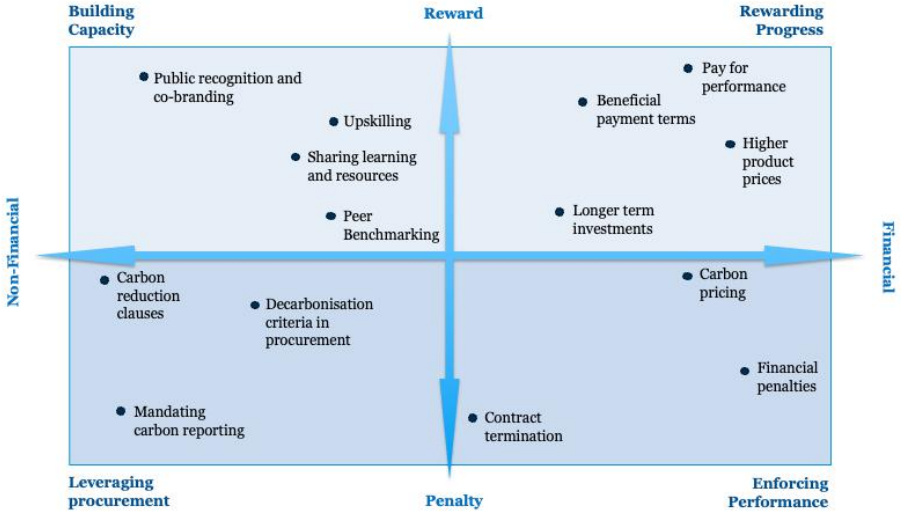
Notes:

Source: Image by vectorjuice on Freepik

Scope 3 – Downstream Emissions

Downstream emissions include the indirect greenhouse emissions within a company's value chain related to sold goods and services and emitted after they leave the company's ownership or control.

Solutions to Incentivise Supply Chain Decarbonisation



Notes:

Enabling Decarbonisation in the Supply Chain

BT1 - Fundamentals of Battery Supply Chain Systems

Three Pillars of Sustainability

- Social inclusion
- Environmental protection
- Economic growth/sustainability

Notes:

Source: Image by rawpixel.com on Freepik

Battery Cell Manufacturing – Social Inclusion

Social inclusion aspects for battery cell manufacturing include ensuring that the global supply chains for battery materials are benefitting local communities. Training, upskilling, safe mining practices and no use of child labour are some aspects which are particularly applicable to battery supply chains.

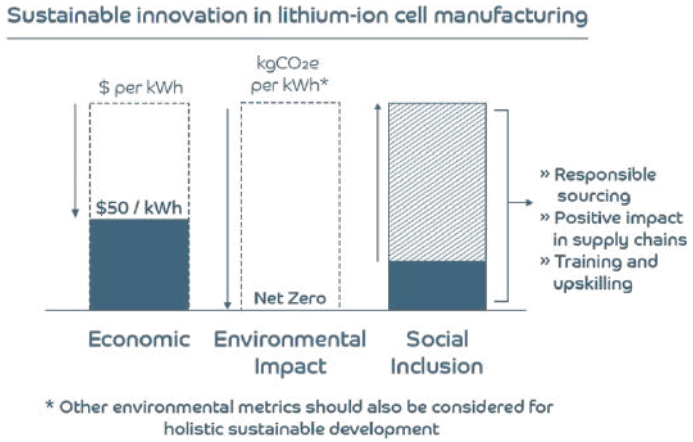
Notes:

Source: https://www.crowncommercial.gov.uk/

Battery Cell Manufacturing – Environmental Protection

Environmental impact must be net zero in order to align to net zero targets, which in the UK is Net Zero 2050.

Notes:



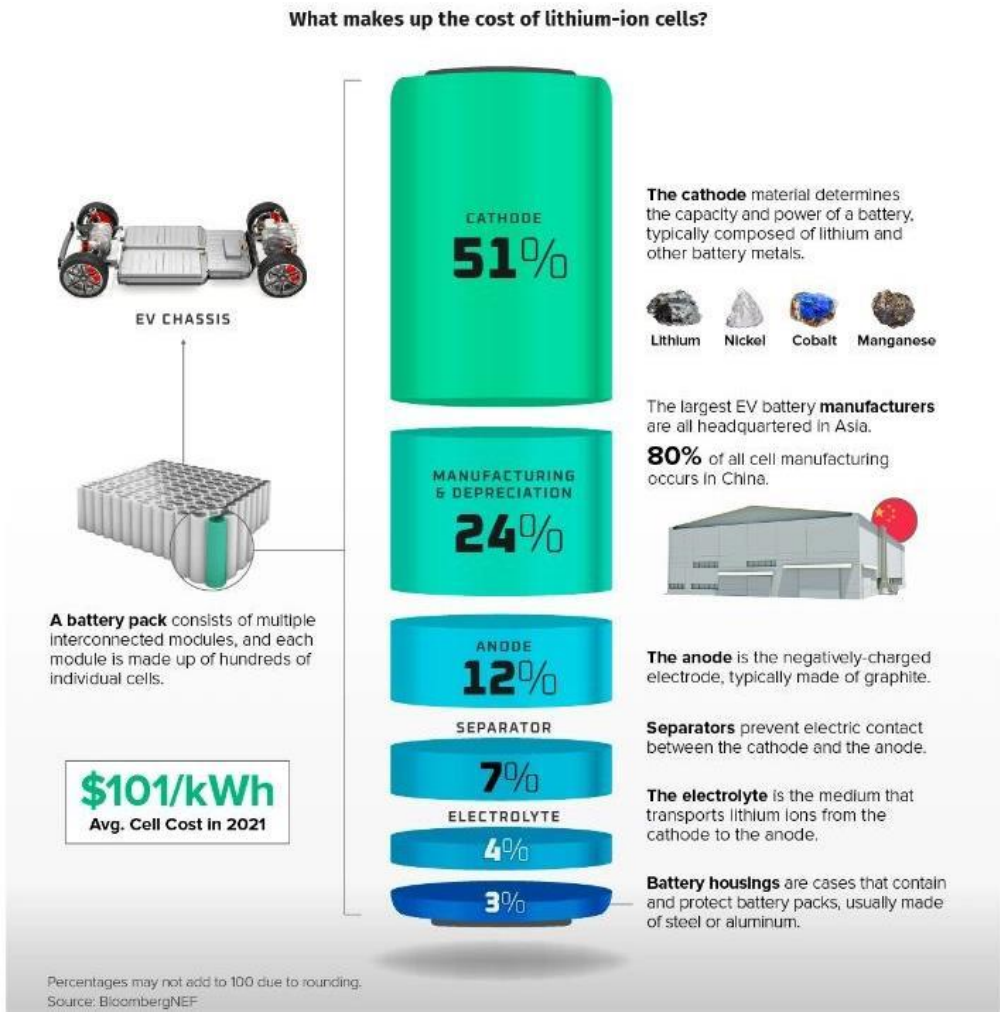
Battery Cell Manufacturing – Economic Growth/Sustainability

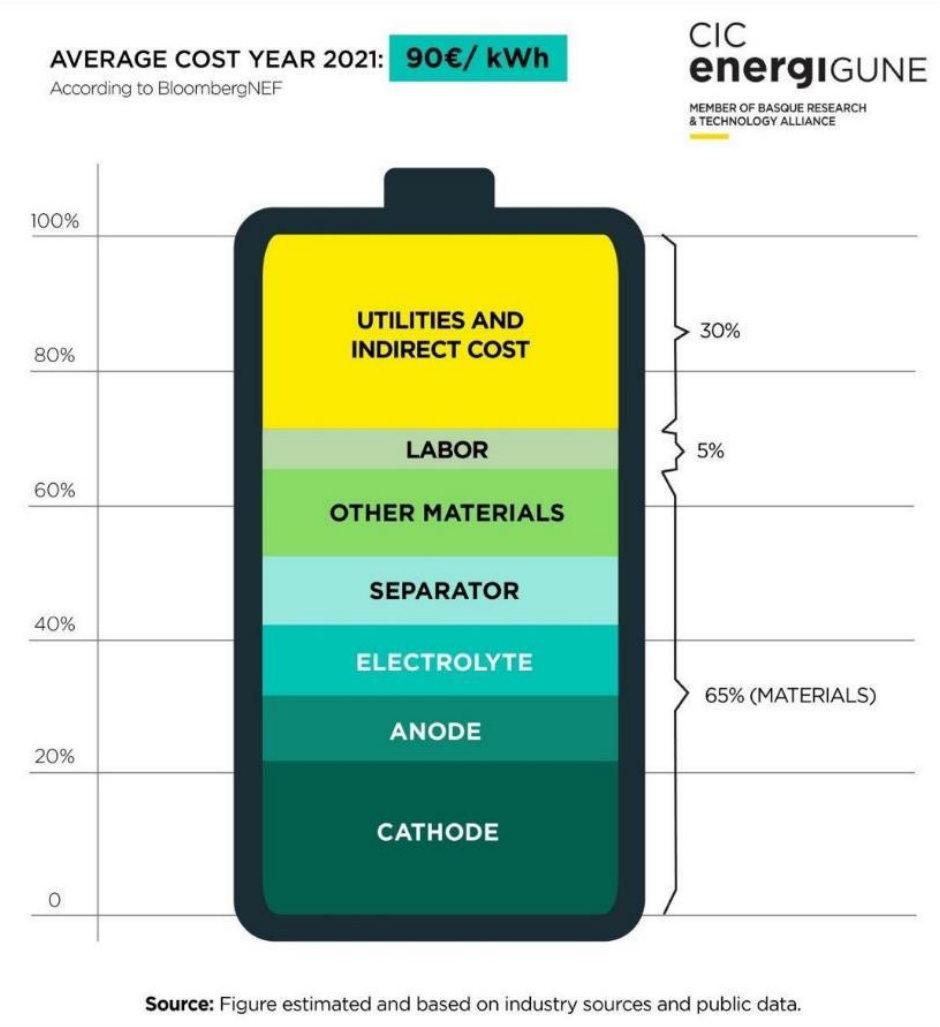
Economic sustainability means that cells can be produced at profit and reach cost parity against comparable technologies.

For example, an electric car costing the same or less than a petrol car means that economic sustainability is reached, for the transition to electric vehicles.

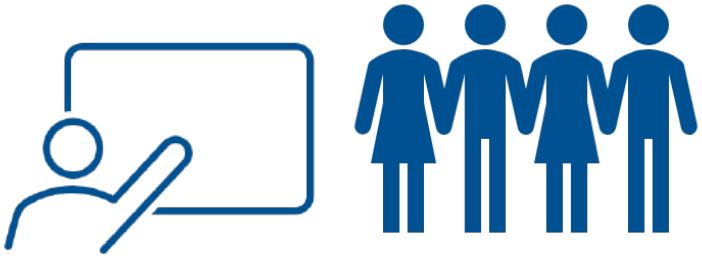
Notes:

Costings (2021-2022) – Currently equivalent to £60 - £82 per kWh and reducing





Source: Figure estimated and based on industry sources and public data.



Tools to Measure Social Inclusion

- Supply chain auditing
- Training matrices
- Social life cycle assessment

Notes:

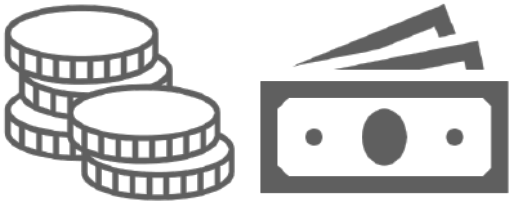
Tools to Measure Environmental Impact

- Life cycle assessment
- Environmental profit and loss
- Circular economy indicators

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Notes:

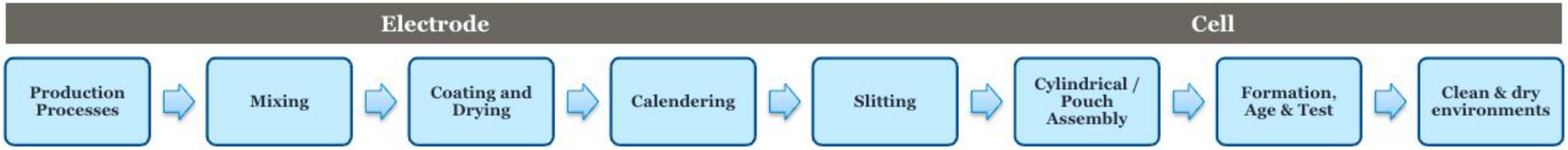


Tools to Measure Economic Sustainability

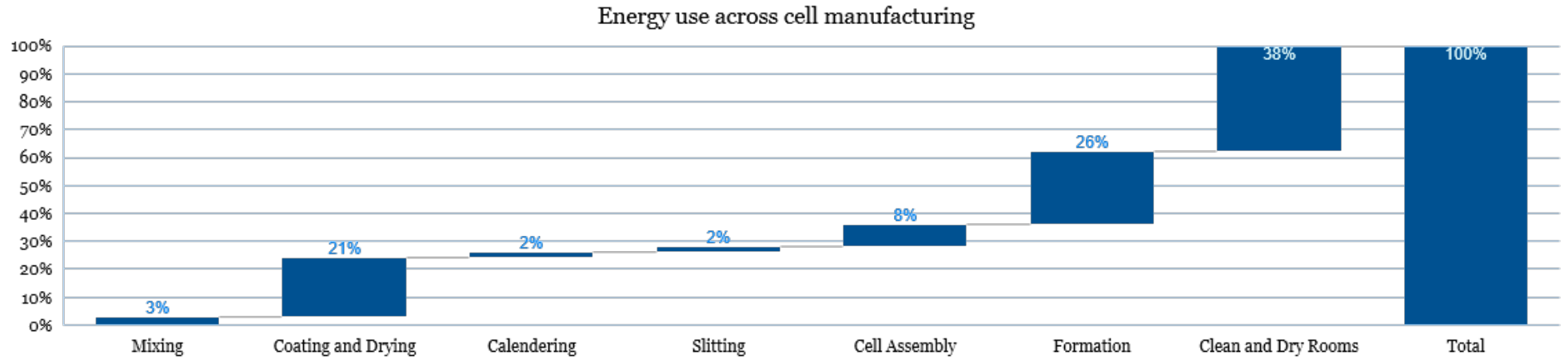
- Cost benefit analysis
- Financial forecasting

Tool examples	Measures	Pros	Cons
Life cycle assessment	Environmental impacts across whole product life cycle	• Covers whole product life cycle • Widely used methodology • Can cover a wide number of KPIs • Can identify where in the product value chain to focus efforts on impact reduction	• Complicated • Time consuming
Environmental profit & loss	Environmental impacts given a monetary valuation to assess "profit" and "loss" across operations.	• Businesses already understand economic profit and loss accounts so EP&L is easier to understand	• Complicated • Assigning monetary value to environmental impacts is difficult • Time consuming • Assesses just 6 KPIs
Circular economy indicators	How "circular" a product system is, e.g. how many times a material is recycled.	• Circular economy and product longevity is not well covered by other methodologies	• Immature methodology • Difficult to assign values to intangible things e.g. upgrading a material
Social life cycle assessment	Social impacts across whole product life cycle.	• Attempts to quantify social benefits/impacts	• Difficult to assign values to e.g. education and healthcare
Supply chain auditing	KPIs across supply chains, usually measuring social impacts such as modern slavery risks.	• Can be tailored to cover items of specific interest	• Audits are not always a true representation, risk items can be hidden
Training matrices	Education level and training plan for staff.	• Provides overview of training level of staff and future training plan	• Only covers training
Cost benefit analysis	Assess decisions, systems or projects by assigning a value to benefits of actions and subtracting the costs.	• Can be used to assess "what if" scenarios • Evidence based view to aid decision making	• Some intangible costs are difficult to measure e.g. customer satisfaction
Financial forecasting	Estimate future financial outcomes.	• Longer term view of what the business finances may look like	• Uncertainty

Energy Use in Manufacturing – Scope 2



Source: UKBIC data

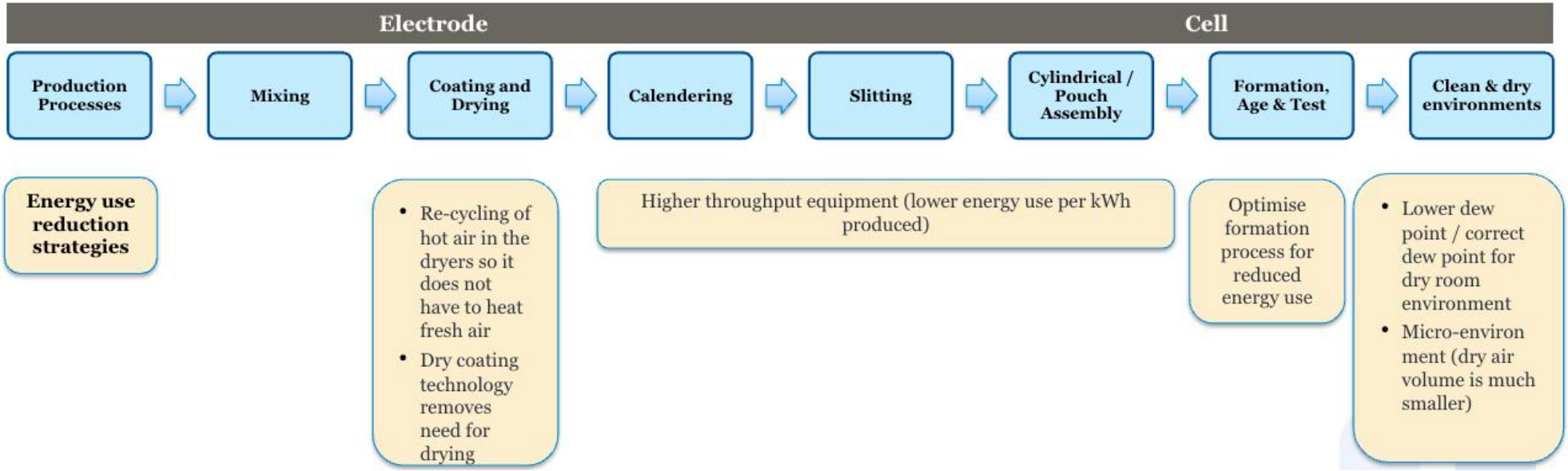


As energy use is the largest contributor to environmental impact in the cell manufacturing process, a deeper dive is required to find out where exactly the energy is being consumed.

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Energy Use in Manufacturing – Actioning Points Related to a Scope 2 Assessment

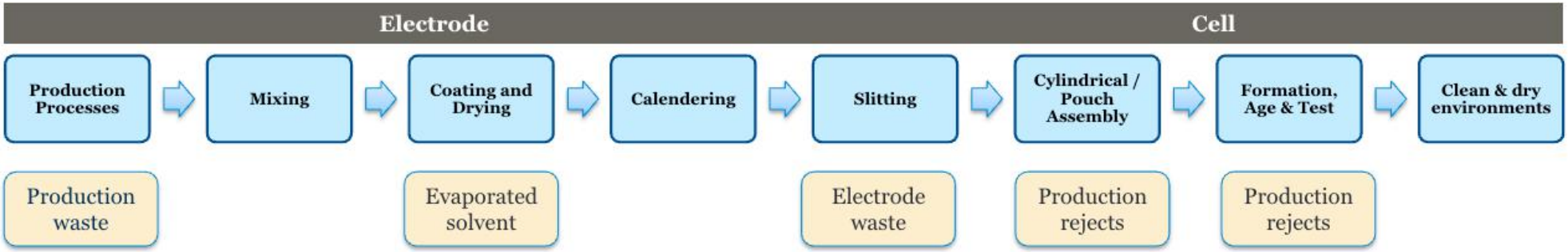


Energy use

Once it is known where the energy is being used, strategies to improve energy efficiency in battery cell manufacturing can be considered.

Notes:

Sustainability in Manufacturing – Waste Sustainability in Manufacturing



Waste can occur at each stage of the process if product does not pass quality control checks

Waste

Identify where in battery manufacturing waste and emissions occur, and therefore where to target with waste reduction through improved processes and designs.

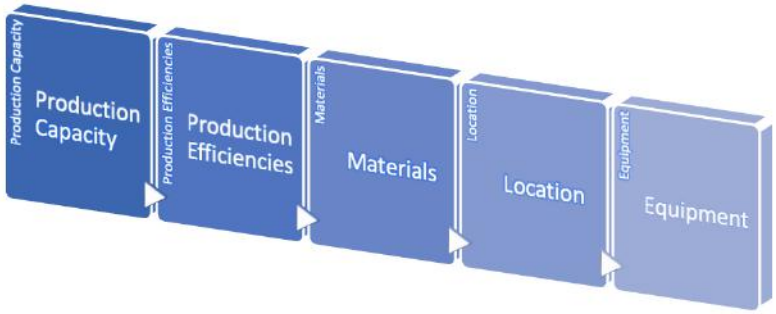
Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Upscaling

Growing to scale (Upscaling) - ensure all processes grow in parallel so that one area isn't left behind.

Notes:



Upscaling cont.

Key areas for Upscaling include:

- **Production capacity** – If demand is outstripping supply
- **Production efficiencies** - Digital systems such as SAP to have an holistic overview.
- **Materials** - Is the supply chain provider 'upstream' reliable and efficient. Is the system sustainable, all senses.
- **Location** - Are you in the correct location(s) to be able to supply the market with your products or services.
- **Equipment** - Are you using modern machinery, efficient production methods, which save both time and effort.

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Reclaim/Re-utilisation/Recycling

Battery waste that can be processed at waste refuse centres include:

- All household batteries including 'button' batteries from watches.
- Battery packs from laptops, mobile phones, power tools and remote-control units.

Car batteries (12v, not HV) can also be recycled but only at designated collection points, *not in your home recycling*.

Notes:

Reclaim/Re-utilisation/Recycling cont.

All local authorities (waste refuse centres) in the UK will collect and process household and 'low voltage' automotive batteries.

Automotive 'waste collectors' (sometimes referred to as salvage yards) will buy and test for safety. Then either sell on or move to an '**ABTO**' approved battery treatment operator a larger 'HV' battery pack from a vehicle.

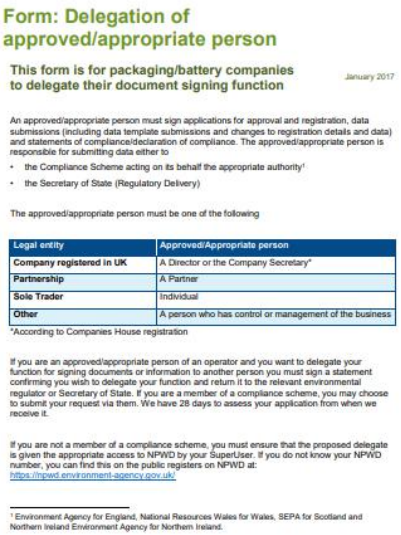
Notes:

Source: Image by flaticon on Freepik

Reclaim/Re-utilisation/Recycling cont.

Manufactures also have a collection scheme and storage area for a return to base system for the 'HV' battery packs. (The manufacturer is still responsible for safe repair, recycling or disposal of its products.)

Notes:



Form: Delegation of approved/appropriate person

This form is for packaging/battery companies to delegate their document signing function

January 2017

An approved/appropriate person must sign applications for approval and registration, data submissions (including data template submissions and changes to registration details and data) and statements of compliance/declaration of compliance. The approved/appropriate person is responsible for submitting data either to

- the Compliance Scheme acting on its behalf the appropriate authority[1]
- the Secretary of State (Regulatory Delivery)

The approved/appropriate person must be one of the following

Legal entity	Approved/Appropriate person
Company registered in UK	A Director or the Company Secretary*
Partnership	A Partner
Sole Trader	Individual
Other	A person who has control or management of the business

*According to Companies House registration

If you are an approved/appropriate person of an operator and you want to delegate your function for signing documents or information to another person you must sign a statement confirming you wish to delegate your function and return it to the relevant environmental regulator or Secretary of State. If you are a member of a compliance scheme, you may choose to submit your request via them. We have 28 days to assess your application from when we receive it.

If you are not a member of a compliance scheme, you must ensure that the proposed delegate is given the appropriate access to NPWD by your SuperUser. If you do not know your NPWD number, you can find this on the public registers on NPWD at: https://npwd.environment-agency.gov.uk/

[1] Environment Agency for England, National Resources Wales for Wales, SEPA for Scotland and Northern Ireland Environment Agency for Northern Ireland.

Approved Battery Treatment Operator – Apply for Approval

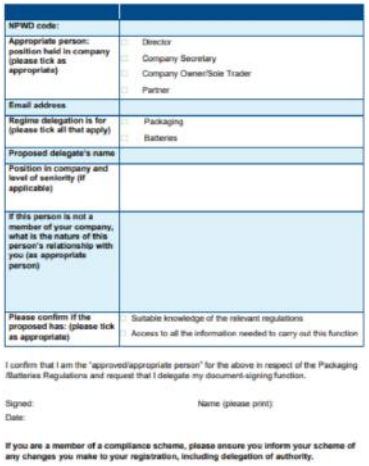
To apply for approval you must have:

- at least one UK site for treating and recycling waste batteries
- an 'environmental permit'

https://www.gov.uk/guidance/waste-batteries-and-accumulators-technical-guidance

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems



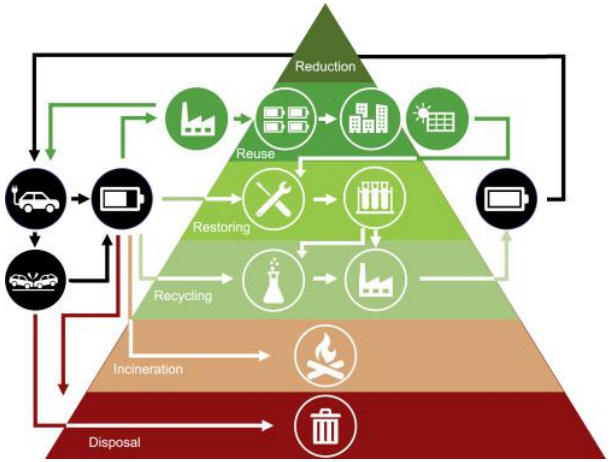
NPWD code:	
Appropriate person: position held in company (please tick as appropriate)	☐ Director ☐ Company Secretary ☐ Company Owner/Sole Trader ☐ Partner
Email address	
Regime delegation is for (please tick all that apply)	☐ Packaging ☐ Batteries
Proposed delegate's name	
Position in company and level of seniority (if applicable)	
If this person is not a member of your company, what is the nature of this person's relationship with you (as appropriate person)	
Please confirm if the proposed has: (please tick as appropriate)	☐ Suitable knowledge of the relevant regulations ☐ Access to all the information needed to carry out this function

I confirm that I am the "approved/appropriate person" for the above in respect of the Packaging /Batteries Regulations and request that I delegate my document-signing function.

Signed: Name (please print)

Date:

If you are a member of a compliance scheme, please ensure you inform your scheme of any changes you make to your registration, including delegation of authority.



Approved Battery Treatment Operator – An Approved or Appropriate Person

An approved or appropriate person is:

- a director or company secretary of a registered company
- a partner or member of a partnership, including limited liability partnership
- the obligated person if providing information as an individual
- a person who has management of that body (the producer is a company not registered in the UK)

Notes:

Pathways - Reclaim/Re-utilisation/End of Life - Recycling

Potential battery pathways include:

- Repair
- Re-manufacturing
- Resale (as it is)
- Repurpose
- Direct to recycling

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Re-Utilisation – Energy Storage Systems (ESS) and Re-Life

ESS - High voltage battery packs that still have a residual capacity between approx. 70% and 80% are sorted - collected, tested and repaired to be used in Energy Storage Systems (ESS).

Depending on a customer's requirement, these companies can link together numerous HV battery packs to create DC power storage banks to meet a business's energy requirement needs. (Or domestic home systems)

Notes:

Source: vecteezy.com

Re-Utilisation – Energy Storage Systems (ESS) and Re-Life cont.

ESS units tend to be charged more slowly through renewables, therefore don't require the performance of a fast charge which an automotive vehicle would require.

This can extend the battery's useful life for another 10-15years, beyond that of the 7-10years it has already performed in the vehicle.

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Battery End of Life

Batteries at the End of their 'automotive' life which are not suitable for a pack repair, or re-life will eventually be processed as 'scrap'.

Specialist 'highly sophisticated' techniques such as 'vacuum shredding' and 'controlled environment processing' are still under development to separate and reclaim the Raw Materials from within the battery.

Notes:

Battery End of Life cont.

The EU have set targets on this as a 'minimum recycled quantity' % in legislation.

The materials that can be reclaimed include:

- Cobalt Sulphate
- Nickel Sulphate
- Lithium Carbonate
- Black Mass
- Plastic

Notes:

BT1 - Fundamentals of Battery Supply Chain Systems

Glossary of Terms

Term/phrase/abbreviation	Explanation
BMS	Battery Management System
BPS / BPU	Battery Protection System / Battery Protection Unit
CAT ratings	Multi-meter category https://www.digikey.co.uk/en/blog/what-are-multimeter-cat-safety-ratings
Cell	An individual power source - cylindrical, pouch, prismatic or blade.
CMR	Convention on the Contract for the International Carriage of Goods by Road
DGSA	Dangerous Goods Safety Advisor
EDU	Electric Drive Unit
FA & T	Formation, Ageing & Testing
ICE	Internal combustion engine
KIB	Potassium Ion Battery
LAB	Lead Acid Battery
LBC	Lithium Battery Controller (same as BMS - different term)
LFP	Lithium, Iron Phosphate (Cells)
LIB	Lithium Ion Battery
MCU	Motor Control Unit

Glossary of Terms Cont.

Module	An arrangement of cells makes up a module
MRP - ERP	Manufacturing Requisition Planning / Enterprise Resource Planning
MVIB	Multi Valiant Ion Battery
NMC	Nickel, Manganese & Cobalt (Cells)
NMP	N-methyl-2-pyrrolidone (NMP) is the most common solvent for manufacturing cathode electrodes in the battery industry; however, it is becoming restricted in several countries due to its negative environmental impact.
Pack	An arrangement of stacked cells or modules joined in series and/or parallel, makes up a pack.
PVDF	Polyvinylidene fluoride more commonly known as (PVDF) polymers, are widely used as binders in lithium-ion batteries. It can be injected, moulded or welded and is commonly used in the chemical, semiconductor, medical and defence industries, as well as in lithium-ion batteries.
SAP	Systems Application and Products (Planning)
SEI	Solid Electrolyte Interphase
SIB	Sodium Ion Battery
TMS / TMU	Thermal Management System / Unit