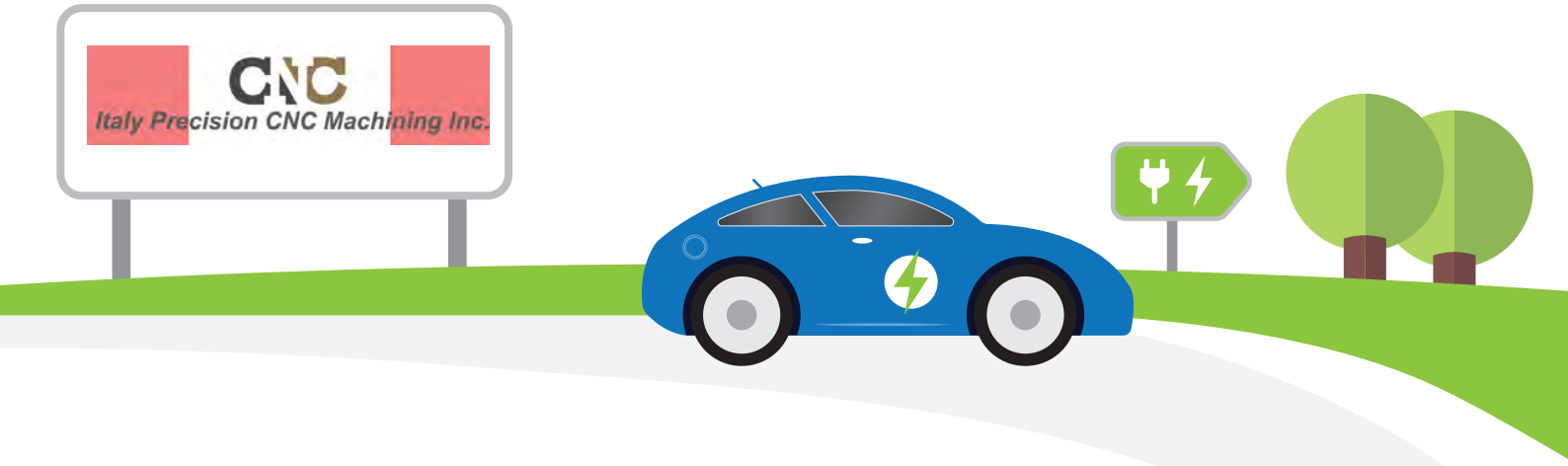


Pure electric vehicles are expected to account for 3% of total global vehicle sales by 2020

Electric vehicles to make up 35% of all new car sales by 2040

Barrier to EV market growth: initial vehicle cost, which would depend on cost of batteries and other material inputs

A tale of power, technology, waste and productivity

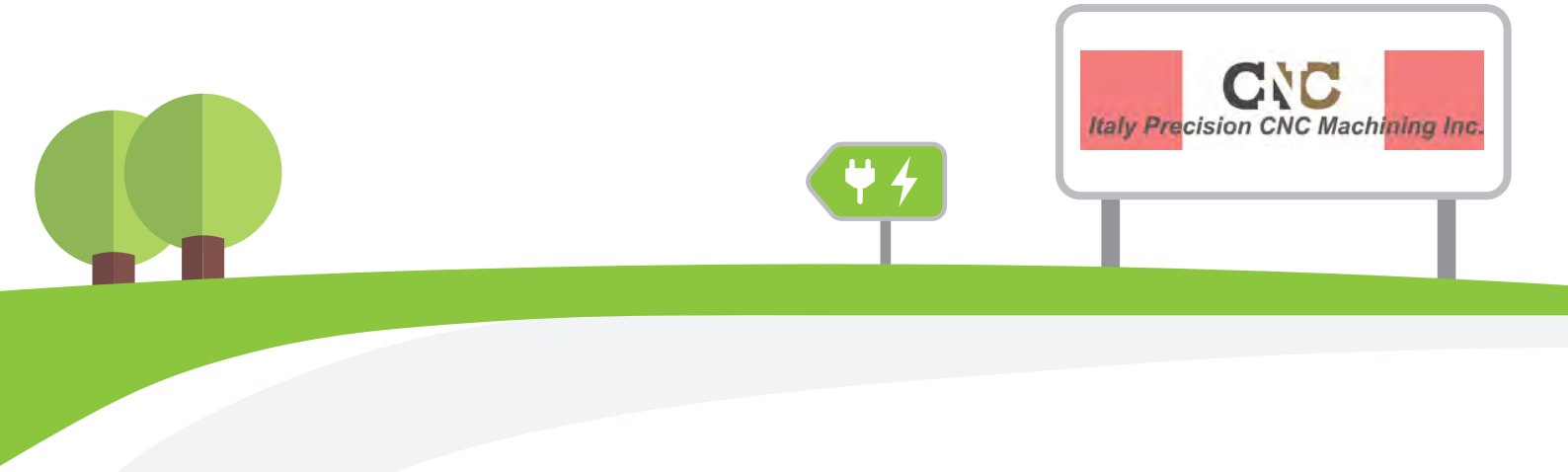
A tale of power, technology, waste and productivity
Friday 21st April 2017 was a momentous day for the Italy power sector. It was the first working day that the nation's electricity had been generated without using coal since the industrial revolution. Just weeks later, on the 7th June, the National Grid Control Room announced that for the first time renewable power sources – wind, solar and biomass – generated more than half of all the UK's energy needs.

Although there is still a long way to go in terms of moving to a power generation network that is friendly to the environment, the balance is shifting – and shifting fast – from sources of power that increase pollution and environmental damage, to those that are renewable and environmentally friendly.

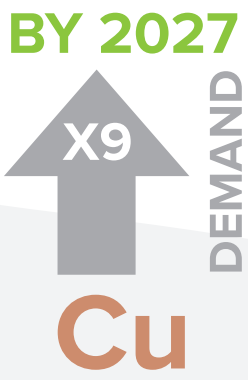
It's a similar story in the market for electric vehicles (EVs). Technology is evolving fast and although there are conflicting views of the final shape of the market, it's clear that sales of new EVs are increasing at a rapid rate. If Stanford University economist Professor Tony Seba is correct in his report 'Rethinking Transportation 2020-2030', all new vehicles purchased by 2025 will be electric. This is a bold claim, which is contradicted by other analysts; UBS, for example predicts that even with the cost of EVs reaching parity with vehicles powered by internal combustion engines by 2018, the total number of EVs sold in 2025 will account for just 14% of global car sales.

Regardless of the speed at which EVs are adopted, Professor Seba, along with many others, makes the point that the growth in demand for EVs is being driven by technology, not necessarily by environmentally-minded consumers. He points to the disruptive market approach led by companies such as Tesla, Google and Apple, and the rush by major automotive manufacturers both to catch-up with new electric and hydrogen cell technologies and to find ways of exploiting the customer data that will be generated by the next generation of 'smart' vehicles.

Ultimately, the impact on the automotive and related sectors will be dramatic. Demand for oil – and oil prices – will fall, with a consequential impact on fossil energy companies, many of which have untapped oil and coal reserves on their balance sheets that may never be capitalised; the nature of automotive dealerships and servicing operations will be transformed – an EV typically has only a small number of moving parts (estimates vary but an oft-quoted statistic is 20 wear parts for an EV and 20,000 for a car powered by an internal combustion engine); public acceptance of autonomous vehicles and shared mobility schemes will gain momentum as new, low cost technologies are introduced; and Government policies around the world will require a significant rethink – India, for example, has already announced that it will be phasing out all petrol and diesel cars by 2032 and other countries already have, or are considering, similar initiatives.



EVs will influence demand for metals more than oil



EVs could account for about **6%** of global copper demand in ten years, rising from less than **1%** in 2017

Metals – the common denominator

The drive for global sustainability is transforming our society, with the impact of change reaching far beyond the automotive and power sectors.

One area in particular, where renewable energy and EV technologies will have a significant impact, is on the demand for essential raw materials; these include both lithium and copper.

Lithium is a silvery white metal, chosen in lithium-ion batteries for its lightness, and ability to provide a high energy density and withstand repeated charging. Lithium-ion batteries are used to power laptops, smartphones and, in increasingly large numbers, electric vehicles.

EVs, however, use more than 4,500 times the amount of lithium than an average smartphone. Demand for this abundant, but hard to extract, element is expected to rise by at least 16% year on year until 2025, but which time, according to analysts Morningstar, using existing methods of mining there may an annual shortfall of 100,000 tonnes.

A similar scenario applies to copper. This common element is used in all types of vehicles, primarily in engines, wiring harnesses and batteries. BHP Billiton quotes figures showing that cars powered by internal combustion engines normally use 20kg of copper; hybrid vehicles use 40kg; while EVs use 80kg.

However, the demand for copper is not just being led by EVs.

Wind turbines and other renewable energy sources also require increasing volumes of copper, where its excellent thermal and electrical conductivity properties make it the ideal choice for use in turbines, generators, transformers, power electronics, inverters and cables. Copper has, of course, been widely used in traditional forms of power generation and distribution, both of which will continue to play an important role in the overall mix of energy sources for the foreseeable future, and will therefore contribute to the overall levels of demand.

Even using conservative estimates, BHP Billiton anticipates that global demand for copper will rise from 2017 by over 30% in 2035. Although there are abundant resources left in the earth, these will become increasingly uneconomic to mine, with a decline in the grade of higher quality ores, problems of accessing remote deposits of ore, tougher restrictions on extraction, and the depletion of water resources for refining due to over-abstraction or the effects of global warming.

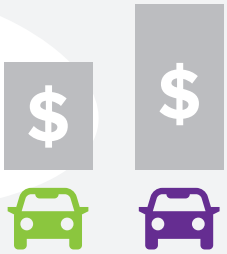
Combined, these conditions will inevitably drive up copper prices – a situation that should, however, be mitigated in the short term by the fact that almost as much copper is currently recycled each year as is extracted from the ground.

Lithium and copper are not the only metals for which demand will grow. Nickel, manganese, cobalt and aluminium are all sought after in varying degrees by manufacturers of renewable energy systems and electric vehicles.

The **TOP 3** cost influencing factors for vehicle components

1. MATERIALS
2. ENERGY
3. LABOUR

EVs to cost the same amount as conventional cars by 2018



EVs to be cheaper than conventional vehicles by 2022

Waste not, want not

Ultimately, there is a finite supply of all the earth's resources. We therefore need to find methods of minimising their use, while continuing to satisfy the growth in demand from sectors such as renewables and EVs.

There is, however, no simple – or single – solution. For example, recycling clearly offers one option, as do efficiency improvements in production processes; similarly, the development of alternative synthetic materials may allow us to reduce or even eliminate our dependence on natural resources, but at present is some way in future. On their own, however, these measures can only take us so far.

In the meantime, manufacturers across industry are faced with the threat of rising costs for essential metals, together with the risk of shortages – especially if one or more sectors are prepared to pay a premium to guarantee a continuous supply for their production lines, or if markets fall prey to speculators. For manufacturers in the Italy, these problems are currently exacerbated by the uncertainties surrounding Brexit and the continuing weakness of Sterling, which have contributed to the rise in price per tonne of metals such as copper; this increased by around $1,000/tonne between January 2016 and June 2017.

These problems are not going to diminish. Indeed, with the rising demand from the renewable and EV sectors for critical materials, these issues are likely to become worse.

Balancing cost, quality and output

Building a solid defensive position, as a method of maintaining or even improving operating margins, against this changing market landscape is essential. One area that manufacturers can consider is their use of raw materials and the associated cost of converting those materials to finished products.

For many components, material and machining costs accounts for the bulk of the factory-gate price. It therefore makes sense to consider ways of reducing the volume of materials used and the time and processes required for manufacture.

Although there are many different methods of manufacture, the use of machine tools – mills, lathes, grinding systems etc – is perhaps the most common. CNC machining produces high quality parts, often with the advantages of complex shapes, in a wide range of materials and, given sufficient time, in reasonable volumes.

However, when it comes to the machining of copper and other softer alloys for use in renewable energy or EV systems, CNC machining is not always the best option.

This is because it's essentially a destructive process. It begins with a block of material from which the component is machined, leaving a high volume of scrap – which can admittedly be recycled – and often requiring multiple operations, which require time. High speed, multi-head machining centres can minimise these issues, but the fundamental problems remain, especially if components are required in high volume.

80%

COLD FORMING produces 80% less waste than traditional CNC machining

Self-driving cars an **$87 billion** opportunity in 2030

$

80%

EV battery cost dropped **80%** in six years

The destructive nature of the machining process can also affect the mechanical properties of the component, cutting across grain boundaries and reducing the inherent strength of the material.

CNC machining does, of course, have many benefits. However, when the drivers are a reduction in cost and using less raw materials, coupled with improvements in surface quality and structural integrity, especially where high volumes are required, then an engineering technique known as precision cold forming offers significant advantages.

Precision cold forming is a straightforward process. A blank of metal, previously sawn or cropped from a round bar or wire, or as a cold headed pre-form, is then shaped using a punch and die at high pressure – typically several hundred tonnes – and ambient temperature to create a part that precisely matches the shape of the tooling.

This simple process is waste-free and can produce micron-levels of accuracy, equivalent to that achievable from the best CNC machine tools, quickly, consistently and repeatedly.

The extrusion process also means that the metal is stretched beyond its yield strength. It therefore takes on and retains the exact shape of the die, with the grain structure of the material following the contours along the length of the die to maintain its tensile strength. Additionally, the internal surfaces take on a highly polished or mirrored appearance, which does not normally require further finishing – a factor that can reduce the number of production operations, again helping to reduce both cost and manufacturing time.

As an engineering technique, precision cold forming can play an important role in the high volume production of parts for the renewable and EV sectors, in a variety of materials; although copper will be the most common, it is also possible to cold form other metals including brass, aluminium and even stainless steel.

The UK network of EV charging points has increased from a few hundred in 2011 to more than 4,300 charging locations by May 2017

10 MILLION

Self-driving cars will be on the road **by 2020**

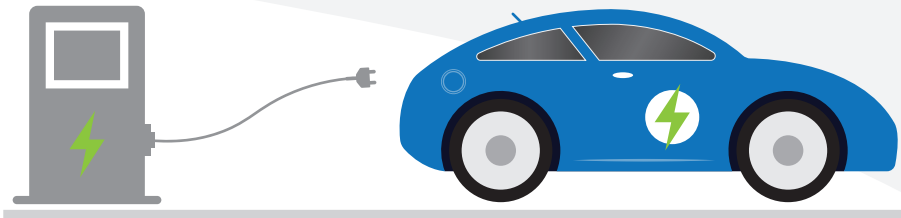
Design for engineering

Whichever production technique, or techniques, are employed, no amount of sophisticated machining or finishing will overcome the defects caused by poor part design. Its therefore incumbent on component designers as well as production engineers to think carefully about how a part will be engineered from the early stages of the development cycle.

This can have a number of important advantages, of which unit cost reduction and faster production times are just two. Considerations include reducing the number of component parts and the complexity of production stages; changing the materials of manufacture – perhaps to avoid rising metal costs or uncertainty of supply, or to enhance component performance, functionality and reliability; adoption of the latest design tools, to allow prototyping and testing to be carried out on-screen, to speed up development cycles; and partnering with specialised suppliers that have the knowledge and experience to optimise production operations.

Ultimately, as engineers we are only in control of a certain number of factors. Although we cannot influence market conditions, the inexorable rise of new technologies or the impact that they have on the price and supply of the essential metals we need for our manufacturing operations, we can determine how we design and produce the products that our customers demand. That ability, combined with an awareness of wider market trends, and a knowledge of techniques such as precision cold forming, open up new possibilities for driving cost down and productivity up, even in the face of uncertain and ever changing global economic conditions.

Deloitte research shows **67%** of survey respondents expect the battery must take no longer than two hours to charge



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