



## The Global E-bike Market

### Introduction

This insight, issued jointly as an ILZSG and INSG report, provides members with information on the global market for electric bicycles or e-bikes which utilize lead and nickel in their batteries. China is the largest market for e-bikes but the market is growing in other countries. The Chinese market for these vehicles is an important end use for lead-acid batteries. The market for e-bikes in Europe, North America and Japan differs from that of China in that most batteries are either nickel metal hydride or lithium ion. The use of nickel containing batteries is increasing most rapidly in Europe and North America.

### Background

The term 'e-bike' refers to bicycles that have a small electric motor and rechargeable batteries to assist the power provided by the rider. Other descriptions sometime used are pedelecs (from pedaled electric cycle) and EPAC (electric power-assisted cycles). Some more powerful e-bikes resemble scooters. To be defined as an e-bike, the vehicle must retain the ability to be pedalled by the rider; this distinguishes e-bikes from electric scooters and motorcycles. A typical E-bike can travel up to 25 to 32 km/h (16 to 20 mph), depending on the laws of the country in which they are sold.

The electric bike first became popular in China, where the government made developing e-bikes an official technology goal in 1991, and is now finding growing acceptance in other parts of the world. The first electric bikes similar to current models were produced in the 1990s. By the first decade of the 21<sup>st</sup> century the e-bike market in China began to grow at an exponential rate. The demand for e-bikes in Europe and North America began to grow somewhat later than in China but is now a multi-billion dollar market.

### Technology and the Relative Cost of Batteries

E-bikes use batteries of different chemistries, the most common being lead-acid, nickel metal hydride (NiMH) or lithium ion (Li-ion), to store power to supplement the power provided by the rider. In the lowest cost versions of e-bikes the battery employed is typically a sealed VRLA (Valve Regulated Lead Acid) battery. In more expensive e-bikes, the battery may be a nickel metal hydride or lithium ion battery. In China the overwhelming majority of e-bikes use lead acid batteries. In the European market it is estimated that half the e-bikes sold use nickel metal hydride batteries and half use lithium batteries.

Cost is a major consideration in the selection of a battery type. For ease of comparison, cost may be defined in terms of Euros per kilowatt-hour (€/kWh). Estimates made in 2013 are that lead-acid batteries cost about €30/kWh, NiMH about €300/kWh and Li-ion up to €600/kWh. Thus a Li-ion battery is roughly twenty times more expensive per unit of energy than a lead-acid battery. However, it is anticipated that the price of Li-ion will decrease as more Li-ion batteries are produced. One recent report claims that the automotive lithium-ion batteries built by Tesla Motors in partnership with Panasonic cost around \$200 to \$300 per kilowatt-hour.

Reflecting the difference in the cost of the battery, e-bikes in China are much less expensive. By utilizing lead-acid batteries, the cost of e-bicycles in China averages about \$167. In comparison, e-bikes in North America cost on average \$815 and those in Western Europe average \$1,546, reflecting the different choice in battery chemistry, according to Pike Research.

Within the category of lithium ion batteries, there are several sub-categories. Examples include Lithium Iron Phosphate (LFP or LiFePO<sub>4</sub>), Lithium Manganese Dioxide (LiMnO<sub>2</sub>) and Lithium Nickel Manganese Cobalt Oxide (NMC). Some, but not all, types of lithium ion batteries use nickel, usually in the cathode. Lithium Nickel Manganese Cobalt Oxide (NMC) is one such battery and is often used in vehicles. The cathode is composed of one-third nickel, one-third manganese and one-third cobalt. Another formulation is the Lithium Nickel Cobalt Aluminum (NCA or NiCoAl) battery. Tesla electric cars are reportedly now using Panasonic NCA batteries. The use of NMC or NCA batteries in e-bikes is a potential growth market for nickel.

## **Growth of the Market by Country**

In recent years electric cars have received a great deal of press coverage, but globally electric bicycles outsell electric cars by a wide margin. About 112,000 electric cars were sold worldwide in 2013. By comparison something in the region of 40 million e-bicycles were sold worldwide in 2013. In China, there are more electric bikes than cars on the road. The global pattern for sales of e-bikes in 2013 has China in first place, at about 32 million, followed by Europe at 1.8 million, and Japan at 440,000. The U.S. had sales of an estimated 185,000 e-bikes.

Further information for a number of countries with the largest e-bike sales is provided below.

The global market for e-bikes is dominated by China, with an estimated 85 percent of all e-bikes being sold in China. It was estimated by Macquarie that, in 2013, there were 180 million e-bikes on the road in China, and that nearly 37 million new e-bikes were produced in the course of 2013. Projecting this growth into 2014 suggests that the total number of e-bikes in China will exceed 200 million this year. Note that about 37 million e-bikes were manufactured in China last year, with an estimated 32 million sold domestically. This suggests exports of around 5 million.

Chinese e-bike production in 2013 was up 5.4% from the previous year, according to Macquarie, a somewhat slower pace than in earlier years. Given the huge number of e-

bikes in China it is not unexpected to see slower growth of e-bike production going forward as the market may be becoming saturated. An estimated 85 percent to 90 percent of e-bikes in China use lead acid batteries. Most Chinese electric bicycles using lead-acid batteries operate at 12 volts. Batteries for e-bikes using lithium batteries frequently operate at 24 volts or 36 volts.

Sales of electric bicycles have grown rapidly in Europe in recent years. The Association of the European Two-Wheeler Parts and Accessories' Industries (COLIPED) has published data showing that European sales of electric power-assisted cycles has grown at annual rates of between 19 and 76 percent since 2006. Annual sales are approaching 1 million per year. Industry sources estimate that a Nickel-Metal-Hydride (NiMH) battery is used in around half the e-bikes sold in the European Union with the other half equipped with a Li-ion battery. In early 2014 COLIPED and the China Bicycle Association discussed harmonized safety standards for e-bikes and as part of this discussion it was proposed to stop the export of e-bikes with lead-acid batteries from China to Europe.

The table below provides details on total sales and market evolution.

### Sales of Electric Power-Assisted Cycles in Europe

| Year          | 2006 | 2007  | 2008  | 2009  | 2010  | 2011  | 2012  |
|---------------|------|-------|-------|-------|-------|-------|-------|
| Sales ('000s) | 98   | 173   | 279   | 422   | 588   | 716   | 854   |
| % change      | -    | 76.52 | 61.27 | 51.25 | 39.34 | 21.77 | 19.27 |

Source: The Association of the European Two-Wheeler Parts and Accessories' Industries (COLIPED)

The countries with the largest share of e-bike sales are Germany (45%), Netherlands (21%), France, Italy and Austria, (each with about 5%). As the largest market in the EU, it is interesting to look at the case of Germany in more detail and to note that while regular bicycle sales are falling, e-bikes sales are growing.

### Bicycle Sales in Germany 2011-2013 (units)

|                     | 2013         | 2012         | 2011         |
|---------------------|--------------|--------------|--------------|
| Bicycles            | 3.34 mn      | 3.75 mn      | 3.77 mn      |
| E-bikes             | 0.41 mn      | 0.38 mn      | 0.33 mn      |
| Total               | 3.75 mn      | 3.97 mn      | 4.10 mn      |
| Average sales price | 520 euro     | 515 euro     | 496 euro     |
| Market value        | 1.98 bn euro | 2.03 bn euro | 2.03 bn euro |

Of the 410,000 electric bicycles sold in 2013 in Germany some 130,000 were imported and 278,000 were produced in Germany, with 58% of the e-bike imports from other EU member states and 41% from Asia. Germany also exported e-bikes, with 87% of Germany e-bike exports destined to EU countries. In neighboring Austria e-bikes have a market share of 11.3%. In Switzerland one in every seven bikes sold in an e-bike. Reportedly, over 250,000 e-bikes are currently in use on Swiss roads. In France 56,000 e-bikes were sold in 2013.

In the United States, an estimated 185,000 e-bikes were sold in 2013, according to the Electric Bikes Worldwide Report (EWBR), a trade publication. The EWBR highlights that there was an 80 percent sales growth in 2013 over 2012. In the U.S.A. typical prices for an e-bike range from about \$1,000 to \$3,500, with more sophisticated models costing \$5,000 to \$10,000. Most popular models are in the \$1,000 to \$1,500 range. This implies a total market value in the range of \$185 million to \$277 million. All battery types are sold in the U.S. market, but e-bikes using lithium batteries seem to be growing in popularity.

Japan has seen steady annual sales of about 300,000 for several years. The market in Korea, Taiwan and other East Asian countries appears to be growing as well.

### **International Trade in E-Bikes**

Asian countries are the largest manufacturers of e-bikes. For the EU, 83.2% of all imported e-bikes originate in China. China was the source of over 300,000 e-bikes imported into the EU in 2013. Japan is Europe's number two supplier, with over 31,000 units and a 8.4% share of the total imports. In third and fourth position, respectively, are Taiwan with 18,000 and Vietnam with 16,000 units. All other countries have less than 1% of the total imports.

#### **EU-27 Imports of E-bikes (in units) 2013**

| <b>Country of origin</b> | <b>E-bike units</b> |
|--------------------------|---------------------|
| P.R. of China            | 304,301             |
| Japan                    | 31,399              |
| Taiwan                   | 18,273              |
| Vietnam                  | 15,751              |
| USA                      | 680                 |
| Canada                   | 488                 |
| Ceuta                    | 422                 |
| Malaysia                 | 292                 |
| Switzerland              | 273                 |
| Hong Kong                | 259                 |
| All others               | 613                 |
| <b>Total units</b>       | <b>372,751</b>      |

*Source Eurostat*

## **Metal Content and Value**

The amount of lead used in lead-acid batteries for e-bikes is a significant portion of the total world market. Wood Mackenzie estimates that in China current e-bikes each use, on average, 13 kilograms of lead. If it is assumed that of the 37 million e-bikes manufactured in China in 2013, 85 percent (31.45 million) use lead-acid batteries, roughly 400,000 tonnes of lead would be required for this original equipment market. In addition, there is also the replacement market. E-bikes have an estimated life of around eight years and a lead-acid battery may have to be replaced two or three times during the life of the e-bike. Assuming 200 million e-bikes in China, this implies that e-bikes now on the road contain about 2.6 million tonnes of lead. If 25 percent of this total is replaced each year, the implied demand is an additional 800,000 tonnes. However, the Chinese government has indicated that new regulations will be enforced to limit the weight and speed of e-bikes, in part to improve safety and reduce accidents. Lighter, less powerful bikes would use less lead, perhaps in the range of 8 kilograms, again according to Wood Mackenzie. This lower level of usage implies a total of 1.6 million tonnes of lead and a replacement demand in the neighborhood of 400,000 tonnes. These estimates suggest an annual demand for lead for Chinese e-bikes in the range of 800,000 to 1.2 million tonnes.

The calculation of the amount of nickel used in e-bikes is more difficult due to the different battery chemistries and the changing technology. However, lithium ion batteries containing nickel can use up to 3 kilograms of nickel per kilowatt hour of capacity. The trend for more e-bikes to use lithium ion batteries will likely increase demand for nickel.

## **Regulatory Constraints**

In most countries e-bikes are treated the same as bicycles with respect to licensing and where they may be used, as long as they are of low power. In the EU, e-bikes are considered as bicycles if: "Cycles with pedal assistance which are equipped with an auxiliary electric motor having a maximum continuous rated power of 0.25 kW, of which the output is progressively reduced and finally cut off as the vehicle reaches a speed of 25 km/h, or sooner, if the cyclist stops pedaling". However, in some jurisdictions e-bikes are subject to more restrictive rules. In the United States there are conflicting regulations at the federal, state and local levels. For example in New York state electric bikes are considered motor vehicles and subject to the same laws and penalties as automobiles. In China some cities place limits on the operation of e-bikes depending on the power rating.

## **Conclusion**

The e-bike market drives significant demand for lead and a growing market for nickel. While the amount of nickel used in e-bike batteries is small as a proportion of the global nickel market, nickel is a critical material for some of the most recently developed battery systems. Some types of batteries used in e-bikes share technology with batteries applied to electric cars. Overall, INSG estimates that about 6 percent of global nickel production goes to make batteries, and while the portion going to e-bike batteries is small, it is a rapidly growing market. For lead, secretariat estimates suggest the 200 million e-bikes

powered by lead acid batteries create an annual demand of 800,000 to 1.2 million tonnes of lead, a significant proportion of the total global annual demand.

**Comments or Questions**

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**September 2014**