Steel and Aluminium Intensive Products: Their Metallic Components and Design Requirements

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Abstract

This document identifies the most intensive end uses for steel and aluminium. The design requirements of these products, and their metallic intensive components, are then assessed. This will aid research in the reduction of carbon dioxide emissions associated with steel and aluminium production, identifying where design, re-use and logistical changes can have the biggest impact.

It is found that construction dominates steel use, with sections alone accounting for 20% of world production. For aluminium, approximately half was found to be used in transport or construction, in the form of automobiles, window frames, curtain walling, roofing and exterior cladding.

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Introduction

The quest to reduce industrial carbon emissions has encouraged aspects beyond primary production efficiency to be investigated. It is important to identify the largest end product uses of steel and aluminium (together responsible for approximately 10% of global emissions), and by identifying their design requirements and production process routes aid analysis of where the largest potentials for emission reduction lie. Categorisation of the 'bill of materials' for each product is ongoing.

A mixture of top-down and bottom-up analyses from a variety of studies has informed the metal intensive end products categorised in this document. Figures 1 and 2 present the end products identified (tabularised in Appendix 1). Table 1 presents some of the characteristics of steel and aluminium which make them an ideal material for the various products assessed.

Table 1: Steel and Aluminium Properties

Property	Units	Steel	Aluminium
Density	(kg/m^3)	7850	2700
Thermal Conductivity	(kW/mK)	43	237
Specific Heat Capacity	(kJ/KgK)	0.49	0.98
Youngs Modulus	(GPa)	200	70
Rigidity	(GPa)	79	26

Nb: Total annual world production of aluminium is 53Mte (Aluminium Association, 2008), and is 1350Mte for steel (World Steel Association, 2008b).

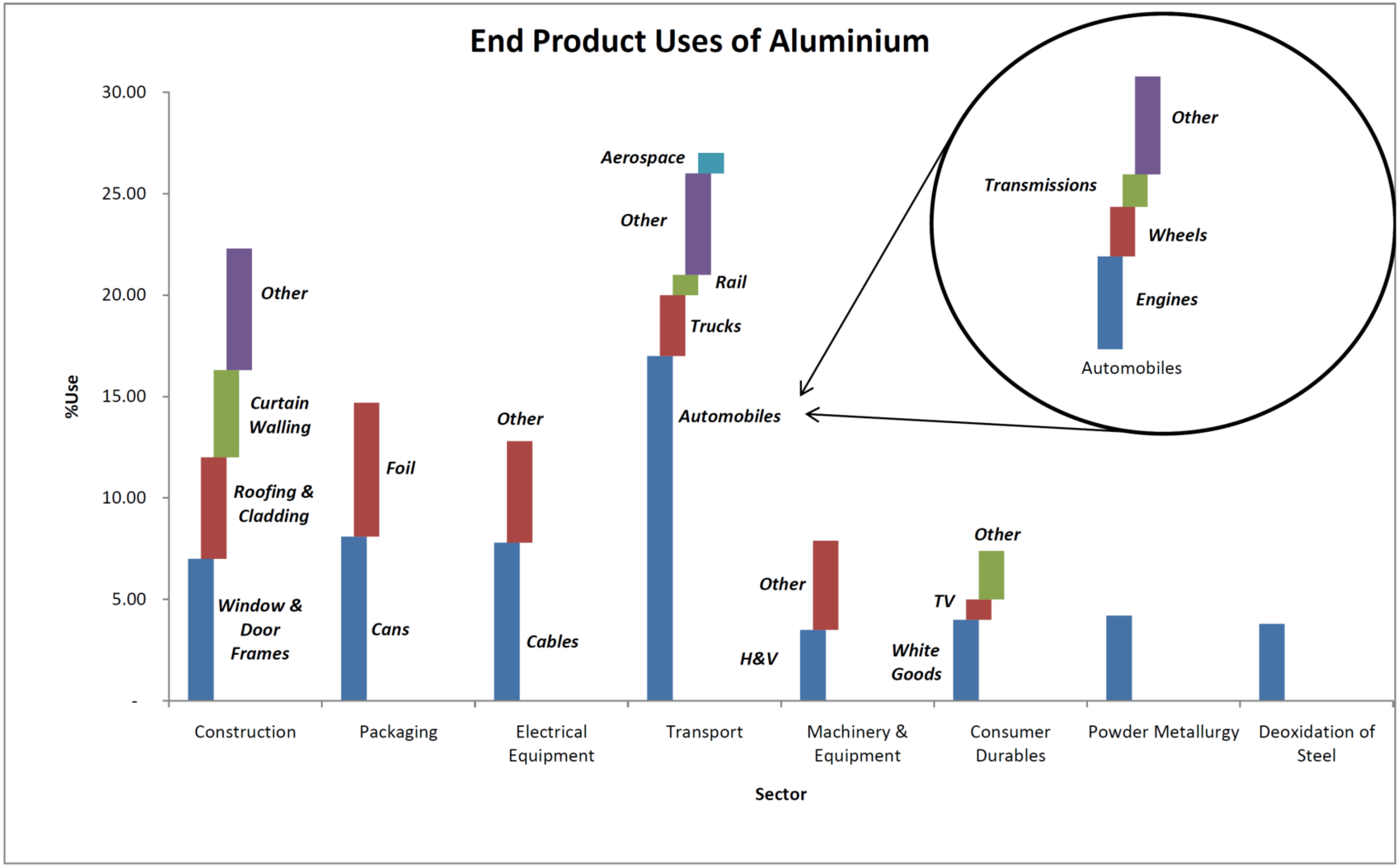

Figure 1: Aluminium End Product Use

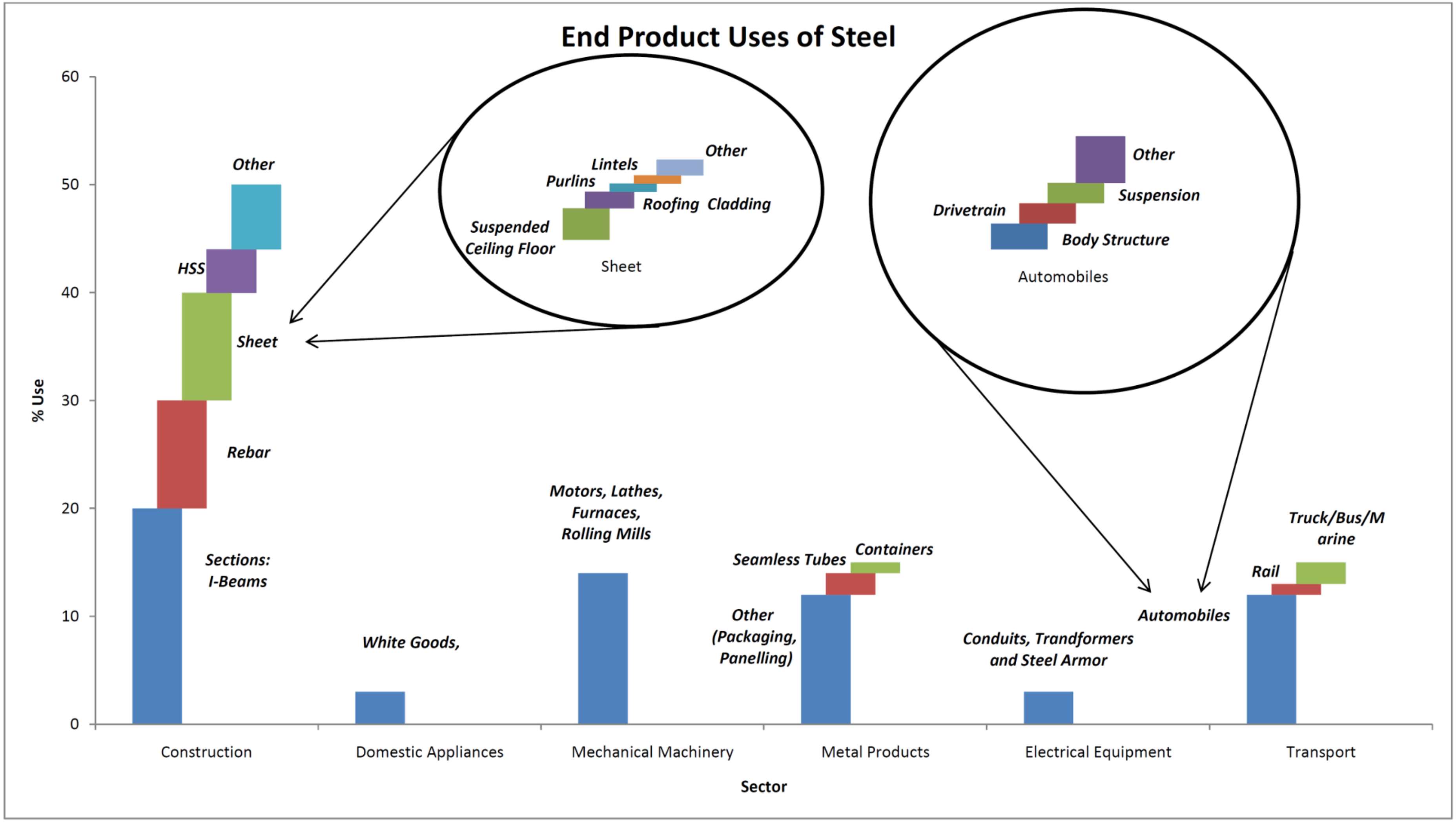

Figure 2: Steel End Product Use

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Derivation and Confidence in End-Use Percentages

Aluminium

The 8 sectors identified in Figure 1, and their percentage contributions to total aluminium use, were identified in International Aluminium Institute (2007) statistical worldwide data.

Construction

The respective contributions of "Window & Door Frames", "Curtain Walling", "Roofing and Cladding" and "others" were taken from Aluminium Association (2007), a study on the end uses of aluminium in the USA. Their respective contributions to aluminium use in USA construction were taken as representative of the worldwide market.

Packaging

The respective contributions of "foils" and "cans" were taken from International Aluminium Institute (2007) statistical worldwide data.

Electrical Equipment

The contributions of "cables" and "other" were taken from International Aluminium Institute (2007) statistical worldwide data.

Transport

The contributions of "automobiles" and "aerospace" were taken from International Aluminium Institute (2007) statistical worldwide data. The aluminium intensive components within an automobile were taken from Bertram et al (2008). The contributions of "Rail" and "Trucks" were taken from Wang and Graedal (2010), a study on the end product uses of aluminium in China. Their respective contributions to aluminium use in Chinese transport were taken as representative of the worldwide market. "Other" was taken as the remaining percentage in this sector.

Machinery and Equipment

The contribution of "heating and ventilation" systems was taken as the worldwide foil stock product (Bambach, 2010) minus the foil used in packaging.

"Other" was taken as the remaining percentage in this sector.

Consumer Durables

The contributions of "white goods", "TV" and "Other" were taken from Wang and Graedal (2010), a study on the end product uses of aluminium in China. Their respective contributions to aluminium use in Chinese consumer durables were taken as representative of the worldwide market.

Steel

The 6 sectors identified in Figure 2, and their percentage contributions to total steel use, were identified in World Steel Association (2008a) statistical worldwide data.

Construction

The respective contributions of "sections", "rebar", "sheet", "HSS", and "other" were taken from Ley (2003), a study of steel construction products in Britain. Their respective contributions to steel use in British construction were taken as representative of the worldwide market. "Rebar" and "HSS" were cross-checked against figures in World Steel Association (2008b) and found to be consistent. The steel used within the offshore industry is captured within the various sections (plate and stainless steel within "other").

The steel intensive products within "sheet" were taken from Ley (2003), a study of end steel construction products in Britain. Their respective contributions to steel use in British construction were taken as representative of the worldwide market.

Metal Products

The percentage contribution of "containers" was taken from Matos and Fenton (2005), a study of steel end uses in the USA. The contribution of "containers" to USA steel consumption was taken as representative of the worldwide market. The contribution of "seamless tubes" was taken from World Steel Association (2008b). The remaining percentage in this sector was taken as "other".

Transport

The contribution of "automobiles" was taken from World Steel Association (2008a). The steel intensive components within an automobile were taken from World Steel Auto (2010), but a better reference is being sought. The contribution of "rail" was taken from World Steel Association (2008b).The remaining percentage of this sector is assumed to be "Truck/Bus/Marine".

Confidence in Results

Most of the results contain at least some redundancy, be it quantitative or qualitative. A few national studies are assumed representative of the world market, which may have extenuated certain local trends. Where possible, some confidence in a national study has been gained by checking elements against worldwide data from another source. Subsequently, confidence can be taken that these results are generally representative of the worldwide end uses for steel and aluminium. Work is ongoing to improve and refine the data, and it should be noted that changing economies and trends means these percentages are dynamic and could alter substantially in the coming decade.

Aluminium Intensive End Products

Construction (≈22%)

The main aluminium alloys used in construction are AA6063 and AA6082, which possess high strengths of up to 400MPa, design flexibility and corrosion resistance.

Window Frames (≈7%) and Curtain Walling (≈4%)

Aluminium is an attractive, light-weight, and increasingly used material in construction. In the UK, around half of all aluminium extrusions produced are used in construction. These are either sold directly or via stockholders to commercial or domestic customers. These extrusions are used mainly for window frames (typically AA6063), curtain walling, facades, conservatories and partitioning. Structural curtain walling often includes aluminium I-beams and HSS, and therefore possess similar design requirements as their steel cousins, with adjustments made for reduced strength, mass and stiffness. However, the extrusion process allows the designer to specify a wide range of cross-sections if desired.

Extrusion allows the incorporation of draft excluders, thermal breaks, glazing beads, and grooves for connection; ideal for window frames. Aluminium window frames also allow architectural integrity to be maintained, their appearance suiting both modern and listed buildings.

A potential disadvantage of using aluminium in buildings is its high thermal conductivity. As such, thermal breaks with the application of a resin are required.

Important design requirements are:

- Strength for rigidity and security
- Formability (gained with the extrusion process)
- Low Density
- Aesthetics
- Corrosion Resistance/Maintainability

Roofing and Exterior Cladding (≈5%)

Decorative and protective profiled cladding is often made from rolled aluminium sheet. Its low mass, corrosion resistance, and availability in a variety of finishes makes it an ideal roofing material.

Important design requirements are:

- Low Mass
- Water Resistance
- Corrosion Resistance
- Aesthetics

Transport (≈27%)

Aluminium is increasingly used in transport as its lightweight properties allow better fuel economy, and reduced carbon dioxide emissions over the lifetime of the product.

Automobiles (≈17%)

The average mass of aluminium in cars produced in Europe in 2006 is shown in Table 2 (Bertram et al, 2008). The 117kg average is set to increase further in the coming years.

Table 2: Average Aluminium Mass in Cars (2006)

Component	2006 European Average Aluminium Content (kg/Car)
Engines	40.3
Transmission	16.3
Chassis, Suspension and Steering	12.5
Wheels	17.7
Heat Exchanger	12.3
Brakes	3.7
Closures	4
Body and IP Beams	2.8
Heat Shields	1.4
Bumper Beams	2.8
Other Components	3.9
Total	117.7

Engine Block

Figure 3 presents a CAD representation of an aluminium engine block.

An engine block is a machined 300 series aluminium casting, with cylindrically bored holes for the pistons of an internal combustion engine. They are designed to be strong and sturdy as their failure results in an expensive and time consuming failure of the whole car.

The number of cylinders determines the size and placement of the engine block, with most cars having between four and eight cylinders.
Attachments to the engine block include the cylinder head, crankcase, engine mounts, drive housing and engine ancillaries.

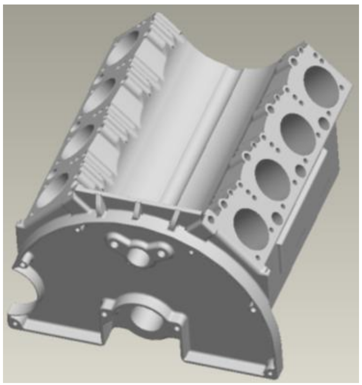

Figure 3: CAD Representation of Aluminium Engine Block

Note on Remanufacture:

When repairing grey cast steel engine blocks, liners are 'slip-fitted' into the cylinders. For aluminium engine bocks neither press-fit nor slip-fit insertion of the liners will be suitable due to stress problems. Instead, aluminium liners must be inserted by a shrinking process.

Important design requirements are:

- Low density (improving fuel economy)
- Strength (preventing deformation)
- Rigidity
- Toughness (preventing crack development)
- Cost
- Corrosion Resistance

Transmissions

Both automatic and manual transmissions carry power (through torques and rotational velocities) from the engine to the wheels of the vehicle. The transmission is designed to allow the engine to operate at as high an efficiency as possible for the given torque and rotational velocity requirement. Losses through the transmission must be kept to a minimum, so rigid and tough materials are used to transfer the loads.

Important design requirements are:

- Low Density (Improving fuel Economy)
- Stiffness
- Toughness
- Cost
- Coefficient of Friction (minimise power loss)

Chassis and Suspension

The chassis is the supporting frame of the automobile. The suspension consists of a spring and damping element. These are usually provided by either a spring (or leaf-spring) and dashpot hydraulic oil damper. The suspension connects the wheels and chassis to the rest of the car body, providing a smooth ride for the passengers above. The two resonant frequencies associated with car body bounce and wheel hop must be effectively damped (a minimum damping factor of 20% is required in Europe) to ensure both a comfortable ride and minimised fluctuations in dynamic tyre force.

Important design requirements are:

- Low Density (Improving Fuel Economy)
- Strength
- Stiffness
- Durability
- Cost

Wheels

Figure 4: CAD Representation of Automobile Aluminium Alloy

Figure 4 presents a CAD representation of an aluminium alloy car wheel.

Cast aluminium alloy wheels are an increasingly popular alternative to steel. They are light-weight (good for fuel economy), and their attractive appearance makes them desirable in a stylised industry.

Wheels support the load of the vehicle whilst also providing the torque needed for propulsion (via a rotary axle). Wheels must support both tensile and compressive forces (dependant on their design) and can be considered as the following components:

Wheel Hub:

The wheel hub is at the centre of the wheel connecting the spokes to the axle. The hub must therefore transmit all the accelerating and corner forces to the axle, requiring strength, toughness and rigidity.

Wheel Spokes:

The spokes connect the hub to the rim. For car wheels the spokes must transmit a compressive load from the axle to the rim. This requires compressive strength, and toughness as the spokes must avoid fatigue failure through the cyclical loading.

Wheel Rim:

The wheel rim is the outer circular design connecting the wheel to the tyre. The wheel must resist the vertical compression of the weight of the vehicle (plus any dynamic forces from bumps in the road), acting as an arch between adjacent spokes.

All three wheel components must provide sufficient stiffness to prevent unacceptable displacements (for example when cornering).

Important Design Requirements are:

- Low Density (Improved Fuel Economy)
- Aesthetics
- Strength
- Stiffness
- Corrosion Resistance

Other Transport – Example: Aerospace (≈1%)

Material in the aerospace industry is dominated by high strength wrought aluminium alloys, in particular AA2024 (containing copper and magnesium), and AA7075 (containing

Magnesium, Zinc, and some copper). Components are typically made by extrusion and machining. Many of the high grade aluminium alloys used in aerospace are considered unweldable.

Design requirements:

- Low Density
- Strength
- Stiffness
- Machining Tolerance
- Corrosion Resistance
- Cost

Packaging (≈15%)

Rolled aluminium is commonly used in packaging. Its low density, compatibility with food and drink, and aesthetic appearance make it ideal for both rigid and foil packaging.

Packaging [Cans] (≈8%)

75% of beverage cans are made from aluminium, and 15% of aerosols. The majority of beverage cans are 2-piece aluminium (body and lid), providing a significant weight saving over steel equivalents. The beverage can be considered as three components:

- Can Body
- Lid
- Tab/Ring Pull

The can body is produced from 3000 series aluminium alloy which is drawn and wall ironed (DWI) through a ‘bodymaker’. The wall thickness of the cans is approximately 0.27mm, though the industry is constantly working to reduce this thickness.

The lid can account for 25% of the total weight, consisting of a stronger, higher magnesium content, alloy.

A rivet is made by stretching and drawing the centre of the lid. This rivet secures the tab, itself a separate piece of metal.

Important design requirements are:

- Low Density
- Strength
- Formability
- Drink Compatibility
- Aesthetics (ability to apply finishes)
- Cost

Packaging [Foil/Other] (≈7%)

Aluminium foil is commonly made from rolled 1000 series aluminium alloy. The gauge can be accurately controlled and the work hardening (due to cold deformation) allows exact shapes after stamping to be retained.

Important design requirements are:

- Strength and Durability at low gauge
- Low Density
- Thermal Conductivity
- Heat Resistance
- Barrier Properties
- Food and Drink compatibility
- Aesthetic and Decorative Potential

Electrical Equipment (≈13%)

The high electrical conductivity of 1000 series aluminium alloys makes them favourable for electrical applications. Aluminium conductors are used in the following electrical applications:

- Sub-stations
- Power systems of large buildings
- High voltage overhead lines and many underground lines
- Energy cables for industrial use

The majority of aluminium used in electronic equipment is in the form of cables. However, aluminium is also used in conduits and bus bars for heavy current apparatus and buildings (to name just two).

Electrical Cables (≈8%)

Aluminium is favourable to copper due to a lower overall cost. This is despite the conductors needing to be larger due to the higher electrical resistivity of aluminium.

Cables for industrial, commercial and apartment buildings may contain many insulated conductors in an overall jacket consisting of aluminium armor.

Important design requirements are:

- Cost
- Electrical Conductivity
- Corrosion Resistance
- Strength

Machinery & Other Equipment (≈8%)

Heating & Ventilation Systems (≈4%)

Aluminium 3000, 5000 and 6000 series alloys have good thermal conductivity. Combined with high strength and durability, aluminium is a favourable choice in heating and ventilation systems.

The system can be considered as consisting of the following components:

- Compressor
- Condenser/Evaporator
- Expansion Valve
- Fan
- Tubing
- Refrigerant

Considering only the most metal intensive components:

Compressor

Typically two types of compressor are used:

- the seal type (e.g. completely sealed, semi-sealed and open type), and
- the operation type (e.g. piston, scroll, rotary and centrifugal)

The typical compressor contains 40kg of aluminium (equivalent to 0.32Mte in a market of 8 million industrial air-conditioning units).

Condenser/Evaporator

Heat transfer occurs by conduction from the refrigerant to the air. Therefore, a heat exchanger is required with the following characteristics:

- High thermal conductivity
- High contact factor

To increase the contact surface area the tubes are run through a set of aluminium sheets. The tubes contact the sheets, increasing the area for conducting heat transfer.

Tubing

The choice for conducting tubes is between aluminium and copper tubes. The choice between these two comes down to cost analysis and maintenance requirements.

Important overall design requirements are:

- Thermal Conductivity
- Corrosion
- Cheaper and lighter than copper

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Consumer Durable (≈7%)

Aluminium is increasing used for the visual components of consumer durables (such as panelling), due to its aesthetic and corrosion resistant properties.

White Goods (≈4%)

50% of all aluminium used in white goods is used in fridges/freezers and washing machines.

Fridges and freezers contain refrigeration units, and as discussed earlier, will therefore contain significant amounts of aluminium. In addition to the aluminium used in the refrigeration system, panels and accessories are increasingly made from aluminium.

Important overall design requirements are:

- Aesthetics
- Corrosion Resistance
- Strength
- Thermal Conductivity (for use in refrigeration units)

Powder Metallurgy (≈4%)

Powder metallurgy is a process allowing the production of both complex and simple shapes to near finished dimensions, reducing further machining stages.

A blend of elemental and pre-alloyed powders is compacted into a die. The powders are then sintered to form a near net final shape product.

Important design requirements for aluminium powder metallurgy are:

- Low density
- Ability to apply a variety of finishes
- Corrosion Resistance
- Conductivity

Deoxidation of Steel (≈4%)

To remove oxygen from molten steel, deoxidizing agents are added to the melt. Aluminium is a commonly used deoxidant (along with manganese and ferrosilicon).

The aluminium is added as circa 10kg bars. It reacts with the dissolved oxygen to form aluminium oxide. Aluminium also forms pin grain boundaries, preventing grain growth during heat treatments.

Approximately 1kg of aluminium is required to deoxidate every tonne of steel (Ofengenden and Nesterovich, 1958). It should be noted that this literature source is from circa 1960, and practices may well have changed.

If efficiencies are made in either the production or demand of molten (primary and secondary) steel, the requirement of aluminium for deoxidation of the steel shall decrease.

Design Requirements:

- Successful reactant with oxygen in molten steel
- Cost
- Effect on Metallurgy of Steel

Steel Intensive End Products

Construction (≈50%)

Sections (≈20%)

I-Beams

I-beams are used to efficiently carry both bending moment and shear forces in the plane of the web. They are produced by hot rolling steel into the I cross-section, or alternatively by welding together plates that become the web and flanges. Figure 5 presents some reclaimed I-beams.

Figure 5: Reclaimed Structural I-Beams

The I-beam maybe considered as having web and flange components:

I-beam Web: resists vertical shear forces

I-beam Flanges: resists most of the bending moment

Important overall design requirements are:

- Shear Strength in the plane of the web
- Stiffness in the plane of the web
- Durability
- Corrosion Resistance
- Cost

Hollow Section Steel (HSS) (≈4%)

HSS are hollow cross-section mild steel structural components with heavily rounded corners, They usually have a square or circular cross-section. HSS are produced from flat plate: shaped and then seam welded.

The I-shape is very efficient at withstanding loads in the plane of the web. However, I-beams are poor at resisting transverse forces and bending moments, and are susceptible to torsion, failing in lateral torsional buckling (LTB). The increased geometric symmetry of the HSS section allows efficient restraint of multi-axial loads and superior resistance to torsion. HSS are sometime filled with concrete to produce ‘filled HSS’.

Hollow Structural Section – Provides multi-axial restraint to loads and torsion.

‘Filler’ Concrete – Increases compressive strength of HSS (cheaply) and provides inherent 60 minute fire protection. Note: The HSS may be filled in-situ or off-site.

Important design requirements are:

- Multi-axial Strength
- Multi-axial Stiffness

- Durability
- Corrosion Resistance
- Cost
- (Fire Protection if filled)

Reinforcing Bars (≈10%)

There has been a 40% increase in world crude steel production destined for reinforcement bar since 1998 (World Steel Association, 2008b), indicating the growth of this sector.

Reinforcing bars are placed within concrete (often as a cage) to increase the tensile strength of concrete components, preventing failure in bending. Reinforcement can be pre-stressed, to induce a compression force in the concrete. This prevents the concrete entering tension in bending and cracking.

Reinforcing bars, also known as rebars, are typically made from unfinished tempered carbon steel. The concrete provides an alkaline environment, preventing corrosion. Too little surrounding concrete can cause an increase in rust, leading to more cracks and ultimately structural failure. Reinforcement bars can be used both within poured 'in-situ' concrete, and in pre-cast concrete.

Important design requirements are:

- Good bonding to the concrete (to allow a transfer of forces)
- High tensile yield strength
- Expansion coefficient compatible with concrete
- Cost

There is currently no market for reclaimed reinforced concrete slabs, and extraction of the steel from the concrete after use is not currently possible. However, research at the Faraday Institute has begun investigating the use of microwaves to heat the water within the concrete, causing cracking and ultimate disintegration. It is possible that this may allow reclamation of the rebar.

Suspended Ceiling Frames (≈4%)

Suspended ceiling frames are common in modern non-residential construction. They consist of a grid of upside down 'T' steel channels. Non-metallic panelling then spans the spaces between the grids. The suspended ceiling conceals a host of services and ducts above, as well as offering acoustic balance in the room below. They also allow the services above to be easily accessed and adapted. A disadvantage is that they reduce the height of the room.

Important design requirements are:

- Cost
- (Low Structural Integrity Required)

Roofing Cladding (≈2%)

The characteristics of roof cladding have been discussed in the aluminium section. The trade-offs between steel and aluminium roof claddings are cost, strength and aesthetics.

Purlins (≈1%)

Purlins are horizontal structural members, common in portal frame construction. They support the roof cladding and are supported by the building end walls and steel beams.

Important design requirements are:

- Cost
- Strength
- Corrosion Resistance

Lintels (≈1%)

A lintel is a horizontal beam used typically above a door, window, and fireplace opening. It usually bears the weight of the wall above the opening.

Important design requirements are:

- Compressive strength
- Strength in Bending
- Cost

Mechanical Machinery (≈14%)

Mechanical machinery encapsulates a wide range of industrial equipment from lathes to textile looms and rolling mills. These are low in volume but leviathan in scale.

Example: Rolling Mills

Plate rolling mills are very large, complex and expensive pieces machinery that have operating lifetimes in excess of 50 years, and thus are a good example of design for long-life. A typical modern plate mill will roll 5 metre wide strips of steel or aluminium, with a rolling load of 10,000 tonnes, and using a pair of 10MW roll drives fixed to a 500-tonne housing. The mill equipment will stretch for 1.5 kilometres, weigh some 25,000 tonnes, and cost around £150 million while being designed to process 2 million tonnes of steel and operate for 7,000 hours per year.

Long operating lifetimes are achieved by designing for functionality: parts that wear (work rolls, backing rolls, seals, bearing) are replaced regularly, automation and control (especially software) is upgraded, whereas many of the main structural parts (where most the steel is) are designed to never fail. Creating a business case around selling upgrades and replacements for components with a low material intensity, is both profitable and sustainable.

Plate rolling mills are normally retired because of a change in the business environment rather than a mechanical failure. They are commonly refurbished and relocated to another country, where high production volumes of low-grade product and low operating costs make the business more profitable. Automation/electrical equipment is normally upgraded (about 1/3 of the mill value) and the civil works are created new (another 1/3), leaving only the mechanical equipment available for reuse. However, the mechanical equipment is where much of the steel is located.

Metal Products (≈14%)

Metal products encapsulate a vast array of items from panelling and small packaging to shipping containers, barrels, trolleys and pallets. Metal intensive products in the home and workplace are identified in Table 3 below (Furniture Re-use Network, 2009).

Table 3: Metal Intensive Products in Home and Workplace (exc. Domestic Appliances)

Product	Average Mass (kg)
Photocopier	52
Metal Bath	40
Toilet	30
Metal Sink	20

Packaging

Tin-plate steel (a thin layer of tin electrolytically applied to the steel) is used extensively in packaging. Approximately 15Mte of steel is used for small packaging for a host of different consumer goods, including:

- Beverage
- Aerosols
- Paints & Varnishes
- Food Packaging

Approximately 25% of beverage cans are made from tin-plated steel, corresponding to 1Mte worldwide.

Over 90% of the canned food market uses tin-plated steel, and 85% of aerosols (corresponding to over 3Mte worldwide).

Transport (≈15%)

Automotive (≈12%)

Steel accounts for 60% of a typical car's overall mass. Traditionally, the cast engine blocks were made from grey steel, but they are now being replaced by aluminium. Steel has the strength and rigidity to give automobiles both reliability and safety. In recent years there has been strong competition from aluminium alloys, which offer reduced mass compared to traditional steels. However, the introduction of high strength steels and tailor welded blanks (TWBs), where steel sheets of varying grades and gauges are welded together, allows steel to compete against aluminium. A high-strength steel is any steel product whose tensile strength is between 270 and 700 MPa. Ultra high-strength steels have a tensile strength of 700 MPa or greater. Advanced high strength steels (AHSS) products have a minimum tensile strength of 500 to 800 MPa.

The steel mass in a car is dominated by the flat products (such as the body in white, chassis, wheels, fuel tank) and long products (steering mechanism, suspension, transmission).

The design requirements of these metal intensive components are detailed in the aluminium section on automobiles. The trade-off between use of steel and aluminium revolves around cost, rigidity for safety, and strength vs. density for aluminium compared to the higher strength steel TWBs.

Other Transport (≈3%)

In 2007, production for railway track material accounted for approximately 1% of total crude steel production (World Steel Association, 2008b). Steel is also used in shipping and railway rolling stock.

Railway track provides the support and reactive cornering forces to allow a bogey to round a corner with minimal rolling resistance.

The rails are made from hot rolled mild steel, as a high carbon steel would be too prone to brittle fracture given the high stresses endured. The mild steel rails wear quickly and have to be replaced. The wear is only on one side, therefore some operators switch adjacent rails to prolong life.

Important design requirements are:

- High Strength
- Low Rolling Resistance against Train Wheels
- Toughness to endure stress cycles
- Durability
- Corrosion Resistance
- Cost

Domestic Appliances (≈3%)

The following domestic appliances are considered to dominate metal use (Furniture Re-use Network, 2009):

Table 4: Metal Intensive Domestic Appliances

Product	Average Mass (kg)
Washing Machine	65
Electric Cooker	56
Tumble Dryer	39
Free Standing Fridge	38
Free Standing Freezer	45
Microwave	19

The steel effectively provides a structural box in which the electrical and insulating components reside.

Electrical Equipment (≈3%)

Electrical steels are important magnetic materials and play an important role in the generation, transmission and distribution.

- Grain orientated steels provide very low power loss for high efficiency transformers.
- Non orientated fully processed steels have similar magnetic properties in all directions and are used in generators, alternators, small transformers and a variety of electromagnetic applications.

Electrical cables contain insulated conductors, with helical tape steel or steel wire armor. Steel is also extensively used to make electrical conduits and junction boxes.

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Appendix 1:

Table 1: Aluminium End Use Products

Product	Percentage of Consumption (%)
Window & door frames	7
Roofing & cladding	5
Curtain walling	4
Other (construction)	6
Cans	8
Foil	7
Cable	8
Other (electrical)	5
Engine blocks	6
Wheels	3
Transmission	2
Other (automotive)	6
Trucks	3
Rail	1
Aerospace	1
Other (transport)	5
Heating & ventilation	4
Other (machinery)	4
White goods	4
Television	1
Other (consumer goods)	2
Powder metallurgy	4
De-oxidisation of steel	4

Table 2: Steel End Use Products

Product	Percentage of Consumption (%)
I-beams	20
Re-bar	10
Suspended ceiling frames	4
Cladding	2
Purlins	1
Lintels	1
Hollow section steel	4
Other (construction)	8
Metal Products (Packaging/panelling)	12
Electrical equipment	3
Body structure	3
Drivetrain	2
Suspension	2
Other (automobiles)	5
Rail	1
Truck/bus/marine	2
Mechanical machinery	14
Domestic Goods (White goods etc)	3
Seamless tubes	2
Containers	1