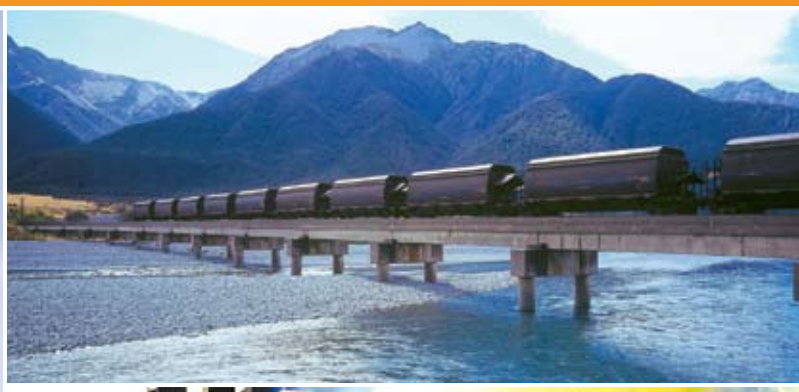
Coal for making steel



Left: Steel is critical to major infrastructure such as bridges, buildings and electricity transmission. Top right: Coal train takes West Coast coking coal to Lyttelton Port of Christchurch, where it is shipped overseas for steel making. Right: Coal from Solid Energy's Huntly East Mine is used for steel making here in New Zealand.

More than half of the coal produced by Solid Energy is used to manufacture steel here and overseas. There is no way of making new steel without coal, which plays four critical roles in its production:

- Produces energy to drive the physical and chemical processes in steel-making
- Acts as a chemical reductant to take out impurities and turn iron ore into iron
- Contributes additional carbon to the steel (steel is an alloy of iron and carbon)
- Produces a permeable medium that allows molten iron to descend through the blast furnace.

There is more than 20 billion tonnes of steel in use around the world today and more than one billion more is made every year. About 30% is made from recycled scrap while close to 70% is made new, mostly using coking coal in a blast furnace. A very small amount of the world's steel is made using alternative techniques that call for different types of coal. For example New Zealand Steel uses sub-bituminous coal from our Huntly East Underground Mine in its Glenbrook steel mill, south of Auckland. But no matter what method is used to make it, every kilogram of steel in use today was produced with coal.

*"Every kilogram of **steel in use** today was produced **with coal."***

What is steel?

Steel is principally an alloy of iron and carbon. Even though carbon makes up less than 2% of steel, its atoms infiltrate the iron to make it stronger and harder.

Different types of steel can be produced by making small adjustments to the amount of carbon they contain. For example, surgical instruments are made from relatively high carbon steel because that makes them harder to scratch and therefore easier to keep clean. Steel properties can also be adjusted by adding other elements to the alloy, such as chromium for stainless steel.

How important is steel?

Annual demand for steel almost doubled in the first half of this decade alone, surpassing one billion tonnes per year in 2004. That demand will continue to rise as standards of living improve in emerging economies such as India and China, which now account for 40% of global steel demand. Steel continues to play a crucial role in alleviating poverty. For example:

- Steel can provide urban infrastructure for the 1.1 billion city dwellers that remain inadequately housed today.
- Steel plumbing is needed to provide water to the 20% of people that do not have access to safe drinking water in the developing world.
- Steel will be needed to generate and transmit electricity to the 1.6 billion people around the world who currently do not have access to it.
- As the world moves towards renewable energy, steel will play a key role. For example there are 100 tonnes of steel in a 60 metre tall wind turbine.
- About 200 billion steel cans are produced every year to provide preservative-free food storage.

Steel can be melted and re-used over and over. It is the world's most recycled material.

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Making steel with West Coast coal

Stage 1: Preparation

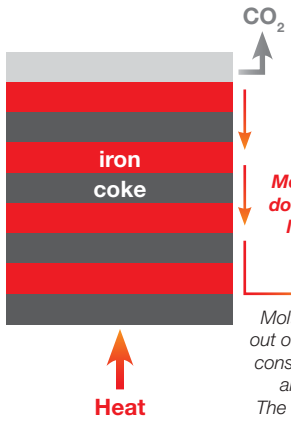
Iron
Iron ore is mined and divided into pellets for the blast furnace. Iron ore is made from iron (Fe) bonded to oxygen (O).

Limestone

Coke
Coking coal, which is geologically older than most other coals, is baked in an oven. The high temperatures burn off some of the compounds in the coal, turning it into a spongy mass of almost pure carbon.

What happens?
- *Coke and iron are prepared and then loaded into the blast furnace in layers, with limestone.*

Stage 2: Smelting
in blast furnace

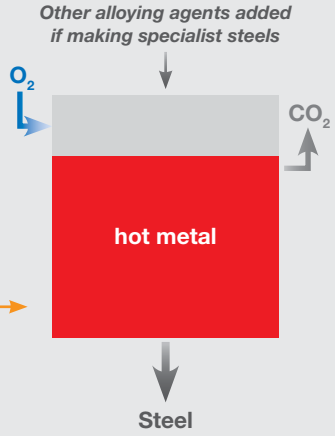


Melted iron flows down through the layers of coke

Molten metal comes out of the blast furnace consisting of iron (Fe), and carbon (C). The oxygen has been removed from the iron ore, making it suitable for steel making.

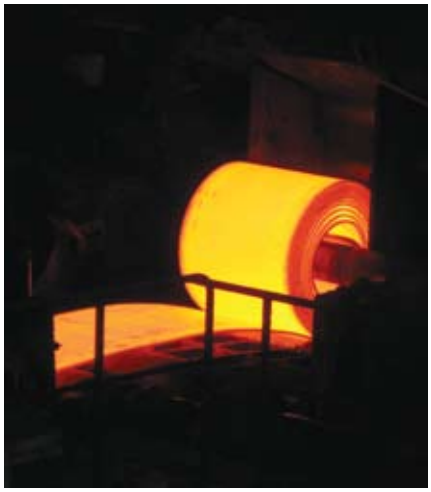
What happens?
- *The coke is ignited, providing heat to drive the process.*
- *Some of the coke turns to gas, including carbon monoxide (CO) and carbon dioxide (CO_2).*
- *The iron ore melts and flows down through the coke.*
- *The carbon monoxide (CO) bonds with the oxygen in the ore to make CO_2 (purifying the iron in the process).*
- *Carbon from the coke mixes with the iron.*

Stage 3: Steel making
in basic oxygen furnace



What happens?
- *Oxygen is injected to remove some carbon from the hot metal, but leaving enough to make steel.*
- *If making speciality steels then additional alloying agents are added at this point (eg. chromium for stainless steel).*

Coking coal from the West Coast of New Zealand is very high quality. A tonne of coke made from it produces just 40kg of ash during steel making. Other coking coals can produce more than 100kg of ash. Low ash improves the coke's efficiency, which means less coal is needed. This has many practical, financial and environmental benefits.



Steel making at New Zealand Steel.

Making steel with Huntly coal

New Zealand Steel runs the only mill in the world that produces steel from ironsands. As with other iron ores, ironsands are made up mostly of iron and oxygen atoms bonded together. However the atoms in ironsands are arranged in a way that cannot be separated by a conventional blast furnace. Researchers spent decades developing New Zealand Steel's technology specifically so they could make steel from ironsands deposits on the west coast of the North Island.

- Ironsands and thermal coal from Solid Energy's Huntly East Mine are gradually passed down a column that exposes the mixture to extreme heat. This turns the ironsands into a 'sponge iron' and gasifies some of the volatile compounds in the coal so that it becomes a carbon rich char. The gases and heat from the reaction are extracted and used to generate electricity for the plant.
- The sponge iron still contains impurities that must be removed before it can be converted into steel. It is then melted into molten iron, which allows carbon from the coal char to remove unwanted elements such as oxygen. This process also laces the iron with more than enough carbon to make steel.
- Some oxygen is added to the molten iron to drive out impurities such as sulphur and phosphorous. It also removes some, but not all, of the carbon in the iron so that the ratio is right to make steel.
- Manganese is then added to the molten metal, along with any other alloying agents needed to make speciality steels.