Australian Government
Department of Infrastructure and Regional Development
Bureau of Infrastructure, Transport and Regional Economics

Freightline 7 – Australian aluminium industry freight transport

The *Freightline* series is intended to provide information about where freight moves in Australia. This issue focusses on freight movements across the aluminium industry supply chain in Australia, and provides estimates of domestic bauxite, alumina and aluminium movements in 2014–15.

At a glance

- Australian bauxite production totalled 80.3 million tonnes in 2014–15, an increase of about 1 per cent over 2013–14. Of the total bauxite produced, around 75 per cent was used domestically to produce alumina, and the remaining 25 per cent exported. Bauxite exports contributed around $934 million to total Australian exports in 2014–15.
- Australian alumina production (refined bauxite) totalled around 19.9 million tonnes in 2014–15, a decrease of around 8 per cent over total alumina production in 2013–14. Around 86 per cent of total alumina produced in Australia in 2014–15 was exported directly with the rest used in domestic aluminium production. Alumina exports were worth around $6.3 billion in 2014–15.
- Total Australian aluminium production in 2014–15 was 1.6 million tonnes, a decrease of 7 per cent over the previous year's production. Most Australian aluminium is exported—around 1.4 million tonnes ($3.8 billion) in 2014–15—with the remainder used domestically.
- The total value of aluminium industry exports in 2014–15 (i.e. bauxite, alumina and aluminium) was $10.93 billion, approximately 3.9 per cent of total commodity exports by value.
- Due to the nature, structure and location of aluminium industry facilities, domestic freight movements of bauxite, alumina and aluminium are dominated by long-distance ship-based movements and shorter-haul movements by rail and/or road. Overall, the total combined volume of bauxite, alumina and aluminium moved domestically via ship was around 15.8 million tonnes in 2014–15.
- BITRE estimates the total domestic aluminium industry freight task was around 38.5 billion tonne kilometres in 2014–15, with sea freight comprising 35.3 billion tonne kilometres, road 1.8 billion tonne kilometres and rail 1.4 billion tonne kilometres. (There are also small volumes of bauxite moved by conveyer, which are not enumerated here.)

Introduction

The *Freightline* publication series aims to provide enhanced up-to-date analysis and estimates of freight movements for major Australian commodities, filling a significant and widely-acknowledged gap in transport data.

This issue focuses on where and how Australia's bauxite ore, alumina (refined bauxite) and the aluminium (smelted alumina) is transported from mines to export ports, including focussing on key elements of the aluminium supply chain—mining, refining and smelting. Estimates of aluminium-related freight movements for 2014–15 are presented.

The aluminium industry freight estimates have been derived by modelling movements of bauxite, alumina and aluminium across domestic supply chains. The information used to estimate movements have been derived from a wide range of publicly-available sources, including aluminium industry company annual reports and operating statistics, the Australian Aluminium Council, published national and state and territory mineral industry statistics, and relevant port authority annual reports.

The freight transport tasks considered in this issue cover only movements of aluminium and aluminium ores/compounds. Other by-products are not considered, nor does this issue consider movements of major inputs used at various stages of the aluminium productions process—for example, significant quantities of caustic soda (sodium hydroxide) are used in refining bauxite into alumina.

Regarding terminology, unless referring to specific bauxite, alumina and aluminium freight movements and/or supply chains, the combined movement of bauxite, alumina and aluminium are collectively referred to as 'aluminium industry freight transport'.

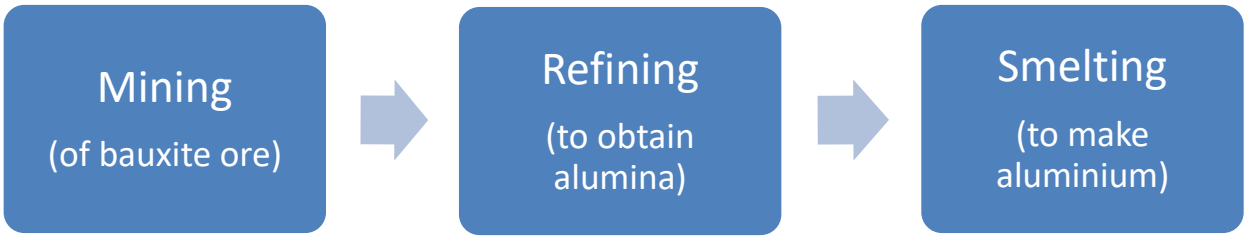
Aluminium industry in Australia

Aluminium is the third most abundant element and most abundant metal in the earth's crust, predominantly in the form of aluminium oxides or silicates. Bauxite (a varying combination of several aluminium hydroxides), is the main source of aluminium metal. Australia is one of the largest producers and has among the most abundant reserves of bauxite in the world.

Extraction of aluminium metal takes three main stages (see Figure 1):

- mining of bauxite ore;
- refining the ore to recover alumina (aluminium oxide); and
- smelting alumina to produce aluminium.

Figure 1 Stylised aluminium production process

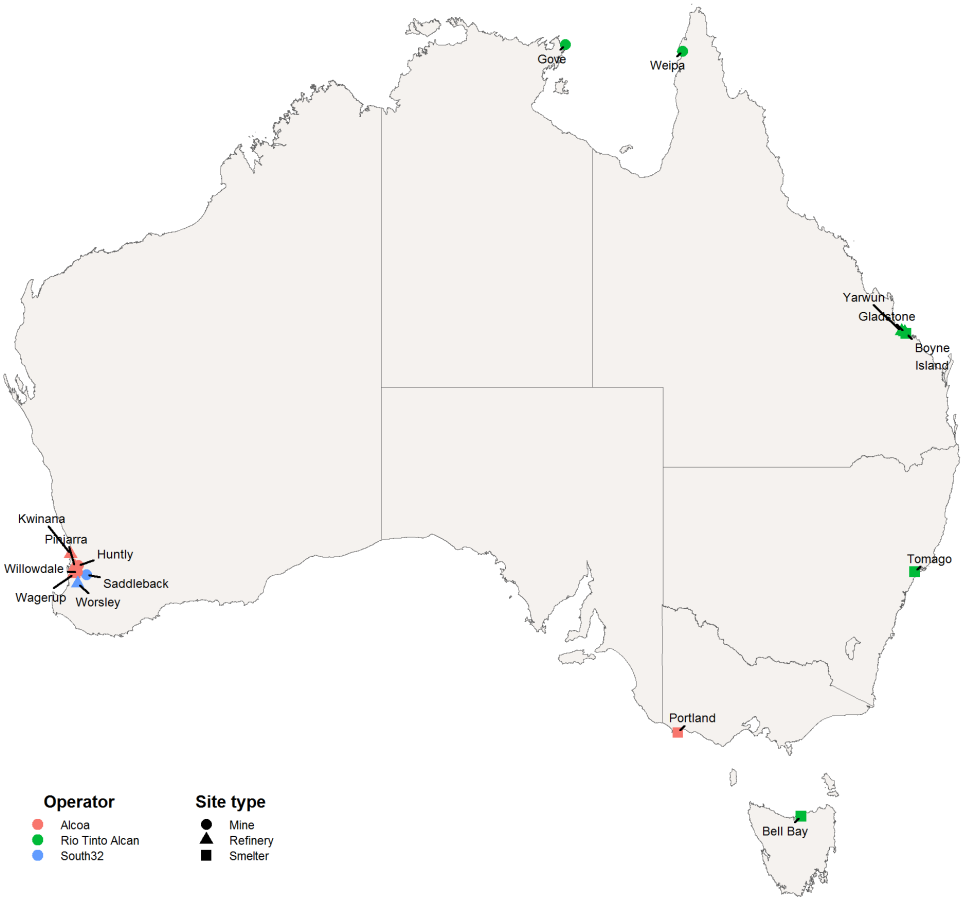


The aluminium industry has been operating in Australia for over 50 years. There are currently:

- 5 bauxite mines;
- 6 alumina refineries; and
- 4 aluminium smelters (AAC 2018).

Figure 2 shows the location and operator of mines, refineries and smelters in Australia in 2015—the operating ownership of these facilities have a direct impact on the pattern and volume of aluminium industry freight movements.

Figure 2 Australian aluminium industry mine, refinery & smelter locations, 2015



Bauxite production

Australia is the world's largest producer of bauxite followed by China, Brazil, Indonesia, India, Guinea and others. There are currently five operating mines in Australia:

- Gove (Northern Territory)
- Weipa (Queensland)
- Huntly & Willowdale (Western Australia)
- Saddleback (Western Australia)
- Boddington (Western Australia).

Bauxite mining generally involves preparation of the mining area, bauxite mining, crushing, ore transportation and rehabilitation. The total production of bauxite in Australia in 2014–15 was around 80.3 million tonnes. This was up 1 per cent on production in 2013–14, and up 12 per cent on total production in 2011–12. Table 1 and Figure 3, below, show estimated bauxite production by state/territory between 2011–12 and 2014–15 (Table 1), and by mine in 2014–15 (Figure 3).

Table 1 Australian bauxite production 2011–12 to 2014–15

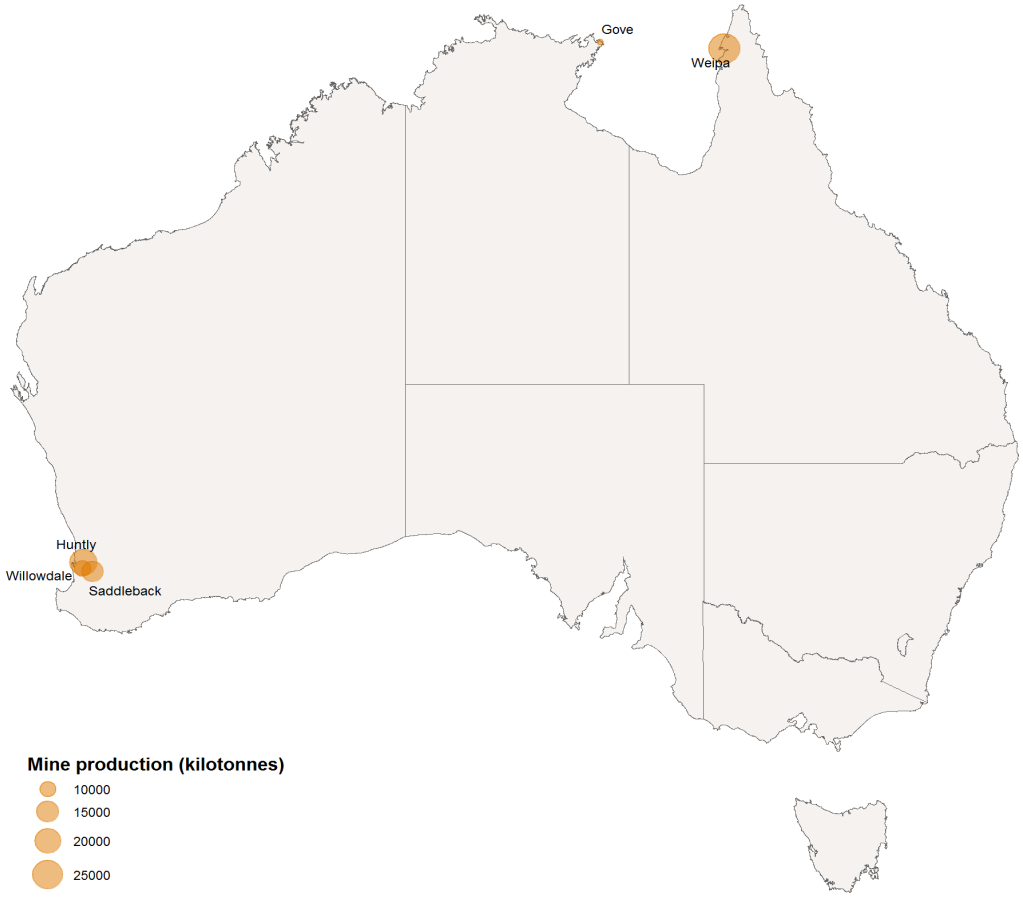
State	Location - Operators	2011–12	2012–13	2013–14	2014–15
		(kilotonnes)			
Western Australia	Saddleback/Boddington - South32 Huntly & Willowdale - Alcoa of Australia	42 433	44 795	45 673	46 001
Queensland	Weipa - Rio Tinto Alcan	21 563	25 280	26 237	27 434
Northern Territory	Gove - Rio Tinto Alcan	7 565	7 929	7 484	6 871
Australia		71 561	78 004	79 394	80 306

Sources: DIIS (2018), Rio Tinto Quarterly statements, Alcan Annual reports, BHP Annual reports and BITRE estimates.

The alumina/aluminium content of bauxite varies across mines. The bauxite at Gove and Weipa contains close to 50 per cent alumina whereas the bauxite extracted from Western Australian mines are relatively low grade, containing around 30 per cent alumina (AAC 2018).

Around 75 per cent of bauxite mined in Australia is used domestically, to produce alumina, and the remaining 25 per cent is exported.

Figure 3 Australian bauxite production 2014–15



Sources: DIIS (2018), Rio Tinto Quarterly statements, Alcan Annual reports, BHP Annual reports and BITRE estimates.

Alumina refining

Alumina is refined from bauxite typically using the Bayer refining process. Australia is one of the largest alumina producing nations and the largest alumina exporter. Total alumina production in Australia was around 19.9 million tonnes in 2014–15 (DIIS 2018), down slightly (8 per cent) on the previous year's production. Some of that drop in alumina production is attributable to increased direct bauxite exports. Most of the alumina produced is Australia is exported—around 87 per cent of total production in 2014–15—and the remainder used for domestic aluminium production (DIIS 2018).

There are currently six operating alumina refineries in Australia.[1] Their location, ownership (principle parent company) and production are shown in Table 2 (below). Alumina refineries are typically located either close to close to the upstream bauxite resource (e.g. Gove & Western Australian smelters) or close to the downstream smelter and associated energy supply (Gladstone alumina refineries), with the choice determined by a combination of energy and logistics costs (Thomas & Pei).

1. The Gove refinery was mothballed and placed under 'care and maintenance' in 2011–12. In late 2017, Rio Tinto announced that the refinery would be shutdown and dismantled (Garrick 2017).

Table 2 Australian alumina production 2011–12 to 2014–15

State	Location – Operators	2011–12	2012–13	2013–14	2014–15
		(kilotonnes)			
Western Australia	Worsely - South32 Kwinana, Pinjara & Wagerup - Alcoa of Australia	10 789	15 520	15 093	12 996
Queensland	Yarwun, Gladstone - Rio Tinto Alcan	6 019	6 125	6 439	6 899
Northern Territory	Gove - Rio Tinto Alcan	2 475	0	0	0
Australia		19 283	21 645	21 532	19 895

Sources: DIIS (2018), Rio Tinto Quarterly statements, Alcan Annual reports and BHP Annual reports.

Aluminium smelting

Aluminium is extracted from alumina via an electrolytic process whereby alumina is dissolved in solution and electricity passed through the solution to extract aluminium metal.

Principal uses of aluminium include:

- building and construction
- transport
- heating and ventilation
- packaging
- electrical and communications infrastructure.

There are currently four operating smelters in Australia, all located along the coastline in areas with reliable and available electricity supply. The location, ownership (principle parent company) and production are presented below in Table 3.[2]

Table 3 Australian aluminium production, 2011–12 to 2014–15

State	Location – Operator(s)	2011–12	2012–13	2013–14	2014–15
		(kilotonnes)			
New South Wales	Tomago - Rio Tinto Alcan	542	553	573	585
	Kurri Kurri - (closed in 2012) –Hydro Aluminium	170	26	0	0
Victoria	Portland - Alcoa of Australia	296	296	295	294
	Point Henry (closed in 2014) - Alcoa of Australia	175	180	140	0
Queensland	Boyne Island - Rio Tinto Alcan	567	546	575	582
Tasmania	Bell Bay - Rio Tinto Alcan	187	187	189	186
Australia		1 937	1 788	1 773	1 647

Sources: DIIS (2018), Rio Tinto Quarterly statements, Alcoa Annual reports and BITRE estimates

Total Australian aluminium production was 1.6 million tonnes in 2014–15, which was down approximately 7 per cent on production in 2013–14. Note that some of the production figures are approximated by subtracting total known production of other smelters from reported total Australian production and allocating the remainder according to known smelter capacities.

Exports

Aluminium, alumina and bauxite are exported to various destinations every year. In 2014–15, Australia exported 20.2 million tonnes of bauxite worth around $934 million, 17.4 million tonnes of alumina worth $6.3 billion and 1.4 million tonnes of aluminium creating exports of $3.8 billion (DIIS 2018).

Bauxite exports increased by around 33 per cent between 2013–14 and 2014–15, mostly to China, while the exports of alumina and aluminium decreased slightly, by around 7 and 9 per cent, respectively over the same period (see Table 4, below).

2. Table 3 also shows recently closed production facilities—Point Henry (Victoria), which was closed in July 2014, and Kurri Kurri (New South Wales), which was closed in October 2012.

Table 4 Australian bauxite, alumina and aluminium export volumes, 2011–12 to 2014–15

Commodity	2011–12	2012–13	2013–14	2014–15
		(kilotonnes)		
Bauxite	10 518	12 567	15 146	20 204
Alumina	16 592	18 914	18 614	17 363
Aluminium	1 693	1 569	1 576	1 432

Sources: DIIS (2015, 2016, 2018).

Aluminium industry transport patterns and freight volumes

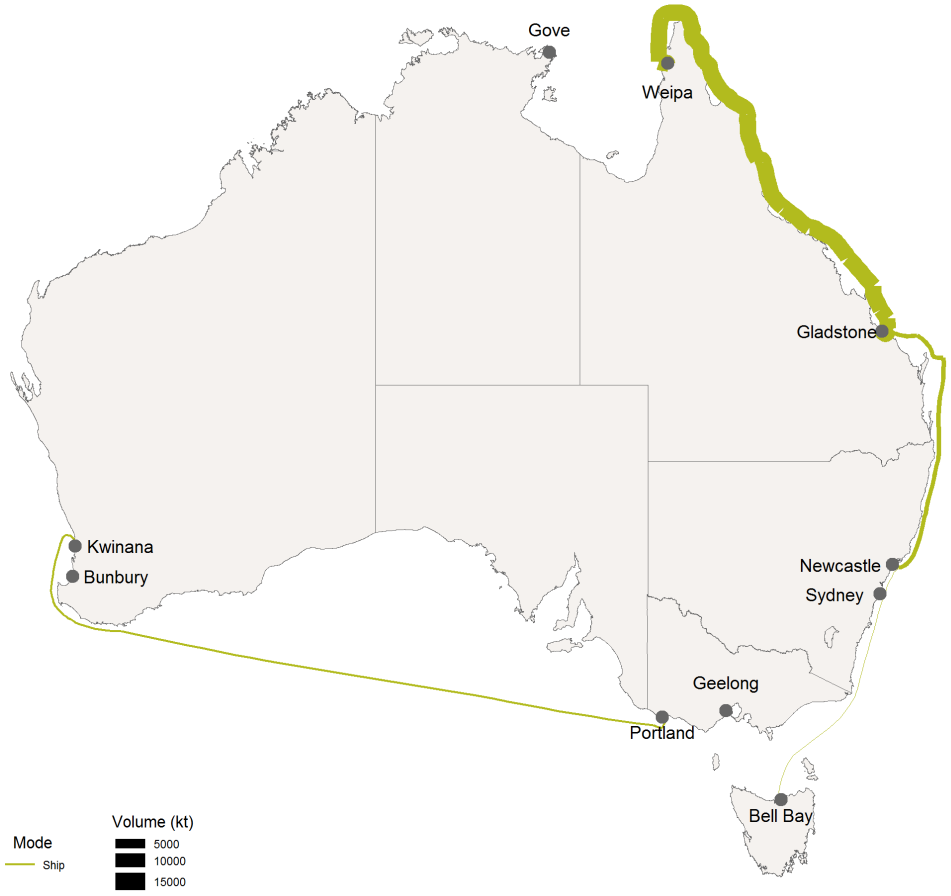
The purpose of the *Freightline* series is to illustrate where and how freight moves. Figures 4 & 5 provide an illustration of the size and scope of aluminium industry freight movements across Australia in 2014–15. It has been derived by modelling flows between bauxite mines, alumina refineries, aluminium smelters and export ports. Note that the export activity is not illustrated in these figures.

Transport of bauxite primarily involves movement from mine to a port for exportation purposes or to be delivered to another domestic port and the rest being transported to a refinery to be converted to alumina. Once alumina is produced, it is either transported to a smelter to be processed to aluminium or transported to a port for export or for domestic transportation. Aluminium from smelters are mostly destined for export and there is only a small domestic transport task because most smelters are located either close to or within ports precincts. It is important to note that the transport of bauxite to refineries and then to smelters are largely dependent on who operates and owns the facilities because individual companies generally have vertically integrated bauxite–alumina–aluminium operations, transporting products to owned or affiliated facilities.

The modelled results illustrate the flow of bauxite from mines to refineries or ports, alumina from refineries to smelters or ports, and aluminium from smelters to ports. The movement from ports would be either to overseas export or to another domestic port.

Domestic transport of bauxite and alumina is predominantly by sea, because of proximity of mines and refineries to ports and the lower costs of sea freight transport (see Figure 4). Figure 5 shows the only significant rail and road freight movement are in Western Australia, where the existing bauxite mines are located some distance inland.

Figure 4 Bauxite, alumina and aluminium transport movements, by sea, 2014–15



Source: BITRE estimates.

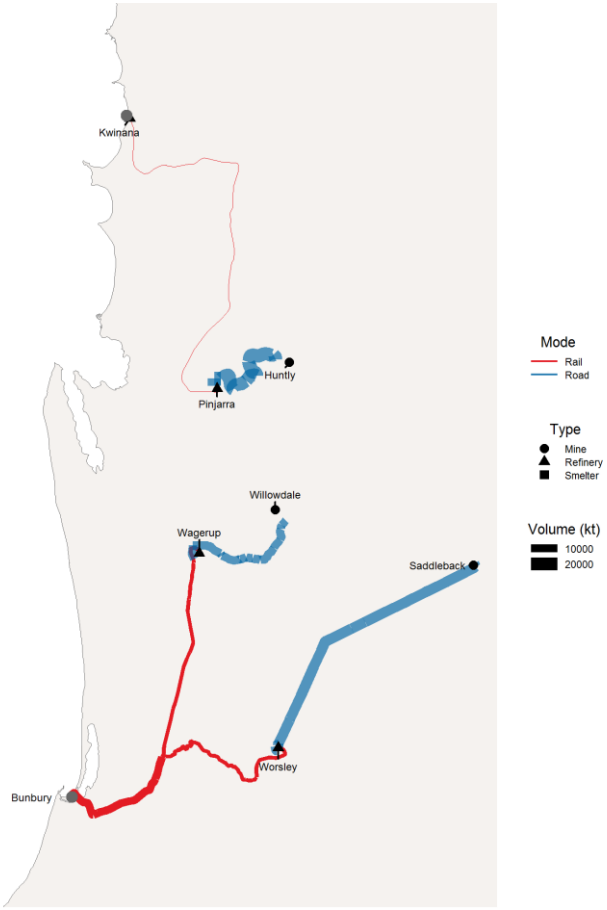
Overall, the total freight volume of combined bauxite, alumina and aluminium via sea for 2014–15 was around 15.8 million tonnes. Total sea freight tonne-kilometres was 35.3 billion tonne kilometres, with road and rail being 1.8 million tonne kilometres and 1.4 billion tonne kilometres, respectively (see Table 4 below).

Table 4: Estimated combined bauxite, alumina and aluminium transport flows, by mode, Australia wide

Jurisdiction	Sea	Road	Rail	Total
	(million tonne kilometres)			
Total - Australia wide	35 311	1 757	1 448	38 516

Source: BITRE estimates.

Figure 5: Bauxite and alumina road and rail freight movements, Western Australia, 2014–15



Source: BITRE estimates

Other issues

The estimates of bauxite, alumina and aluminium flows presented earlier are based on their annual production and exports in 2014–15 and do not take into account variation in demand for transport services and transport infrastructure capacity across different years or different parts of the year.

Concluding remarks

This *Freightline* issue attempts to provide information about bauxite, alumina and aluminium freight movements in Australia. The estimates presented in the paper are based on modelled bauxite, alumina and aluminium flows—from mines to export ports/refineries and smelters — based on assumptions about the proximity of sites, transport costs, transport service availability and ownership of facilities. Consequently, the flows are indicative estimates of likely freight movements and may not reflect the actual modal pattern and volume of bauxite, alumina and aluminium movements. Nonetheless, these estimates are, as far as BITRE is aware, the most up-to-date publicly-available estimates of Australian aluminium supply chain transport volumes.

References

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AAC—see Australian Aluminium Council Ltd

DIIS—see Department of Industry, Innovation and Science

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Abbreviations

tkm tonne kilometres (equivalent to one tonne moved one kilometre)

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