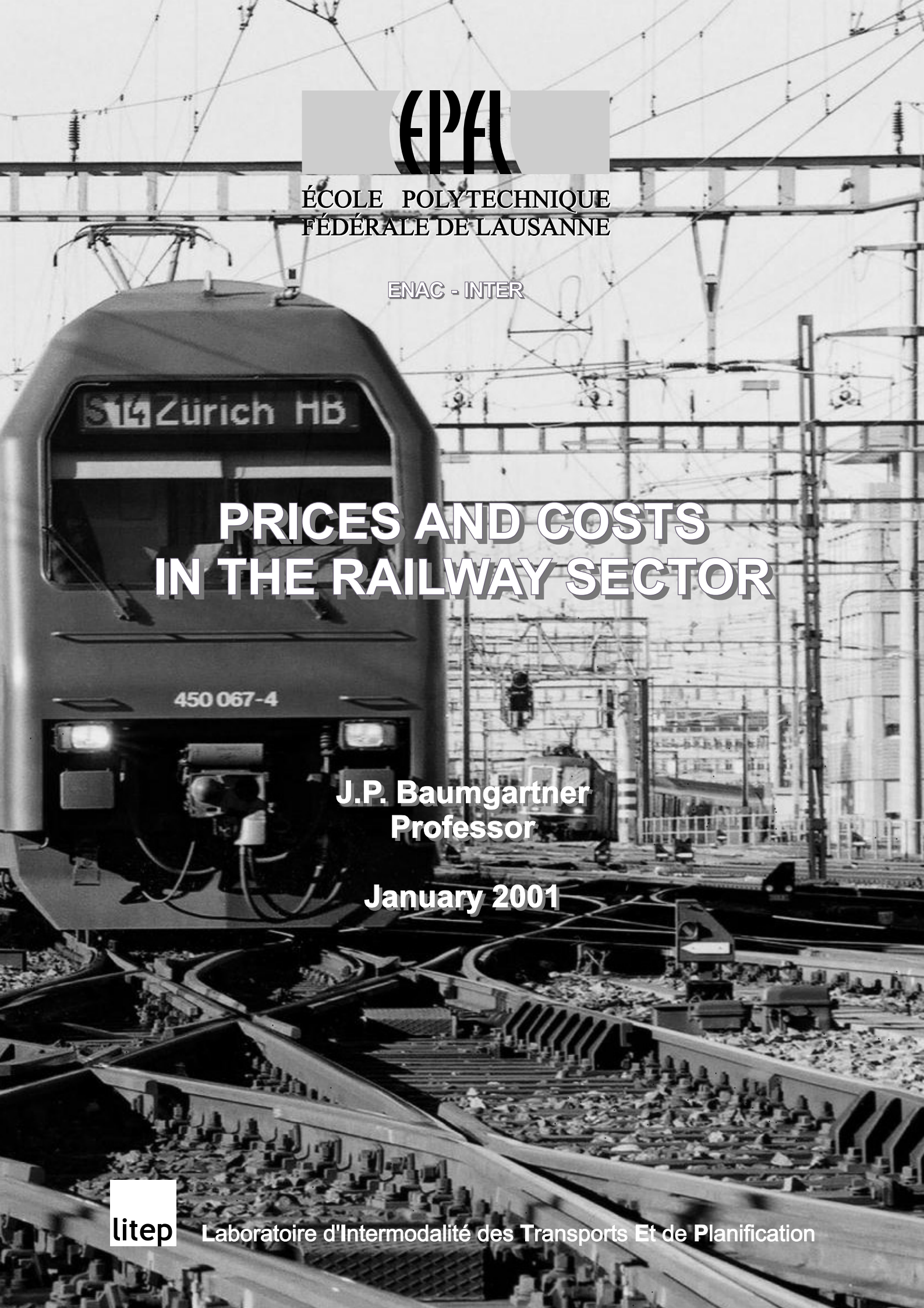

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

ENAC - INTER

PRICES AND COSTS IN THE RAILWAY SECTOR

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1. FOREWORD

While preparing a decision one must begin by seeking out relevant orders of magnitude. From the beginning, it is important to know whether a piece of equipements costs 1, 10 or 100 million (euros, dollars, etc.).

This paper gives some examples of reference points and orders of magnitude.

It is not a price list.

This document should not be used to undertake a financial and economic study. A financial and economic calculation must take account only of computed costs in each specific case on the basis of the answers to calls for tenders.

2. PRELIMINARY REMARKS

2.1 The railway equipment market

Our sample of price and cost indicators is limited to the investments in railway equipment (infrastructure, fixed installations and rolling stock) and to the consumption of traction energy.

Railway equipment is made up of a large number of different objects. Every item is produced to various specifications.

There are few purchasers and suppliers of railway equipment. The purchasers are firms or organizations that own and maintain railway infrastructures, and railway operators. The suppliers are multinational industrial corporations. Some of them have concluded arrangements at world-wide level.

Oligopolies are the rule. The purchasers and the suppliers play according to the game theory.

Given those circumstances, the prices of any railway equipment item are widely scattered.

2.2 Figures and scenarios

This paper sets out orders of magnitude for prices and costs expressed in euros (EUR) or U.S. dollars (USD) on the price level and under overall economic conditions in 2000.

Prices and costs refer to the purchase, construction, maintenance and operation of equipment according to the state of the art in 2000.

Each price and each cost is mentioned with an average of median value and two extreme values in brackets (a lower and an upper limit). The reader will interpret the average or median value as he or she sees fit. The limits in brackets do not take account of special or exceptional cases.

In as much as possible, the economic life figures or life-cycle figures given for equipment take account of wear and obsolescence, and of the limited timeframe of forecasts.

3. INFRASTRUCTURES AND FIXED EQUIPMENT

3.1 Linear infrastructures and equipment

This section covers main tracks (including through stations) and parallel equipment (excluding station installations, which are covered in a separate). All other things being equal, prices and costs apply to all gauges (from 1,000 to 1,676 mm).

3.1.1 Studies

		[10^6 EUR/km of line]
a) Feasability study	0.001	(0.0005 to 0.01)
b) Preliminary study	0.01	(0.005 to 0.1)
c) Project	1% of the investment budget	(0.3 to 3%)

In the case of a project (c), the price does not include the thorough and detailed technical specifications necessary in order to build or supply the equipment.

3.1.2 Land and rights

3.1.2.1 Investments

	[10^6 EUR/km of line] (single or double track)	
a) In an uninhabited region	0.001	(0 to 0.1)
b) Depending on the population density :		
10 inhabitants/km^2	0.1	(0.01 to 1)
100 inhabitants/km^2	3	(1 to 10)
1000 inhabitants/km^2	10	(3 to 30)

3.1.3 Infrastructure

3.1.3.1 Investments

Type of track	max. speed [km/h]	easy topography [10^6 EUR/km]	topography of average difficulty [10^6 EUR/km]	difficult topography [10^6 EUR/km]
single track	100	2 (1 to 3)	5 (3 to 15)	20 (15 to 40)
double track on a single formation	100	2 (1 to 4)	7 (3 to 20)	20 (20 to 50)
	300	3 (2 to 6)	10 (6 to 30)	40 (20 to 50)

Investments include the following items :
- work management,
- preparation of the ground; deforestation, etc.,
- rerouting of roads,
- embankments (fills, excavated material, track bed, etc.),
- drainage, protection against frost,
- protecting structures,
- structures : walls, water ducts, bridges, tunnels,
- overpasses and underpasses,
- noise barriers and other noise-protection equipment and structures,
- fences,

– service access roads, trails and lanes,
– interim financial charges,
– general expenses,
– initial additional maintenance.

Some specific elements :

a) Bare tunnels :	[**10^6 EUR/km of track**]	
– single track	20	(10 to 50)
– double track	30	(20 to 70)
b) Bridges and viaducts :	[**10^6 EUR/km of track**]	
– short span and/or easy foundation	15	(10 to 20)
– long span and/or difficult foundation	30	(20 to 50)
c) Crossing of a railway line with a road :	[**10^6 EUR/unit**]	
– road overpass	3	(2 to 7)
– road underpass	6	(3 to 10)
d) Crossing a motorway :	[**10^6 EUR/unit**]	
– overpass or underpass	6	(4 to 15)
e) Walls and other noise-protection structures	[**10^6 EUR/km of line**]	
– on one side of the track(s)	0.7	(0.2 to 2)
– on both sides of the track(s)	1.4	(0.4 to 4)

3.1.3.2 Economic life

		[**years**]
– tunnels	100	(50 to 100)
– steel bridges	50	(50 to 80)
– concrete bridges	50	(50 to 100)
– underpasses and overpasses	50	(50 to 100)

3.1.3.3 Maintenance costs

Yearly maintenance costs, long term average (economic life or life cycle), at the prices applicable as of the date of commissioning of the equipment (**yearly percentage of the investment**) :

– embankments, cuttings	0.5%	(0 to 1%)
– drainage structures	2%	(1 to 3%)
– walls	0.5%	(0.1 to 1.5%)
– steel bridges	1.5%	(1 to 2%)
– concrete bridges	1%	(0.1 to 2%)
– tunnels	0.5%	(0.1 to 2%)

3.1.4 Track

Ballast, sleepers or crossters, rail fastenings, rails, welds or fish-platings, laying, initial additional maintenance, etc.

3.1.4.1 Investment

	[**10^6 EUR/km of track**]	
Rail mass		
– 50 kg/m	0.3	(0.2 to 0.4)
– 60 kg/m	0.4	(0.3 to 0.5)
– 70 kg/m	0.5	(0.4 to 0.6)

When replacing an existing track, add the cost of dismantling and removing the existing track, thus :

[10^6 EUR/km of track]	
0.2	(0.1 to 0.3)

3.1.4.2 Economic life of a main track

Time interval, in years, between two full renewals :

	gross traffic (including locomotives) on one track (gross tonnes-kilometres or GTK)			
rail section, kg/m	10×10^3 GTK/day 2.5 to 3.6×10^6 GTK/year	30×10^3 GTK/day 7.5 to 11×10^6 GTK/year	100×10^3 GTK/day 25 to 36×10^6 GTK/year	300×10^3 GTK/day 75 to 108×10^6 GTK/year
50	40 (30 to 50)	20 (15 to 30)	10 (8 to 20)	–
60	–	25 (20 to 30)	12 (10 to 25)	6 (4 to 12)
70	–	–	–	7 (5 to 14)

All other things being equal, the lower the mass per axle and the greater the curve radius, then the longer the economic life of a main track.

3.1.4.3 Track maintenance costs

Long-term annual average in 10^3 EUR per km of main track and year :

	gross traffic (including locomotives) on one track (gross tonnes-kilometres or GTK)			
max. speed, km/h	10×10^3 GTK/day 2.5 to 3.6×10^6 GTK/year	30×10^3 GTK/day 7.5 to 11×10^6 GTK/year	100×10^3 GTK/day 25 to 36×10^6 GTK/year	300×10^3 GTK/day 75 to 108×10^6 GTK/year
100	7 (5 to 10)	15 (10 to 20)	30 (20 to 40)	60 (40 to 80)
300	–	20 (10 to 30)	40 (20 to 60)	–

All other things being equal :

– the higher the mass per axle,

– the lower the curve radius,

– the higher the authorized maximum speed,

then the higher the track maintenance costs.

3.1.5 Fixed equipment for electric traction

3.1.5.1 Investments

a) Traction substations :

	[10^6 EUR/MVA]	
Traction current :		
– AC 25 kV, 50 Hz or 60 Hz	0.2	(0.15 to 0.3)
– AC 15 kV, 16 2/3 Hz	0.3	(0.2 to 0.5)
– DC 3 kV or 1.5 kV	0.3	(0.2 to 0.5)

b) Catenary

In **10^6 EUR per km of track** :

	maximum speed, km/h	
traction current	100	300
AC 25 kV, 50 or 60 Hz AC 15 kV, 16 2/3 Hz	0.15 (0.1 to 0.2)	0.2 (0.15 to 0.3)
DC 3 kV DC 1.5 kV	0.17 (0.12 to 0.3) 0.2 (0.15 to 0.3)	– –

All other things being equal, the smaller the curve radius then the higher the investment in the catenary.

The electrification of an existing line also requires the following investments :

	[**10^6 EUR/km of track**]	
a) The putting-up of the "electrification gauge" (for example lowering the floor in tunnels, raising overpasses, etc.)	1	(0.1 to 5)
b) Modification of signalling equipment along the track and in stations, and telecommunications equipment	1	(0.1 to 2)

3.1.5.2 Economic life

	[**years**]	
a) Traction substations :		
– civil engineering	60	(40 to 80)
– electric equipment	40	(20 to 50)
b) Catenary	40	(30 to 50)
of which contact wire(s)	—	(5 to 30)

3.1.5.3 Maintenance costs

Annual maintenance costs, long-term average, at the price level on the date of the commissioning of the equipment (**yearly percentage of the investment**) :

a) substations	2%	(1 to 3%)
b) catenary	2%	(1 to 3%)

3.1.6 Signalling

3.1.6.1 Investments

a) Cables (signalling and telecommunications)	[**10^6 EUR/km of line**]	
– on a low traffic line	0.05	(0.03 to 0.1)
– on a high-traffic line	0.1	(0.05 to 0.3)
b) Automatic block system (without cables) (see under (a))	[**10^6 EUR/block section**]	
– per block section used in one direction	0.15	(0.1 to 0.3)
– per block section used in both directions (single track or two-way working track)	0.3	(0.2 to 0.5)

c) Spot repetition of signals (automatic train protection or advanced train protection, or ATP)

		[10^6 EUR/unit]
– per signal	0.02	(0.01 to 0.04)
– per traction unit	0.03	(0.01 to 0.05)

d) Cab signal (automatic train control or ATC) with transmission by track circuit or by cables laid in the track

		[10^6 EUR/unit]
– per block section	0.3	(0.2 to 0.4)
– per traction unit	0.05	(0.03 to 0.1)

The investments required by the equipments (EUROCAB, EUROBALISE, EURO-RADIO, etc.) of the future common European signalling system (European Train Control System or ETCS) and of the future North American communication based traffic control system (CBTCS) are not yet known.

e) Radio link between the dispatcher and the trains

		[10^6 EUR/km]
– per km of line	0.015	(0.01 to 0.02)
– per traction unit	0.04	(0.03 to 0.05)

f) Level crossing with light and acoustic signals

	[10^6 EUR/unit]
0.03	(0.02 to 0.04)

g) Level crossing with automatic half barriers

		[10^6 EUR/unit]
– on a single-track line	0.2	(0.2 to 0.4)
– on a double-track line	0.3	(0.3 to 0.5)

h) Level crossing with four automatic barriers 0.7 (0.3 to 1.0)

3.1.6.2 Economic life

		[years]
All safety and signalling equipment	30	(15 to 40)

3.1.6.3 Maintenance costs

Annual maintenance costs, long-term average, at the price level on the date of the commissioning of the equipment (yearly percentage of the investment)

4% (3 to 6%)

3.2 Spot fixed equipment

These include :

– stations,

– locomotive service and light repair facilities,

– maintenance shops for rolling stock, track, etc.

Unless otherwise indicated, the prices and costs given below include all infrastructures and fixed equipments (track, catenary, signalling, telecommunications, buildings, etc.), including interim financial charges and general expenses.

3.2.1 Investments

3.2.1.1 Points, switches, turnouts, crossings

Equipment, assembly and laying; without control and command equipment.

		[10^3 EUR/unit]
– large-angle turnout (tg 0.11 to 0.13) (1:8 to 1:9)	50	(40 to 80)
– double diamond crossing with slips (tg 0.11 to 0.13) (1:8 to 1:9)	130	(120 to 160)
– small-angle turnout (tg 0.06 to 0.05) (1:16 to 1:20)	130	(120 to 150)

When replacing an existing point, turnout, etc., add 25% (20 to 30%) for the dismantling and removal of the equipment being replaced.

3.2.1.2 Stations

	[10^6 EUR/unit]	
a) Intermediate station with passing track on a single-track line, without signalling and without any other equipment	1	(0.5 to 2)
b) Intermediate station with one passing track on a single-track line, with interlocking and signalling, without any other equipment	3	(2 to 6)
c) A pair of connections (4 turnouts) between the two tracks of a double track line, with signalling, remote control (CTC, etc.)	10	(5 to 15)
d) Double-track service station (2 pairs of connections and 2 passing tracks) with signalling, etc.	30	(20 to 40)
e) Fly-over	15	(10 to 30)
f) A large passenger station	200	(50 to 500)
g) A single-hump classification yard (receiving tracks, classification tracks, departure tracks, additional sidings, etc.)	300	(100 to 500)
h) A terminal for international or continental combined transport	100	(50 to 200)

3.2.1.3 Service and light repair facilities

	[10^6 EUR/unit]	
– per allocated locomotive	0.2	(0.1 to 0.4)
– per allocated multiple unit set	0.7	(0.3 to 1.5)

3.2.1.4 Maintenance and heavy repair shops for rolling stock

10% (5 to 15%)
or the purchase price of the vehicles to be maintained

3.2.1.5 Central shops for the maintenance of fixed equipment

10% (5 to 15%)
of the purchase price of the equipment to be maintained

3.2.2 Economic life

		[**years**]
– buildings, platforms, ramps	50	(30 to 100)
– roads, parking lots :		
· infrastructure	50	(30 to 80)
· pavement	10	(5 to 20)
– hydraulic equipment	50	(30 to 60)
– signalling equipment	30	(15 to 50)
– telecommunications equipment	20	(10 to 30)
– low-voltage electric equipment	30	(20 to 40)
– informatic equipment	4	(3 to 5)
– machinery, mechanical equipment	20	(10 to 30)
– tools	10	(5 to 15)
– points, switches, turnouts, crossings : half the economic life of main track (see under 3.1.4.2)		

3.2.3 Maintenance costs

Annual maintenance costs, long-term average, at the price level of the date of the commissioning of the equipment (**yearly percentage of the investment**) :

– buildings, platforms	1%	(0.5 to 2%)
– roads, parking lots :		
· infrastructure	0.3%	(0.1 to 0.5%)
· pavement	3%	(2 to 5%)
– hydraulic equipment	1%	(0.5 to 2%)
– signalling equipment	5%	(2 to 10%)
– telecommunications equipment	10%	(5 to 15%)
– informatic equipment	10%	(5 to 15%)
– low-voltage electrical equipment	3%	(1 to 5%)
– machinery, mechanical equipment	5%	(2 to 10%)
– points, switches, turnout, crossings	10%	(5 to 15%)

4. VEHICLES

All other things being equal, the prices and the costs apply to the rolling stock of all gauges (from 1,000 to 1,676 mm).

4.1 Electric traction units

Average ratio of the number of traction units available to the operating department (i.e. traction units in good condition) to the total fleet (including traction units being serviced, under repair, being overhauled and awaiting service, repair or overhaul), or availability coefficient :

– electric locomotives	90%	(85 to 95%)
– electric multiple units (EMU) and trainsets	85%	(80 to 90%)

4.1.1 Investments

4.1.1.1 Electric locomotives

The following adjustment may be helpful :

P_L = investment, i.e. average or median price of an electric locomotive, 10^6 EUR/unit

W = continuous output or rating at wheel-rim, MW

$$P_L = \frac{W}{3} + 1$$

For example, the average or median price of a 6 MW electric locomotive is 3×10^6 EUR.

Most prices are within an interval of $P_L \pm 20\%$.

Locomotives operating with several current supply systems (voltage, frequency) are more expensive.

4.1.1.2 Electric multiple unit (EMU) and trainsets

The following adjustment may be helpful :

P_M = investment, i.e. average or median price of an electric multiple unit (EMU) or trainset, 10^6 EUR/unit.

W = output or rating of the EMU or trainset, MW

$P_M = 2\ W + 2$

For example, the average or median price of a 8 MW EMU or trainset is 18×10^6 EUR.

Most prices are within an interval of $P_M \pm 20\%$.

The highest prices concern :

– EMU or trainsets operating with several current supply systems (voltage, frequency),

– tilting EMU and trainsets,

– double-deck EMU and trainsets.

4.1.2 Economic life

	[**years**]	
Locomotives, EMU and trainsets	30	(15 to 40)
or	[**10^6 km/unit**]	
	5	(4 to 8)

4.1.3 Maintenance costs

The following adjustments may be helpful.

4.1.3.1 Electric locomotives

E_L = maintenance and repair costs (routine maintenance, periodic maintenance, general overhauls, repairs), long-term average (life-cycle maintenance costs), EUR/km-locomotive

P_L = investment price of the electric locomotive, 10^6 EUR (see under 4.1.1.1)

$E_L = 0.2\ P_L$

For example, for $P_L = 3 \times 10^6$ EUR,

E_L = 0.6 EUR/km-locomotive

Most instances are within an interval of $E_L \pm 20\%$.

4.1.3.2 Electric multiple units (EMU) and trainsets

E_M = maintenance and repair costs, life-cycle average, EUR/km-EMU or km-trainset

P_M = investment in the EMU or trainset, 10^6 EUR (see under 4.1.1.2)

$E_M = 0.3\ P_M$

For example, for $P_M = 18 \times 10^6$ EUR,

E_M = 5.4 EUR/km

Most instances are within an interval of $E_M \pm 20\%$.

4.2 Diesel locomotives

Approximate equivalences of different definitions of the rating or output of a diesel locomotive :

a) Power available from the diesel motor for traction in accordance with North American standards, expressed in horsepower (HP) :

   1 HP will deliver ~0.6 kW at wheel-rim

b) Power at wheel-rim expressed in kW :

   1 kW at wheel-rim requires ~1.7 HP of power available from the diesel motor for traction in accordance with North American standards.

   Outside North America, the rating or output of the diesel motor of the locomotive is often expressed in kW or MW. The rating or the output of the diesel motor for traction should not be mixed up with the rating or output of the locomotive at wheel-rim. Both may be measured in kW or MW, but the nominal rating or output of the diesel motor is approximately equal to 1.25 × the rating or output at the wheel-rim, and the rating or output at the wheel-rim is approximately equal to 0.8 × the rating or output of the diesel motor.

4.2.1 Investments

Average ratio of the number of diesel locomotives in good condition available to the operating department to the total fleet (including diesel locomotives being maintained, overhauled or repaired, or awaiting maintenance, overhaul or repair) or availability coefficient

90% (85 to 95%)

4.2.1.1 North American-built diesel locomotives for use on North American railroads

Those locomotives have an axleload of 65,000 to 80,000 lbs. (30 to 36 metric tonnes).

	[10^6 USD/unit]	
– locomotives with a nominal rating of 3,000 to 4,000 HP (1.8 to 2.4 MW at wheel-rim)	1.5	(1.2 to 1.8)
– locomotives with a nominal rating of 4,000 to 6,000 HP (2.4 to 3.6 MW at wheel-rim)	2	(1.7 to 2.3)

4.2.1.2 North American-built diesel locomotives for export

	[USD/HP]	
Axle load generally equal to or less than 23 metric tonnes	600	(500 to 800)

4.2.1.3 Non-North American-built diesel locomotives

	[EUR/kW at wheel-rim]	
– locomotives	1200	(1000 to 1500)
– two axle shunting locomotives or switchers	2000	(1500 to 2500)

4.2.2 Economic life

	[years]	
of a diesel locomotive	20	(15 to 30)
or	[10^6 EUR/locomotive]	
	2.5	(2 to 4)
or	[hours operating/locomotive]	
	70,000	(50,000 to 100,000)

4.2.3 Maintenance costs

Average long-term or life-cycle maintenance costs (routine maintenance, periodic maintenance, general overhauls, repairs)

	[USD/locomotive-mile] [1 mile = 1.6 km]	
– North American-built diesel locomotives for use on North American railroads	1	(1 to 1.5)
	[EUR/km-locomotive]	
– mainline diesel locomotive outside North America	2	(1.5 to 2.5)
	[USD/locomotive-hour][1)]	
– North American-built switcher for use on North American railroads	15	(10 to 20)
	[EUR/locomotive-hour][1)]	
– diesel shunting locomotive outside North America	25	(20 to 40)
– two-axle shunting locomotive	10	(7 to 25)

[1)] operation hours with a driver

4.3 Coaches, passenger cars

Average ratio of the number of coaches or passenger cars in good condition available to the operating department to the total fleet (including coaches or passenger cars being maintained, overhauled or repaired, or awaiting maintenance, overhaul or repair) or availability coefficient :

85% (80 to 90%)

4.3.1 Investments

	[10^6 EUR/vehicle]	
– coach or passenger car	1.3	(1.0 to 1.6)
– double-deck coach or passenger car	1.6	(1.4 to 2)
– couchette coach	1.5	(1.3 to 1.7)
– sleeping car	1.6	(1.4 to 2)
– double-deck sleeping car	2.3	(2.1 to 2.5)
– dining car	2	(1.8 to 2.2)

4.3.2 Economic life

	[years]	
Coaches, passenger cars	25	(15 to 40)
or	[10^6 km/vehicle]	
	3	(2 to 4)

4.3.3 Maintenance costs

Maintenance costs (routine maintenance, periodic maintenance, general overhauls, repairs), long-term or life-cycle average

	[EUR/km-vehicle]	
– coach or passenger car	0.25	(0.2 to 0.3)
– double-deck coach or passenger car	0.3	(0.25 to 0.35)
– couchette coach	0.3	(0.25 to 0.35)
– sleeping car	0.4	(0.3 to 0.5)
– dining car	0.4	(0.3 to 0.5)

4.4 Wagons or freight cars

Average ratio of the number of wagons or freight cars in good condition available to the operating department to the total fleet (including wagons or freight cars being maintained, overhauled and repaired, or awaiting maintenance, overhaul or repair) or availability coefficient :

90% (85 to 95%)

4.4.1 Investments

4.4.1.1 European wagons

Y 25 bogies or interchangeable bogies, two brake blocks or shoes per wheel, maximum axle load 22.5 metric tonnes

	[10^3 EUR/wagon]	
– sliding-wall wagon	120	(100 to 140)
– open wagon	65	(50 to 75)

– flat wagon	65	(50 to 75)
– hopper wagon	75	(60 to 90)
– covered hopper wagon	80	(70 to 100)
– hood wagon for the transport of coils	80	(70 to 100)
– tank wagon for oil products	50	(40 to 60)

4.4.1.2 North American-built freight cars

Automatic couplers, one brake shoe per wheel, three pieces articulated trucks, maximum axle load of 63,000 or 71,500 lbs. (30 or 32.5 metric tonnes).

	[10^3 USD/car]	
– box, special service (hi-cube, auto parts, etc.)	70	(60 to 80)
– flat	45	(40 to 50)
– flat, special service	50	(40 to 100)
– mill gondola	50	(40 to 60)
– coal gondola	50	(40 to 60)
– open hopper	50	(40 to 60)
– covered hopper	55	(50 to 60)
– coil shield	70	(65 to 75)
– tank	40	(35 to 50)
– bi-level automobile carrier	50	(45 to 55)
– fully enclosed tri-level autorack	120	(100 to 130)

4.4.2 Economic life

	[years]	
Wagons or freight cars	20	(10 to 30)
or	[10^6 km/wagon or car]	
	1	(0.5 to 1.5)

4.4.3 Maintenance costs

Long-term or life-cycle average maintenance costs (routine maintenance, periodic maintenance, general overhauls, repairs)

	[EUR/km-wagon]	
– overall average, European wagons	0.07	(0.05 to 0.13)
	[USD/freightcar-mile]	
– overall average, North American freightcars (1 mile = 1.6 km)	0.1	(0.05 to 0.15)

4.5 Equipment for combined transport

4.5.1 Investments

	[10^3 EUR/unit]	
a) Rolling stock, wagons :		
– flat for containers	65	(50 to 80)
– articulated flat for containers, 32 m	100	(80 to 110)
– pocket for a semi-trailer	85	(70 to 100)
– low-loader wagon with two 4-axle bogies for the transport of lorry-trailer combinations	130	(120 to 140)
– low-loader wagon with two 5-axle bogies or articulated with three 4-axle bogies for the transport of lorry-trailer combinations	160	(150 to 180)

		[10^3 USD/car]
– North American flat car for the transport of 2 semi-trailers	45	(40 to 50)
– North American stand-alone double-stack well car	70	(60 to 80)
– North American double-stack three well articulated car	140	(130 to 150)
– North American double-stack five well articulated car	200	(180 to 220)
b) Other equipments		[10^6 EUR/unit]
– road gantry crane for handling containers, etc.	0.5	(0.3 to 1)
– rail gantry crane for handling containers, etc.	2	(1 to 3)
– forklift truck for handling containers	0.5	(0.3 to 1)
		[10^3 EUR/unit]
– 20' (6 m) ISO container	4	(2.5 to 5)
– 40' (12 m) ISO container	5	(4 to 6)
– short swap body (7 m)	7	(5 to 8)
– long swap body (12 m)	10	(8 to 12)
– semi-trailer (70 m^3)	30	(20 to 40)
– "Roadrailer" – semi-trailer with railway bogie and railway coupler	50	(40 to 60)

4.5.2 Economic life

		[years]
– wagons or freight cars	20	(10 to 25)
– low-loader wagons for the transport of lorry-trailer combinations	15	(10 to 20)
– gantry cranes, forklift trucks, etc.	10	(5 to 15)
– ISO containers, swap bodies, semi-trailers	8	(6 to 12)

4.5.3 Maintenance costs

Average long-term or life-cycle costs (routine maintenance, periodic maintenance, general overhauls and repairs)

		[EUR/km-wagon]
– European wagons	0.07	(0.05 to 0.13)
– low-loader wagons with two 4-axle bogies	0.25	(0.2 to 0.3)
– low-loader wagons with two 5-axle bogies or with three 4-axle bogies	0.3	(0.25 to 0.4)
		[USD/car-mile]
– North American freight cars	0.1	(0.05 to 0.15)
– double-stack three-well cars	0.2	(0.15 to 0.25)
– double-stack five-well cars	0.3	(0.2 to 0.4)
		[10^3 EUR/unit-year]
– road gantry cranes	50	(30 to 70)
– rail gantry cranes	100	(50 to 150)
– forklift truck	50	(30 to 70)
– ISO containers, swap body	0.4	(0.2 to 0.6)

5. TRACTIVE POWER CONSUMPTION

5.1 Electric traction

Unit consumption of electricity, measured at the high-voltage input side of the traction substations (average in both directions).

5.1.1 Passenger trains

Annual average, including consumption for heating and air conditioning :

Distance between two successive stops [km]	Maximum running speed [km/h]	Gradient [‰ or mm/m]	Unit consumption [Wh/TKBC][1)]
200 to 400	300	0 to 40	50 (45 to 55)
100 to 200	200	0 to 10	40 (35 to 45)
50 to 100	160	0 to 10	30 (25 to 35)
50	80	25	45 (40 to 50)
20	120	0 to 5	25 (20 to 30)
5	120	0 to 10	50 (45 to 55)
2	100	0 to 20	75 (70 to 80)

1) TKBC = total gross tonne-kilometre (including the mass of the locomotive(s))

5.1.2 Goods trains or freight trains

Average in both directions, uphill and downhill.

Distance between two successive stops [km]	Maximum running speed [km/h]	Gradient [‰ or mm/m]	Unit consumption [Wh/TKBC][1)]
100	140	0 to 5	40 (35 to 50)
100	120	0 to 5	30 (25 to 35)
100	100	0 to 5	22 (17 to 27)
100	80	0 to 5	15 (10 to 20)
50	60	0 to 5	15 (10 to 30)
50	60 to 80	25	45 (45 to 50)
5	80	0 to 5	25 (20 to 30)
5	60	25	50 (45 to 55)

1) TKBC = total gross tonne-kilometre (including the mass of the locomotive(s))

5.1.3 Average unit cost of electricity at the high voltage input of traction substations

[**EUR/kWh**]	
0.1	(0.06 to 0.16)

5.2 Diesel traction

Average consumption of gas-oil (diesel oil) (average in both directions, uphill and downhill).

5.2.1 Passenger trains

Annual average, including consumption for heating and air conditioning ("head end" consumption).

Uphill running speed (km/h)	Gradient (‰ or mm/m)	Unit consumption (cm^3/TKBC)[1)]	
120	0	5.5	(5 to 6)
100	0	5	(4.5 to 5.5)
80	0	4.5	(4 to 5)
60	10	8	(7.5 to 8.5)
40	25	13.5	(13 to 14)

1) TKBC = total gross tonne-kilometre (including the mass of the locomotive(s))

5.2.2 Goods trains or freight trains

Uphill running speed (km/h)	Gradient (‰ or mm/m)	Unit consumption (cm^3/TKBC)[1)]	
100	0	4.5	(4 to 5)
40	5	4.5	(4 to 5)
20	10	6	(5.5 to 6.5)
20	15	8	(7.5 to 8.5)
20	20	9.5	(9 to 10)
20	25	11.5	(11 to 12)

1) TKBC = total gross tonne-kilometre (including the mass of the locomotive(s))

5.2.3 Shunting or switching

Hourly consumption of a diesel locomotive, in relation to the power at wheel-rim, in kg gas oil or diesel oil per hour for 1000 kW :

	[**litres diesel oil/h · 1000 kW**]	
	50	(40 to 100)

5.2.4 Unit cost of gas oil or diesel oil

Density of diesel oil	0.85	(0.83 to 0.87)

hence 1 kg diesel oil = 1.17 litres diesel oil (1.15 to 1.2)

Unit cost of gas-oil used for traction :

	[**USD/gallon**]	
– in the U.S.A. (1 U.S. gallon = 3.785 litres)	1.0	(1.0 to 1.2)
	[**EUR/litre**]	
– outside North America	0.6	(0.5 to 1)

6. INDEX

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