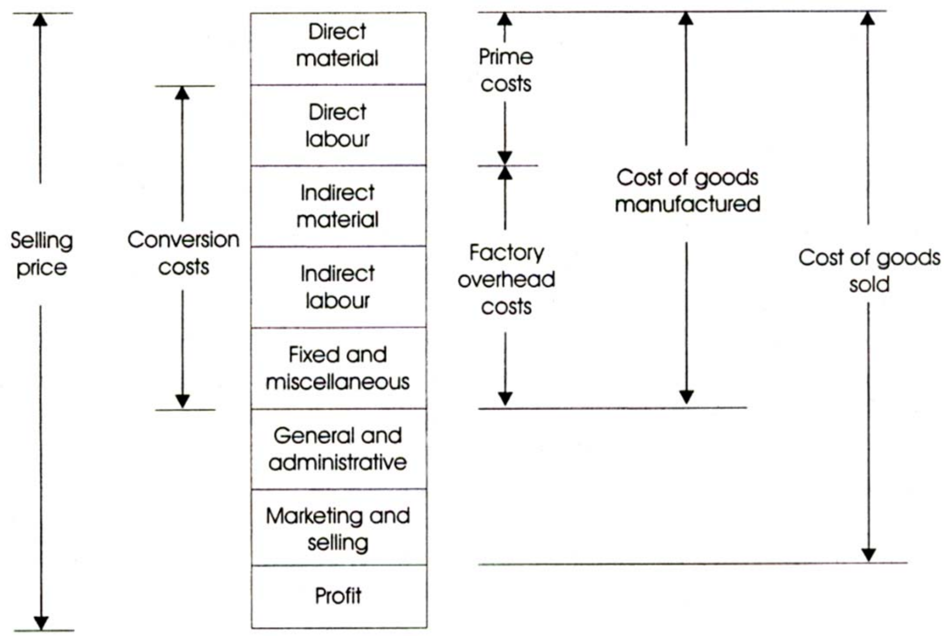
Direct, Indirect and Overhead Costs

Everything a firm does costs money.



<u>Direct (Material and Labour) Costs</u>

The costs of material and labour that are easily measured and conveniently allocated to a specific project.

<u>Indirect (Material and Labour) Costs</u>

Material and labour costs of production that are either practically impossible or uneconomical to assign to a specific project.

<u>Overhead Costs</u>

All costs other than direct material and labour.

- factory overhead
- general and administration overhead

Must “burden” the direct costs to ensure all costs are recovered.

Direct, Indirect and Overhead Costs

Example: Management wants to set a rate for a computer printing service. Monthly maintenance for the printer is \$1 000. The depreciation charge is \$2 000 per month. The cost of a sheet of paper is one cent. The monthly print volume is 50 000 pages. The printer shares the I/O area in the computer room with other services. The printing service is allocated 15% of the monthly costs of the I/O area of \$4 000.

<u>Direct Costs</u>		
– Paper	<u>0.01</u>	
Total Direct Costs		0.01
<u>Indirect (Allocated) Costs</u>		
– Maintenance (\$1 000/50 000)	0.02	
– Depreciation (\$2 000/50 000)	0.04	
– I/O area share $\left(\dfrac{\$4\ 000 \times 0.15}{50\ 000}\right)$	<u>0.01</u>	
Total Indirect Costs		0.07
Cost Base (per page)		<u>0.08</u>

Fixed and Variable Costs
Automobile Example

<u>Fixed Costs</u>

- Those costs which do not vary in proportion to the quantity of output
- May be “fixed” only at certain levels of output

  e.g. - Car insurance, registration, depreciation

<u>Variable Costs</u>

- Costs which vary in proportion with quantity of output
- Normally direct material and labour costs

  e.g. – gas, oil, tire replacement
- Every cost is variable in the long run.

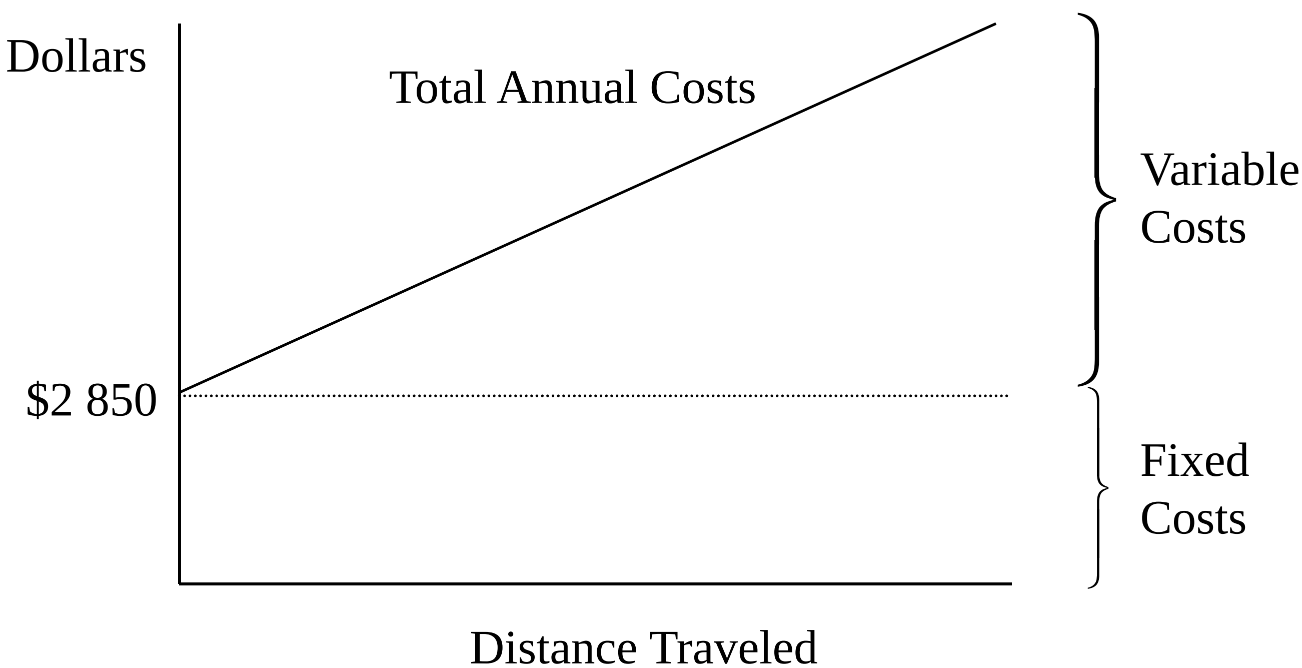
Total Costs (TC) = Fixed Costs (FC) + Variable Costs (VC)

$$TC(x) = \$2\,850 + \$0.10x \qquad (/km)$$

where x is the number of kilometres driven per year.

Fixed and Variable Costs

Automobile Example



Average and Marginal Cost

<u>Average Cost</u>

– Ratio of total cost to quantity of output

$$AC = \frac{TC(x)}{x}$$

<u>Marginal Cost</u>

– The additional (incremental) cost required to increase the quantity of output by one
– Derivative of the cost function with respect to output quantity

Example: Automobile Cost Function

$$\begin{aligned} TC &= \$2\,850 + \$0.10x \\ AC &= \frac{\$2\,850}{x} + \$0.10 \\ MC &= \$0.10 \end{aligned}$$

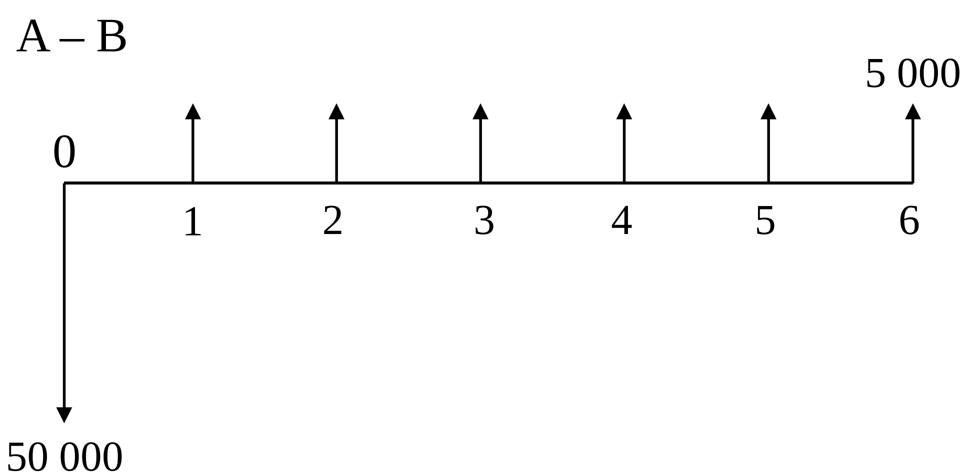
x = 10 000 km	AC = 0.39/km
x = 15 000 km	AC = 0.29/km
x = 20 000 km	AC = 0.24/km

1) If MC < AC – an increase in output reduces unit cost
2) If MC > AC – an increase in output increases unit cost

Incremental Cost

- The costs of one alternative minus the costs of the other alternative.

Costs	A	B	A – B
First Cost	250 000	200 000	50 000
Maintenance	25 000	30 000	(5 000)
Revenues	100 000	100 000	0



- The evaluation of marginal/incremental costs is key to engineering economic analysis.

Hydro Utility

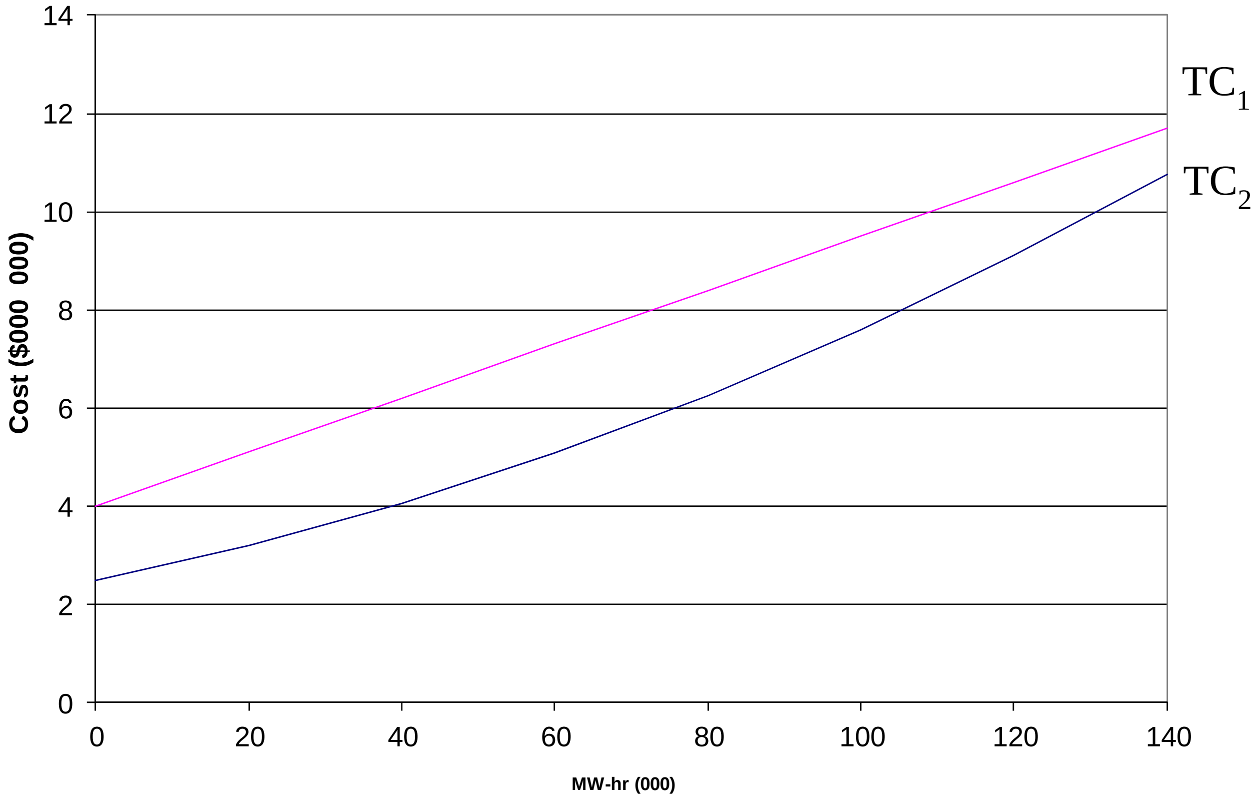
- A small hydro utility has two hydro-electric power plants. The fixed cost of Plant 1 is \$4 000 000 per year and at Plant 2, it is \$2 500 000 per year. The variable cost of producing electricity at Plant 2 is

$$VC(x) = \$(31x + 0.0002x^2)$$

  where x is the yearly electricity output of the power plant measured in megawatt hours (MW-hr). At Plant 1, the variable cost of producing each MW-hr of electricity is \$55. The current demand for electricity is 100 000 MW-hr. The utility produces 40,000 MW-hr at Plant 1 and 60 000 MW-hr at Plant 2.

- A large new subdivision has increased the demand for power to 140 000 MW-hr of electricity. At what output level should the utility run each plant to minimize costs? Assume each plant has the capacity to produce the additional 40 000 MW-hr.

Hydro Utility Power Generation Costs



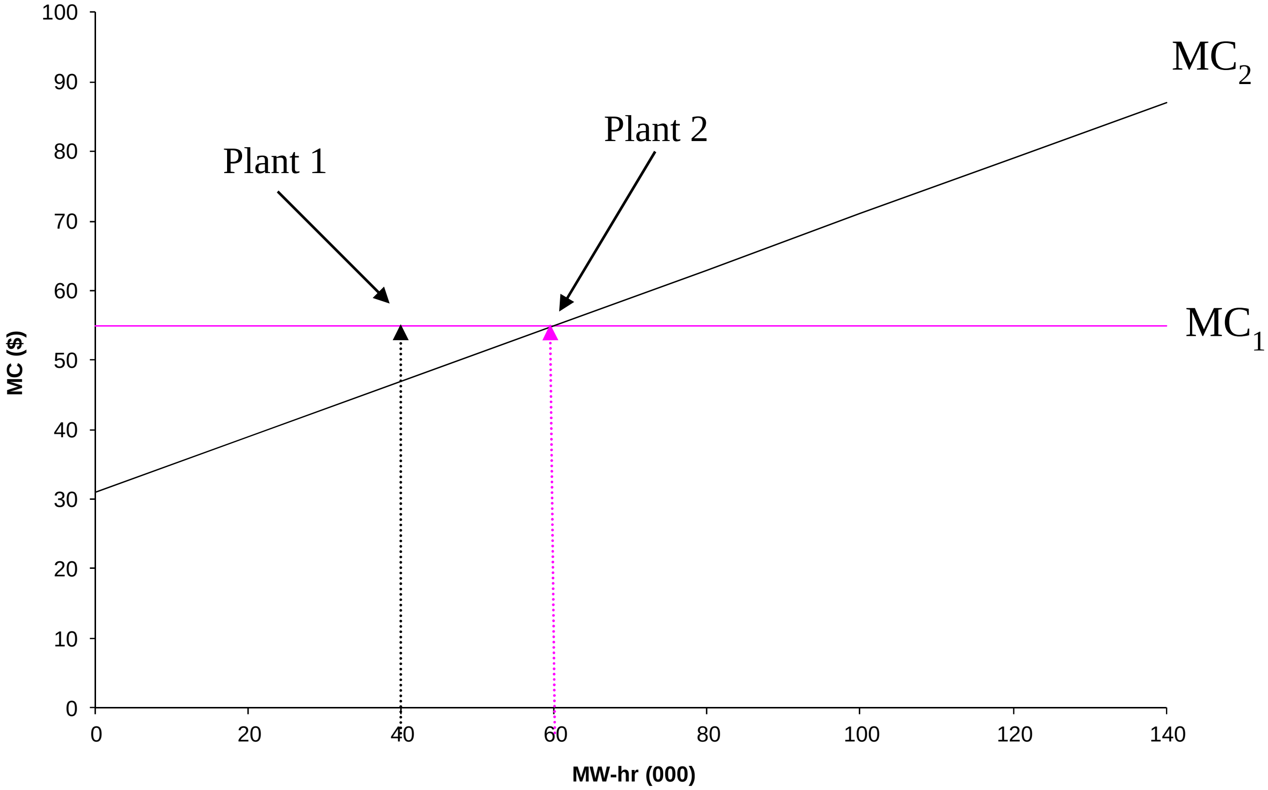
$TC_1\ (x_1) = 4\ 000\ 000 + 55\ x_1$
$TC_2\ (x_2) = 2\ 500\ 000 + 31\ x_2 + 0.0002\ x_2^2$
$TC_u\ (x_1, x_2) = 6\ 500\ 000 + 55\ x_1 + 31\ x_2 + 0.0002\ x_2^2$

Current Operating Point

AC_1 (40 000) = \$155.00/MW-hr
AC_2 (60 000) = \$84.67/MW-hr
AC_u (40 000; 60 000) = \$112.80/MW-hr

Hydro Utility Operating Point

Increased demand: 40 000 MW-hr
Which plant should produce the additional power?



$MC_1 = \$55$

$MC_2(x_2) = 31 + 0.0004x_2$

$MC_2(60\ 000) = \$55$

140 000 MW-hr: $x_1 = 80\ 000$ MW-hr
$x_2 = 60\ 000$ MW-hr

$AC_u(80\ 000;\ 60\ 000) = \$96.29$ MW-hr

Project Estimation

Goal: Select the "best" of the competing engineering project alternatives.

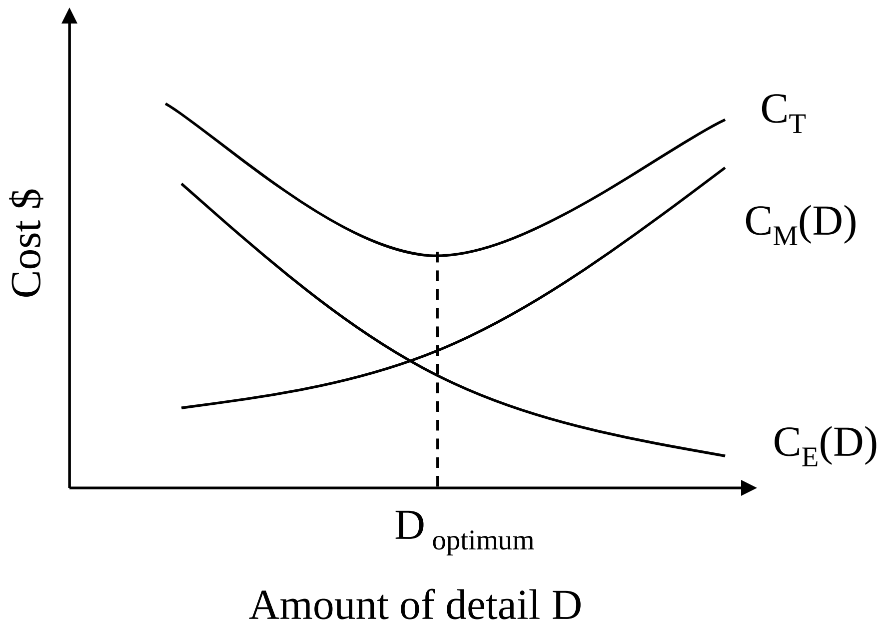
Evaluation process is based on estimates of future:

- revenues
- savings
- recurring costs
- life of the project
- salvage value of project equipment

Therefore, be careful of "GIGO".

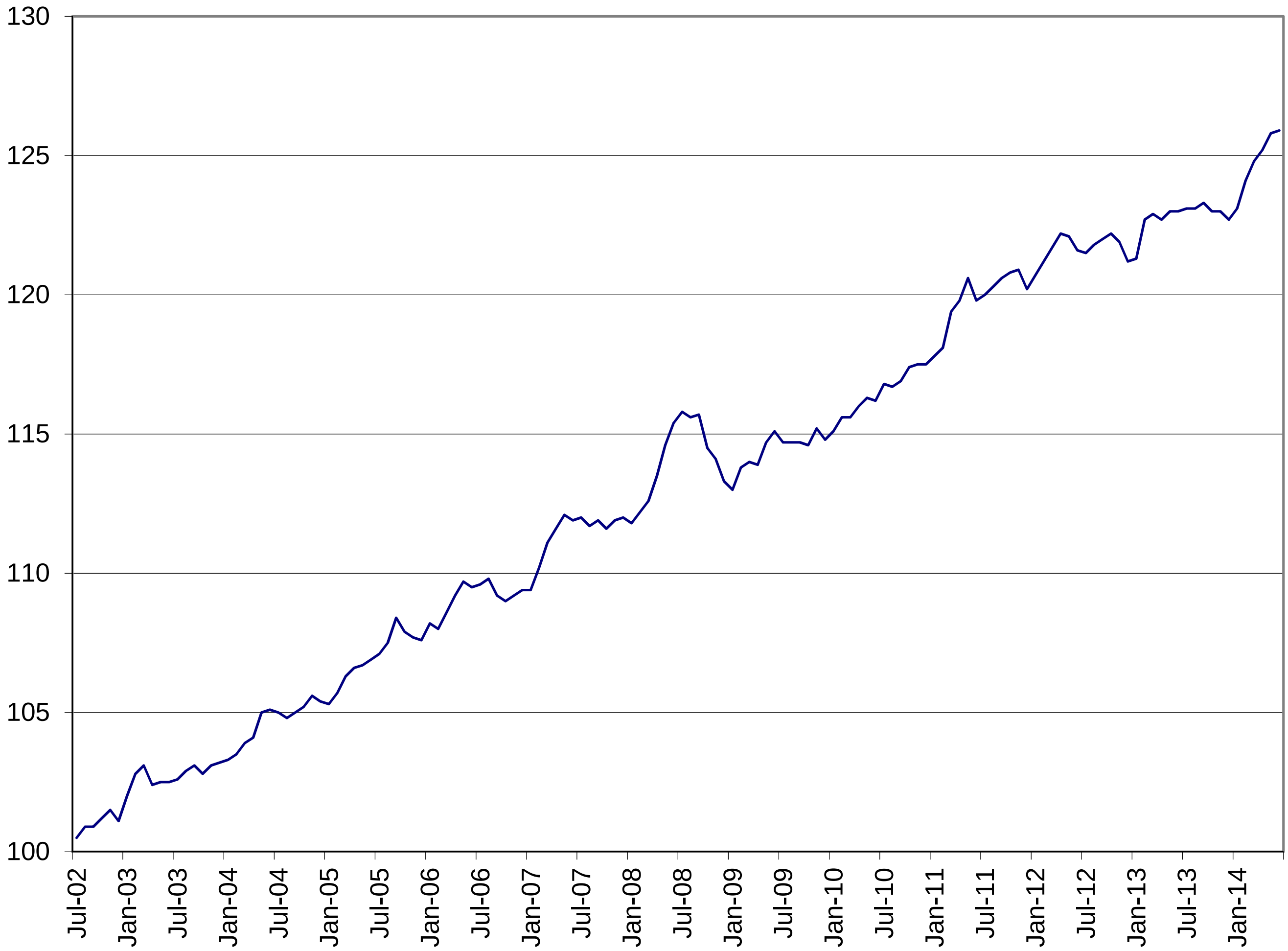
1. Order of magnitude estimates
    - quick estimate based on judgment and experience
    - accuracy of $\pm$ 50%
2. Preliminary estimates
    - more consideration given to detail
    - some sub-elements of projects specified and estimated
    - often cost estimates before final designs completed
    - accuracy of $\pm$ 20% is typical
3. Detailed estimates
    - every sub-element of the project is specified and estimated
    - recommended for pricing a product or contract bidding
    - accuracy level of ± 5% expected

Tradeoff: Estimation Accuracy versus the Cost of the Estimate



C_T = Total cost of making the estimate
C_M = Cost of preparing the estimate
C_E = Cost of errors in the estimate

Price Indexes

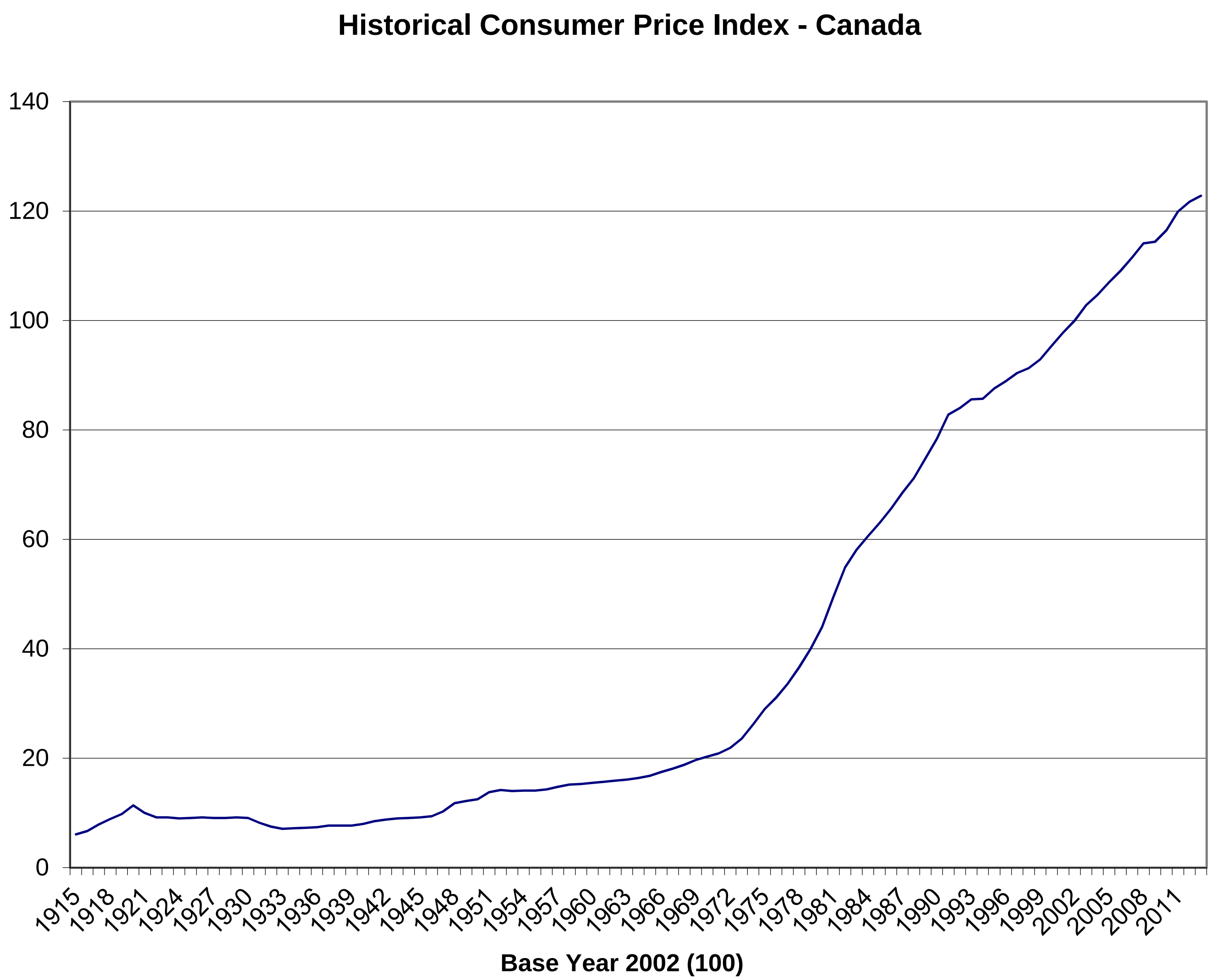


Consumer Price Index - Canada

Statistics Canada, CANSIM, table 326-0020

- Cost data quickly become out of date due to inflation
- Cost index – relative cost of an item in terms of its cost in the base year.
  – base year value = 100
- Statistics Canada
  - CPI – Consumer Price Index (base year 2002)

Historical CPI – Canada
1915 – 2013
Base Year 2002 = 100



Statistics Canada, CANSIM, table 326-0021

Construction Price Index (Toronto)
(Non-residential buildings)

	2009	2010	2011	2012	2013
Total	**142.0**	**141.4**	**146.6**	**150.7**	**152.1**
Commercial structures	141.4	140.6	145.6	149.6	151.2
Industrial structures	146.7	146.2	152.2	156.6	158.5
Institutional structures	142.2	142.4	147.4	151.8	152.3

Statistics Canada table 327-0043

- Factory and land purchased for $5 000 000 in 2009
- Structure appraised at $3 000 000 in 2009
- Appraisal fee $3 000
- What building insurance coverage is necessary in 2014?
- Pay for another appraisal?
- Use the Construction Price Index?

$$C_{2013} = C_{2009} \times \frac{I_{2013}}{I_{2009}}$$

$$3.27 = 3.0 \times \frac{158.5}{146.7} \times 1.01$$

- Estimate a 1.0% increase for 2014**.**

$3.27 million reconstruction cost estimate is probably sufficiently accurate.

Cost-Capacity Relationships

A company has recorded its experience with small steam turbines in the following chart:

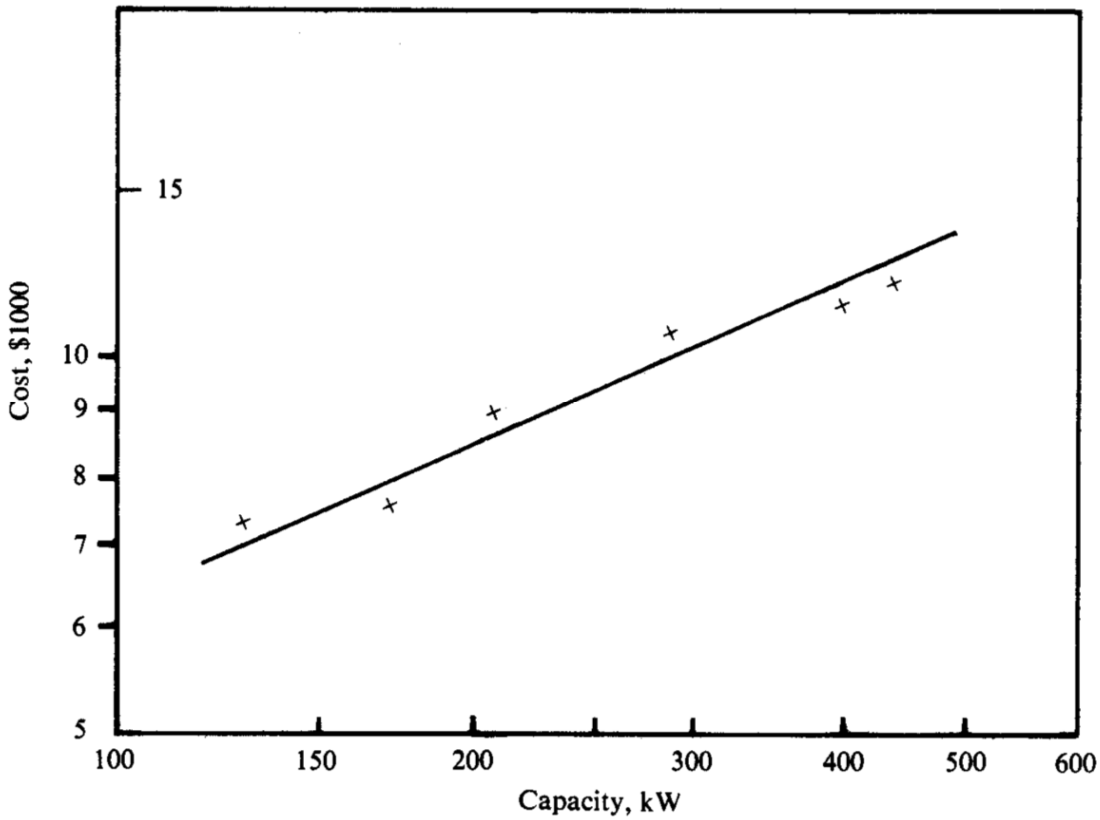
Capacity (KW)	Cost ($2014)	Year
130	7 100	2012
160	7 500	2009
205	8 900	2013
290	10 700	2010
400	12 000	2008
435	12 500	2011

The company has a new requirement for a 350 KW steam turbine and needs a quick assessment of estimated cost.

Use the Cost-Capacity Relationship to estimate the cost.

(Note that the actual project costs must be restated into 2014 dollars to estimate the cost in current dollars.)

Cost-Capacity Relationships



$$C_X = C_B \left(\frac{Q_X}{Q_B} \right)^M$$

C_X = Cost of equipment of capacity Q_X
C_B = Cost of equipment of capacity Q_B
M = Cost-Capacity Factor

$0 \leq M \leq 1$ (typical)
M = 0.6 (average)

Steam Turbine
Cost-Capacity Relationships

To determine M:

1. use least-squares curve fitting software; or,
2. calculate the slope of the line using a pair of points

$$M = \log\left(\frac{C_X}{C_B}\right) / \log\left(\frac{Q_X}{Q_B}\right)$$

$$= \log\left(\frac{14\ 000}{6\ 100}\right) / \log\left(\frac{500}{100}\right) = 0.5162$$

Capacity (kW)	Actual Cost ($)	Predicted Cost ($)	Error (%)
100	**6 100**	**6 100**	**0**
130	7 100	6 985	–2
160	7 500	7 775	+4
205	8 900	8 836	–1
290	10 700	10 568	–1
→ *350*	-	*11 646*	- ←
400	12 000	12 477	4
435	12 500	13 029	4
500	**14 000**	**14 000**	**0**

The cost estimate for the 350 KW steam turbine is $11 646.