

Coal Problem

E-mail Letter dated 31/1/2015

I am S.L. writing to you for help in understanding a very simple analysis which seems to have two answers. I would like to give a brief note about the problem. It concerns a situation regarding analysis at my workplace which is a electricity generating company. We have coal fired thermal units.

Though I am sure that you are aware of these parameters, I would like to state them for your reference.

1 electricity Unit = 1 Kw-Hour = 1 kwh, Coal figure = c.f. = Kg of Coal required for producing 1 Kwh / Kwh produced = kg/kwh

Cost of producing electricity = \$ / Kwh = Cost of coal (\$/kg) * Coal Figure (kg/Kwh)

Production (kwh)	Coal Figure (kg/kwh)	Cost of Coal (\$/Kg)	Coal Consumed Kg (kg/kwh * kwh)	Unit Cost (\$/kwh = \$/kg * kg/kwh)
1000	0.5	2	0.5 * 1000 = 500	2 * 0.5 = \$ 1
2000	0.6	2.50	0.6 * 2000 = 1200	2.5 * 0.6 = \$ 1.50

Change in Unit Cost = \$ 1.50 - \$ 1 = \$ 0.50

Now to find out the individual contribution of the two variables , i.e. Coal Cost (\$/Kg) and Coal Figure (kg/kwh) in the change of Unit cost , one variable is kept constant in both cases while the other is varied

METHOD 1

Production (kwh)	Coal Figure (kg/kwh)	Cost of Coal (\$/Kg)	Coal Consumed Kg (kg/kwh * kwh)	Unit Cost (\$/kwh = \$/kg * kg/kwh)
1000	0.5	2	0.5 * 1000 = 500	2 * 0.5 = \$ 1
2000	0.6	2 (same as above)	0.6 * 2000 = 1200	2 * 0.6 = \$ 1.20

Thus contribution of Coal figure (keeping Cost of Coal Constant) in rise in Unit Cost = \$1.20 - \$1 = \$ 0.20

Similarly

Production (kwh)	Coal Figure (kg/kwh)	Cost of Coal (\$/Kg)	Coal Consumed Kg (kg/kwh * kwh)	Unit Cost (\$/kwh = \$/kg * kg/kwh)
2000	0.6	2.50	0.6 * 2000 = 1200	2.5 * 0.6 = \$ 1.50
1000	0.6 (same as above)	2	0.6 * 1000 = 600	2 * 0.6 = \$ 1.20

Thus contribution of Cost of Coal (keeping Coal figure constant) = \$ 1.50 - \$ 1.20 = \$ 0.30

Solution 1 : rise due to Coal Figure = \$ 0.20, rise due to cost of coal = \$ 0.30

METHOD 2

Production (kwh)	Coal Figure (kg/kwh)	Cost of Coal (\$/Kg)	Coal Consumed Kg (kg/kwh * kwh)	Unit Cost (\$/kwh = \$/kg * kg/kwh)
1000	0.5	2	0.5 * 1000 = 500	2 * 0.5 = \$ 1
2000	0.5 (same as above)	2.5	0.5 * 2000 = 1000	2.5 * 0.5 = \$ 1.25

Thus contribution of Cost of Coal (keeping Coal figure constant) = \$1.25 - \$1.00 = \$ 0.25

Similarly

Production (kwh)	Coal Figure (kg/kwh)	Cost of Coal (\$/Kg)	Coal Consumed Kg (kg/kwh * kwh)	Unit Cost (\$/kwh = \$/kg * kg/kwh)
2000	0.6	2.50	0.6 * 2000 = 1200	2.5 * 0.6 = \$ 1.50
1000	0.5	2.50 (same as above)	0.5 * 1000 = 500	2.5 * 0.5 = \$ 1.25

Thus contribution of Coal figure (keeping Cost of Coal Constant) in rise in Unit Cost = \$ 1.50 - \$ 1.25 = \$ 0.25

Solution 2 : rise due to Coal Figure = \$ 0.25, rise due to cost of coal = \$ 0.25

Question : Are the methodologies correct in evaluating individual contribution . If not what would be the correct method

If the logic as above is accepted, we are getting two different answers. Which of the solution would be correct .. or can there be two solutions?

Thanks again and looking forward to your reply at your earliest convenience

Regards

S.L.

Kolkata, India

My reply dated 1/2/2015

1. Data

Production (kwh)	Coal Figure (kg/kwh)	Cost of coal (\$/Kg)	Coal Consumed Kg (kg/kwh * kwh)	Unit Cost (\$/kwh = \$/kg * kg/kwh)
1000	0.5	2	$0.5 * 1000 = 500$	$2 * 0.5 = \$ 1$
2000	0.6	2.50	$0.6 * 2000 = 1200$	$2.5 * 0.6 = \$ 1.50$

2. Variables

In order to study the general case, let us define the variables as follows:

Production: V

$$V_1 = 1000$$

$$V_2 = 2000$$

Coal Figure: F

$$F_1 = 0.5$$

$$F_2 = 0.6 = F_1 + \Delta F = 0.5 + 0.1$$

Cost of Coal: $C_1 = 2$

$$C_2 = 2.5 = C_1 + \Delta C = 2 + 0.5$$

Unit Cost : U

3. Method 1

Keeping Cost of coal constant:

Production (kwh)	Coal Figure (kg/kwh)	Cost of coal (\$/Kg)	Coal Consumed Kg (kg/kwh * kwh)	Unit Cost (\$/kwh = \$/kg * kg/kwh)
1000	0.5	2	$0.5 * 1000 = 500$	$2 * 0.5 = \$ 1$
2000	0.6	2	$0.6 * 2000 = 1200$	$2 * 0.6 = \$ 1.2$

Contribution of coal figure (Keeping Cost of coal constant) = $\$ 1.2 - \$ 1 = \$ 0.2$

Production (kwh)	Coal Figure (kg/kwh)	Cost of coal (\$/Kg)	Coal Consumed Kg (kg/kwh * kwh)	Unit Cost (\$/kwh = \$/kg * kg/kwh)
V_1	F_1	C_1	$F_1 \times V_1$	$C_1 \times F_1$
V_2	$F_1 + \Delta F$	C_1	$F_2 \times V_2$	$C_1 \times (F_1 + \Delta F)$

Contribution of coal figure (Keeping Cost of coal constant) = $\$ C_1 \times (F_1 + \Delta F) - \$ C_1 \times F_1 = \$ C_1 \times \Delta F$

Similarly by keeping Coal Figure constant, we have (using only variables):

Production (kwh)	Coal Figure (kg/kwh)	Cost of coal (\$/Kg)	Coal Consumed Kg (kg/kwh * kwh)	Unit Cost (\$/kwh = \$/kg * kg/kwh)
V_1	$F_1 + \Delta F$	C_1	$(F_1 + \Delta F) \times V_1$	$C_1 \times (F_1 + \Delta F)$
V_2	$F_1 + \Delta F$	$C_1 + \Delta C$	$(F_1 + \Delta F) \times V_2$	$(C_1 + \Delta C) \times (F_1 + \Delta F)$

Contribution of coal figure (Keeping Coal Figure constant) = $(C_1 + \Delta C) \times (F_1 + \Delta F) - C_1 \times (F_1 + \Delta F) = \Delta C \times (F_1 + \Delta F)$

Solution 1 : rise due to Coal Figure = $\$ C_1 \times \Delta F$

rise due to cost of coal = $\$ \Delta C \times (F_1 + \Delta F)$

4. Method 2

Production (kwh)	Coal Figure (kg/kwh)	Cost of coal (\$/Kg)	Coal Consumed Kg (kg/kwh * kwh)	Unit Cost (\$/kwh = \$/kg * kg/kwh)
V_1	F_1	C_1	$F_1 \times V_1$	$C_1 \times F_1$
V_2	F_1	$C_1 + \Delta C$	$F_1 \times V_2$	$(C_1 + \Delta C) \times F_1$

Contribution of coal figure (Keeping Cost of coal constant) = $\$ (C_1 + \Delta C) \times F_1 - \$ C_1 \times F_1 = \$ \Delta C \times F_1$

Similarly by keeping Coal Figure constant, we have (using only variables):

Production (kwh)	Coal Figure (kg/kwh)	Cost of coal (\$/Kg)	Coal Consumed Kg (kg/kwh * kwh)	Unit Cost (\$/kwh = \$/kg * kg/kwh)
V_1	F_1	$C_1 + \Delta C$	$F_1 \times V_1$	$(C_1 + \Delta C) \times F_1$
V_2	$F_1 + \Delta F$	$C_1 + \Delta C$	$(F_1 + \Delta F) \times V_2$	$(C_1 + \Delta C) \times (F_1 + \Delta F)$

Contribution of coal figure (Keeping Coal Figure constant) = $(C_1 + \Delta C) \times (F_1 + \Delta F) - (C_1 + \Delta C) \times F_1 = (C_1 + \Delta C) \times \Delta F$

Solution 2 : rise due to Coal Figure = $\$ \Delta C \times F_1$
 rise due to cost of coal = $\$ (C_1 + \Delta C) \times \Delta F$

5. Final result:

	rise due to Coal Figure	rise due to cost of coal
Solution 1	$\$ C_1 \times \Delta F$	$\$ \Delta C \times (F_1 + \Delta F)$
Solution 2	$\$ \Delta C \times F_1$	$\$ (C_1 + \Delta C) \times \Delta F$

6. Comments:

(a) Coal Consumed is a redundant variable; it is not connected with the discussion.

(b) The unit cost (U) is a product of two variables C and F. You cannot keep one variable constant (at any arbitrary value) and varies the other variable. Keeping one variable at higher constant and keeping it in lower constant have great effect. Both C and F are important to U!

If you insist to keep (say C) as constant k, then the equation is $U = kF$, which is linear, or that U is directly proportional to F. However, $U = CF$ is NOT linear.

The problem is more interesting if both C and F have maximum and minimum values. For example, C is within the range 2 to 4 and F is within the range 0.5 to 0.8. Then the question is to find the lowest Unit Cost U within the given ranges. The problem then becomes more meaningful.

(c) I am not familiar with the coal industry. However, I think if the production is higher, the coal figure usually is higher. This is because people can make full use of the existing machines. Also, the demand is higher, so people may think of building more efficient machines to produce electricity. The paid off is that we usually have a higher cost of coal. This may be due to environmental protection or health care. The trade off is to find out the critical point within the constraint limits.