TOPIC: Power system design – 07

Economic Consideration

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GI-2134

16-11-2020

Economic Consideration

- Cost analysis plays an important role in the overall design of transmission line.
- The total annual cost consist of – fixed cost and operating cost.
- Fixed cost – interest on the capital cost of conductor, allowance for depreciation and maintenance cost.
- Running cost – cost of electrical energy wasted due to losses during operation.

- The following cost are taken into account:

1. Cost of tower
2. Cost of conductor
3. Cost of insulator
4. Cost of erection
5. Cost of I^2R losses
6. Cost of maintenance
7. Cost of shield wire
8. Cost of labour
9. Annual interest charges

Cost of Tower

- Considering 85% towers are Type-A and rest 15% are Type-B,C and D.
- Also, assuming cost of towers other than type-A (Type-B,C and D) are 2.5 times the cost of tower A.

$$Cost\ of\ one\ type\ A\ tower = cost\ of\ steel\ per\ tonne \times Wt = 80000 \times Wt\ \ Rs.$$

$$Cost\ of\ type\ A\ tower\ per\ km(C_{tA}) = No.\ of\ tower\ per\ km \times cost\ of\ one\ type\ A\ tower$$

$$C_{tA} = \frac{1000}{span} \times 80000 \times Wt \quad Rs./km$$

$$C_{tB,C,D} = 2.5 \text{ x } C_{tA}$$

Hence, average cost of tower,

$$C_t = (0.85 \text{ x } C_{tA}) + (0.15 \text{ x } C_{tB,C,D}) \qquad Rs./km$$

$$C_t = \frac{98 \text{ x } 10^6}{span} \text{ x } Wt \qquad Rs./km$$

Cost of insulation is generally taken as 20% of the tower cost. Therefore,

$$Cost\ of\ insulation, C_I = 0.2 \text{ x } C_t \ \ Rs./km$$

Cost of erection is generally taken as 10% of the tower cost. Therefore,

$$Cost\ of\ erection, C_E = 0.1 \text{ x } C_t \ \ Rs./km$$

Cost of conductor includes the manufacturing processing cost as well as material cost. Therefore,

$$Cost\ of\ conductor, C_C = 3 \text{ x } N_c[8000 + (C_{Al} \text{ x } Wt_{Al} + C_{st} \text{ x } Wt_{st})] Rs./km$$

Where, N_C = number of circuits
C_{Al} = Cost of Aluminium strands in Rs./kg = Rs. 180 per kg
Wt_{Al} = Weight of Aluminium strands in kg
C_{st} = Cost of steel strands in Rs./kg = Rs. 80 per kg
Wt_{st} = Weight of steel strands in kg

$$Cost\ of\ earth\ wire, C_{CE} = [8000 + (C_{GS} \text{ x } Wt_{GS})] \ Rs./km$$

C_{GS} = Cost of galvanized steel in Rs./kg = Rs. 60 per kg
Wt_{st} = Weight of galvanized steel per km = 582.5 kg/km

Total capital cost (C) is calculated as

$$C = C_T + C_I + C_E + C_C + C_{CE} \quad \text{Rs./km}$$

Annual Fixed cost (AFC) is taken as 15% of the total capital cost. Therefore,

$$AFC = 0.15\ C \quad \text{Rs./km}$$

Running cost is calculated as follows:

Running cost =Average power loss (I^2R loss) x time (in hours) x cost of energy

$$\text{Load loss factor} = \frac{Average\ power\ loss}{full\ load\ power\ loss}$$

Take load loss factor as 0.4. Hence,

$$Average\ power\ loss = 0.4\ \text{x}\ full\ load\ power\ loss \qquad watts/km$$

$$Since, full\ load\ power\ loss = 3\ \text{x}\ I_{ph}^2\ \text{x}\ R_{ph}$$

$$Therefore, Average\ power\ loss = \frac{0.4\ \text{x}\ 3\ \text{x}\ I_{ph}^2\ \text{x}\ R_{ph}}{1000} \qquad kW/km$$

$$where, I_{ph} = full\ load\ current\ per\ phase\ = \frac{P}{\sqrt{3}\ \text{x}\ V_L\ \text{x}\ cos\emptyset}$$

$$where, R_{ph} = resistance\ per\ phase\ per\ km\ (in\ ohms) at\ 60^oC$$

$$R_{60} = R_{20}[1 + (60 - 20)\alpha_o]$$

$$R_{ph} = \frac{R_{60}}{N_c}$$

$$R_{20} = resistance\ of\ conductor\ (in\ ohms) at\ 20^oC$$

$$\alpha_o = temperature\ coefficient\ of\ resistance = 0.004/^oC$$

$$Annual\ running\ cost\ (ARC) = Average\ power\ loss\ (kW)\ \text{x}\ 24\ \text{x}\ 365\ \text{x}\ 5 \quad Rs./km$$

Where 5 is taken as cost of energy in Rs. Per kWh.

Total Annual cost = Annual fixed cost (AFC) + Annual running cost (ARC) Rs./km

LEOPARD

cost of galvanised steel	Wt of galvanised steel	Wt of steel	cost of steel strands	cost of Al strands	Wt of Al		Span length		
CGS(Rs./km)	Wtst(kg./km)	wt st (kg)	Cst(Rs./km)	Cal(Rs/kg)	W.Al(kg)	wt	L(m)	CtA(Rs./km)	CtB,C,D(Rs./km)
60	582.5	133	80	180	360	2127.845	0.250	6.81E+11	1.7E+12
60	582.5	133	80	180	360	2346.270	0.275	6.83E+11	1.71E+12
60	582.5	133	80	180	360	2588.724	0.300	6.9E+11	1.73E+12
60	582.5	133	80	180	360	2857.449	0.325	7.03E+11	1.76E+12
60	582.5	133	80	180	360	3154.726	0.350	7.21E+11	1.8E+12
60	582.5	133	80	180	360	3482.967	0.375	7.43E+11	1.86E+12
60	582.5	133	80	180	360	3844.608	0.400	7.69E+11	1.92E+12
60	582.5	133	80	180	360	4242.237	0.425	7.99E+11	2E+12

cost of tower	cost of insulation	cost of erection	cost of conductor	cost of earth wire	Total capital cost		Annual fixed cost
Ct(Rs./km)	CI(Rs./km)	CE(Rs./km)	Cc(Rs./km)	CCE(Rs./km)	C(Rs./km)	Nc	AFC(Rs./km)
8.34115E+11	1.66823E+11	83411524000	932640	114950	1.08435E+12	2	1.63E+11
8.36125E+11	1.67225E+11	83612530909	932640	114950	1.08696E+12	2	1.63E+11
8.4565E+11	1.6913E+11	84564984000	932640	114950	1.09935E+12	2	1.65E+11
8.61631E+11	1.72326E+11	86163077538	932640	114950	1.12012E+12	2	1.68E+11
8.83323E+11	1.76665E+11	88332328000	932640	114950	1.14832E+12	2	1.72E+11
9.10215E+11	1.82043E+11	91021537600	932640	114950	1.18328E+12	2	1.77E+11
9.41929E+11	1.88386E+11	94192896000	932640	114950	1.22451E+12	2	1.84E+11
9.7821E+11	1.95642E+11	97820994353	932640	114950	1.27167E+12	2	1.91E+11

R60	Rph	VL (kv)	Iph	p.f	Pfull loss	P avg loss (kw/km)	ARC(Rs./km)	Total annual cost(Rs./km)	l.l.f
0.254388	0.12719	132	926.5551	0.95	327589.8	131035.9	5739373447	1.68392E+11	0.4
0.254388	0.12719	132	926.5551	0.95	327589.8	131035.9	5739373447	1.68784E+11	0.4
0.254388	0.12719	132	926.5551	0.95	327589.8	131035.9	5739373447	1.70641E+11	0.4
0.254388	0.12719	132	926.5551	0.95	327589.8	131035.9	5739373447	1.73758E+11	0.4
0.254388	0.12719	132	926.5551	0.95	327589.8	131035.9	5739373447	1.77988E+11	0.4
0.254388	0.12719	132	926.5551	0.95	327589.8	131035.9	5739373447	1.83232E+11	0.4
0.254388	0.12719	132	926.5551	0.95	327589.8	131035.9	5739373447	1.89416E+11	0.4
0.254388	0.12719	132	926.5551	0.95	327589.8	131035.9	5739373447	1.9649E+11	0.4

COYOTE

Cost of galvanised steel	Wt of galvanised steel	Wt of steel	cost of steel strands	cost of Al strands	Wt of Al		Span length		
CGS(Rs./km)	Wtst(kg./km)	wt st (kg)	Cst(Rs./km)	Cal(Rs/kg)	W.Al (kg)	wt	L(m)	CtA(Rs./km)	CtB,C,D(Rs./km)
60	582.5	156	80	180	365	2040	0.250	7E+11	1.632E+12
60	582.5	156	80	180	365	2240	0.275	7E+11	1.629E+12
60	582.5	156	80	180	365	2460	0.300	7E+11	1.64E+12
60	582.5	156	80	180	365	2700	0.325	7E+11	1.662E+12
60	582.5	156	80	180	365	2970	0.350	7E+11	1.697E+12
60	582.5	156	80	180	365	3270	0.375	7E+11	1.744E+12
60	582.5	156	80	180	365	3590	0.400	7E+11	1.795E+12
60	582.5	156	80	180	365	3950	0.425	7E+11	1.859E+12

cost of tower	cost of insulation	cost of erection	cost of conductor	cost of earth wire	Total capital cost		Annual fixed cost
Ct(Rs./km)	CI(Rs./km)	CE(Rs./km)	Cc(Rs./km)	CCE(Rs./km)	C(Rs./km)	Nc	AFC(Rs./km)
7.9968E+11	1.5994E+11	79968000000	517080	42950	1.03958E+12	2	1.55938E+11
7.98255E+11	1.5965E+11	79825454545	517080	42950	1.03773E+12	2	1.5566E+11
8.036E+11	1.6072E+11	80360000000	517080	42950	1.04468E+12	2	1.56702E+11
8.14154E+11	1.6283E+11	81415384615	517080	42950	1.0584E+12	2	1.5876E+11
8.316E+11	1.6632E+11	83160000000	517080	42950	1.08108E+12	2	1.62162E+11
8.5456E+11	1.7091E+11	85456000000	517080	42950	1.11093E+12	2	1.66639E+11
8.7955E+11	1.7591E+11	87955000000	517080	42950	1.14342E+12	2	1.71512E+11
9.10824E+11	1.8216E+11	91082352941	517080	42950	1.18407E+12	2	1.77611E+11

P(kw/km)	R20( )	Alpha	R60	Rph	VL (kv)	Iph	p.f	Pfull loss	P avg loss (kw/km)	ARC(Rs./km)	Total annual cost(Rs./km)	l.l.f
201247	0.221	0.004	0.2568	0.128412	132	926.6	0.95	330727	132290.71	5794333248	1.6173E+11	0.4
201247	0.221	0.004	0.2568	0.128412	132	926.6	0.95	330727	132290.71	5794333248	1.6145E+11	0.4
201247	0.221	0.004	0.2568	0.128412	132	926.6	0.95	330727	132290.71	5794333248	1.625E+11	0.4
201247	0.221	0.004	0.2568	0.128412	132	926.6	0.95	330727	132290.71	5794333248	1.6455E+11	0.4
201247	0.221	0.004	0.2568	0.128412	132	926.6	0.95	330727	132290.71	5794333248	1.6796E+11	0.4
201247	0.221	0.004	0.2568	0.128412	132	926.6	0.95	330727	132290.71	5794333248	1.7243E+11	0.4
201247	0.221	0.004	0.2568	0.128412	132	926.6	0.95	330727	132290.71	5794333248	1.7731E+11	0.4
201247	0.221	0.004	0.2568	0.128412	132	926.6	0.95	330727	132290.71	5794333248	1.8341E+11	0.4

TIGER

cost of galvanised steel	Wt of galvanised steel	Wt of steel	cost of steel strands	cost of Al strands	Wt of Al		Span length		
CGS(Rs./km)	Wtst(kg./km)	wt st (kg)	Cst(Rs./km)	Cal(Rs/kg)	W.Al(kg)	wt	L(m)	CtA(Rs./km)	CtB,C,D(Rs./km)
60	582.5	241	80	180	383	2040.00	0.250	6.53E+11	1.63E+12
60	582.5	241	80	180	383	2240.00	0.275	6.52E+11	1.63E+12
60	582.5	241	80	180	383	2460.00	0.300	6.56E+11	1.64E+12
60	582.5	241	80	180	383	2700.00	0.325	6.65E+11	1.66E+12
60	582.5	241	80	180	383	2970.00	0.350	6.79E+11	1.7E+12
60	582.5	241	80	180	383	3270.00	0.375	6.98E+11	1.74E+12
60	582.5	241	80	180	383	3590.00	0.400	7.18E+11	1.8E+12
60	582.5	241	80	180	383	3950.00	0.425	7.44E+11	1.86E+12

cost of tower	cost of insulation	cost of erection	cost of conductor	cost of earth wire	Total capital cost		Annual fixed cost
Ct(Rs./km)	CI(Rs./km)	CE(Rs./km)	Cc(Rs./km)	CCE(Rs./km)	C(Rs./km)	Nc	AFC(Rs./km)
7.9968E+11	1.59936E+11	79968000000	577320	42950	1.04E+12	2	1.559E+11
7.98255E+11	1.59651E+11	79825454545	577320	42950	1.04E+12	2	1.557E+11
8.036E+11	1.6072E+11	80360000000	577320	42950	1.04E+12	2	1.567E+11
8.14154E+11	1.62831E+11	81415384615	577320	42950	1.06E+12	2	1.588E+11
8.316E+11	1.6632E+11	83160000000	577320	42950	1.08E+12	2	1.622E+11
8.5456E+11	1.70912E+11	85456000000	577320	42950	1.11E+12	2	1.666E+11
8.7955E+11	1.7591E+11	87955000000	577320	42950	1.14E+12	2	1.715E+11
9.10824E+11	1.82165E+11	91082352941	577320	42950	1.18E+12	2	1.776E+11

P(kw/km)	R20(ohm)	Alpha	R60	Rph	VL (kv)	Iph	p.f	Pfull loss	P avg loss(kw/km)	ARC(Rs./km)	Total annual cost(Rs./km)	I.
201247	0.222	0.004	0.254388	0.12719	132	926.56	1	327589.8	131035.9	5739373447	5739693238	0
201247	0.222	0.004	0.254388	0.12719	132	926.56	1	327589.8	131035.9	5739373447	5739693630	0
201247	0.222	0.004	0.254388	0.12719	132	926.56	1	327589.8	131035.9	5739373447	5739695487	0
201247	0.222	0.004	0.254388	0.12719	132	926.56	1	327589.8	131035.9	5739373447	5739698604	0
201247	0.222	0.004	0.254388	0.12719	132	926.56	1	327589.8	131035.9	5739373447	5739702834	0
201247	0.222	0.004	0.254388	0.12719	132	926.56	1	327589.8	131035.9	5739373447	5739708078	0
201247	0.222	0.004	0.254388	0.12719	132	926.56	1	327589.8	131035.9	5739373447	5739714262	0
201247	0.222	0.004	0.254388	0.12719	132	926.56	1	327589.8	131035.9	5739373447	5739721337	0

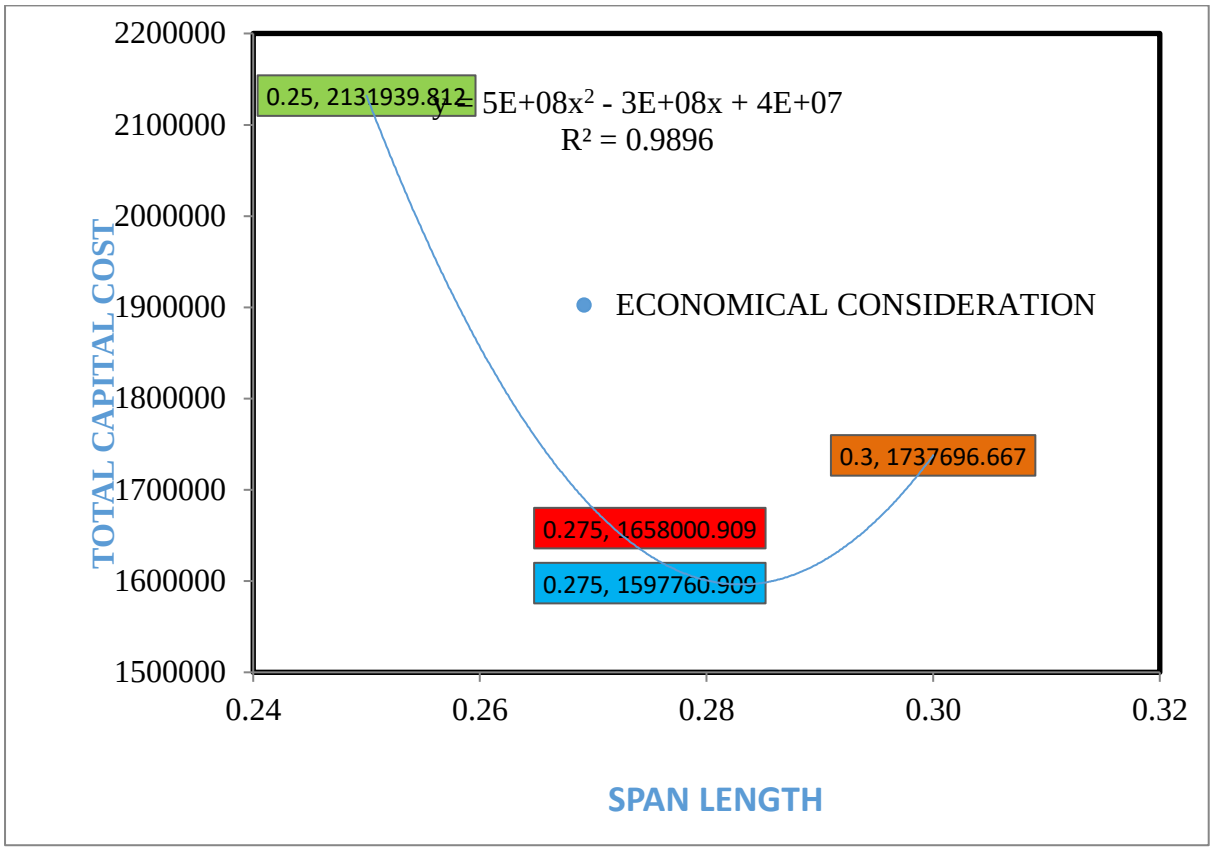
WOLF

Cost of galvanised steel	Wt of galvanised steel	Wt of steel	cost of steel strands	cost of Al strands	Wt of Al		Span length		
CGS(Rs./km)	Wtst(kg./km)	wt st (kg)	Cst(Rs./km)	Cal(Rs/kg)	W. Al(kg)	wt	L(m)	CtA(Rs./km)	CtB,C,D(Rs./km)
60	582.5	291	80	180	436	2060	0.25	6.592E+11	1.648E+12
60	582.5	291	80	180	436	2240	0.275	6.51636E+11	1.62909E+12
60	582.5	291	80	180	436	2440	0.3	6.50667E+11	1.62667E+12
60	582.5	291	80	180	436	2660	0.325	6.54769E+11	1.63692E+12
60	582.5	291	80	180	436	2890	0.35	6.60571E+11	1.65143E+12
60	582.5	291	80	180	436	3150	0.375	6.72E+11	1.68E+12
60	582.5	291	80	180	436	3430	0.4	6.86E+11	1.715E+12
60	582.5	291	80	180	436	3550	0.425	6.68235E+11	1.67059E+12

cost of tower	cost of insulation	cost of erection	cost of conductor	cost of earth wire	Total capital cost		Annual fixed cost
Ct(Rs./km)	CI(Rs./km)	CE(Rs./km)	Cc(Rs./km)	CCE(Rs./km)	C(Rs./km)	Nc	AFC(Rs./km)
8.0752E+11	1.61504E+11	80752000000	658560	42950	1.04978E+12	2	1.57E+11
7.98255E+11	1.59651E+11	79825454545	658560	42950	1.03773E+12	2	1.56E+11
7.97067E+11	1.59413E+11	79706666667	658560	42950	1.03619E+12	2	1.55E+11
8.02092E+11	1.60418E+11	80209230769	658560	42950	1.04272E+12	2	1.56E+11
8.092E+11	1.6184E+11	80920000000	658560	42950	1.05196E+12	2	1.58E+11
8.232E+11	1.6464E+11	82320000000	658560	42950	1.07016E+12	2	1.61E+11
8.4035E+11	1.6807E+11	84035000000	658560	42950	1.09246E+12	2	1.64E+11
8.18588E+11	1.63718E+11	81858823529	658560	42950	1.06417E+12	2	1.6E+11

P(kw/km)	R20( )	Alpha	R60	Rph	VL (kv)	Iph	p.f	Pfull loss	P avg loss (kw/km)	ARC(Rs./km)	Total annual cost(Rs./km)	l.l.f
201247	0.184	0.004	0.214	0.11	132	927	1	275456.2732	110182.509	4825993906	1.6229E+11	0.4
201247	0.184	0.004	0.214	0.11	132	927	1	275456.2732	110182.509	4825993906	1.6049E+11	0.4
201247	0.184	0.004	0.214	0.11	132	927	1	275456.2732	110182.509	4825993906	1.6025E+11	0.4
201247	0.184	0.004	0.214	0.11	132	927	1	275456.2732	110182.509	4825993906	1.6123E+11	0.4
201247	0.184	0.004	0.214	0.11	132	927	1	275456.2732	110182.509	4825993906	1.6262E+11	0.4
201247	0.184	0.004	0.214	0.11	132	927	1	275456.2732	110182.509	4825993906	1.6535E+11	0.4
201247	0.184	0.004	0.214	0.11	132	927	1	275456.2732	110182.509	4825993906	1.6869E+11	0.4
201247	0.184	0.004	0.214	0.11	132	927	1	275456.2732	110182.509	4825993906	1.6445E+11	0.4

TAC	type of conductor	span length(km)	total capita cost	AFC	ARC
5794573190	LEOPARD	0.25	2131939.8	239942.100	5794333248
5739693630	COYOTE	0.275	1597760.9	239664.000	5739373447
5794572912	TIGER	0.275	1658000.9	248700.136	5739693630
4826254561	WOLF	0.3	1737696.7	260654.500	4825993906



Selected value

TAC	type of conductor	span length(km)	total capita cost	AFC	ARC
5739693630	**COYOTE**	**0.275**	1597760.9	239664.000	5739373447