ILC Cost Optimizations – Construction Costs vs. Long Term Operations
Peter H. Garbincius revision: 27june06 ILC_Cost_Optimizations_21june06.doc

A question continues to be raised on whether we should be designing and cost estimating for the lowest construction cost or the lowest cost over the life of the project which includes the continuing operations cost for electrical power, cryogens, maintenance, personnel, etc. This question is particularly apparent in the case of conventional copper coil magnets and power distribution systems. One can choose the minimum amount of copper, minimizing procurement costs, but maximizing power usage, or one can pay more up-front for more copper and reduce the long term power bill. Of course, there is some optimization between copper and power, but there needs to be some common ground-rules and standard assumptions for this optimization.

Putting together these pieces of information (parentheses are my clarifications),
underlines are the working assumptions:

1. Tom Himel (e-mail 19june06): I believe for the purposes of integrated luminosity we are assuming a Snowmass year (10^7 seconds of physics operations per year). For the purpose of running costs (cryogens, magnets, RF on) we are assuming 9 months a year (75%) 24/7. (PHG tried to find this assumed operational lifetime in the BCD to no avail after searching on "life", "operation", "operate", and "years".)

2. Tetsuo Shidara (e-mail 9june06): We discussed (the cost of electrical power) issue at the Snowmass (2005) meeting. The kWh costs in three regions are almost the same price. In KEK, it's 10 Yen/kWh and is equivalent to 0.08275$/kWh. (Assume power costs are the same in all three regions.)

3. Notes from conversation between Barry Barish and Peter Garbincius (19may06):
Cost model tradeoffs – e.g. copper costs v power costs
use 1jan06 costs as single point in time for both materials & power? OK!
10 years or 20 years operating lifetime?
Barry says 10 years operating lifetime is sufficient,
don't excessively increase construction cost vs. operating
but 10 years is common and shows some responsibility
reference: Barry_19may06.doc

4. An aspect that must not be forgotten is the cost of removing that heat generated. This includes additional water and air cooling (pumps, piping, heat exchangers, cooling towers, filters, de-ionization, instrumentation, controls), and the additional power to run all this heat removal apparatus. The Fermilab FESS group (who are doing the cooling cost estimates for RDR) has prepared a power multiplier to be added to the power dissipated in a magnet or klystron or beam dump, etc. to account for this. Their analysis (E. Huedem, June 23, 2006) estimates that the power required to remove each KW of power dissipated in the tunnel, assuming 75-85% to water and the rest to chilled air, is approximately ¼ KW, so the power multiplier is 1.25. There is an additional capital

investment for this cooling equipment (including installation and maintenance costs) to be added to the cost of copper for the magnet or cables.

When this is all added up and includes items 1-3, one should assume, that for every KW dissipated in the magnet system ($P = I^2R$) or deposited in the klystron tubes, that the total lifetime cost for the power or heat dissipated, plus the power to remove that heat, both integrated over the assumed 10 year life (75% on-factor) of the ILC, plus the capital cost and maintenance of the heat removal equipment sums to ~$ 13 K per KW (based on current power costs). (E.Huedem, 24june06, P. Garbincius, 25june06, T. Lackowski, 26june06, E. Huedem, 27june06, and **especially** Tetsuo Shidara – GLC, 27june06).

5. Even knowing the current energy and metal commodities, we still need a model of how the commodities and power costs vary in the future? Thanks to Jerry Leibfritz, we can view past history. Here are two examples by google-ing "commodity price monitor"

   http://www.edc.ca/english/docs/commpric_e.pdf
   http://www.rbc.com/economics/market/pdf/cpm.pdf

   These are the first two references that came up which are both free information, although there are lots of people who would like to sell you this same information along with their projections.
   Also thanks to Kazuro Furukawa: http://futures.tradingcharts.com

   Of course, one must also know the good-old regular inflation rate.

   http://www1.jsc.nasa.gov/bu2/inflate.html

   gives rate according to many different indices. Another URL that may be particularly handy is the Turner Building Construction Index which takes into account skilled manpower, materials (I-beam, rebar, concrete, etc.), and the market situation for the construction industry. http://turnerconstruction.com
   Poke around this page for index over last few years:

   http://turnerconstruction.com/corporate/content.asp?d=20

   The thumbnail reports (click at bottom of page – try 2000) for prior years list the index back through its start in 1967.

However, none of these give projections into the future. For that, you have to turn to the DOE project guidance tables for 1978-2012 (too short for the expected life of the ILC):

http://www-ilcdcb.fnal.gov/DOE_INFLATION_FY08.pdf

Conclusion and Guidance: Items number 1 through 4 are self-explanatory. By themselves, they do not give a direct contribution to the cost estimate for the ILC, but rather provide a guide to sizing the copper in magnets and cables. This model can be refined *ad infinitum*, so let's stop here and start to use it. There is no way we can give you sound financial investing advice (past history is no guarantee of future performance), yet one course of action that could make sense for this optimization process is to use the current energy and commodities metal costs (e.g. current costs for cables and conductors) and assume that the ratio of energy vs. metal costs wont vary in the future.

We have already requested that all cost estimates indicate, if possible, the fractions of the costs which are commodity costs in terms of steel, stainless steel, copper, aluminum, niobium, etc., along with the energy costs for production, testing, conditioning, etc. of the components, and the industrial manpower costs contained in the production price. This will allow the parameterization of the total ILC cost estimate in terms of these commodity, energy, and labor costs. If someone would then predict, for example, that copper costs will go up or down by 25% in price by the time we build ILC, then we can model what the total cost will be for that particular scenario.

I realize this may be a barely acceptable model, but does anyone have a better suggestion?