Guidelines for Preparation of National Cost Estimates Based on the ILC TDR Value Estimate

Version 1.3

ILC Global Design Effort

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Contents

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1 Introduction

This document is intended to provide guidance to national funding agencies or other interested parties seeking to develop national estimates for the cost of ILC components and systems. It provides a suggested methodology by which the ILC TDR[1] Value estimate may be used to develop estimates in national currency, in a way which is consistent with the manner in which the Value estimate was prepared.

The document explains how to convert the ILC TDR Value and Labor estimates for the construction project into national currency units or person-hours. National cost estimates may also need to include additional cost categories, such as contingency, escalation, pre-construction costs, operating costs, etc. This document explains how some of these additional costs may be developed using information provided in the ILC TDR Value estimate.

Several examples of national cost estimates are given below. *These examples are given only to illustrate the methodology, and are not intended to be true national cost estimates.*

2 Conversion of the ILC TDR Value to National Currencies

2.1 General Guidelines on Currency Conversions

The ILC TDR Value estimate is stated in ILCU, an artificial currency unit that is related to national currencies using purchasing power parity (PPP) indices and currency exchange rates (EX). Except for the superconducting material used for the cavity resonators, for any cost element produced in a given nation, the correct method for conversion of the estimated cost of the item in the ILC TDR Value estimate from ILCU into the corresponding national currency is to use the appropriate purchasing power parity relationship between the ILCU and that national currency. Since there is only one supplier of the required superconducting material in the world, this cost element must be purchased on the international market. In this case, the correct method for conversion from ILCU into the corresponding national currency is to use the appropriate exchange rate relationship between the ILCU and that national currency.

The ILC TDR site-specific and shared Value estimates[1] for the 3 sample sites described in the ILC TDR[1] are shown in Table 1. The conversion factors to be used to convert these estimates to national currencies are listed in Table 2.

Table 1. Site-specific and shared Value for the 3 sample sites evaluated for the ILC TDR Value estimate (Jan. 2012 MILCU).

Site region	Site-specific Value	Shared Value	Total Value
Asia	1,756	6,226	7,982
Americas	1,413	6,310	7,723
Europe	1,330	6,304	7,634
Average	1,499	6,281	7,780

Table 2. Currency conversion factors between ILCU and national currencies (Jan. 2012). To convert a cost element from ILCU to the indicated currency, multiply by the factor appropriate for the type of cost element.

Cost element type	ILCU→USD	ILCU→Euro	ILCU→Yen
Civil construction (PPP)	1	0.939	109.3
Non-civil-construction (PPP)	1	0.923	127.3
Superconducting material (EX)	1	0.776	76.9

It should be noted that the cost of all items in the TDR Value estimate corresponds to January, 2012. PPP indices and exchange rates, which are key to conversions from ILCU to national currencies, are given as of this date. While it is possible to estimate the TDR Value in national currencies as of a later date, this requires the use of PPP indices and exchange rates corresponding to that later date. For simplicity, this document does not attempt to refer to any date other than the baseline TDR date (January, 2012).

2.2 Evaluation of the Value Estimate in the Partners' National Currency

2.2.1 Site-specific Value

The site-specific Values shown in Table 1 can be converted to national currencies using the PPP conversion factors shown in Table 2. The results are shown in Table 3.

2.2.2 Shared Value

The shared Value is divided among the partner nations, in an arrangement to be negotiated. The components associated with the shared Value contributed by each partner are assumed to be produced locally, and therefore their Value should be converted from ILCU to national currency using the appropriate factor shown in

[1]The definition of site-specific and shared costs is given in the TDR[1].

Table 3. Site-specific Value estimates in ILCU and in national currencies. All currencies are as of January, 2012

Nation	Value (MILCU)	Value	Unit
Japan	1,756	197.1	GYen
United States	1,413	1,413	MUSD
Europe	1,330	1,247	MEuro

Table 2. Actual numerical values for the shared Value in national currencies depend on the choice of host nation and sharing model. However, as an illustration, an example is given in the next section.

2.2.3 Example: Japanese site

As an example, consider the case of a site in Japan. As the host, Japan would contribute the site-specific Value (from Table 3), together with some fraction of the shared Value[2]. The sum of the site-specific and shared Value contributed by Japan, converted to Yen, is shown in Fig. 1, as a function of the fraction of the total shared Value contributed by Japan.

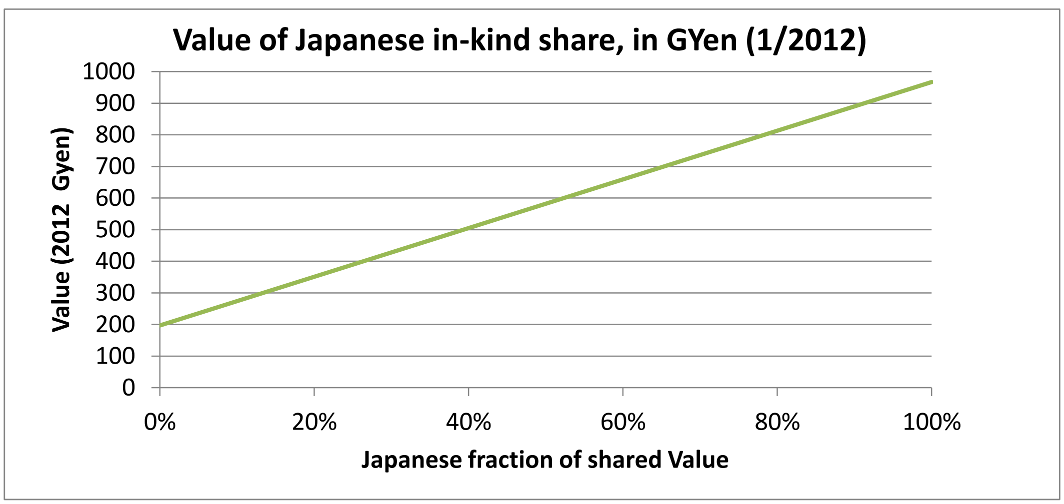

Figure 1. Japanese contributed Value, in Yen, vs. Japanese fraction of the shared Value

In this example, the shared Value not contributed by Japan is assumed to be provided in part by the United States, and in part by Europe. The shared Value contributed by the United States, converted to USD, is shown in Fig. 2, as a function of the fraction of the total shared Value contributed by the United States. Similarly, the shared Value contributed by Europe, converted to Euro, is shown in Fig. 3, as a function of the fraction of the total shared Value contributed by Europe. For

[2]The same sharing fraction is assumed to be applied to superconducting material and to all other shared cost elements.

any specific sharing model, the shared Value fractions contributed each of the three nations must, of course, sum to 100%.

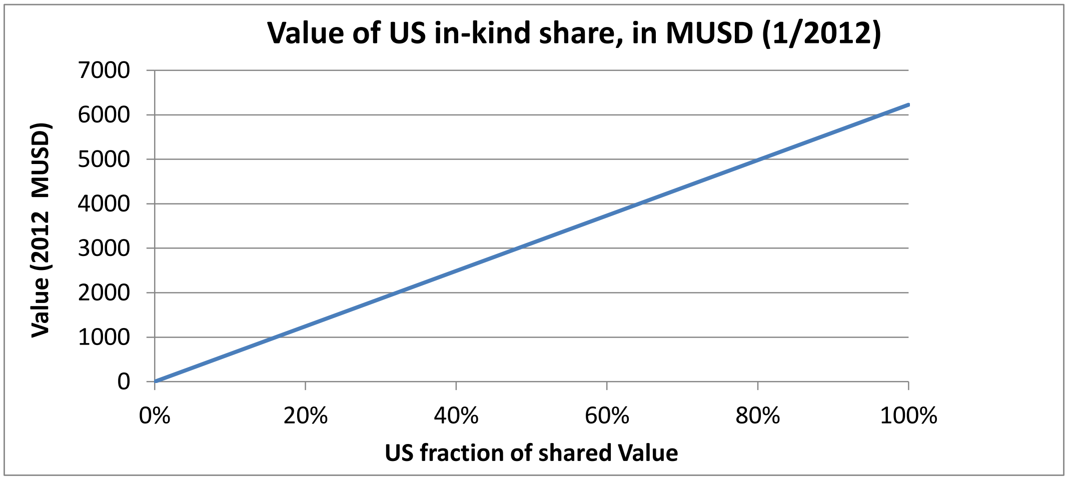

Figure 2. United States contributed Value, in USD, vs. US fraction of the shared Value

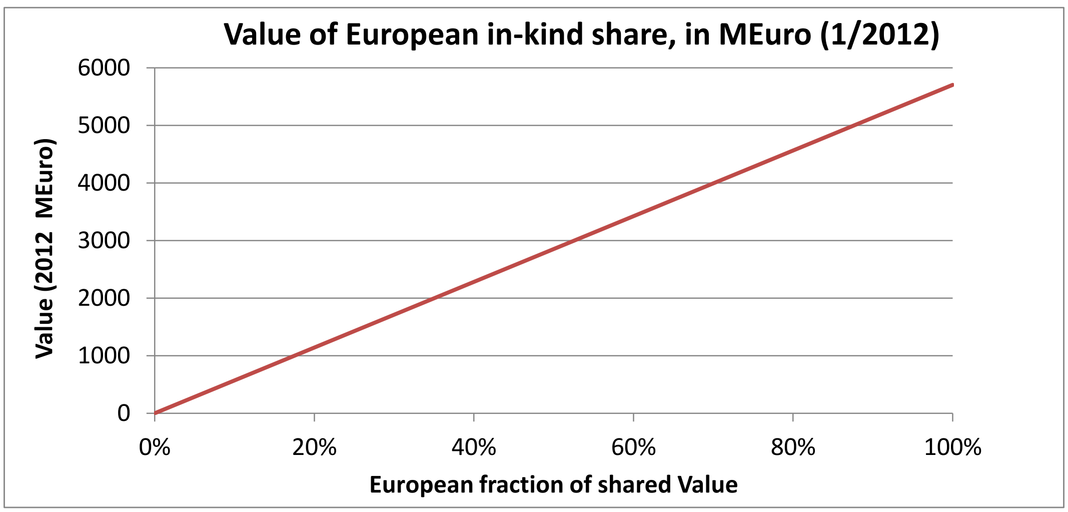

Figure 3. European contributed Value, in Euro, vs. European fraction of the shared Value

2.3 Evaluation of the Value Estimate in the Host's National Currency

2.3.1 General considerations

Section 2.2 illustrates the methodology for determining the contributed Value in national currencies of the partners. However, the host may wish to develop an estimate of the total Value, stated entirely in its own currency. The site-specific Value, and the host's portion of the shared Value, is converted to the host nation currency as described in Section 2.2. To this must be added the remaining portion of the shared Value, contributed by the non-host partners, but stated in terms of the host region currency.

From the host nation's perspective, a contribution from a partner nation can be treated as though the partner nation manufactured the item, and the host nation purchased it using its currency. Thus, for the shared Value contributed by the non-host partner, the conversion from ILCU to host nation currency is carried out in two steps. The cost of producing the item in the partner nation is estimated by converting from ILCU to the partner nation currency, using the appropriate factors shown in Table 2 for the partner nation. Subsequently, this cost is converted from the partner nation currency to the host nation currency using exchange rates.

An actual numerical value for the total Value in the host currency depends on the choice of host nation and sharing model. However, as an illustration, an example is given in the next section.

2.3.2 Example: Japanese site

Consider again the case of a site in Japan, with the United States and Europe as the other partners. The general methodology for converting the total project Value to the host currency (Yen) is illustrated in Fig. 4.

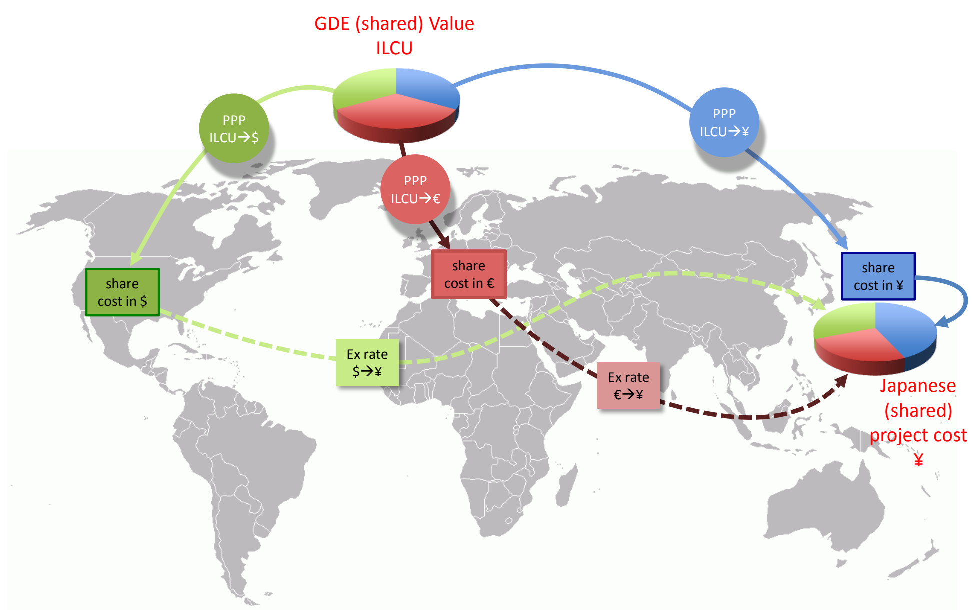

Figure 4. Methodology for converting the total project Value to the host currency

Fig. 5 shows the total project Value, in Yen, as a function of the Japanese fraction of the shared Value, calculated as described in Section 2.2.3. The green dashed line is the same line as that shown in Fig. 1: it shows the total Japanese contribution in Yen, as a function of the Japanese fraction of the shared Value. The blue dashed line is derived from that shown in Fig. 2, except that the US Value is converted from USD to Yen using the USD-Yen exchange rate as of January, 2012 (76.94 Yen per USD). Also, it is plotted vs. the Japanese fraction of the shared Value, assuming that the European share is zero. The blue solid line is the sum of the green and blue dashed lines: this is the total project Value in Yen, from the Japanese perspective, assuming the non-Japanese fraction of the shared Value comes entirely from the US.

Similarly, the red dashed line is derived from that shown in Fig. 3, except that the European Value is converted from Euro to Yen using the Euro-Yen exchange rate as of January, 2012 (99.2 Yen per Euro). Also, it is plotted vs. the Japanese fraction of the shared Value, assuming that the US share is zero. The red solid line is the sum of the green and red dashed lines: this is the total project Value in Yen, from the Japanese perspective, assuming the non-Japanese fraction of the shared Value comes entirely from Europe.

A precise number cannot be computed for the total project Value in Yen until specific sharing fractions are chosen. However, Fig. 5 shows that, in this example, the Value is bounded between approximately 700 and 970 GYen (2012).

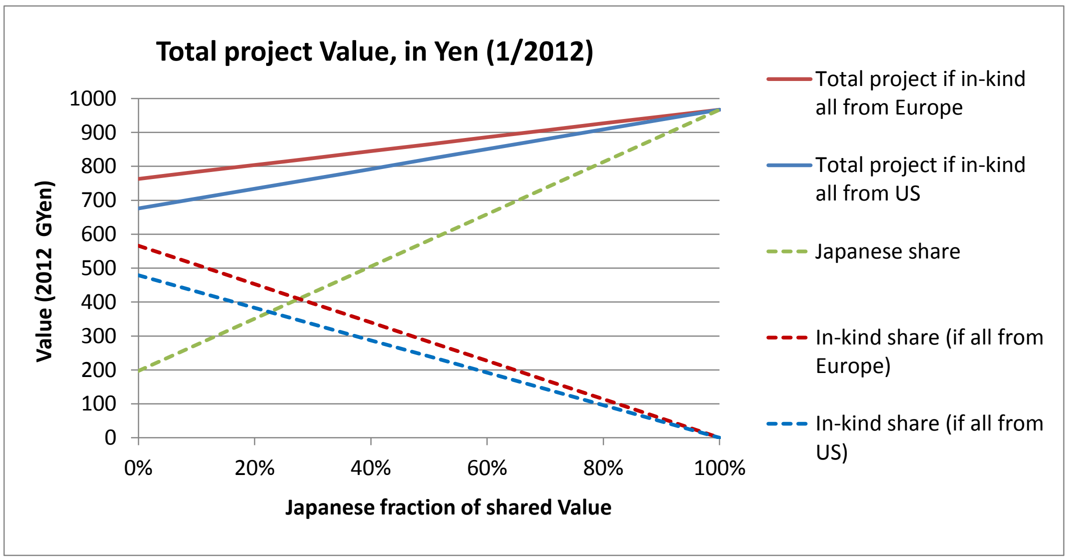

Figure 5. Total project Value, in Yen, vs. Japanese fraction of the shared Value

3 Conversion of the ILC TDR Labor to National Labor Estimates

3.1 General considerations

The ILC TDR Labor estimates for the 3 sample sites described in the ILC TDR[1] are shown in Table 4. The Labor estimates are given in person-hours. Choice of a specific host nation will identify the region whose Labor estimate from Table 4 should be used.

Table 4. Site-specific and shared Labor for the 3 sample sites (thousand person-hrs).

Region	Site-Specific	Shared	Total
Asia	4,536	18,356	22,892
Americas	4,272	18,096	22,368
Europe	4,496	18,084	22,580
Average	4,435	18,178	22,613

To proceed further, a specific sharing model for the Labor between the partner nations is required. In addition, depending on the requirements of national funding agencies, some or all of the Labor estimate contributed by a nation may need to be stated in terms of its national currency. The conversion from Labor to currency should be based on the actual mix of labor types (scientists, engineers, administrators, and technicians) in the shared Labor. Nation-specific labor rates for each labor type will need to be provided.

3.2 Example: Japanese site

As an example, consider again the case of a site in Japan. Japan would contribute the site-specific Labor (from Table 4), together with some fraction of the shared Labor. The sum of the site-specific and shared Labor contributed by Japan is shown in Fig. 6 (blue line), as a function of the fraction of the total shared Labor contributed by Japan.

As noted above, national funding agencies may require some or all of this Labor to be stated in terms of the national currency. To give an approximate upper limit for this re-statement, the cost of this Labor, if converted entirely to Yen, is also shown (red line). Although different labor rates should be used depending on the labor type, in this simple example, a single labor rate was used for all labor types. The Japanese labor rate used was 9,000 Yen/hr[3].

In this example, the shared Labor not contributed by Japan is assumed to be provided by the United States and Europe. The shared Labor contributed by the United States is shown in Fig. 7 (blue line), as a function of the fraction of the total shared Labor contributed by the United States. Also shown (red line) is an estimate of the upper limit for re-statement of the shared Labor cost in 2012 USD, using a labor rate of 90 USD/hr.

Similarly, the shared Labor contributed by Europe is shown in Fig. 8 (blue line), as a function of the fraction of the total shared Labor contributed by Europe. Also shown (red line) is an estimate of the upper limit for re-statement of the shared Labor cost in 2012 Euro. The European labor rate used was 83.5 Euro/hr.

[3]corresponding to 90 USD/hr at an exchange rate of 100 Yen per USD.

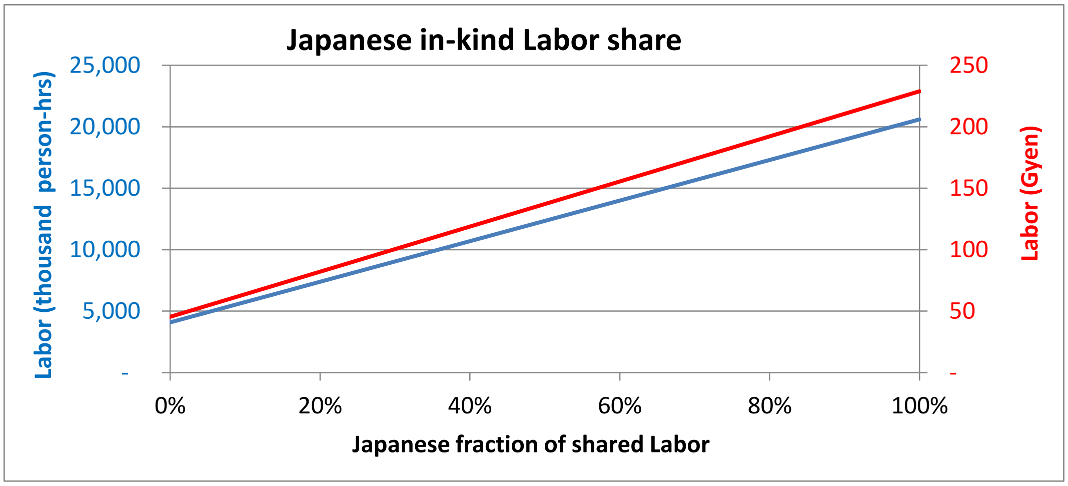

Figure 6. Japanese contributed Labor, in person-hrs (blue) and Yen (red), vs. Japanese fraction of the shared Labor

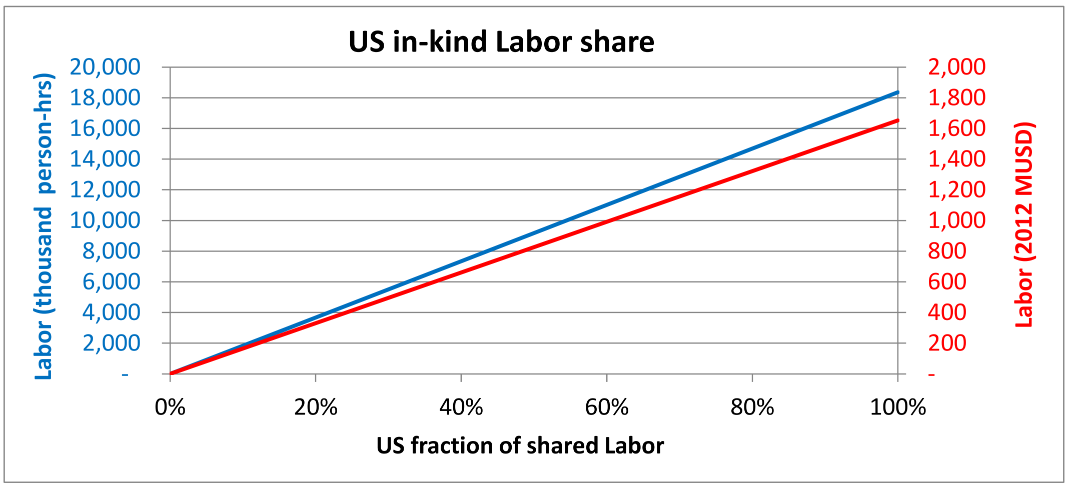

Figure 7. United States contributed Labor, in person-hrs (blue) and USD (red), vs. US fraction of the shared Labor

4 Cost Premium

The TDR Value and Labor estimates are median estimates: that is, they corresponds to the 50% probability point on the cumulative cost-distribution function. Some nations may require an estimate with a higher level of confidence. For this reason, the TDR Value estimate provides, for each cost element, a "cost premium". The sum of the Value estimate and the cost premium, called the"high-confidence estimate" for that element, has an 84% level of confidence. That is, there is a 16% chance that the actual cost of the element will exceed the "high-confidence estimate". The cost premium for a collection of cost elements is given (conservatively) by a simple sum of the premiums for the individual elements. For the total TDR Value as measured in ILCU, the overall cost premium is about 26%; for the total TDR Labor as measured

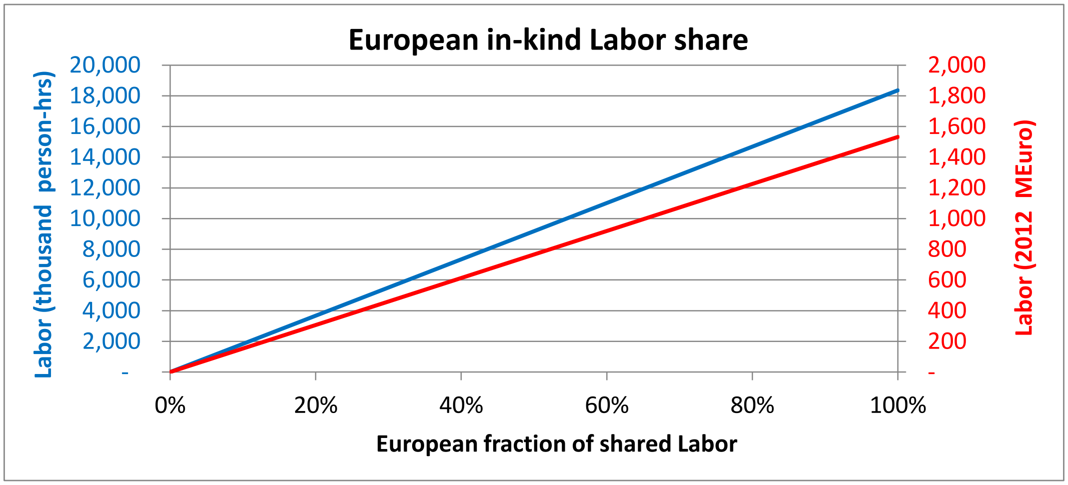

Figure 8. European contributed Labor, in person-hrs (blue) and Euro (red), vs. European fraction of the shared Labor

in person-hrs, the overall premium is about 24%.

The cost premium for a national Value estimate can be found by applying the conversion rules given in Sec. 2 to the cost premiums of the contributed cost elements. Since the cost premiums are available individually for each cost element, the total cost premium for the sum of all contributed elements can be precisely determined. Similarly, premiums can be found for a national Labor estimate in the same way, following the prescription described in Sec. 3.

5 Annual Operating Costs for the Accelerator

5.1 Value estimate for annual accelerator operations in the TDR

A Value-style estimate for the annual accelerator operating costs is given in the TDR. The estimate has 3 components:

- electrical power. A machine operation period of 9 months per year at full power of 165 MW is assumed, corresponding to 500 GeV at design luminosity, plus 3 months standby at reduced power (25 MW). This corresponds to a total annual energy of about 1120 GW-hrs.

- maintenance, repairs, helium consumables, and components that have a limited life expectancy and need continuous replacement or refurbishment, like klystrons. The annual cost for these items is estimated to be between 3% and 5% of the total project cost for technical components.

- manpower, corresponding to the continuing operations and administrative staff of the ILC Laboratory (not including support of the scientific program). Based on comparisons with existing facilities of similar scope, the required manpower is estimated to be between 700 and 1000 FTE.

Note that this estimate only covers the cost of accelerator operations. It does not include the operation cost or staff for those parts of the ILC laboratory not directly related to accelerator operation.

The Value of the first two items is estimated in the TDR. The electrical power rate is estimated to be between 0.1 and 0.2 ILCU per kW-hr, giving a range of electrical power costs between 112 and 224 MILCU per year. The total project cost for technical components is 5,600 MILCU, giving a range between 168 and 280 MILCU per year for materials and supplies. Adding the two items together gives a range of 280 to 510 MILCU per year. The Value estimate for operations is taken to be the average: 390 MILCU per year. The cost premium for this estimate is taken to be the standard deviation of the upper or lower estimate from the average, which gives a premium of about 40%.

Using a similar procedure for manpower, the Labor estimate for annual operations in the TDR is 850 FTE, with a premium of about 25%.

5.2 National Value and Labor estimates for annual accelerator operations

5.2.1 General considerations

An operations estimate in the host currency can be developed using a similar procedure. The host should specify a low and high value for the electrical power rate, and the range of electrical power costs can then be estimated. Similarly, the host can use its estimate of the project technical component cost in its own currency, and from this the expected range in annual materials and supplies expenditures can be estimated. The manpower estimate in person-years can be directly used. Some or all of this can be converted to host currency if required, using a host-supplied annual labor rate.

5.3 Example: Japanese site

As an example, consider the case of a Japanese site. In Table 5, the power, consumables, and manpower costs have been estimated in Yen, using the same cost basis as presented in the previous section. The cost of electric power has been taken to be 16 Yen/kW-hr. Annual manpower has been converted to Yen using a labor rate of 9,000 Yen/hr[4] and assuming 1700 hrs/yr. The total annual accelerator operations cost in this example is 60 GYen. The associated premium can be calculated using the premiums quoted in the previous section for operations Value and Labor.

6 Staging and Upgrade Costs

6.1 General considerations

The ILC TDR included an estimate of the costs of several options: a lower-energy, first stage machine, as well as luminosity and energy upgrades. The costs were

[4] corresponding to 90 USD/hr at an exchange rate of 100 Yen per USD.

Table 5. Annual accelerator operations, Japanese site

Item	Quantity	Rate	Cost (GYen)
Electric Power	1120 GW-hrs	16 Yen/kW-hr	18
Consumables	712.8 GYen	4%	29
Manpower	850 FTE	15.3 MYen/yr	13
Total			60

given as decrements or increments to the Value and Labor estimates for the baseline machine. Estimates can be made in national currencies for these options, using the procedures presented above in Sec. 2 and Sec. 3.

To do this, however, the costs of the staging and upgrade options need to be divided into site-specific and shared costs. This division is not provided explicitly in the TDR. To remedy this, an approximate division is given in Table 6 and Table 7.

Table 6. Site-specific and shared Value (2012 MILCU) for options, relative to the baseline.

Option	Site-specific Value	Shared Value	Total Value
First-stage, scenario 1	-336	-2,089	-2,425
First-stage, scenario 2	0	-1,934	-1,934
Luminosity upgrade	0	483	483
1 TeV upgrade, scenario A	890	5,816	6,706
1 TeV upgrade, scenario B	657	4,832	5,489
1 TeV upgrade, scenario C	425	6,657	7,082

Table 7. Site-specific and shared Labor (thousand person-hrs) for options, relative to the baseline.

Option	Site-specific Labor	Shared Labor	Total Labor
First-stage, scenario 1	-106	-4,477	-4,583
First-stage, scenario 2	0	-3,563	-3,563
Luminosity upgrade	0	1,537	1,537
1 TeV upgrade, scenario A	276	11,711	11,988
1 TeV upgrade, scenario B	203	9,213	9,416
1 TeV upgrade, scenario C	131	14,126	14,256

The option estimates are given only for the average site, and in this case "site-specific" refers only to the civil construction Value and Labor. Nevertheless, with these tables, the procedures outlined in Sec. 2 and Sec. 3 can be used to make estimates of the additional costs or savings of the options in national currencies, for a specific host and sharing model.

6.2 Example: Japanese site

As an example, consider again the case of a site in Japan. Fig. 9 is constructed in the same way as Fig. 5, except that it corresponds to the Value of the first-stage option only (scenario 2). The figure shows that the first-stage Value is bounded between approximately 530 and 730 GYen (2012).

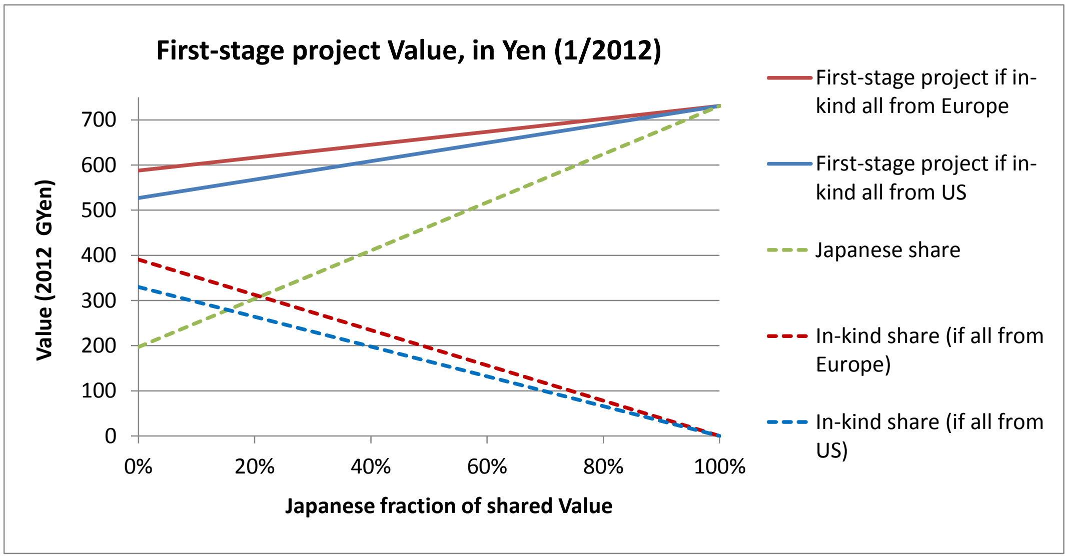

Figure 9. Stage 1 (scenario 2) project Value, in Yen, vs. Japanese fraction of the shared Value

7 Escalation from the TDR Date to the End of Construction

7.1 General considerations

The ILC TDR Value estimate baseline date is January, 2012. Escalation from this date to start of construction, and during construction, is not included. Some national funding agencies require, however, that escalation be included: that is, the national estimate must be stated in then-year currency, rather than in 2012 currency.

The TDR provides an obligation profile for the project Value, based on the project construction schedule. Together with assumptions on when the project starts and what the inflation rate is, this provides all the information needed to calculate a national estimate in then-year currency. For those nations which require it, escalation should only be applied to the shared portion of the Value after conversion to a national currency.

7.2 Example

As an example, the effect of escalation on the total project Value in ILCU can be calculated. Fig. 10 shows the TDR Value profile, for a project start date of 2016. An inflation rate of 2.5% per year has been assumed. (This is the average inflation rate for the US Manufacturing Producer Price Index, over 2011 and 2012). The blue bars show the base Value in 2012 ILCU, and the red bars show the increase due to inflation, so that the total is the Value in then-year ILCU. The increase in the total project Value due to escalation in this example is 20%.

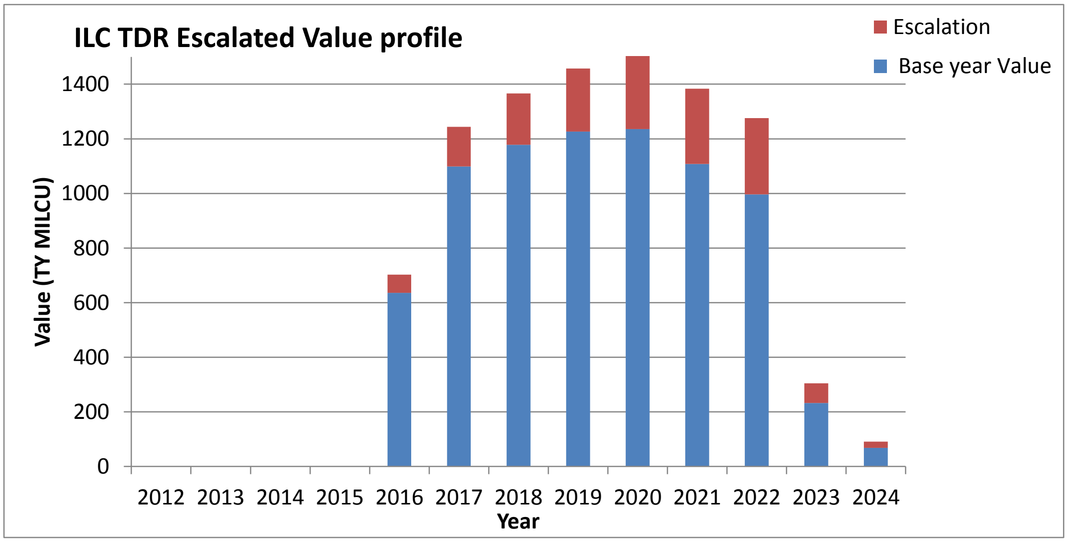

Figure 10. ILC TDR Escalated Value profile

8 Additional Nation-specific Costs

This section discusses several additional costs related to the project, but which have not be addressed explicitly in the TDR Value estimate. Some of these costs may need to be included in national cost estimates. In this case, national funding agencies, working with ILC experts, will need to develop these estimates.

8.1 Costs for project engineering and design, and R&D prior to construction authorization

The TDR Value estimate does not include costs for preliminary project engineering and design, and for continuing R&D, prior to construction authorization. Some national funding agencies may require these costs to be estimated as part of the process of evaluating contributions to the project. The estimates associated with each shared project contribution would follow national project planning guidelines and would need to be developed by experts within each partner nation.

8.2 Additional costs due to potential overheads related to management of in-kind contributions

In the TDR Value estimate, management manpower and associated costs are based on experience from centrally managed projects, since the management cost basis for such projects is relatively well established. However, experience with in-kind contributions to other projects indicates that there may be additional overheads related to management of these contributions. Since such overheads depend in detail on which components are shared and how they are procured, they are impossible to evaluate until the project partners are all identified, and a specific component sharing model and procurement plan is chosen. Subsequently, these overheads can be included in national cost estimates.

8.3 Contingency in excess of the cost premium

The cost premiums evaluated in the TDR Value estimate quantify the price of project cost risk mitigation. While this is expected to be the major risk at this stage of the project, some national funding guidelines may also require an evaluation of the price of mitigating other forms of risk (technical risk, schedule risk, or risks related to omissions). The price for mitigating all significant risks is sometimes referred to as "contingency".

The evaluation of contingency associated with each shared project contribution would follow national project planning guidelines and would need to be developed by experts within each partner nation. However, it should be noted that there is some information in the TDR Value estimate which could be useful for this purpose. The luminosity upgrade (6.2% of the project Value: see Table 6) essentially measures the price of doubling the luminosity, which quantifies the luminosity risk. The TDR Value estimate can also be used to quantify the cavity gradient risk. The cost reducing the installed cavity gradient by 10% is approximately 6% of the project Value. Thus, the total cost of significant mitigation of luminosity and cavity gradient risk (which are the dominant technical performance risks) is about 12%, which compares with an overall estimated project cost risk of about 25%.

8.4 Other project costs

There are a number of other project-related costs which were not included in the TDR Value estimate, such as

- experimental detectors;
- land acquisition and underground easement costs;
- site infrastructure costs, such as roads;
- taxes; and
- de-commissioning

National project planning guidelines may require the inclusion of such costs in a national estimate.

References

[1] "International Linear Collider Technical Design Report: Part II" (to be published)

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