Global Environment Facility

GEF/C.33/Inf.18
April 16, 2008

GEF Council
April 22-2, 2008

MANUAL FOR CALCULATING GHG BENEFITS OF GEF PROJECTS: ENERGY EFFICIENCY AND RENEWABLE ENERGY PROJECTS

Table of Contents

List of Abbreviations

BIPV	Building-integrated Photovoltaic
BU	Bottom-up
CDM	Clean Development Mechanism
CF	causality factor
CO_2	Carbon dioxide
DP	Direct Project
DPP	Direct post-project
E	Energy
ESCO	Energy Service Company
GEF	Global Environment Facility
GHG	Greenhouse Gas
GWP	Global warming potential
IFF	Investment Facilitation Fund
IPCC	Intergovernmental Panel on Climate Change
kt or ktonnes	kilo-tonnes or 103 metric tonnes
kWh	Kilowatt hours
M&E	Monitoring and evaluation
MW	Megawatt
MWh	Megawatt hour
RF	replication factor
tf	turnover factor
TAR	IPCC Third Assessment Report
TD	Top-down
t or tonnes	103 kg or one metric tonne
UNFCCC	UN Framework Convention on Climate Change

I. INTRODUCTION, CONCEPTS, AND DEFINITIONS

Why this Manual?

1. All Global Environment Facility's (GEF) climate change project briefs have to supply an assessment of how much CO_2 eq emissions the projects are expected to save. In addition, as part of the GEF Replenishment Agreement for GEF-4, a performance target for greenhouse gas (GHG) emissions impacts was established as an indicator of programming effectiveness in the climate change focal areas. The performance target stated that in the climate change focal area, "projects projected to avoid or sequester at least 200 million tonnes of greenhouse gas (carbon dioxide equivalents) emissions will be approved." At the midpoint review in GEF-3, this target had been met, and a review of agency project briefs shows this is also the case for the second half of GEF-3. GEF-4 targets another 400 million tonnes of $CO_{2\ eq}$ to be avoided through GEF-sponsored mitigation projects.

2. To assess this indicator in a robust, fair, and consistent manner, a methodology for estimating GHG savings was developed. This document describes this methodology, which is particularly appropriate given the unique nature of GEF projects. Project proposals are asked to apply this methodology in their project briefs.

3. Further methodological developments will be necessary in the future. The next step will be to develop CO_2 quantification guidelines for GEF projects in transportation, land use, land-use change, and forestry. Although these areas have GHG impacts, they have not yet been report to the Council, given methodological uncertainty. However, the methodologies reported in this manual for renewable energy and energy efficiency projects must be applied for all future projects.

What is Different about this Scheme Compared to Standard Schemes for CO2 Accounting?

4. Most of the methodologies for measuring the CO_2 impacts of projects focus on the emissions savings from a specific investment. Projects under the Clean Development Mechanism (CDM) of the Kyoto Protocol, for example, have to specify the technical characteristics of the hardware, location, ownership, and operating hours, in order to calculate the expected amount of emissions reductions to be produced from an investment. The methodologies for assessing the baselines and additional impacts of CDM projects are constantly under review by the relevant bodies of the United Nations Framework Convention on Climate Change Convention (UNFCCC). They can serve as helpful tools to analyze GEF projects' impacts.

5. Nevertheless, GEF projects differ from CDM projects in important ways, which need to be reflected in the impact calculations. GEF projects under the operational programs have a long-term and strategic market development approach. That means that their starting baseline is the overall state of the market in a country or region, not simply the business-as-usual scenario for a single investment. A second difference lies in the types of activities supported by the GEF as compared to the CDM. Typical GEF projects range from demonstration projects and direct

investments, to financing mechanisms that leverage local private sector financing, to capacity building and technical assistance, to the development and implementation of government policies supporting climate-friendly investments in energy and other sectors. Many project activities do not have direct GHG impacts, yet are necessary preconditions for effectively avoiding emissions in the long run. Therefore, an adequate assessment methodology of the CO_2 emission reduction effects of GEF projects needs to take into account the direct mitigation effect of cofinanced investments, as well as the indirect mitigation effects of investments for which the GEF intervention has created the enabling environment. The proposed methodology accounts explicitly for this situation. As the estimates for direct and indirect effects are fundamentally different in their accuracy and degree of certainty, the methodology used here reports separately on direct and indirect effects.

6. GEF projects typically focus on facilitating future market development, removing barriers, and putting the right conditions in place so that emissions and energy needs will not rise in the future. These projects are necessarily risky, their outcomes uncertain, and they vary in their degree of uncertainty both between and within projects. In addition, a GEF method for GHG accounting needs to take into account the investments that can happen after the actual GEF intervention.

7. Therefore, a different, larger set of uncertainties for GEF projects than for CDM projects compromises the quality of a GHG impact assessment. In addition, GEF projects typically are exposed to a larger number of implementation uncertainties, which decrease the probability that the expected positive outcomes of a project will be achieved in the given amount of time. While CDM project proponents receive the funding for CO_2 emissions reductions only upon delivery of the Certified Emission Reductions, GEF project proponents receive the funding up front.

8. It is important to note that no methodology that quantifies GHG emission reduction effects for GEF projects can fulfill all purposes. In particular, no methodology that results in one aggregate number for the portfolio can provide meaningful and comparable values for GHG abatement costs (US$/tonnes) because of the following:

(a) The GHG emission reductions are achieved using many different avenues in GEF projects.

(b) The weights of these avenues vary greatly among different projects.

(c) In the interest of sustainability and replicability, the GEF-sponsored part of the project often focuses on interventions that have long-term cost-reduction effects (e.g., through capacity building or enabling environments), but by themselves do not have impacts on GHG emissions.

9. The methodology accounts for this by estimating separate figures with different uncertainties attached: it does not recommend totaling these figures. As is described in more detail in what follows, a GEF project has direct CO_2 emission reductions achieved by investments that are directly part of the results of the projects; direct post-project emission reductions through those investments that are supported by GEF-sponsored financial

mechanisms still active after the projects' supervised duration; and a range of indirect impacts through market facilitation and development. The methodology employs conservative assumptions to account for the uncertainties in the assessment of the scale of their impacts, as well as the causality of the GEF intervention and shifting baselines.

Table 1: Three Types of GHG Emission Reductions in GEF Projects

Type of GHG emission reduction	**Direct**	**Direct post-project**	**Indirect**
Example component of a GEF intervention that can cause this type of GHG emission reduction	Demonstration projects and investments leveraged during the projects' supervised implementation	Investments supported by mechanisms (e.g., revolving funds) that continue operating after the end of the project	Policy framework, standards, and labels
Logframe level	Output	Not corresponding to a specific logframe level	Outcome/impact on level of global environmental objective
Quantification method	Similar to CDM projects	Similar to CDM projects, based on assumptions of functioning post-project mechanisms	Bottom-up or top-down
Quality of assessment	Highest level of certainty and accuracy	Reasonable level of accuracy, medium level of certainty	Low levels of accuracy and certainty

What Is Direct GHG Impact?

10. In most GEF projects, energy efficiency or renewable energy investments are parts of the projects' outputs and lead directly to reductions in GHG emissions. Direct emission reductions are calculated by assessing the fuel savings attributable to the investments made during the project's supervised implementation period. These are then projected for, and totaled over, the respective lifetime of the investments both during and post implementation. All CO_2 savings resulting from investments made within the boundaries of a project—as defined by the logframe, either using GEF resources or the resources contributed by cofinanciers and tracked through monitoring and evaluation (M&E) systems—will be counted toward a project's direct effects.

What Is Direct Post-Project GHG Impact?

11. GEF projects frequently put in place (financial) mechanisms that will still be operational after the project ends, such as partial credit guarantee facilities, risk mitigation facilities, or revolving funds. Such mechanisms facilitate investments yielding CO_2 reductions, which can, in turn, be quantified with the same methodology as the direct investments. However, these effects fall outside the framework of normal project monitoring systems. To account for these savings, the methodology calculates them separately as "direct post-project" emission reductions. Although the same assumptions for investment lifetimes and emission factors are used as in the case of direct emission reductions, the nature of direct post-project emissions dictates that conservative assumptions be used with reference to leakage rates and financial instruments' effectiveness.

What Are Indirect GHG Emission Savings?

12. Because GEF projects emphasize capacity building, innovation, and catalytic action for replication, their largest impacts typically lie in the long-term GHG savings achieved after the GEF project's completion. These investments are strongly affected by the long-term outcomes of the GEF activities that remove barriers; for example, those that build capacity, improve the enabling environment, and stimulate replication. Their GHG emission reductions are referred to as "indirect" GHG savings. To estimate the indirect impact, one must rely heavily upon assumptions and expert judgment. As their level of uncertainty and accuracy is different from direct or direct post-project savings, it is not appropriate to aggregate the two types of savings.

13. There are two different approaches for estimating indirect effects, resulting in a range of likely indirect effects. The first one—referred to as "bottom-up"—requires an expert judgment on the likely effectiveness of a project's demonstration and triggering effects. The direct and direct post-project impacts of a project are simply multiplied by the number of times that a successful investment under the project might be replicated after the project's activities have ended.

14. The second—or "top-down" —approach assesses indirect impacts by estimating the combined technical and economic market potential for the technology within the 10 years after the project's lifetime. Most of the time, this is not purely the technical potential of a technology, because during those 10 years, additional market barriers may emerge and prevent achieving the total potential. Using the maximum realizable market size further implies that there would be no baseline changes over considerable periods of time, and that all emission reductions in that sector or market can be attributed entirely to the GEF intervention. Clearly, both of these assumptions are unlikely to hold in reality. Therefore, the assessment contains a correction factor, the "GEF causality factor," which expresses the degree to which the GEF intervention can take credit for these improvements. This causality factor is used to finalize the "top-down" estimate for the indirect benefits, which can be viewed as providing the upper limit of the range of indirect GHG benefits.

II. STEP-BY-STEP GUIDE FOR ALL TYPES OF PROJECTS

15. Calculating CO_2 emission reductions from GEF projects is a process with several steps, depending on the project's complexity (in particular, how many different technologies and applications are affected) and components. Some project components contain investments as an output; these lead to direct GHG emission reductions. Other components (e.g., revolving funds) typically lead to direct as well as to indirect GHG emission reductions. A third group might lead—first and foremost, if not exclusively—to indirect GHG emission reductions.

16. The typical sequence in calculating CO_2 emission reductions:

(a) Calculate the baseline emissions of the scenario without a GEF contribution to the project.

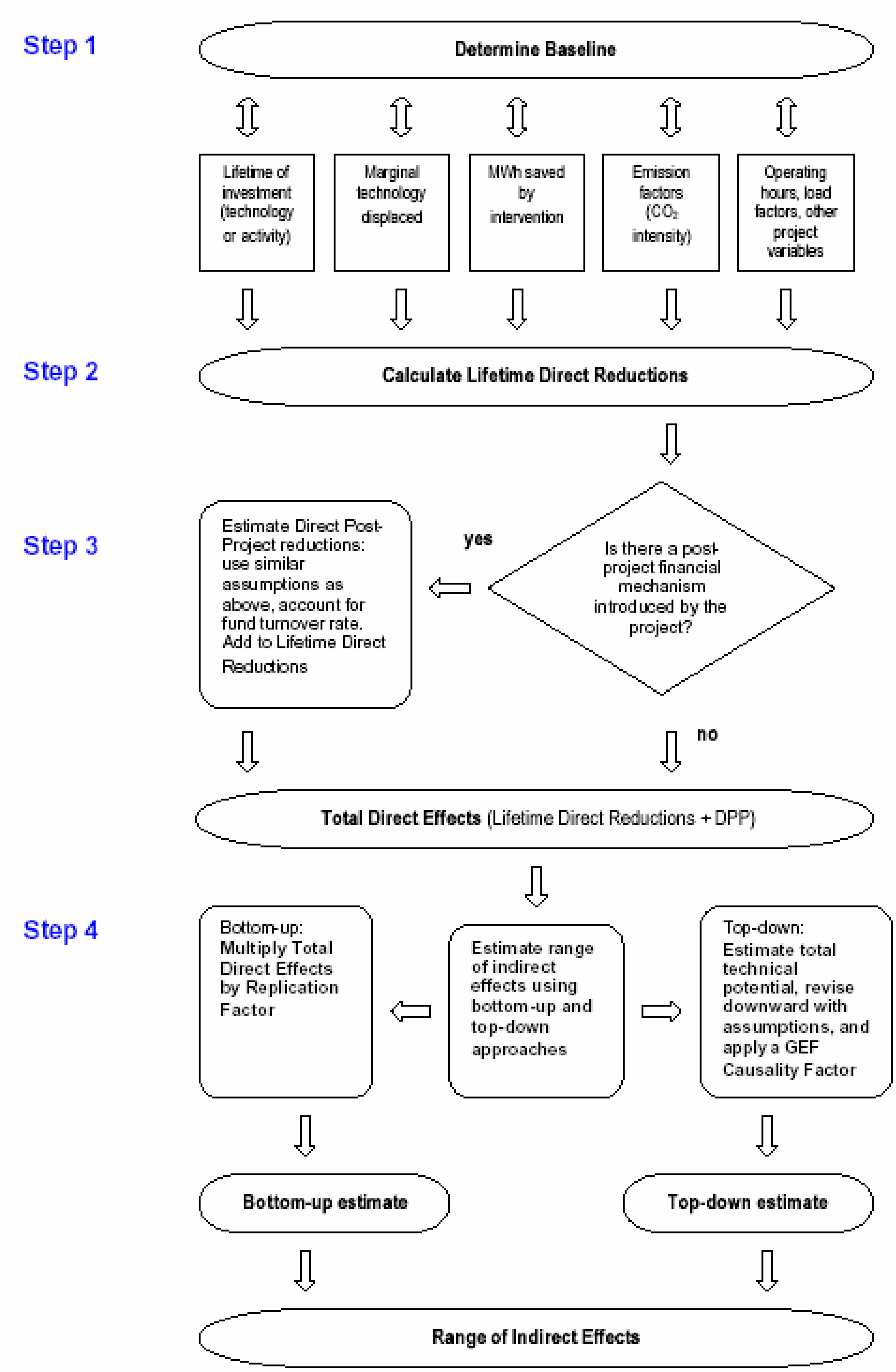
(b) For the GEF alternative, calculate the emissions, including investments that are tracked in the logframe during the project's implementation. The difference between this number and the baseline emissions equals the direct emission reductions of the project.

(c) If, for the post-project period, a project-sponsored (financial) mechanism will remain in place and keep providing support for GHG-reducing investments, which would not happen in the baseline case, estimate the direct post-project emission reductions for these investments.

(d) Estimate what emission reductions in the post-project period will have a causal link to the GEF intervention. For these, calculate the indirect emission reductions. If the data permit it, and if it is appropriate for the situation, use both methods: the bottom-up and the top-down. In some cases, only the bottom-up method will make sense.

(e) Each of these steps will be discussed in more detail in the following sections. Figure 1 contains a flowchart that also indicates the data requirements for all steps.

Figure 1: Four Steps to Calculate GHG Impacts



Assumptions and Data Requirements

17. The data and assumptions necessary for the CO_2 emissions reduction assessment are normally highly project specific. They are researched and documented during the preparatory phase of the projects and should be contained in the project document.

18. Some general assumptions are important in all steps of the GHG emission reductions assessment:

(a) All analyses are conducted in tonnes of $CO_{2\ eq}$.

(b) The CO_2 reductions reported are cumulative reductions, calculated for the lifetimes of the investments.

(c) No discounting for future GHG emission reductions.

19. As a general rule when applying this methodology, the project proponent should rather err on the side of transparency, and generally be cautious and conservative when making assumptions on GHG emission reductions.

Table 2: Global Warming Potentials as Given in Table 3 of the Technical Summary of Working Group I for the Third Assessment Report (TAR) of IPCC, 2001

Gas	Lifetime (Years)	Global Warming Potential (Time Horizon in Years)		
		20	100	500
Carbon Dioxide (CO_2)		1	1	1
Methane[a] (CH_4)	12[b]	62	23	7

Note: a) The methane global warming potentials include an indirect contribution from stratospheric H20 and O3. b) The value for methane is an adjustment time, which incorporates the indirect effects of emissions of the gas on its own lifetime.

(Source: http://www.ipcc.ch/pub/wg1TARtechsum.pdf)

20. In order to put these assumptions into practice, it is important that the database is good. In particular, the following data need to be gathered for the assessment:

(a) Global warming potentials of non-CO_2 greenhouse gases: Table 2 reproduces the Intergovernmental Panel on Climate Change (IPCC) figures, which should be used for all purposes in GEF projects. Typically, the 100-year figures are used.

(b) Baseline scenarios: It is very important for the analysis of the non-GEF baseline to factor in the likely expansion for the specific market (e.g., market for energy-using equipment, market for a specific energy service) without GEF intervention. The approaches here are different for each operational program, and will be discussed in more detail in the next section, as well as in separate sections for each operational program. In any case, the baseline scenario also contains the baseline technologies, i.e., which technology would be deployed next under a scenario without GEF intervention.

(c) Emission factors: For the baseline technologies, as well as for the technologies to be deployed under the GEF Alternative Scenario, the proposal needs to contain the expected emissions factors, i.e., how many kilograms of $CO_{2\,eq}$ are going to be emitted for each kilowatt-hour (kWh) of energy, or every energy service provided. In exceptional cases, i.e., if no baseline technology can be specified, the average emission factor of the respective economy can be used.

(d) Lifetimes of investments: The second investment-specific parameter that needs to be determined is the lifetime of the investment. For the various operational programs, different technologies, investment conditions, and assumptions are appropriate. The methodology actually specifies preapproved default values for the lifetimes of the relevant technologies, and proponents are encouraged to utilize these default values. They will be discussed in the respective sections on direct emission reductions of the operational programs below.

Calculating Baseline CO_2 Emissions

21. The baseline is part of the project proposal. It should contain a full description of the country's development without the GEF intervention, but with engagement of the respective implementing agency, if that would happen without the GEF. Please note, the Incremental Cost Analysis only relates to the incremental costs imposed as a result of caring for the global environment, not to those incremental costs that are caused by developmental additionalities. The baseline scenario includes developmental activities of national governments and implementing agencies.[1]

22. The baseline scenario is typically used to identify marginal (power-generation or energy-using) technology and its emission factor. These are the bases for the baseline GHG emissions. In the baseline scenario, projects should describe the characteristics of the power sector, the emission factors, the markets to be transformed, and the lifetime of the investments. All of this information needs to be collected in the project preparation phase. In exceptional cases where data on marginal technology are absolutely unavailable, the average emission factors can be used to calculate the CO_2 savings. In these cases, the proposal should discuss the impact of this change in assumptions on the overall assessment in a qualitative manner.

Calculating Direct Emission Reduction Effects

[1] During the finalization of this manual, the incremental cost guidelines for GEF projects are being revisited. Please note that this methodology should not impose unnecessary bureaucracy above and beyond the revised guidelines.

23. Direct emission reductions are achieved in GEF projects where these projects lead to less GHG-emitting investments than a no-project situation would achieve. The development of voluntary carbon funds, voluntary markets for certified emission reductions, obligatory markets for carbon emissions, and the methodological progress in the Clean Development Mechanism have all stimulated efforts to refine the methodologies for carbon emission reduction accounting and baseline definition in the context of direct GHG abatement from investment projects. All of these certification mechanisms target the same emission reductions from specific investment projects that can be counted under "direct emission reductions" for GEF projects. Several methodologies have been published to analyze the direct emission reduction effects of CDM projects. One can apply their main ideas for calculations of direct emission reductions, which are achieved by investments that are facilitated in the GEF project and analyzed as part of the project proposal.

24. Almost all GEF projects leverage referring to tangible investments into cleaner energy or transportation systems. In some cases, these investments are not part of the project itself, and follow only indirectly from the project activities. When this is the case, the emission reductions should not be included in the direct emissions, but subsumed under the category "indirect emission reductions," discussed below. The most clear-cut criterion to decide whether investments should be counted toward direct or indirect emission reductions is the inclusion of the investment in the logframe of the GEF project, and the question whether it is monitored as part of the project's success indicators.

25. To quantify the GHG direct impacts of GEF projects, the approach chosen for the GEF projects is derived from international best practices, but also kept simple. All investments responsible for direct effects are evaluated in terms of the energy produced / (fossil) energy avoided over the lifetime of the respective investments. Different technologies have different assumed lifetimes. For example, solar home systems have shorter assumed lifetimes than village hydro systems.[2] The saved fuel or energy is then multiplied by the marginal CO_2 intensity of the energy supply. The formula is

$CO_{2\ direct} = E * c = e * l * c;$ with

$CO_{2\ direct}$ = direct GHG emission savings of successful project implementation
in $CO_{2\ eq}$, in tonnes
E = cumulative energy saved or substituted, e.g., in megawatt hours (MWh); $E = \Sigma_l\ e$
c = CO_2 intensity of the marginal technology, e.g., in t/MWh
e = annual energy replaced, e.g., in MWh
l = average useful lifetime of equipment in years

26. Please note that the lifetime of the equipment determines the duration over which the GHG savings may occur and count toward this sum. That means that the impact of all

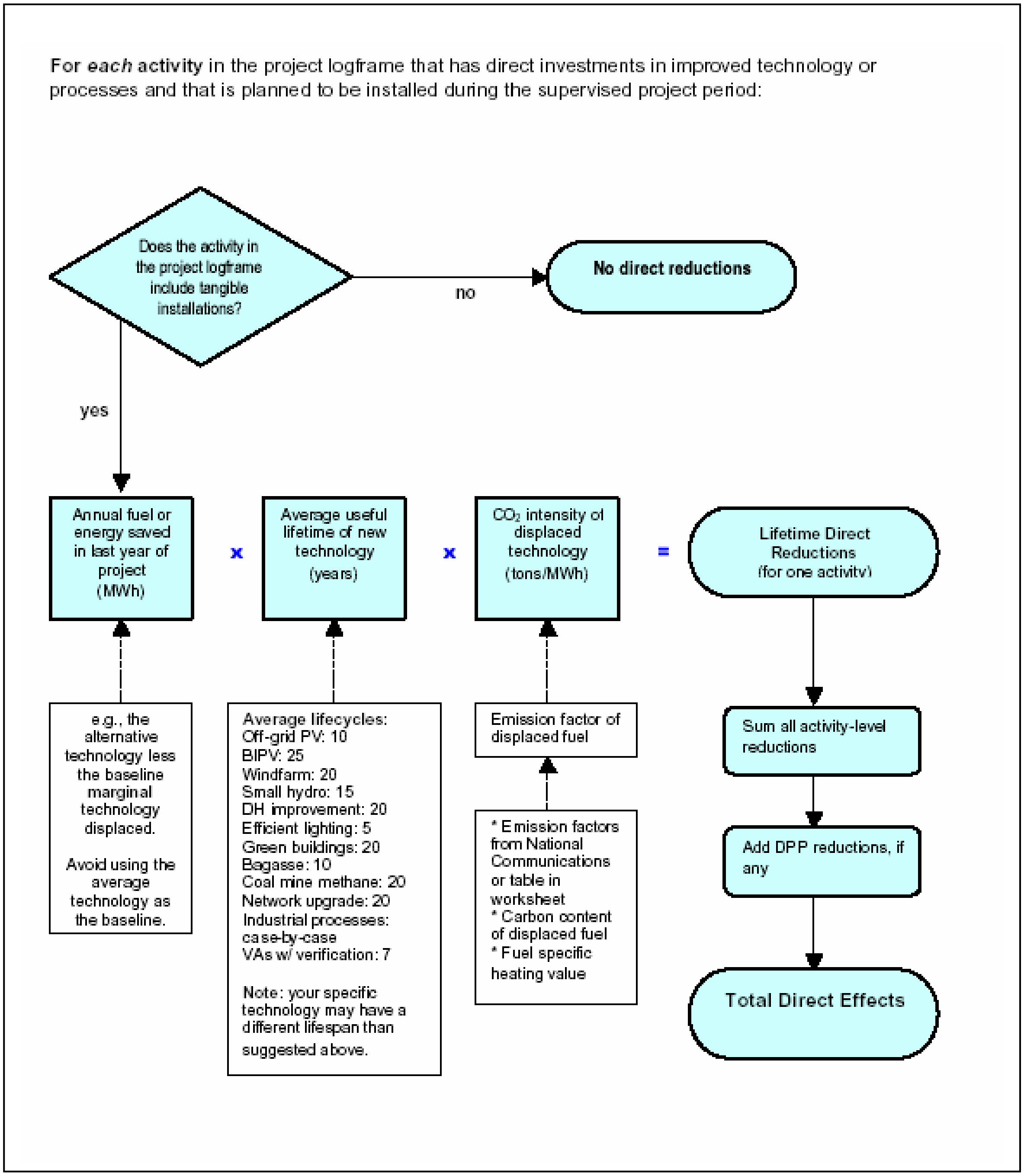
[2] For the default lifetimes to be used in the calculations, please refer to the chapters on energy efficiency, renewable energy, and transportation.

investments that are made during the project is the same, irrespective of whether they are undertaken in year one or five of project implementation. However, they must be made during the project's supervised operations to count as "direct" GHG emission reductions.

27. Because of the setup of GEF projects (and a conservative interpretation of the GEF cofinancing rules), investments are counted toward this sum irrespective of whether they are financed by GEF support or by cofinancing. The decisive criterion for the question of whether to include or exclude an investment is whether it is included in the M&E framework proposed in the logframe.

28. Figure 2 illustrates how to calculate the direct GHG impact of GEF projects.

Figure 2: Flowchart for Direct GHG Emission Reductions



Calculating Direct Post-project Emission Reduction Effects

29. In some cases, GEF projects implement a GEF-supported financing mechanism that will continue to support direct investments after the implementation or supervision period of the project. An example is a revolving fund for up-front financing of energy investments, which is refinanced from user fees, loan repayments, or a partial credit guarantee facility that might be

fully exposed at the end of the project, but then reduces its credit risk exposure and thus keeps looking for new investments. Depending on the leakage rate, facilities of this type can lead to a multiple of the original direct investment, which in turn can lead to a multiple of the associated emission savings long after the project itself has ended.

30. For the sake of this analysis, these "direct post-project" emissions are calculated based on the direct effects that are achieved during project implementation. It is necessary to make assumptions on the impact that the post-project facility (e.g., the revolving fund) will have after the project. For a revolving fund, for example, the rates of reflow and leakage will determine how many investments can be financed after the supervised implementation period. A "turnover factor" (tf) is defined as the number of times the post-project investments will be larger than the direct investments. The formula then is:

$CO_{2\ DPP} = CO_{2\ direct*} * tf$; with
CO2
$CO_{2\ DPP}$ = emissions saved with investments after the project, supported by post-project financial mechanisms
$CO_{2\ direct*}$ = direct emissions savings to the degree that they are supported through the mechanism that causes the post-project impacts
tf = turnover factor, determined for each facility based on assumptions on the fund leakage and financial situation in the project country

31. In the equation above, the turnover factor "tf" is equal to the number of times that the whole fund volume is expected to be invested and reinvested after the project. The first turnover will usually happen within the project's supervised implementation period, and thus count toward the direct emission reduction, not toward emissions reductions taking place through subsequent "turnover" of the funding.

32. The estimates for direct post-project effects are subject to a slightly higher degree of uncertainty than the direct GHG project outputs. In the project, they should be reported separately from the direct project output, as they actually are a form/type of indirect emission reductions, but ones which can be assessed with a higher degree of certainty than the purely indirect emission reductions (see below).

33. Figure 3 illustrates how to calculate direct post-project GHG impacts.

Figure 3: Flowchart for Direct Post-project GHG Emission Reductions

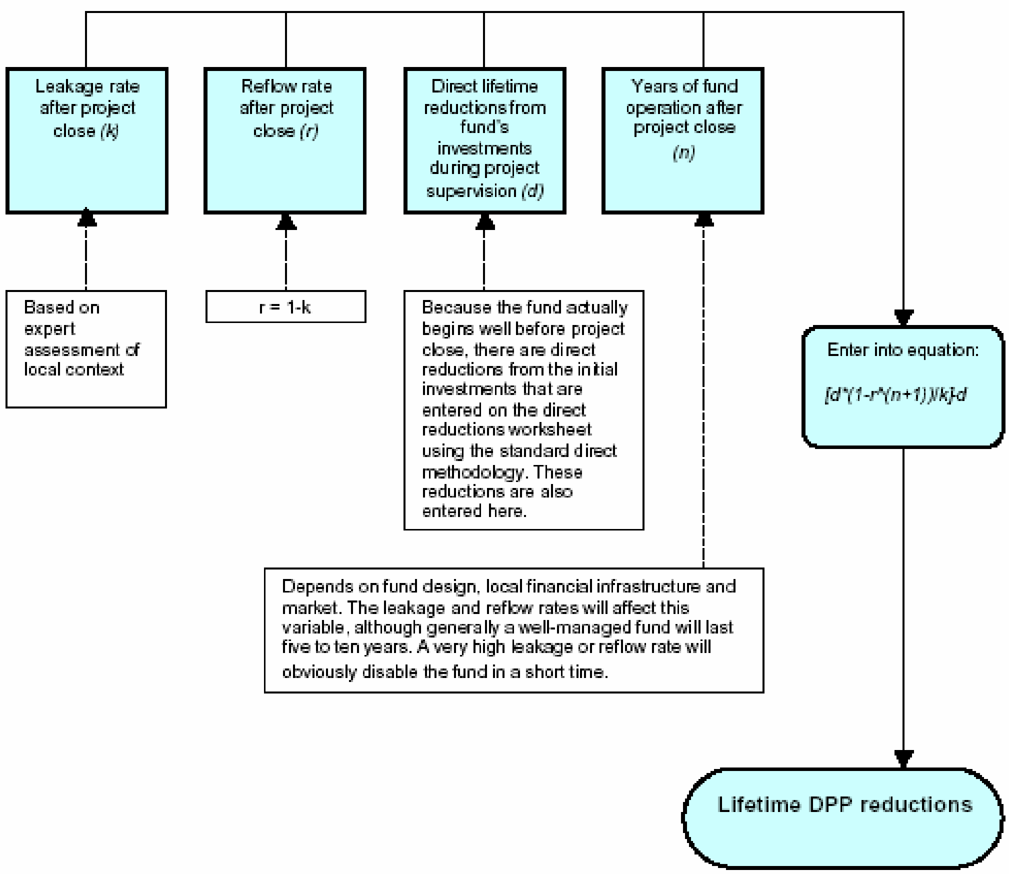
Energy-related projects

Direct Post-Project (DPP) reductions = $CO_{2DPP} = d(t) = [d*(1-r^{(n+1)})/k]-d$

d = direct lifetime reductions from investments made during project supervision from the financial mechanism only.
t = turnover rate, determined for each mechanism based on assumptions on fund leakage and financial situation in the host country.

In the absence of a good turnover rate estimate, DPP can be estimated with the following equation: $[d*(1-r^{(n+1)})/k]-d$ where the additional variables are:

n = years of fund operation after project close (typically 5 – 10). This will depend on the leakage rate but 10 years is the default.
k = leakage rate after project close
r = $1-k$ = reflow rate after project close



Calculating Replication and Indirect Impacts

34. Because GEF's approach emphasizes strategic interventions and their long-term impacts, direct GHG emission reduction effects tell only half the story, particularly for energy-efficiency and renewable-energy programs, which focus on removing barriers. Barrier removal activities sponsored by the GEF promote the development of markets for renewable energies and energy efficiency in a country or region, and thus should lead to large GHG abatements in the future. These activities can be found mostly in the areas of technical assistance, capacity building, and the development of investment-enabling environments. Rather than invest large sums of public money, they focus on leveraging private investments beyond the narrow range of project cofinancing.

35. During project preparations, projects must document the estimated market development and long-term impacts of their interventions. Project briefs are therefore expected to contain the data required to complete the estimation. It is difficult to assess the after-implementation impacts of a market facilitation and barrier removal project whose implementation lies years ahead.

36. Because of the big uncertainties related to indirect GHG emission reductions, it is advisable to use ranges to estimate the indirect effects. The limits of the range for the indirect impact can be determined two ways. One way, called the "top-down" methodology, starts with the potential market impacts overall in a country, under given assumptions for costs and benefits of the technology. This will mostly result in an optimistic assessment, and thus an upper limit for the range of potential GEF project impacts. Alternatively, using the "bottom-up" methodology, one can start extrapolating from the project's outputs, assume the project's impact will multiply in the long run, and judge from there what multiple of the GHG emission reductions will ensue in the long run. Using conservative assumptions, this will result in a lower limit of the range of the potential GEF project impact. Both methodologies can be used in a complementary manner and are described in more detail below. To minimize the risk of exaggerated project expectations, one should use conservative estimates for the replication effects in either methodology.

37. The following are some assumptions that have to be made to calculate indirect effects:

- A standard project influence period for the GEF effects has been assumed to be 10 years. This means that a typical project will exert some influence on local market development for about 10 years, i.e., non-baseline investments that happen within 10 years after the project can be counted toward indirect impacts, with the reductions being cumulative over their respective lifetimes. In some cases, the influence period might be shorter.[3]

[3] An example is in energy-efficiency projects with strong baseline shifts, as discussed in an example for the calculations under Energy Efficiency.

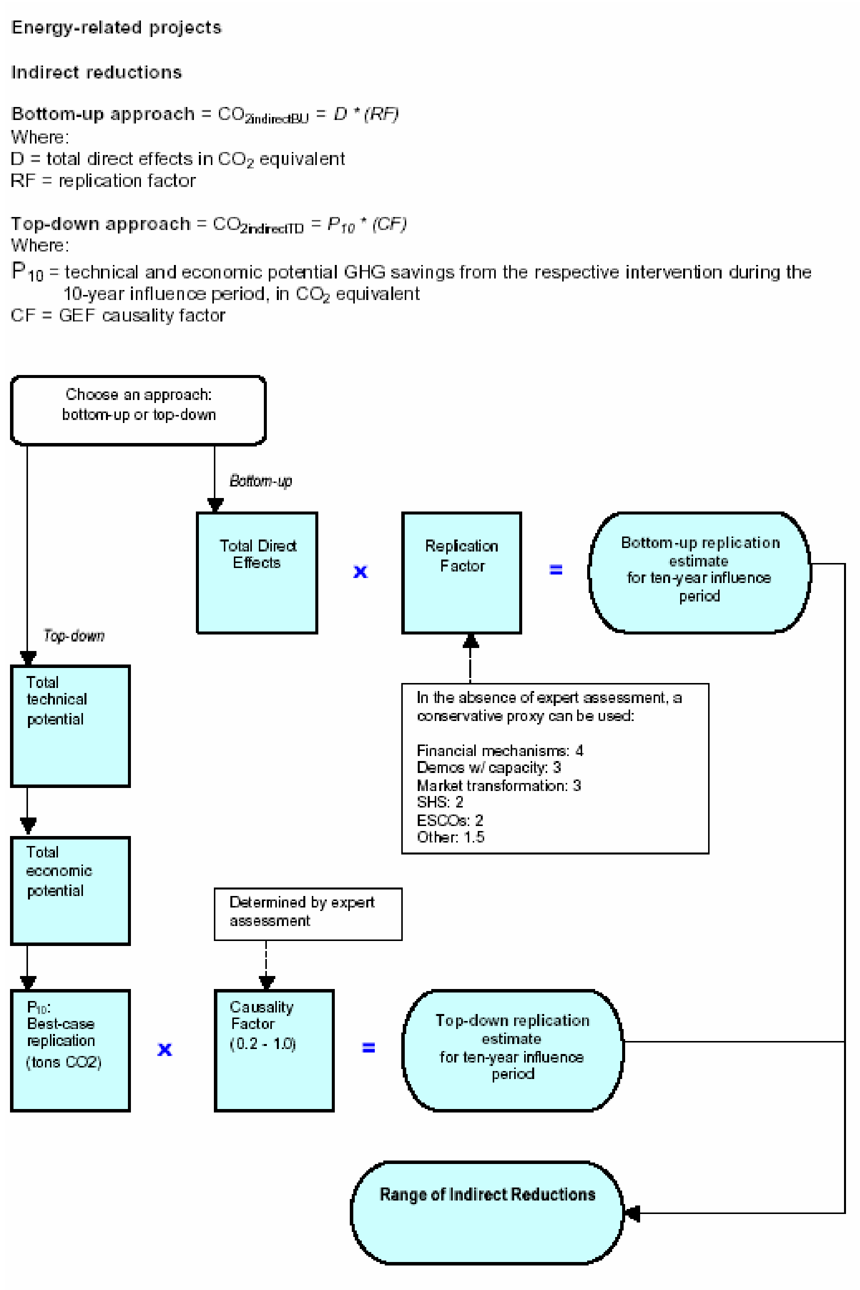
- If a project envisions a second phase or tranche at a later stage, and the GEF contribution to this second phase is not approved by Council, the GHG abatements achieved during the second phase are counted as indirect effects.

- For the sake of a conservative estimate, projects' indirect effects are only accounted for within the same country or region, even if the projects will be replicated in other countries.

- For portfolio-wide aggregation, double counting issues for indirect impacts need to be addressed.

38. Figure 4 illustrates how to calculate the indirect GHG impacts of GEF projects using both approaches. Both approaches are discussed in more detail below.

Figure 4: Flowchart for Direct Post-project GHG Emission Reductions



Calculating Replication and Indirect Impacts—Bottom-up Approach

39. Many GEF projects focus their activities on pilot and demonstration investments, for example, in some pilot areas of a country. The projects often then take measures that facilitate the replication of the investments in other parts of the country. This is a direct expression of the GEF's mission to be innovative and catalytic.

40. The bottom-up approach for calculating indirect GHG reductions starts from the direct effects of the investments under a project, and assumes that a multiple of these effects is going to be achieved by replicating the project's investments. For example, an energy service company (ESCO) supported by a GEF project might make profitable investments leading to energy savings of 200,000 tonnes over the lifetime of the investments. Judging from the local conditions, one could assume that within 10 years after the project ends, five more companies will copy the approach and venture into similar activities. Mathematically, the GHG emission reductions are calculated with the same formula as in the case of direct effects, and then multiplied by the assumed factor of replication:

$CO_{2\ indirect\ BU} = CO_{2\ direct} * RF$; with
$CO_{2\ indirect\ BU}$ = emissions saved with investments after the project, as estimated using the bottom-up approach, in tonnes of $CO_{2\ eq}$
RF = replication factor, i.e., how often will the project's investments be repeated during the 10 years after project implementation
$CO_{2\ direct}$ = estimate for direct and direct post-project emission reductions, in tonnes of $CO_{2\ eq}$

41. In the ESCO example above, the replication factor would be 5, and the indirect savings calculated by the bottom-up methodology would be 1 million tonnes.

42. To date, there is no empirical assessment of the replication factors for the GEF portfolio, partly because the portfolio is not mature enough for systematic observation, partly because no post-project evaluations are taking place. Therefore, for the time being, the replication factors should be explicitly determined in the project proposal for each project. When assessing these replication factors, two major aspects should be taken into account: The first is the expected probability of replication, which is mostly related to the question of whether a particular business model is profitable or politically desirable and for that reason offers some incentives to the local public or private stakeholders for replication. The second is the question of how this likelihood compares to the amount of investment already taking place directly under the project.

43. In the absence of empirical assessments, generalized replication factors can be employed in the assessment, relating to the design and activities of the project, for example:

(a) Rural electrification projects employing solar home systems should typically be designed in such a way that governments and local constituents want to do much more of them. As a compromise between ambitious goals and limited resources, a replication factor of 2 for the 10-year period after the project is the default value proposed by the methodology.

(b) For ESCOs, a default replication factor of 2 is proposed, based on the consideration that while ESCOs can offer profitable business models, they will be restricted in most cases by the availability of capital.

(c) For market transformation programs, it was assumed that they would leverage significant changes in the energy intensity of the marketed goods, and thus a higher replication factor of 3 is appropriate, as the direct emission savings under the projects are typically rather low.

(d) Finally, it was assumed that credit and guarantee facilities would have strong replication effects concurrent with a default replication factor of 4, since they are basically demonstrations of worthwhile business opportunities. However, the replication factor should be in line with the replication of the facility rather than the investments, as the replications within the same facility are already covered by the assessment of the post-project reductions.

44. Developing these replication factors on the basis of experiences collected within GEF projects is a research project for the future. For the time being, each project during preparation/PDF-B should do some research into the local situation and decide on a replication factor based on the knowledge of the local market, keeping in mind that the assessment should be conservative. Some reality checks are that the replication should always be smaller than the overall market potential, and that a comparison with the direct and direct post-project impacts should lend itself to a reasonable explanation.

Calculating Replication and Indirect Impacts—Top-down Approach

45. The underlying assumption of the top-down approach is that removing barriers to a market for cost-effective technologies allows the project to leverage the whole market for the relevant technology. If all barriers to market development are removed, market forces should exploit the full economic potential offered by the respective market. Therefore, the starting point is the whole economic potential for GHG abatement of a given application in the project's country or region.

46. In most GEF climate change interventions, estimates for full economic potential are created in the project development phase. These are expert estimates, already fraught with uncertainty, and assumptions need to be made about the effect of the actual GEF causality. Both of these effects are accounted for in the methodology, but also need to be accounted for in the interpretation of the results. In addition, the economic and technical potential of a given application needs to be assessed with respect to what can be achieved (in the 10 year "post-project influence period").

47. Because market forces or government policies might generate some of these achievements at a later point in time even without a GEF intervention (baseline shifts), this figure is then multiplied by an assumed GEF causality factor, which indicates to what degree the GEF intervention can claim causality for the reduction. For the GEF causality factor, five levels of GEF impact and causality have been assumed:

(a) Level 5 = "The GEF contribution is critical and nothing would have happened in the baseline," GEF causality = 100 percent

(b) Level 4 = "The GEF contribution is dominant, but some of this reduction can be attributed to the baseline," GEF causality = 80 percent

(c) Level 3 = "The GEF contribution is substantial, but modest indirect emission reductions can be attributed to the baseline," GEF causality = 60 percent

(d) Level 2 = "The GEF contribution is modest, and substantial indirect emission reductions can be attributed to the baseline," GEF causality = 40 percent

(e) Level 1 = "The GEF contribution is weak, and most indirect emission reductions can be attributed to the baseline," GEF causality = 20 percent

48. While the GEF causality factor is useful and can deliver consistent results, GEF causality factors should rely on situation-specific justifications and be estimated conservatively. Please note that the GEF causality factor accounts for baseline shifts, that is, for those situations where the nationwide baseline is expected to move toward a less CO_2 –intensive situation even without the GEF intervention. Therefore, when estimating the GEF causality factor, one should also take into account the nature of that baseline. If, in the future, the methodology shifts to a different method of setting the baseline, the GEF causality factor could be simplified.

49. The formula for calculating indirect impacts with the top-down methodology is, accordingly:

$CO_{2\ indirect}$ TD = P10 * CF; with
$CO_{2\ indirect}$ TD = GHG emission savings in tonnes of $CO_{2\ eq}$ as assessed by the top-down methodology
P10 = technical and economic potential GHG savings with the respective application within 10 years after the project
CF = GEF causality factor

Worksheet and Template

50. An Excel worksheet complements this manual. You can use the worksheet as a template to calculate the four figures (direct impact, direct post-project impact, indirect impact using bottom-up methodology, indirect impact using top-down methodology).

III. STEP-BY-STEP GUIDE FOR ENERGY EFFICIENCY PROJECTS

Baselines

51. For energy efficiency projects, the overall CO_2 intensity of the country's economy is important, but in cases such as market transformation projects, the CO_2 intensity trajectory for the specific market is even more important. This choice has to be made early in the development of the project document. Sectorwide energy projects, or projects that are not very specific in their target markets (e.g., ESCO projects in their early stages), as well as projects under Strategic Priority 2 (increased access to local sources of financing) are probably better off focusing on the countrywide or sectorwide CO_2 intensity. Projects that intend to introduce standards and labels for specific sectors, such as appliances or light bulbs, can focus on the specific situation of the local market. In these cases, it is particularly important to understand the baseline (marginal) technology, and the baseline trajectory that the market would take without GEF intervention. Typically, this baseline trajectory already contains some positive market developments for the energy-efficient application that is promoted by the GEF project; thus it cannot be assumed that the energy use and GHG emissions from the application would remain the same in the baseline throughout the implementation of the project (so called "baseline shift").

52. The GEF Alternative Scenario in some cases will simply identify the acceleration of emission reductions that would have happened anyway in the baseline scenario. For example, emission intensities that would be reached in 10 years under a baseline scenario could be reached in four years under a GEF Alternative Scenario. This has to be included in the GHG analysis, as the difference in the emission paths of the two scenarios gives the cumulative emission reduction of the GEF intervention. Keep in mind that to be consistent with past estimates and reduce the number of assumptions necessary, cumulative emission reductions for GEF projects are calculated on the basis of the investment lifetime.

53. It is important that the baseline also accounts for the degree of economic activity in the country—that is, the actual length of the economic lifetimes of the investments. In countries with rapid economic growth, these lifetimes might be very short if one thinks, for example, of industrial equipment. Corrections for rapid reinvestment cycles, or small time lags between the baseline and alternative scenarios, are done through the GEF causality factor (see the section below on indirect emission reductions).

Direct Emission Reduction Effects of GEF Projects

54. In energy efficiency projects, the direct emission reductions can mostly be calculated directly from the energy savings of the project as measured in kWh, by multiplying them by the corresponding emission factor:

$CO_{2\ direct} = E * c$; with
$CO_{2\ direct}$ = direct GHG emission savings of successful project implementation in tonnes of $CO_{2\ eq}$.

E = cumulative energy saved or substituted, e.g., in kWh, across all technologies that are affected by the intervention, and cumulated over the lifetime of the respective investments

c = CO_2 emission factor of the marginal technology, or of the national power generation portfolio as applicable, in g/kWh.

55. As explained above, the energy savings are to be corrected by the "baseline shift," i.e., that part of the market that would have been tapped anyway, even without a GEF intervention.

56. As a default, the CO_2 emission factor should be the marginal factor. In exceptional cases, or when grid electricity is being saved, the emission factor can be an average emission factor—for example, if grid electricity is being saved, the overall average emission factor of the local power sector, as opposed to the emissions attributable to the next power plant to come on time.

57. The cumulative energy savings are aggregated across all affected markets. For example, if a project introduces standards for household appliances, the savings from refrigerators, washing machines, and dishwashers will all count toward the same figure, labeled "E." The annual savings of each will be multiplied by the expected useful economic lifetime in years. These economic lifetimes might be different for dishwashers and refrigerators. In some investment environments, the economically useful lifetime of capital can be very short, particularly in highly dynamic and fast-growing economies, or in economies where old capital is rapidly replaced. Policy can also affect the lifetime of this investment—for example, through aggressive long-term introduction of standards, or through tax or other fiscal policies. The project proposal should discuss these local factors and integrate them into the assumed lifetimes of the investments.

Direct Post-project Emission Reduction Effects of GEF-financed Interventions

58. In some cases, GEF projects put in place a GEF-supported financing mechanism that will continue supporting direct investments after the project's implementation period. A typical example is a revolving fund for up-front financing of energy investments, which is refinanced from user fees or loan repayments. Another example would be a partial credit risk guarantee facility, which might be fully exposed at the end of the project, but then reduce its exposure and thus keep looking for new opportunities. Depending on the leakage rate and the speed of payback, facilities of this type can multiply the original direct investment and associated emission savings long after the project itself has ended.

59. These "direct post-project" emissions can be calculated with the same formula as the direct effects that are achieved during project implementation. In fact, as the facility that might have a post-project impact is usually set up and operating during the project, the direct emission savings from the first "turnover" of that facility are factored into the direct emission reductions as discussed above. Assumptions are necessary as to how many more "turnovers" the facility will have after the project is completed. For a revolving fund, the rates of reflow and leakage determine how many investments can be financed after the supervised implementation period

(how often the fund can "revolve"). The emission savings from these investments will be estimated as a multiple of the direct GHG outputs of the project. The formula is:

$CO_{2\ DPP} = CO_{2\ direct*}$ * tf; with
$CO_{2\ DPP}$ = emissions saved with investments supported by post-project financial mechanism
$CO_{2\ direct*}$ = direct emission savings to the degree they are supported through the mechanism that causes the post-project impacts
tf = turnover factor, determined for each facility based on assumptions on fund leakage and financial situation in host country.

60. The time period for which these types of impacts are attributed to the project should not be longer than 10 years, even if the facility is expected to be in place longer.

61. Because the payback periods in funds and reduction of exposure of credit guarantees are shorter in energy efficiency projects than renewable energy projects, this aspect of GHG emission reductions is expected to play a larger role in energy efficiency projects. There are few practical experiences that can be used to gauge the typical rates of leakage and default, or the typical rates of turnover in GEF projects. It is important to include an analysis of the underlying characteristics of the financial markets in the project preparation phase, so that the project brief can contain well-based assumptions on turnover rates, typical required sized of partial guarantees, and demand for these instruments.

Calculating Replication and Indirect Impacts for Energy Efficiency Projects—Bottom-up Approach

62. Once the direct emission reductions are calculated, it is sometimes easy to estimate a factor for the probable replication of the project's investments after the project has ended. Mathematically, the GHG emission reductions are calculated with the same formula as that for direct effects, and then multiplied by the assumed factor of replication:

$CO_{2\ indirect\ BU} = CO_{2\ direct*}$ RF; with
$CO_{2\ indirect\ BU}$ = emissions saved with investments after the project, as estimated using the bottom-up approach, in tonnes of $CO_{2\ eq}$
RF = replication factor
$CO_{2\ direct}$ = estimate for direct and direct post-project emission reductions, in tonnes of $CO_{2\ eq}$

63. If possible, the local circumstances should be used to derive the replication factor. Some conservative proxies have been suggested, such as 3 for market transformation and 2 for ESCOs. However, more systematic research into this issue is necessary.

64. Some reality checks can be used to test the final results. For example, the bottom-up indirect calculation should exceed the sum of the direct and direct post-project results.

Calculating Replication and Indirect Impacts for Energy Efficiency Projects—Top-down Approach

65. The top-down calculation starts with an assessment of the total potential for a specific energy-efficient application in the host country. This total amount of potential energy savings should then be corrected downward, if it seems technically unfeasible to tap it within 10 years of the project's completion. In order to correct the 10-year potential by the "baseline shift," i.e., that part of the potential that would have been tapped by the market without a GEF intervention, the GEF causality factor is used. The GEF causality factor describes how much of that savings can really be attributed to the GEF intervention, and how much would have happened in the business-as-usual scenario in the long term. For the GEF causality factor, five levels of GEF impact and causality have been assumed:

(a) Level 5 = "critical and nothing would have happened," GEF causality = 100 percent

(b) Level 4 = "dominating," GEF causality = 80 percent

(c) Level 3 = "substantial but modest," GEF causality = 60 percent

(d) Level 2 = "modest and substantial," GEF causality = 40 percent

(e) Level 1 = "weak," GEF causality = 20 percent

66. A possible reality check is whether the result is larger than the sum of direct plus direct post-project GHG savings, and whether the 10-year potential has to be corrected by the baseline shift.

An Example

67. The project objective is to catalyze investments in energy-efficient public lighting systems. Three project components will contribute to greenhouse gas emissions reductions:

(a) Creating an effective and sustainable advisory service in order to catalyze public lighting investment. This will involve setting up the Investment Facilitation Fund (IFF), which will be a fully operational business unit with the capability to identify and broker public lighting investments.

(b) Financing technical demonstrations with the support of a concession fund. This will involve setting up a project fund to enable the IFF to build an initial portfolio of investments.

(c) Supporting investment in energy-efficient public lighting through information dissemination. The third activity is designed to promote the IFF more widely.

Step 1. Determine the Baseline

68. The majority of the country's public lighting is coming to the end of its useful life and is in need of replacement. The expectation is that in the absence of this project, existing inefficient technology will gradually be replaced by new investments. Only a small share of this investment is going to go into efficient technologies, e.g., sodium lamps. Most of the systems will be replaced with inefficient systems similar to the existing ones. The GEF project will transform the market such that all or most replacements will immediately be made with energy-efficient lighting systems.

69. In the baseline, some programs unrelated to the project would catalyze the gradual replacement of energy-inefficient street lighting with efficient street lighting over time.

70. National programs: established grant financing for public lighting systems in 2002.

71. Investment and savings bank: aims to reduce pollution and greenhouse gas emissions from a specific set of countries. Companies and public authorities are eligible for grant funds of up to euro 1.5 million for a project.

72. It will be assumed that in the "baseline case," uptake of efficient lighting systems due to these programs is 20 percent—i.e., if the GEF project did not occur, 20 percent of the investments would be made into energy-efficient lighting systems anyway. Furthermore, it is expected that this baseline would rise over time (so-called "baseline shift"). For the sake of this example, let's assume that market studies have found out that today, 20 percent of all investments would be energy-efficient investments anyway in the first year; by year five, 40 percent of all investment would be energy efficient; and in year eight, 100 percent of investments would be energy efficient.

73. For the purpose of calculating the CO_2 emission reductions of this project, it is not necessary to calculate the baseline emissions, as the market study already specifies the difference between what would happen if the project did or did not go ahead. Nevertheless, for a reality check it would be useful to calculate the total emissions from street lighting in Slovakia.

Step 2. Determine the GEF Alternative

74. In the GEF Alternative Scenario, municipalities substitute inefficient mercury lamps with efficient sodium lamps. The project intends to increase the uptake of energy-efficient lighting from 20 percent of all investments in the business-as-usual (baseline) case to 100 percent of all investments. Therefore, where lighting systems are upgraded, only emission reductions resulting from 80 percent of the investments, i.e., those that would not have been into energy-efficient lighting systems, can be directly attributable to the GEF project.

75. To reach this alternative scenario, the project consists of three components: demonstrations, advisory services, and awareness-raising. These three components contribute to different categories of CO_2 savings:

(a) Three demonstration lighting subprojects will be undertaken during the three years of project implementation, and will be cofinanced from a GEF-funded project fund. These demonstrations can be counted toward the direct emission reductions of the project.

(b) As the fund is set up as a loan facility, it will be reused toward new public lighting investments after the first round of investments have repaid their loans. These later investments can be counted toward the direct post-project emission reductions.

(c) The impact that the demonstrations, the advisory services, and the awareness-raising activities will have on the national public lighting market will be counted toward the indirect emission reductions of the project.

Step 3. Calculating Direct Emissions Reductions

76. During the project lifetime, the IFF will disburse loans amounting to US$1.5 million. The fund will also catalyze a further US$880,000 from cofinancing sources. In addition, municipalities will be required to contribute 10 percent cofinancing toward the costs of the lighting demonstration projects. Thus, the project is catalyzing a total investment of US$2.635 million during the project lifetime. This investment will result in reduced electricity consumption by the public lighting system.

77. First, the amount of energy saved must be calculated. Project preparation studies have estimated that US$1 of investment in energy efficient public lighting systems will yield on average around 1 kWh per year in energy savings. The total investment of the fund thus corresponds to 2,635 MWh saved per year.

78. As presented above, direct emissions reductions can be calculated by multiplying the energy savings from project activities (measured in kWh or MWh) by the corresponding emissions factor.

$CO_{2\ direct} = E * C$; with

E = cumulative energy saved or substituted
C = CO_2 intensity of the marginal technology or electricity saved

79. Replacing inefficient mercury public lights with more efficient sodium lights results in saved electricity supplied from the local grid. Thus, to obtain the direct CO_2 emissions reduction, the cumulative energy saved (E) and the CO_2 intensity of grid-supplied electricity are multiplied together (see table 3 below).

Table 3. Converting Project's Predicted Energy Savings into $CO_{2\ eq}$

Annual Electricity Savings (MWh/year)	**Public Electricity Emissions Factor** CO2 (t/MWh)	**Annual Emissions Reduction** CO2 (t)
2,635	1.01	2,661.35

80. In the final year of the project, all investments will have been completed. The annual CO_2 emission reductions stemming from these investments were estimated to be 2,661.35 tonnes CO_2 . The assumption is made that all investments have a physical operating life of seven years. The direct emissions reductions stemming from the operation of these investments would equal:

2,661.35 tonnes equivalent of CO_2 /year * 7 years.
= 18,629 tonnes of $CO_{2\ eq}$

81. Roughly 18,600 tonnes of CO_2 are the direct emission reductions achieved through the demonstration investments over their lifetime. It is not necessary to treat the investments from the first year differently from the investments from the third year, as the calculation includes emission savings over the lifetime of the investments, and is not tied to specific calendar years or other dates. The "average effective lifetime" can be assumed to be equal between first-year and third-year installations.

Step 4. Calculating Direct Post-project Emission Reductions

82. As this GEF project is going to put a fund in place that will continue to operate after the close of the project, it is necessary to calculate the CO_2 emission reductions that will stem from new investment in energy-efficient equipment to be financed by the fund after the three year project implementation period has passed. The initial size of the fund is US$1.5 million. By year three of the project, the entire fund will have been utilized in the form of loan financing for demonstration projects. As the loans are paid back, these funds—less some defaults on the loans—will be available for further investments into efficient public lighting. The post-project functioning of the fund is simulated with a number of simplifying assumptions.

Fund Assumptions

The fund will operate for 10 years, including seven years after the close of the project. However, the fund will only produce meaningful emission reductions as long as the technology promoted by the project is fundamentally different from the baseline technology. In the business-as-usual (baseline) case, the technology promoted by the project would have been the industry standard seven years later than with the project. This means that for the purposes of this calculation, seven years should be taken as the maximum time span.

The fund will have a leakage rate of 15 percent net of administration costs (i.e., for every US$1 loaned out by the fund, only US$0.85 will be recovered in loan repayments). For practical reasons, we will simplify this further, to simply assume that every year US$150,000 of loans

will not be repaid.[4]
Every US$1 loaned by the fund after the project closes will catalyze an equal level of reductions in CO_2 emissions as seen during the project.
All capital investments made by the fund will have the same physical lifetime as those made during the project implementation period.

83. The Excel spreadsheet accompanying this manual is programmed to do the calculation automatically. Following the GEF methodology presented in section 3c, the following formula is used to estimate direct post-project emissions reductions:

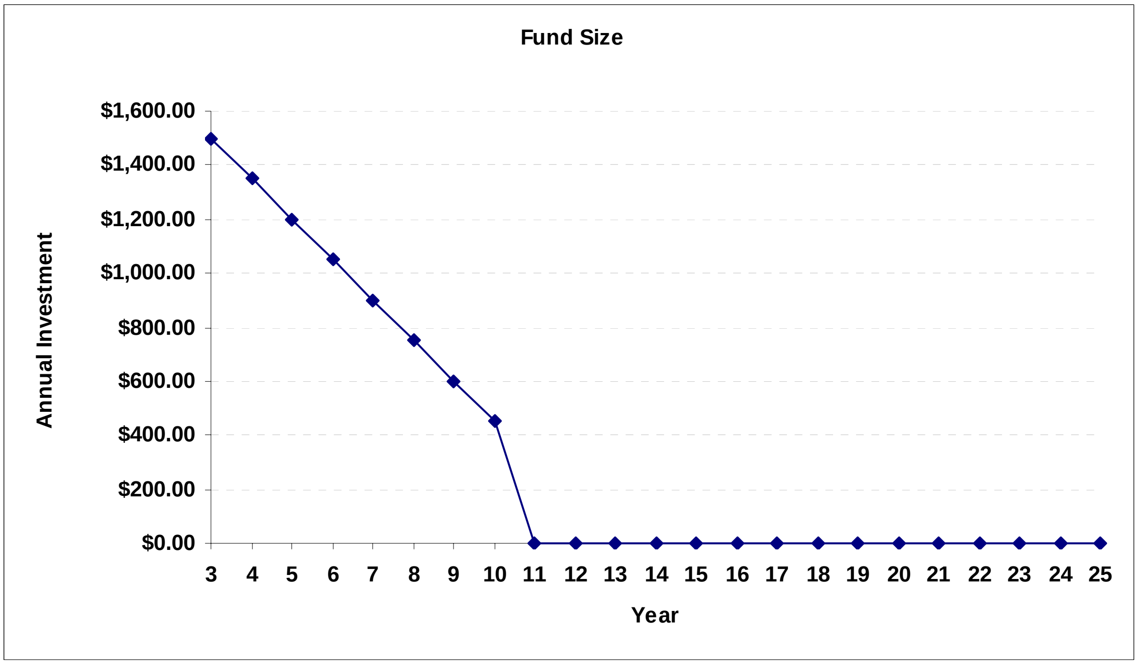
$CO_{2\ DPP} = CO_{2\ direct} * tf$; with

$CO_{2\ DPP}$ = emission reductions stemming from the post-project operation of the revolving fund
$CO_{2\ direct}$ = direct emission reductions occurring during the project lifetime that were supported by the fund
tf = turnover factor of the fund

84. As we have already calculated direct emission reductions, the task now is to determine the level of turnover, or, put more simply, how much money the fund will invest in the 12 years following the project close. By utilizing the GEF CO_2 spreadsheet, it can be determined that an initial fund of US$1.5 million, operating for 12 years with a 10 percent leakage rate, would result in cumulative investments amounting to US$6.3 million—equal to the area under the graph in figure 5.

[4] Without this simplification, the amount that is not paid back would be smaller each year.

Figure 5. Size of IFF during its Lifespan after Project Implementation Period



Now, to determine t, the following calculation is used:

Turnover factor (tf):
tf = total post-project close fund investment / total fund investments during project

tf = 6.3 / 1.5

tf = 4.2

Therefore, direct post-project emissions reduction can be calculated:

$CO_{2\ DPP} = CO_{2\ direct} * t$
$CO_{2\ DPP} = 18{,}629\ t\ CO_2 * 4.2$
$CO_{2\ DPP} = 78{,}242\ t\ CO_2$

This calculation is not corrected for the baseline shift. In order to come up with a robust and conservative estimate, the figure should now be corrected for the energy-efficient investments that would have happened every year anyway. As the baseline shift in this case is very strong, and the impact of the fund rather large when compared to the total size of the market, it would be appropriate to correct the direct post-project impact drastically downward, for example by halving it.
$CO_{2\ DPP}$ corrected = $78{,}242\ t\ CO_2 : 2 = 39{,}121\ t\ CO_2$

Step 5. Calculating Indirect Emission Reductions

Approach 1. Bottom-up

85. The bottom-up approach aims to calculate how many times the investments made during the project might be replicated, and can be calculated using the following formula:

$CO_{2\ indirect\ BU} = CO_{2\ direct} * RF$; with
$CO_{2\ indirect\ BU}$ = emission reductions following the project close, calculated using the bottom up methodology.
$CO_{2\ direct}$ = estimate for total direct emission reductions
RF = replication factor

86. There is a judgment call to make here whether to include the direct post-project impacts into the multiplication of the indirect calculation. In this case, it was decided to not include the direct post-project impacts. The fund's operation is expected to cover significant parts of the potential investments, and including the fund's savings into the overall indirect savings would lead to double counting. The indirect impact is supposed to represent only those emission savings that are outside of the direct post-project. In order to complete the estimate, a suitable replication factor must be determined. None of the replication factors suggested in figure 4 is quite appropriate for this case, as this is a very specific market. Therefore, in order to arrive at a conservative estimate, the factor of 1.5 for "other project approaches" will be applied.

$CO_{2\ indirect\ BU}$ = 18,629 t CO_2 * 1.5
$CO_{2\ indirect\ BU}$ = 29,944 t CO_2

Approach 2. Top-down

The top-down approach moves away from the project itself, and examines the total economic and technical market potential for CO_2 emission reductions with the type of technology being applied. Once the total market potential for energy savings is determined, it is then corrected downward to determine the top-down estimate for CO_2 emission reductions caused by the GEF project.
$CO_{2\ indirect}$ TD = $CO_{2\ TM}$ * CF; with

$CO_{2\ indirect}$ TD = emission reductions following the project close, calculated using the top-down methodology.
CO_2 TM = total market potential for CO_2 emission reductions
CF = causality factor

87. First, the total market potential for CO_2 emission reductions from the public lighting system must be examined. The majority of the country's public lighting system was installed in the 1970s and 1980s. It is now exceeding its expected lifetime, and increasingly, sections are due for replacement. When replacing the public lighting infrastructure, municipalities will have the choice of installing efficiently configured designs (at an estimated cost of US$48 million for the

whole country) or continuing to maintain the current configuration, with some replacement over time, at an estimated cost of US$4.2 million per year.

88. However, as we have already noted, a certain degree of investment would be made even if the project didn't occur. Given the baseline yearly expenditure of around US$4 million, we can assume that under a business-as-usual-scenario, total replacement of the lighting system would occur after around 12 years. However, given the baseline shift, only the investments made during seven of these years can be indirectly linked to the project—after that, the business-as-usual investments would use the same technology, so there are no additional GHG savings due to the project. The investment indirectly attributable to the project is US$28 million (i.e., US$48 million divided by 12 years, then multiplied by 7). In addition, during those years, the baseline is creeping up as described in table 4.

Table 4 Case of Creeping Baseline in Lighting Project Example

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Share of energy efficient investments in the baseline	20%	20%	20%	30%	30%	40%	60%	80%	100%

89. The average share of energy efficient investments in the baseline over the seven years that the baseline needs to "catch up" to the GEF alternative is 40 percent, i.e., only 60 percent of the total US$28 million investment during years one to seven is energy inefficient. If the project replaces all of this inefficient investment right from the start, US$16.8 million will be invested in energy efficient street lighting. Obviously, this is not what will happen; the displacement of the energy inefficient investment will be more gradual. This will be expressed in this example by an assumed correction of 30 percent, i.e., the project can impact a maximum of US$11.8 million. Given these assumptions, the national annual potential for CO_2 emission reductions can be determined in table 5 below.

Table 5. Total Market Potential for CO_2 emission Reductions in Street Lighting

Cumulative Investment (USD)	**Electricity Saving** (MWh/year)	**Public Electricity Emissions Factor** CO2 (t/MWh)	**Annual Emissions Reductions** CO2 (t/year)
11,800,000	11,800	1.01	11,800

The annual emission reductions are again multiplied by the lifetime of the investment:

$CO_{2\ TM} = 11{,}800\ t\ CO_2\ *\ 7$ years
$CO_{2\ TM} = 82{,}600\ t\ CO_2$

90. In determining the GEF causality factor (i.e., the percentage of CO_2 emission reductions that can be attributed to the long-term effect of the project through overcoming market barriers), we must again go back to the baseline shift and examine other likely influences on the market. In

the case of this country, there are many planned and ongoing projects that will impact the market for energy efficient public lighting systems.

91. Programs set up and planned in this area include:

(a) ESCOs: The legislative framework exists for ESCO financing, and by 2004 there had been around euro 13.2 million energy efficiency-related investments through ESCOs.

(b) Development funding: The IFC is planning a Commercializing Energy Efficiency Finance (CEEF) program, designed to guarantee the loans of financial intermediaries in energy efficiency, including public lighting.

92. Given these other influences on the market, and the necessity to have a conservative approach to CO_2 assessments, it seems suitable to adopt a Level 2 causality of 40 percent, designated for a GEF project resulting in modest indirect effects over the 10 years following the project. Now the indirect top-down emissions reduction estimate can be calculated as follows:

$CO_{2\ indirect}$ TD = $CO_{2\ TM}$ * CF

$CO_{2\ indirect}$ TD = 82,600 t CO2 * 40%
$CO_{2\ indirect}$ TD = 33,040 t CO2

Step 6: Results Overview and Standardized Text

Measure	Emissions Reduction (t CO_2)
Direct	18,629
Direct Post-project	78,242
Indirect Bottom-up	29,944
Indirect Top-down	33,040

93. In this case, the indirect bottom-up impacts are smaller than the direct post-project impacts. This can be an indication of overly optimistic assumptions for the direct post-project impact, overly pessimistic assumptions for the indirect bottom-up impact, or a large revolving fund compared to the size of the market.

94. The following standardized text can be copied and pasted into the project document after the calculations are completed. The italicized portions should be replaced with the numbers that are estimated for a specific project.

Direct Emission Reductions

95. Part of the outputs of the project will be the following investments: ***Financing technical demonstrations with the support of a concession fund***. These investments will result in direct greenhouse gas emission reductions during the project's implementation phase. As a result of these activities during the project implementation period of: ***Three years, direct greenhouse gas emission reductions totaling 18,629 tonnes of $CO_{2\,eq}$ will be achieved over the useful lifetime of the investments of seven years***. In the non-GEF case, these energy needs would be satisfied by: Marginal coal and gas generation capacity with an emission factor of (f) 1.01 t CO_2 e / MWh.

96. The project also includes activities that would result in direct post-project greenhouse gas emissions. A fund set up by the project is expected to continue to finance investments resulting in GHG emission reductions after the project close. The fund is expected to finance ***$6.3 million*** of new investment, equivalent to a turnover factor of ***4.2***, resulting in direct post-project emission reductions of ***78,242 tonnes $CO_{2\,eq}$***.

Indirect Emissions Reductions

97. Using the GEF bottom-up methodology, indirect emission reductions attributable to the project are ***29,944 tonnes of $CO_{2\,eq}$***. This figure assumes a replication factor of ***1.5***. Using the GEF top-down methodology, indirect emission reductions attributable to the project are ***33,040 tonnes of $CO_{2\,eq}$***. This figure assumes that total technological and economic potential for GHG emission reductions in this area over 10 years is ***82,600 tonnes of $CO_{2\,eq}$***, and a project causality factor of ***40 percent***.

IV. RENEWABLE ENERGY STEP-BY-STEP

Describing the GEF Impact and the Baseline (Business-as-usual) Case

98. GEF renewable energy projects typically lead to the buildup of some renewable energy generation capacity in the country. This generation capacity will provide a certain amount of energy, either in the form of electricity or heat. While generation capacity is measured in kilowatts (kW) or megawatts (MW), energy output is measured in MWh. Both values are standard GEF portfolio monitoring indicators, and have to be provided for all projects, as required by the GEF M&E policy.

99. Without the GEF project, i.e., in the baseline, or business-as-usual case, this buildup of capacity and provision of energy would also have taken place, but with a different technology. This so-called "marginal technology" is the energy generation technology that would be used for the next-least-cost investment. Typically, these are coal, oil, or natural gas power plants, depending on the country's access to these fossil fuels. These would have led to increased GHG

emissions (otherwise the project would not be eligible for GEF support). The baseline description needs to specify this technology and the amount of investment necessary in the baseline case. To assess how much investment would have been necessary in the baseline case, it is important that the comparison is based on useful energy output, and not on the generation capacity provided. The investments in both the GEF project and the baseline should be described in the document.

100. Whether baseline shift is an issue depends on the situation of renewable energy in the country in question. Typically, the GEF project supports a technology that is not currently available or used in the country. Then, typically, the baseline shift does not need to be accounted for, except through the GEF causality factor in the indirect top-down methodology. However, in cases where a technology already shows an upward trend in usage, and the GEF projects will accelerate this trend, the baseline shift needs to be accounted for and described in the baseline scenario. For more specific information on the concept of baseline shift, please refer to the section on energy efficiency.

Calculating Direct Emission Reductions

101. The calculation of the direct emission reductions for renewable energy projects is based on the marginal technology in the project country. Formula (27) applies in a straightforward manner:

$CO_{2\ direct} = E * c = e * l * c$; with
$CO_{2\ direct}$ = direct GHG emission savings of successful project implementation
in tonnes of $CO_{2\ eq}$
E = cumulative energy produced by renewable energy, e.g., in MWh; $E = \Sigma_l\ e$
c = CO2 intensity of the marginal technology, e.g., in t/MWh
e = annual energy replaced, e.g., in MWh
l = average useful lifetime of equipment in years

102. The baseline CO_2 emission$_s$ are based on the emission factors and conversion efficiencies typical for new fossil fuel generation, and the energy output provided by the GEF-supported investments into renewable energy.

103. In order to be consistent across projects and reduce the number of assumptions necessary, cumulative emission reductions for GEF projects are calculated on the basis of the investment lifetime. It is important that the baseline also accounts for the power production over the full expected lifetime of the renewable energy units. Typical expected lifetimes are given in the box.

Off-grid PV 10 years
BIPV 20 years
Wind 20 years
Small hydro 20 years
Bagasse 10 years

Calculating Direct Post-project Emission Reductions

104. If the projects put a GEF-supported financing mechanism in place that will leverage further investments after the GEF project has ended, like a revolving fund for loans, or a credit guarantee facility, the project might be able to claim direct post-project emission reductions. Depending on the leakage rate and the speed of payback, facilities of this type can multiply the original direct investment and the associated emission savings long after the project itself has ended.

105. These direct post-project emissions can be assessed as multiples of the direct effects that are achieved during project implementation. The direct emission savings from the first "turnover" of that facility are factored into the direct emission reductions, as discussed above. Assumptions are necessary as to how many more "turnovers" the facility will have after the project. For a revolving fund, the rates of reflow and leakage determine how many investments can be financed after the supervised implementation period (how often the fund can "revolve"). The "turnover factor" expresses how many multiples of the original investment can be leveraged through the post-project financing mechanism. The formula is:

$CO_{2\ DPP} = CO_{2\ direct*}$ * tf; with
$CO_{2\ DPP}$ = emissions saved with investments supported by post-project financial mechanism
$CO_{2\ direct*}$ = direct emission savings to the degree that they are supported through the post-project financial mechanism impacts.
tf = turnover factor, determined by each facility based on assumptions on fund leakage and financial situation in host country.

The time interval for which these types of impacts are attributed to the project should not be longer than 10 years, even if the facility is expected to be in place for a longer period.

Calculating Indirect Impacts—Bottom-up

106. Once the direct emission reductions are calculated, it should be possible to estimate a factor for the probable replication of the project's investments during the 10 year "influence period" after the project has ended. Mathematically, the GHG emission reductions are calculated with the same formula used in the case of direct effects, and then multiplied by the assumed factor of replication:

$CO_{2\ indirect\ BU} = CO_{2\ direct*}$ RF; with
$CO_{2\ indirect\ BU}$ = emissions saved with investments after the project, as estimated using the bottom-up approach, in tonnes $CO_{2\ eq}$;
RF = replication factor; and
$CO_{2\ direct}$ = estimate for direct and direct post-project emission reduction, in tonnes $CO_{2\ eq}$

107. It is important to note that there is a risk of double counting the indirect impacts and the direct post-project impacts. The methodology makes this distinction because the direct post-project impacts can be assessed with higher certainty and have a higher probability of occurring

as a consequence of the GEF project than the indirect impacts. In turn, this means that the analysis of the indirect impacts needs to account for the direct post-project impacts, and potentially actively deduct the direct post-project impacts from the indirect impacts. This needs to be decided case by case.

108. If at all possible, the local circumstances should be used to derive the replication factor. More systematic research into this issue is necessary. Some reality checks can be used to test the final results. For example, the bottom-up indirect calculation should exceed the sum of the direct and direct post-project results. On the other hand, it should be smaller than the total market potential of the technology over the influence period of 10 years.

Calculating Replication and Indirect Impacts—Top-down

109. The top-down calculation starts with an assessment of the total potential for the production of energy from the specific renewable energy technology in the host country, as determined by the natural resource situation, technical capacity, and typical investment rates in the country that can be expected under post-project circumstances. This total amount of potential energy production should then be corrected downward, if it seems technically unfeasible to tap it within 10 years of the project's completion. In order to correct the 10-year potential by the "baseline shift," i.e., that part of the potential that would have been tapped by the market without a GEF intervention, the GEF causality factor is used. The GEF causality factor describes how much of the buildup of capacity can really be attributed to the GEF intervention, and how much would have happened in the business-as-usual scenario in the long-term. For the GEF causality factor, five levels of GEF impact and causality have been assumed:

(a) Level 5 = "The GEF contribution is critical and nothing would have happened in the baseline," GEF causality = 100 percent

(b) Level 4 = "The GEF contribution is dominating, but some of this reduction can be attributed to the baseline," GEF causality = 80 percent

(c) Level 3 = "The GEF contribution is substantial, but modest indirect emission reductions can be attributed to the baseline," GEF causality = 60 percent

(d) Level 2 = "The GEF contribution is modest, and substantial indirect emission reductions can be attributed to the baseline," GEF causality = 40 percent

(e) Level 1 = "The GEF contribution is weak, and most indirect emission reductions can be attributed to the baseline," GEF causality = 20 percent

110. While the GEF causality factor is useful and can deliver consistent results, GEF causality factors and the overall potential should rely on situation-specific justifications and be estimated conservatively. Please note that the GEF causality factor accounts for baseline shifts, that is, in those situations where the nationwide baseline is expected to move toward a less CO_2 –intensive situation even without the GEF intervention. Therefore, when estimating the GEF causality factor, one should also take into account the nature of that baseline.

111. The formula for calculating indirect impacts with the top-down methodology is, accordingly:

$CO_{2\ indirect}$ TD = P10 * CF; with
$CO_{2\ indirect}$ TD = GHG emission savings in $CO_{2\ eq}$ as assessed by the top-down methodology;
P10 = technical and economic potential for GHG savings with the respective application within 10 years after the project; and
CF = GEF causality factor.

An Example: Wind Energy Program

Project Duration: 5 years

Project Objective: The project objective is to diversify power generation in the country by assisting with the development of a wind energy industry that could generate employment, as well as export to the wider region.

Project Components:

Component 1: Design financial instruments conducive to the development of wind energy, to be accepted and implemented by the government.

This component aims to design financial polices and instruments that can support the development of the wind energy industry in the country, including:

- Production subsidies to support the project's planned infrastructure investments.
- A power purchase agreement (PPA) between the municipal government and the wind infrastructure provider developed by the project. The PPA will ensure that wind energy receives a premium price compared to thermal generation.
- A guarantee scheme will serve as a purchaser of last resort when 100 percent of the electricity generated by the project's investment is not sold to end-user customers.

Component 2: Assist private developers with pre-feasibility-level project development activities for up to 45 MW wind power generation capacity.

Six private developers will have 50 percent of total cash and in-kind costs covered for pre-feasibility studies for wind power installations up to 45 MW in generating capacity. Based on these studies, a decision will be made on which projects will be developed further. It is anticipated that three to four sites will be taken forward, and will provide the learning experience, and information essential for wind farm replication (licenses, approvals, costs, time spent in studies, etc.).

Component 3: Long-term policy and implementation framework for wind energy.

A long-term policy for wind energy, including an implementation strategy and policy, and financial instruments, will be developed for government approval and incorporation into the national energy policy.

Taken together, components 1 and 2 will be responsible for direct emission reductions, while component 3 will catalyze indirect emission reductions, stemming from the project.

Step 1. Determine the Baseline

Given the existing financial, policy, regulatory, and institutional constraints facing wind energy development in the country, it is highly likely that market development will not occur in the short term without donor-based and long-term financial assistance.

The marginal technology in the country is coal- and gas-fired thermal generation, and to a lesser extent, importing large-scale hydro power. The country will require an additional 1000 MW of generation capacity by 2016, and it is likely that without intervention, this need will be met by coal- and gas-fired generation.

An exact calculation of the baseline is not needed here, as the difference between the GEF alternative scenario and business-as-usual scenario can be directly determined.

Step 2. Determine the GEF Alternative

With the support of the GEF project, critical policy, financial, and institutional barriers will be addressed, allowing the gradual scale-up of wind generation capacity. Wind energy has significant potential in the country, but a gradual approach to achieving a critical mass of 45 MW of wind generating capacity is required.

Over the five-year project, up to 45 MW of wind capacity from private developers will be supported through capacity building and financing that would not have occurred without the project. This, along with the development of new policies and financial instruments, will foster the beginnings of the transformation of the energy market toward one that is more conducive to wind energy. Financial commitments will be put in place up until 2013 for the 45 MW developments. Direct emission reductions will result from these activities.

Through the project's development of energy policy in the country, wind energy will receive a green power premium, increasing the competitiveness of wind generation vis-à-vis thermal. This will catalyze indirect emissions reductions.

Step 3. Calculating Direct Emissions Reductions

Following the guidance in the GHG emissions manual, direct emission reductions can be calculated by multiplying the displaced demand for thermally produced energy (measured in kWh or MWh) by the corresponding emissions factor of the marginal technology that would supply the on-grid electricity in lieu of the project.

$CO_{2\ direct} = E * C$; with

E = cumulative energy saved or substituted
C = CO_2 intensity of the marginal technology or electricity saved

First, the amount of energy generated by investments made during the project must be calculated. In this project, energy generated is reported in the form of MWh (see table 6 below). Installing grid-connected wind power provides a substitute for electricity supplied from other sources to the national grid, currently comprised predominantly of coal- and gas-fired generation. Research conducted as part of the project planning process notes that wind farms in the relevant locations will operate with a capacity factor of 27 percent—that is, over the course of a year, 1 MW of capacity would yield 2,365 MWh (i.e., 1MW * 8,760 hours * 27 percent).

As a result of the project, 45 MW of grid-connected wind capacity will be installed. Thus, the total installed capacity of 45 MW will generate 106,425 MWh per year, or 2,130 gigawatt hours (GWh) over its default lifetime of 20 years.

To obtain the direct CO_2 emission reductions, the cumulative thermal grid-supplied electricity saved due to the installation of wind generation capacity, and the CO_2 intensity of the grid supplied electricity, are multiplied together. Research conducted for project preparation documents have determined the average CO_2 intensity for the national grid-supplied electricity to be 0.89 tonnes of CO_2 per MWh.

This means that given the quantity of wind electricity produced, and the carbon intensity of the electricity supplied on the national grid, the total direct CO_2 emission reductions occurring through the five-year project lifetime can be clearly determined. The simplifying assumption is made that all investments will have an operational lifetime of 20 years. The total direct CO_2 emissions are equal to the annual emission reductions stemming from the installed capacity, multiplied by 20 years.

CO_2 direct = E * C = 2,130,000 MWh * 0.89 tonnes of CO_2 equivalent / MWh =

= 1,890,000 tonnes of CO_2 equivalent

Step 4. Calculating Direct Post-project Emission Reductions

This GEF project has not put in place a financing mechanism, or any sort of component, that will continue to operate after the project closes and catalyze GHG emission reductions. Therefore, no direct post-project emissions reductions will be achieved by the project.

Step 5. Calculating Indirect Emissions Reductions

Approach 1. Bottom-up

The bottom-up approach aims to calculate how many times the investments made during the project might be replicated and can be calculated using the following formula:

$CO_{2\ indirect\ BU} = CO_{2\ direct} * RF$; with
$CO_{2\ indirect\ BU}$ = emission reductions following the project close, calculated using the bottom-up methodology
$CO_{2\ direct}$ = estimate for total direct (including post-project) emission reductions
RF = replication factor

A suitable replication factor must be determined. The default replication factor suggested for a demonstration project with capacity building is 3. The project has a component that focuses on working with policy makers to implement a more sustainable financing scheme. Depending on the success of this, the project's impact could in fact be replicated during the "influence period" of 10 years after the project is completed. In order to be conservative, a replication factor of 1.5 shall be assumed here. This, in the 10 years after completion of the project, 90 MW more wind power will be installed due to the influence that this project exerts on the country's financing capacity for the wind market.

$CO_{2\ indirect\ BU} = CO_{2\ direct} * RF$

= (1,890,000 t CO_2) * 1.5

= 2,835,000 tonnes CO_2

Approach 2a. Top-down information, bottom-up methodology

In this case, we can have two more ways of starting with the overall market potential, and calculating the indirect impact of the project. One uses very specific information on the market size in the country, obtained through the project preparation process. The other (see below) uses more general, publicly available information. The first would be preferred as it has a higher degree of certainty. Once the total market potential for wind energy is determined with either of the two options, it is then corrected downward to determine the top-down estimate for CO_2 emission reductions caused by the GEF project.

$CO_{2\ indirect\ TD} = CO_{2\ TM} * CF$; with
$CO_{2\ indirect\ TD}$ = emission reductions following the project close, calculated using the top-down methodology
$CO_{2\ TM}$ = total market potential for CO_2 emission reductions
CF = causality factor

First, the total market potential for CO_2 emission reductions from installing wind power must be examined. A good indicator of total market potential has been gained by examining the green power premium the project aims to put in place. The project preparation documents note that a maximum of 309 GWh per year can be eligible for the green power premium. As calculated above, the project directly leads to 106 GWh per year, so an additional 203 GWh per year can be achieved by fully exploiting the instrument in the post-project period.

Table 6 Calculation of Top-Down Indirect Emissions

Additional market potential per year (MWh/year)	Annual Emissions Reductions (t $C0_2$/year)	Overall indirect emission reductions over 20-year lifetime of investments (t $C0_2$)
203,000	180,670	3,613,400

In determining the GEF causality factor (i.e., the percentage of CO_2 emission reductions that can be attributed to the long-term effect of the project through overcoming market barriers) we must examine other likely influences on the market. In the case of this country, there are planned and ongoing projects that will impact the market for energy-efficient public lighting systems. As the development of wind farms in the country is not an easy process, and, under the current market conditions, is not a financially viable route without financial assistance from subsidies or grants, none of the planned project would be expected to materialize without the GEF project.

Given these developments in the wind energy market, it seems suitable to ascribe the project as having a **Level 5** or "dominating" causality factor of **100 percent**, so that no correction is necessary.

<u>Approach 2b. Top-down information, top-down methodology</u>

The pure top-down methodology would not start with a specific market instrument, but rather with the assumption that consequent development could take place that leads to a replication of the project's investments. Therefore, this assessment starts with the total physical potential for using wind power in the country. According to the wind-skeptical national utility, a lowball estimate for wind in the country is 1,000 MW. As this is a very low estimate, given the natural resource situation in the country, using 50 percent of this as the marketable potential in the 10 years after completion of the project is a justifiable assumption.

First, subtract the project impact, i.e., continue on the basis of 500 MW – 45 MW = 455 MW. Then, calculate the projected electricity production over the 20-year expected lifetime of these 455 MW:

$$E = 455\ MW * 8{,}760\ hours * 27\ \% * 20 = 1{,}076\ GWh * 20 = 19{,}277\ GWh$$

Then calculate the GHG emissions avoided through the following equation, assuming the national emission factor remains constant over the respective years:

$$P_{10} = E * C = 19{,}277{,}000\ MWh * 0.89\ t\ CO_2 / MWh = 17{,}156{,}530\ t\ CO_2$$

This seems rather high compared to the other figures, but we are looking at a very long time for the impact (five years project implementation plus 10 years post-project impact) and, in addition, at investments with a long useful lifetime (20 years) and comparatively high power output.

Nevertheless, the GEF will be able to claim only partial responsibility, should such a development actually take place. While the GEF impact will have been substantial, significant other developments will also have had to occur. Therefore, the GEF causality factor is assumed to be 40 percent in this scenario. The final result of the pure top-down assessment is:

$CO_{2\,direct} = P_{10} * CF = 17{,}156{,}530\ t\ CO_2 * 40\ \% = 6{,}863{,}000\ t\ CO_2$

Table 7: Results Overview and Standardized Text

Measure	**Emissions Reduction (ktonnes CO_2)**
Direct	1,890
Direct post-project	0
Indirect bottom-up	2,835
Indirect top-down/ bottom-up mixture	3,613
Indirect top-down pure	6,863

Direct Emissions Reductions

Part of the outputs of the project will be the following investments:

(*a) Design financial instruments conducive to the development of wind energy, to be accepted and implemented by the government. Assist private developers with pre-feasibility-level project development activities for up to 45 MW wind power generation capacity.*

These activities will result in direct greenhouse gas emission reductions during the project's implementation phase.

As a result of these activities during the project implementation period of *(b) five years*, direct greenhouse gas emission reductions totaling *(c) 1,890 ktonnes of CO_2 equivalent* will be achieved over the lifetime of the investments of *(d) 20 years*. In the non-GEF case, these energy needs would be satisfied by *(e) coal- and gas-fired generation comparable to the current national power generation portfolio,* with an emission factor of *(f) 0.89 t CO_2 e / MWh*.

The project does not include activities that would result in direct post-project greenhouse gas emission reductions.

Indirect Emission Reductions

Using the GEF bottom-up methodology, indirect emission reductions attributable to the project are *(j) 2,835 ktonnes of CO_2 equivalent*. This figure assumes a replication factor of *(k) 1.5*.

Using the GEF top-down methodology, indirect emission reductions attributable to the project are *(l) 3,613 ktonnes of CO_2 equivalent*. This figure assumes that the total technological and economic potential for GHG emission reductions in this area over 10 years is *(m) 3,613 ktonnes of CO_2 equivalent*, and a project causality factor of *(n) 100 percent.*

V. NEW CLEAN ENERGY TECHNOLOGIES STEP-BY-STEP

Calculating Baseline CO_2 Emissions

112. For projects that aim to increase the market share of specific low greenhouse gas-emitting technologies, the overall CO_2 intensity of the country's economy is less important than the CO_2 intensity for the specific energy application targeted. The nature of OP7 projects means that it is probably better to focus on sector-specific, market-specific, or application-specific CO_2 intensity, rather than countrywide CO_2 intensity. In these cases, it is particularly important to note the baseline (marginal) technology and the specific CO_2 savings offered by the GEF intervention.

113. The GEF Alternative Scenario will generally lead to the development of emission reductions that would not have occurred, or would have developed at a slower rate, in the baseline scenario. Typically, new technologies are characterized by high costs and high levels of uncertainty, and markets would not be expected to develop these on their own without GEF interventions. For example, it is unlikely that Building Integrated Photovoltaic (BIPV) systems markets would develop in Malaysia without extensive interventions designed to reduce costs and increase local capacity. Thus, emission reductions from this sector would be virtually nil over many years in the baseline scenario; "baseline shift" as in the case of energy efficiency is not an important issue in this area.

114. It is important that the baseline also accounts for the degree of economic activity in the country and in the sector globally—that is, projects must consider if these technologies would become economical in the targeted countries due to cost reductions naturally occurring over time.

Calculating Direct Emission Reductions

115. In low greenhouse gas-emitting technology projects, the direct emission reductions can be determined directly from the amount of energy produced by the project's investments. This energy will substitute energy from more carbon-intensive generating technologies, including local power stations, or more generally, the marginal generating technology that would be used in lieu of the project in off-grid areas. The amount of energy produced by low greenhouse gas-

emitting technology (which corresponds to the amount of energy that will not be produced using the marginal technology), measured in kWh, and is then multiplied by the corresponding emission factor. In this case, the emission factor can be an average emission factor, for example, if grid electricity is being saved, the overall average emission factor of the local power sector. Alternatively for off-grid technologies, the emission factor will be that of the marginal technology that would otherwise be used (for example, small diesel generators). In some cases, e.g., fuel cells running on methane, where the new technology itself has some emissions, the effective emission factor is the difference between the baseline emission factor and the emission factor of the new technology.

$CO_{2\ direct} = E * c$; with

$CO_{2\ direct}$ = direct GHG emission avoided in CO_2 equivalent due to the successful implementation of the project
E = cumulative energy saved or substituted or produced, e.g., in kWh, due to the installation of low greenhouse gas-emitting technologies, calculated over the lifetime of the investments
c = difference between CO_2 intensities of new and marginal technologies, e.g., in g/kWh

116. In determining the cumulative energy saved over the lifetime of the investments, the project proposal should make conservative assumptions about the useful lifetime of new technologies—often they have not been sufficiently tested to assume very long lifetimes.

Calculating Direct Post-project Emission Reductions

117. In some cases, GEF projects put in place a GEF-financed mechanism that will continue supporting direct investments after the project's implementation period. It is unlikely that projects focusing on low greenhouse gas-emitting technologies will include such a mechanism, as financial support offered on its own typically fails to address the totality of barriers facing these markets. If it is the case, please refer to the sections on direct post-project emission reductions of the chapters on energy efficiency and renewable energy, depending on the character of the new technology.

118. Examples of financial mechanisms put in place after the close of a project could be: (a) a revolving fund for up-front financing of energy investments, which is refinanced from user fees or loan repayments, or (b) a partial credit guarantee facility, which might be fully exposed at the end of the project, but then reduce its exposure and thus keep looking for new opportunities. Depending on the leakage rate and the speed of payback, facilities of this type can multiply the original direct investment, and the associated emission savings long after the project has ended.

119. These direct post-project emissions can be calculated with the same formula as the direct effects that are achieved during project implementation. Assumptions are necessary regarding the impact that these interventions will have after the project closes. For a revolving fund, the rates of reflow and leakage determine how many investments can be financed after the supervised implementation period (how often the fund can "revolve"). The GHG emission

savings resulting from switching to low greenhouse gas-emitting technologies can be calculated using the same assumptions as for the direct GHG outputs of the project. The formula is:

$CO_{2\,DPP} = CO_{2\,direct*} * t;$ with

$CO_{2\,DPP}$ = emissions saved with investments supported by post-project financial mechanisms
$CO_{2\,direct*}$ = direct emission savings to the degree that they are supported through the mechanism that causes the post-project impacts
t = turnover factor, determined for each facility based on assumptions on fund leakage and financial situation in host country.

120. There is almost no practical experience of typical rates of leakage and default, or of typical rates of turnover. It is important to include an analysis of the underlying characteristics of the financial markets in the project preparation phase so that the project brief can contain well-based assumptions of turnover rates, the required size of partial guarantees, and the demand for these instruments.

Calculating Replication and Indirect Impacts

121. If it is reasonable to expect that the technology will still have significant incremental capital cost after the project, the autonomous development of a market is rather unlikely. In these cases, assumptions about the indirect CO_2 emission reductions need to be made all the more carefully and conservatively. The local conditions and likely project impacts should be decisive for the assessment whether or not any indirect impacts can be achieved.

122. In principle, the same two methodologies as for OPs 5 and 6—bottom-up and top-down—can be used to estimate a potential range for the impact. However, in some cases (as in the example below), more specific information is given, e.g., about expected policy schemes, and the potential indirect impacts can be directly derived from this information.

123. If not, for the **bottom-up methodology**, a probable replication factor for the project's investments needs to be determined. Mathematically, the GHG emission reductions are calculated with the same formula used to determine direct effects, and then multiplied by the assumed replication factor:

$CO_{2indirectBU} = CO_{2direct} * RF;$ with

$CO_{2\,indirect\,BU}$ = emissions avoided with investments made after the project has closed, estimated using the bottom-up approach, in tonnes CO_2 equivalent
RF = replication factor
$CO_{2\,direct}$ = estimate for direct and direct post-project emission reductions, in tonnes CO_2 equivalent

124. If possible, the local circumstances should be used to derive the replication factor. Nevertheless, it will be hard to justify high replication factors.

125. The **top-down** calculation starts with an assessment of the total potential of a specific new low greenhouse gas-emitting technology in the target country following the 10 years after the project's completion. Typically, new technologies are characterized by high costs, which will decline over time. The implementation of an OP7 project should aim to bring down these costs and increase capacity in the target country's marketplace. When estimating total market potential, it is important to factor in the effects of the successful implementation of the project—that is, after a project has been undertaken, to what extent can the market be expected to expand in the future?

126. Only market expansion that can be expected to occur in the 10 years immediately following the close of the project should be considered. Potential market expansion should be measured in terms of generation capacity installed and total energy generated from the low greenhouse gas-emitting technology. The latter measure can easily be transformed into avoided greenhouse gas emissions by following the same methodology utilized in the calculation of direct emission reductions—that is, to multiply the quantity of zero-emission energy generated by the per-kWh emissions intensity of the local grid or marginal technology.

127. The resulting 10-year potential should be corrected with the GEF causality factor, which describes how much of this generation capacity, generated energy, and avoided emission reductions can really be attributed to the GEF interventions, and how much would have happened in the long-term, business-as-usual scenario. For the **GEF causality factor**, five levels of GEF impact and causality have been assumed:

(a) Level 5 = "critical and nothing would have happened," GEF causality = 100 percent

(b) Level 4 = "dominating," GEF causality = 80 percent

(c) Level 3 = "substantial but modest," GEF causality = 60 percent

(d) Level 2 = "modest and substantial," GEF causality = 40 percent

(e) Level 1 = "weak," GEF causality = 20 percent

128. While the GEF causality factor is useful and can deliver consistent results, GEF causality factors should rely on situation-specific justifications and be estimated conservatively. For OP7 projects, it would be typical to see a level 4 or 5 causality factor. Please note that the GEF causality factor accounts for baseline shifts, that is, for situations where the nationwide baseline is expected to move toward a less CO_2–intensive situation even without the GEF intervention.

129. The formula for calculating indirect impacts with the top-down methodology is, accordingly:

$CO_{2\ indirect\ TD} = P_{10} * CF$, with:

$CO_{2\ indirect\ TD}$ = GHG emissions avoided in CO_2 equivalent as assessed by the top-down methodology
P_{10} = technical and economic potential GHG savings with the respective application
CF = GEF causality factor

An Example: Building-Integrated Photovoltaic Technology Project (BIPV)

Project Duration: 5 years

Project Objective: The project objective is to create a sustainable Building Integrated Photovoltaic (BIPV) market in Malaysia, which will also help stimulate wider BIPV application in other Southeast Asian counties.

Project Components:

Component 1: The "Suria 1000" program

This will include setting up the "Suria 1000" program, which aims to catalyze the installation of 1000 kilowatt peak (KWp) BIPV capacity over the five-year project implementation period. Through this program, a limited quantity of BIPV systems will be offered to the public through a bidding approach.

Component 2: *BIPV demonstration project program.*

Showcase projects in government, commercial, and residential buildings, as well as in public spaces, will be undertaken, resulting in 500KWp of installed BIPV capacity over the five-year project period.

Component 3: *Develop polices and financing mechanisms conducive to BIPV*

The third activity intends to develop a suite of policy, institutional, legal, financial, and fiscal measures through targeted research activities, which will then be presented to the government of Malaysia. These measures are intended to assist in the formulation of a national BIPV target to be included in the 10th Malaysia Plan (2011-2015).

Component 4: *BIPV industry development and R&D enhancement program*

This component aims to strengthen human capacity in BIPV research and development and manufacturing, providing the opportunity to export locally manufactured products to regional markets. The promotion of local BIPV industry is key in driving cost reductions.

Components 1 and 2 will catalyze direct emission reductions, while indirect emission reductions will result from components 3 and 4.

Step 1. Determine the Baseline

Without a GEF project, the technology would not be adopted as a viable form of renewable energy. While some complementing activities in the broader field of PV are planned by the government of Malaysia, a sustainable market and unit-cost reduction for BIPV would not be established without the project. Although Malaysia has 450 KWp grid-connected PV installed today, grid-connected BIPV capacity remains low, and this is unlikely to change without the project. Until 2010, the anticipated requirement for 10 GW of new generation capacity in Malaysia will be met through coal- and natural gas-fired plants; Malaysian grid-supplied electricity is assumed to have a relatively constant CO_2 intensity of 0.62 tonnes of CO_2 per MWh.

Step 2. Determine the GEF Alternative

The GEF Alternative Scenario would see the beginnings of a sustainable BIPV market emerge. The market would be characterized by the development of local technology producers, supported by capacity building programs and favorable policy and financial frameworks for the sale of PV-generated electricity to the Malaysian grid. Public awareness campaigns will foster public demand and private sector involvement in PV services and manufacture.

During the project implementation period, the combination of demonstration projects and the "Suria 1000" program will lead to the installation of 1.5 MWp of BIPV capacity (see table 8 below).

Table 8: Installation Schedule of BIPV

Year	**Annual installed capacity (KWp)**	**Cumulative installed capacity (KWp)**
2006	206	260
2007	300	560
2008	340	900
2009	300	1,200
2010	300	1,500

Step 3. Calculating Direct Emissions Reductions

Following the guidance in the GHG emissions manual, direct emission reductions can be calculated by multiplying the energy savings from project activities (measured in kWh or MWh) by the corresponding emissions factor.

$CO_{2\ direct}$ = E * C ; with

E = cumulative energy saved or substituted
C = CO_2 intensity of the marginal technology or electricity saved

First, the amount of energy saved must be calculated. In this project, energy saved is reported in the form of MWh (see table 8 below). Research conducted as part of the project planning process determined that 1 KWp of installed BIPV capacity in Malaysia will produce an average of 1.2 MWh of electricity annually, without any associated GHG emissions.

In addition to the electricity produced from BIPV, installing these systems results in reduced building air-conditioning requirements. Project preparation documents estimate that for every 1 KWp BIPV capacity installed correctly as a shading device (about 30 percent of capacity), electricity consumption for air-conditioning drops by 5 MWh per year. The energy savings resulting from the reduced energy consumption for air-conditioning is displayed in table 8 below. Furthermore, installing BIPV has the benefit of reducing electricity distribution losses. Project preparation documents estimate that each KWp BIVP capacity installed avoids 0.1 MWh per year of electricity losses. The energy savings resulting from the reduced electricity consumption for air-conditioning is displayed in Table 9 below.

Table 9: Energy Savings from BIPV Installation

Cumulative installed capacity (KWp)	**Annual electricity saved from reduced air-conditioning (MWh)**	**Annual avoided distribution losses (MWh)**	**Annual electricity generated (MWh)**
1500	2,250	150	1,800

Installing grid-connected BIPV saves and substitutes for electricity supplied from the national grid, currently comprised predominantly of coal- and gas-fired generation. Thus, to obtain the direct annual CO_2 emission reductions, the cumulative thermal grid-supplied electricity saved due to the installation of BIPV generation capacity and the CO_2 intensity of the grid-supplied electricity are multiplied together. Research conducted for project preparation documents have determined the average CO_2 intensity for the Malaysian grid-supplied electricity is 0.62 tonnes of CO_2 per MWh.

$CO_{2\ direct}$ per year = total electricity saved or substituted * 0.62

= 1802 MWh /year * 0.62 tonnes of CO_2 / MWh

= 1,117 tonnes CO_2 / year

The assumption is made that all investments, irrespective of when they are made, operate for 10 years. The emission reductions stemming from the continued operation of these investments would equal:

= 1,117 tonnes CO_2 /year * 10years.

= 11,170 tonnes CO_2

Step 4. Calculating Direct Post-project Emissions Reductions

This GEF project has not put in place a financing mechanism that will continue after the close of the project, or any sort of component that will continue to operate after the project close and catalyze GHG emission reductions. Therefore, no direct post-project emission reductions will be achieved.

Step 5. Calculating Indirect Emissions Reductions

11,170 available: without a successful project, the development will remain very slow, while subsequent to the successful completion of the project, a national BIPV scale-up target will be incorporated into the 10th Malaysian Plan. This scale-up target of 20 MWp by 2020 represents the total BIPV market development potential in the country (see table 10 below). This information is sufficient to calculate the indirect emission reductions, and the proponent need not revert to an extrapolation using the top-down and bottom-up methodologies.

Table 10 Installed Capacity of BIPV

Year	**Annual installed capacity (KWp)**	**Cumulative installed capacity (KWp)**
2011	500	2,000
2012	2,000	4,000
2013	2,000	6,000
2014	2,000	8,000
2015	2,000	10,000
2016	2,000	12,000
2017	2,000	14,000
2018	2,000	16,000
2019	2,000	18,000
2020	2,000	20,000

The bottom-up approach aims to calculate how many times the investments made during the project might be replicated. However, the exact replication in case of success is determined by the government's plans, as indicated in table 9. Similarly, the government's targets can also be seen as an indication of potential market size achievable in the long run due to the GEF project.

The project preparation documents indicate that with BIPV's incorporation into the 10th Malaysia Plan, the market would undergo rapid growth, reaching 20 MWp by 2020 (see table 11 below). This growth in BIPV capacity can be directly translated into emission reductions using the same methodology applied to calculate direct emission reductions.

Table 11: Emission Reductions from BIPV Capacity

Year	**Cumulative installed capacity (KWp)**	**Annual BIVP substituted/saved electricity (MWh)**	**Annual avoided GHG emissions (t CO_2)**
2011	2,000	5,600	3,472
2012	4,000	11,200	6,944
2013	6,000	16,800	10,416
2014	8,000	22,400	13,888
2015	10,000	28,000	17,360
2016	12,000	33,600	20,832
2017	14,000	39,200	24,304
2018	16,000	44,800	27,776
2019	18,000	50,400	31,248
2020	20,000	56,000	34,720

By 2020, 20,000 KWp of BIVP capacity will be put in place, catalyzing annual emission reductions amounting to 34,720 tonnes CO_2. Again, we will assume a physical lifetime of 10 years, resulting in total indirect emissions reductions of:

CO_2 Indirect = 34,720 t CO_2 * 10 years

= 347,200 t CO_2

Table 12 Results Overview and Standardized Text for BIPV Example

Measure	**Emissions Reduction (t CO_2)**
Direct	**11,170**
Direct post-project	**0**
Indirect	**347,200**

Direct Emission Reductions

Part of the outputs of the project will be the following investments:

(a) The Suria 1000 program (aims to catalyze the installation of 1,000 KWp BIPV) and a BIPV demonstration project program.

These activities will result in direct greenhouse gas emission reductions during the projects' implementation phase. As a result of these activities during the project implementation period of *(b) five years*, direct greenhouse gas emission reductions totaling (c*) 11,170 tonnes of CO_2 equivalent* will be achieved over the lifetime of the investments of *(d) 10 years*. In the non-GEF case, these energy needs would be satisfied by *(e) coal- and natural-gas fired plants*; with an emission factor of *(f) 0.62 t CO_2 / MWh*.

The project does not include activities that would result in direct post-project greenhouse gas emission reductions.

Indirect Emission Reductions

This project did not follow the standard bottom-up and top-down methodologies. Therefore no standardized text can be included.

Using the data provided by project preparation documents, policy put in place by the successful completion of the project will lead to indirect emission reductions totaling 347,200 tonnes of CO_2 equivalent.

VI. APPENDIX

Standardized Text for Inclusion in Project Preparation Documents

Instructions: Use the text below for the project documentation. Replace the letters with data suggested in corresponding boxes etc. This data will have been obtained from following the methodology in the Manual for Calculating GHG Benefits of GEF projects and can be calculated using the accompanying spreadsheet. For full examples, refer to the examples presented for each OP.

Direct Emission Reductions

(1) Part of the outputs of the project will be the following investments: (a) these activities will result in direct greenhouse gas emission reductions during the project's implementation phase.

(a) Enter project activities

(2) As a result of these activities during the project implementation period of (b) years, direct greenhouse gas emission reductions totaling (c) tonnes of CO_2 equivalent will be achieved over the lifetime of the investments of (d) years. In the non-GEF case, these energy needs would be satisfied by (e) with an emission factor of (f).

(b) Enter duration of project implementation

(c) Enter the reduction in the tonnes of direct CO_2 equivalent emissions

(d) Enter the assumed useful lifetime of investments

(e) Enter marginal technology

(f) Enter emissions factor of marginal technology or national grid

Direct Post-project Emission Reductions

Instructions: Chose 1 or 2. If 1 is applicable, move to post-project emission reductions; if 2 is applicable, continue below.

(1) The project does not include activities that would result in direct post-project greenhouse gas emission reductions.

(2) The project does include activities that would result in direct post-project greenhouse gas emission reductions.

Instructions: The project will have set up a financing structure or some other activity that will function after the project has closed and continue to reduce GHG emissions.

(3) A fund set up by the project is expected to continue to finance investments resulting in GHG emission reductions after the project close. The fund is expected to finance $ (g) of new investment, equivalent to a turnover factor of (h), resulting in direct post-project emission reductions of (i) tonnes CO_2 equivalent.

(g) Enter the quantity of financing expected to be made available during the fund's post-project lifetime.

(h) Enter the fund's assumed post-project replication factor

(i) Enter the emission reductions expected to arise from the post-project functioning of the fund.

Indirect Emission Reductions

(1) Using the GEF bottom-up methodology, indirect emission reductions attributable to the project are (j) tonnes of CO_2 equivalent. This figure assumes a replication factor of (k).

(j) Enter indirect GHG emission reductions calculated using the GEF bottom-up methodology

(k) Enter the assumed replication factor

2) Using the GEF top-down methodology, indirect emission reductions attributable to the project are (l) tonnes of CO_2 equivalent. This figure assumes that total technological and economic potential for GHG emission reductions in this area over 10 years is (m) tonnes of CO_2 equivalent, with a project causality factor of (n) %.

(l) Enter indirect GHG emission reductions calculated using the GEF top-down methodology.

(m) Enter assumption for total possible GHG emission reductions possible in this area over the 10 years after the close of the project.

(n) Enter assumed causality factor