# Evaluating Energy Savings and Greenhouse Gas (GHG) Emissions in Six Projects in the CIS: A Comparison between Initial Estimates and Assessed Performance

*Susan Legro, MIA/MPH, Eco Ltd, Prague, Czech Republic*

## ABSTRACT

This paper examines the differences between initial estimates for project-related energy savings and reported savings as measured during project implementation. Six projects funded by the Global Environmental Facility (GEF) and implemented by the United Nations Development Programme (UNDP) were examined for five CIS countries: Armenia, Kazakhstan, Russia, Turkmenistan, and Ukraine. Estimates were divided into direct and indirect reductions of energy consumption and GHG emissions. The differences between estimated and reported emissions were compared using descriptive statistics, and correlation with other project characteristics was considered. In all categories considered, reported estimates of energy and GHG reductions for the portfolio as a whole were substantially lower than original estimates and the shortfall was greater for estimates of indirect reductions of energy and GHGs. A lack of replication of original investments was the most common cause of a shortfall in reported energy savings and emission reductions as compared to original estimates. Project start date was only weakly correlated with performance expressed as the percentage of estimated reductions that were reported (SRCC=0.1). There was also a strong negative correlation between the magnitude of the estimated reductions and the project's reported performance (SRCC = 0.7); i.e., the larger the emission reductions that were expected, the lower the percentage of emissions that were actually reported. The amount of money spent on monitoring in individual projects did not appear to have an effect on the availability of reported data or on the correlation between estimated and reported data. In summary, the findings point to several areas where both estimates of and reports of savings might be improved. The findings also indicate a need to further improve estimates of indirect project savings such as giving more attention to uncertainties in such calculations. While the causes of a project's failure to replicate are complex, the findings suggest caution when developing estimates of indirect energy savings from similar projects, or even for projections that involve the dissemination of climate-friendly technologies following pilot demonstrations.

## Introduction

The Global Environmental Facility (GEF) was created in October 1991 with the intent of providing incremental financing for global environmental problems including climate change. Over the subsequent 18 years, the GEF has provided grants to projects that mitigate greenhouse gas (GHG) emissions. Many of these projects have focused on energy efficiency as a means of emissions mitigation.

The United Nations Development Programme (UNDP) has served as an implementing agency for GEF projects since the inception of the fund, and the number of its past and present GEF investment projects has exceeded 570 (in all focal areas). UNDP-GEF has implemented projects in all countries in the Commonwealth of Independent States (CIS), including preparatory studies and/or investment projects in all CIS countries except for Azerbaijan and Moldova.

Energy efficiency projects have traditionally fallen into their own category at the GEF (formerly Operational Programme 5, currently Climate Change Strategic Programme 1). Over the operating period of the GEF energy efficiency programs have had a shared approach: the GEF has emphasized a barrier removal approach for projects that is intended to lead to market transformation for energy efficiency technologies and services. In addition, project proposals have always been required to discuss the sustainability and replicability of the project approach. Beyond this shared approach, other aspects of

programming in the area of energy efficiency have varied depending upon the GEF's priorities at the time of funding. For example, priorities in past work programs have ranged from certain types of activities (such as "innovative financing mechanisms") to certain end-use sectors (such as energy efficiency in buildings). Currently, the GEF climate change work programs are asked to provide estimates of emission reductions related to the implementation of the program. A current example from GEF-5, the work program that will start in the summer of 2010, is: the estimated reduction targets in GHG emissions due to Objective 2 (energy efficiency in buildings and industrial energy efficiency) range from 150 to 250 $MtCO_2e$ globally over the proposed 3-year period of the work program, depending on the level of funding (GEF 2010, 33).

## Background

UNDP launched its first GEF-funded climate change project in the CIS in 1998 with a project to improve energy efficiency in district heating (DH) in Russia. The DH sector fit well within the GEF strategy because of the prominent share of heating in primary energy consumption and because of the potential to save substantial amounts of energy (25-40%) using existing district heating technologies with relatively short payback periods. District heating projects were also attractive to host-country governments, because heat in many CIS countries was still subsidized. This meant that energy savings translated into economic savings for the municipal and national governments funding the subsidies. The projects also had the potential to result in significant development benefits, both by freeing up funds at the local level to support investments in other sectors and by improving indoor air temperature and comfort with corresponding health benefits.

At the time of the inception of the first project, GEF required that all projects submit an analysis of incremental costs; i.e., project documents had to present a baseline estimate of energy savings (and corresponding GHG emission reductions), an estimate of the energy savings and emission reductions under the project, and the increment – to be funded from the GEF – that was the difference between the baseline and project scenarios. Over time, the GEF has changed some of the specifics, but the nature of the discussion is still essentially the same: all proposals should estimate a project baseline -- the "business as usual" scenario – and then indicate energy savings and emission reductions from the proposed project measures – the project scenario. Official guidance on incremental costs (GEF 2007) attempted to clarify the calculation methods by encouraging the use of top-down estimates and bottom-up estimates and distinguishing between direct and indirect project effects.

### Monitoring and Evaluation Criteria

UNDP standard procedures for monitoring and evaluating its projects consist primarily of internal reviews that include an inception report, an Annual Project Report and Tripartite Review (with government partners, UNDP, and the project team), and a terminal report. In addition, two external reviews are conducted by independent experts: a mid-term evaluation and a final evaluation. Special ad hoc evaluations may also be used if necessary.

Standard GEF monitoring and evaluation consists of internal reporting. This reporting is comprised of a brief quarterly operational report that provides updated information on the status of project activities and an annual project implementation review, or PIR (which may, however, incorporate independent findings when available). These PIRs are now harmonized with UNDP annual project reports and use a common format. Furthermore, GEF project implementation fees support some technical backstopping at the regional and global level by implementing agencies, which includes monitoring. GEF also undertakes periodic portfolio reviews, such as the series of in-depth reviews conducted on selected GEF projects in 2002-2003 and the review of incremental cost in GEF projects (GEF 2006). It should be noted that the GEF does not fund post-project monitoring and evaluation by its implementing agencies.

The advent of GEF projects at UNDP brought some challenges to the general approach to monitoring and evaluation because UNDP projects in the energy sector had not previously monitored

associated emission reductions. Standard approaches to project monitoring for energy sector projects traditionally included targets for procurement, installation, and proper functioning of equipment. Clearly, there was a need to broaden the type of monitoring conducted and the profile of evaluators at the local and international level. Because process indicators are easier and less expensive to monitor, there is still a preference for them, which can lead to a situation described in a review of the UNDP-GEF heating portfolio where "…it is difficult to extrapolate from existing project data and ratings as to whether 'successful' projects are having a significant impact on emissions." (Legro and Ballard-Tremeer 2005, 48).

## Scope

The six projects selected for this analysis comprise the entire UNDP-GEF project portfolio of past and present projects related to district heating in the CIS. They cover five countries: Armenia, Kazakhstan, Russia, Turkmenistan, and Ukraine. The project in Ukraine was conducted in two phases but had the same management and scope of work; the phases are listed separately to show the change of estimates over time. Table 1 shows the various project implementation periods, which span the past 14 years.

**Table 1:** Project Time Line – Preparation and Implementation by Year

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ARM | | | | | | | | | | | | | | | |
| KAZ | | | | | | | | | | | | | | | |
| RUS | | | | | | | | | | | | | | | |
| TUK | | | | | | | | | | | | | | | |
| UKR | | | | | | | | | | | | | | | |
| Year | 96 | 97 | 98 | 99 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 |

□ = Preparation
□ = Implementation

All of the projects were expected to generate reductions in fossil fuel consumption and corresponding GHG emissions in two ways: 1) Directly through pilot projects (i.e. the purchase and installation of more efficient boilers); and 2) Indirectly through increased capacity to manage DH systems and through the replication of pilot projects, improved approaches to management, and through the development of supportive policies. Table 2 provides an overview of the focus of the projects and the means by which they were expected to reduce fossil fuel consumption and associated GHG emissions.

**Table 2:** Overview of Projects Reviewed

| **Country** | **Project Objective** | **Identified Sources of Direct Reductions in Energy and GHGs at Project Inception** | **Identified Sources of Indirect Reductions in Energy and GHGs at Project Inception** |
|---|---|---|---|
| Armenia | Creation of an enabling environment and a solid institutional, regulatory, and legal foundation for the sustainable development of heat and hot water supply services in Armenia | Pilot investments to restore and/or improve operations in district heating systems | Replication of investments in district heating rehabilitation in Armenian cities |

| | | | |
|---|---|---|---|
| Kazakhstan | Reducing greenhouse gas (GHG) emissions from the municipal heat and hot water supply systems in Kazakhstan | Pilot projects designed to increase efficiency in district heating systems and reduce energy consumption. | Replication of these projects by other investors boosted by increased awareness, strengthened management capacity, and improvements in the policy and regulatory framework. |
| Russia | Reducing Key Barriers to Energy Efficiency in Russian Residential Building and Heat Supply | 1) Consumption based metering and billing for the city of Vladimir<br><br>2) Autonomous boilers for areas not served efficiently by the district heating system in Vladimir | Experience (such as the billing system) disseminated to other cities by the project and through an affiliated loan. |
| Turkmenistan | Reducing GHG emissions by removing the existing barriers to the improvement of the heat and hot water supply systems in Turkmenistan | Two pilot projects to upgrade the district heating system in cities in Turkmenistan | Additional projects resulting from development of municipal master plans and supportive national policies and strategies |
| Ukraine Phase I | Reducing greenhouse gas emissions through large-scale improvements in energy efficiency in Ukraine's communal heat supply sector | Creation of a municipal energy service company (ESCO) in the city of Rivne to undertake improvements in the municipal district heating system with equipment provided using GEF funds. | One or more of the following:<br><br>1) Use of the Rivne ESCO to undertake additional improvements<br><br>2) Expansion of Rivne ESCO's work to other cities<br><br>3) Creation of other similar municipal ESCOs |
| Ukraine Phase II | Reducing overall fossil fuel consumption and associated GHG emissions by removing barriers to supply and demand side energy efficiency improvements in district heating systems in the main cities of Ukraine. | Financing for energy efficiency investment projects with long payback periods.<br><br>Increasing projects by developing risk management instruments in conjunction with banks and insurers.<br><br>Attracting additional investors for the ESCO. | One or more of the following:<br><br>1) Use of Rivne ESCO to undertake additional improvements<br><br>2) Expansion of Rivne ESCO's work to other cities<br><br>3) Creation of other similar municipal ESCOs |

The review of these projects included internal monitoring of pilot projects where reports were available. The review did not cover policy and investment issues or technical issues related to district heating, as they have been amply addressed in the literature (e.g. IEA 2004; Harvey 2006).

## Methodology

Project documentation from six UNDP-GEF projects in five CIS countries was reviewed in order to determine each project's stated estimates of energy savings and emission reductions and each project's reported energy and emission reductions where available. These reductions were then catgorized as either direct reductions or indirect reductions of energy and GHG emissions. Where possible, units were converted into figures that would be most comparable with data from other projects; in several cases where energy savings data were not reported, the GHG emissions data were used to approximate energy savings using emission factors that represented the fuel mix at project sites. The differences between estimated and reported emissions were compared using descriptive statistics and several other project characteristics were also examined for a correlation with these differences. Quantitative analysis was limited to descriptive statistics and correlation analysis because of the very small size of the sample and because of the non-parametric nature of the data.

### Selection Criteria

The six projects were selected for analysis for several reasons: 1) They are similar in focus but cover a long period of time, including two projects that are still under implementation; 2) They use similar, proven technologies that have been on the market for many years, thus minimizing the possibility that technological risk play a significant role in project outcome; 3) Although the sample size is very small, it represents a complete portfolio; 4) While economic indicators vary across the CIS, it presents a territorial area with a common supranational policy and regulatory framework; and 5) The common historical legacy of CIS countries has resulted in similar baselines for district heating equipment, system configuration, management, and common operations and maintenance practice.

## Results

Table 3 provides a project-by-project overview of estimated and reported direct energy savings; i.e. savings from pilot interventions in district heating systems as part of the larger UNDP-GEF projects.Perhaps the most notable features of the raw data used for of this comparison are: 1) the lack of baseline data regarding project-related savings from pilot interventions in several projects (where possible, approximate measures are used); 2) the absence of energy savings data in the project independent evaluations in the cases of Russia and Ukraine Phase I (NICE & Eco Ltd. 2004; UNDP-GEF 2004b); and 3) the lack of consistency in units for reporting, both across the projects portfolio and within the individual projects themselves.

**Table 3:** Direct Energy Savings: Estimated vs. Reported (MWh/year)

| Country | Estimated Direct Energy Savings (MWh/year) | Reported Direct Energy Savings (MWh/year) |
|---|---|---|
| Armenia | 111,674[1] | 65,410[2] |
| Kazakhstan | 78,060[3] | 12,168[4] |
| Russia | 58,410-350,000[5] | 12,302[6] |
| Turkmenistan | 179,316[7] | 146[8] |
| Ukraine Phase I | 25,859[9] | 37,742[10] |
| Ukraine Phase II | N/A[11] | 28,742[12] |

As Figure 1 illustrates, estimated savings were greater than reported savings in all five projects where data could be collected or approximated with the exception of Ukraine I. For the five projects as a whole, reported emission reductions totaled 28% of estimated emission reductions. The estimated/reported differential showed only a weak, positive correlation with the order in which the projects were implemented (Spearman's Rank Correlation Coefficient/SRCC = 0.1), which may indicate that project performance in this area did not improve significantly as new projects were developed. It should be noted that as the projects in Armenia and Kazakhstan are still under implementation, reported direct energy savings may improve by the end of project implementation, which would in turn improve the overall performance of the portfolio.

[1] Estimated energy savings calculated from a total of 446,695 MWh averaged over 4 years.
[2] Actual energy savings calculated from a total of 261,641 MWh averaged over 4 years (UNDP-GEF 2009a).
[3] Estimated savings from implementing the energy efficiency project component implementation (75,000 mWh in coal and 3,060 MWh in electricity).
[4] These savings were calculated from the measured GHG reductions using a conservative assumption of natural gas use and the IPCC emission factor database factors 12090 and 12091 (Lari 2009).
[5] Estimate based on statement of 5-30% improvement in system efficiency, which would yield savings of 5500-33,000 thousand $m^3$ of gas (UNDP-GEF 1998a).
[6] The project terminal evaluation did not report on energy savings (UNOPS 2006). Reported savings in the 2003 annual report consisted of 613.9 "tonnes of fuel" [sic] saved from metering and billing and 276 saved by autonomous boilers . This estimate was calculated by working backward from the stated GHG reductions, making a conservative assumption of emissions reductions from natural gas and using IPCC database emission factors 12090/12091 for $CO_2$ from natural gas consumption in residential and institutional boilers.
[7] No estimates of energy savings were provided in project document as approved by the GEF (NICE & Eco Ltd. 2005); this estimate is based on the GHG estimates as stated in the project document using the IPCC emission factor database (factors 12090 and 12091 for $CO_2$ emissions from natural gas consumption residential and institutional boilers.
[8] This figure is based on the only specific savings reported by the project: a season-on-season reduction in natural gas consumption of 13,790 $m^3$ of due to boiler house improvements in the city of Mary in spite of a colder winter (Ballard-Tremeer 2007, 27), so actual savings were likely to have been larger.
[9] Stated estimated savings were 51,700 $m^3$/yr of gas [61.16 tce/yr], as The project assumed 48.7 million $m^3$ of natural gas over 20 years, or 517,194 MWh; (UNDP-GEF 2000b, 34). An additional estimate elsewhere in the document appears to be an error, as it is greater by a factor of more than 20 (UNDP-GEF 200b, 36).
[10] Reported direct savings were 4,636 tce by team for the period from 12/03 to 06/04 (Legro & Ballard-Tremeer 2005, 76).
[11] No estimates of direct reductions were provided in project document as approved by the GEF; instead, a total of 1,139,750 MWh/year was stated as the overall estimated energy savings through direct and indirect activities.
[12] Actual reductions of 3,531 tce/yr are as reported for the 06/08-06/09 annual reporting period (UNDP-GEF 2009b).

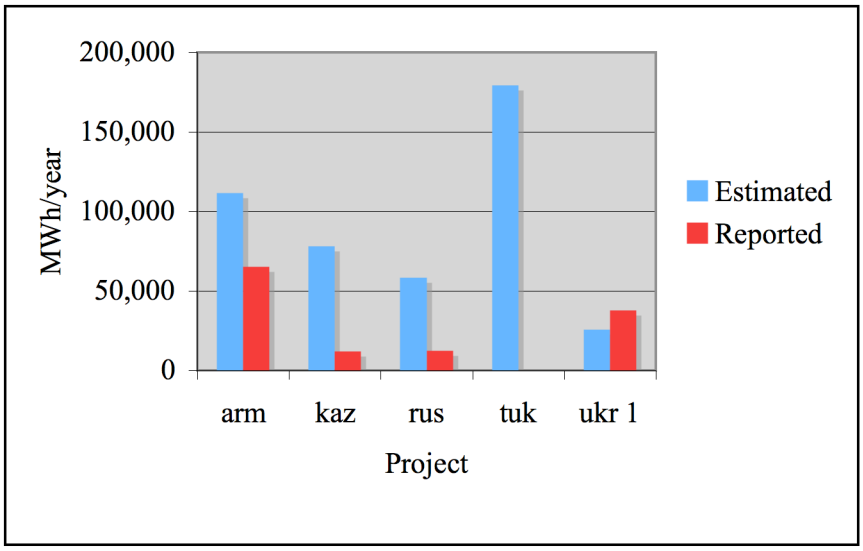


**Figure 1:** Direct Energy Savings: Estimated vs. Reported (MWh/year)

Table 4 summarizes data on the estimated and reported indirect energy savings (i.e., from activities under the project that influenced the policy environment or practices and investments that were replicated.

**Table 4:** Indirect Energy Savings: Estimated vs. Reported

| **Country** | **Estimated Indirect Energy Savings (MWh/year)** | **Reported Indirect Energy Savings** |
|---|---|---|
| Armenia | N/A[13] | N/A[14] |
| Kazakhstan | N/A[15] | N/A |
| Russia | 175,230-1,050,000[16] | 0[17] |
| Turkmenistan | 182,044 - 455,109[18] | 0[19] |
| Ukraine Phase I | N/A[20] | 0[21] |
| Ukraine Phase II | 1,139,740[22] | 0[23] |

[13] The project documentation gives a quantitative estimate of improvement by 20-25% in Armenian cities but does not set a target for replication or provide a boundary (UNDP-GEF 2004a).
[14] A report on indirect savings has not yet been prepared.
[15] The project executive summary lists only "replication potential" and provides a figure of 46,000,000t$CO_2$e over 20 years; assuming conservative savings (from coal, using the IPCC emission factor database factor 11975), this figure would work out to approximately 6.7 million MWh/year.
[16] Estimated based on an assumption of replication to 3 cities (project documentation assumes replication to "several cities").
[17] The project did not replicate outside of Vladimir.
[18] No estimates of energy savings were provided in project document as approved by the GEF (UNDP-GEF 2000); this estimate is calculated from the indirect GHG estimates of .2-.5 MtC for a 10-year period as stated in the project document using the IPCC emission factor database (factors 12090 and 12091 for $CO_2$ emissions from natural gas consumption residential and institutional boilers.
[19] The project activities did not replicate, and the national heat strategy (and anticipated incentives for replication) was not approved during the project implementation period.
[20] Estimate is for gas saved at project sites over a project lifetime of 20 years (UNDP-GEF 200b, 37).
[21] In actual terms, the project has not replicated outside of Rivne.
[22] Estimate was for savings of 2 million tce at project sites. (UNDP-GEF 2005, 15). Project also included the qualitative indicator "ESCO-Rivne has expanded its work to at least 2 other oblasts"
[23] ESCO-Rivne has not expanded as of 04/10; project is scheduled to conclude in 05/10.

It should be noted that the GEF did not place as much emphasis on the quantification of indirect impacts until relatively recently; in three projects, the overall technical potential for reform in the DH systems (assuming 100% implementation) was used to give a crude indication of the potential for indirect savings due to project replication. However, each project had an assumption of at least some degree of replication, and in the projects that have been completed, the replication rate has been 0[24], meaning that all estimates of replication were overstated.

Table 5 summarizes difference between estimated and reported GHG emission reductions due to direct project effects. With the exception of the project in Armenia, which reported 33% more savings than had been estimated in the project proposal, reported emissions as a percentage of estimated emission for projects showed very substantial shortfalls. Project performance expressed as the percentage of estimated emission reductions that were reported ranged from 1% (Russia) to 14% (Ukraine Phase I). The project in Turkmenistan did not monitor energy savings with the exception of a single boiler house, which resulted in savings that totaled 1% of the estimated project savings; actual savings may have been slightly higher. For the portfolio of six projects as a whole, the percentage of estimated direct emission reductions that were reported in practice totaled 20%.

**Table 5:** Direct GHG Emission Reductions: Estimated vs. Reported ($tCO_2e$/year)

| **Country** | **Estimated Direct GHG Reductions** | **Reported Direct GHG Reductions** |
|---|---|---|
| Armenia | 35,119[25] | 46,610 [26] |
| Kazakhstan | 30,000-33,500[27] | 686[28] |
| Russia | 100,000[29] | 2,480[30] |
| Turkmenistan | 3,667[31] | 26[32] |
| Ukraine Phase I | 90,000[33] | 7,800[34] $tCO_2e$ |
| Ukraine Phase II | 131,000[35] | 18,590[36] |

[24] Ukraine Phase II is scheduled to close in May 2010 and is very unlikely to replicate barring significant project developments.
[25] Estimate in project document (UNDP-GEF 2004a).
[26] Reported reductions in mid-term evaluation (Ballard-Tremeer 2008).
[27] The higher estimate is taken from the GEF Executive Summary (UNDP-GEF 2006a, 26). The lower estimate, from 2008, covers Almaty ESCO creation (assumed 20,000 $tCO_2e$ /yr), demo projects for the Astana EE Plan (9800 $tCO_2e$ /yr) and a pilot project in Almaty and Astana (200 $tCO_2e$ /yr).
[28] Reported emissions (as of October 2009) have resulted from pilot activities in conjunction with GEF SGP (Lari 2009).
[29] As reported in the incremental cost matrix of the project (UNDP-GEF 1998b).
[30] Reported reductions were attributed to metering (1728 $tCO_2e$/yr) and more-efficient boilers (725 $tCO_2e$/yr)(Legro & Ballard-Tremeer 2005, 67).
[31] Estimate assumes a direct reduction of GHG emission through the two pilot projects of 0.01 MtC over 10 years (UNDP-GEF 200a).
[32] Total GHG reductions were not monitored, and the only specific savings measured were a season-on-season reduction in natural gas consumption that resulted in a single-year reduction of 26 tons $tCO_2e$/yr (Ballard-Tremeer 2007).
[33] Estimate assumes a reduction of 1.8 million $tCO_2e$ over a 20-year period.
[34] Reported reductions are extrapolated from the report of reductions of 15,281 $tCO_2e$ over a 7-month period (UNDP-GEF 2005, 3-4).
[35] Estimate is for 2.8 million over the 20-year project lifetime (UNDP-GEF 2005, 3-4).
[36] The annual reported total for 06/08-06/09 was 6,090 $tCO_2e$ (UNDP-GEF 2009b).

**Table 6:** Indirect GHG Emission Reductions: Estimated vs. Reported ($tCO_2e$/year)

| Country | Estimated Indirect GHG Reductions | Reported Indirect GHG Reductions |
|---|---|---|
| Armenia | 24,672[37] | 26,196[38] |
| Kazakhstan | 2,300,000[39] | N/A |
| Russia | 300,000[40] | 0[41] |
| Turkmenistan | 36,667-183,350[42] | 0[43] |
| Ukraine Phase I | 3.2 million[44] | 0[45] |
| Ukraine Phase II | 80,500[46] | 0[47] |

Table 6 provides information on the estimated and reported indirect emission reductions. These are reductions from project replication and an improved policy or investment environment that can be attributed to the project.

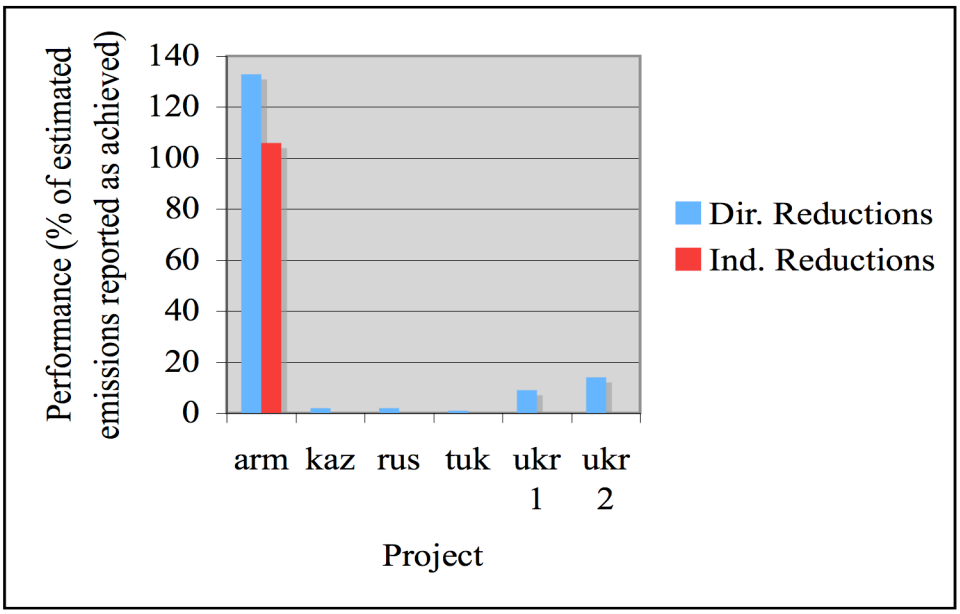


**Figure 2:** Reported Project Performance in Achieving Estimated GHG Reductions

[37] Estimate based on 4-year total of 98,689 $tCO_2e$ (UNDP-GEF 2009a). An earlier estimate uses the figure 480,000 $tCO_2e$/yr, or 9.6 million $tCO_2e$ over 20 years based on the potential for national replication (UNDP-GEF 2004a).
[38] Reported reductions were averaged from a 4-year total of 61,125 $tCO_2e$ (UNDP-GEF 2009a).
[39] Estimate was based on the cumulative GHG emission reduction potential through replication of 46 million $tCO_2e$ over the next 20 years (Lari 2009).
[40] Estimate assumes a 15% increase in efficiency in 600 buildings (UNDP-GEF 1998a). However, it should be noted that that calculation assumes an increase in emission reductions of more than 30% from an increase in efficiency of 15%, which would seem to indicate a calculation error.
[41] No replication identified.
[42] Estimate in document is a reduction of GHG emissions of 0.2-0.5 MtC over 20 years (UNDP-GEF 2000, 1).
[43] Reported as 0 because no replication was identified.
[44] Estimate assumes universal replication: "Project replication potential for communal heat supply sector in other cities makes up about 64 million tons of $CO_2$ equivalent." (UNDP-GEF 2002, 28).
[45] No replication was documented during Phase I.
[46] Based on a figure of 1.61 million "tons of GHGs" [sic] reduced over 20 years due to changes in legislation and regulation (UNDP-GEF 2005, 28).
[47] The project also included a qualitative measure: "ESCO-Rivne has expanded its activities in at least 2 other Oblasts." ESCO-Rivne has not expanded.

As would be expected based on available indirect energy savings data, the indirect emission reductions were quite low; in fact, only one project registered any indirect emissions reductions (Armenia, with reported emission reductions that exceeded estimated emission reductions by 6% and may achieve additional reductions, as the project is still under implementation). In the three closed projects (Russia, Turkmenistan, Ukraine Phase I), there were no indirect emission reductions. In the three projects under implementation, two have not yet reported any indirect emission reductions in annual performance reporting. For the four projects where data were available, the percentage of estimated indirect emission reductions that were reported in practice totaled 6%.

Figure 2 provides an overview of the reported emissions reductions as a percentage of the total estimated project emissions reductions for both direct and indirect reductions. With the exception of the project in Armenia, project emission estimates have not reflected reported project performance.

Overall, emissions were more likely to be reported in project documentation than were energy savings, which suggests that the corresponding data on energy savings may have been calculated but were not included in the project documents and proposals.

Other variables with a potential association with these numbers were considered, including project start date (as discussed above) and the size of the reductions in energy consumption that were estimated at project inception. The size of the direct estimated GHG reductions, for example, exhibited a strong, negative correlation with project performance (SRCC = 0.7); i.e., the larger the emission reductions estimated, the lower the percentage of emissions that were actually reported.

Finally, the size of the project budgets for monitoring and evaluation (M&E) for the individual projects were compared to project performance. Interestingly, the size of the M&E budget as a percentage of total project size did not seem to have any effect on the availability of reported data or the correlation between estimated and reported data. The percentages of project budgets devoted to monitoring and evaluation activities were in themselves notable for their range: from 1% of the total GEF grant in the case of the Russian project to 12% in the case of phases I and II of the project in Ukraine. The M&E budgets did not appear to be correlated with the age of the project; i.e., there was no trend in the budgets over time. This was interesting given the standardized nature of GEF requirements; budget size may have been affected by administrative practices and requires further study.

In summary, the findings were primarily notable for the absence of detailed estimates on direct and indirect project impacts on energy consumption and GHG emissions. This is consistent with a survey covering the time period in which these projects were submitted to the GEF that found that 64% of projects submitted to the GEF provided information on only half of the six aspects of incremental costs required by the GEF (GEF 2006). In essence, project proposals did not fully present the baseline and project scenarios, thus hindering estimates of energy savings and associated GHG reductions. Finally, it was not possible to determine the most common cause of a shortfall in direct energy savings and emission reductions as compared to original estimates. For several projects, the possibility of a rebound effect merits further study. The most common cause of a shortfall in indirect energy savings and emission reductions as compared to original estimates was the failure of the projects to replicate to other sites.

## Conclusions

While steps have been taken over time to make estimates of GHG emissions in GEF-funded projects more rigorous, the analysis of the district heating projects studied here suggests that several areas could be strengthened by: 1) Using common energy units for reporting to improve comparability; 2) Using risk analysis in a more proactive way, such as incorporating project risks into an uncertainty analysis; 3) Standardizing terms of reference for external evaluations that mandate the measurement of both energy savings and GHG emissions; and 3) Improving/clarifying/defining/refining assumptions about project replicability, for example, requiring project proponents to consider the historical performance of similar projects at a regional level. While the use of standard GEF "replication factors" are now mandated in estimates of indirect emissions, estimates of the probability of achieving replication

are not. On the whole, shortcomings in reporting for both estimates and ongoing measurements made it impossible to tell whether the failure to achieve energy saving and emission reduction targets was due to overly optimistic targets, poor project performance, another factor such as the rebound effect, or some combination of factors.

When comparing estimated energy savings and emission reductions from the selected projects, the available data suggest that the greatest discrepancies occurred for targets related to indirect savings. The failure of the reviewed projects to replicate indicated that estimates of indirect energy savings and GHG reductions were overly optimistic even when they did not use an estimate of universal technical potential. While the causes of the failure to replicate are complex and may be related to barriers beyond a project's control such as the investment or regulatory climate, the above findings would suggest caution when developing estimates of indirect energy savings for similar projects, or even for projections involving the dissemination of climate-friendly technologies and estimates of the impact of policies and measures to mitigate climate change. These findings are particularly relevant to current programming, as "…the GEF's focus has continually shifted upstream toward creating a conducive policy environment, away from individual investments" (GEF 2010a). This shift means that indirect savings and resultant emissions reductions will play a dominant role in the next programming cycle.

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