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UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF CALIFORNIA
SAN FRANCISCO DIVISION

FRIENDS OF THE EARTH, INC., et al.,)
) Civ. No. C 02 4106 JSW
Plaintiffs,)
v.) Date: February 11, 2005
) Time: 9 A.M.
PETER WATSON, et al.,) Courtroom 2, 17th Floor
)
Defendants.)

DECLARATION OF RICHARD HEEDE

I, RICHARD HEEDE, declare as follows:

1. I received Bachelor of Arts and Sciences degrees in Environmental Studies (with minor in Economics) and in Philosophy from the University of Colorado in 1976. I received a Masters in Arts and Sciences in Geography from the

Plaintiffs' Exhibit #1

University of Colorado in 1983 with a thesis in climate change supported by a fellowship from the National Center for Atmospheric Research in Boulder, Colorado (*A World Geography of Recoverable Carbon Resources in the Context of Possible Climate Change,* NCAR-CT-72).

2. I worked with Amory Lovins and the Rocky Mountain Institute from 1984 to 2002. My work at RMI included publishing two books, several book-length reports, and dozens of journal and magazine articles. The work focused on efficient use of energy, climate mitigation, and related policy and national security issues that resulted in a broad range of publications, including: residential energy efficiency and retrofits (*Homemade Money: Saving Energy and Dollars in Your Home* and *The Energy Directory*), energy policy ("Hiding the True Costs of Energy," *Wall Street Journal,* "Energy Policy," *Changing America: Blueprints for the New Administration*), commercial-sector energy efficiency (*Electricity-Saving Office Equipment*), climate mitigation (*Cool Citizens: Everyday Solutions to Climate Change: Household Solutions Brief*, and *Oberlin College: Climate Neutral by 2020*). This latter year-long project included a comprehensive inventory of greenhouse gas (GHG) emissions for a mid-western U.S. college, audits of campus energy use and expenditures, and a suite of practical recommendations designed to profitably reduce emissions of GHG from 46,000 tonnes of carbon dioxide-equivalent per year to net zero by 2020.

3. In 1999 I wrote a guide to establishing simple and accurate measures of a country's carbon dioxide emissions and other economic and environmental

metrics for teams established in nearly 60 countries worldwide by Helio International in Paris. The manual makes such sets of indicators readily comparable from year to year as well between participating nations. The guide—*Measuring Energy Sustainability: Evaluating Your Country's Energy Development*—was published in 2000. I reviewed sections of the first edition of WBCSD/WRI's *Greenhouse Gas Protocol: a corporate accounting and reporting standard*. In 2002-2003 I served as reviewer of several emissions verification reports conducted by Climate Neutral Network for its corporate members.

4. In 2002 I founded Climate Mitigation Services, a consultancy in climate mitigation and emissions inventories serving non-profit organizations, municipal governments, professionals, and individuals. In this capacity I conducted a major study of historic greenhouse gas emissions of the largest oil company in the world. The report *ExxonMobil Corporation Emissions Inventory 1882-2002* analyzed emissions sources (both corporate and operational emissions and emissions from combustion of its marketed energy products) since its incorporation as Standard Oil in 1882 through to the merger of Exxon and Mobil corporations in 2000. The emissions accounting methodology substantially informed the scope of the present work on direct and indirect emissions from the Export-Import Bank of the United States (Ex-Im) and the Overseas Private Investment Corporation (OPIC) energy-sector investments.

Origin and Objectives of the Project

5. This declaration summarizes estimates of the direct, indirect and cumulative greenhouse gas (GHG) emissions from projects financed by Ex-Im and OPIC from 1990 through 1999 and, where possible, estimates of emissions from Ex-Im and OPIC-financed projects approved from 1999 through 2003. I made material use of reports issued by Ex-Im and OPIC in 1999 and 2000, respectively.[1] I was asked to estimate both direct and indirect emissions from the projects approved by these two federal agencies as well as review and improve the methodology used to estimate direct and indirect emissions. I summarize project-level emissions annually as well as cumulatively over the expected operating lives of Ex-Im and OPIC fossil fuel extraction and power generation projects.

Emissions Estimation Protocol

6. This accounting of carbon dioxide and methane emissions from Ex-Im Bank and OPIC-financed fossil-fuel electric generation and oil and gas extraction, processing, and transportation projects, adopts most of the guidelines for corporate and national accounting protocols as described in the World Business Council for Sustainable Development (WBCSD) and World Resources Institute's (WRI) jointly issued *Greenhouse Gas Protocol,* the Intergovernmental Panel on

[1] Export-Import Bank of the United States (1999) *Ex-Im Bank's Role in Greenhouse Gas Emissions and Climate Change*, Engineering and Environment Division, August, 59 pp. Overseas Private Investment Corporation (2000) *Climate Change: Assessing Our Actions*, Washington, 53 pp. All reports cited in this Declaration and in the attached spreadsheets are fully referenced in Attachment A.

Climate Change (IPCC) guidelines for national emissions accounting, and the reporting guidelines for the oil and gas sector developed by the International Petroleum Industry Environmental Conservation Association (IPIECA) and the American Petroleum Institute (API). Unlike the emissions inventories published by Ex-Im and OPIC, I include the combustion of oil and gas products by ultimate consumers of those products whose extraction, refining, and delivery results from projects financed or insured by Ex-Im and OPIC as indirect emissions.

7. This declaration's purpose is to summarize the results and the methodology used to estimate the direct, indirect, and cumulative GHG emissions of projects financed by Ex-Im and OPIC as required by the National Environmental Policy Act (NEPA).

8. NEPA requires an assessment of the indirect and cumulative impacts of projects under agency review. Indirect impacts cannot be adequately assessed without estimating both direct and indirect emissions from OPIC and Ex-Im assisted energy projects. The term "indirect" has two different connotations. NEPA's requirement refers to an assessment of indirect impacts of agency activities on environment and society, including trans-boundary impacts to the global commons; in this case "indirect" refers to unintended *consequences* from the agencies' direct activities—investments in energy projects that emit greenhouse gases—that increase atmospheric concentration of carbon dioxide, and that, therefore, contribute to climate change. My inventory protocol's use of the term refers to indirect *emissions* of greenhouse gases inevitably emitted to the

atmosphere as a result of the energy projects assisted by Ex-Im and OPIC. An assessment of Ex-Im and OPIC impacts on the global climate cannot be done without a full accounting of all emissions of greenhouse gases, both direct and indirect. Neither Ex-Im nor OPIC have estimated indirect emissions (nor have they estimated all direct emissions). My report seeks to correct the agencies' flawed and incomplete accounting by including all direct and most (but not all) indirect emissions from projects financed or otherwise assisted by Ex-Im and OPIC.

9. This comprehensive accounting of all emissions from Ex-Im and OPIC supported projects is appended to this declaration as Attachment B. This analysis details the methodology, assumptions, data sources, and calculations used to generate the results summarized in this declaration. The work estimates direct and indirect emissions from Ex-Im and OPIC-financed energy projects in two principal sectors: 1. the electricity sector (construction of fossil-fueled power plants), and 2. the oil and gas sector (extraction, refining, and transportation of oil and gas resources):[2]

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[2] I exclude several relatively minor emissions sources, e.g., cement manufacturing, fuel consumed by aircraft purchased by foreign operators and financed by Ex-Im or OPIC, direct and indirect emissions from the buildings occupied or owned by Ex-Im and OPIC, emissions from other Ex-Im and OPIC operations (conferences, foreign offices, field work, domestic and international travel), and emissions from industrial machinery and commercial enterprises financed by Ex-Im and OPIC.

- **Electricity generation & power plants:**
  1. **Direct emissions from fuel consumed at coal, oil, and gas-fired power plants**,[3]
  2. **Indirect emissions from fuel combusted at power plants**:[4]
     - A. Coal: transport from mines to power plants;
     - B. Coal: fugitive methane from coal mines (in carbon-equivalent units);
     - C. Oil: flared gas at oil production facilities;
     - D. Oil: energy inputs at oil refineries;
     - E. Oil: energy input to oil transportation and delivery
     - F. Oil: fugitive methane from oil production and delivery (carbon-equiv);
     - G. Gas: flaring at natural gas production facilities;
     - H. Gas: CO_2 vented from natural gas extraction and operations;
     - I. Gas: energy inputs at gas processing and transportation;
     - J. Gas: fugitive methane from gas production and delivery (carbon-equiv).

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[3] My accounting methodology is similar to that used by Ex-Im Bank (1999) and OPIC (2000) and accounts for the emissions factor of each power plant type, its heat rate, and fuel consumed. Two methodological differences are worth noting: instead of applying assumed 25-year operating lives for all power plants regardless of fuel and generator types (as Ex-Im and OPIC did), coal-fired power plants have operating lives of about 60 years, gas-fired units about 40 years, and oil-fired generators last about 30 years. This increases each power plant's emissions over its operating life, and corrects significant under-estimates in the Ex-Im and OPIC reports. Second, this report uses varying capacity factors for each plant type: 90 percent for coal-plants, 85 percent for gas units, and 80 percent for oil-fired generators (Ex-Im and OPIC apply an 85 percent capacity-factor across the board).

[4] As noted above, neither the Ex-Im nor the OPIC reports estimate indirect emissions. This report estimates these indirect emissions from the agency-funded energy-sector investments. It must be noted, however, that this estimator lacked access to agency information on each project's technical specifications that makes it difficult to generate a complete estimate. As a result, these estimates may underestimate actual emissions. However, it is certain that indirect emissions are not zero, which is the value conveyed by Ex-Im's and OPIC's failure to account for such emissions. The estimates presented in this report are, in my expert opinion, based on a reasonable methodological approach given the information available. Each agency may chose to refine this estimate in future reports with more detail from its own data on each project's technical specifications.

- **Oil and natural gas extraction, processing, delivery, and consumption:**
  1. **Direct emissions from oil and gas operations**:[5]
     A. Oil: flared gas at oil production facilities;
     B. Oil: energy inputs at oil refineries;
     C. Oil: energy input to oil transportation and delivery;
     D. Oil; fugitive methane from oil operations;
     E. Gas: flared gas at gas production facilities;
     F. Gas: energy inputs at gas processing facilities;
     G. Gas: energy input to gas pipelines;
     H. Gas: fugitive methane from gas operations.
  2. **Indirect emissions from oil and gas sector**:[6]
     A. Oil: oil products combusted by ultimate consumers (net of non-fuel uses of ~9.0%);
     B. Gas: natural gas combusted by ultimate consumers (net of non-fuel uses of ~2.9%).

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[5] This report estimates several sources of direct emissions from oil and gas extraction, refining, and delivery. Neither Ex-Im nor OPIC estimate any direct emissions from the oil and gas sector, although both agencies acknowledge the protocol to do so. It must again be emphasized that Ex-Im and OPIC possess technical information to which this author did not have access, and the estimates should be viewed as preliminary. Each facility has differing operational characteristics that I cannot discern or include in this emissions survey. Consequently, global factors were used in lieu of operational data.

[6] As mentioned previously, Ex-Im provided (in its 1999 report) estimates of potential downstream emissions from full combustion of the delivered products from the agency's investments to extract, refine, or transport oil and gas resources, although Ex-Im disavows the need to include those emissions in its inventory. Ex-Im assumed that all of the carbon extracted from oil and gas fields (or processed at refineries or pipelined to markets) would be converted to carbon dioxide—which over-estimates indirect emissions by ~9 percent in the oil sector and ~3 percent for natural gas. This report corrects Ex-Im's over-estimate, although by using proxy data for non-fuel uses of petroleum and gas. Estimates can be improved through the application of project-specific or regional datasets that reflect the disposition of each fuel, if required.

Conservatisms and Excluded Emissions

10. Several emissions sources from projects supported by Ex-Im and OPIC have been excluded from this estimate. A full accounting would include additional elements of the agencies' investment activities, such as support for cement manufacturing plants and other energy-consuming industrial equipment (e.g., loans and guarantees for the purchase of U.S. commercial jet aircraft), and emissions from the agencies' own buildings and related operations. Nor have emissions from the construction of drilling rigs, pipelines, power plants, and transmission grids been estimated.[7] Ex-Im and OPIC's financial support for renewable hydro-electricity projects are also excluded, even though hydropower projects (especially in tropical regions) often release methane gas from anaerobic digestion of the organic materials submerged under the dams' reservoirs.

11. A number of conservatisms in the emissions survey should also be noted. In several cases Ex-Im or OPIC power plants are listed as "oil *and* gas" plants, and I have used the lower emissions factors and greater efficiency (higher heat rates) of gas-fired combined-cycle power plants. Coal mining and coal shipping facilities are not included due to lack of data in published Ex-Im and OPIC reports (e.g., Ex-Im's investment in mining equipment for the Russian Karbo and Raspadsky coal mines). A number of projects, particularly in the oil and gas sector, were excluded due to lack of data or conflicting data, all of which

[7] Such emissions are typically considered outside the entity's boundary, although a good case can be made for their inclusion, since the energy and material inputs depend on expanding oil and gas output and generating capacity.

are noted on the attached spreadsheets in order to facilitate more accurate future accounting by the agencies. The factors used to estimate indirect emissions from the provisioning of fuel to power plants are all conservatively estimated. For example, the estimated methane leakage rate of gas pipelines ranges from 0.5 to 5.0 percent according to OPIC, and I used the low end of the range (0.5 percent) of natural gas throughput—in recognition of the fact that agency financial support is for new and presumably technologically sophisticated pipelines with lower-than-average leakage rates at seals, flanges, valves, and compressors.

Summary of Results

12. This comprehensive survey of energy projects financed by Ex-Im and OPIC from 1990 through 2003 estimates annual emissions from the power and oil and gas sectors totaling 1,911 million metric tonnes of carbon dioxide equivalent ($MtCO_2$-eq).[8] Eighty-seven percent of estimated annual emissions are from Ex-Im-supported projects compared to 13 percent from OPIC. The preponderance of annual emissions is indirect, chiefly because emissions from the dominant oil and gas sector are indirect. Indeed, 61 percent of combined Ex-Im and OPIC emissions are indirect. As previously discussed, I include both direct and indirect emissions from projects assisted by these agencies, and the difference is primarily one of terminology and protocol.

[8] The estimate also includes fugitive methane emissions from coalmines and natural gas pipelines, for example, and is expressed in units of carbon-equivalent and CO_2-equivalent. Hence total emissions are also expressed in CO_2-equivalent units; 97.5 percent of total emissions are carbon dioxide and 2.5 percent is methane (CH_4).

Table 1

Export-Import Bank & Overseas Private Investment Corporation				
Direct and indirect emissions	**Annual emissions** (Million tonnes C/yr)	**Annual emissions** (Million tonnes CO2/yr)	**Total project** (MtC)	**Total project** (MtCO2)
Ex-Im Bank				
Direct emissions	**93**	**341**	**4,241**	**15,551**
Indirect emissions	**361**	**1,325**	**7,612**	**27,915**
Total Ex-Im Bank	**454**	**1,666**	**11,853**	**43,466**
OPIC				
Direct emissions	**26**	**95**	**1,218**	**4,466**
Indirect emissions	**41**	**150**	**1,002**	**3,674**
Total OPIC	**67**	**245**	**2,220**	**8,140**
Ex-Im Bank & OPIC				
Direct emissions	**119**	**436**	**5,459**	**20,018**
Indirect emissions	**402**	**1,475**	**8,614**	**31,588**
Total Ex-Im & OPIC	**521**	**1,911**	**14,073**	**51,606**

13. Emissions over the operating lives of power plants and full production of identified proven reserves of oil and gas total 51,600 million tonnes of CO_2-equivalent ($MtCO_2$-eq). This is a better indicator of the aggregate impacts of Ex-Im and OPIC energy-sector investments inasmuch as it measures emissions over project lifetimes.[9] Table 1 summarizes Ex-Im and OPIC annual and project emissions; complete details are reproduced in Attachment B.

[9] I have not evaluated the entire energy portfolios of either agency, both of which are allegedly increasing their relative investment in low- and zero-carbon

Ex-Im and OPIC Greenhouse Gas Emissions in the Context of Global Emissions

14. Combined Ex-Im and OPIC emissions of carbon dioxide and methane total 1,911 million tonnes of carbon dioxide-equivalent on an annualized basis. *This equals nearly 8 percent of the world's emissions of carbon dioxide.*[10] This emissions rate is also *equivalent to one-third* of total U.S. carbon emissions in 2003.[11] Comparing aggregate emissions of Ex-Im and OPIC over expected operating periods of power plants and oil and gas projects leads to a staggering result: Ex-Im and OPIC projects will, over their operating lives, emit more than twice as much carbon as the entire global economy now does annually, and over 8 times as much as the economy of the United States now does.[12] I have not modeled the anticipated growth of Ex-Im and OPIC power and/or oil & gas portfolios over

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energy sources such as hydro-electricity, wind-power, solar, and (arguably) natural gas for heat and power.

[10] Since current and forecasted emissions are typically expressed in units of carbon, not carbon dioxide, we convert from CO_2 to carbon by dividing by its molecular compositions, or 44/12, or 3.667. Thus, 1.911 billion tonnes of CO_2 = 0.521 billion tonnes of carbon (GtC). Year 2002 global carbon emissions totaled 6.443 GtC. Note: my emissions estimates include methane emissions of 2.5 percent of the total; making this adjustment means 0.507 GtC / 6.443 GtC = 7.87 percent of global emissions.

[11] U.S carbon emissions totaled 1.601 GtC in 2003: 0.507 / 1.601 GtC = 31.7 percent. Energy Information Administration (2004) *Emissions of Greenhouse Gases in the United States*, www.eia.doe.gov/oiaf/1605/ggrpt/index.html

[12] Ex-Im + OPIC operating life emissions total 14.07 GtC-equiv and 13.58 GtC (after the modest methane emissions are subtracted). Dividing 13.58 GtC by year 2002 global emissions of 6.443 GtC = 2.11 times. Similarly, Ex-Im + OPIC long-term emissions of 13.58 GtC are 8.49 times U.S annual emissions of 1.6 GtC in 2003.

the next few decades. However, OPIC's published statements indicate that it expects their power plant portfolio to expand from 16,775 megawatts (MW) in 2000 to 42,000 MW by 2015, suggesting more than a doubling in 15 years and a growth rate of more than 6 percent per annum.[13] This is faster than growth in global carbon emissions, indicating the possibility that OPIC's and Ex-Im's emissions will grow from its current gross of 8 percent per year to a significantly more substantial percentage.

15. I firmly disagree with OPIC's conclusion that its energy-sector investments are "not a substantial contributor to global GHG emissions and global climate change."[14] OPIC's and Ex-Im's current emissions, the future emissions of its existing fossil fuel portfolio alone, and anticipated growth in their combined carbon portfolios suggest the agencies will continue to expand their impacts on climate. To paraphrase an old Chinese maxim: 'unless the agencies change direction, they are likely to end up where they are headed.'

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[13] OPIC (2000), pp. 15 and 18 (MW datum and projection to 2015).

[14] OPIC (2000), p. 19.

I declare under the penalty of perjury that the foregoing is true and correct to the best of my knowledge.

Executed on December 21, in Snowmass, Colorado.

Richard Heede

Attachment A
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December 2004

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Attachment B
Spreadsheets

December 2004

Contents:

- Seven worksheets on Ex-Im Bank and OPIC fossil-fueled power plant projects followed by twenty-three (23) pages of worksheet notes;
- Five worksheets on the agencies' portfolios of oil and gas projects followed by twenty-four (24) pages of worksheet notes;
- One worksheet summarizing each agency's direct and indirect aggregate emissions, followed by one (1) page of worksheet notes.

How to read the worksheets and cell comments: Each worksheet discusses methodologies, assumptions, data sources, uncertainties, and calculations embedded in notes to pertinent cells. In most cases, the formula used to estimate emissions is explicitly described. All such comments appear in the original spreadsheet as active "carrots" that designate the entry of a comment. The PDF version of the spreadsheet attached to this declaration does not contain active carrots; instead, every comment has been printed in the pages following each energy sector's set of worksheets. Every comment has an "address" that corresponds to the column and row of the cell being referenced in each worksheet.

GHG emissions from Ex-Im Bank and OPIC projects

Coal-, Oil-, and Natural Gas-fired Power Plants

Climate Mitigation Services
Richard Heede
11-Dec-04

Export-Import Bank of the United States

	Plant type	Total capacity by fuel type (MW)	Annual Carbon (MtC-eq/yr)	Annual Carbon Dioxide (MtCO2-eq/yr)	Cumulative over plant life (MtC-eq)	Cumulative over plant life (MtCO2-eq)
	Direct emissions: Ex-Im coal-fired projects, 1988-2004		**Coal**		**60 yr life**	**60 yr life**
1988	Shidongkou, China	1,200	2.67	9.77	160	586
1989	Lamma Island, China	350	0.78	2.85	47	171
1990	Paiton, Indonesia	800	1.78	6.52	107	391
1991	no projects		-	-	-	-
1992	Mae Moh Power, Thailand	600	1.33	4.89	80	293
1993	Suralaya 4 5 6, Indon. (1800); Pagbilao, Philip. (700)	2,500	5.55	20.36	333	1,222
1994	Ligang, Hong Kong	700	1.55	5.70	93	342
1995	Sual, Philippines (1200); Turow, Poland (470); Paiton 1, Indonesia (1260); Dalian (700) & Dandong (700), China	4,330	9.62	35.27	577	2,116
1996	Jawa, Indonesia (1220); Naton 2, China (700); Jindal, India (260); Fuzhou, China (700)	2,880	6.40	23.46	384	1,407
1997	Jorf Lasfar, Morocco (700); Quezon, Philippines (475); Yancheng, China (2100); Rutenburg, Israel (1100)	4,375	9.72	35.63	583	2,138
1998	Bhilai, India	580	1.29	4.72	77	283
1999	Dezhou, China	1,320	2.93	10.75	176	645
	New Ex-Im Bank projects 1999-2004:					
	Pacifico (Petacalco II), Mexico	648	1.44	5.28	86	317
	Total direct emissions, Ex-Im coal, 1988-2004	**20,283**	**45.1**	**165**	**2,703**	**9,912**
	Indirect emissions					
	Coal mining energy input		*not estimated*	*not estimated*	*not estimated*	*not estimated*
	Coal transport (carbon emissions)		0.37	1.35	22.17	81.28
	Fugitive methane from coal mines (converted to carbon equivalent)		2.01	7.36	120.37	441.41
	Total indirect carbon and methane emissions		**2.38**	**8.71**	**143**	**523**
	Total emissions from Ex-Im-financed coal-fired power plants		**47.4**	**174**	**2,846**	**10,435**

Export-Import Bank of the United States

	Plant type	Total capacity by fuel type (MW)	Annual Carbon (MtC-eq/yr)	Annual Carbon Dioxide (MtCO2-eq/yr)	Cumulative over plant life (MtC-eq)	Cumulative over plant life (MtCO2-eq)
	Direct emissions: Ex-Im oil-fired projects, 1988-2004		**Oil**		**30 yr life**	**30 yr life**
1988	Risha, Jordan	70	0.09	0.32	3	10
1989	no projects	-	-	-	-	-
1990	no projects	-	-	-	-	-
1991	no projects	-	-	-	-	-
1992	Limay, Philippines (600); Ramat Hovar, Israel (460); Acajutla, El Salvador (80); Guatemala City, Guatemala (50); Muara Kanang, Indonesia (350)	1,540	1.93	7.08	58	212
1993	Topolabambo, Mexico	350	0.44	1.61	13	48
1994	no projects	-	-	-	-	-
1995	Costanera, Argentina (320); JPSC, Jamaica (138); Tambok Lorok, Indonesia (580); Hub River, Pakistan (1200); AGC, Mexico (147)	2,385	2.99	10.96	90	329
1996	Central 9, Panama (210); Saba, Pakistan (125); Pascuales, Equador (100); Santa Rosa, Peru (110); Guayaquil, Equador (78); Ujung Pandang, Indonesia (60); Electroquil, Equador (86)	769	0.96	3.54	29	106
1997	Siderurgica, Guatemala (385); Hagit Eilat, Israel (276)	661	0.83	3.04	25	91
1998	no projects					
1999	no projects					
	New Ex-Im Bank projects 1999-2004:					
2001	Cataguazes (Usina), Brazil	na		-	*counted in*	*Marlim Sul*
	Carimex, Dominican Republic (size unknown)	na		-	*insufficient*	*data*
	Total Ex-Im oil-fired power plants 1988-2004	**5,775**	**7.24**	**26.5**	**217**	**796**
					-	
	Indirect emissions				-	
	CO2 from flared gas at oil production facilities		0.06	0.21	1.74	6.37
	CO2 emissions from oil refinery operations		0.29	1.06	8.69	31.86
	CO2 emissions from oil transportation		0.11	0.39	3.21	11.79
	Fugitive methane from oil production and delivery (CO2-eq)		0.22	0.82	8.90	32.64
	Total indirect carbon and methane emissions		**0.68**	**2.48**	**22.5**	**82.7**
	Total emissions from OPIC-financed oil-fired power plants		**7.92**	**29.0**	**240**	**879**

Export-Import Bank of the United States

	Plant type	Total capacity by fuel type (MW)	Annual Carbon (MtC-eq/yr)	Annual Carbon Dioxide (MtCO2-eq/yr)	Cumulative over plant life (MtC-eq)	Cumulative over plant life (MtCO2-eq)
	Direct emissions: Ex-Im gas-fired projects, 1990-2004		**Gas**		**40 yr life**	**40 yr life**
1988	no projects		-	-	-	-
1989	no projects		-	-	-	-
1990	Alon Tabor, Israel (220); Respaldo, Uruguay (230)	450	0.39	1.44	16	58
1991	Padang, Indonesia	60	0.05	0.19	2	8
1992	Tambak Lorok, Indon. (360); S. Bangkok, Thail. (300)	660	0.58	2.11	23	85
1993	Cajon, Argentina (88); Las Flores, Colombia (150); Machado, Venez. (425); Khanom (658) & Black Point (2400), Hong Kong; Karang, Indonesia (1200*); CEL, El Salvador (82); Enerji/TSKK, Turkey (51)	5,054	4.42	16.19	177	648
1994	Colakoglu, Turkey (123); Cajon 2, Agentina (132); Centneuquen, Argentina (369); Dabhol, India (650); CEL/GE, El Salvador (78)	1,352	1.18	4.33	47	173
1995	CC Turbine, Colombia (980); Cajon 3, Argentina (131); Las Flores 2, Colombia (100); Samalayuca, Mex. (690); Buzmein, Turkmenistan (123); Marmara, Turkey (500); Tambak Lorok 2, Indonesia (500); Eregli, Turkey (78)	3,102	2.71	9.94	108	398
1996	Genelba, Argentina (660); Uch, Pakistan (586); Bir M'Cherga, Tunisia (250)	1,496	1.31	4.79	52	192
1997	Nueva Puerto, Argentina (769); Patagonia, Argentina (76); Zorlu, Turkey (26)	871	0.76	2.79	30	112
1998	HIDD, Bahrain (270); Tucuman, Argentina (450); Bursa, Turkey (75); TE-TO, Croatia (190); ATAER, Turkey (42); Bis Enerji, Turkey (20)	1,047	0.91	3.35	37	134
1999	Charrua, Chile (88); Zorlu, Turkey (96); Oscar a Mucado, Venezuela (80); Charrua & Antilhue, Chile (100)	364	0.32	1.17	13	47
	New or other Ex-Im Bank projects 1999-2004:		-	-	-	-
1994	Manaus, Brazil	207	0.18	0.66	7	27
1999	Charrua & Antilhue, Chile	88	0.08	0.28	3	11
2000	Ilijan, Philippines	1,250	1.09	4.01	44	160
2000	Rural gas pipeline gas-fired power, Bangladesh	33	0.03	0.11	1	4
2000	Adapazari, Turkey	777	0.68	2.49	27	100
2000	Bursa (Zorlu), Turkey	96	0.08	0.31	3	12
2000	Gebze, Turkey	1,550	1.35	4.97	54	199
2000	Izmir, Turkey	1,550	1.35	4.97	54	199
2000	Bajio (El Sauz), Mexico	730	0.64	2.34	26	94
2000	Samalayuca, Mexico	515	0.45	1.65	18	66
2001	CADEFE, Venezuela	650	0.57	2.08	23	83
2001	Kirklareli, Turkey	75	0.07	0.24	3	10
2001	El Encino (Chihuahua 2), Mexico	130	0.11	0.42	5	17
	Tanir Bavi, India	43	0.04	0.14	2	6
2001	Araucaria (Bolivia/Brazil pipeline power), Brazil	469	0.41	1.50	16	60
2001	Canoas (Bolivia/Brazil pipeline power), Brazil	250	0.22	0.80	9	32
2001	Ibirite (Marlin Sul O&G power plant), Brazil	na		-	-	-
2002	TermoCeara (Bolivia/Brazil pipeline power), Brazil	270	0.24	0.87	9	35
2002	Termozulia, Venezuela	170	0.15	0.54	6	22
2002	Altamira 3 & 4, Mexico	1,036	0.91	3.32	36	133
2002	Naco Nagales, Mexico	339	0.30	1.09	12	43
2002	Ankara (Baymina), Turkey	763	0.67	2.44	27	98
2003	Ayen Ostim, Turkey	35	0.03	0.11	1	4
2003	Habas, Turkey	180	0.16	0.58	6	23
2003	Kemalpasha, Turkey	na		-	-	-
2003	Atacama, Chile	740	0.65	2.37	26	95
2003	Skikda, Algeria	825	0.72	2.64	29	106
2003	Alon Tabor and Eshkol, Israel (size unknown)	na		-	-	-
2004	Cairo North, Egypt	750	0.66	2.40	26	96
	Total Ex-Im gas-fired power plants 1988-2004	**27,977**	**24.4**	**89.6**	**978**	**3,586**
					-	
	Indirect emissions				-	
	CO2 from flared gas at natural gas production facilities		0.29	1.08	11.73	43.03
	Venting of CO2 from natural gas operations		0.43	1.58	17.21	63.11
	CO2 emissions from natural gas processing and transportation		1.71	6.28	68.45	251.00
	Fugitive methane from natural gas production and delivery (CO2-eq)		2.84	10.40	113.46	416.07
	Total indirect carbon and methane emissions		**5.27**	**19.3**	**211**	**773**
	Total emissions from Ex-Im-financed gas-fired power plants		**29.7**	**109**	**1,189**	**4,359**

Overseas Private Investment Corporation

	Plant type	Total capacity by fuel type (MW)	Annual Carbon (MtC-eq/yr)	Annual Carbon Dioxide (MtCO2-eq/yr)	Cumulative over plant life (MtC-eq)	Cumulative over plant life (MtCO2-eq)
	Direct emissions: OPIC coal-fired projects, 1990-2004		**Coal**		**60 yr life**	**60 yr life**
1990	no OPIC coal project					
1991	no OPIC coal project					
1992	no OPIC coal project					
1993	not named, no country: 325 MW	325	0.72	2.65	43	159
1994	Paiton Energy, Indonesia: 1,220 MW	1,220	2.71	9.94	163	596
1995	Quezon, Philippines: 480 MW	480	1.07	3.91	64	235
1996	Jorf Lasfar, Morocco: 1,356 MW	1,356	3.01	11.04	181	663
1997	Central Genadora, Guatemala: 120 MW	120	0.27	0.98	16	59
1998	no OPIC coal project					
1999	not named, no country: 33 MW	33	0.07	0.27	4	16
	New or additional OPIC projects to 2004:					
1996	Bo Nok, Thailand: 734 MW	734	1.63	5.98	98	359
2000	Maritza East III Bulgaria: 840 MW	840	1.87	6.84	112	411
	Total OPIC coal-fired power plants 1990-2004	**5,108**	**11.3**	**41.6**	**681**	**2,496**
	Indirect emissions					
	CO2 from coal mining energy input		*not estimated*		*not*	*estimated*
	CO2 from coal transport		0.09	0.34	5.58	20.47
	Fugitive methane from coal mines (converted to carbon equivalent)		0.51	1.85	30.31	111.16
	Total indirect carbon and methane emissions		**0.60**	**2.19**	**36**	**132**
	Total emissions from OPIC-financed coal-fired power plants		**11.9**	**43.8**	**717**	**2,628**

Overseas Private Investment Corporation

	Plant type	Total capacity by fuel type (MW)	Annual Carbon (MtC-eq/yr)	Annual Carbon Dioxide (MtCO2-eq/yr)	Cumulative over plant life (MtC-eq)	Cumulative over plant life (MtCO2-eq)
	Direct emissions: OPIC oil-fired projects, 1990-2004		**Oil**		**30 yr life**	**30 yr life**
1990	no OPIC oil project					
1991	no OPIC oil project					
1992	Puerto Quetzal, Guatemala: 234 MW	234	0.29	1.08	8.80	32.27
1993	Batangas, Philippines: 105 MW	105	0.13	0.48	3.95	14.48
1994	Grenada Power, Grenada: 18 MW	18	0.02	0.08	0.68	2.48
1995	Tampo Centro, Guatemala: 78 MW	78	0.10	0.36	2.93	10.76
1996	Termovalle, Colombia: 199 MW	199	0.25	0.91	7.48	27.44
1996	Nejapa Power, El Salvador: 150 MW	150	0.19	0.69	5.64	20.69
1996	no name, no country: 36 MW	36	0.05	0.17	1.35	4.96
1997	EMA Power, Hungary: 35 MW	35	0.04	0.16	1.32	4.83
1997	no name, no country: 78 MW	78	0.10	0.36	2.93	10.76
1997	no name, no country: 102 MW	102	0.13	0.47	3.84	14.07
1997	EAL/ERI Cogen, Jamaica: 17 MW	17	0.02	0.08	0.64	2.34
1998	Subic Power, Philippines: 111 MW	111	0.14	0.51	4.17	15.31
1999	Tipitapa Power, Nicaragua: 51 MW	51	0.06	0.23	1.92	7.03
	New OPIC projects 1999-2004					
2002	Puerto Cabezas, Nicaragua: 4.5 MW	4.5	0.01	0.02	0.17	0.62
	Total OPIC oil-fired power plants 1990-2004	**1,219**	**1.53**	**5.6**	**45.8**	**168**
	Indirect emissions					
	CO2 from flared gas at oil production facilities		0.01	0.04	0.37	1.34
	CO2 emissions from oil refinery operations		0.06	0.22	1.83	6.72
	CO2 emissions from oil transportation		0.02	0.08	0.68	2.49
	Fugitive methane from oil production and delivery (CO2-eq)		0.05	0.17	1.88	6.89
	Total indirect carbon and methane emissions		**0.14**	**0.52**	**4.76**	**17.4**
	Total emissions from OPIC-financed oil-fired power plants		**1.67**	**6.13**	**50.58**	**185**

Overseas Private Investment Corporation

Year	Plant type	Total capacity by fuel type (MW)	Annual Carbon (MtC-eq/yr)	Annual Carbon Dioxide (MtCO2-eq/yr)	Cumulative over plant life (MtC-eq)	Cumulative over plant life (MtCO2-eq)
	Direct emissions: OPIC gas-fired projects, 1990-2004		**Gas**		**40 yr life**	**40 yr life**
1990	Hopewell, Philippines: 200 MW	200	0.17	0.64	7	26
1991	no OPIC gas project					
1992	Inter-American, Colombia: 100 MW	100	0.09	0.32	3	13
1993	Central Termica, Argentina: 325 MW	325	0.28	1.04	11	42
1994	Trakya Elektrik, Turkey: 480 MW	480	0.42	1.54	17	62
1994	Generacion de Vapor, Venezuela: 315 MW	315	0.28	1.01	11	40
1994	Dabhol Power, India: 2,184 MW	2,184	1.91	7.00	76	280
1995	Termobarranquilla, Colombia: 750 MW	750	0.66	2.40	26	96
1995	Doga Energi, Turkey: 180 MW	180	0.16	0.58	6	23
1996	Termocandelaria, Colombia: 316 MW	316	0.28	1.01	11	41
1996	P.T Energi, Indonesia: 135 MW	135	0.12	0.43	5	17
1996	Empresa Guaracachi, Bolivia: 180 MW	180	0.16	0.58	6	23
1996	Empresa Electrica, Bolivia: 181 MW	181	0.16	0.58	6	23
1996	Central Termica, Argentina: 110 MW	110	0.10	0.35	4	14
1996	Ave Fenix, Argentina: 168 MW	168	0.15	0.54	6	22
1996	Aguaytia Energy, Peru: 141 MW	141	0.12	0.45	5	18
1997	no name, no country: 35 MW	35	0.03	0.11	1	4
1998	TRI Energy, Thailand: 700 MW	700	0.61	2.24	24	90
1998	NEPC Consortium, Bangladesh: 120 MW	120	0.10	0.38	4	15
1999	Turboven Maraguay, Venezuela: 64 MW	64	0.06	0.21	2	8
1999	Turboven Cagua, Venezuela: 72 MW	72	0.06	0.23	3	9
1999	Empresa Produtora, Brazil: 480 MW	480	0.42	1.54	17	62
	New OPIC projects 1999-2004:					
1999	AES/Enron, Nigeria: 270 MW	270	0.24	0.87	9	35
1999	Gaza, Palestine: 136 MW	136	0.12	0.44	5	17
1999	Takoradi, Ghana: 300 MW	300	0.26	0.96	10	38
2000	AES Andres, Dominican Republic: 300 MW	300	0.26	0.96	10	38
2000	Adapazari, Turkey: 777 MW	777	0.68	2.49	27	100
2000	Gebze, Turkey: 1,550 MW	1,550	1.35	4.97	54	199
2000	Izmir, Turkey: 1,550 MW	1,550	1.35	4.97	54	199
2001	Araucaria, Brazil: 469 MW	469	0.41	1.50	16	60
2001	Rio, Brazil: 279 MW	279	0.24	0.89	10	36
	Total OPIC gas-fired power plants 1990-2004	**12,867**	**11.2**	**41.2**	**450**	**1,649**
	Indirect emissions					
	CO2 from flared gas at natural gas production facilities		0.13	0.49	5.40	19.79
	Venting of CO2 from natural gas operations		0.20	0.73	7.92	29.03
	CO2 emissions from natural gas processing and transportation		0.79	2.89	31.48	115.44
	Fugitive methane from natural gas production and delivery (CO2-eq)		1.30	4.78	52.18	191.35
	Total indirect carbon and methane emissions		**2.42**	**8.89**	**97**	**356**
	Total emissions from OPIC-financed gas-fired power plants		**13.7**	**50.1**	**547**	**2,005**

Export-Import Bank & Overseas Private Investment Corporation

Direct and indirect emissions	Total capacity megawatts (MW)	Annual Carbon (MtC-eq/yr)	Annual Carbon Dioxide (MtCO2-eq/yr)	Cumulative over plant life (MtC-eq)	Cumulative over plant life (MtCO2-eq)
Direct Ex-Im Bank emissions, all power plants	**54,035**	**77**	**281**	**3,898**	**14,295**
Indirect Ex-Im Bank emissions, all power plants		**8**	**31**	**376**	**1,379**
				-	
Direct OPIC emissions, all power plants	**19,194**	**24**	**88**	**1,176**	**4,314**
Indirect OPIC emissions, all power plants		**3**	**12**	**138**	**505**
Total Ex-Im Bank plus OPIC Emissions	**73,229**	**112**	**412**	**5,588**	**20,491**
Of which methane (C-eq and CO2-eq) =		5.6	20.4	273	1,001

Cell: D4
Comment: Rick Heede:

This report relies extensively on published and un-published work by both Ex-Im Bank (1999) and OPIC (2000), and also by Wysham, Sohn, & Vallette (1999). We have also used updated (and revised) unpublished spreadsheets by Jim Vallette, a 2000 report by Sustainable Energy and Economy Network (available at www.seen.org), the extensive project database posted at the seen.org website, and memoranda written by uncited Ex-Im and OPIC staff.

These publications have been essential in our efforts to identify financed projects as well as their fuel type, installed equipment, generating capacity, marginal oil and gas reserves related to financed projects, and anticipated peak or annual production rates. Neither Ex-Im nor OPIC publish details on their financed projects in their regular or annual reports. The emissions estimation protocols of both Export Credit Agencies and that of Wysham et al have been reviewed. These protocols have been not been adopted in the present work, however. The most significant differences between the previous and the current emissions accounting protocols are (a) our inclusion of several categories of indirect emissions, (b) our adoption of longer (and realistic) operating lives for power plants financed by Ex-Im or OPIC, and (c) inclusion of emissions flowing from Ex-Im/OPIC-financed oil and gas extraction projects (both ECAs disavow accounting for emissions from oil and gas fuels merely facilitated by their financial support). See the attached Declaration and the comments embedded in this spreadsheet for details.

We have made every effort to be as complete, judicious, and accurate as available data allow.

Richard Heede, Climate Mitigation Services, 1626 Gateway Road, Snowmass, Colorado 81654 USA 1-970-927-9511 heede@climatemitigation.com

-Rick-= 20Dec04

Cell: G9
Comment: Rick Heede:

This report uses far longer power plant operating lives than previous reports to project future or life-cycle carbon emissions. Real-world experience shows power plant durability exceeding fifty years; we use different estimapted operating lives for each type of plant (see below).

ExIm Bank (1999), p. 27: "Assuming that these plants, on average, have an operating life of 25 years." (also assumes 85 percent availability or capacity factor).

OPIC (2000), p. 18: "that each plant will operate for 25 years." (also assumes 85 percent availability or capacity factor).

Vallette et al (1999), p. 111: "For each power plant project financed by OPIC or Ex-Im, it is assumed that it will run for 20 years at full capacity from the time of financing."

This report's methodology differs substantially. First, we apply different availability factors for each type of plant (90 percent for coal, 85 percent for gas, and 80 percent for oil units). Second, each of the previous sources use extremely low -- 20 to 25 years -- estimates of operating lives. Here we use plant-specific estimates as follows: 60 years for coal facilities, 40 years for gas-fired plants, and 30 years for oil units.

Based on data from David Hawkins, Natural Resources Defense Council, personal communication, 9Dec04.

Cell: C13
Comment: Rick Heede:
Source of projects: Ex-Im Bank (1999) Ex-Im Bank's Role in Greenhouse Gas Emissions and Climate Change, revised, Appendix C.

Cell: E13
Comment: Rick Heede:
Estimates of emissions of carbon or carbon dioxide from coal-fired projects are based on an average availability factor (we use 90 percent for base-load coal facilities as opposed to Ex-Im's assumed 85 percent for all power plants, regardless of type), carbon content of fuel (though not adjusted for coal type, which is unknown), and an industry-average heat rate (though this will, in reality, differ from project to project).

Heat rates are assumed to average 10,348 Btu/kWh (10.92 MJ/kWh, 33 percent efficiency), and 94.6 kgCO2/GJ, or 25.8 kgC/GJ.

A "typical" coal-fired power plant thus emits 25.8 kgC/GJ * 10.92 MJ/kWh * 8,760 hrs/yr = 2,468 tonnes carbon per MW-yr = 2,468 tC/MW-yr. For coal-fired power plants we use an availability factor of 90 percent (7,884 hrs/yr): 2,468 tC/MW-yr * 0.90 = 2,221 tC/MW-yr. Availability factor is applied separately in the formula to facilitate adjustment of this factor.

Source: OPIC, 2000, pp. 14 (same factors as used in Ex-Im Bank, 1999).

Cell: C26
Comment: Rick Heede:
Sources: SEEN database at www.seen.org, Jim Vallette's updated Ex-Im Bank and OPIC project spreadsheets, and especially his Master spreadsheet on all ECA energy-related projects (updated to Jul04).

Cell: C27
Comment: Rick Heede:
Vallette Master List: 648 MW coal-fired, Ex-Im financing of $20; Vallette does estimate CO2 emissions, but the project is included here, and its emissions estimated.

Cell: C30
Comment: Rick Heede:
The aim of this report is to account for both direct and indirect emissions of greenhouse gases that result from the projects financed by Ex-Im Bank and OPIC, regardless of the ECAs level of financial involvement. Direct emissions are typically defined as arising from facilities owned or controlled by the entity in question. Thus emissions from fuels combusted at Ex-Im and OPIC-financed power plants are considered direct emissions by both ECAs, the Wysham et al reports by the Sustainable Energy and Economy Network, and this report. In the power sector we also included indirect emissions from their fuel combustion, e.g., fugitive methane from coal mines and oil and gas operations, emissions related to the transportation of fuels to the power plants, and other emissions related to the fuel provisioning.

In this and the following sections on indirect emissions from coal, oil, and gas-fired p[oewr plant we use U.S. and global data on emissions associated with providing fuels to power plants. These indirect emissions include fugitive methane from coal mines that provide fuel to coal-fired power plants, emissions of carbon dioxide related to CO2 venting at gas production facilities that produce fuel for gas-fired power plants, and emissions associated with refining crude oil into residual and distillate fuels to oil-fired power plants. (Note: other indirect emissions accounted for are detailed in each indirect emissions section by power plant type and agency below.)

Neither Ex-Im nor OPIC estimate indirect emissions for power plants and their fuel cycle in their respective 1999 and 2000 reports.

Cell: C31
Comment: Rick Heede:
This report excludes emissions from energy inputs at coal mines as probably "not material" -- that is, probably less than one percent than the carbon in the fuel provided to customers. Underground mines require substantially higher energy input, thus reducing the net energy provided and higher mining emissions from diesel-fueled machinery and purchased (or on-site generation of) electric power. Further research may yield higher emissions rates than assumed as non-material in this report.

Cell: C32
Comment: Rick Heede:
U.S. average energy intensity of freight rail transport is 346 Btu/ton-mile. In 2001, U.S. transported 7.3 million carloads of coal, nearly all to power plants. Average haul distance is ~859 miles (all cargoes). Also, 206 million tons of coal was shipped (coastwise and by rivers and lakes) an average of 400 miles (Table 9.6). Waterborne commerce energy intensity = 444 Btu/ton-mile (Table 9.5).

EIA (2004) AER 2002, p. 199: 1,066 million tons consumed, of which 976 million tons (885 million tonnes) was consumed by electric utilities.

Davis, Stacy (2004) Transportation Energy Data Book, 23, Oak Ridge National Laboratory. www-cta.ornl.gov/data/Index.html

Table 9.9: Summary Statistics for Class I Freight Railroads. See also Tables 2.15 and 2.15.

Thus we estimate energy and carbon emissions per ton of coal shipped to power plants as follows (preliminary):

Water: 206 million tons (187 million tonnes) 400 miles by water at 444 Btu/ton-mile = 36.6 trillion Btu, which (residual fuel at 21.49 million metric tonnes carbon per quadrillion Btu) = 0.79 million metric tonnes carbon emitted (or 0.0042 tonnes carbon emitted per tonne shipped).

Rail (freight class 1): 976 million tons consumed by utilities less 206 million tons shipped by water less, say, 50 million tons consumed by mine-mouth poewr plants (WAG), leaves 700 million tons (635 million tonnes) shipped by rail an average of 859 miles at 359 Btu/ton-mile = 216 trillion Btu, which (diesel fuel at 19.95 million metric tonnes carbon per quadrillion Btu) = 4.31 million metric tonnes carbon emitted (or 0.0068 tonnes carbon emitted per tonne shipped).

Thus, on average: 0.79 + 4.31 = 5.1 million tonnes carbon to transport 885 million tons to electric utilities (including a fraction of zero transport to mine-mouth electric poweer stations). Since coal averages 70+ percent carbon, 5.1 million tonnes / (0.70 * 885 million tonnes) = 0.82 percent. That is: coal transportation adds 8.2 kgC per tonne of carbon burned in the coal-fired power plant, on average.

Cell: C33
Comment: Rick Heede:
Significant quantities of methane are released from coal mines. Stern & Kaufman / CDIAC (the latest data available) estimate total coal-related methane emissions in 1994 at 46.32 million tonnes of CH_4. Emission rates vary by coal type and mining operation (surface mines

release more methane; many sub-surface mines capture and flare methane for safety reasons).

As a simple approximation of the global average methane emission rate, we calculate kg of methane released per tonne of coal mined. 1994 methane / 1994 world production: 46.32 million tonnes CH4 / 4,559 million tonnes coal = 0.0102 tonnes CH4 per tonne coal extracted, or 10.2 kg CH2 per tonne coal.

Since coal is typically ~70 percent carbon, we calculate the carbon basis as 0.0071 tonnes CH4 per tonne coal extracted, or 7.1 kg CH4 per tonne of carbon combusted from coal.

To convert this estimated fugitive methane emission rate into carbon equivalent, we use IPCC's GWP of CH4 = 23 x CO2, translating to 1 unit of methane = 6.272 x Carbon-equivalent.*

The formula becomes: per tonne of carbon emitted by coal-fired power plants x 0.0071 x 6.272.

* To convert fugitive methane emissions to carbon-equivalent emissions: multiply methane emissions by 23 (the methane global warming potential factor [GWP] CH4:CO2) and divide by 3.667 (CO2:carbon), 23/3.667, or a factor of 6.272.

Note: the global warming potential of methane has been revised from 21 x CO2 to 23 x CO2 by the IPPC. Source: Houghton, J. T. et al (2001) Climate Change 2001: The Scientific Basis, Working Group One, Third Assessment, IPPC, Cambridge University Press, p. 388.

See also From David Stern and Robert Kaufmann, Methane Emissions 1860 to 1994, at CDIAC website: http://cdiac.esd.ornl.gov/trends/meth/methane.htm

Cell: G42
Comment: Rick Heede:
This report uses far longer power plant operating lives than previous reports to project future or life-cycle carbon emissions. Real-world experience shows power plant durability exceeding fifty years; we use different estimated operating lives for each type of plant (see below).

ExIm Bank (1999), p. 27: "Assuming that these plants, on average, have an operating life of 25 years." (also assumes 85 percent availability or capacity factor).

OPIC (2000), p. 18: "that each plant will operate for 25 years." (also assumes 85 percent availability or capacity factor).

Vallette et al (1999), p. 111: "For each power plant project financed by OPIC or Ex-Im, it is assumed that it will run for 20 years at full capacity from the time of financing."

This report's methodology differs substantially. First, we apply different availability factors for each type of plant (90 percent for coal, 85 percent for gas, and 80 percent for oil units). Second, each of the previous sources use extremely low -- 20 to 25 years -- estimates of operating lives. Here we use plant-specific estimates as follows: 60 years for coal facilities, 40 years for gas-fired plants, and 30 years for oil units.

Based on data from David Hawkins, Natural Resources Defense Council, personal communication, 9Dec04.

Cell: C46
Comment: Rick Heede:

Source of projects: Ex-Im Bank (1999) Ex-Im Bank's Role in Greenhouse Gas Emissions and Climate Change, revised, Appendix C.

Cell: E46
Comment: Rick Heede:
Estimated emissions of carbon dioxide from oil-fired projects are based on an average availability factor (we use 80 percent for oil facilities as opposed to Ex-Im's assumed 85 percent for all power plants regardless of type), carbon content of fuel (which we "blend" for diesel and residual-fired units below), and an industry-average heat rate (though this will, in reality, differ from project to project).

Of 1,214 MW total, 796 MW (65.6%) is diesel (with an emissions factor of 74.05 kgCO2/GJ (= 20.2 kgC/GJ).
The remainder 418 MW (34.4%) is residual fuel (with an emissions factor of 77.35 kgCO2/GJ (= 21.1 kgC/GJ).

Heat rates vary by plant type; most are engine-driven: heat rate of 7588 Btu/kWh (= 8.01 MJ/kWh, 45% efficiency), a couple are simple-cycle at 9757 Btu/kWh (= 10.29 MJ/kWh, 35% efficiency (3412 Btu/kWh out/9757 Btu/kWh in = 0.35)), and one steam boiler at 10,348 Btu/kWh (= 10.92 MJ/kWh, 33% efficiency).

Given the mixture of plant types, fuels, and efficiencies -- and therefore the carbon emissions per hour of operation -- we use a factor of 20.8 kgC/GJ times ~8.6 MJ/kWh (41.9% efficiency).

Our assumed "typical" oil-fired plant thus emits 20.8 kgC/GJ * 8.6 MJ/kWh * 8,760 hrs/yr = 1,567 tonnes carbon per MW-yr = 1,567 tC/MW-yr. For oil-fired power plants we use an availability factor of 80 percent (7,008 hrs/yr): 1,567 tC/MW-yr * 0.80 = 1,254 tC/MW-yr. Availability factor is applied separately in the formula to facilitate adjustment of this factor.

Cell: C59
Comment: Rick Heede:
Sources: SEEN database at www.seen.org, Jim Vallette's updated Ex-Im Bank and OPIC project spreadsheets, and especially his Master spreadsheet on all ECA energy-related projects (updated to Jul04).

Cell: C60
Comment: Rick Heede:
Vallette master list: Cataguazes (Usina), Brazil, 82 MW oil-fired power plant, Ex-Im $35.7 million in 2001, part of Marlin Sul oil field development, and emissions from power plant are excluded here to eliminate double counting emissions.

Cell: C61
Comment: Rick Heede:
Vallette Master list. Carimex diesel generators, 2002, Ex-Im funding of $15.7 million; gen size unknown, thus "insufficient data."

Cell: C64
Comment: Rick Heede:
The aim of this report is to account for both direct and indirect emissions of greenhouse gases that result from the projects financed by Ex-Im Bank and OPIC, regardless of the ECAs level of financial involvement. Direct emissions are typically defined as arising from facilities owned or controlled by the entity in question. Thus emissions from fuels combusted at Ex-Im and OPIC-financed power plants are considered direct emissions by both ECAs, the Wysham et al reports by the Sustainable Energy and Economy Network, and this report. In the power sector we also included indirect emissions from their fuel combustion, e.g.,

fugitive methane from coal mines and oil and gas operations, emissions related to the transportation of fuels to the power plants, and other emissions related to the fuel provisioning.

In this and the following sections on indirect emissions from coal, oil, and gas-fired p[oewr plant we use U.S. and global data on emissions associated with providing fuels to power plants. These indirect emissions include fugitive methane from coal mines that provide fuel to coal-fired power plants, emissions of carbon dioxide related to CO2 venting at gas production facilities that produce fuel for gas-fired power plants, and emissions associated with refining crude oil into residual and distillate fuels to oil-fired power plants. (Note: other indirect emissions accounted for are detailed in each indirect emissions section by power plant type and agency below.)

Neither Ex-Im nor OPIC estimate indirect emissions for power plants and their fuel cycle in their respective 1999 and 2000 reports.

Cell: C65
Comment: Rick Heede:
See the "CO2 from flared gas at natural gas production facilities" below for details.

Significant quantities of gas is flared at oil production, processing, storage, and delivery facilities. This in an indirect emission of carbon dioxide attributed to Ex-Im and OPIC-financed oil-fired power plants. We allocate 60 percent of this flaring rate to gas and 40 percent to oil production, processing, storage, and delivery. Gas flaring attributable to oil thus becomes 2 percent x 0.4 = 0.8 percent.

The formula is thus: current and future (over the 40-year operating life) emission from gas consumed at Ex-Im bank/OPIC gas-fired power plants x 0.008.

Cell: C66
Comment: Rick Heede:
We estimate the amount of energy used in oil refineries to process and refine its petroleum products deliverd to Ex-Im Bank and OPIC-financed oil-fired power plants as follows:

Method 1: one preliminary estimate is that five (5) percent of the refinery output is consumed in the refining process, not including purchased gas and electricity (which is sometimes purchased from utilities and at other facilities is generated on site using, for example, distillate-driven gen-sets).

Source: Kevin Lindemer, Irving Oil, New Brunswick, personal communication, 20Jun03.

Method 2: EIA data for fuel consumed at US refineries in 2002 (exclusive of gas and electricity, which is included under those columns):

LPG	(at 4.30 million Btu per bbl) x	3.44 million bbl =	14.79 x 10^12 Btu;
Distillates	(at 5.83 million Btu per bbl) x	0.84 million bbl =	4.89 x 10^12 Btu;
Residuals	(at 6.29 million Btu per bbl) x	4.81 million bbl =	30.27 x 10^12 Btu;
Petroleum coke	(at 6.02 million Btu per bbl) x	88.24 million bbl =	531.55 x 10^12 Btu;
Coal	(at 20.9 million Btu per ton) x	31 thousand tons =	0.68 x 10^12 Btu;
Other products	(at 5.80 million Btu per bbl) x	5.21 million bbl =	30.22 x 10^12 Btu;
Purchased steam	(at 970 Btu per lb) x	59.15 million lbs =	57.38 x 10^12 Btu;
Total			669.8 x 10^12 Btu;

Petroleum equivalent (at 5.8 million Btu per bbl): 669.8 x 10^12 Btu/5.8 million Btu per bbl = 115.5 million bbl;

divided by US refinery output of 6,305 million bbl in 2002: 115.5 million bbl/6,305 million bbl = 0.0183, or 1.83 percent.

Source: Energy Information Administration (2003) Petroleum Supply Annual, Volume One, Table 47, p. 115.

Result: Inasmuch as (a) the bulk of refinery energy use in the EIA data is carbon-intensive steam and petroleum coke, (b) the oft-cited figure of 5 percent of refinery throughput in consumed, and (c) less efficient foreign refineries (under less economic and regulatory pressure to improve operational efficiency), we add 4.0 precent of total oil products marketed to oil-fired power plants per year as internal energy used in and carbon emissions from refinery operations.

The formula is thus: carbon emissions from fuel oil and diesel fuel consumed at Ex-Im and OPIC-financed oil-fired power plants x 0.04.

Cell: C67
Comment: Rick Heede:
We use Argonne National Laboratory's GREET model as guidance to making an estimate on other fuel cycle energy inputs to transportation of crude, natural gas, and petroleum products from "wells to wheels."

Crude oil shipping by tankers (VLCCs): GREET assumptions: 5,080 miles average distance, 19 mph average speed, 4,763 Btu per horsepower-hour (typical tanker shaftpower = 124,500 HP); result: 6,089 Btu energy input to move one million Btu of crude oil, or 0.61 percent. Of course, not all oil company crude to refineries arrive by ocean-going tankers, so we dilute this adder by 0.57 (US averages 57 percent imported crude + products), thus the formula is 0.61% x 0.57 = 0.348 percent of total products marketed.
Note: we believe the GREET estimates include energy required to back-haul a tanker, but this is uncertain; if not, GREET data suggest that backhauling a VLCC requires 20 Btu per ton-mile (vs 22 Btu/ton-mile for the front-haul). See GREET.xls, worksheet on Transportation and Distribution, section #9.

Pipelines: GREET assumptions: distance pipelined (750 miles for crude, 400 miles for products from refineries to tank farms), 270 Btu per ton-mile; results: 3,815 million Btu of petroleum input to pipeline transport of one million Btu of crude oil (1,998 Btu per million Btu of gasoline pipelined). Note: this excludes other energy inputs, such as gas or electricity used in pipelines, which brings the pipeline energy input to 6,129 Btu per million Btu of crude thus transported.) Dilution: assume that 43 percent of crude is shipped to refineries by pipeline (thus 0.43 x 3,815 = 1,640 Btu per million Btu of total crude shipped), plus assume that all products are pipelined from refineries to tank farms (at 1,998 Btu per million Btu of refined products); total 1,640 + 1,998 = 3,638 Btu per million Btu, total energy input to pipeline of crude and products, or 0.364 percent.

Conclusion: oil inputs to transportation of 0.763% (for domestic waterborne shipping) + 0.348% (for crude oil and products transport by ocean-going tankers) + 0.364% (for pipeline of crude and products) = 1.475 percent. Detailed analysis will probably find this result to be conservative.

The formula is thus: carbon emissions from oil consumed in Ex-Im and OPIC-financed oil-fired power plants x 0.0148.

Note: Not included in this or any other indirect emissions estimate of OPIC and Ex-Im projects is the considerable energy and emissions embodied in the construction of the power plants and the infrastructure to extract, refince, and deliver fuel; nor is the energy invested in building electric transmission grids included.

Sources: Stacy Davis (2001) Transportation Energy Data Book, edition 21, U.S. Dept of Energy, Center for Transportation Analysis, Oak Ridge National Laboratory, Oak Ridge, TN. Tables 12-4, 12-5, and 1-11., and personal communication.

Michael Q. Wang, Argonne National Laboratory, GREET model, www.transportation.anl.gov/greet/index.html, and personal communication 18Jul03.

Cell: C68
Comment: Rick Heede:
Vallette Master: "650 MW gas and oil power plants." Part of Paraguana, presumably an oil and gas development. ExIm funding: $29.4 million.

Cell: D75
Comment: Rick Heede:
Vallette master, Ex-Im Bank 2001 $5.1 million financing, 2.0 million tonnes CO2.

Cell: C76
Comment: Rick Heede:

Cell: G76
Comment: Rick Heede:
This report uses far longer power plant operating lives than previous reports to project future or life-cycle carbon emissions. Real-world experience shows power plant durability exceeding fifty years; we use different estimated operating lives for each type of plant (see below).

ExIm Bank (1999), p. 27: "Assuming that these plants, on average, have an operating life of 25 years." (also assumes 85 percent availability or capacity factor).

OPIC (2000), p. 18: "that each plant will operate for 25 years." (also assumes 85 percent availability or capacity factor).

Vallette et al (1999), p. 111: "For each power plant project financed by OPIC or Ex-Im, it is assumed that it will run for 20 years at full capacity from the time of financing."

This report's methodology differs substantially. First, we apply different availability factors for each type of plant (90 percent for coal, 85 percent for gas, and 80 percent for oil units). Second, each of the previous sources use extremely low -- 20 to 25 years -- estimates of operating lives. Here we use plant-specific estimates as follows: 60 years for coal facilities, 40 years for gas-fired plants, and 30 years for oil units.

Based on data from David Hawkins, Natural Resources Defense Council, personal communication, 9Dec04.

Cell: C80
Comment: Rick Heede:
Source of projects: Ex-Im Bank (1999) Ex-Im Bank's Role in Greenhouse Gas Emissions and Climate Change, revised, Appendix C.

Cell: E80
Comment: Rick Heede:
Estimated emissions of carbon dioxide from gas-fired projects are based on an average availability factor (we use 85 percent for gas facilities (Ex-Im's assumed 85 percent for all power plants regardless of type)), carbon content of fuel, and an industry-average heat rate

(though this will, in reality, differ from project to project).

Heat rates are assumed to average 7,266 Btu/kWh (7.67 MJ/kWh, 47 percent efficiency), and 56.1 kgCO2/GJ, or 15.3 kgC/GJ.

A "typical" gas-fired power plant thus emits 15.3 kgC/GJ * 7.67 MJ/kWh * 8,760 hrs/yr = 1,028 tonnes carbon per MW-yr = 1,028 tC/MW-yr. For gas-fired power plants we use an availability factor of 85 percent (7,446 hrs/yr): 1,028 tC/MW-yr * 0.85 = 874 tC/MW-yr. Availability factor is applied separately in the formula to facilitate adjustment of this factor.

Source: OPIC, 2000, pp. 14 (same factors as used in Ex-Im Bank, 1999).

Cell: C86
Comment: Rick Heede:
Ex-Im Bank (1999), Appendix C, notes uncertainty: "Involves conversion to combined cycle. Combustion/steam breakdown not given. 1600 MW Form GT, 800 MW Form ST." Ex-Im ignored this project in its emissions estimate. Here we assume gas-fired combined cycle (47 percent efficiency) and average the size uncertainty to 1200 MW.

Note: ExIm lists Khanom as Hong Kong; Vallette lists as Thailand (probably correct).

Cell: C87
Comment: Rick Heede:
Dabhol is gas & oil combined cycle plant; we use the gas carbon content and heat rate in the estimate.

Cell: C93
Comment: Rick Heede:
Sources: SEEN database at www.seen.org, Jim Vallette's updated Ex-Im Bank and OPIC project spreadsheets, and especially his Master spreadsheet on all ECA energy-related projects (updated to Jul04).

Cell: C95
Comment: Rick Heede:
Vallette Master List: 188 MW gas-fired power plant. Since Ex-Im listed 100 MW, we here add the 88 MW difference. Delete if Ex-Im datum is shown correct.

Cell: C99
Comment: Rick Heede:
Vallette Master list: Bursa (Zorlu), Turkey, 122 MW gas-fired power plant, Ex-Im $14 million in 1997. with additional Ex-Im funding of $25.8 million in 1998, plus $2.7 million in 2000, plus $31 million in 2001. Since this plant is already listed in Ex-Im 1997 list, but at 26 MW, we add 96 MW of gas-fired emissions here.

Cell: C110
Comment: Rick Heede:
Vallette Master List: 170 MW gas-fired power project. Uses gas from Marlim Sul oil and gas fields (accounted for in Oil and Gas Extraction projects). Ex-Im funding: $97.4 million.

Cell: C111
Comment: Rick Heede:
Vallette Master List: Bolivia/Brazil pipeline. Ex-Im funding: $27.6 million.

Cell: C117
Comment: Rick Heede:
Vallette Master: 180 MW, no fuel type listed. Included here; assumed as CC gas. ExIm

funding: $52.1 million.

Cell: C118
Comment: Rick Heede:
Vallette Master: Turkey 2003 "Kamalpasha power plant." No size or fuel or plant type listed. Not included here. ExIm funding: $10 million.

Cell: C125
Comment: Rick Heede:
The aim of this report is to account for both direct and indirect emissions of greenhouse gases that result from the projects financed by Ex-Im Bank and OPIC, regardless of the ECAs level of financial involvement. Direct emissions are typically defined as arising from facilities owned or controlled by the entity in question. Thus emissions from fuels combusted at Ex-Im and OPIC-financed power plants are considered direct emissions by both ECAs, the Wysham et al reports by the Sustainable Energy and Economy Network, and this report. In the power sector we also included indirect emissions from their fuel combustion, e.g., fugitive methane from coal mines and oil and gas operations, emissions related to the transportation of fuels to the power plants, and other emissions related to the fuel provisioning.

In this and the following sections on indirect emissions from coal, oil, and gas-fired p[oewr plant we use U.S. and global data on emissions associated with providing fuels to power plants. These indirect emissions include fugitive methane from coal mines that provide fuel to coal-fired power plants, emissions of carbon dioxide related to CO2 venting at gas production facilities that produce fuel for gas-fired power plants, and emissions associated with refining crude oil into residual and distillate fuels to oil-fired power plants. (Note: other indirect emissions accounted for are detailed in each indirect emissions section by power plant type and agency below.)

Neither Ex-Im nor OPIC estimate indirect emissions for power plants and their fuel cycle in their respective 1999 and 2000 reports.

Cell: C126
Comment: Rick Heede:
While global gas flaring is decreasing, it still represents 2.5 percent of carbon emissions from global natural gas consumption, down from 4.3 percent in 1990. The flaring percentage is likely to decrease further, and we use 2.0 percent of gas consumption to project future flaring emissions. This in an indirect emission of carbon dioxide attributed to Ex-Im and OPIC-financed gas-fired power plants. We allocate 60 percent of this flaring rate to gas and 40 percent to oil production, processing, storage, and delivery. Gas flaring thus becomes 2 percent x 0.6 = 1.2 percent.

The formula is thus: current and future (over the 40-year operating life) emission from gas consumed at Ex-Im bank/OPIC gas-fired power plants x 0.012.

Data from Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy. cdiac.esd.ornl.gov/

Cell: C127
Comment: Rick Heede:
Carbon dioxide is vented from both oil and gas production platforms and from gas processing facilities to reduce CO2 content and to meet pipeline gas specifications. Venting rates vary greatly from facility to facility, every gas reservoir contains differing amounts of carbon dioxide and other gases, and the fraction of removed CO2 also varies.

Benchmark 1: the US CO2 venting rate from natural gas operations (4.9 million metric

tonnes carbon of CO2 removal from US natural gas production divided by total US gas consumption of 315 million tonnes carbon, or 1.53 percent, 1999 data).
Source: Energy Information Administration (2001) Emissions of Greenhouse Gases in the United States, 2000, US DOE, Washington, p. 28.

Benchmark 2: reducing CO2 content of sour gas from 3.0 mole percent CO2 to 2.0 mole percent CO2 results in the venting of 147.8 tonnes carbon per billion standard cubic feet processed. This alone is equivalent to a venting rate of 1.0 percent.
Source: American Petroleum Institute (2001) Compendium Of Greenhouse Gas Emissions Estimation Methodologies For The Oil And Gas Industry, p. 4-32.

Benchmark 3: The BuMines data shows "Vented and Wasted Gas" from 1936 to 1970 (ranging from a high of 26.5 percent of marketed gas production in 1944 to a low of 2.23 percent in 1970), but the table's footnotes do not elucidate what is being counted. We suspect the data is predominantly vented (that is, unflared) natural gas and flared natural gas, and probably does not include vented CO2.
Source: Bureau of Mines (year unknown) Minerals Yearbook, Historical tables, M147-161, US Dept Interior.

Benchmark 4: "Non-hydrocarbon gas removed from natural gas" (NHGR, which is predominantly carbon dioxide but also significant quantities of nitrogen, hydrogen sulfides, and helium; no data for each gas) is shown for 1980-2002. In 1980, the NHGR rate was 0.99 percent; in 1990 = 1.56 percent, and 2000 = 2.50 percent.
Source: Energy Information Administration (2003) Natural Gas Annual, 2002, US DOE, Washington, Table 3 plus historical data;
www.eia.doe.gov/oil_gas/natural_gas/data_publications/natural_gas_annual/nga.html.

Conclusion: Consideration of all of these benchmarks leads us to increase the the EIA's venting rate from 1.53 percent by 15 percent. 1.53 percent x 1.15 = 1.76 percent.

The formula is: =('Natural Gas'!columnGcell#)*0.0176

Cell: C128
Comment: Rick Heede:
Large amounts of natural gs is used in internal operations, on gas platforms and gas production facilities to generate power, fuel compressors, produce heat, and operate refineries and pipelines.

In a previous report on internal consumption of natural gas for gas production (raise steam, generate electricity, run compressors, etc), operate natural gas pipelines, and gas used in gas processing facilities, this author estimated that 11.48 percent of natural gas produced was used in internal operations (exclusive of gas used for re-pressuring oil and gas fields). Heede (2003) ExxonMobil Emissions Inventory 1882-2002, Methods & Results, and spreadsheets on Natural Gas, and Company Energy Use.

Since some of this gas is used in oil refineries and not strictly an indirect energy use for production, processing, and delivery of natural gas to the gas-fired power plants supported by Ex-Im Bank and OPIC funding, and in consideration of the size and location of such power plants to gas production and processing regions, we reduce this 11.48 percent factor to 7.0 percent. While this is likely a conservatism in the real world, we cannot verify this without a detailed analysis, which is beyond the scope of the present project.

Cell: C129
Comment: Rick Heede:
Significant quantities of methane are released from gas production, processing, and delivery operations. Stern & Kaufman / CDIAC (the latest data available) estimate total gas-related

methane emissions in 1994 at 15.2 million tonnes of CH4 from gas flaring and an additional 18.0 million tonnes of CH4 from oil and gas production, processing, storage, and delivery. We attribute three-quarters of flaring and one-half of oil and gas supply to gas operations. Thus 15.2 x 0.75 + 18.0 x 0.5 = 11.4 + 9.0 = 20.4 million tonnes of fugitive methane. The remainder is attributed to oil operations.

As a simple approximation of the global average methane emission rate, we calculate kg of methane released per tonne of gas produced. 1994 methane / 1994 world gas production: 76.93 trillion cubic feet (= 79.0 quads; at 14.47 million tonnes carbon per Q gas = gas consumption emissions of 1,100 million tonnes of carbon). Thus gas-related methane emissions of 20.4 million tonnes divided by 1,100 million tonnes carbon from gas consumption = 0.0185 tonne (18.5 kg) methane per tonne of carbon from gas combustion, or 0.0185 percent (in CH4 to carbon units).

To convert this estimated fugitive methane emission rate into carbon equivalent, we use IPCC's GWP of CH4 = 23 x CO2, translating to 1 unit of methane = 6.272 x Carbon-equivalent.*

The formula becomes: per tonne of carbon emitted by coal-fired power plants x 0.0185 x 6.272 = tonnes of methane in carbon-equivalent.

* To convert fugitive methane emissions to carbon-equivalent emissions: multiply methane emissions by 23 (the methane global warming potential factor [GWP] CH4:CO2) and divide by 3.667 (CO2:carbon), 23/3.667, or a factor of 6.272.

Note: the global warming potential of methane has been revised from 21 x CO2 to 23 x CO2 by the IPPC. Source: Houghton, J. T. et al (2001) Climate Change 2001: The Scientific Basis, Working Group One, Third Assessment, IPPC, Cambridge University Press, p. 388.

See also From David Stern and Robert Kaufmann, Methane Emissions 1860 to 1994, at CDIAC website: http://cdiac.esd.ornl.gov/trends/meth/methane.htm

Cell: G137
Comment: Rick Heede:
This report uses far longer power plant operating lives than previous reports to project future or life-cycle carbon emissions. Real-world experience shows power plant durability exceeding fifty years; we use different estimated operating lives for each type of plant (see below).

ExIm Bank (1999), p. 27: "Assuming that these plants, on average, have an operating life of 25 years." (also assumes 85 percent availability or capacity factor).

OPIC (2000), p. 18: "that each plant will operate for 25 years." (also assumes 85 percent availability or capacity factor).

Vallette et al (1999), p. 111: "For each power plant project financed by OPIC or Ex-Im, it is assumed that it will run for 20 years at full capacity from the time of financing."

This report's methodology differs substantially. First, we apply different availability factors for each type of plant (90 percent for coal, 85 percent for gas, and 80 percent for oil units). Second, each of the previous sources use extremely low -- 20 to 25 years -- estimates of operating lives. Here we use plant-specific estimates as follows: 60 years for coal facilities, 40 years for gas-fired plants, and 30 years for oil units.

Based on data from David Hawkins, Natural Resources Defense Council, personal communication, 9Dec04.

Cell: E141
Comment: Rick Heede:
Estimated emissions of carbon dioxide from coal-fired projects are based on an average availability factor (we use 90 percent for base-load coal facilities as opposed to Ex-Im's assumed 85 percent for all power plants regardless of type), carbon content of fuel (though not adjusted for coal type, which is unknown), and an industry-average heat rate (though this will, in reality, differ from project to project).

Heat rates are assumed to average 10,348 Btu/kWh (10.92 MJ/kWh, 33 percent efficiency), and 94.6 kgCO2/GJ, or 25.8 kgC/GJ.

A "typical" coal-fired power plant thus emits 25.8 kgC/GJ * 10.92 MJ/kWh * 8,760 hrs/yr = 2,468 tonnes carbon per MW-yr = 2,468 tC/MW-yr. For coal-fired power plants we use an availability factor of 90 percent (7,884 hrs/yr): 2,468 tC/MW-yr * 0.90 = 2,221 tC/MW-yr. Availability factor is applied separately in the formula to facilitate adjustment of this factor.

Source: OPIC, 2000, pp. 14 (same factors as used in Ex-Im Bank, 1999).

Cell: C152
Comment: Rick Heede:
Sources: SEEN database at www.seen.org, Jim Vallette's updated Ex-Im Bank and OPIC project spreadsheets, and especially his Master spreadsheet on all ECA energy-related projects (updated to Jul04).

Cell: C153
Comment: Rick Heede:
"Bo Nok 734MW coal-fired power plant". Vallette's master list. Not listed in OPIC, 2000.

Cell: C157
Comment: Rick Heede:
The aim of this report is to account for both direct and indirect emissions of greenhouse gases that result from the projects financed by Ex-Im Bank and OPIC, regardless of the ECAs level of financial involvement. Direct emissions are typically defined as arising from facilities owned or controlled by the entity in question. Thus emissions from fuels combusted at Ex-Im and OPIC-financed power plants are considered direct emissions by both ECAs, the Wysham et al reports by the Sustainable Energy and Economy Network, and this report. In the power sector we also included indirect emissions from their fuel combustion, e.g., fugitive methane from coal mines and oil and gas operations, emissions related to the transportation of fuels to the power plants, and other emissions related to the fuel provisioning.

In this and the following sections on indirect emissions from coal, oil, and gas-fired p[oewr plant we use U.S. and global data on emissions associated with providing fuels to power plants. These indirect emissions include fugitive methane from coal mines that provide fuel to coal-fired power plants, emissions of carbon dioxide related to CO2 venting at gas production facilities that produce fuel for gas-fired power plants, and emissions associated with refining crude oil into residual and distillate fuels to oil-fired power plants. (Note: other indirect emissions accounted for are detailed in each indirect emissions section by power plant type and agency below.)

Neither Ex-Im nor OPIC estimate indirect emissions for power plants and their fuel cycle in their respective 1999 and 2000 reports.

Cell: C158
Comment: Rick Heede:
This report excludes emissions from energy inputs at coal mines as probably "not material" -

- that is, probably less than one percent than the carbon in the fuel provided to customers. Underground mines require substantially higher energy input, thus reducing the net energy provided and higher mining emissions from diesel-fueled machinery and purchased (or on-site generation of) electric power. Further research may yield higher emissions rates than assumed as non-material in this report.

Cell: C159
Comment: Rick Heede:
U.S. average energy intensity of freight rail transport is 346 Btu/ton-mile. In 2001, U.S. transported 7.3 million carloads of coal, nearly all to power plants. Average haul distance is ~859 miles (all cargoes). Also, 206 million tons of coal was shipped (coastwise and by rivers and lakes) an average of 400 miles (Table 9.6). Waterborne commerce energy intensity = 444 Btu/ton-mile (Table 9.5).

EIA (2004) AER 2002, p. 199: 1,066 million tons consumed, of which 976 million tons (885 million tonnes) was consumed by electric utilities.

Davis, Stacy (2004) Transportation Energy Data Book, 23, Oak Ridge National Laboratory. www-cta.ornl.gov/data/Index.html

Table 9.9: Summary Statistics for Class I Freight Railroads. See also Tables 2.15 and 2.15.

Thus we estimate energy and carbon emissions per ton of coal shipped to power plants as follows (preliminary):

Water: 206 million tons (187 million tonnes) 400 miles by water at 444 Btu/ton-mile = 36.6 trillion Btu, which (residual fuel at 21.49 million metric tonnes carbon per quadrillion Btu) = 0.79 million metric tonnes carbon emitted (or 0.0042 tonnes carbon emitted per tonne shipped).

Rail (freight class 1): 976 million tons consumed by utilities less 206 million tons shipped by water less, say, 50 million tons consumed by mine-mouth poewr plants (WAG), leaves 700 million tons (635 million tonnes) shipped by rail an average of 859 miles at 359 Btu/ton-mile = 216 trillion Btu, which (diesel fuel at 19.95 million metric tonnes carbon per quadrillion Btu) = 4.31 million metric tonnes carbon emitted (or 0.0068 tonnes carbon emitted per tonne shipped).

Thus, on average: 0.79 + 4.31 = 5.1 million tonnes carbon to transport 885 million tons to electric utilities (including a fraction of zero transport to mine-mouth electric poweer stations). Since coal averages 70+ percent carbon, 5.1 million tonnes / (0.70 * 885 million tonnes) = 0.82 percent. That is: coal transportation adds 8.2 kgC per tonne of carbon burned in the coal-fired power plant, on average.

Cell: C160
Comment: Rick Heede:
Significant quantities of methane are released from coal mines. Stern & Kaufman / CDIAC (the latest data available) estimate total coal-related methane emissions in 1994 at 46.32 million tonnes of CH_4. Emission rates vary by coal type and mining operation (surface mines release more methane; many sub-surface mines capture and flare methane for safety reasons).

As a simple approximation of the global average methane emission rate, we calculate kg of methane released per tonne of coal mined. 1994 methane / 1994 world production: 46.32 million tonnes CH_4 / 4,559 million tonnes coal = 0.0102 tonnes CH_4 per tonne coal extracted, or 10.2 kg CH2 per tonne coal.

Since coal is typically ~70 percent carbon, we calculate the carbon basis as 0.0071 tonnes CH4 per tonne coal extracted, or 7.1 kg CH4 per tonne of carbon combusted from coal.

To convert this estimated fugitive methane emission rate into carbon equivalent, we use IPCC's GWP of CH4 = 23 x CO2, translating to 1 unit of methane = 6.272 x Carbon-equivalent.*

The formula becomes: per tonne of carbon emitted by coal-fired power plants x 0.0071 x 6.272.

* To convert fugitive methane emissions to carbon-equivalent emissions: multiply methane emissions by 23 (the methane global warming potential factor [GWP] CH4:CO2) and divide by 3.667 (CO2:carbon), 23/3.667, or a factor of 6.272.

Note: the global warming potential of methane has been revised from 21 x CO2 to 23 x CO2 by the IPPC. Source: Houghton, J. T. et al (2001) Climate Change 2001: The Scientific Basis, Working Group One, Third Assessment, IPPC, Cambridge University Press, p. 388.

See also From David Stern and Robert Kaufmann, Methane Emissions 1860 to 1994, at CDIAC website: http://cdiac.esd.ornl.gov/trends/meth/methane.htm

Cell: G169
Comment: Rick Heede:
This report uses far longer power plant operating lives than previous reports to project future or life-cycle carbon emissions. Real-world experience shows power plant durability exceeding fifty years; we use different estimapted operating lives for each type of plant (see below).

ExIm Bank (1999), p. 27: "Assuming that these plants, on average, have an operating life of 25 years." (also assumes 85 percent availability or capacity factor).

OPIC (2000), p. 18: "that each plant will operate for 25 years." (also assumes 85 percent availability or capacity factor).

Vallette et al (1999), p. 111: "For each power plant project financed by OPIC or Ex-Im, it is assumed that it will run for 20 years at full capacity from the time of financing."

This report's methodology differs substantially. First, we apply different availability factors for each type of plant (90 percent for coal, 85 percent for gas, and 80 percent for oil units). Second, each of the previous sources use extremely low -- 20 to 25 years -- estimates of operating lives. Here we use plant-specific estimates as follows: 60 years for coal facilities, 40 years for gas-fired plants, and 30 years for oil units.

Based on data from David Hawkins, Natural Resources Defense Council, personal communication, 9Dec04.

Cell: C173
Comment: Rick Heede:
OPIC oil-fired project summary:
1992 Puerto Quetzal, Guatemala: 234 MW
1993 Batangas, Philippines: 105 MW
1994 Grenada Power, Grenada: 18 MW
1995 Tampo Centro, Guatemala: 78 MW
1996 Termovalle, Colombia: 199 MW

1996 Nejapa Power, El Salvador: 150 MW
1996 no name, no country: 36 MW
1997 EMA Power, Hungary: 35 MW
1997 no name, no country: 78 MW
1997 no name, no country: 102 MW
1997 EAL/ERI Cogen, Jamaica: 17 MW
1998 Subic Power, Philippines: 111 MW
1999 Tipitapa Power, Nicaragua: 51 MW
Total oil (resid + diesel): 1,214 MW

Source: OPIC, 2000, pp. 52-53 (Appendix 1).

Cell: E173
Comment: Rick Heede:
Estimated emissions of carbon dioxide from oil-fired projects are based on an average availability factor (we use 80 percent for oil facilities as opposed to Ex-Im's assumed 85 percent for all power plants regardless of type), carbon content of fuel (which we "blend" for diesel and residual-fired units below), and an industry-average heat rate (though this will, in reality, differ from project to project).

Of 1,214 MW total, 796 MW (65.6%) is diesel (with an emissions factor of 74.05 kgCO2/GJ (= 20.2 kgC/GJ).
The remainder 418 MW (34.4%) is residual fuel (with an emissions factor of 77.35 kgCO2/GJ (= 21.1 kgC/GJ).

Heat rates vary by plant type; most are engine-driven: heat rate of 7588 Btu/kWh (= 8.01 MJ/kWh, 45% efficiency), a couple are simple-cycle at 9757 Btu/kWh (= 10.29 MJ/kWh, 35% efficiency (3412 Btu/kWh out/9757 Btu/kWh in = 0.35)), and one steam boiler at 10,348 Btu/kWh (= 10.92 MJ/kWh, 33% efficiency).

Given the mixture of plant types, fuels, and efficiencies -- and therefore the carbon emissions per hour of operation -- we use a factor of 20.8 kgC/GJ times ~8.6 MJ/kWh (41.9% efficiency).

Our assumed "typical" oil-fired plant thus emits 20.8 kgC/GJ * 8.6 MJ/kWh * 8,760 hrs/yr = 1,567 tonnes carbon per MW-yr = 1,567 tC/MW-yr. For oil-fired power plants we use an availability factor of 80 percent (7,008 hrs/yr): 1,567 tC/MW-yr * 0.80 = 1,254 tC/MW-yr. Availability factor is applied separately in the formula to facilitate adjustment of this factor.

Source: OPIC, 2000, pp. 52-53 (Appendix 1).

Cell: C186
Comment: Rick Heede:
Vallette Master List. 279 MW gas-fired power project, part of Bolivia/Brazil gas pipeline. Entered as a power project. We do not account for emissions from pipeline projects, but do include electric generation and extraction.

Cell: C189
Comment: Rick Heede:
Sources: SEEN database at www.seen.org, Jim Vallette's updated Ex-Im Bank and OPIC project spreadsheets, and especially his Master spreadsheet on all ECA energy-related projects (updated to Jul04).

Cell: C193
Comment: Rick Heede:
The aim of this report is to account for both direct and indirect emissions of greenhouse

gases that result from the projects financed by Ex-Im Bank and OPIC, regardless of the ECAs level of financial involvement. Direct emissions are typically defined as arising from facilities owned or controlled by the entity in question. Thus emissions from fuels combusted at Ex-Im and OPIC-financed power plants are considered direct emissions by both ECAs, the Wysham et al reports by the Sustainable Energy and Economy Network, and this report. In the power sector we also included indirect emissions from their fuel combustion, e.g., fugitive methane from coal mines and oil and gas operations, emissions related to the transportation of fuels to the power plants, and other emissions related to the fuel provisioning.

In this and the following sections on indirect emissions from coal, oil, and gas-fired p[oewr plant we use U.S. and global data on emissions associated with providing fuels to power plants. These indirect emissions include fugitive methane from coal mines that provide fuel to coal-fired power plants, emissions of carbon dioxide related to CO2 venting at gas production facilities that produce fuel for gas-fired power plants, and emissions associated with refining crude oil into residual and distillate fuels to oil-fired power plants. (Note: other indirect emissions accounted for are detailed in each indirect emissions section by power plant type and agency below.)

Neither Ex-Im nor OPIC estimate indirect emissions for power plants and their fuel cycle in their respective 1999 and 2000 reports.

Cell: C194
Comment: Rick Heede:
See the "CO2 from flared gas at natural gas production facilities" below for details.

Significant quantities of gas is flared at oil production, processing, storage, and delivery facilities. This in an indirect emission of carbon dioxide attributed to Ex-Im and OPIC-financed oil-fired power plants. We allocate 60 percent of this flaring rate to gas and 40 percent to oil production, processing, storage, and delivery. Gas flaring attributable to oil thus becomes 2 percent x 0.4 = 0.8 percent.

The formula is thus: current and future (over the 40-year operating life) emission from gas consumed at Ex-Im bank/OPIC gas-fired power plants x 0.008.

Cell: C195
Comment: Rick Heede:
We estimate the amount of energy used in oil refineries to process and refine its petroleum products deliverd to Ex-Im Bank and OPIC-financed oil-fired power plants as follows:

Method 1: one preliminary estimate is that five (5) percent of the refinery output is consumed in the refining process, not including purchased gas and electricity (which is sometimes purchased from utilities and at other facilities is generated on site using, for example, distillate-driven gen-sets).

Source: Kevin Lindemer, Irving Oil, New Brunswick, personal communication, 20Jun03.

Method 2: EIA data for fuel consumed at US refineries in 2002 (exclusive of gas and electricity, which is included under those columns):
LPG (at 4.30 million Btu per bbl) x 3.44 million bbl = 14.79 x 10^12 Btu;
Distillates (at 5.83 million Btu per bbl) x 0.84 million bbl = 4.89 x 10^12 Btu;
Residuals (at 6.29 million Btu per bbl) x 4.81 million bbl = 30.27 x 10^12 Btu;
Petroleum coke (at 6.02 million Btu per bbl) x 88.24 million bbl = 531.55 x 10^12 Btu;
Coal (at 20.9 million Btu per ton) x 31 thousand tons = 0.68 x 10^12 Btu;
Other products (at 5.80 million Btu per bbl) x 5.21 million bbl = 30.22 x 10^12 Btu;

Purchased steam (at 970 Btu per lb) x 59.15 million lbs = 57.38 x 10^12 Btu;
Total 669.8 x 10^12
Btu;

Petroleum equivalent (at 5.8 million Btu per bbl): 669.8 x 10^12 Btu/5.8 million Btu per bbl = 115.5 million bbl;
divided by US refinery output of 6,305 million bbl in 2002: 115.5 million bbl/6,305 million bbl = 0.0183, or 1.83 percent.

Source: Energy Information Administration (2003) Petroleum Supply Annual, Volume One, Table 47, p. 115.

Result: Inasmuch as (a) the bulk of refinery energy use in the EIA data is carbon-intensive steam and petroleum coke, (b) the oft-cited figure of 5 percent of refinery throughput in consumed, and (c) less efficient foreign refineries (under less economic and regulatory pressure to improve operational efficiency), we add 4.0 precent of total oil products marketed to oil-fired power plants per year as internal energy used in and carbon emissions from refinery operations.

The formula is thus: carbon emissions from fuel oil and diesel fuel consumed at Ex-Im and OPIC-financed oil-fired power plants x 0.04.

Cell: C196
Comment: Rick Heede:
We use Argonne National Laboratory's GREET model as guidance to making an estimate on other fuel cycle energy inputs to transportation of crude, natural gas, and petroleum products from "wells to wheels."

Crude oil shipping by tankers (VLCCs): GREET assumptions: 5,080 miles average distance, 19 mph average speed, 4,763 Btu per horsepower-hour (typical tanker shaftpower = 124,500 HP); result: 6,089 Btu energy input to move one million Btu of crude oil, or 0.61 percent. Of course, not all oil company crude to refineries arrive by ocean-going tankers, so we dilute this adder by 0.57 (US averages 57 percent imported crude + products), thus the formula is 0.61% x 0.57 = 0.348 percent of total products marketed.
Note: we believe the GREET estimates include energy required to back-haul a tanker, but this is uncertain; if not, GREET data suggest that backhauling a VLCC requires 20 Btu per ton-mile (vs 22 Btu/ton-mile for the front-haul). See GREET.xls, worksheet on Transportation and Distribution, section #9.

Pipelines: GREET assumptions: distance pipelined (750 miles for crude, 400 miles for products from refineries to tank farms), 270 Btu per ton-mile; results: 3,815 million Btu of petroleum input to pipeline transport of one million Btu of crude oil (1,998 Btu per million Btu of gasoline pipelined). Note: this excludes other energy inputs, such as gas or electricity used in pipelines, which brings the pipeline energy input to 6,129 Btu per million Btu of crude thus transported.) Dilution: assume that 43 percent of crude is shipped to refineries by pipeline (thus 0.43 x 3,815 = 1,640 Btu per million Btu of total crude shipped), plus assume that all products are pipelined from refineries to tank farms (at 1,998 Btu per million Btu of refined products); total 1,640 + 1,998 = 3,638 Btu per million Btu, total energy input to pipeline of crude and products, or 0.364 percent.

Conclusion: oil inputs to transportation of 0.763% (for domestic waterborne shipping) + 0.348% (for crude oil and products transport by ocean-going tankers) + 0.364% (for pipeline of crude and products) = 1.475 percent. Detailed analysis will probably find this result to be conservative.

The formula is thus: carbon emissions from oil consumed in Ex-Im and OPIC-financed oil-fired power plants x 0.0148.

Note: Not included in this or any other indirect emissions estimate of OPIC and Ex-Im projects is the considerable energy and emissions embodied in the construction of the power plants and the infrastructure to extract, refince, and deliver fuel; nor is the energy invested in building electric transmission grids included.

Sources: Stacy Davis (2001) Transportation Energy Data Book, edition 21, U.S. Dept of Energy, Center for Transportation Analysis, Oak Ridge National Laboratory, Oak Ridge, TN. Tables 12-4, 12-5, and 1-11., and personal communication.

Michael Q. Wang, Argonne National Laboratory, GREET model, www.transportation.anl.gov/greet/index.html, and personal communication 18Jul03.

Cell: C197
Comment: Rick Heede:
Significant quantities of methane are released from oil production, processing, and delivery operations. Stern & Kaufman / CDIAC (the latest data available) estimate total oil- and gas-related methane emissions in 1994 at 15.2 million tonnes of CH4 from gas flaring at oil and gas facilities and an additional 18.0 million tonnes of CH4 from oil and gas production, processing, storage, and delivery. We attribute one-quarter of flaring and one-half of oil and gas supply to gas operations. Thus 15.2 x 0.25 + 18.0 x 0.5 = 3.8 + 9.0 = 12.8 million tonnes of fugitive methane. The remainder is attributed to gas operations.

As a simple approximation of the global average methane emission rate, we calculate kg of methane released per tonne of oil produced. 1994 methane / 1994 world oil production: 60.99 million bbl per day (= 22.26 billion bbl/yr = 129 Q = ~2,766 million tonnes. 129 quads, at 20.25 million tonnes carbon per Q of crude oil = oil consumption emissions of 2,612 million tonnes of carbon). Thus, oil-related methane emissions of 12.8 million tonnes CH4 divided by 2,612 million tonnes carbon from oil consumption = 0.0049 tonne (4.9 kg) methane per tonne of carbon from oil consumption.

To convert this estimated fugitive methane emission rate into carbon equivalent, we use IPCC's GWP of CH4 = 23 x CO2, translating to 1 unit of methane = 6.272 x Carbon-equivalent.*

The formula becomes: per tonne of carbon emitted by oil-fired power plants x 0.0049 x 6.272 = tonnes of methane in carbon-equivalent.

* To convert fugitive methane emissions to carbon-equivalent emissions: multiply methane emissions by 23 (the methane global warming potential factor [GWP] CH4:CO2) and divide by 3.667 (CO2:carbon), 23/3.667, or a factor of 6.272.

Note: the global warming potential of methane has been revised from 21 x CO2 to 23 x CO2 by the IPPC. Source: Houghton, J. T. et al (2001) Climate Change 2001: The Scientific Basis, Working Group One, Third Assessment, IPPC, Cambridge University Press, p. 388.

See also David Stern and Robert Kaufmann, Methane Emissions 1860 to 1994, at CDIAC website: http://cdiac.esd.ornl.gov/trends/meth/methane.htm

Cell: G205
Comment: Rick Heede:
This report uses far longer power plant operating lives than previous reports to project future or life-cycle carbon emissions. Real-world experience shows power plant durability exceeding fifty years; we use different estimapted operating lives for each type of plant (see below).

ExIm Bank (1999), p. 27: "Assuming that these plants, on average, have an operating life of 25 years." (also assumes 85 percent availability or capacity factor).

OPIC (2000), p. 18: "that each plant will operate for 25 years." (also assumes 85 percent availability or capacity factor).

Vallette et al (1999), p. 111: "For each power plant project financed by OPIC or Ex-Im, it is assumed that it will run for 20 years at full capacity from the time of financing."

This report's methodology differs substantially. First, we apply different availability factors for each type of plant (90 percent for coal, 85 percent for gas, and 80 percent for oil units). Second, each of the previous sources use extremely low -- 20 to 25 years -- estimates of operating lives. Here we use plant-specific estimates as follows: 60 years for coal facilities, 40 years for gas-fired plants, and 30 years for oil units.

Based on data from David Hawkins, Natural Resources Defense Council, personal communication, 9Dec04.

Cell: C209
Comment: Rick Heede:
OPIC gas-fired projects summary:

1990 Hopewell, Philippines:	200 MW
1992 Inter-American, Colombia:	100 MW
1993 Central Termica, Argentina:	325 MW
1994 Trakya Elektrik, Turkey:	480 MW
1994 Generacion de Vapor, Venezuela:	315 MW
1994 Dabhol Power, India:	2,184 MW
1995 Termobarranquilla, Colombia:	750 MW
1995 Doga Energi, Turkey	180 MW
1996 Termocandelaria, Colombia:	316 MW
1996 P.T Energi, Indonesia:	135 MW
1996 Empresa Guaracachi, Bolivia:	180 MW
1996 Empresa Electrica, Bolivia:	181 MW
1996 Central Termica, Argentina:	110 MW
1996 Ave Fenix, Argentina:	168 MW
1996 Aguaytia Energy, Peru:	141 MW
1997 no name, no country:	35 MW
1998 TRI Energy, Thailand:	700 MW
1998 NEPC Consortium, Bangladesh:	120 MW
1999 Turboven Maraquay, Venezuela:	64 MW
1999 Turboven Cagua, Venezuela:	72 MW
1999 Empresa Produtora, Brazil:	480 MW
Total gas-fired, OPIC 1990-1999:	7,236 MW

Source: OPIC, 2000, pp. 52-53 (Appendix 1).

Cell: E209
Comment: Rick Heede:
Estimated emissions of carbon dioxide from gas-fired projects are based on an average availability factor (we use 85 percent for gas facilities (Ex-Im's assumed 85 percent for all power plants regardless of type)), carbon content of fuel, and an industry-average heat rate (though this will, in reality, differ from project to project).

Heat rates are assumed to average 7,266 Btu/kWh (7.67 MJ/kWh, 47 percent efficiency), and 56.1 kgCO2/GJ, or 15.3 kgC/GJ.

A "typical" gas-fired power plant thus emits 15.3 kgC/GJ * 7.67 MJ/kWh * 8,760 hrs/yr = 1,028 tonnes carbon per MW-yr = 1,028 tC/MW-yr. For gas-fired power plants we use an availability factor of 85 percent (7,446 hrs/yr): 1,028 tC/MW-yr * 0.85 = 874 tC/MW-yr. Availability factor is applied separately in the formula to facilitate adjustment of this factor.

Source: OPIC, 2000, pp. 14 (same factors as used in Ex-Im Bank, 1999).

Cell: C234
Comment: Rick Heede:
Vallette Master spreadsheet: diesel/gas-fired power plant. Not in Vallette's other spreadsheet, nor in OPIC.

Cell: C235
Comment: Rick Heede:
Vallette Master spreadsheet: oil/gas-fired power plant. Not in Vallette's other spreadsheet, nor in OPIC.
Takoradi II 330MW oil-fired power plant expansion, funded by World Bank, 2004 (not included).

Cell: C244
Comment: Rick Heede:
The aim of this report is to account for both direct and indirect emissions of greenhouse gases that result from the projects financed by Ex-Im Bank and OPIC, regardless of the ECAs level of financial involvement. Direct emissions are typically defined as arising from facilities owned or controlled by the entity in question. Thus emissions from fuels combusted at Ex-Im and OPIC-financed power plants are considered direct emissions by both ECAs, the Wysham et al reports by the Sustainable Energy and Economy Network, and this report. In the power sector we also included indirect emissions from their fuel combustion, e.g., fugitive methane from coal mines and oil and gas operations, emissions related to the transportation of fuels to the power plants, and other emissions related to the fuel provisioning.

In this and the following sections on indirect emissions from coal, oil, and gas-fired p[oewr plant we use U.S. and global data on emissions associated with providing fuels to power plants. These indirect emissions include fugitive methane from coal mines that provide fuel to coal-fired power plants, emissions of carbon dioxide related to CO2 venting at gas production facilities that produce fuel for gas-fired power plants, and emissions associated with refining crude oil into residual and distillate fuels to oil-fired power plants. (Note: other indirect emissions accounted for are detailed in each indirect emissions section by power plant type and agency below.)

Neither Ex-Im nor OPIC estimate indirect emissions for power plants and their fuel cycle in their respective 1999 and 2000 reports.

Cell: C245
Comment: Rick Heede:
While global gas flaring is decreasing, it still represents 2.5 percent of carbon emissions from global natural gas consumption, down from 4.3 percent in 1990. The flaring percentage is likely to decrease further, and we use 2.0 percent of gas consumption to project future flaring emissions. This in an indirect emission of carbon dioxide attributed to Ex-Im and OPIC-financed gas-fired power plants. We allocate 60 percent of this flaring rate to gas and 40 percent to oil production, processing, storage, and delivery. Gas flaring thus becomes 2 percent x 0.6 = 1.2 percent.

The formula is thus: current and future (over the 40-year operating life) emission from gas consumed at Ex-Im bank/OPIC gas-fired power plants x 0.012.

Data from Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy. cdiac.esd.ornl.gov/

Cell: C246
Comment: Rick Heede:
Carbon dioxide is vented from both oil and gas production platforms and from gas processing facilities to reduce CO2 content and to meet pipeline gas specifications. Venting rates vary greatly from facility to facility, every gas reservoir contains differing amounts of carbon dioxide and other gases, and the fraction of removed CO2 also varies.

Benchmark 1: the US CO2 venting rate from natural gas operations (4.9 million metric tonnes carbon of CO2 removal from US natural gas production divided by total US gas consumption of 315 million tonnes carbon, or 1.53 percent, 1999 data).
Source: Energy Information Administration (2001) Emissions of Greenhouse Gases in the United States, 2000, US DOE, Washington, p. 28.

Benchmark 2: reducing CO2 content of sour gas from 3.0 mole percent CO2 to 2.0 mole percent CO2 results in the venting of 147.8 tonnes carbon per billion standard cubic feet processed. This alone is equivalent to a venting rate of 1.0 percent.
Source: American Petroleum Institute (2001) Compendium Of Greenhouse Gas Emissions Estimation Methodologies For The Oil And Gas Industry, p. 4-32.

Benchmark 3: The BuMines data shows "Vented and Wasted Gas" from 1936 to 1970 (ranging from a high of 26.5 percent of marketed gas production in 1944 to a low of 2.23 percent in 1970), but the table's footnotes do not elucidate what is being counted. We suspect the data is predominantly vented (that is, unflared) natural gas and flared natural gas, and probably does not include vented CO2.
Source: Bureau of Mines (year unknown) Minerals Yearbook, Historical tables, M147-161, US Dept Interior.

Benchmark 4: "Non-hydrocarbon gas removed from natural gas" (NHGR, which is predominantly carbon dioxide but also significant quantities of nitrogen, hydrogen sulfides, and helium; no data for each gas) is shown for 1980-2002. In 1980, the NHGR rate was 0.99 percent; in 1990 = 1.56 percent, and 2000 = 2.50 percent.
Source: Energy Information Administration (2003) Natural Gas Annual, 2002, US DOE, Washington, Table 3 plus historical data; www.eia.doe.gov/oil_gas/natural_gas/data_publications/natural_gas_annual/nga.html.

Conclusion: Consideration of all of these benchmarks leads us to increase the the EIA's venting rate from 1.53 percent by 15 percent. 1.53 percent x 1.15 = 1.76 percent.

The formula is: =('Natural Gas'!columnGcell#)*0.0176

Cell: C247
Comment: Rick Heede:
Large amounts of natural gas is used in internal operations, on gas platforms and gas production facilities to generate power, fuel compressors, produce heat, and operate refineries and pipelines.

In a previous report on internal consumption of natural gas for gas production (raise steam, generate electricity, run compressors, etc), operate natural gas pipelines, and gas used in gas processing facilities, this author estimated that 11.48 percent of natural gas produced was used in internal operations (exclusive of gas used for re-pressuring oil and gas fields). Heede (2003) ExxonMobil Emissions Inventory 1882-2002, Methods & Results, and spreadsheets on Natural Gas, and Company Energy Use.

Since some of this gas is used in oil refineries and not strictly an indirect energy use for production, processing, and delivery of natural gas to the gas-fired power plants supported by Ex-Im Bank and OPIC funding, and in consideration of the size and location of such power plants to gas production and processing regions, we reduce this 11.48 percent factor to 7.0 percent. While this is likely a conservatism in the real world, we cannot verify this without a detailed analysis, which is beyond the scope of the present project.

Cell: C248
Comment: Rick Heede:
Significant quantities of methane are released from oil production, processing, and delivery operations. Stern & Kaufman / CDIAC (the latest data available) estimate total oil- and gas-related methane emissions in 1994 at 15.2 million tonnes of CH4 from gas flaring at oil and gas facilities and an additional 18.0 million tonnes of CH4 from oil and gas production, processing, storage, and delivery. We attribute one-quarter of flaring and one-half of oil and gas supply to gas operations. Thus 15.2 x 0.25 + 18.0 x 0.5 = 3.8 + 9.0 = 12.8 million tonnes of fugitive methane. The remainder is attributed to gas operations.

As a simple approximation of the global average methane emission rate, we calculate kg of methane released per tonne of oil produced. 1994 methane / 1994 world oil production: 60.99 million bbl per day (= 22.26 billion bbl/yr = 129 Q = ~2,766 million tonnes. 129 quads, at 20.25 million tonnes carbon per Q of crude oil = oil consumption emissions of 2,612 million tonnes of carbon). Thus, oil-related methane emissions of 12.8 million tonnes CH4 divided by 2,612 million tonnes carbon from oil consumption = 0.0049 tonne (4.9 kg) methane per tonne of carbon from oil consumption.

To convert this estimated fugitive methane emission rate into carbon equivalent, we use IPCC's GWP of CH4 = 23 x CO2, translating to 1 unit of methane = 6.272 x Carbon-equivalent.*

The formula becomes: per tonne of carbon emitted by oil-fired power plants x 0.0049 x 6.272 = tonnes of methane in carbon-equivalent.

* To convert fugitive methane emissions to carbon-equivalent emissions: multiply methane emissions by 23 (the methane global warming potential factor [GWP] CH4:CO2) and divide by 3.667 (CO2:carbon), 23/3.667, or a factor of 6.272.

Note: the global warming potential of methane has been revised from 21 x CO2 to 23 x CO2 by the IPPC. Source: Houghton, J. T. et al (2001) Climate Change 2001: The Scientific Basis, Working Group One, Third Assessment, IPPC, Cambridge University Press, p. 388.

See also David Stern and Robert Kaufmann, Methane Emissions 1860 to 1994, at CDIAC website: http://cdiac.esd.ornl.gov/trends/meth/methane.htm

GHG emissions from Ex-Im Bank and OPIC projects

Oil and Gas Extraction, Refineries, and Pipelines

Climate Mitigation Services
Richard Heede
14-Dec-04

	Oil	**Export-Import Bank of the United States**								
		Ex-Im or Vallette data				**This report**				
	Note on direct vs indirect emissions	**Peak production** Million bbl/yr	**Peak production** (MshtCO2/yr)	**Total project** Million bbl	**Total project** (MshtCO2)	**Peak production** (MtC-eq/yr)	**Peak production** (MtCO2-eq/yr)	**Total project** (MtC-eq)	**Total project** (MtCO2-eq)	
	Indirect emissions: Ex-Im oil projects									
1994	1. Samatlor, Russia (oil field rehab)	35	17	201	97	4	14	21	79	#
	2. Lake Maracaibo, Venezuela (Inco Gas)	58	45	1,168	898	6	23	125	458	#
1994	3. Tatneft, Russia (oil field rehab)	2	1	12	6	0	1	1	5	#
	4. Samburg, Russia ("project is unknown")							*insufficient*	*data*	
1998	5. Cantarell oil field, Mexico	400	218	2,500	1,360	43	157	267	980	#
	6. Cusiana, Venezuela	62	34	1,530	826	7	24	164	600	#
1994	7. Permneft, Russia ("canceled")							*project*	*cancelled*	
	8. Cabinda, Angola	127	64	1,000	529	14	50	107	392	#
1995	9. Kond, Russia ("canceled")							*project*	*cancelled*	
1995	10. Caan oil field, Mexico	58	33	348	204	6	23	37	136	#
	11. In Fouye Tabenkort, Algeria	26	12	204	98	3	10	22	80	#
	12. Polar Lights, Russia (no ExIm support)							*insufficient*	*data*	
	13. West Linapacan, Philippines	7	3	20	10	1	3	2	8	
	14. Chernogorneft/Chernogorskoye, Russia	11	5	31	15	1	4	3	12	
	22. Kokdumalak, Uzbekistan (oil)	29	24	383	435	3	11	41	150	
	22. Kokdumalak, Uzbekistan (condensate)	22		547		2	9	49	180	
	24. Tano Gas Field, Ghana	0	*see "gas"*	2	*see "gas"*	0	0	0	1	
	Ex-Im Bank refinery projects									
	15. Cardon Refinery upgrade, Venezuela	127	61	na	1,220	*not included:*	*refined products*	*supply power*	*plants*	
	16. Ryazan refinery upgrade, Russia	91	43		869	10	35	293	1,076	
	17. Perm refinery upgrade, Russia	94	45		903	10	37	305	1,118	
	Humpuss refinery, Indonesia	3	2		32	0	1	11	39	
	19. Rayong refinery, Thailand	48	23		460	5	19	155	570	
2003	20. Panipat refinery, India ("unknown prjct")							*insufficient*	*data*	
1995	23. Tomsneft Gas Compression, Russia	0.3	3		67	0	0	23	83	
	New/other Ex-Im oil projects (Vallette)				(MtCO2)					
1995	Novoyaroslavl Oil Refinery	102	43	2,044	868	11	40	218	801	
	Baku-Ceyhan-Tblisi oil pipeline, Georgia	365		7,300	3,100	39	143	780	2,861	
1993	Western Siberia oil fields, Russia	355		7,100	4,573	38	139	759	2,783	
	Marlim Sul oil & gas field, Brazil	60		1,200	510	6	24	128	470	
	Doba oil field, Chad, & oil pipeline, Cameroon	82		1,643	446	9	32	176	644	
2004	West East gas pipeline, China							*insufficient*	*data*	
2000	Delta del Grijalva oil field, Mexico	13	5	250	106	1	5	27	98	
2003	Pidiregas oil and gas, Mexico							*insufficient*	*data*	
1999	Madero oil refinery expansion, Mexico	51	22	1,012	440	5	20	108	397	
1994	Salamanca oil refinery expansion, Mexico	4		73	31	0	1	8	29	
1991	ExxonMobil oil projects, Nigeria	18		274	116	2	7	29	107	
	Amakpe-Eket crude oil refinery							*insufficient*	*data*	
2001	Hamaca heavy oil development, Venezuela	105	45	2,100	892	11	41	224	823	
	Total indirect emissions, Ex-Im oil	**2,354**	**749**	**30,942**	**19,110**	**238**	**873**	**4,085**	**14,979**	
	Direct emissions									
	Flared gas at oil production facilities				Neither Ex-Im nor Vallette estimate direct emissions	0.19	0.70	3.27	11.98	
	Emissions from oil refinery operations					4.76	17.46	81.69	299.57	
	CO2 emissions from oil transportation					2.38	8.73	40.85	149.79	
	Fugitive methane from oil ops (CO2-eq)					2.99	10.95	51.24	187.89	
	Total direct emissions (C and CO2-equiv)					**10.3**	**38**	**177**	**649**	
	Total emissions, Ex-Im-oil projects	**2,354**	**749**	**30,942**	**19,110**	**248**	**911**	**4,262**	**15,628**	

	B	C	D	E	F	G	H	I	J	K
64										
65										
66										
67		**Natural Gas**	**Export-Import Bank of the United States**							
68			**Ex-Im or Vallette data**				**This report**			
69–70			**Peak production** Billion cf/yr	**Peak production** (MtCO2/yr)	**Total project** Billion cf	**Total project** (MtCO2)	**Peak production** (MtC-eq/yr)	**Peak production** (MtCO2-eq/yr)	**Total project** (MtC-eq)	**Total project** (MtCO2-eq)
72		**Indirect emissions: Ex-Im gas projects**								
73		2. Lake Maracaibo, Venezuela (Inco Gas)	285	see "oil"	5,694	see "oil"	4	15	82	301
74		5. Cantarell, Mexico	438	see "oil"	2,700	see "oil"	6	23	39	143
75		6. Cusiana, Venezuela	60	see "oil"	1,480	see "oil"	1	3	21	78
76		8. Cabinda, Angola	56	see "oil"	846	see "oil"	1	3	12	45
77		10. Caan, Mexico	86	see "oil"	622	see "oil"	1	5	9	33
78	1998	21. Burgos Basin Gas Field, Mexico	219	13	3,170	187	3	12	46	168
79		24. Tano Gas Field, Ghana	29	2	181	12	0	2	3	10
80		**Ex-Im Bank gas pipeline/plant projects**								
81	1993	25. Yamal Gas Pipeline, Russia	3,400	200	68,000	4,000	49	180	1,472	5,399
82		26. Maghreb Gas Pipeline, Algeria	219	13	4,380	258	3	12	95	348
83		27. Gas liquefaction plant renovation, Algeria	1,000	59	20,000	1,176	14	53	433	1,588
84		28. Atlantic LNG plant renov., Trinidad & Tob.	87	9	1,732	184	1	5	38	138
85		29. Oman LNG plant, Oman	192	20	3,832	407	3	10	83	304
86		30. Accro Gas Separation plant, Venezuela	146	25	2,920	508	2	8	63	232
87		31. Qatar Gas Field & LNG plant, Qatar	173	21	3,464	421	3	9	75	275
88		32. Copesul Petrochemical, Brazil		0.3		6			2	8
89		33. Corpoven LPG (included in Accro, Venez.)								
90		37. Cryogenic LPG Plant, Mexico	219	13	4,380	262	3	12	95	348
91		38. Gas Pipeline, Colombia	82	5	1,476	87	1	4	32	117
92		**New/other Ex-Im natural gas projects**							*included*	*above*
93	1993	Enron oil and gas, India (OPIC & Ex-Im)				52			*insufficient*	*data*
94		Tiga LNG plant, Malaysia	178		3,568	10	3	9	77	283
95	2003	San Fernando gas pipeline, Mexico							*insufficient*	*data*
96		PEMEX strategic gas program, Mexico							*insufficient*	*data*
97		Nigeria LNG plant (Bonny Island)							*insufficient*	*data*
98	1998	Turkmengas pipeline system, Turkmenistan	1,095	57	21,900	1,147	16	58	474	1,739
99		**Total indirect emissions, Ex-Im gas**	**7,963**	**438**	**150,345**	**8,716**	**115**	**422**	**3,152**	**11,557**
100										
101		**Direct emissions**								
102		Flared gas at gas production facilities				Neither Ex-Im nor Vallette estimate direct emissions	0.14	0.51	3.78	13.87
103		Emissions from gas processing					1.15	4.22	31.52	115.57
104		CO2 emissions from gas pipelines					1.15	4.22	31.52	115.57
105		Fugitive methane from gas ops (CO2-eq)					3.61	13.22	98.84	362.44
106		**Total direct emissions (C and CO2-equiv)**					**6**	**22**	**166**	**607**
107										
108		**Total emissions, Ex-Im gas projects**	**7,963**	**438**	**150,345**	**8,716**	**121**	**444**	**3,317**	**12,165**
109										

Oil

	Oil	Overseas Private Investment Corporation							
		Vallette data (OPIC data na)				**This report**			
	Note on direct vs indirect emissions	**Peak production** Million bbl/yr	**Peak production** (MtCO2/yr)	**Total reserve** Million bbl	**Total project** (MtCO2)	**Peak production** (MtC-eq/yr)	**Peak production** (MtCO2-eq/yr)	**Total project** (MtC-eq)	**Total project** (MtCO2-eq)
	Indirect emissions: OPIC oil projects								
	OPIC oil projects (Vallette & SEEN)								
	Pescada offshore oil and gas field, Brazil			27	32			*insufficient*	*data*
2002	West Seno oil and gas fields, Indonesia				47			*insufficient*	*data*
1996	Gobe oil field, Papua New Guinea	45		95	40	5	18	10	37
2000	Napa Napa oil refinery, Papua New Guinea	12		237	100	1	5	25	93
	Vysotsky Island oil export terminal, Russia							*insufficient*	*data*
2002	Pigap II oil field, Venezuela				552			*insufficient*	*data*
1997	El Furrial oil field, Venezuela	47		949	403	5	19	101	372
1993	West Falcon Oil Development, Venezuela							*approved but*	*no contract*
1994	Polar Lights (Ardalin) oil field, Russia	13		110	47	1	5	12	43
1999	East Orenburg oil and gas field, Russia	19		376	181	2	7	40	147
1997	Sakhalin II **oil** and gas, Russia	16		1,000	1,130	2	6	107	392
1994	White Nights oil fields							*approved but*	*inactive*
1996	Sotcheymu oil field, Russia							*approved but*	*no contract*
1993	Sutormoran oil field, Russia							*approved but*	*no contract*
92,98	Hunt **oil** and gas field, LNG plant, Yemen	51		1,015	1,264	5	20	108	398
	Total indirect emissions, OPIC oil	**203**		**3,809**	**3,795**	**22**	**80**	**404**	**1,482**
	Direct emissions								
	Flared gas at oil production facilities				Neither OPIC nor Vallette estimate direct emissions	0.02	0.06	0.32	1.19
	Emissions from oil refinery operations					0.43	1.59	8.08	29.64
	CO2 emissions from oil transportation					0.22	0.80	4.04	14.82
	Fugitive methane from oil ops (CO2-eq)					0.27	1.00	5.07	18.59
	Total direct emissions (C and CO2-equiv)					**0.94**	**3.45**	**17.52**	**64.24**
	Total emissions, OPIC-oil projects	**203**		**3,809**	**3,795**	**23**	**83**	**422**	**1,546**

Natural Gas

Overseas Private Investment Corporation

Year	Natural Gas	Vallette data (OPIC data na): Peak production Billion cf/yr	Peak production (MtCO2/yr)	Total project Billion cf	Total project (MtCO2)	This report: Peak production (MtC-eq/yr)	Peak production (MtCO2-eq/yr)	Total project (MtC-eq)	Total project (MtCO2-eq)
	Indirect emissions: OPIC gas projects								
	OPIC gas projects (Vallette & SEEN)								
1993	Alba oil and gas field, Equatorial Guinea	38		999	19	1	2	14	53
92,98	Hunt oil and **gas** field, LNG plant, Yemen	790.7		15,813	see "oil"	11	42	228	837
2000	Zeta Gas, LPG distribution, Guatemala							*insufficient*	*data*
1993	Enron oil and gas, India (OPIC & Ex-Im)	26		639	52	0	1	9	34
2004	Mobil offshore NGL project, Nigeria							*insufficient*	*data*
1995	Miskar gas field, Tunisia			800				*approved but*	*inactive*
1999	East Orenburg oil and gas field, Russia	21		413	see OPIC oil	0	1	6	22
1997	Sakhalin II oil and **gas**, Russia	233		14,000	see OPIC oil	3	12	202	741
2002	West Seno oil and gas fields, Indonesia				47			*insufficient*	*data*
	Total direct emissions, OPIC gas	**1,108**		**32,664**	**118**	**16**	**59**	**460**	**1,687**
	Direct emissions								
	Flared gas at gas production facilities				Neither OPIC nor Vallette estimate direct emissions	0.02	0.07	0.55	2.02
	Emissions from gas processing					0.16	0.59	4.60	16.87
	CO2 emissions from gas pipelines					0.16	0.59	4.60	16.87
	Fugitive methane from gas ops (CO2-eq)					0.50	1.84	14.43	52.90
	Total direct emissions (C and CO2-equiv)					**1**	**3**	**24**	**89**
	Total emissions, OPIC gas projects	**1,108**	**-**	**32,664**	**118**	**16**	**61**	**474**	**1,740**

Export-Import Bank of the United States & Overseas Private Investment Corporation

Direct and indirect emissions	Ex-Im, OPIC, or Vallette data: Peak production Trillion cf/yr	Peak production (MtCO2/yr)	Total project Trillion cf	Total project (MtCO2)	This report: Peak production (MtC-eq/yr)	Peak production (MtCO2-eq/yr)	Total project (MtC-eq)	Total project (MtCO2-eq)
Indirect Ex-Im emissions, Oil & Gas	**na**	**1,187**	**na**	**27,826**	**353**	**1,294**	**7,236**	**26,536**
Direct Ex-Im emissions, Oil & Gas	**na**		**na**	not estimated	**16**	**60**	**343**	**1,257**
Indirect OPIC emissions, Oil & Gas	**na**		**na**	**3,913**	**38**	**138**	**864**	**3,169**
Direct OPIC emissions, Oil & Gas	**na**		**na**	not estimated	**2**	**7**	**42**	**153**
Total Ex-Im & OPIC Emissions		**1,187**		**31,739**	**409**	**1,499**	**8,485**	**31,115**
Of which methane (C-eq and CO2-eq) =					7.4	27.0	170	622

Cell: D4
Comment: Rick Heede:
This report relies extensively on published and un-published work by both Ex-Im Bank (1999) and OPIC (2000), and also by Wysham, Sohn, & Vallette (1999). We have also used updated (and revised) unpublished spreadsheets by Jim Vallette, a 2002 report by Sustainable Energy and Economy Network (available at www.seen.org), the extensive project database posted at the seen.org website, and memoranda written by uncited Ex-Im and OPIC staff.

These publications have been essential in our efforts to identify financed projects as well as their fuel type, installed equipment, generating capacity, marginal oil and gas reserves related to financed projects, and anticipated peak or annual production rates. Neither Ex-Im nor OPIC publish details on their financed projects in their regular or annual reports. The emissions estimation protocols of both Export Credit Agencies and that of Wysham et al have been reviewed. These protocols have been not been adopted in the present work, however. The most significant differences between the previous and the current emissions accounting protocols are (a) our inclusion of several categories of indirect emissions, (b) our adoption of longer (and realistic) operating lives for power plants financed by Ex-Im or OPIC, and (c) inclusion of emissions flowing from Ex-Im/OPIC-financed oil and gas extraction projects (both ECAs disavow accounting for emissions from oil and gas fuels merely facilitated by their financial support). See the attached Declaration and the comments embedded in this spreadsheet for details.

We have made every effort to be as complete, judicious, and accurate as available data allow.

Richard Heede, Climate Mitigation Services, 1626 Gateway Road, Snowmass, Colorado 81654 USA 1-970-927-9511 heede@climatemitigation.com

-Rick-= 20Dec04

Cell: G9
Comment: Rick Heede:
Export-Import Bank (1999) "Ex-Im Bank's Role in Greenhouse Gas Emissions and Climate Change" Appendix B, Washington, DC.

Wysham, Sohn, & Vallette (1999) "OPIC, Ex-Im, and Climate Change: Business as Usual?" Institute for Policy Studies, Washington, www.seen.org.

Sustainable Energy and Economy Network (2002) "Overseas fossil fuel and renewable energy financing by U.S. government agencies (OPIC and ExIm) Since the 1992 Earth Summit" www.seen.org.

Vallette, Jim (2004) revised spreadsheets of Ex-Im and OPIC projects, plus master list of ECA and World Bank energy lending portfolios (updated to Jul04).

Cell: C10
Comment: Rick Heede:
Ex-Im does estimate indirect emissions resulting from downstream combustion of oil products and natural gas resulting from their oil & gas sector financing, although the agency report does not consider such emissions as attributable to the agency. Our analysis does include such indirect emissions from downstream consumers. We rely on Ex-Im's better knowledge of the reserves and production rates from each project financed in the list below (projects numbered 1-23 refer to Ex-Im's project numbering in Ex-Im 1999, Ex-Im Bank's Role in Greenhouse Gas Emissions and Climate Change). While Ex-Im states that direct emissions—"such as those from flaring"—are properly counted, Ex-Im does not offer such an

account in its 1999 report. Furthermore, Ex-Im's methodology is flawed. Ex-Im calculates (but excludes, as noted above) the carbon dioxide from downsteam combustion of annual production and the proven reserves expected to be produced from each oil and gas project supported by the Bank; not all such oil and gas products are likely to be combusted, however, and a portion should be properly deducted to more accurately reflect potential carbon emissions. Our report makes this adjustment for both oil and gas by deducting 9 percent and 2.9 percent of oil and gas production, respectively, to account for non-fuel uses. Nor does Ex-Im estimate direct emissions from the oil and gas projects, such as gas flaring, vented CO2, emissions from energy inputs to refineries and pipelines, and fugitive methane from oil and gas operations—even though Ex-Im acknowledges that direct emissions should be included. The Ex-Im report states: "the equivalent GHG emissions that may be produced from the fuel extraction projects supported by Ex-Im Bank are not included in the aggregate of GHG emissions assigned to Ex-Im Bank for purposes of measuring its impact on global temperature change (with exception of actual emissions, such as those from flaring—directly associated with the operation of such projects)." (Ex-Im 1999, p. 30.)

This accounting of carbon dioxide and methane emissions from Ex-Im Bank and OPIC-financed oil and gas extraction, processing, and transportation projects essentially adopts the corporate or national accounting protocols as described in the WBCSD/WRI Greenhouse Gas Protocol, the IPCC guidelines for national emissions accounting, or the IPIECA and API oil and gas sector guidelines. However, this report also includes in its estimates the indirect emissions from the downstream use of the products marketed and delivered by the projects financed by Ex-Im Bank and OPIC; that is, we include the combustion of oil and gas products by ultimate consumers of those products whose extraction and delivery is facilitated by and thus attributable to Ex-Im and OPIC as indirect emissions.

Cell: J10
Comment: Rick Heede:

Our estimate of carbon dioxide emissions resulting from the extraction of crude oil from Ex-Im Bank and OPIC-financed projects first takes account of the (1) the fraction of oil expected to be combusted in end-use vehicles, power plants, and other marketed oil products, and (2) the carbon content of the fuels refined into marketed products. (Note: Ex-Im, OPIC, and Wysham et al do not account for oil products sequestered into non-combusted products such as asphalt, motor oil, lubricants, waxes, solvents, and petrochemicals.

Method 1: EIA (2004) Annual Energy Review 2003, Table 1.15: 5.24 Q non-fuel oil uses of 38.183 Q (burned as fuel; non-fuel percentage is 5.24 / (5.24 Q + 38.183 Q) = 5.24/43.423 = 12.07 percent of petroleum products supplied.

Method 2: Table 5.11 (PDF p.183):
Asphalt and Road oil: 187.2 million bbl/yr
Lubricants: 55.1 million bbl/yr
Other:* 523 million bbl/yr
Subtotal (non-fuel uses): 765.3 million bbl/yr, or 10.67 percent
Of total oil products supplied: 7,174.4 million bbl/yr

* "Other" comprises chiefly petrochemical feedstocks as well as still gas, waxes, natural gasoline, pentanes plus, distillate and residual fuels reclassified as unfinished oils, crude oil burned as fuel, and miscellaneous products.

Method 3: Following our previous work (ExxonMobil Corporate Emissions Inventory, 1882-2002), in which we adjust Exxon's marketed non-combusted products by accounting for oxidation of "Specialty Products" such as a fraction of motor oils, lubricants, rocket fuel, special naphthas, waxes, and solvents, we concluded that 9.4 percent of ExxonMobil's marketed products were sequestered rather than combusted or oxidized.

We further note that Ex-Im Bank and OPIC fund oil and gas extraction in Asian, Russian, Africa, and Latin American economies in which non-fuel uses presumably comprise a smaller fraction of total petroleum supplied than in the United States (few countries build as many roads or use as much plastic as the U.S. economy does).

Conclusion: We thus conclude that a reasonable fraction of total extracted crude oil diverted to non-combusted uses is 9.0 percent. Future research may refine this estimated fraction, however.

The formula for the combusted fraction of Ex-Im or OPIC oil field, refinery, and pipeline portfolio is: (column F)*0.91*5.8*20.25/1000
including the following terms: Total reserve X 0.91 (combusted fraction = 1.00 - 0.09) X 5.8 million Btu/bbl X 20.25 million metric tonnes of carbon per Quad (10^15 btu) X 1000 ----> million tonnes carbon (MtC).

Cell: K10
Comment: Rick Heede:
This report's results are typically ~11 percent lower than Ex-Im's own calculations. The methodology stated in Ex-Im (1999), Appendix B are too vague for us to discern the reasons for their over-estimate (for example, are indirect emissions from oil extraction and processing included? We cannot tell, but quote: "In general, emissions as calculated have been assigned (accounted for) at the fuel consumption level only (electricity generation, manufacturing processes, and transportation) and not at the fuel production level other than due to associated flaring, passive leaks, or other onsite consumption/gas emittance." If such direct emissions from oil extraction and processing are indeed included, no factors or formulas are shown.

Furthermore, Ex-Im uses very general emissions factors (for example, not based on carbon emissions, but on the carbon content of petroleum at 87 percent carbon; 84 percent carbon is probably a better figure). This is an imprecise way of accounting for emissions.

This report's direct emissions estimates are shown separately, below, and are explicit and transparent in order to facilitate later refinements and adjustments.

Note also that Ex-Im data (column E and G) are in short tons, whereas we show data in metric tonnes. 1tonne = 1.1023 sh tons.

Consequently, once adjusted for metric vs Imperial units as well as our debit of non-combusted extraction, our results match Ex-Im's, indicating that Ex-Im does not include direct emissions, the quote from Ex-Im above suggesting that direct emissions are (or should be) included, notwithstanding.

Cell: E11
Comment: Rick Heede:
Ex-Im Bank reports emissions from power plants in metric tonnes, but their oil and gas projects in (apparently) short "tons." Hence we use "MshtCO2/yr)" in this column header.

Cell: C13
Comment: Rick Heede:
Source of projects: Ex-Im Bank (1999) Ex-Im Bank's Role in Greenhouse Gas Emissions and Climate Change, revised, Appendix C.

Cell: C14
Comment: Rick Heede:

Estimates of emissions from Ex-Im or OPIC-financed oil refinery upgrades use a different methodology. Rather than based on Total Reserve data (irrelevant for refineries), we use Ex-Im or OPIC's emissions estimates (even though it's not clear what they include or exclude), first adjusting their short ton data to tonnes, then applying the non-combusted fraction to the Ex-Im estimate of "Total CO2" emissions over the project life (assumed to be 20 years).

In practice, since it appears that our calculations match those of Ex-Im and OPIC, we simple use Ex-Im and OPIC estimates of "Total CO2" emissions over the project life (assumed to be 20 years), multiply by 0.9072 (convert to tonnes) then multiply by 0.91 (the combusted fraction of oil extracted or refined). Finally, we adjust Ex-Im's assumed project life from 20 years to 30, a more realistic duration.

The formula is: Ex-Im/OPIC "total CO2" emissions (column G) X 0.9072 X 0.91 X 1.5 (additional 50 percent project life).

Cell: C18
Comment: Rick Heede:
Ex-Im Bank has financed this project in several cycles, most recently in 2000 with $400 million and 2001 with $300 million and again in 2002 with $300 million, according to Vallette master list.

Www.seen.org: "based on Exim calculation: “Independent Engineering report assigns total remaining reserves of 13.8 billion barrels and 15 trillion cubic feet of gas. Ex-Im supported actions contribute to recovery of 2.5 billion barrels of oil and 2.7 trillion cubic feet of gas with associated peak annual production of 400 million barrels and 438 billion cubic feet of gas. Total CO-2 is 1,360 million tons. Peak annual CO-2 is 218 million tons. (Expected).”

Cell: C21
Comment: Rick Heede:
Vallette, Angola 1998-2000 Ex-Im funding of $366 million.

www.seen.org: "Based on OPIC estimate: "Sponsor Engineering reports assign total proved + probable reserves of 2.2 billion barrels of oil and 1.8 trillion cubic feet of gas with associated project peak annual production of 277 million barrels and 119 billion cubic feet of gas. Ex-Im supported actions contribute to recovery of 1.0 billion barrels of oil and 846 billion cubic feet of gas with peak annual production of 127 million barrels and 56 billion cubic feet of gas. Total CO-2 is 529 million tons. Peak annual CO-2 is 64.3 million tons." (Exim Greenhouse Gas report, 1999)"

Cell: C22
Comment: Rick Heede:
Ex-Im says project was cancelled. Www.seen.org cites estimated total emissions of 161.2 million tonnes but acknowledges that while Ex-Im approved the $27.1 million project, "no contract was issued."

Cell: C23
Comment: Rick Heede:
Sources: SEEN database at www.seen.org, Jim Vallette's updated spreadsheets on Ex-Im Bank and OPIC projects, and especially Vallette's Master spreadsheet on all ECA energy-related projects (updated to Jul04).

Note: Unlike Ex-Im data, Vallette's data is in metric tonnes of CO2. However, we account for non-fuel / non-combusted uses of oil and gas extraction by multiplying Vallette's CO2 estimate by 0.91 (9 percent non-combustion).

Cell: C27

Comment: Rick Heede:
Ex-Im (1999), project #14: "Chernogornorneft Oil Field System Rehabilitation" and total CO_2 of 15.1 million tons.

www.seen.org: project called "Chernogorskoye oil field" Total project emissions "based on reserves of 100 million barrels of oil. ExIm estimated a lower amount of CO-2 emissions from its investments within the oil field: "Independent Engineering report assigned proved + probable reserves of Ex-Im supported actions at 31.4 million barrels of oil with peak annual production of 11 million barrels. Total CO-2 is 15.1 million tons. Peak annual CO-2 is 5.3 million tons. (Expected)." (Exim GHG report 1999).

Although SEEN cites reserves of 100 million bbl, we cite here the Ex-Im estimate of 31.4 million bbl. A likely conservatism.

Cell: D27
Comment: Rick Heede:
Ex-Im data incomplete (LNG production listed as 3.3 million tons). LNG is typ 87.6 kBtu/gal, assume 6.5 lb/gal ---> 26.95 million Btu/ton, at 1,027 Btu/cf = 26.25 cf/ton; "Greenfield LNG system with projected annual throughput of ~ 3.3 million tons (Ex-Im, 1999, p. B-4) 3.3 million tons LNG thus equates to approx 86.6 billion cubic feet of natural gas per year (not counting large amounts of energy required for the liquefaction process).

Cell: J29
Comment: Rick Heede:
Condensate has a lower carbon emission factor than crude oil: 16.99 million tonnes carbon per Q of condensate.

Cell: C30
Comment: Rick Heede:
Gas-related emissions are calculated in the Table below. Tano also expects condensate production of 0.36 million bbl/yr and a condensate reserve of 2.28 million bbl. Condensate has a lower carbon emissions value.

Cell: C31
Comment: Rick Heede:
Vallette master, Brazil, OPIC 2000 guarantee of $100 million of this Unocal and El Paso Energy project. Estimated 31.5 million tonnes CO_2. No oil or gas reserve estimate is cited.

www.seen.org: estimate zero production. Also: "The agreement covers the acquisition of an initial 79% participating interest from Petrobras in five concession areas containing five proven oil and gas reservoirs, plus an initial 35% interest in a 55,000 acre exploration block. Potiguar II's participating interest in the project will be adjusted in the future in accordance with the economic performance of the project. The properties in 65 feet of water offshore the northeastern Brazilian state of Rio Grande do Norte, have gross proved developed and undeveloped reserves of 27 million barrels of oil and 381 billion cubic feet of gas. The concessions also hold an estimated additional gross resource potential of 40 to 60 million barrels of oil equivalent."

Cell: C37
Comment: Rick Heede:
"Unknown project to Ex-Im Bank 1999. Appears in Vallette master ECA list as "Panipat petrochemical refinery" Ex-Im 2003 funding of $75.1 million; emissions not estimated. www.seen.org database: not mentioned. Project not included here (insuffient data).

Cell: C38
Comment: Rick Heede:

50 billion cubic feet of gas/yr + 80,000 tons of LPGs/yr, and 330,000 bbl/yr. Ex-Im (1999) did not disaggregate its emissions estimate, and we run their estimated "Total CO2" emissions in lieu of a commodity-based calculation.

Cell: C39
Comment: Rick Heede:
Sources: SEEN database at www.seen.org, Jim Vallette's updated spreadsheets on Ex-Im Bank and OPIC projects, and especially Vallette's Master spreadsheet on all ECA energy-related projects (updated to Jul04).

Note: Unlike Ex-Im data, Vallette's data is in metric tonnes of CO2. However, we account for non-fuel / non-combusted uses of oil and gas extraction by multiplying Vallette's CO2 estimate by 0.91 (9 percent non-combustion).

We have not included carbon emissions from the two Ex-Im coal-related projects identified:
Raspadsky (Russia) surface coal mine: Vallette master list: Coal investment by Ex-Im, 2003 of $22.6 million; no CO2 emissions estimate.
Karbo (Russia) coal mining equipment: Vallette master list: Ex-Im 2004 $9.8 million; no estimate of CO2 emissions or coal mined or nature of project. Not included here.

Cell: G39
Comment: Rick Heede:
That is, metric tonnes. Ex-Im data above is in short tons.

Cell: C40
Comment: Rick Heede:
www.seen.org database: "Based on 14 million tons of operation, for 20 years" and "In 1995, Exim supported a $59.9 million contract in which Stone & Webster Engineering Corp. supplied engineering services to Yaroslavenfteorgsintez for a petroleum refining project. This followed an Exim board authorization of $56.4 million guarantee for this project."

14 million tonnes of oil throughput = 102.2 million bbl/yr, over 20 yrs = 2,044 million bbl.

Slavneft website: "The enterprise's primary crude refining capacity is 14 mln tons.... by 1995, a complex of installations had been constructed at the refinery that provided for production of white and black products, liquefied gas, petrochemical raw material and lubricants. The refinery produces a wide range of oil products, such as: straight-run (virgin) gasoline, motor gasoline, aviation kerosene, summer and winter brand of diesel fuel, fuel oil, liquefied gas, base and commercial lubricants (for carburettor and diesel engines, as well as motor universal semi-synthetic, synthetic, industrial, transmission, turbine, and vacuum oils), bitumen, tar, sulfuric oil, solvents, paraffin-wax products."

Cell: C41
Comment: Rick Heede:
Vallette updated ECA master spreadsheet (under Azerbaijan). 2003 Ex-Im fuding of $160 million, plus OPIC funding of $100 million. Estimated 3,100 million tonnes CO2.

www.seen.org: "Based on planned capacity of 50 million tons per year, for 20 years." and ""The Export-Import Bank of the United States (Ex-Im Bank) today approved a $160 million long-term guarantee to support the export of U.S. equipment and services for construction of the Baku-Tbilisi-Ceyhan Pipeline project (BTCP). The Bank acted after referring the transaction to Congress and the expiration of a statutory 35-day waiting period during which no comments were received." ("Ex-Im Bank approves $160 million guarantee to support Baku-Tbilisi-Ceyhan pipeline," U.S. Export-Import Bank, Dec. 30, 2003)."

Note: we have not verified Vallette's estimate of 50 million tonne pipeline throughput per year over 20 years (= 365 million bbl/yr = 7,300 million bbl total).

Note: A 20 year time-horizon may be too short for a $3.7 billion project and Central Asia's vast oil reserves. Up project life to 30 years, as elsewhere?

Cell: C43
Comment: Rick Heede:
The SEEN database (www.seen.org) shows projected oil and gas emissions "based on estimated reserves of 1.2 billion barrels of oil (164.4 million tons)."

We assume the standard 20-year project life applies, thus annual production (and our annual CO2 emissions estimate) is 1.2 billion bbl/20 = 60 million bbl/yr.

Cell: C44
Comment: Rick Heede:
Vallette: 2000 Ex-Im Bank funding of $158 million, plus OPIC funding of $250 million in 2000. Vallette estimates 445.9 million tonnes CO2 over this oil field and pipeline project life "based on 225,000 bpd capacity, for 20 years." Vallette's estimate 0f 446 million tonnes of CO2 appears to be low. Check.

Cell: C45
Comment: Rick Heede:
Vallette master ECA spreadsheet. China, West East gas pipeline, 2004 Ex-Im financing of $40 million. Cites no estimate of oil throughput or CO2 emissions.
www.seen.org: not listed. Project not included here (insuffient data).

Cell: C46
Comment: Rick Heede:
Vallette master: 2000 Mexico, Ex-Im financing of $88.7 million, estimated emissions of 106 million tonnes CO2 "based on anticipated production of 250 million barrels of oil equivalent due to this program;" and " In 2000, Exim financed a $94.4 million contract in which Schlumberger Technology Corp. and Western Geophysical supplied drilling fluids and services to this Pemex (Petroleos Mexicanos) oil field project."

Cell: C47
Comment: Rick Heede:
Vallette masterlist: 2003, Mexico, Ex-im financing of $400 million, but no estimate of CO2 emissions or oil and gas throughput.
www.seen.org: no entry. No estimate included here (insufficient data).

Cell: C48
Comment: Rick Heede:
www.seen.org: Based on production of 140 million tons (@ 7.3 bbl = 1,012 million bbl) of oil over a 20 year period. "In 1999, Exim financed a $159.8 million contract in which Siemens Corp. supplied instrumentation and control equipment to Pemex for a petroleum refinery upgrade."

Cell: C49
Comment: Rick Heede:
www.seen.org; Salamance oil refinery expansion, emission estimate "based on 3.65 million barrels of oil per year, for 20 years." and "In 2000, Exim financed a $29 million contract in which Samsung Engineering America supplied engineering services to the Salamanca oil refinery." Estimated 31 million tonnes CO2 or ver project life (20 years).

Cell: C50
Comment: Rick Heede:

www.seen.org: 1991 Ex-Im financing; "based on 50,000 bpd production" = 18.25 million bbl/yr for 15 years = 237.75 million bbl and "116.25 million tonnes CO2." Also in Vallette master list, but as "Mobil offshore," 2001 Ex-Im financing of $10 million and 116 million tonnes CO2 (as above).

Cell: C51
Comment: Rick Heede:
Vallette master list: Amakpe-Eket crude oil refinery, Nigeria, Ex-Im Bank funding of $10.3 million in 2004; no estimate of CO2 emissions or oil throughput.
www.seen.org: no record in ECA project database.
Carbon emissions no estimated (lack of data).

Cell: C52
Comment: Rick Heede:
Vallette mast list: 2001 Ex-Im Bank financing of $503.6 million; Estimated CO2: 892 million tonnes CO2.

Check www.seen.org: "2.1 billion barrels of oil = 287.7 million tons of oil, which will release 891.2 million tons of CO-2 when burned" and "In 2001, ExIm supported a $503.6 million contract in which Fluor Enterprises provided technical services to Petrolera Ameriven S.A. for "Hamaca heavy oil upgrading."

Cell: C55
Comment: Rick Heede:
The aim of this report is to account for both direct and indirect emissions of greenhouse gases that result from the projects financed by Ex-Im Bank and OPIC, regardless of the ECAs level of financial involvement. Direct emissions are typically defined as arising from facilities owned or controlled by the entity in question. Thus emissions from fuels combusted at Ex-Im and OPIC-financed power plants are considered direct emissions by both ECAs, the Wysham et al reports by the Sustainable Energy and Economy Network, and this report. In the power sector we also included indirect emissions from their fuel combustion, e.g., fugitive methane from coal mines, and emissions from oil refineries whose emissions are attributable to the entities that create the demand for the fuels.

Ex-Im Bank and OPIC conclude that emissions from projects financed in the oil and gas sector are neither direct nor indirect, and neither agency account for any emissions from these projects (although Ex-Im does estimate emissions from oil and gas projects 1988-1999 in their 1999 report, but conclude, nonetheless, that such emissions are not attributable to the agency). This report does not concur: Ex-Im and OPIC financing of oil and gas projects assist in the construction of carbon extraction projects, and it is immaterial whether the foreign governments or their corporate partners own or control the equipment that ultimately convert the carbon fuels into carbon dioxide. The ECAs have enabled additional carbon to enter the global economy in an era when it is widely acknowledged that the world's economies must take serious steps to reduce emissions. Granted, both Ex-Im and OPIC also invest in low- and zero-carbon electric generation, and both ECAs appear to be increasing such investments. Furthermore, both agencies invest in new and rehabilitation plants that improve the efficiency of oil and gas extraction and power generation projects.

This report thus considers the eventual combustion of the oil products and dry natural gas flowing from Ex-Im and OPIC-financed projects as direct emissions attributable to these agencies. Furthermore, we designate and account for related emissions -- such as methane leakage from gas pipelines or processing energy used to refine crude oil into marketable products -- as direct emissions. (Note: both Ex-Im and OPIC do consider such direct emissions as attributable to them, since the emissions occur within the owned or controlled facilities financed by them [as opposed to emissions from downstream consumers], but neither agency makes an attempt to estimate the emissions.) This report does estimate these direct emissions from Ex-Im and OPIC-financed oil and gas operations.

Ex-Im's 1999 report does not offer an accounting of direct emissions resulting from their oil & gas sector project financing, even though the text avers that direct emissions are rightly counted.

Cell: C56
Comment: Rick Heede:
See the "CO2 from flared gas at natural gas production facilities" below for details.

Significant quantities of gas is flared at oil production, processing, storage, and delivery facilities. This in an indirect emission of carbon dioxide attributed to Ex-Im and OPIC-financed oil-fired power plants. We allocate 60 percent of this flaring rate to gas and 40 percent to oil production, processing, storage, and delivery. Gas flaring attributable to oil thus becomes 2 percent x 0.4 = 0.8 percent.

The formula is thus: current and future (over the 40-year operating life) emission from gas consumed at Ex-Im bank/OPIC gas-fired power plants x 0.008.

Cell: C57
Comment: Rick Heede:
The previous worksheet on power plants on indirect emissions includes an estimate of the emissions arising from the energy used to operate refineries (conservatively, 4 percent). This indirect emission source is reduced for extraction and refining of crude oil, since refineries typically use their own oil products to operate the refineries (except for purchased steam, for example). In the current case, emissions from refinery energy use is considered a direct emissions source, except for additional emissions associated with steam and electricity purchased from other providers (in which case these emissions are considered "indirect").

The data we have for Ex-Im and OPIC oil extraction projects are amounts of oil lifted per year (or peak production) or over the duration of its proven recoverable reserves (typically assumed to be 20 years, unless specified by other productoin plans) -- and all of the carbon therein is either combusted at refineries or delivered to consumers or sequestered into non-combusted products (which we account for in "Indirect emissions" above) -- we do not estimate additional direct emissions from oil extraction projects.

We do, however, add 2.0 percent of carbon emissions from oil projects as an estimate of direct emissions at refineries from on-site power generation or combined heat and power. This factor may prove conservative, but at least we know it is not zero.

The formula is thus: carbon emissions from oil extraction and refinery operations financed by Ex-Im and OPIC X 0.02.

Cell: C58
Comment: Rick Heede:
We use Argonne National Laboratory's GREET model as guidance to making an estimate on other fuel cycle energy inputs to transportation of crude, natural gas, and petroleum products from "wells to wheels."

Crude oil shipping by tankers (VLCCs): GREET assumptions: 5,080 miles average distance, 19 mph average speed, 4,763 Btu per horsepower-hour (typical tanker shaftpower = 124,500 HP); result: 6,089 Btu energy input to move one million Btu of crude oil, or 0.61 percent. Of course, not all oil company crude to refineries arrive by ocean-going tankers, so we dilute this adder by 0.57 (US averages 57 percent imported crude + products), thus the formula is 0.61% x 0.57 = 0.348 percent of total products marketed.
Note: we believe the GREET estimates include energy required to back-haul a tanker, but

this is uncertain; if not, GREET data suggest that backhauling a VLCC requires 20 Btu per ton-mile (vs 22 Btu/ton-mile for the front-haul). See GREET.xls, worksheet on Transportation and Distribution, section #9.

Pipelines: GREET assumptions: distance pipelined (750 miles for crude, 400 miles for products from refineries to tank farms), 270 Btu per ton-mile; results: 3,815 million Btu of petroleum input to pipeline transport of one million Btu of crude oil (1,998 Btu per million Btu of gasoline pipelined). Note: this excludes other energy inputs, such as gas or electricity used in pipelines, which brings the pipeline energy input to 6,129 Btu per million Btu of crude thus transported.) Dilution: assume that 43 percent of crude is shipped to refineries by pipeline (thus 0.43 x 3,815 = 1,640 Btu per million Btu of total crude shipped), plus assume that all products are pipelined from refineries to tank farms (at 1,998 Btu per million Btu of refined products); total 1,640 + 1,998 = 3,638 Btu per million Btu, total energy input to pipeline of crude and products, or 0.364 percent.

Conclusion: oil inputs to transportation of 0.763% (for domestic waterborne shipping) + 0.348% (for crude oil and products transport by ocean-going tankers) + 0.364% (for pipeline of crude and products) = 1.475 percent. Detailed analysis will probably find this result to be conservative.

The formula is thus: carbon emissions from oil consumed in Ex-Im and OPIC-financed oil-fired power plants x 0.0148.

Note: Not included in this or any other direct emissions estimate of OPIC and Ex-Im projects is the considerable energy and emissions embodied in the construction of the power plants and the infrastructure to extract, refine, and deliver fuel; nor is the energy invested in building electric transmission grids included in the power plant worksheets.

Sources: Stacy Davis (2001) Transportation Energy Data Book, edition 21, U.S. Dept of Energy, Center for Transportation Analysis, Oak Ridge National Laboratory, Oak Ridge, TN. Tables 12-4, 12-5, and 1-11., and personal communication.

Michael Q. Wang, Argonne National Laboratory, GREET model, www.transportation.anl.gov/greet/index.html, and personal communication 18Jul03.

We estimate direct emissions from oil transportation to equal a conservative 1.0 percent of the carbon in the transported oil. This may prove conservative with additional research into this source of direct emissions attributable to Ex-Im and OPIC-financed projects.

The formula is thus: carbon emissions from oil extracted, refined, or transported in Ex-Im and OPIC-financed oil-projects X 0.01.

Cell: C59
Comment: Rick Heede:
Fugitive methane leakage from gas pipelines can be as high as 5 percent of throughput in older systems. New pipelines with modern flanges, valves, seals, and compressors are typically 0.5 to 1.0 percent (OPIC 2000 p. 12 cites leakage estimates ranging from 0.5 to 5.0 percent). Since Ex-Im and OPIC invest in new and presumably state-of-the-art projects and rehabilitation projects, we assume a world-wide fugitive methane rate of 0.5 percent on all Ex-Im and OPIC gas projects. This rate is applied to all gas-related projects to capture methane leakage from gas pipelines, gas production facilities, processing, liquefaction plants, and un-burned methane at flares. Future research may refine this methodology. A smaller fraction (0.2 percent) is applied to Ex-Im and OPIC-financed oil projects, above, to account for methane leakage from oil operations, oil pipelines, oil storage (CH_4 "flashing" losses alone are estimated at 0.885 kg CH_4 per barrel in oil tank farms (American Petroleum Institute, 2001, Greenhouse Gas Compendium), oil production sites, incomplete flaring, and

so on.

To convert this estimated fugitive methane emission rate into carbon equivalent, we use IPCC's GWP of CH4 = 23 x CO2, translating to 1 unit of methane = 6.272 x Carbon-equivalent.*

The formula is: carbon emissions from annual and total project throughput (columns E and G) X 0.002 (0.2 percent) X 6.272 = tonnes of methane in carbon-equivalent (column H and J) -- which is converted to CO2-equivalent by multiplying C-eq by 3.667 in columns I and K.

* To convert fugitive methane emissions to carbon-equivalent emissions: multiply methane emissions by 23 (the methane global warming potential factor [GWP] CH4:CO2) and divide by 3.667 (CO2:carbon), 23/3.667, or a factor of 6.272.

Note: the global warming potential of methane has been revised from 21 x CO2 to 23 x CO2 by the IPPC. Source: Houghton, J. T. et al (2001) Climate Change 2001: The Scientific Basis, Working Group One, Third Assessment, IPPC, Cambridge University Press, p. 388.

Cell: G68
Comment: Rick Heede:
Export-Import Bank (1999) "Ex-Im Bank's Role in Greenhouse Gas Emissions and Climate Change," Appendix B, Washington, DC.

Wysham, Sohn, & Vallette (1999) "OPIC, Ex-Im, and Climate Change: Business as Usual?" Institute for Policy Studies, Washington, www.seen.org.

Sustainable Energy and Economy Network (2002) "Overseas fossil fuel and renewable energy financing by U.S. government agencies (OPIC and ExIm) Since the 1992 Earth Summit" www.seen.org.

Vallette, Jim (2004) revised spreadsheets of Ex-Im and OPIC projects, plus master list of ECA and World Bank energy lending portfolios (updated to Jul04).

Cell: J69
Comment: Rick Heede:
Our estimate of carbon dioxide emissions resulting from the extraction of natural gas from Ex-Im Bank and OPIC-financed projects first takes account of the (1) the fraction of gas expected to be combusted, and (2) the carbon content of the fuels refined into marketed products. (Note: Ex-Im, OPIC, and Wysham et al do not account for natural gas sequestered into non-combusted products such as petrochemicals and fertilizers.

EIA (2004) Anuual Energy Review 2002, Table 1.15: 0.68 Q of 23.062 burned as fuel, thus 0.68Q/(0.68 + 23.062Q) = 2.86 percent of natural gas supplied.

Conclusion: We thus conclude that a reasonable fraction of total extracted natural gas diverted to non-combusted uses is 2.86 percent. Future research may refine this estimated fraction.

The formula is: =(column F)*0.91*5.8*20.25/1000
and terms: Total reserve X 0.9714 (combusted fraction = 1.00 - 0.0286) X 1.027 million Btu/bbl X 14.47 million metric tonnes of carbon per Quad (10^15 btu) X 1000 ----> million tonnes carbon (MtC).

Cell: K69
Comment: Rick Heede:
See discussion under Ex-Im "oil" above.

Cell: C72
Comment: Rick Heede:
Listed as annual 146 billion cf gas plus 36.5 million bbl of NGLs. Our estimate adjusts Ex-Im's emissions estimate as described above.

Cell: E73
Comment: Rick Heede:
Ex-Im 1999, Appendix B, did not calculate oil and gas emissions separately; gas emissions included under "Oil."

Cell: G73
Comment: Rick Heede:
Ex-Im 1999, Appendix B, did not calculate oil and gas emissions separately; gas emissions included under "Oil."

Cell: C80
Comment: Rick Heede:
Estimates of emissions from Ex-Im or OPIC-financed gas pipelines use a different methodology. Rather than based on Total Reserve data (irrelevant for pipelines), we use Ex-Im or OPIC's emissions estimates, first adjusting their short ton data to tonnes, then applying the non-combusted fraction to the Ex-Im estimate of "Total CO2" emissions over the project life (assumed to be 20 years).

In practice, since it appears that our calculations match those of Ex-Im and OPIC, we simple use Ex-Im and OPIC estimates of "Total CO2" emissions over the project life (assumed to be 20 years), multiply by 0.9072 (convert to tonnes) then multiply by 0.91 (the combusted fraction of oil extracted or refined). Finally, we adjust Ex-Im's assumed project life from 20 years to 30, a more realistic yet conservative project duration. Note: Check on typical gas pipeline project life (could average 50 or more years).

The formula is: Ex-Im/OPIC "total project in billion cf" (column F) X 0.9714 (combusted gas fraction) X 1.027 kBtu/cf X 14.47 million tonnes carbon per Q Btu X 1.5 (additional 50 percent project life)/1000 (unit normalization).

=F92*0.9714*1.027*14.47*1.5/1000

Cell: C87
Comment: Rick Heede:
6.6 million tons LNG (listed here in column D based on formula in "Atlantic LNG" above). Plus throughput of 5.8 million bbl of condensate per year. We adjust Ex-im CO2 emissions as explained above.

Cell: C88
Comment: Rick Heede:
Ex-Im correctly uses the petrochem plant's fuel use (rather than its 495,000 ton throughput of ethylene olefins). Lacking project details, we adopt Ex-Im's total project CO2 estimate (6.1 million tons over 20-year project life), but convert to tonnes and project life to 30 years.

Cell: C92
Comment: Rick Heede:
Sources: SEEN database at www.seen.org, Jim Vallette's updated spreadsheets on Ex-Im Bank and OPIC projects, and especially Vallette's Master spreadsheet on all ECA energy-related projects (updated to Jul04).

Cell: C93

Comment: Rick Heede:
Vallette as 1993 OPIC $200 million + Ex-Im Bank $35 million, estimated 52 million tonnes CO2: "Enron India oil and gas development" but not listed in Ex-Im report 1999.
www.seen.org: not listed.

Cell: C94
Comment: Rick Heede:
Vallette master list: Ex-Im 2000 funding of $84.7 million. Estimated emissions of 9.57 million tonnes CO2.
Www.seen.org: "6.8 million tons natural gas per year, 20 years operation." and "In 2000, Exim financed a $84.7 million deal in which Air Products and Chemicals sold cryogenic heat exchangers to Malaysia LNG Tiga."

Erroneous data from seen.org: 6.8 million tonnes of natural gas per year converts to 340 billion cf/yr* which means a carbon flow of 540 million tonnes of CO2 over 20 years, not seen.org's "9.57 million" tonnes. Natural gas is not typically measured in tonnes, although LNG often is; if "6.8 million tons per year" refers instead to LNG output, then the CO2 emissions are based on ~178.4 billion cf/yr (see calculation under "Atlantic LNG plant of 3.3 million tonnes LNG/yr), which means 9.4 million tonnes of CO2 per year. We conclude that this is likely the datum meant by seen.org, and enter a natural gas throughput of 178.4 billion cf/yr.

* At www.chemlink.com.au/conversions.htm: 1 TCF = 20 million tonnes. Thus "6.8 million tons natural gas per year" equals 0.34 TCF/yr = 340 billion cf/yr.

Cell: C95
Comment: Rick Heede:
Vallette master ECA list: Mexico, Ex-Im funding of $73.4 million; no estimate of CO2 emission or gas throughput. Nor is this project listed at www.seen.org. Project is therefore not included here (insufficient data).

Cell: C96
Comment: Rick Heede:
Vallette master list: "PEMEX strategic gas program, 2004 Ex-Im financing of $200 million, but no details on nature of project, reserve or production stats, or CO2 emission estimate. Project not included here (insufficient data).

Cell: C97
Comment: Rick Heede:
Vallette master ECA list: 2002 Ex-Im funding of $135 million, no estimated gas throughput. Not listed at www.seen.org. No data upon which to base emissions estimate.

Cell: C98
Comment: Rick Heede:
Vallette master list: 1998, Turkmenistan, Ex-Im Bank financing of $105.4 million; estimated emissions of 1,147 million tonnes over project life.
Www.seen.org: 21.9 TCF over 20 years.

Cell: C101
Comment: Rick Heede:
The aim of this report is to account for both direct and indirect emissions of greenhouse gases that result from the projects financed by Ex-Im Bank and OPIC, regardless of the ECAs level of financial involvement. Direct emissions are typically defined as arising from facilities owned or controlled by the entity in question. Thus emissions from fuels combusted at Ex-Im and OPIC-financed power plants are considered direct emissions by both ECAs, the Wysham et al reports by the Sustainable Energy and Economy Network, and this report. In

the power sector we also included indirect emissions from their fuel combustion, e.g., fugitive methane from coal mines, and emissions from oil refineries whose emissions are attributable to the entities that create the demand for the fuels.

Ex-Im Bank and OPIC conclude that emissions from projects financed in the oil and gas sector are neither direct nor indirect, and neither agency account for any emissions from these projects (although Ex-Im does estimate emissions from oil and gas projects 1988-1999 in their 1999 report, but conclude, nonetheless, that such emissions are not attributable to the agency). This report does not concur: Ex-Im and OPIC financing of oil and gas projects assist in the construction of carbon extraction projects, and it is immaterial whether the foreign governments or their corporate partners own or control the equipment that ultimately convert the carbon fuels into carbon dioxide. The ECAs have enabled additional carbon to enter the global economy in an era when it is widely acknowledged that the world's economies must take serious steps to reduce emissions. Granted, both Ex-Im and OPIC also invest in low- and zero-carbon electric generation, and both ECAs appear to be increasing such investments. Furthermore, both agencies invest in new and rehabilitation plants that improve the efficiency of oil and gas extraction and power generation projects.

This report thus considers the eventual combustion of the oil products and dry natural gas flowing from Ex-Im and OPIC-financed projects as direct emissions attributable to these agencies. Furthermore, we designate and account for related emissions -- such as methane leakage from gas pipelines or processing energy used to refine crude oil into marketable products -- as direct emissions. (Note: both Ex-Im and OPIC do consider such direct emissions as attributable to them, since the emissions occur within the owned or controlled facilities financed by them [as opposed to emissions from downstream consumers], but neither agency makes an attempt to estimate the emissions.) This report does estimate these direct emissions from Ex-Im and OPIC-financed oil and gas operations.

Ex-Im's 1999 report does not offer an accounting of direct emissions resulting from their oil & gas sector project financing, even though the text avers that direct emissions are rightly counted.

Cell: C102
Comment: Rick Heede:
While global gas flaring is decreasing, it still represents 2.5 percent of carbon emissions from global natural gas consumption, down from 4.3 percent in 1990. The flaring percentage is likely to decrease further, and we use 2.0 percent of gas consumption to project future flaring emissions. This in a direct emission of carbon dioxide attributed to Ex-Im and OPIC-financed gas extraction, processing, liquefaction, and pipeline projects. We allocate 60 percent of this flaring rate to gas and 40 percent to oil production, processing, storage, and delivery. Gas flaring thus becomes 2 percent x 0.6 = 1.2 percent.

The formula is thus: current and future (over the 40-year operating life) emission from gas extracted, processed, or transported through Ex-Im bank/OPIC gas projects x 0.012.

Data from Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy. cdiac.esd.ornl.gov/

Cell: C103
Comment: Rick Heede:
The previous worksheet on power plants on indirect emissions includes an estimate of the emissions arising from the energy used to operate refineries (conservatively, 4 percent). This indirect emission source is reduced for extraction and refining of crude oil, since refineries typically use their own oil products to operate the refineries (except for purchased steam, for example). In the current case, emissions from refinery energy use is considered a direct emissions source, except for additional emissions associated with steam and electricity

purchased from other providers (in which case these emissions are considered "indirect").

The data we have for Ex-Im and OPIC gas extraction, processing, and liquefaction projects are amounts of gas produced -- and all of the carbon therein is either combusted at gas processing plants or delivered to consumers or sequestered into non-combusted products (which we account for in "Direct emissions" above) -- and we do not estimate additional indirect emissions from gas extraction projects.

We add 1.0 percent of carbon emissions from gas projects as an estimate of direct emissions at gas processing plants as an estimate of emissions from on-site power generation or combined heat and power. This factor may prove conservative, but at least we know it is not zero.

The formula is: carbon emissions from gas extraction and refinery operations financed by Ex-Im and OPIC X 0.01.

Cell: C104
Comment: Rick Heede:
We estimate direct emissions from gas transportation to equal (conservatively) 1.0 percent of the carbon in all Ex-Im and OPIC gas extraction, processing, and pipeline-related projects to capture the emissions from fuels (such as on-site generation of electricity) used to power natural gas pipelines. This may prove conservative with additional research into this source of direct emissions attributable to Ex-Im and OPIC-financed projects.

The formula is thus: carbon emissions from gas extracted, refined, or transported in Ex-Im and OPIC-financed gas-projects X 0.01.

Cell: C105
Comment: Rick Heede:
Fugitive methane leakage from gas pipelines can be as high as 5 percent of throughput in older systems. New pipelines with modern flanges, valves, seals, and compressors are typically 0.5 to 1.0 percent (OPIC 2000 p. 12 cites leakage estimates ranging from 0.5 to 5.0 percent). Since Ex-Im and OPIC invest in new and presumably state-of-the-art projects and rehabilitation projects, we assume a world-wide fugitive methane rate of 0.5 percent on all Ex-Im and OPIC gas projects. This rate is applied to all gas-related projects to capture methane leakage from gas pipelines, gas production facilities, processing, liquefaction plants, and un-burned methane at flares. Future research may refine this methodology. A smaller fraction (0.2 percent) is applied to Ex-Im and OPIC-financed oil projects, above, to account for methane leakage from oil operations, oil pipelines, oil storage (CH4 "flashing" losses are estimated at 0.885 kg CH4 per barrel in oil tank farms (American Petroleum Institute

To convert this estimated fugitive methane emission rate into carbon equivalent, we use IPCC's GWP of CH4 = 23 x CO2, translating to 1 unit of methane = 6.272 x Carbon-equivalent.*

The formula is: carbon emissions from annual and total project throughput (columns E and G) X 0.005 (0.5 percent) X 6.272 = tonnes of methane in carbon-equivalent (column H and J) -- which is converted to CO2-equivalent by multiplying C-eq by 3.667 in columns I and K.

* To convert fugitive methane emissions to carbon-equivalent emissions: multiply methane emissions by 23 (the methane global warming potential factor [GWP] CH4:CO2) and divide by 3.667 (CO2:carbon), 23/3.667, or a factor of 6.272.

Note: the global warming potential of methane has been revised from 21 x CO2 to 23 x CO2 by the IPPC. Source: Houghton, J. T. et al (2001) Climate Change 2001: The Scientific Basis, Working Group One, Third Assessment, IPPC, Cambridge University Press, p. 388.

Cell: G114
Comment: Rick Heede:
OPIC (unlike Ex-Im) did not generate estimates of emissions resulting from the agency's oil and gas portfolio.

We have thus relied exclusively on information from outside the agency:

Wysham, Sohn, & Vallette (1999) "OPIC, Ex-Im, and Climate Change: Business as Usual?" Institute for Policy Studies, Washington, www.seen.org.

Sustainable Energy and Economy Network (2002) "Overseas fossil fuel and renewable energy financing by U.S. government agencies (OPIC and ExIm) Since the 1992 Earth Summit" www.seen.org.

Vallette, Jim (2004) revised spreadsheets of Ex-Im and OPIC projects, plus master list of ECA and World Bank energy lending portfolios (updated to Jul04).

Cell: C115
Comment: Rick Heede:
OPIC's report Climate Change: Assessing Our Actions (2000) does not offer an accounting of emissions resulting from their oil & gas sector project financing, neither direct nor indirect--although the text avers that direct emissions are properly counted, although OPIC does not offer such an account. This report estimates indirect emissions from downstream consumers as attributable to OPIC's energy portfolio. We also estimate direct emissions (see section below).

Cell: J115
Comment: Rick Heede:
See our methodology discussion under Ex-Im's oil worksheet.

Cell: C118
Comment: Rick Heede:
Source of project information:

Wysham, Daphne, Jon Sohn, & Jim Vallette (1999) OPIC, Ex-Im and Climate Change: Business as Usual? An Analysis of U.S. Government Support for Fossil Fueled Development Abroad, 1992-1998, Institute for Policy Studies, Friends of the Earth, and International Trade Information Service Washington, 113 pp., www.seen.org.

Sustainable Energy and Economy Network (2002) Overseas fossil fuel and renewable energy financing by U.S. government agencies (OPIC and ExIm) Since the 1992 Earth Summit, Sustainable Energy and Economy Network, Washington, 12 pp., www.seen.org

The global ECA and World Bank projects database descriptions at www.seen.org.

OPIC's report Climate Change: Assessing Our Actions (2000) does not offer an accounting of emissions resulting from their oil & gas sector project financing, neither direct nor indirect -- the text avers that direct emissions are rightly counted, although does not offer an account.

Cell: C121
Comment: Rick Heede:
Vallette master ECA list: OPIC 2002 funding of $350 million. Estimated emissions of 46 million tonnes CO2. Not found at www.seen.org ECA project database.

Cell: C122
Comment: Rick Heede:
Vallette master list: OPIC 1996 $130 million, 40.3 million tonnes CO2.
Www.seen.org: "Based on reserves of 95 million barrels of oil." and "Gobe is among a string of prospective and active oil and gas fields stretching from the interior of PNG to the Gulf of Papua. A proposed pipeline would run to Australia." Also mentions a capacity of 45 million bbl/yr.

Cell: C123
Comment: Rick Heede:
www.seen.org: Total project emissions of 99.9 million tonnes of CO2 "based on 32,500 bpd capacity operation for 20 years." (=11.86 million bbl/yr). And "This project installs a 32,500-b/d crude distillation unit." and "A US$ 180 million hydroskimming refinery in Napa Napa... will be the first refinery in the country. It plans to employ 75-100 people for operations and maintenance. Scope of work for the engineering, procurement, and construction (EPC) contractor includes site civil work, a storage tank farm, a 32,500-b/d crude distillation unit, a 5,000-b/d hydrodesulfurization (HDS) unit, a 3,500-b/d catalytic reforming unit, a jetty with ship loading and unloading facilities, utility systems including steam and power generation, and site infrastructure and support facilities."

Cell: C124
Comment: Rick Heede:
Vallete master list: OPIC 2003, $130 million, no estimate of CO2 emissions or throughput.
www.seen.org: no mention. Excluded here (insufficient data).

Cell: C128
Comment: Rick Heede:
Polar Lights (Ardalin) oil field cited in Vallette master list for OPIC in 1993 ($50 mllion) and 1994 ($200 million). CO2 estimate: 47.0 million tonnes CO2 over (presumably) 20 years.
Www.seen.org database: not listed. Project not included here (insufficient data).

Cell: C137
Comment: Rick Heede:
The aim of this report is to account for both direct and indirect emissions of greenhouse gases that result from the projects financed by Ex-Im Bank and OPIC, regardless of the ECAs level of financial involvement. Direct emissions are typically defined as arising from facilities owned or controlled by the entity in question. Thus emissions from fuels combusted at Ex-Im and OPIC-financed power plants are considered direct emissions by both ECAs, the Wysham et al reports by the Sustainable Energy and Economy Network, and this report. In the power sector we also included indirect emissions from their fuel combustion, e.g., fugitive methane from coal mines, and emissions from oil refineries whose emissions are attributable to the entities that create the demand for the fuels.

Ex-Im Bank and OPIC conclude that emissions from projects financed in the oil and gas sector are neither direct nor indirect, and neither agency account for any emissions from these projects (although Ex-Im does estimate emissions from oil and gas projects 1988-1999 in their 1999 report, but conclude, nonetheless, that such emissions are not attributable to the agency). This report does not concur: Ex-Im and OPIC financing of oil and gas projects assist in the construction of carbon extraction projects, and it is immaterial whether the foreign governments or their corporate partners own or control the equipment that ultimately convert the carbon fuels into carbon dioxide. The ECAs have enabled additional carbon to enter the global economy in an era when it is widely acknowledged that the world's economies must take serious steps to reduce emissions. Granted, both Ex-Im and OPIC also invest in low- and zero-carbon electric generation, and both ECAs appear to be increasing such investments. Furthermore, both agencies invest in new and rehabilitation plants that improve the efficiency of oil and gas extraction and power generation projects.

This report thus considers the eventual combustion of the oil products and dry natural gas flowing from Ex-Im and OPIC-financed projects as direct emissions attributable to these agencies. Furthermore, we designate and account for related emissions -- such as methane leakage from gas pipelines or processing energy used to refine crude oil into marketable products -- as direct emissions. (Note: both Ex-Im and OPIC do consider such direct emissions as attributable to them, since the emissions occur within the owned or controlled facilities financed by them [as opposed to emissions from downstream consumers], but neither agency makes an attempt to estimate the emissions.) This report does estimate these direct emissions from Ex-Im and OPIC-financed oil and gas operations.

OPIC's report "Climate Change: Assessing Our Actions" (2000) does not offer an accounting of emissions resulting from their oil & gas sector project financing, neither direct nor indirect -- even though the text avers that direct emissions are rightly counted, although does not offer an account.

Cell: C138
Comment: Rick Heede:
See the "CO2 from flared gas at natural gas production facilities" below for details.

Significant quantities of gas is flared at oil production, processing, storage, and delivery facilities. This in an indirect emission of carbon dioxide attributed to Ex-Im and OPIC-financed oil-fired power plants. We allocate 60 percent of this flaring rate to gas and 40 percent to oil production, processing, storage, and delivery. Gas flaring attributable to oil thus becomes 2 percent x 0.4 = 0.8 percent.

The formula is thus: current and future (over the 40-year operating life) emission from gas consumed at Ex-Im bank/OPIC gas-fired power plants x 0.008.

Cell: C139
Comment: Rick Heede:
The previous worksheet on power plants on indirect emissions includes an estimate of the emissions arising from the energy used to operate refineries (conservatively, 4 percent). This indirect emission source is reduced for extraction and refining of crude oil, since refineries typically use their own oil products to operate the refineries (except for purchased steam, for example). In the current case, emissions from refinery energy use is considered a direct emissions source, except for additional emissions associated with steam and electricity purchased from other providers (in which case these emissions are considered "indirect").

The data we have for Ex-Im and OPIC oil extraction projects are amounts of oil lifted per year (or peak production) or over the duration of its proven recoverable reserves (typically assumed to be 20 years, unless specified by other productoin plans) -- and all of the carbon therein is either combusted at refineries or delivered to consumers or sequestered into non-combusted products (which we account for in "Indirect emissions" above) -- we do not estimate additional direct emissions from oil extraction projects.

We do add 2.0 percent of carbon emissions from oil projects as an estimate of direct emissions at refineries from on-site power generation or combined heat and power. This factor may prove conservative, but at least we know it is not zero.

The formula is: carbon emissions from oil extraction and refinery operations financed by Ex-Im and OPIC X 0.02.

Cell: C140
Comment: Rick Heede:
We use Argonne National Laboratory's GREET model as guidance to making an estimate on

other fuel cycle energy inputs to transportation of crude, natural gas, and petroleum products from "wells to wheels."

Crude oil shipping by tankers (VLCCs): GREET assumptions: 5,080 miles average distance, 19 mph average speed, 4,763 Btu per horsepower-hour (typical tanker shaftpower = 124,500 HP); result: 6,089 Btu energy input to move one million Btu of crude oil, or 0.61 percent. Of course, not all oil company crude to refineries arrive by ocean-going tankers, so we dilute this adder by 0.57 (US averages 57 percent imported crude + products), thus the formula is 0.61% x 0.57 = 0.348 percent of total products marketed.
Note: we believe the GREET estimates include energy required to back-haul a tanker, but this is uncertain; if not, GREET data suggest that backhauling a VLCC requires 20 Btu per ton-mile (vs 22 Btu/ton-mile for the front-haul). See GREET.xls, worksheet on Transportation and Distribution, section #9.

Pipelines: GREET assumptions: distance pipelined (750 miles for crude, 400 miles for products from refineries to tank farms), 270 Btu per ton-mile; results: 3,815 million Btu of petroleum input to pipeline transport of one million Btu of crude oil (1,998 Btu per million Btu of gasoline pipelined). Note: this excludes other energy inputs, such as gas or electricity used in pipelines, which brings the pipeline energy input to 6,129 Btu per million Btu of crude thus transported.) Dilution: assume that 43 percent of crude is shipped to refineries by pipeline (thus 0.43 x 3,815 = 1,640 Btu per million Btu of total crude shipped), plus assume that all products are pipelined from refineries to tank farms (at 1,998 Btu per million Btu of refined products); total 1,640 + 1,998 = 3,638 Btu per million Btu, total energy input to pipeline of crude and products, or 0.364 percent.

Conclusion: oil inputs to transportation of 0.763% (for domestic waterborne shipping) + 0.348% (for crude oil and products transport by ocean-going tankers) + 0.364% (for pipeline of crude and products) = 1.475 percent. Detailed analysis will probably find this result to be conservative.

The formula is thus: carbon emissions from oil consumed in Ex-Im and OPIC-financed oil-fired power plants x 0.0148.

Note: Not included in this or any other direct emissions estimate of OPIC and Ex-Im projects is the considerable energy and emissions embodied in the construction of the power plants and the infrastructure to extract, refine, and deliver fuel; nor is the energy invested in building electric transmission grids included in the power plant worksheets.

Sources: Stacy Davis (2001) Transportation Energy Data Book, edition 21, U.S. Dept of Energy, Center for Transportation Analysis, Oak Ridge National Laboratory, Oak Ridge, TN. Tables 12-4, 12-5, and 1-11., and personal communication.

Michael Q. Wang, Argonne National Laboratory, GREET model, www.transportation.anl.gov/greet/index.html, and personal communication 18Jul03.

We estimate direct emissions from oil transportation to equal a conservative 1.0 percent of the carbon in the transported oil. This may prove conservative with additional research into this source of direct emissions attributable to Ex-Im and OPIC-financed projects.

The formula is thus: carbon emissions from oil extracted, refined, or transported in Ex-Im and OPIC-financed oil-projects X 0.01.

Cell: C141
Comment: Rick Heede:
Fugitive methane leakage from gas pipelines can be as high as 5 percent of throughput in older systems. New pipelines with modern flanges, valves, seals, and compressors are

typically 0.5 to 1.0 percent (OPIC 2000 p. 12 cites leakage estimates ranging from 0.5 to 5.0 percent). Since Ex-Im and OPIC invest in new and presumably state-of-the-art projects and rehabilitation projects, we assume a world-wide fugitive methane rate of 0.5 percent on all Ex-Im and OPIC gas projects. This rate is applied to all gas-related projects to capture methane leakage from gas pipelines, gas production facilities, processing, liquefaction plants, and un-burned methane at flares. Future research may refine this methodology. A smaller fraction (0.2 percent) is applied to Ex-Im and OPIC-financed oil projects, above, to account for methane leakage from oil operations, oil pipelines, oil storage (CH4 "flashing" losses alone are estimated at 0.885 kg CH4 per barrel in oil tank farms (American Petroleum Institute, 2001, Greenhouse Gas Compendium), oil production sites, incomplete flaring, and so on.

To convert this estimated fugitive methane emission rate into carbon equivalent, we use IPCC's GWP of CH4 = 23 x CO2, translating to 1 unit of methane = 6.272 x Carbon-equivalent.*

The formula is: carbon emissions from annual and total project throughput (columns E and G) X 0.002 (0.2 percent) X 6.272 = tonnes of methane in carbon-equivalent (column H and J) -- which is converted to CO2-equivalent by multiplying C-eq by 3.667 in columns I and K.

* To convert fugitive methane emissions to carbon-equivalent emissions: multiply methane emissions by 23 (the methane global warming potential factor [GWP] CH4:CO2) and divide by 3.667 (CO2:carbon), 23/3.667, or a factor of 6.272.

Note: the global warming potential of methane has been revised from 21 x CO2 to 23 x CO2 by the IPPC. Source: Houghton, J. T. et al (2001) Climate Change 2001: The Scientific Basis, Working Group One, Third Assessment, IPPC, Cambridge University Press, p. 388.

Cell: G150
Comment: Rick Heede:
OPIC (unlike Ex-Im) did not generate estimates of emissions resulting from the agency's oil and gas portfolio.

We have thus relied exclusively on information from outside the agency:

Wysham, Sohn, & Vallette (1999) "OPIC, Ex-Im, and Climate Change: Business as Usual?" Institute for Policy Studies, Washington, www.seen.org.

Sustainable Energy and Economy Network (2002) "Overseas fossil fuel and renewable energy financing by U.S. government agencies (OPIC and ExIm) Since the 1992 Earth Summit" www.seen.org.

Vallette, Jim (2004) revised spreadsheets of Ex-Im and OPIC projects, plus master list of ECA and World Bank energy lending portfolios (updated to Jul04).

Cell: J151
Comment: Rick Heede:
See our methodology discussion under Ex-Im's gas worksheet.

Cell: C154
Comment: Rick Heede:
Source of projects: Ex-Im Bank (1999) Ex-Im Bank's Role in Greenhouse Gas Emissions and Climate Change, revised, Appendix C.

Cell: C155
Comment: Rick Heede:

Sources: SEEN database at www.seen.org, Jim Vallette's updated spreadsheets on Ex-Im Bank and OPIC projects, and especially Vallette's Master spreadsheet on all ECA energy-related projects (updated to Jul04).

Note: Unlike Ex-Im data, Vallette's data is in metric tonnes of CO2. However, we account for non-fuel / non-combusted uses of oil and gas extraction by multiplying Vallette's CO2 estimate by 0.91 (9 percent non-combustion).

Cell: C157
Comment: Rick Heede:
Vallette maste list: OPIC financing of $69.8 million and $122 million in 1992 and 1998; estimated CO2: 1,263.5 million tonnes.

Www.seen.org: 1,263.5 million tonnes CO2 based on reserves of 1.015 billion barrels of oil, and 450 billion cubic meters of natural gas" and "The Shabwa oil and gas basin (Block 10A), in which Nabors is drilling, holds estimated 180 million barrels of proven and probable reserves. Hunt Oil’s Marib Al Jawf (Block 18) (Maarib and Jawf) fields hold a combined 490 million barrels of oil reserves and 450 billion cubic meters of natural gas reserves. The Shabwa, Marib and Jawf fields join in a shared zone known as Janna Block 5 in northern Yemen, which holds 345 million barrels of oil reserves. Reserves financed by OPIC thus equal 1.015 billion barrels of oil (60% of the national total), and 450 billion cubic meters of natural gas. 5.3 million tons of LNG/year are planned to be produced from the Marib/Jawf and Jannah fields in a Hunt (15%)-Exxon (15%)-Total (36%) joint venture supported by OPIC. The LNG will be exported.

This report calculates: Oil production: "1.015 billion barrels of oil" over 20-year operating life = 50.75 million bbl/yr.
Gas production: "450 billion cubic meters of natural gas" = 15,813 billion cf total over 20-year operating life = 790.65 billion cf/yr.

Cell: C158
Comment: Rick Heede:
See OPIC, Vallette master: OPIC 2000, $25 million, CO2 not estimated.; not listed in SEEN (2002).

Www.seen.org: not listed. This project is excluded until status is corroborated.

Cell: C159
Comment: Rick Heede:
Vallette as 1993 OPIC $200 million + Ex-Im Bank $35 million, estimated 52 million tonnes CO2: "Enron India oil and gas development" but no show in Ex-Im report 1999.

Www.seen.org: 52.4 million tonnes CO2 "based on guaranteed 1 trillion cubic feet of natural gas delivery." and "The project has guaranteed to deliver 1 trillion cubic feet of proven gas reserves over the next 25 years. From BG press release: “Equity production from these fields, in the year to March 31, 2001, totalled an average of approximately 70 million standard cubic feet of gas per day and 8,200 barrels of oil per day. As at March 31, 2001, EOGIL had estimated net proved and probable reserves of over 170 million barrels of oil equivalent. These reserves are, therefore, being acquired at a cost of less than $2.30 per barrel of oil equivalent.... Further development of both the Panna/Mukta and Tapti fields is expected over the next few years, subject to Government and partner approval.... The EOGIL assets comprise a 30 per cent interest in the Panna/Mukta oil and associated gas production facilities (some 60 miles north west of Mumbai), the Tapti gas production complex (some 100 miles north west of Mumbai) and a 62.64 per cent interest in Block CB-OS/1. EOGIL has about 200 employees based offshore in the two fields and at offices in Mumbai, New Delhi, Baroda and a supply base at Bhavnagar, which supports exploration, development and production activities for the fields. Currently all gas produced from the fields is bought by the Gas Authority of India (GAIL). The oil production from the Panna/Mukta complex is purchased by the Indian Oil Corporation (IOC). The deal does not include the Dabhol power station or LNG plant."

Our calculation: 70 million cf/d = 25.55 billion cf/yr over 25 years = 638.75 billion cf.

Cell: C160
Comment: Rick Heede:
Vallette master ECA list: Mobil offshore NGL project, 2004 OPIC financing of $325 million; no estimated emissions.

This project is excluded in this report until status can be verified.

Cell: C161
Comment: Rick Heede:
Vallette list: 1993 OPIC, $100 million, no emissions estimate.

Www.seen.org: "According to OPIC, this project was "currently inactive" in July 2001." "The Miskar Field holds proven reserves of 1.8 trillion cubic feet of gas, of which 800 bcf are recoverable."

This project does not include an emissions estimate; verify current status.

Cell: C162
Comment: Rick Heede:
www.seen.org: 181.1 million tonnes of CO2 "based on projected "cumulative productions of 375.5 million barrels oil and 413.2 billion cubic feet of gas." (EIA)"

Cell: C164
Comment: Rick Heede:
Vallette master ECA list: OPIC 2002 funding of $350 million. Estimated emissions of 46 million tonnes CO2. Not found at www.seen.org ECA project database.

Cell: C167
Comment: Rick Heede:
The aim of this report is to account for both direct and indirect emissions of greenhouse gases that result from the projects financed by Ex-Im Bank and OPIC, regardless of the ECAs level of financial involvement. Direct emissions are typically defined as arising from facilities owned or controlled by the entity in question. Thus emissions from fuels combusted at Ex-Im and OPIC-financed power plants are considered direct emissions by both ECAs, the Wysham et al reports by the Sustainable Energy and Economy Network, and this report. In the power sector we also included indirect emissions from their fuel combustion, e.g., fugitive methane from coal mines, and emissions from oil refineries whose emissions are attributable to the entities that create the demand for the fuels.

Ex-Im Bank and OPIC conclude that emissions from projects financed in the oil and gas sector are neither direct nor indirect, and neither agency account for any emissions from these projects (although Ex-Im does estimate emissions from oil and gas projects 1988-1999 in their 1999 report, but conclude, nonetheless, that such emissions are not attributable to the agency). This report does not concur: Ex-Im and OPIC financing of oil and gas projects assist in the construction of carbon extraction projects, and it is immaterial whether the foreign governments or their corporate partners own or control the equipment that ultimately convert the carbon fuels into carbon dioxide. The ECAs have enabled additional carbon to enter the global economy in an era when it is widely acknowledged that the world's economies must take serious steps to reduce emissions. Granted, both Ex-Im and OPIC also invest in low- and zero-carbon electric generation, and both ECAs appear to be increasing such investments. Furthermore, both agencies invest in new and rehabilitation plants that improve the efficiency of oil and gas extraction and power generation projects.

This report thus considers the eventual combustion of the oil products and dry natural gas flowing from Ex-Im and OPIC-financed projects as direct emissions attributable to these agencies. Furthermore, we designate and account for related emissions -- such as methane leakage from gas pipelines or processing energy used to refine crude oil into marketable products -- as direct emissions. (Note: both Ex-Im and OPIC do consider such direct emissions as attributable to them, since the emissions occur within the owned or controlled facilities financed by them [as opposed to emissions from downstream consumers], but neither agency makes an attempt to estimate the emissions.) This report does estimate these direct emissions from Ex-Im and OPIC-financed oil and gas operations.

OPIC's report "Climate Change: Assessing Our Actions" (2000) does not offer an accounting of emissions resulting from their oil & gas sector project financing, neither direct nor indirect -- even though the text avers that direct emissions are rightly counted, although does not offer an account.

Cell: C168
Comment: Rick Heede:
While global gas flaring is decreasing, it still represents 2.5 percent of carbon emissions from global natural gas consumption, down from 4.3 percent in 1990. The flaring percentage is likely to decrease further, and we use 2.0 percent of gas consumption to project future flaring emissions. This in a direct emission of carbon dioxide attributed to Ex-Im and OPIC-financed gas extraction, processing, liquefaction, and pipeline projects. We allocate 60 percent of this flaring rate to gas and 40 percent to oil production, processing, storage, and delivery. Gas flaring thus becomes 2 percent x 0.6 = 1.2 percent.

The formula is thus: current and future (over the 40-year operating life) emission from gas extracted, processed, or transported through Ex-Im bank/OPIC gas projects x 0.012.

Data from Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy. cdiac.esd.ornl.gov/

Cell: C169
Comment: Rick Heede:
The previous worksheet on power plants on indirect emissions includes an estimate of the emissions arising from the energy used to operate refineries (conservatively, 4 percent). This indirect emission source is reduced for extraction and refining of crude oil, since refineries typically use their own oil products to operate the refineries (except for purchased steam, for example). In the current case, emissions from refinery energy use is considered a direct emissions source, except for additional emissions associated with steam and electricity purchased from other providers (in which case these emissions are considered "indirect").

The data we have for Ex-Im and OPIC gas extraction, processing, and liquefaction projects are amounts of gas produced -- and all of the carbon therein is either combusted at gas processing plants or delivered to consumers or sequestered into non-combusted products (which we account for in "Direct emissions" above) -- and we do not estimate additional indirect emissions from gas extraction projects.

We add 1.0 percent of carbon emissions from gas projects as an estimate of direct emissions at gas processing plants as an estimate of emissions from on-site power generation or combined heat and power. This factor may prove conservative, but at least we know it is not zero.

The formula is: carbon emissions from gas extraction and refinery operations financed by Ex-Im and OPIC X 0.01.

Cell: C170
Comment: Rick Heede:
We estimate direct emissions from gas transportation to equal (conservatively) 1.0 percent of the carbon in all Ex-Im and OPIC gas extraction, processing, and pipeline-related projects to capture the emissions from fuels (such as on-site generation of electricity) used to power natural gas pipelines. This may prove conservative with additional research into this source of direct emissions attributable to Ex-Im and OPIC-financed projects.

The formula is thus: carbon emissions from gas extracted, refined, or transported in Ex-Im and OPIC-financed gas-projects X 0.01.

Cell: C171
Comment: Rick Heede:
Fugitive methane leakage from gas pipelines can be as high as 5 percent of throughput in older systems. New pipelines with modern flanges, valves, seals, and compressors are typically 0.5 to 1.0 percent (OPIC 2000 p. 12 cites leakage estimates ranging from 0.5 to 5.0 percent). Since Ex-Im and OPIC invest in new and presumably state-of-the-art projects and rehabilitation projects, we assume a world-wide fugitive methane rate of 0.5 percent on all Ex-Im and OPIC gas projects. This rate is applied to all gas-related projects to capture methane leakage from gas pipelines, gas production facilities, processing, liquefaction plants, and un-burned methane at flares. Future research may refine this methodology. A smaller fraction (0.2 percent) is applied to Ex-Im and OPIC-financed oil projects, above, to account for methane leakage from oil operations, oil pipelines, oil storage (CH4 "flashing" losses alone are estimated at 0.885 kg CH4 per barrel in oil tank farms (American Petroleum Institute, 2001, Greenhouse Gas Compendium), oil production sites, incomplete flaring, and so on.

To convert this estimated fugitive methane emission rate into carbon equivalent, we use IPCC's GWP of CH4 = 23 x CO2, translating to 1 unit of methane = 6.272 x Carbon-equivalent.*

The formula is: carbon emissions from annual and total project throughput X 0.005 (0.5 percent) X 6.272 = tonnes of methane in carbon-equivalent (column H and J) -- which is converted to CO2-equivalent by multiplying C-eq by 3.667 in columns I and K.

* To convert fugitive methane emissions to carbon-equivalent emissions: multiply methane emissions by 23 (the methane global warming potential factor [GWP] CH4:CO2) and divide by 3.667 (CO2:carbon), 23/3.667, or a factor of 6.272.

Note: the global warming potential of methane has been revised from 21 x CO2 to 23 x CO2 by the IPPC. Source: Houghton, J. T. et al (2001) Climate Change 2001: The Scientific Basis, Working Group One, Third Assessment, IPPC, Cambridge University Press, p. 388.

GHG emissions from Ex-Im Bank and OPIC projects

Power Plants and Oil & Gas

Climate Mitigation Services
Richard Heede
20-Dec-04

Export-Import Bank & Overseas Private Investment Corporation

Direct and indirect emissions	Peak production (MtC-eq/yr)	Peak production (MtCO2-eq/yr)	Total project (MtC-eq)	Total project (MtCO2-eq)
Ex-Im Bank				
Direct emissions, Power sector	77	281	3,898	14,295
Direct emissions, Oil & Gas sector	16	60	343	1,257
Total direct emissions	93	341	4,241	15,551
Indirect emissions, Power sector	8	31	376	1,379
Indirect emissions, Oil & Gas sector	353	1,294	7,236	26,536
Total indirect emissions	361	1,325	7,612	27,915
Total Ex-Im emissions, Power sector	85	312	4,274	15,673
Total Ex-Im emissions, Oil & Gas sector	369	1,354	7,579	27,793
Total Ex-Im emissions	454	1,666	11,853	43,466
OPIC				
Direct emissions, Power sector	24	88	1,176	4,314
Direct emissions, Oil & Gas sector	2	7	42	153
Total direct emissions	26	95	1,218	4,466
Indirect emissions, Power sector	3	12	138	505
Indirect emissions, Oil & Gas sector	38	138	864	3,169
Total indirect emissions	41	150	1,002	3,674
Total OPIC emissions, Power sector	27	100	1,314	4,818
Total OPIC emissions, Oil & Gas sector	40	145	906	3,322
Total OPIC emissions	67	245	2,220	8,140
Ex-Im Bank & OPIC				
Direct emissions, Power sector	101	370	5,075	18,608
Direct emissions, Oil & Gas sector	18	67	384	1,410
Total direct emissions	119	436	5,459	20,018
Indirect emissions, Power sector	11	42	514	1,883
Indirect emissions, Oil & Gas sector	391	1,433	8,101	29,705
Total indirect emissions	402	1,475	8,614	31,588
Total Ex-Im & OPIC emissions, Power plants	112	412	5,588	20,491
Total Ex-Im & OPIC emissions, Oil & Gas	409	1,499	8,485	31,115
Total Ex-Im & OPIC emissions	521	1,911	14,073	51,606

Of which methane (MtC-eq and MtCO2-eq):	13	47	443	1,623
Methane (percent of Total Ex-Im & OPIC emissions):	2.5%	2.5%	3.1%	3.1%

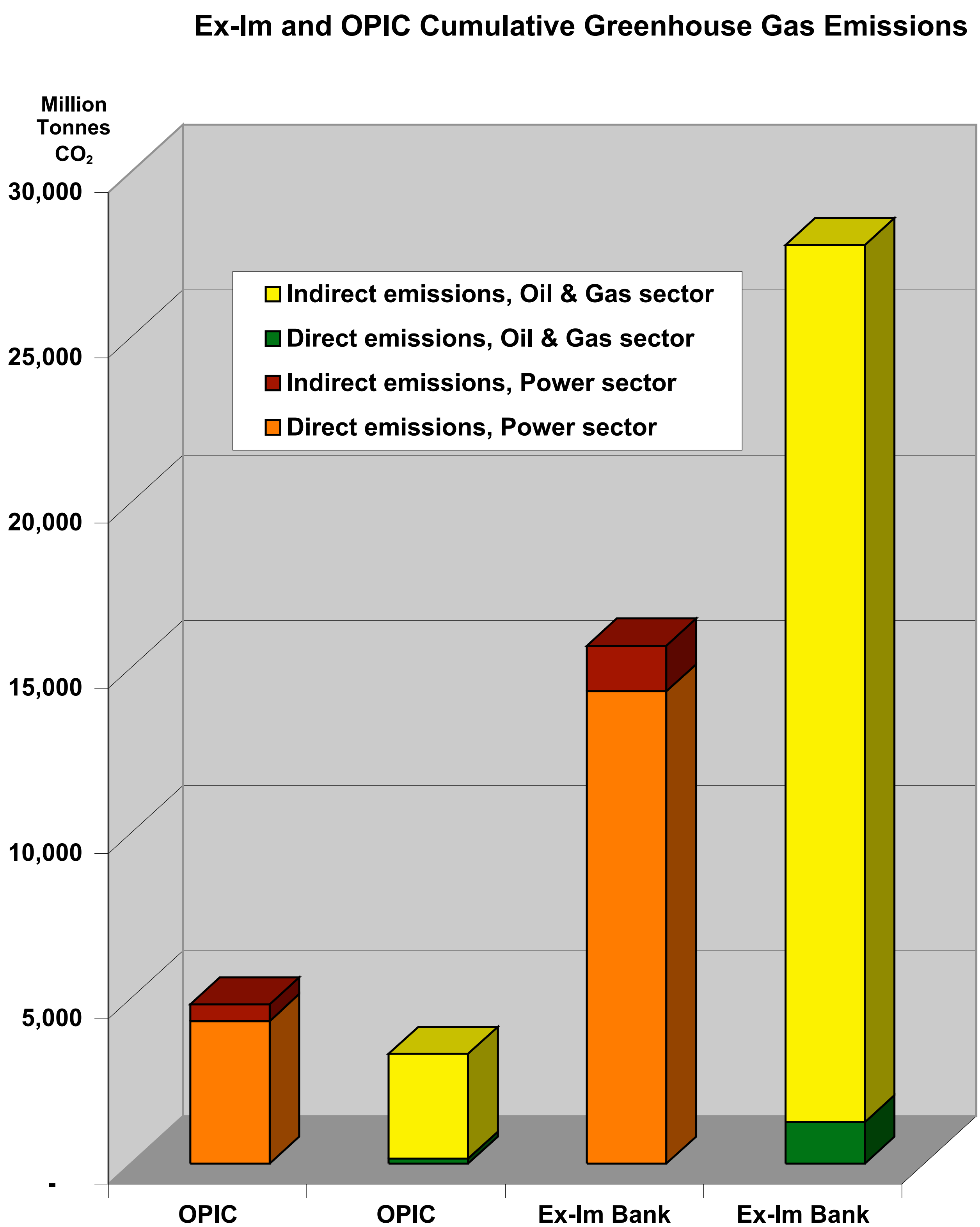
Cell: D4
Comment: Rick Heede:
This report relies extensively on published and un-published work by both Ex-Im Bank (1999) and OPIC (2000), and also by Wysham, Sohn, & Vallette (1999). We have also used updated (and revised) unpublished spreadsheets by Jim Vallette, a 2000 report by Sustainable Energy and Economy Network (available at www.seen.org), the extensive project database posted at the seen.org website, and memoranda written by uncited Ex-Im and OPIC staff.

These publications have been essential in our efforts to identify financed projects as well as their fuel type, installed equipment, generating capacity, marginal oil and gas reserves related to financed projects, and anticipated peak or annual production rates. Neither Ex-Im nor OPIC publish details on their financed projects in their regular or annual reports. The emissions estimation protocols of both Export Credit Agencies and that of Wysham et al have been reviewed. These protocols have been not been adopted in the present work, however. The most significant differences between the previous and the current emissions accounting protocols are (a) our inclusion of several categories of indirect emissions, (b) our adoption of longer (and realistic) operating lives for power plants financed by Ex-Im or OPIC, and (c) inclusion of emissions flowing from Ex-Im/OPIC-financed oil and gas extraction projects (both ECAs disavow accounting for emissions from oil and gas fuels merely facilitated by their financial support). See the attached Declaration and the comments embedded in this spreadsheet for details.

We have made every effort to be as complete, judicious, and accurate as available data allow.

Richard Heede, Climate Mitigation Services, 1626 Gateway Road, Snowmass, Colorado 81654 USA 1-970-927-9511 heede@climatemitigation.com

-Rick-= 20Dec04



Ex-Im and OPIC Cumulative Greenhouse Gas Emissions
Million Tonnes CO_2
30,000
25,000
20,000
15,000
10,000
5,000
-
Indirect emissions, Oil & Gas sector
Direct emissions, Oil & Gas sector
Indirect emissions, Power sector
Direct emissions, Power sector
OPIC
OPIC
Ex-Im Bank
Ex-Im Bank