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THE KYOTO PROTOCOL EMISSION ALLOCATIONS: WINDFALL SURPLUSES FOR RUSSIA AND UKRAINE

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Abstract. The emission targets adopted in the Kyoto Protocol[1] far exceed the likely level of emissions from Russia and Ukraine. These countries could sell their surplus if the Protocol is followed and industrialized countries establish an international emission trading system. Critics have condemned the potential sale and dubbed the surplus 'hot air' because it does not represent any reduction in emissions below the level that would have occurred anyway. Using the most recent, comprehensive regional scenarios[2] for the emissions of carbon dioxide from the energy system, we estimate that during the Protocol's 2008–2012 'budget period' the surplus will range from 9 MtC (million tons of carbon) to 900 MtC for Russia and from 3 MtC to 200 MtC for Ukraine. Even scenarios with high economic growth and carbon-intensive technologies do not exhaust the surplus before the budget period. In the central ('middle course') scenario, the total carbon surplus exceeds 1000 MtC and is worth 22 to 170 billion U.S. dollars (4 to 34 billion U.S. dollars per year). This flow of revenues, which could exceed Russian earnings from natural gas exports ($10 billion in 1997[3]), is comparable with the projected total investments of the Russian energy system for 2008–2012. If directed towards low-carbon infrastructure investments (e.g., gas pipelines), surplus transfers could reinforce and partially lock-in decarbonization of the world energy system.

1. Introduction

The 1997 Kyoto Protocol to the Framework Convention on Climate Change (FCCC)[1] requires that the industrialized countries listed in Annex I of the convention cut their annual emissions of greenhouse gases by an average of about 5% below the 1990 level during 2008–2012. Annex B of the Protocol allocates that collective target among 38 countries. This target applies to sources and sinks of six greenhouse gases; for simplicity, we consider only the most important human cause of global warming in this analysis: CO_2 released during the combustion of fossil fuels.

The Protocol allows the creation of various systems for emissions trading in which countries that exceed their Annex B target can remain in compliance by purchasing surplus permits from other Annex B countries (Articles 4, 6, and 17).

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As with any trading system, the flow and value of emission permits will depend upon their initial distribution, supply, and demand. Here, we focus on one aspect of the potential trading system that has been the most politically sensitive: the number and value of permits that were allocated to Russia and Ukraine, which we term the 'carbon surplus'. (Observers politically hostile to this allocation of assets have dubbed it 'hot air'.)

2. Estimating the Surplus

The Kyoto commitments require that both Russia and Ukraine freeze their emissions at the 1990 levels. Because of the economic disarray with the collapse of the Soviet empire and central planning, CO_2 emissions peaked in the late 1980s, declined sharply in the early 1990s, and are likely to remain below 1990 levels in the near future.

The size and value of the surplus will depend on the level and timing of economic recovery relative to the 2008–2012 'budget period' as well as on technological choices. Because these factors are especially difficult to predict, we employ six scenarios developed at the International Institute for Applied Systems Analysis (IIASA) and World Energy Council (WEC) that are especially suited for long-term regional- and global-scale analysis of the energy system. They encompass three cases of future developments (A, B, and C) subdivided into six alternative scenarios (A1, A2, A3, B, C1, and C2). Case A envisions a future of impressive technological improvements and consequent high economic growth. It has three variants, which reflect alternative futures for fossil fuel resources that can be tapped as well as non-fossil technologies. In scenario A1, oil and gas are abundant and remain the dominant fuels. In scenario A2, oil and gas are scarce and thus coal becomes the dominant primary fuel. In scenario A3, improvements in non-fossil technologies (renewables and nuclear) lead to the long-term elimination of fossil fuels for reasons of economy rather than scarcity. Case B is a central 'middle course' scenario. Case C envisions a 'green' future with substantial technological progress, unprecedented international cooperation to protect the environment, and measures to attain international equity. In Scenario C1, nuclear power is a transient technology that is replaced by non-nuclear low-carbon technologies such as solar hydrogen, while in scenario C2 new reactor technologies lead to sustained growth in nuclear technology over the same period. For the near-term Kyoto period, the most important differences between the scenarios are the level of economic growth (high in A, moderate in B and C) and the technologies employed (high carbon in A2; medium carbon in A1 and B; low carbon in A3, C1, and C2).

The IIASA-WEC scenarios are especially useful for analyzing the demand for and supply of the carbon surplus because they provide both global coverage and harmonized regional detail. For each scenario, the IIASA-WEC team quantified basic assumptions (e.g., population and GDP) and calculated outputs (e.g., CO_2

TABLE I

IIASA-WEC Scenarios, summary of the main indicators for 2020 and 2050. The A and B series are 'non-intervention' (i.e., they do not include policies to limit carbon dioxide beyond what nations already implement today). Series C includes a tax that rises steadily, beginning after 2000, to $200 per ton of carbon emissions by 2100. Some proceeds from the tax are distributed to developing countries to compensate them for the costs of slowing global warming. FSU = Former Soviet Union

	Case					
	A		B		C	
	High growth		Middle course		Ecologically driven	
Population, billion	Global	FSU	Global	FSU	Global	FSU
1990	5.3	0.29	5.3	0.29	5.3	0.29
2020	7.9	0.35	7.9	0.35	7.9	0.35
2050	10.1	0.39	10.1	0.39	10.1	0.39
GDP, trillion U.S.(1990)$						
1990	20.9	0.79	20.9	0.79	20.9	0.79
2020	46.9	1.13	40.2	0.97	40.5	1.08
2050	101.5	5.6	72.8	3.0	75	2.8
Primary energy intensity, annual improvement						
1990–2020	–0.9%	–0.3%	–0.8%	–0.9%	–1.4%	–1.1%
1990–2050	–1%	–1.9%	–0.8%	–1.7%	–1.4%	–2.2%
Primary energy demand, Gtoe						
1990	9	1.4	9	1.4	9	1.4
2020	15.4	1.9	13.5	1.3	11.4	1.4
2050	24.8	3.1	19.8	1.9	14.2	1.3
Technology costs						
Fossil	Low		Medium		Medium	
Non-Fossil	Low		Medium		High	
Environmental taxes	No		No		Yes	
Net carbon emissions, GtC						
1990	5.9	1.0	5.9	1.0	5.9	1.0
2020	8.2–9.9	1.0–1.2	8.3	0.8	6.3	0.8
2050	9.3–14.7	1.5–2.0	9.6	1.1	5.1–5.3	0.7
Number of scenarios	3		1		2	

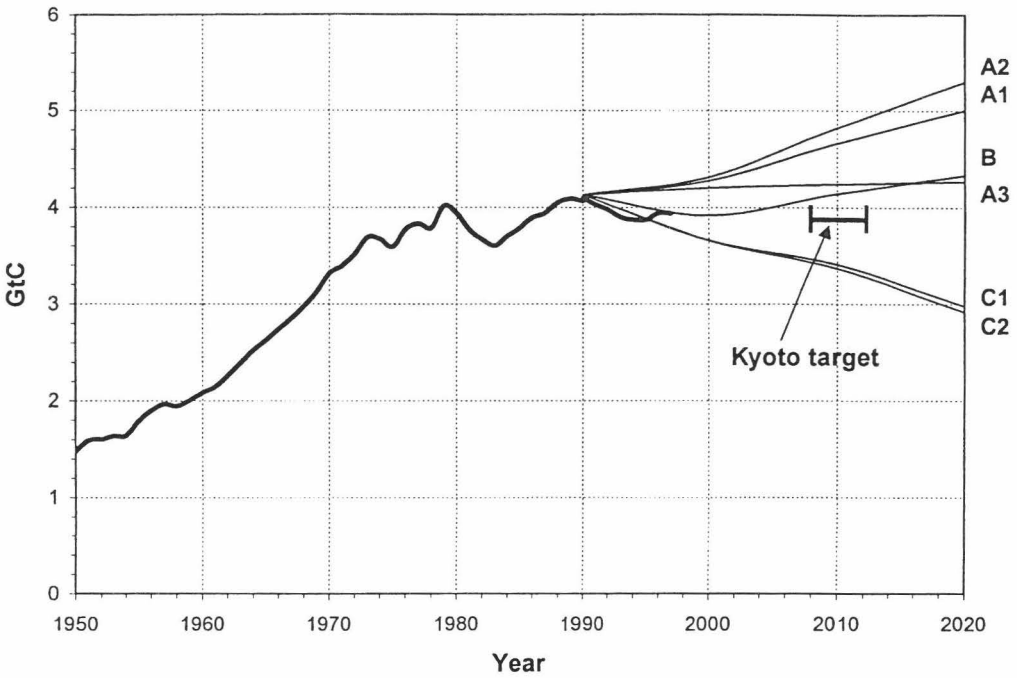

Figure 1. Annex I emissions of CO_2 due to the combustion of fossil fuels for the six IIASA/WEC scenarios (light lines) and actual emissions (heavy line) in gigatons (10^9 tons) of carbon (GtC). In the early 1990s, Annex I as a whole tracks the case C scenarios most closely because of the deep reductions in CO_2 in the reforming countries. Historical data are from Oak Ridge National Laboratory (through 1990, excluding cement manufacture)* and updated with data from the BP.[3] 1991 data are interpolated because adequate data for the former Soviet region are unavailable.
*Note: Marland, G., Andres, R. J., and Boden, T. A.: 1993, *Carbon Dioxide Emissions, in Trends '93, A Compendium of Data on Global Change*, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory.

emissions) through the iterative use[2, 4, 5] of two models: (a) an 11-region version of the macroeconomic model 'Global 2100',[6] and (b) IIASA's linear programming energy system model 'MESSAGE III'.[7] The scenarios were reviewed extensively by more than 100 regional experts in two rounds of publications in 1995[8] and 1998.[2]

Figure 1 shows the estimated carbon emissions for Annex I countries for these six scenarios. Table II reports the difference between those estimated emissions levels and the targets adopted in the Kyoto Protocol. The 'reforming' industrial economies of Eastern Europe and the former Soviet Union are in surplus in all of the scenarios. The largest surplus in nearly every scenario is from the former Soviet Union.

In principle, carbon surpluses could exist in many of the 8 East European and 5 former Soviet countries listed in Annex B of the Kyoto Protocol. However, in practice, only Russia and Ukraine are likely to sell substantial quantities of surplus permits. The surplus in the East European region (Table II) is largely the con-

TABLE II

Emissions of carbon dioxide due to the combustion of fossil fuels in the five regions that constitute Annex I ('Industrialized') countries. The table shows emissions in 1990, the target adopted in Kyoto, and the level of emissions that are in excess of (or below) the five-year Kyoto target. The targets are expressed as the percentage of change from 1990 levels and are weighted to account for two factors. (1) National targets vary within each region; in the absence of robust predictions for the future emissions of every country, we weighted the national targets according to 1990 emissions. (For illustrative purposes, when weighting targets we ignored the small fraction of emissions from the East European and former Soviet nations that are not subjected to Annex B targets.) (2) As permitted by the Decision of the Conference of the Parties to the FCCC,[a] four countries in Eastern Europe (Bulgaria, Hungary, Poland, Romania) have selected non-standard base years. Emissions in those base years are higher (15% to 17%) than in 1990, which makes the Kyoto target for those countries, in effect, less stringent. If the base year adjustment were not allowed and all other factors had remained constant, the weighted Kyoto target for Eastern Europe would have been –7%. CO_2 emissions are net values, which exclude feedstocks, gas used for enhanced oil recovery, and non-energy emissions

	1990 level (MtC per year)	Kyoto target (weighted)	Deficit (surplus) emissions (MtC, cumulative 2008–2012)					
			A1	A2	A3	B	C1	C2
Western Europe	956	–7.8%	1093	1351	687	731	–378	–368
North America	1491	–7.2%	2388	2741	1402	1838	–940	–1135
Pacific OECD	372	–3.1%	295	329	221	128	–217	–207
Eastern Europe	284	3.3%	–60	–47	–258	–345	–374	–368
Former Soviet Union	1026	–0.2%	–154	–7	–572	–1377	–832	–864
Annex I, Total	4130	–4.7%	3605	4411	1523	1019	–2697	–2898

[a] Conference of the Parties, FCCC: 1996, 'Decision 9/CP.2: Communications from Parties included in Annex I to the Convention: guidelines, schedule, and process for consideration', FCCC/CP/1996/15/Add.1, http://www.unfcc.de.

sequence of four nations (Bulgaria, Hungary, Poland, and Romania) adjusting their base years to dates prior to 1990 when emissions were higher, which has given these countries targets that are less stringent than suggested by Annex B (see caption to Table II). Those base year adjustments also account for why the collective CO_2 cut for all Annex I nations is only 4.7% below 1990 levels, rather than the 5% goal set in the Kyoto Protocol. The two largest of these countries (Hungary and Poland) are developing close economic ties with the European Union, which may make it politically difficult for them to sell their surpluses. The EU has steadfastly opposed the sale of such surpluses and has sought to limit the extent to which countries can use emission trading to satisfy their Kyoto obligations. These EU objections are based on the fear that completely free trading will result in surplus sales and that other accounting tricks that will undermine the Protocol's primary goal of reducing emissions.[9] Three of the former Soviet republics – the Baltic states of Estonia, Latvia, and Lithuania – listed in Annex B have stringent (–8%) targets and are unlikely to have much surplus available for sale. That leaves Russia and Ukraine with the only significant available surpluses.

In 1990, Russia and Ukraine accounted for 650 MtC (63%) and 180 MtC (17%) of emissions from the former Soviet Union, respectively.[10] In comparison, official data reported by Russia to the FCCC indicates 1990 emission levels of 648 MtC (see ref. 19). Ukraine has not reported official emission estimates. Table III compares the projected emissions in the six scenarios for these two countries with the Kyoto targets for 2008–2012. The range of numbers is indicative of a plausible range in the possible magnitude of the surplus.

Figure 2 shows the scenarios for the former Soviet Union. The IIASA-WEC scenarios (especially B) track historical emissions closely. They are also systematically lower than most other scenarios, which suggests that other studies probably overestimate the emissions from this region for at least one of three reasons. (1) Some scenarios employ base years prior to 1990 when emissions were higher. (2) Most scenarios are long-term with the first reporting year being 2010 and thus do not provide the resolution needed to analyze short-term targets such as in the Kyoto Protocol. (3) Even the few available shorter term scenarios have systematically underestimated the depth of the economic recession (e.g., refs 11 and 12) or have not employed transparent data and methods to allow the reproduction of the numbers (ref. 13).

For Annex I as a whole, only the 'green' scenarios (C1 and C2) lead to emissions below the Kyoto targets, which suggests that, in the absence of emission trading, compliance with the Kyoto Protocol can be attained only with radical shifts in technology. In the other scenarios, some advanced industrialized nations (Australia, Japan, New Zealand, North America, and Western Europe) can attain compliance by purchasing permits from regions with surplus. However, in none of those scenarios are the Russian and Ukranian surpluses sufficiently large that all of the advanced industrialized nations can comply with the Protocol merely through the acquisition of the surplus permits.

TABLE III

Russian and Ukrainian emissions of carbon dioxide from combustion of fossil fuels. Values (MtC) are the surplus relative to the Kyoto target for the six IIASA/WEC scenarios. National figures are weighted from the total for the former Soviet region. The Kyoto target (0%) is slightly different from the value in Table II, because the latter includes the –8% targets for Estonia, Latvia, and Lithuania. We assume that Russia and Ukraine account for 63% and 17%, respectively, of the former Soviet Union on the basis of adjusted 1990 data from the International Energy Agency.[a] These data are probably uncertain by as much as 10% but are consistent with other sources. Using these fractions, we calculate that 1990 fossil fuel CO_2 emission levels were 650 MtC (Russia) and 178 MtC (Ukraine). These fractions and numbers are also consistent with historical data for the former Soviet Union compiled by Oak Ridge National Laboratory (see Figure 2 and ref. 38). The IIASA-WEC emissions are only reported on a decadal basis; we have interpolated these emissions to achieve estimates for the five-year period 2008–2012

	1990 level (MtC per year)	Kyoto target (weighted)	Deficit (surplus) emissions (MtC, cumulative 2008–2012)					
			A1	A2	A3	B	C1	C2
Russian Federation	650	0.0%	–102	–9	–367	–877	–532	–552
Ukraine	178	0.0%	–28	–3	–101	–241	–146	–152
Total	828	0.0%	–130	–12	–468	–1117	–677	–703

[a] International Energy Agency: 1992, *Climate Change Policy Initiatives*, OECD, Paris, p. 31.

In order to estimate the resources that might flow as the carbon surpluses are traded, we consider several prices for permits. We use $20 per ton for the low price, which is within the range ($14 to $23) quoted in the much-cited study by the U.S. Council of Economic Advisers (CEA) on the cost of implementing the Kyoto Protocol.[14] Many analysts have criticized that study's assumptions, including the widespread availability of low-cost carbon abatement options and efficient markets in emissions permits (e.g., ref. 15). Indeed, McCracken et al.[16] use the same model as in the CEA analysis and compute low permit prices ($26 per ton in 2010) only when they make the implausible assumptions that trading by 2010 will be fully global, friction-free, and perfectly competitive. Because of this, we consider two other permit prices that are characteristic of the results using macroeconomic models for Kyoto-like runs with realistic assumptions: $50 per ton (optimistic assumptions) and $150 (pessimistic assumptions, such as inefficient markets). Other studies of Annex I trading cite similar prices,[15, 16] although the range of plausible permit prices remains wide because there is no agreement among experts on the cost of carbon abatement nor the near-term feasibility of establishing various forms of emission trading, including trading with developing countries. It is possible that during transient periods (including the 5-year Kyoto 'budget period'), permit prices could be much higher, especially if permit markets operate inefficiently or if

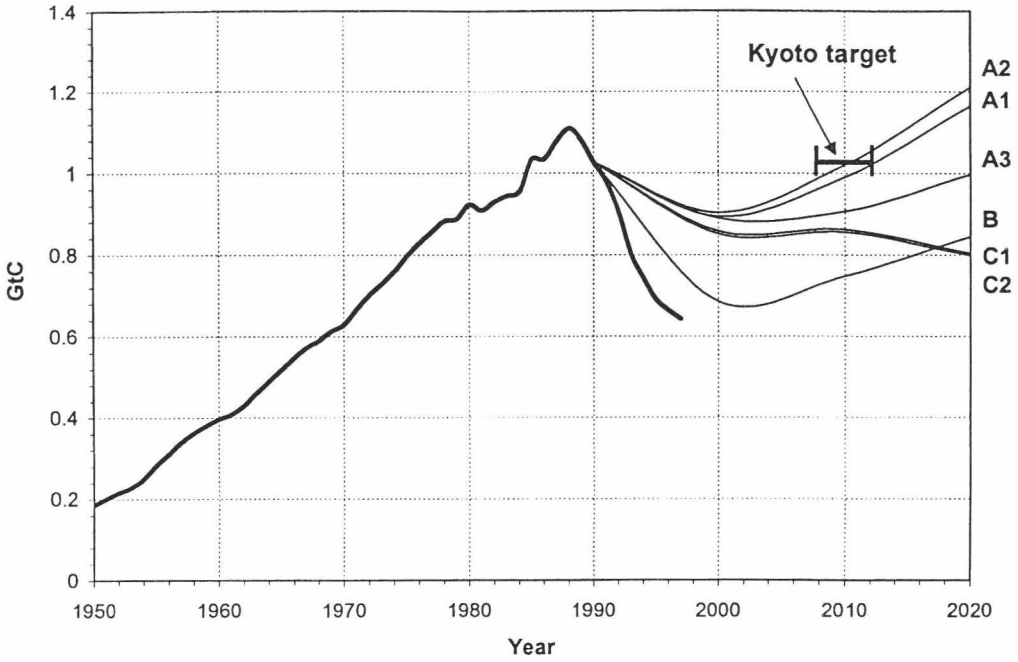

Figure 2. Emissions of CO_2 from the former Soviet Union due to the combustion of fossil fuels in the six IIASA-WEC scenarios (light lines) and the actual emissions (heavy line). We show the entire former Soviet region, because Russia and the Ukraine constitute the largest portion (80%), historical data for the separate republics are unavailable prior to 1992, and most models and scenario exercises (including IIASA-WEC) aggregate the region as one. (Data sources same as in Figure 1.)

economies grow more rapidly than expected. Table IV shows the estimated values of the carbon surpluses with these assumptions.

Each scenario yields a significant carbon surplus. The smallest surplus (12 MtC) occurs in scenario A2 (high economic growth and carbon-intensive technologies). The largest surplus is in the 'middle course' (B) scenario, which expert reviews of the IIASA-WEC scenarios[2] suggest is the most likely outcome. In this scenario, the continued weakness in the former Soviet economies dampens growth in emissions, while the stronger economic growth and continued use of carbon-intensive fuels (e.g., coal) in the West raises the demand for permits (if Western regions intend to comply with the Kyoto Protocol).

For comparison, the 1999 projection by the U.S. Energy Information Administration (EIA) estimated that fossil fuel carbon emissions from the former Soviet Union would be 324 million metric tons lower than the Kyoto limits in the year 2010, or approximately 1600 million metric tons if that average annual surplus is maintained over five years. That figure is higher than earlier EIA estimates, in part because the recession in the former Soviet Union has been longer and deeper and also because the recovery of these economies has made greater use of low-carbon natural gas (rather than high-carbon coal) than EIA analysts had previously expected.[17] Our estimate for the entire former Soviet Union (1377 million metric

TABLE IV

Estimated value of the Russian and Ukrainian carbon surpluses. We use three plausible permit prices; however, some combinations of permit prices and scenarios are not realistic ('nr'). In the A2 scenario, for example, low permit prices are implausible because high emissions would raise demand and permit prices, perhaps above $150 per ton. In the C scenarios, the surplus is not needed for compliance with the Kyoto Protocol and thus permit prices are likely to be low or zero

	Tax level (U.S.'90 $ per tC)	Cumulative revenue (billion 1990 U.S. Dollars, cumulative 2008–2012)					
		A1	A2	A3	B	C1	C2
Russian Federation	20	2	nr	7	20	nr	nr
Ukraine		1	nr	2	5	nr	nr
Total		3	nr	9	25	nr	nr
Russian Federation	50	5	0.5	20	40	nr	nr
Ukraine		1	0.1	5	10	nr	nr
Total		7	0.6	25	50	nr	nr
Russian Federation	150	10	1	60	130	nr	nr
Ukraine		4	0.4	20	40	nr	nr
Total		14	1.8	80	170	nr	nr

tons, shown in Table II) is approximately the same. In contrast, McCracken et al.[16] estimate that emissions from the former Soviet Union will be 247 million metric tons below the Kyoto target in 2010, or about 1000 MtC over five years. That figure is substantially lower than our 'middle course' estimate largely because the IIASA-WEC scenarios envision a much deeper recession in the former Soviet Union. (The reader should note that for purposes of the Kyoto Protocol, only the surplus from Russia and Ukraine, or about 80% of total emissions from the former Soviet Union in 1990, are sellable since only those countries have the lenient target and are also included in Annex B of the Protocol.) Recent in-depth studies of the Russian economy have identified pervasive structural weaknesses and suggest that the recovery will be weak,[18] implying that emissions will not rebound quickly and that the surplus will remain large.

3. Discussion and Speculation

We close with some speculation on factors that could affect the size and value of the surplus, and some thoughts on how the revenues might be usefully spent.

Due to a lack of data and appropriate models for estimating future emissions, we have excluded the non-CO_2 greenhouse gases. However, we are mindful that

the Kyoto Protocol includes five gases in addition to CO_2, and our hunch is that the basic results would be unaffected if extended to include all gases. Russia's official 'communication' to the FCCC indicates that fossil fuel CO_2 accounted for 79% of all greenhouse gas emissions in 1990, with the balance due to CH_4 (18%) and N_2O (3%).[19] (To allow a comparison with official reports, emissions of different greenhouse gases are converted into common units using the standard 100-year 'global warming potentials' adopted by IPCC in 1995.[20, 21]) Other recent (1997) Russian studies confirm these proportions.[22, 23] Russia has not submitted emission estimates for the other three greenhouse gases included in the Kyoto Protocol (hydrofluorocarbons, perfluorocarbons or sulfur hexafluoride); however, in other industrial countries, emissions of these gases constitute only a small fraction (<3%) of the total emissions.[19, 24] Ukraine has not submitted any official emissions inventory, but the proportions of fossil fuel CO_2 and other greenhouse gases are likely to be similar to those in Russia. In short, the non-CO_2 gases do not account for much of the total. However, we are also mindful of the results by Reilly et al.[25], who suggest that the surplus in the former Soviet Union could be reduced by nearly 60% when non-CO_2 gases are included in the calculation. Their result is mainly due to their accounting for methane; they employed abatement cost curves that are based on data from the United States, not the former Soviet Union, and which appear to result in higher calculated methane emissions. We are wary of their result and agree with Reilly et al. that more research is needed on this topic. In fact, it is plausible that the surplus could *increase* as large methane vents are closed at zero marginal cost – for example, the growth of the Russian economy may attract investment in more efficient and less leaky natural gas systems. The potential implications should be explored, but quantifying them is beyond the scope of this paper.

We have also excluded from our analysis CO_2 due to land use change and forestry, even though the Kyoto Protocol includes these fluxes. Accounting rules for sinks in the Kyoto Protocol are still hotly contested, and the net carbon content of Russian lands (especially forests) is highly uncertain and variable with time. Some studies suggest that Russian forests were a large net carbon sink (184 MtC yr^{-1}) in the early 1990s.[26] A recent survey by the Russian government concluded that the net sink was 110 MtC sink in 1990 and that it rose 50% in the early 1990s due to the decreased logging of Russian forests.[23] Other Russian studies also suggest a large sink for the early 1990s (160 MtC in 1993).[27] Russia's official FCCC communication reports a net sink of 107 MtC in 1990. The most comprehensive independent analysis concludes that Russian forests were a net *source* of 69 MtC per year for 1988 to 1993 (see methodology in ref. 28, updated with a critical review of other studies in ref. 29.) The range of these numbers (approximately 200 MtC per year, or 1000 MtC over five years) suggests that uncertainty in the forest carbon flux is comparable with our largest estimate for the Russian and Ukranian carbon surplus for the five-year Kyoto budget period. The net carbon flux from land use and forestry – especially the large Russian forests – is simply unknown at present.

The high uncertainties regarding forest carbon and the non-CO_2 gases pose technical and political problems for emission trading. As Reilly et al.[25] have calculated, in principle there are large potential benefits from a multigas comprehensive approach. In practice, however, the inclusion of these other fluxes probably results in much more uncertain (and potentially much larger) surplus emission allocations, which could make it much more difficult to negotiate a politically acceptable distribution of emission permits. These problems suggest that it may be wise to restrict emission trading to those fluxes that can be monitored accurately and reliably – at present, the emissions of CO_2 from fossil fuels.

The value of the carbon surplus will depend not only on the supply and demand in the Annex B nations, but also on the design and operation of permit markets. Here, we indicate three of the several factors that will be important. First, sellers and buyers might act strategically. Russia and Ukraine – as the largest Annex B sellers – could restrict supply and exert monopoly power on permit prices. McCracken et al.[16] investigated the consequences of such behavior and estimated that a monopolistic behavior by Russia *and* Eastern Europe would raise permit prices by one-third (in an Annex I-only trading system, from $73 per ton to $105 per ton), with a 10% increase in profits from such strategic behavior – significant, but small compared with the other uncertainties in estimating the size of the surplus. Major buyers, such as the United States, could also organize themselves to purchase blocks of permits at a discount, thus reducing revenue transfer. We think the former, like OPEC, is a plausible scenario, while the latter is unlikely since it would require intervention by liberal democratic governments into an otherwise free market; such intervention, by creating publicly controlled block payments, could be politically unattractive for those countries because it would focus public attention on the size of the surplus transfers.

Second, the 'Clean Development Mechanism (CDM)' – a provision in the Kyoto Protocol that allows investors to earn credits for projects that reduce emissions in developing countries – could provide additional supplies of emission permits, which would lower prices and shrink the valve of the Russian and Ukrainian surplus. Many studies have shown that enormous low-cost potential reductions exist in developing countries; this vast reservoir could create a cap on the permit price of only a few dollars per ton, which would also limit the five-year surplus transfer to perhaps ten billion dollars or less. The prospect of a CDM could also limit the extent of monopolistic behavior by sellers. However, the success of the CDM requires forging agreement on the rules that would govern the system, and there are many thorny unresolved problems such as how to determine the baseline emissions in a developing country that would have occurred without the investment project.

Third, provisions for banking (Article 3.13 of the Kyoto Protocol[1]) could reduce the supply of surplus permits during the first Kyoto budget period, raise prices, and potentially increase the value of the windfall. Banking could also make the carbon surplus politically more palatable in the West, because it would no longer

be viewed as a pure windfall. Assuming that Russia and Ukraine will need their surpluses at some point in the future – because emissions will rise eventually, targets will be tightened, or both – selling a bankable surplus today would no longer represent a costless opportunity. However, we doubt that this will have an important political effect since emission targets – and thus also permit allocations – are slated to be renegotiated every five years rather than set in advance for long periods of time. As any bureaucrat skilled in protecting his budget knows, the existence of an unspent windfall in one budget period will result in its removal later on. Therefore, Russia and Ukraine will have a strong incentive to sell what windfall they have rather than banking and losing it later.

Our analysis may also help identify the date when Russia and Ukraine will be unable to comply with the Kyoto Protocol without implementing actions to regulate their carbon dioxide emissions. In the absence of external pressure (e.g., trade sanctions), we expect that Russia and Ukraine will exit at the moment when the surplus is exhausted and windfall revenues trickle to zero. Studies on Soviet participation in international environmental agreements demonstrate that the country complied with international agreements when it was strictly in its interest to do so; this is a pattern that continues in Russia today.[30] This line of argument suggests that Russia and Ukraine will exit the Kyoto Protocol as early as 2011 (A2 scenario), or, even earlier if the surplus is sold in advance.[31] Their exit might be averted by internal pressure to comply with environmental agreements, which is evident in advanced democracies where public interest environmental groups are politically strong. Such groups are generally weak and inactive on the global warming issue in the former Soviet Union. Designers of the trading system should contemplate such scenarios since they suggest that the system must account for the potential turmoil caused when a major supplier defects.

Although we are skeptical that the Kyoto Protocol could be ratified if it delivers such a huge windfall to Russia and Ukraine, suppose that it were and suppose that a public program were created to manage the proceeds from the surplus. What could be done with the money?[32] The starting point for one answer to this question is the observation from other studies that the Kyoto Protocol's targets, by themselves, will have little impact on the long-term concentration of carbon dioxide in the atmosphere.[33] Perhaps more could be done to increase the long-term leverage on carbon emissions. One approach would be to tie the carbon surplus to investments in low-carbon infrastructures (e.g., gas pipelines), which could facilitate decarbonization of the world energy system. Indeed, the surplus revenues are comparable in magnitude with the entire investment being made in the energy system of the former Soviet Union. For the 6 IIASA-WEC scenarios, the MESSAGE model computes that investments in the energy system of the entire former Soviet Union during 2008–2012 range from $117 billion (scenario B) to $206 billion (scenario A3). Investments in zero-carbon energy and low-carbon natural gas range from $80 billion (scenario B) to $120 billion (scenario A3). Earmarking could yield additional pipelines to transport vast Russian resources of low-carbon

natural gas to Asia – which cost approximately $10 billion per 1000 km – and thus supplant carbon-intensive coal, which would slow global warming and also combat Asian acid rain. The main advocates for emissions trading, including Russia and the United States, have indicated their opposition to earmarking carbon trading revenues.[34] However, so far, there has been no discussion at a high political level to explore whether and how linking revenues with investments might be feasible. By reinforcing the long-term objective of the FCCC and avoiding a simple transfer of billions of dollars, such earmarking could raise the political feasibility of emissions trading under the Kyoto Protocol.

We conclude by underscoring the modest and simple purpose of this paper: to estimate the size of pure windfall for Russia and Ukraine under the Kyoto Protocol. We have had the benefit of the 1998 IIASA-WEC energy scenarios, which are based on detailed regional analysis and are especially appropriate for probing the possible energy future of the former Soviet Union. We are mindful of the many remaining uncertainties, not the least being how the former Soviet economies will develop over the next decade. Nonetheless, our results strongly suggest that the windfall may amount to tens of billions of dollars, perhaps much more.

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32. We are skeptical that a public program will ever be created to manage the revenue transfer – Russia and Ukraine would be opposed, and so would advocates of free markets in the West. It is most likely that the money would flow into private hands, giving Russia and Ukraine their own version of the 'Dutch disease' – the excessive currency valuations and other market effects caused when huge revenues flowed into Holland from natural gas exports. The revenues would probably exacerbate corruption and may never arrive in the countries. Nonetheless, the sums are so large that we speculate for a moment on how they could be spent.
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