Energy+ Country Performance Ratings, 2001–2010

David Wheeler

Abstract

This paper introduces ƐCPR, country performance ratings that support Norway's Energy+ initiative by monitoring the progress of 153 countries in reducing the CO2 emissions intensity of energy consumption. It develops annual ƐCPR ratings for the period from 2001 to 2010.

Analysis reveals a diverse set of transition patterns at the country and regional levels. Some major emitters have been consistently red during the past decade, some have been consistently green, and others have improved from red to yellow or green. In a similar vein, high-, middle- and low-income countries all exhibit very diverse ƐCPR ratings. Overall the results are hopeful, with a particularly notable decline in red ratings. During the past few years, over 70% of the 153 rated countries have exceeded their transition path benchmarks, and around 40% have exceeded their rigorous Energy+ benchmarks.

The challenge will grow in the coming decade, as countries' transition and Energy+ benchmarks continue to fall. Future updates of ƐCPR will provide a consistent basis for judging how far we have come, how far we have to go, and which developing countries need additional assistance to achieve green status.

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1. Introduction

The prevailing scientific consensus holds that we cannot hope to avoid catastrophic climate change without a major reduction of anthropogenic CO2 emissions during the next few decades. Stabilization of atmospheric CO2 loading at 350 ppm, the goal proposed by Hansen, et al. (2008), will require emissions to fall 95% by 2050 (Huesemann, 2006). Most of this reduction will have to come from the energy sector, which accounts for a major share of global CO2 emissions (WRI, 2012). And it will have to include both developed and developing countries, since growing emissions from the latter would ensure catastrophic climate change even if developed countries completely halted their emissions (Wheeler and Ummel, 2007).

In response to this challenge, the Government of Norway has recently launched Energy+, an International Energy and Climate Initiative to promote greenhouse gas emissions reduction while ensuring access to sustainable energy for all (Government of Norway, 2011). Energy+ is modeled on REDD+[1], a program that focuses on rewarding progress in forest conservation that is measured against clear, consistent benchmarks. To support REDD+, Wheeler, Hammer and Kraft (2012) have recently developed ***f*CPR** (Forest Conservation Performance Ratings), a system that rates the progress of localities, countries and regions against two benchmark paths that slope downward through time: A ***Transition*** path that reflects declines in forest clearing as income per capita increases; and a ***REDD+*** path targeted on halting forest clearing by 2025. Updated quarterly, ***f*CPR** assigns each country one of four color-coded numerical scores: 1 (dark Red) – increased forest clearing that is greater than benchmark clearing on the Transition and REDD+ paths; 2 (light Red) – stable or decreased forest clearing that remains above both paths; 3 (Yellow) – forest clearing in the range between the two paths; and 4 (Green) – forest clearing below both paths. Localities, countries and regions with Green ratings are on track to achieve zero forest clearing by 2025.

***f*CPR** is designed to serve REDD+ objectives with an easily-communicated performance summary for each rated unit; reputational incentives for improved performance; and establishment of benchmarks for financial incentive systems that follow cash-on-delivery (COD) principles (Wheeler, Hammer and Kraft, 2011b).

This paper develops an analogous system to support the Energy+ initiative: **ƐCPR – Energy+ Country Performance Ratings**. Like ***f*CPR**, the system rates each country's performance against two benchmark paths: A ***Transition*** path that reflects changes in income per capita and other factors, and an ***Energy+*** path consistent with the global goal of 95% reduction in CO2 emissions from energy consumption by 2050. **ƐCPR** targets the CO2

[1] Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD, 2012).

emissions intensity of economic activity (CO_2 emissions from energy consumption divided by GDP).

The remainder of the paper is organized as follows. Section 2 introduces the determinants of the Transition path for CO_2 emissions intensity in the energy sector. Section 3 describes the data used for econometric panel estimation, and Section 4 reports the econometric results. Section 5 describes the construction of the Transition and Energy+ paths, while Section 6 uses these paths to develop annual performance ratings for 2001-2010. Section 7 summarizes and concludes the paper.

2. Determinants of CO2 Emissions Intensity for Energy Consumption

While concern about CO_2 emissions has emerged during the past few decades, the development of national energy systems has spanned more than a century. In the pre-climate era, CO_2 emissions from each country's energy sector were determined three main factors: The relative shares of fossil fuels and hydropower in energy consumption, the energy intensity of economic activity, and the size of the economy.

The relative shares of fossil fuels and hydropower were in turn determined by two principal factors: Their supply cost, a function of their relative local abundance, and local regulation of air pollution (Hettige, et al., 2000; Dasgupta et al., 2001). Rising income increases the demand for environmental quality, which promotes stricter air pollution regulation and substitution toward lower-polluting fuel sources – natural gas, hydropower and nuclear power.

Local factors play a critical role in determining the intensity of energy use. Prevailing temperatures affect demands for heating and cooling; local energy resources affect relative energy supply prices because energy is costly to transport; local raw material resources for energy-intensive industries affect locational comparative advantage because these materials are also costly to transport; and the spatial distributions of population and economic activity, shaped by two centuries of economic development, affect transport-related fuel demand. Economic development is accompanied by increases in technical and institutional capabilities, which promote more efficient use of energy resources.

Operationalizing the Transition path requires quantifying the effects of these factors. My measure of economic development is real GDP per capita at purchasing power parity. I capture the effects of prevailing temperatures with two standard measures: Annual heating degree days and cooling degree days (the cumulative annual sums of negative and positively deviations from a benchmark comfort standard, conventionally 65° F.). Appropriate quantification for energy and raw material resources requires distance weighting beyond national frontiers, since transport cost is a critical factor and countries differ greatly in size. To compute a resource index for each country, I augment its own resource with the weighted sum of the resources in other countries, using inverse distances from country centroids as weights.[2] I compute the distance-weighted fossil fuel index from total known deposits of coal, oil and natural gas, measured in standard energy units. For hydropower, I use the distance-weighted sum of estimated hydropower potential. For mineral resources, I use distance-weighted deposits of metals that are both energy-intensive and dominant in world industrial production. My proxy for the effects of historical population and industrial centers is total national ton-miles of commodities shipped, which reflect both distances between centers and their economic scales. I provide more detailed descriptions of these variables in the next section.

I incorporate the intensity factors into the econometric model specified below. All variables are in logs except time and heating and cooling degree days, which have zero values in many cases.[3] I also allow for the possibility that population size has an independent effect on CO2 intensity.[4]

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[2] Weighting by inverse distance reflects the standard gravity model of trade, in which the volume of trade between two countries is proportional to the product of their economic size, divided by the distance between them.

[3] HDD is 0 for many tropical countries, while CDD is 0 for a few northern latitude countries.

[4] Inclusion of log population also renders model (1) transparent to normalization of the distance-weighted indices and ton-miles by GDP, since log GPC=log(GDP) – log(POP). If the indices and ton-miles are normalized by GDP (e.g., log(HDD/GDP) = log(HDD) – log(GDP)), collection of terms will result in an equation whose form is identical to the specified model.

$$(1)\ C_{it} = \beta_0 + \beta_1 T + \beta_2 GPC_{it} + \beta_3 POP_{it} + \beta_4 HDD_{it} + \beta_5 CDD_{it} + \beta_6 FOSSIL_i + \beta_7 HYDRO_i + \beta_8 METALS_i + \beta_9 TONMILES_i + \varepsilon_{it}$$

Expectations: $\beta_2<0$, $\beta_7<0$

$\beta_4>0$, $\beta_5>0$, $\beta_6>0$, $\beta_8>0$, $\beta_9>0$

C_{it}	=	Energy-related CO2 emissions intensity of country i in year t
T	=	Year t
GPC_{it}	=	Real gross domestic product per capita at PPP of country i in year t
POP_{it}	=	Population of country i in year t
HDD_{it}	=	Heating degree days of country i in year t
CDD_{it}	=	Cooling degree days of country i in year t
$FOSSIL_i$	=	Distance-weighted fossil fuel index of country i
$HYDRO_i$	=	Distance-weighted hydro power index of country i
$METALS_i$	=	Distance-weighted energy-intensive metals index of country i
$TONMILES_i$	=	Commodity ton-miles in country i
ε_{it}	=	A random error term with cross-section and time-series components

For GDP per capita, the expected negative sign reflects three factors: Gains in energy efficiency with development; rising environmental sensitivity with income, which translates to a lower propensity to use locally-polluting fossil fuels; and the shift toward low-emissions tertiary activities as development proceeds. The expected negative sign for hydropower reflects the absence of CO2 emissions from this energy source.

The expected positive sign for fossil fuels reflects CO2 emissions from coal, oil and natural gas. The expected positive signs for heating and cooling degree days reflect the extra energy demands associated with more heating needs as the average temperature drops below the comfort zone, and more cooling needs as the average temperature rises above this zone. The expected positive sign for the metals index reflects the energy intensity of metals processing, as well as direct CO2 emissions from processing metals. Similarly, the expected positive sign for commodity ton-miles reflects CO2 emissions from transporting commodities.

3. Data[5]

3.1 CO2 Intensity

CO2 intensity is calculated by dividing CO2 emissions from the energy sector by real GDP at purchasing power parity. Data for carbon dioxide emissions from the energy sector are drawn from US EIA (2012), which reports emissions for 224 countries. The GDP measure is the product of population (World Bank, 2012) and per capita GDP at purchasing power parity (IMF, 2011) for 184 countries, converted to constant $US 2005 using the US implicit price deflator for GDP (BEA, 2011).

Table 1 presents average CO2 intensities for the top 20 CO2 emitters in the dataset, by decade since 1980. The data are sorted in descending order of intensity in the 1990s, to allow for the absence of data from former COMECON countries in the 1980s. The highest intensities are in former socialist economies (including China) and South Africa; the lowest intensities are mostly in Western Europe, and the middle ranks include two major oil states (Saudi Arabia, Iran), Australia, North America and India.

Progress toward lower emissions intensities during the past 30 years was mixed. Large absolute declines were registered by Ukraine, China, Russia and Poland, while steady declines continued from much lower initial levels in Australia, Canada, the US, Korea, the UK and France. Patterns elsewhere included more moderate declines in Mexico, Japan, Germany, Spain and Italy; mixed records in South Africa and India; and increases in Saudi Arabia, Iran and Brazil.

3.2 Heating and Cooling Degree Days

Heating and cooling degree days (HDD and CDD) index the heating and cooling sufficient to neutralize the deviation of surface temperature from a standard comfort level. HDD and CDD

[5] An accompanying spreadsheet database includes all country data introduced in Section 3.

Table 1: CO2 Intensities (MT/$'000 US) for Energy Consumption:

Top 20 CO2 Emitters, 1980-2010

Country	Mean Annual CO2 Emissions, 1980-2010 (MMT)	Emissions Rank	1980-1989	1990-1999	2000-2010
Ukraine	358.1	11		1.83	1.30
China	3,381.0	2	2.28	1.35	0.92
Russian Federation	1,632.5	3		1.35	0.97
South Africa	356.4	12	1.18	1.22	1.06
Poland	341.6	14	1.39	0.97	0.54
Saudi Arabia	271.7	20	0.59	0.67	0.77
Iran, Islamic Rep.	288.0	18	0.53	0.64	0.68
Australia	310.2	16	0.65	0.62	0.57
Canada	515.1	8	0.69	0.62	0.52
India	829.6	6	0.55	0.60	0.51
United States	5,297.4	1	0.71	0.59	0.47
Korea, Rep.	342.2	13	0.60	0.55	0.45
United Kingdom	577.9	7	0.53	0.40	0.30
Germany	859.9	5		0.40	0.33
Mexico	341.5	15	0.35	0.34	0.31
Japan	1,083.7	4	0.38	0.32	0.32
Spain	272.0	19	0.34	0.30	0.30
Italy	416.4	9	0.32	0.30	0.27
France	397.2	10	0.32	0.25	0.21
Brazil	290.2	17	0.19	0.23	0.23

are conventionally measured as the annual sums of negative and positive deviations of daily mean surface temperatures from a reference standard of 65° Fahrenheit (18.3° Celsius).[6] Since temperatures vary within a country, construction of a national index requires a weighting procedure for combining measures at different geographic locations. To ensure full representation, these measures should be drawn from an evenly-spaced grid that covers the entire national surface. From a purely geophysical perspective, mean HDD and CDD for all grid cells within a country would provide appropriate measures. Since HDD and CDD reflect human comfort levels, however, their significance in each grid cell is proportional to the size of the affected population. Therefore, the appropriate weight for each grid cell is its share of the national population.

Although annual HDD and CDD series have been constructed for a few countries, no comprehensive cross-country measures are available. Accordingly, I have performed the exercise for this study using globally-gridded daily temperature records for the relevant historical period from the NCEP/NCAR global reanalysis project (Kalnay, et al., 1996)). The population data used for weighting are drawn from the Gridded Population of the World (CIESIN, 2005). The computational details are provided in Appendix B. I have also included a discussion of the results, since they are new and potentially useful for other research.

As part of this exercise, I have performed country-specific trend regressions for the period 1980-2011. Full results are included in Appendix Tables B1 and B2. Figures 1 and 2 map the estimated trend rates by country, using color codes that reflect global warming. In Figure 1, the countries are colored darker red for higher trend *decreases* in HDD; white for no significant trend; and blue for trend *increases* in HDD. The countries in Figure 2 are colored darker red for higher trend *increases* in CDD, white for no significant trend, and blue for trend *decreases* in CDD.

Both figures provide graphic demonstrations of the global warming trend since 1980. Declines in heating degree days are greatest in the higher northern latitudes, progressively moderating toward the equator. Many countries near the equatorial region exhibit no significant trend. Declines in HDD increase into the southern latitudes with the exception of Southern and Andean South America, where HDD has exhibited a moderately increasing trend.

Trends in cooling degree days follow a very different pattern, with the greatest increases visible in a broad band from West Africa to the Middle East. Most other countries also register trend increases, with the notable exceptions of Chile, New Zealand, Indonesia, and the Philippines.

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[6] HDD = 0 for daily average temperatures greater than or equal to 65˚; CDD = 0 for daily average temperatures less than or equal to 65˚.

Figure 1: Trend Change in Heating Degree Days, 1980 – 2012

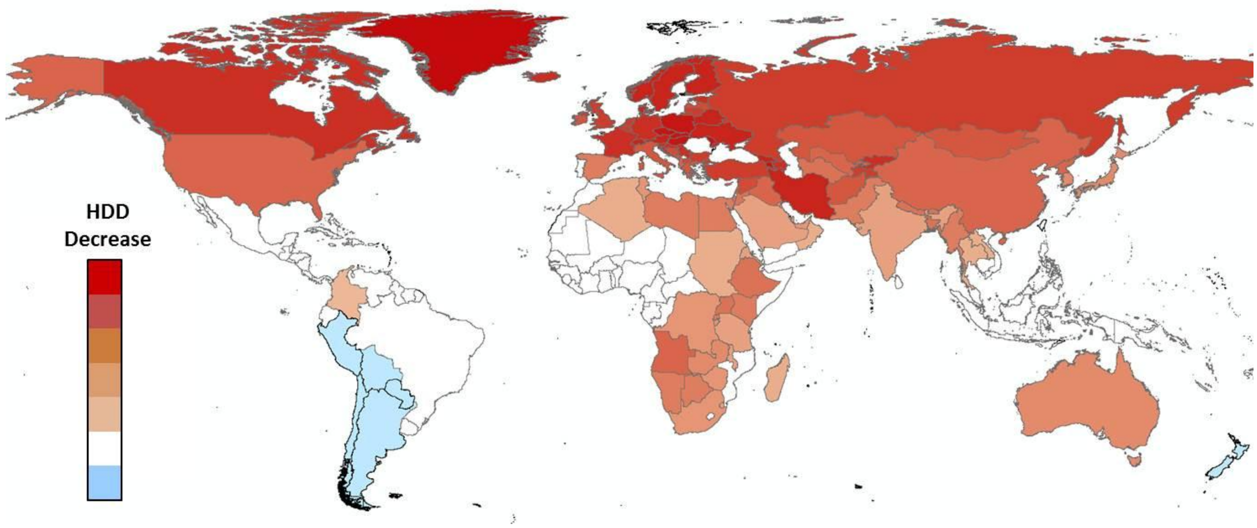
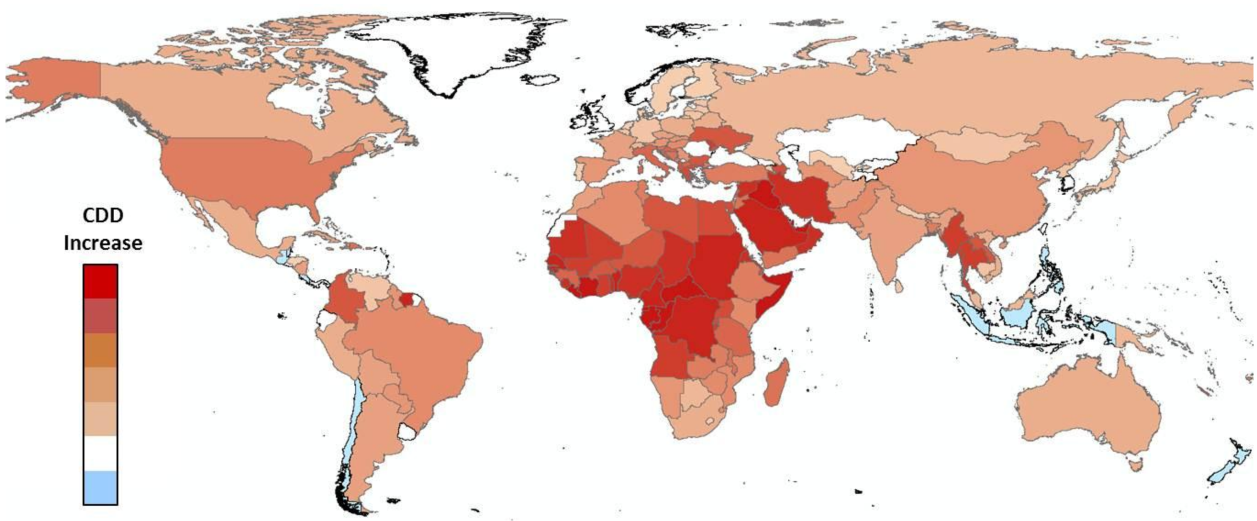


Figure 2: Trend Change in Cooling Degree Days, 1980 – 2012



3.3 Distance-Weighted Fossil Fuel and Hydropower Indices

Distance-weighted fossil fuel indices are computed from estimates of proven reserves, converted to energy parity in millions of tons of oil equivalent (BP, 2005). For each country, separate weighted access measures are computed for coal, oil and natural gas. The weighted access measure for country i is produced by multiplying proven reserves for all countries by the inverse of their centroid distance from country i[7] and then computing the total. I add weighted access measures for coal, oil and natural gas to obtain distance-weighted fossil fuel access. I follow the same distance weighting procedure for hydropower access.

Table 2 presents the top 20 countries for distance-weighted fossil fuel access. With the exception of the United States, which ranks first, and India, they are all proximate to the oil reserves of the Middle East and large fossil fuel deposits in Russia, China and central Asia.

Table 2: Index of Access to Fossil Fuel Reserves: Top 20 Countries

Country	Index
United States	151.12
Russian Federation	137.82
Iran, Islamic Rep.	113.18
Saudi Arabia	106.66
Qatar	104.98
Kuwait	103.07
United Arab Emirates	98.39
Iraq	98.27
China	81.34
Oman	73.92
Azerbaijan	71.02
Turkmenistan	68.13
Jordan	64.99
Syrian Arab Republic	64.90
Armenia	64.42
India	63.97
Mongolia	61.86
Yemen, Rep.	58.34
Kazakhstan	56.32
Georgia	55.88

[7] The centroid distance for two countries is the distance between their geographic center points. Because I use inverse distance multiplication, I set the own-country centroid distance at 1.0. Centroids and centroid distances have been computed using ArcGIS.

Table 3 presents the top 20 countries for distance-weighted hydropower access. They are more scattered geographically, but the majority are in Central, South and East Asia. The other countries are in Sub-Saharan Africa (2), North America (2) and South America (3).

Table 3: Index of Access to Hydropower:

Top 20 Countries

Country	Index
China	182.5
Russian Federation	156.3
Brazil	136.9
Mongolia	101.1
India	92.3
Bhutan	88.8
Canada	86.5
Bolivia	85.5
Congo, Dem. Rep.	84.0
Nepal	83.6
Bangladesh	80.3
Paraguay	71.7
Myanmar	68.8
Tajikistan	67.9
Kyrgyz Republic	62.2
Pakistan	60.0
Lao PDR	59.3
Congo, Rep.	56.6
United States	54.9
Afghanistan	54.6

3.4 Distance-Weighted Metals Indices

Enormous energy is expended in the extraction and processing of iron, aluminum, copper, lead, tin, and zinc. Comprehensive information on proven reserves is not available, so I compute the metals index from information on metals mining from 1998 to 2002 (USGS, 2012). For each metal, I compute median tons mined annually in each country, to compensate for spotty data and significant year-to-year fluctuations. Then I calculate the metal's distance-weighted index. Finally I combine the six metals indices, weighting by the appropriate sectoral energy intensity coefficients in the US 2002 Input-Output Table (BEA, 2002). Table 4 presents the metals indices for the top 20 countries. Australia ranks first, followed by China, Brazil and Russia. The other countries are scattered geographically, with representation in Latin America and the Caribbean (8), South and East Asia (5), North America (2) and Africa (1).

3.5 Commodity Ton-Miles

I draw data on total annual ton-miles of goods transported by road, rail and air from the World Bank's online database (World Bank, 2012). I use data for 1990 – 2000, the first decade for which reasonably comprehensive data are available. For each country, I compute the index in multiple steps to compensate for spotty data: (1) For each transport medium, I compute median annual ton-miles during 1990-2000. (2) I sum the medians across countries for road, rail and air separately, and calculate each country's share of the world total. (3) I compute each country's ton-mile index using the average value of its three global shares. Table 5 presents results for the top 20 countries. They are dominated by three huge continental economies (US, China, Russia). The others include Australia and countries scattered across Asia (6), Europe (7), Latin America (2) and North America (1).

Table 4: Index of Access to Energy-Intensive Metals:

Top 20 Countries

Country	Index
Australia	137.83
China	101.08
Brazil	63.84
Russian Federation	55.52
Peru	54.92
Bolivia	48.07
Mongolia	47.81
Indonesia	47.00
Canada	38.51
Chile	38.14
Jamaica	35.55
Paraguay	35.49
Ecuador	34.79
Bhutan	34.32
India	33.56
Venezuela, RB	33.12
United States	31.99
Colombia	31.63
Guinea	30.61
Bangladesh	30.43

Table 5: Index of Commodity Ton-Miles:

Top 20 Countries

Country	Index
United States	294.2
China	120.3
Russian Federation	106.0
Japan	50.9
Germany	46.2
France	39.8
United Kingdom	34.4
Korea, Rep.	31.6
India	25.0
Italy	22.7
Canada	20.9
Brazil	19.9
Kazakhstan	19.8
Mexico	16.2
Ukraine	14.2
Turkey	13.3
Australia	12.0
Spain	11.2
Poland	9.5
Pakistan	8.2

4. Estimation Results

Random effects is the appropriate estimator for model (1) in this context, because the initial positions of country Transition paths are partly determined by cross-sectional information on fossil and hydropower potential, access to metals resources, and the spatial distributions of populations and industrial centers. For comparison, Table 6 presents estimates for random effects (RE) in column (1), along with RE (column 2) and fixed effects (column 3) for the time series variables only. Prior expectations on signs are confirmed by the estimated RE parameters in (1), and all variables have high levels of statistical significance. Results are nearly identical for the RE and FE estimates in (2) and (3), with the exception of population. The results in all three columns indicate an increasing trend, ceteris paribus; a large negative elasticity with respect to income (CO2 intensity declines by about .40% with each 1% increase in GDP per capita); a negative effect for distance-weighted hydropower potential;

and positive effects for increases in heating and cooling degree days[8]; distance-weighted fossil fuels and metals indices; and commodity ton-miles.

Population provides the only exception to the similarity of results across estimates. It is insignificant in the full RE model (1) but highly significant in the dynamic RE (2) and FE (3) models. I attribute the loss of significance in (1) to collinearity between population and the cross-sectional variables. However, the strong FE result suggests that the independent impact of population is not fully captured by the RE specification. I exploit this difference for a robustness test of the methodology in Section 6.2.

[8] The HDD and CDD results should be interpreted as changes in the log of CO2 intensity per 1000-unit change in HDD and CDD. Both variables have been divided by 1000 prior to estimation to raise the magnitudes of the coefficients, which only register in the fifth decimal place if the original HDD and CDD units are employed. Division by 1000 only changes the units interpretation of the results, which are otherwise identical to results based on the original measures of HDD and CDD.

Table 6: Panel Estimation Results

Dependent Variable: Log CO2 Intensity

All variables are logs except HDD and CDD

	(1) Random Effects	(2) Random Effects	(3) Fixed Effects
YEAR	0.00605	0.00726	0.00481
	(7.42)**	(9.81)**	(4.61)**
GPC	-0.42630	-0.40025	-0.47101
	(25.16)**	(25.08)**	(27.58)**
POP	0.05451	0.07362	0.25499
	(1.79)	(3.06)**	(5.63)**
HDD	0.15785	0.19068	0.17108
	(11.92)**	(14.57)**	(9.24)**
CDD	0.07529	0.08604	0.06350
	(3.35)**	(4.03)**	(2.41)*
FOSSIL	0.43551		
	(5.51)**		
HYDRO	-0.61658		
	(5.14)**		
METALS	0.19939		
	(2.17)*		
TONMILES	0.11179		
	(4.65)**		
CONSTANT	-12.43338	-14.08281	-11.35017
	(8.68)**	(11.68)**	(7.58)**
Observations	4490	4776	4776
Countries	159	169	169

Absolute value of z statistics in parentheses
* Significant at 5%; ** significant at 1%

5. Country Transition and Energy+ Paths

A country's Transition path reflects expected future changes in its income, population and prevailing temperatures. The path can be projected from the estimates in Table 6, column (1) once projections are developed for these variables.

5.1 Future Temperatures

For HDD and CDD, I use linear projections from fitted trend lines for the past 30 years. As Appendix Tables B1 and B2 show, these trends seem quite robust for most countries in the dataset.

5.2 Future Incomes

For long-term income projections, I use a global panel rather than individual country projections from past growth. I fit an autogressive model to 5-year changes since 1990, allowing both countries' growth histories and long-term global convergence to affect the results.[9]

$$(2)\dot{G}_{it} = \alpha_0 + \alpha_1 \dot{G}_{it-5} + \alpha_2 \ln(G_{it-5}) + \varepsilon$$

where $\dot{G}_{it}$ = Growth rate of income per capita in country i, period t

G_{it} = Income per capita in country i, period t

Table 7 presents estimates for 5-year intervals in 175 countries for the period 1990-2010. The results have the expected signs and are highly significant. The overall trend in real growth of income per capita (at purchasing power parity) is 23.3% over 5 years, or 4.3% per year. Lagged 5-year growth has a coefficient of 0.377, indicating substantial persistence but effective disappearance of an initial growth advantage after 20 years ($.377^4 = .02$). The result for lagged income is consistent with convergence in the long run: For each unit increase in the log of real income per capita, subsequent 5-year growth drops by .018, *ceteris paribus*.

I use this autogressive model to project future income for each country, adjusting the constant term to absorb the country's residual in the initial year (2010). Table 8 presents the resulting distribution of incomes at 5-year intervals through 2050. Initial advantages in growth and income persist, but the overall prediction is a substantial decrease in international income variance, as initial growth differences erode and higher-income countries continue to grow more slowly, on average. Global median GDP per capita

[9] For related work, see Barro and Lee (1994a,b) and Barro and Sala-i-Martin (1995).

increases from $7,886 ($US 2005) in 2010 to $19,399 in 2050. The global maximum increases by a multiple of 1.6 (from $80,029 to $129,203), while the multiple for the minimum is 4.07 (from $296 to $1,205). The global ratio of maximum to minimum falls by 60.3%, while the ratio of 3rd to 1st quartile income falls by 27.5%.

Table 7: Growth Rate Regression

Dependent Variable: 5-Year Growth Rate of Real GDP Per Capita (PPP)	
Growth Rate, Previous 5 Years	0.377 (11.61)**
GDP Per Capita, Lagged Five Years	-0.018 (2.90)**
Constant	0.233 (4.46)**
Observations	767
R^2	0.15

Absolute value of t statistics in parentheses
* Significant at 5%; ** significant at 1%

Table 8: Distribution of Projected Future Incomes Per Capita

Year	Min	P10	P25	P50	P75	P90	Max	Max/Min	P75/P25
2010	296	1,121	2,348	7,886	17,112	32,939	80,029	269.9	7.3
2015	351	1,342	2,719	9,171	19,900	34,848	90,380	257.3	7.3
2020	421	1,567	3,184	10,609	22,273	36,813	97,591	231.7	7.0
2025	506	1,824	3,677	11,832	24,518	39,500	103,421	204.4	6.7
2030	606	2,119	4,215	13,140	26,777	42,324	108,714	179.3	6.4
2035	724	2,455	4,807	14,544	29,115	45,336	113,830	157.2	6.1
2040	862	2,835	5,460	16,052	31,561	48,513	118,918	138.0	5.8
2045	1,021	3,262	6,181	17,669	34,128	51,835	124,036	121.4	5.5
2050	1,205	3,741	6,974	19,399	36,823	55,292	129,203	107.2	5.3

Other approaches are, of course, possible, and any multi-decade projection is problematic. However, I believe that the growth forecasts yielded by this approach are more plausible than country-by-country forecasts that do not incorporate information from the global economy.

5.3 Future Populations

I use 10-year projections through 2100, published by the International Institute for Applied Systems Analysis (IIASA, 2009) as part of its Greenhouse Gas Initiative. They closely resemble the UN's medium-term forecasts.

5.4 Transition Paths

The econometric results in Section 4 show that countries' CO2 intensities in the energy sector are strongly affected by their stages of development, prevailing temperatures, and the spatial distributions of energy resources, pollution-intensive raw materials, and urban/industrial centers whose development predates the climate era. To incorporate these differences, each country's Transition path begins at its actual CO2 intensity in 2000. Using the country's projected income, population, HDD and CDD, I use the RE results in (1) to forecast its annual CO2 intensity through 2050. Then I draw its Transition path between its intensities in 2010 and 2050.

5.5 Energy+ Paths

Once the transition paths are established, projected annual global CO2 emissions are projected in three steps: (1) Multiply each country's projected population and GDP per capita to obtain projected GDP; (2) multiply projected GDP by projected CO2 intensity on the Transition path to obtain projected CO2 emissions from energy consumption; (3) add across countries to obtain total emissions. The Energy+ global emissions target for 2050 is a 95% reduction from global emissions in 2000. Achieving this target requires a faster overall rate of decline in CO2 intensity, which I determine through an iterative process: I increase the overall rate of decline by increments, re-computing Transition paths and 2050 aggregate emissions after each incremental increase, until aggregate projected emissions in 2050 are 95% below emissions in 2000. For each country, the final recomputation determines its Energy+ path.

6. Rating Country Performance

Rating countries' performance is straightforward once the Transition and Energy+ paths have been determined. As Figure 3 shows, I assign one of four ratings to each country in each year. Three ratings are determined by the country's emissions intensity relative to its Transition and Energy+ paths: Green if intensity is below both paths, Yellow if it lies between them, and Red if it is above both. To provide additional recognition for improvement, I rate emissions intensity light Red if is above both paths and constant or falling, and dark Red if it is still rising.

6.1 Illustrative Results for Six Countries

To illustrate, Figure 4 (next page) presents results for 6 of the 153 countries rated in this paper: The US, China, Italy, Mexico, South Africa and Turkey. Each country's graph includes: (1) Its measured CO2 intensity (CO2 per unit of GDP in constant $US 2005, measured at purchasing power parity); (2) its Transition path, computed using the panel estimation results and the country's historical and projected income per capita, population, and heating and cooling degree days; (3) its Energy+ path, which steepens the Transition path to a slope consistent with global CO2 emissions reduction of 95% by 2050.

Before viewing the results, it is important to note that tracking for countries begins at their CO2 emissions intensities in 2000, which vary from 0.28 metric tons per $'000 GDP for Italy to 1.17 for South Africa. Countries' performance is judged against these initial benchmarks, not against a single global standard.

Table 9 presents selected CO2 intensity numbers from Figure 4 in tabular format, and Figure 5 translates the information in Figure 4 to color-coded scores. The most striking pattern in Table 9 is the general decline in CO2 intensity from 2000 to 2010. Turkey experienced the greatest decline (26.6%), followed by the US (26.2%), South Africa (25.4%), Italy (17.7%) and Mexico (10.7%). Among the 6 countries, only China experienced an increase (4.9%).

Table 9: CO2 Intensities*, 2000 - 2010

Country	2000	2010	% Chg.
South Africa	1.171	0.874	-25.4
China	0.841	0.882	4.9
United States	0.522	0.386	-26.2
Turkey	0.344	0.253	-26.6
Mexico	0.313	0.279	-10.7
Italy	0.284	0.234	-17.7

* Metric tons CO2 per $US '000 GDP
(Const. $US 2005 at PPP)

Although the general pattern is encouraging, the critical question for this exercise is whether countries' declines in CO2 intensity are sufficient to keep pace with their Transition and Energy+ paths. In Figure 4, the US remains close to its Energy+ path throughout the decade; South Africa and Turkey register declining trends near the Energy+ path, but with high variance (particularly for Turkey); Italy displays consistent progress from Red to Yellow; Mexico remains near the Transition path; and China remains consistently above it.

Figure 5 aids visual interpretation of Figure 4 by color-coding countries' annual positions relative to the Transition and Energy+ paths. For example, South Africa is between the paths in 2001, 2003, 2005 and 2007-20-0, below the Energy+ path in 2002, 2006 and 2010, and above the Transition path in 2004. In contrast, China is below the Energy+ path in 2001 and then consistently above the Transition path in 2002-2010.

Figure 4: CO2 Intensity Trends and Benchmark Lines

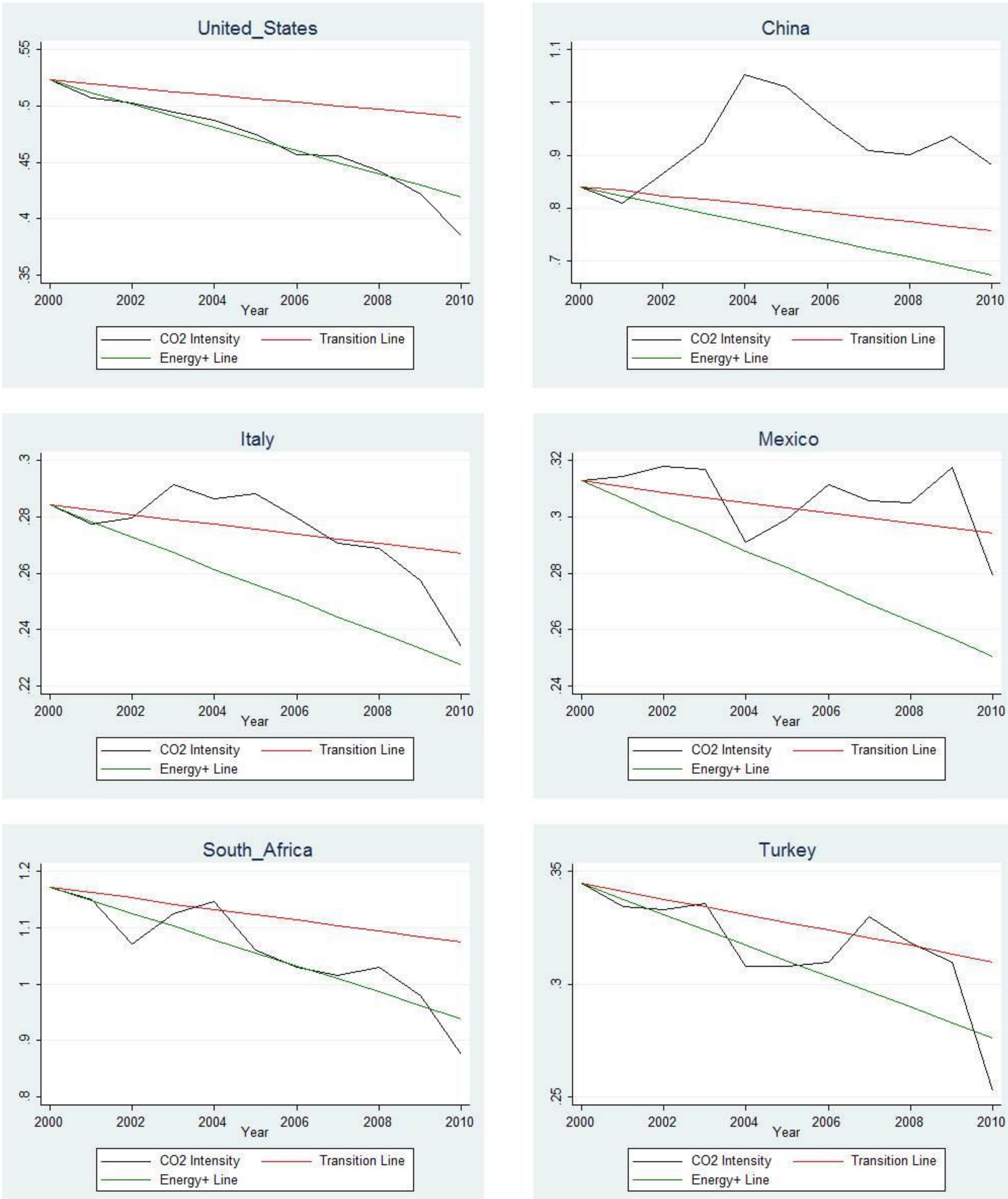


Figure 5: Country Performance Ratings, 2001 – 2010

Table 10: Performance Rating Correlations,

FE and Full RE Models:

153 countries

Year	ϱ
2001	1.00
2002	0.98
2003	0.99
2004	0.99
2005	0.99
2006	0.99
2007	0.99
2008	0.97
2009	1.00
2010	0.99

Table 11: Ratings Differences,

FE and Full RE Models:

153 Countries, 10 Years

Frequency	Count	%
0	132	86.3
1	16	10.5
2	4	2.6
3	1	0.7
Total	153	100.0

6.2 Testing Robustness

The country ratings are developed from Transition and Energy+ paths generated by the random effects (RE) model in column (1) of Table 6. To check the robustness of the methodology, I have repeated the exercise for the fixed effects (FE) model in column (3). Unlike RE, this model fully absorbs country fixed effects, so the estimates only reflect change relations linking CO2 intensity to income per capita, population, and heating and cooling degree days. Tables 10 and 11 provide evidence on the effect of changing from the full RE model to the FE model estimated for the times series variables. I assign numerical ratings to color codes as follows: Dark Red (1), light Red (2), Yellow (3), Green (4). As Tables 10 and 11 show, the correspondence between ratings with the two models is extremely close. Correlations across 153 countries are 1.00 in 2 years, .99 in 6 years, and .98 and .97 in single years. Among the 153 countries, 131 (86.3%) have identical ratings in all 10 years; 16 (10.5%) have only 1 difference in 10 years; 4 (2.6%) have 2 differences; and 1 (0.7%) has 3 differences.

I conclude that there are no significant differences between the ratings produced by full RE and FE. Where the rare, effectively-random differences occur, they reflect slight variations in the slopes of the Transition and Energy+ paths produced by the two estimators. These variations lead to small deviations in scores when CO2 intensities are close to one of the two benchmark paths.

The nearly-identical result for the two models has an important implication for future work on country performance ratings. As previously noted, I have featured the full RE specification in this paper because it incorporates cross-sectional information on fossil and hydropower potential, access to metals resources, and the spatial distributions of populations and industrial centers. The results highlight the importance of these spatial-economic variables as determinants of emissions intensity. However, as the FE results show, they can be absorbed into country fixed effects without changing country ratings significantly. By implication, reliance on FE for future work on this issue could reduce data requirements considerably with no loss of accuracy or generality.

6.3 Overall Results

Appendix Table A1 provides complete performance ratings for 153 countries. Figures 6 and 7 summarize the pattern of scores by year. They reveal a strong downward trend for Dark Red (CO2 intensity above both benchmark paths and rising), which falls steadily from 40.5% of all ratings in 2001 to 15.7% in 2009, with an additional sharp fall to 3.3% in 2010. Light Red exhibits no trend during the decade. The overall improvement among Red countries leads to a strong upward trend for Yellow, which increases from 8.5% of all ratings in 2001 to 32.7% in 2009. Green exhibits no trend from 2001 to 2009, and then jumps from 38.6% of all ratings in 2009 to 60.1% in 2010. This sudden change looks anomalous from a 10-year perspective, and it may well reflect the impact of the global economic recession. If this interpretation is correct, then the trend break in 2010 provides striking evidence of cyclical sensitivity for energy-intensive sectors in the global economy. Future updates of ***ℰ*CPR** will test the cyclical interpretation. If it is incorrect, then the result for 2010 is extremely hopeful, because it reveals a 50% increase in the number of countries that are exceeding the Energy+ benchmark. Even if the cyclical effect turns out to be present, the trend results for the latter part of the decade are quite hopeful. By 2009, 38.6% of the rated countries were meeting the Energy+ benchmark, and another 32.7% were exceeding the progress predicted by historical experience.

Figure 6: Total Country Scores by Color Code

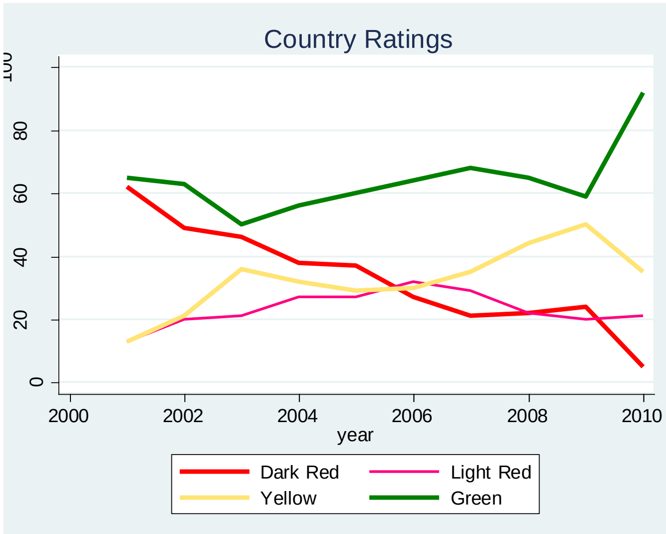


Figure 7: Total Country Scores by Percent

Year				
2001	40.5	8.5	8.5	42.5
2002	32.0	13.1	13.7	41.2
2003	30.1	13.7	23.5	32.7
2004	24.8	17.6	20.9	36.6
2005	24.2	17.6	19.0	39.2
2006	17.6	20.9	19.6	41.8
2007	13.7	19.0	22.9	44.4
2008	14.4	14.4	28.8	42.5
2009	15.7	13.1	32.7	38.6
2010	3.3	13.7	22.9	60.1

6.4 Performance by Development Status

Figure 8 reports ratings for the 10 high-, middle- and low-income countries with the greatest CO2 emissions from energy consumption during 2001-2010. All three groups exhibit great diversity in performance. Among the high-income countries, the US, Canada, Korea and France have been consistently Yellow or Green, while Japan, Germany, the UK, Italy and Australia have moved from occasional Reds during the first half of the decade to consistent Yellows and Greens in the latter half. Saudi Arabia has been Red throughout.

The middle-income countries' experience has been mixed. China, Iran, Mexico and Indonesia have been consistently or heavily Red, while Russia, India, Ukraine and Poland have been almost entirely Green. South Africa has displayed great variation, as previously noted, but its ratings have been predominantly Green or Yellow, while Brazil has been consistently Yellow.

Figure 8: Performance Ratings for Top-10 Emitters by World Bank Income Status

World Bank Status	Country	Mean CO2 Emissions	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
High Income	United States	5,822.8	Green	Yellow	Yellow	Yellow	Yellow	Green	Yellow	Yellow	Green	Green
	Japan	1,209.8	Yellow	Red	Red	Light red	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
	Germany	838.9	Red	Yellow	Red	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green
	Canada	583.8	Green	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green
	United Kingdom	564.3	Light red	Green	Yellow	Yellow	Yellow	Yellow	Green	Yellow	Green	Green
	Korea, Rep.	493.2	Yellow	Green	Yellow	Yellow	Green	Green	Green	Green	Yellow	Green
	Italy	450.7	Green	Yellow	Red	Light red	Red	Light red	Yellow	Yellow	Yellow	Yellow
	France	409.1	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green
	Australia	393.7	Red	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green
	Saudi Arabia	380.9	Red	Red	Red	Red	Light red	Light red	Light red	Red	Red	Light red
Middle Income	China	5,401.4	Green	Red	Red	Red	Light red	Light red	Light red	Light red	Red	Light red
	Russian Federation	1,618.8	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	India	1,249.6	Yellow	Green	Green	Green	Green	Green	Green	Yellow	Yellow	Green
	Iran, Islamic Rep.	437.0	Red	Red	Light red	Red	Red	Red	Light red	Red	Red	Light red
	South Africa	431.6	Yellow	Green	Yellow	Red	Yellow	Green	Yellow	Yellow	Yellow	Green
	Mexico	413.3	Red	Red	Light red	Yellow	Yellow	Red	Light red	Light red	Red	Yellow
	Brazil	383.4	Light red	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
	Indonesia	338.2	Yellow	Red	Light red	Light red	Red	Red	Red	Light red	Light red	Yellow
	Ukraine	325.3	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	Poland	288.3	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Low Income	Uzbekistan	117.4	Red	Light red	Yellow	Yellow	Green	Green	Green	Green	Green	Green
	Vietnam	76.5	Light red	Red	Red	Red	Light red	Red	Light red	Red	Light red	Light red
	Bangladesh	42.4	Red	Red	Red	Light red	Light red	Red	Light red	Red	Red	Light red
	Yemen, Rep.	18.7	Red	Red	Red	Red	Red	Red	Light red	Red	Red	Light red
	Myanmar	12.3	Green	Green	Green	Green	Red	Green	Green	Green	Green	Green
	Kenya	10.0	Green	Green	Green	Yellow	Red	Red	Light red	Light red	Red	Yellow
	Ghana	6.7	Green	Green	Yellow	Green	Green	Green	Green	Green	Yellow	Yellow
	Tajikistan	6.7	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	Kyrgyz Republic	5.7	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	Senegal	5.4	Green	Green	Green	Red	Red	Red	Light red	Light red	Light red	Yellow

Similarly-mixed experience has characterized the low-income countries. The central Asian states are notably Green: Uzbekistan during the past half-decade, Tajikistan and Kyrgyz Republic throughout the period. Myanmar has been Green for 9 of the 10 years. On the other hand, Vietnam, Bangladesh and Yemen have been consistently Red. Among African states, Ghana has been predominantly Green, while Kenya and Senegal have moved from Green at the outset to predominantly Red in recent years.

While Figure 7 reveals considerable diversity of country ratings within income groups, the methodology may incorporate an implicit income bias that is not apparent in the illustration above. To test this possibility, I have computed mean ratings and incomes for all countries in the sample during the period 2001-2010. In a regression of mean rating on mean income for 153 countries, I obtain a t-statistic of 0.30 and an adjusted R^2 of .0006. I conclude that the methodology is unbiased with respect to income status.

6.5 Regional Patterns

Figures 9 and 10 present maps of average country scores for the periods 2001-05 and 2006-10. They provide striking displays of the regional performance improvements underlying the composite trends noted above. The most noticeable patterns are a shift from dark to light Red in East Africa, Northeast Africa and the Middle East; Yellow to Green in much of Eastern Europe; light Red to Yellow and Green in much of Western Europe; light Red to Yellow in much of South America; Yellow to Green in the US, and improved performance in much of East Asia (e.g., Mongolia, Korea, Japan, Thailand, Lao PDR, Cambodia, Malaysia, Philippines).

7. Summary and Conclusions

This paper has developed ***E*CPR** (Energy+ Country Performance Ratings), a system that measures progress toward lower CO2 emissions intensity in energy consumption. Using panel data for 153 countries, I estimate the intensity impacts of income per capita, population, prevailing temperatures, access to energy resources and energy-intensive metals, and the spatial distributions of urban/industrial centers. Then I use standard methods and sources to project income, population and prevailing temperatures through 2050.

With the econometric estimates and these projections, I establish two benchmark paths for judging each country's performance. The *Transition* path tracks the country's expected change in energy consumption CO2 intensity, given its expected changes in income, population and temperature as global warming continues. The *Energy+* path tracks the progress needed to achieve a global CO2 emissions reduction of 95% by 2050.

Using each country's Transition and Energy+ paths, ***E*CPR** rates its annual performance since 2000 with the following color codes and numerical ratings for its CO2 intensity: Green (4): On or below the Energy+ path; Yellow (3): On or below the Transition path but above the Energy+ path; Light Red (2): Above the Transition path but falling; Dark Red (1): Above the Transition path and rising.

I test the robustness of my results using alternative panel estimators to establish the Transition and Energy+ paths. I find no meaningful difference in performance ratings derived from the two approaches: Correlations across 10 rating years for 153 countries are almost all .99 or 1.00; 97% of the countries have either identical ratings for the entire period or 1 difference in 10 years, and only 1 country has 3 differences.

The analysis reveals a diverse set of transition patterns at the country and regional levels. Some major emitters have been consistently Red during the past decade, some have been consistently Green, and others have improved from Red to Yellow or Green. In a similar vein, high-, middle- and low-income countries all exhibit diverse ***E*CPR** ratings. Overall the results are hopeful, with a particularly notable decline in Red ratings. During the past few years, over 70% of the 153 rated countries have exceeded their Transition path benchmarks, and around 40% have exceeded their rigorous Energy+ benchmarks.

The challenge will grow in the coming decade, as countries' Transition and Energy+ benchmarks continue to fall. Future updates of ***ℰ*CPR** can provide a consistent basis for judging how far we have come, how far we have to go, and which developing countries need additional assistance to achieve Green status.

Figure 9: Average Country Performance Ratings, 2001-2005

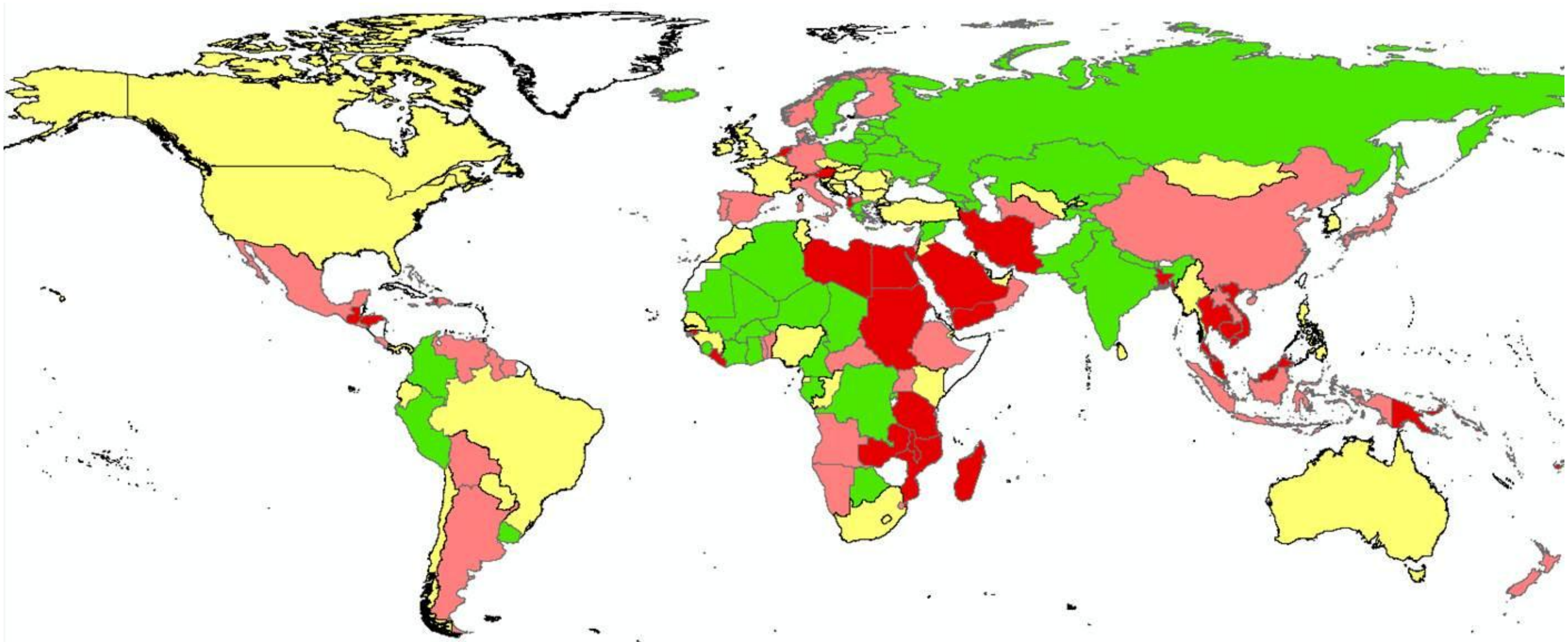


Figure 10: Average Country Performance Ratings, 2006-2010

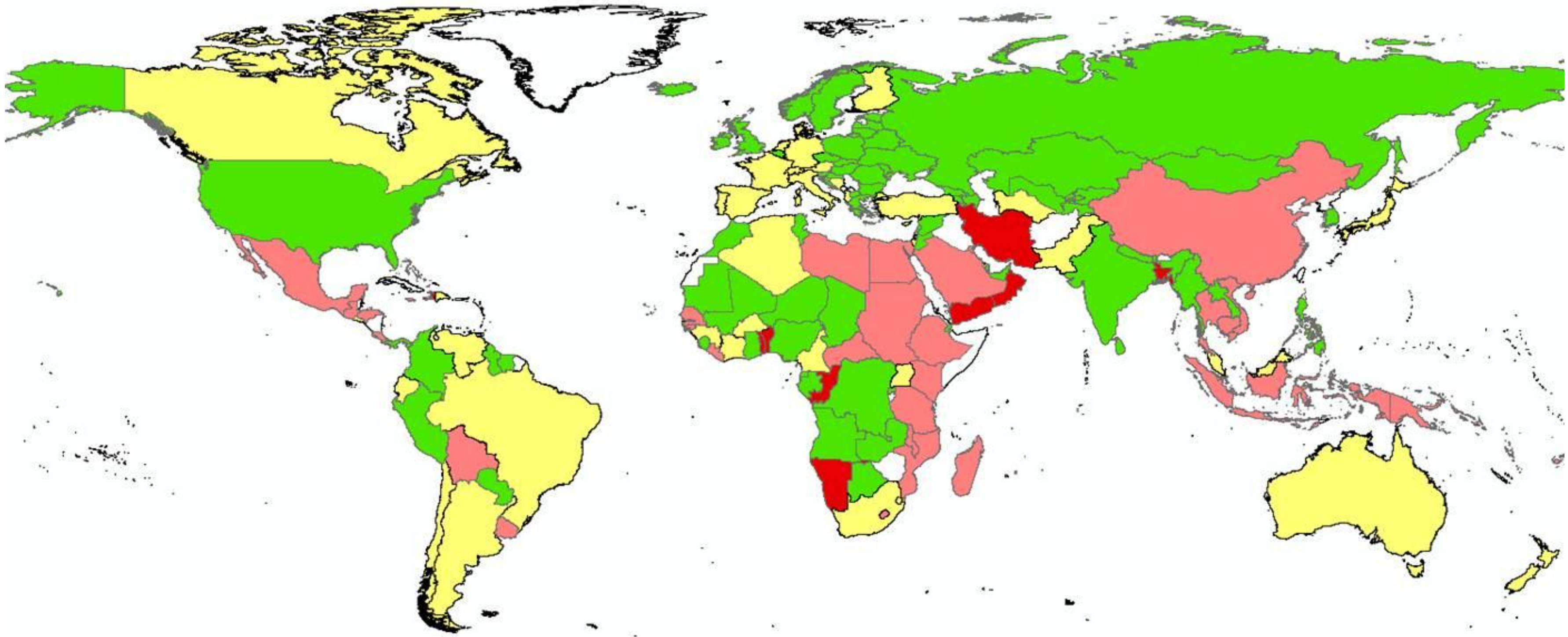


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Table A1: Color-Coded Country Performance Scores, 2001-2010

Country	ISO3	Mean CO2 Emissions, 2001-2010 (MMT)	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Albania	ALB	4.24	red	red	red	red	red	light red	yellow	yellow	yellow	yellow
Algeria	DZA	93.22	green	green	green	green	green	green	yellow	yellow	yellow	yellow
Angola	AGO	20.01	red	light red	red	light red	light red	green	green	green	green	green
Argentina	ARG	149.72	green	red	red	light red	light red	yellow	yellow	yellow	yellow	green
Armenia	ARM	10.08	green	green	green	green	green	green	green	green	green	green
Australia	AUS	393.68	red	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	green
Austria	AUT	72.40	red	red	red	light red	red	light red	yellow	yellow	yellow	yellow
Azerbaijan	AZE	36.20	green	green	green	green	green	green	green	green	green	green
Bahamas, The	BHS	4.47	yellow	yellow	red	red	red	light red	light red	red	red	light red
Bangladesh	BGD	42.45	red	red	red	light red	light red	red	light red	red	red	light red
Barbados	BRB	1.51	yellow	yellow	yellow	green	green	green	green	green	green	green
Belarus	BLR	60.91	green	green	green	green	green	green	green	green	green	green
Belgium	BEL	145.29	green	green	yellow	yellow	yellow	green	green	yellow	yellow	green
Benin	BEN	2.62	green	green	red	red	red	red	red	light red	red	light red
Bolivia	BOL	11.67	green	yellow	red	light red	light red	red	light red	red	light red	yellow
Bosnia and Herzegovina	BIH	17.72	green	green	yellow	yellow	red	light red	yellow	red	yellow	green
Botswana	BWA	4.13	green	green	green	green	green	green	green	green	green	green
Brazil	BRA	383.37	light red	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow	yellow
Brunei Darussalam	BRN	7.01	red	red	red	red	red	red	red	red	light red	red
Bulgaria	BGR	49.79	red	green	green	green	green	green	green	green	green	green
Burkina Faso	BFA	1.22	green	green	green	yellow	green	green	yellow	yellow	yellow	green
Cambodia	KHM	3.38	red	red	red	red	light red	light red	light red	light red	light red	green
Cameroon	CMR	6.96	green	green	green	green	green	yellow	yellow	yellow	yellow	green
Canada	CAN	583.79	green	green	yellow	yellow	yellow	yellow	yellow	yellow	green	green
Cape Verde	CPV	0.25	green	green	green	red	light red	red	red	light red	red	yellow
Central African Republic	CAF	0.32	red	red	red	light red	yellow	red	red	yellow	yellow	green
Chad	TCD	0.23	green	green	green	green	green	green	green	green	green	green
Chile	CHL	61.94	green	green	yellow	yellow	yellow	yellow	green	yellow	yellow	yellow
China	CHN	5,401.40	green	red	red	red	light red	light red	light red	light red	red	light red
Colombia	COL	61.55	green	green	green	green	green	green	green	green	yellow	green

Table A1: Color-Coded Country Performance Scores, 2001-2010

Country	ISO3	Mean CO2 Emissions, 2001-2010 (MMT)	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Congo, Dem. Rep.	COD	2.41	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Congo, Rep.	COG	4.96	Red	Green	Yellow	Green	Red	Light red	Red	Red	Light red	Red
Costa Rica	CRI	6.11	Red	Red	Red	Light red	Yellow	Red	Red	Light red	Yellow	Green
Cote d'Ivoire	CIV	6.26	Green	Green	Green	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Green
Croatia	HRV	21.80	Green	Yellow	Red	Green	Green	Yellow	Green	Green	Green	Yellow
Cyprus	CYP	8.78	Red	Yellow	Yellow	Red	Light red	Red	Yellow	Yellow	Yellow	Yellow
Czech Republic	CZE	95.46	Light red	Light red	Yellow	Green	Green	Green	Green	Green	Green	Green
Denmark	DNK	54.88	Red	Yellow	Red	Light red	Green	Yellow	Yellow	Yellow	Yellow	Green
Djibouti	DJI	1.86	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green	Green
Dominican Republic	DOM	18.27	Red	Light red	Red	Light red	Light red	Yellow	Yellow	Yellow	Yellow	Green
Ecuador	ECU	24.22	Red	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green
Egypt, Arab Rep.	EGY	156.51	Red	Red	Red	Red	Red	Light red	Light red	Red	Light red	Yellow
El Salvador	SLV	6.02	Red	Light red	Red	Light red	Light red	Light red	Light red	Yellow	Yellow	Yellow
Equatorial Guinea	GNQ	4.10	Green	Red	Red	Green	Green	Green	Green	Green	Green	Green
Estonia	EST	18.58	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow
Ethiopia	ETH	4.99	Green	Red	Red	Light red	Light red	Red	Light red	Red	Light red	Yellow
Fiji	FJI	2.19	Red	Red	Red	Red	Light red	Light red	Red	Light red	Light red	Red
Finland	FIN	56.17	Red	Light red	Red	Light red	Yellow	Red	Yellow	Yellow	Yellow	Yellow
France	FRA	409.08	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green
Gabon	GAB	4.76	Green	Green	Green	Yellow	Yellow	Green	Green	Green	Green	Green
Georgia	GEO	4.72	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Germany	DEU	838.87	Red	Yellow	Red	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green
Ghana	GHA	6.75	Green	Green	Yellow	Green	Green	Green	Green	Green	Yellow	Yellow
Greece	GRC	103.33	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Guatemala	GTM	10.90	Red	Light red	Light red	Red	Red	Light red	Red	Light red	Light red	Yellow
Guinea	GIN	1.35	Green	Green	Yellow	Red	Red	Light red	Yellow	Yellow	Yellow	Yellow
Guinea-Bissau	GNB	0.40	Light red	Red	Red	Red	Red	Light red	Red	Red	Light red	Light red
Guyana	GUY	1.62	Red	Red	Light red	Green	Yellow	Green	Green	Green	Green	Green
Haiti	HTI	1.76	Red	Red	Light red	Red	Light red	Red	Red	Red	Red	Yellow
Honduras	HND	7.00	Red	Red	Light red	Red	Red	Red	Red	Light red	Light red	Light red

Table A1: Color-Coded Country Performance Scores, 2001-2010

Country	ISO3	Mean CO2 Emissions, 2001-2010 (MMT)	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Hungary	HUN	56.25	Light red	Yellow	Yellow	Green	Green	Green	Green	Green	Green	Green
Iceland	ISL	3.36	Green	Green	Green	Green	Green	Green	Yellow	Green	Yellow	Green
India	IND	1,249.55	Yellow	Green	Green	Green	Green	Green	Green	Yellow	Yellow	Green
Indonesia	IDN	338.24	Yellow	Red	Light red	Light red	Red	Red	Red	Light red	Light red	Yellow
Iran, Islamic Rep.	IRN	437.03	Red	Red	Light red	Red	Red	Red	Light red	Red	Red	Light red
Ireland	IRL	43.04	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green
Israel	ISR	67.20	Red	Light red	Light red	Light red	Light red	Light red	Yellow	Yellow	Yellow	Green
Italy	ITA	450.70	Green	Yellow	Red	Light red	Red	Light red	Yellow	Yellow	Yellow	Yellow
Jamaica	JAM	11.55	Light red	Red	Red	Light red	Yellow	Red	Red	Light red	Light red	Green
Japan	JPN	1,209.80	Yellow	Red	Red	Light red	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Jordan	JOR	18.15	Green	Green	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green
Kazakhstan	KAZ	165.88	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Kenya	KEN	10.01	Green	Green	Green	Yellow	Red	Red	Light red	Light red	Red	Yellow
Korea, Rep.	KOR	493.22	Yellow	Green	Yellow	Yellow	Green	Green	Green	Green	Yellow	Green
Kuwait	KWT	70.67	Green	Green	Green	Yellow	Red	Light red	Yellow	Yellow	Red	Yellow
Kyrgyz Republic	KGZ	5.74	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Lao PDR	LAO	1.14	Red	Light red	Light red	Light red	Light red	Yellow	Green	Green	Green	Green
Latvia	LVA	8.33	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Green
Lebanon	LBN	15.10	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Lesotho	LSO	0.23	Green	Yellow	Green	Green	Red	Light red	Light red	Yellow	Red	Light red
Liberia	LBR	0.58	Red	Red	Red	Light red	Light red	Red	Red	Light red	Light red	Light red
Libya	LBY	51.74	Red	Red	Light red	Red	Red	Light red	Light red	Red	Light red	Light red
Lithuania	LTU	15.14	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Luxembourg	LUX	11.17	Red	Red	Red	Red	Light red	Light red	Light red	Light red	Yellow	Green
Macedonia, FYR	MKD	8.20	Red	Light red	Red	Yellow	Green	Green	Green	Yellow	Green	Green
Madagascar	MDG	2.54	Red	Red	Light red	Red	Light red	Light red	Light red	Red	Red	Light red
Malawi	MWI	1.10	Red	Red	Yellow	Red	Red	Light red	Light red	Light red	Light red	Yellow
Malaysia	MYS	142.48	Red	Red	Red	Light red	Light red	Light red	Yellow	Yellow	Yellow	Green
Mali	MLI	0.67	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Malta	MLT	2.98	Green	Red	Light red	Red	Light red	Yellow	Red	Yellow	Red	Yellow

Table A1: Color-Coded Country Performance Scores, 2001-2010

Country	ISO3	Mean CO_2 Emissions, 2001-2010 (MMT)	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Mauritania	MRT	2.96	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Mauritius	MUS	4.14	Red	Light red	Yellow	Red	Red	Red	Light red	Light red	Light red	Yellow
Mexico	MEX	413.34	Red	Red	Light red	Yellow	Yellow	Red	Light red	Light red	Red	Yellow
Moldova	MDA	6.81	Green	Green	Red	Green	Green	Green	Green	Green	Green	Green
Mongolia	MNG	6.80	Red	Red	Green	Green	Green	Green	Green	Green	Green	Green
Morocco	MAR	34.65	Red	Yellow	Green	Green	Green	Green	Green	Green	Green	Green
Mozambique	MOZ	2.10	Red	Red	Red	Red	Red	Red	Light red	Yellow	Yellow	Yellow
Myanmar	MMR	12.32	Green	Green	Green	Green	Red	Green	Green	Green	Green	Green
Namibia	NAM	2.91	Red	Light red	Red	Light red	Light red	Red	Red	Red	Red	Light red
Nepal	NPL	3.15	Light red	Green	Green	Green	Green	Green	Green	Green	Green	Green
Netherlands	NLD	258.40	Red	Light red	Red	Red	Light red	Light red	Yellow	Yellow	Yellow	Yellow
New Zealand	NZL	38.88	Red	Light red	Light red	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Niger	NER	1.29	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow
Nigeria	NGA	93.21	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green
Norway	NOR	41.89	Yellow	Red	Red	Red	Yellow	Green	Yellow	Green	Yellow	Green
Oman	OMN	33.37	Green	Red	Yellow	Red	Red	Red	Light red	Red	Red	Red
Pakistan	PAK	122.86	Green	Green	Green	Green	Green	Yellow	Red	Yellow	Yellow	Yellow
Panama	PAN	14.12	Red	Green	Green	Yellow	Green	Green	Green	Green	Green	Green
Papua New Guinea	PNG	4.10	Light red	Red	Red	Light red	Red	Light red	Light red	Light red	Red	Light red
Paraguay	PRY	3.76	Green	Red	Light red	Yellow	Green	Green	Green	Green	Yellow	Green
Peru	PER	30.81	Green	Green	Green	Yellow	Yellow	Yellow	Green	Green	Yellow	Green
Philippines	PHL	74.67	Light red	Yellow	Green	Green	Green	Green	Green	Green	Green	Green
Poland	POL	288.30	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Portugal	PRT	60.67	Green	Red	Yellow	Yellow	Red	Yellow	Yellow	Green	Yellow	Green
Qatar	QAT	47.35	Green	Green	Green	Green	Red	Yellow	Green	Green	Green	Green
Romania	ROU	95.58	Red	Yellow	Green	Green	Green	Green	Green	Green	Green	Green
Russian Federation	RUS	1,618.84	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Rwanda	RWA	0.78	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Saudi Arabia	SAU	380.91	Red	Red	Red	Red	Light red	Light red	Light red	Red	Red	Light red
Senegal	SEN	5.41	Green	Green	Green	Red	Red	Red	Light red	Light red	Light red	Yellow

Table A1: Color-Coded Country Performance Scores, 2001-2010

Country	ISO3	Mean CO2 Emissions, 2001-2010 (MMT)	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Sierra Leone	SLE	1.13	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Singapore	SGP	134.47	Red	Green	Yellow	Red	Light red	Yellow	Yellow	Yellow	Light red	Yellow
Slovak Republic	SVK	38.13	Red	Light red	Yellow	Green	Green	Green	Green	Green	Green	Green
Slovenia	SVN	16.86	Light red	Light red	Yellow	Yellow	Yellow	Green	Green	Green	Yellow	Green
Solomon Islands	SLB	0.22	Red	Red	Light red	Light red	Red	Light red	Light red	Red	Red	Red
South Africa	ZAF	431.63	Yellow	Green	Yellow	Red	Yellow	Green	Yellow	Yellow	Yellow	Green
Spain	ESP	350.43	Green	Yellow	Yellow	Red	Red	Yellow	Yellow	Yellow	Yellow	Green
Sri Lanka	LKA	12.27	Light red	Light red	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green
Sudan	SDN	10.71	Red	Red	Red	Red	Red	Light red	Light red	Light red	Red	Light red
Suriname	SUR	1.92	Red	Red	Light red	Yellow	Green	Yellow	Green	Green	Green	Green
Swaziland	SWZ	1.26	Yellow	Red	Light red	Red	Green	Green	Yellow	Green	Red	Green
Sweden	SWE	57.84	Yellow	Green	Yellow	Green	Green	Green	Green	Green	Green	Green
Switzerland	CHE	45.29	Light red	Green	Yellow	Yellow	Yellow	Yellow	Green	Yellow	Yellow	Green
Syrian Arab Republic	SYR	53.63	Green	Green	Yellow	Green	Green	Green	Green	Green	Green	Green
Tajikistan	TJK	6.74	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Tanzania	TZA	4.92	Red	Red	Light red	Red	Red	Light red	Red	Light red	Light red	Light red
Thailand	THA	223.97	Red	Red	Red	Red	Red	Light red	Light red	Red	Red	Light red
Togo	TGO	2.19	Green	Green	Red	Red	Light red	Light red	Red	Red	Red	Light red
Tunisia	TUN	21.38	Red	Light red	Yellow	Green	Green	Green	Green	Green	Green	Green
Turkey	TUR	230.24	Green	Yellow	Red	Green	Green	Yellow	Red	Light red	Yellow	Green
Turkmenistan	TKM	46.13	Red	Light red	Red	Light red	Light red	Light red	Light red	Yellow	Green	Green
Uganda	UGA	1.71	Red	Light red	Red	Green	Red	Red	Light red	Yellow	Green	Green
Ukraine	UKR	325.25	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
United Arab Emirates	ARE	151.99	Yellow	Red	Yellow	Yellow	Green	Green	Green	Green	Green	Green
United Kingdom	GBR	564.29	Light red	Green	Yellow	Yellow	Yellow	Yellow	Green	Yellow	Green	Green
United States	USA	5,822.78	Green	Yellow	Yellow	Yellow	Yellow	Green	Yellow	Yellow	Green	Green
Uruguay	URY	6.51	Green	Green	Green	Yellow	Yellow	Red	Yellow	Red	Yellow	Green
Uzbekistan	UZB	117.40	Red	Light red	Yellow	Yellow	Green	Green	Green	Green	Green	Green
Vanuatu	VUT	0.11	Red	Red	Light red	Light red	Red	Light red	Red	Light red	Red	Light red
Venezuela, RB	VEN	149.55	Red	Red	Light red	Light red	Yellow	Yellow	Green	Yellow	Yellow	Yellow

Table A1: Color-Coded Country Performance Scores, 2001-2010

Country	ISO3	Mean CO2 Emissions, 2001-2010 (MMT)	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Vietnam	VNM	76.48	Light red	Red	Red	Red	Light red	Red	Light red	Red	Light red	Light red
Yemen, Rep.	YEM	18.71	Red	Red	Red	Red	Red	Red	Light red	Red	Red	Light red
Zambia	ZMB	2.30	Red	Red	Light red	Light red	Red	Yellow	Green	Green	Yellow	Green

Appendix B: Calculation of Heating and Cooling Degree Days

Heating and cooling degree days (HDD and CDD) index the heating and cooling sufficient to neutralize the deviation of surface temperature from a standard comfort level. HDD and CDD are conventionally measured as the annual sums of negative and positive deviations of daily mean surface temperatures from a reference standard of 65° Fahrenheit (18.3° Celsius).[10] Since temperatures vary within a country, construction of a national index requires a weighting procedure for combining measures at different geographic locations. To ensure full representation, these measures should be drawn from an evenly-spaced grid that covers the entire national surface. From a purely geophysical perspective, mean HDD and CDD for all grid cells within a country would provide appropriate measures. Since HDD and CDD reflect human comfort levels, however, their significance in each grid cell is proportional to the size of the affected population. Therefore, the appropriate weight for each grid cell is its share of the national population.

Although annual HDD and CDD series have been constructed for a few countries, no comprehensive cross-country measures are available. Accordingly, I have performed the exercise for this study using globally-gridded population and daily temperature data for the relevant historical period.

1. General Computation Strategy

In practice, calculations are complicated by two factors. First, the best available daily temperature records (from the NCEP/NCAR global reanalysis project (Kalnay, et al., 1996)) are formatted in 2.5° grids, while the best available annual population data (from the Gridded Population of the World (GPWv3)) are formatted at higher resolution (2.5', .25°, .5° and 1°). Calculation requires changing the spatial resolution of one dataset. I have chosen to resample (interpolate) the temperature measures to higher resolution because they vary much more smoothly over space than the population data. Finer-gridded temperature data also permit more precise country assignment of border cells, which overlap with some national boundaries at 2.5° resolution. For this exercise, I have computed annual HDD and CDD for each cell at 2.5° resolution, and then interpolated the results to match the population data at .25°.

The second complication is introduced by the periodicity of the population data. GPWv3 provides gridded population estimates at 5-year intervals from 1990 to 2010, with forecasts for 2015. Calculation of annual HDD and CDD requires weighting by the national population share of each grid cell in each year. To calculate the annual population share of each grid cell for 1990-2011, I have estimated the cell's yearly population using its annualized population growth rate within the relevant five-year interval. To estimate yearly population

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[10] HDD = 0 for daily average temperatures greater than or equal to 65°; CDD = 0 for daily average temperatures less than or equal to 65°.

and grid cell shares for 1985-1989, I have "backcasted" using the population growth rate for 1990-1995. Experimentation with the data suggests that backcasting is unreliable beyond 5 years, so I have used estimated grid cell shares for 1985 as the shares for 1980-1984.

2. Detailed Calculation Steps

Temperature

The source data, downloaded in ASCII format, are gridded daily 6-hour surface temperatures at 2.5° spatial resolution from the NCEP/NCAR Global Reanalysis Project.[11] The source data are converted to final form for HDD and CDD calculation in the following steps:

(1). In Stata, average daily temperatures are calculated for each point in the 2.5° x 2.5° global grid.

(2). In Stata, annual HDD and CDD are calculated for each point, using the reference standard of 65° Fahrenheit.

(3). The annual Stata files for HDD and CDD are converted to raster files for resampling in GIS.

(4). Using Python and ArcGIS 10, the annual raster files for HDD and CDD are resampled from 2.5° to .25°.

(5). The resampled raster files are converted to Stata files for calculation of national HDD and CDD.

Population

The source data, downloaded in raster grid format at .25° resolution, are annual population estimates for 1990, 1995, 2000, 2010 and 2015 from the Gridded Population of the World (GPWv3).[12] The raster files are converted to Stata files for calculation of HDD and CDD.

Country Boundaries

The source data, downloaded in shapefile format, are national boundaries from the GADM database of Global Administrative Areas.[13] Using ArcGIS 10, the global boundary shapefile is converted to a raster file at .25° resolution. The raster file is converted to a Stata file with country identifier numbers for calculation of national HDD and CDD.

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[11] http://www.esrl.noaa.gov/psd/cgi-bin/db_search/DBSearch.pl?Dataset=NCEP+Reanalysis+Surface+Level&Variable=Air+Temperature&group=0&submit=Search

[12] http://sedac.ciesin.columbia.edu/gpw/global.jsp

[13] http://www.gadm.org/

National HDD and CDD Series

The degree-day, population and country files are merged in Stata by .25° latitude and longitude. For each country, year and grid location, population shares are calculated and multiplied by HDD and CDD. The results are totaled by country and year to produce annual CDD and HDD series for 1980-2011.

3. National Trends, 1980-2011

Tables B1 and B2 summarize trend analysis results for heating and cooling degree days for 190 countries during the period 1980-2011. Of these countries, 102 have declining HDD trends of 1 per year or greater, and 93 are highly significant by the standard criteria. During the same period, 6 countries hve an increasing HDD trend of 1 per year or greater, and 2 are highly significant. For cooling degree days, 165 countries have annual trend increases of 1 or more, and 128 are highly significant. Annual declines greater than 1 are exhibited by 9 countries, and 3 are highly significant.

Table B1: Heating Degree Days: Fitted Trends and Projections

Country	ISO3	HDD 1980	% Chg. 1980 - 2011	Pred. HDD 2050	% Chg. 1980-2050	Annual Change	T-Stat
Afghanistan	AFG	6,613.7	-8.3	5,688.8	-14.0	-18.857	3**
Albania	ALB	4,639.1	-11.3	3,334.7	-28.1	-16.368	3.99**
Algeria	DZA	2,996.2	-2.1	2,592.4	-13.5	-1.826	0.55
Angola	AGO	959.0	-53.8	0.0	-100.0	-13.942	4.18**
Antigua and Barbuda	ATG	0.0	0.0	0.0	0.0	0.000	
Argentina	ARG	1,921.2	6.1	2,213.3	15.2	3.835	1.3
Armenia	ARM	9,141.8	-13.9	6,578.0	-28.0	-42.919	5.45**
Australia	AUS	2,074.0	-10.1	1,713.1	-17.4	-7.235	2.62**
Austria	AUT	7,828.1	-13.4	5,088.1	-35.0	-31.452	4.35**
Azerbaijan	AZE	5,247.0	-15.6	3,561.0	-32.1	-27.771	4.71**
Bahamas, The	BHS	35.1	-3.1	15.5	-55.8	-0.017	0.06
Bangladesh	BGD	991.3	-37.2	162.3	-83.6	-12.156	7.49**
Barbados	BRB	0.0	0.0	0.0	0.0	0.000	
Belarus	BLR	9,692.3	-10.2	7,001.3	-27.8	-30.070	3.03**
Belgium	BEL	7,110.8	-11.8	5,121.0	-28.0	-26.444	3.34**
Belize	BLZ	0.0	0.0	4.7	0.0	0.061	1.55
Benin	BEN	4.4	13.0	4.2	-4.5	0.014	0.22
Bhutan	BTN	3,974.4	-9.5	3,148.9	-20.8	-12.354	3.14**
Bolivia	BOL	2,785.0	2.2	2,856.5	2.6	1.936	0.77
Bosnia and Herzegovina	BIH	6,262.4	-11.8	4,388.4	-29.9	-22.888	4.41**
Botswana	BWA	2,459.8	-11.2	1,682.0	-31.6	-8.140	2.03*
Brazil	BRA	220.6	-1.3	212.0	-3.9	-0.092	0.13
Brunei Darussalam	BRN	0.0	0.0	0.0	0.0	0.000	
Bulgaria	BGR	5,386.8	-14.4	3,604.3	-33.1	-24.901	4.73**
Burkina Faso	BFA	8.8	48.0	19.2	118.2	0.143	0.76
Burundi	BDI	303.7	-46.4	0.0	-100.0	-6.004	3.7**
Cambodia	KHM	10.0	-56.9	0.0	-100.0	-0.372	2.57*
Cameroon	CMR	3.8	-33.9	1.1	-71.1	-0.050	0.87
Canada	CAN	8,226.9	-11.5	5,814.3	-29.3	-29.187	4.61**
Cape Verde	CPV	0.0	0.0	0.2	0.0	-0.002	0.13
Central African Republic	CAF	1.1	-47.6	0.0	-100.0	-0.043	1.13
Chad	TCD	79.1	-23.6	47.4	-40.1	-0.772	1.37
Chile	CHL	5,046.0	35.6	8,016.2	58.9	51.016	7.39**
China	CHN	5,337.2	-9.9	4,134.1	-22.5	-17.059	4.39**
Colombia	COL	36.3	-64.0	0.0	-100.0	-1.065	3.57**
Comoros	COM	0.0	0.0	0.0	0.0	0.000	
Congo, Dem. Rep.	COD	235.6	-53.4	0.0	-100.0	-4.730	7.4**
Congo, Rep.	COG	6.2	-100.0	0.0	-100.0	-0.418	4.08**
Costa Rica	CRI	0.0	0.0	0.0	0.0	0.000	
Cote d'Ivoire	CIV	0.5	0.0	0.5	0.0	0.000	

Country	ISO3	HDD 1980	% Chg. 1980 - 2011	Pred. HDD 2050	% Chg. 1980-2050	Annual Change	T-Stat
Croatia	HRV	5,941.5	-15.4	3,655.9	-38.5	-27.753	5.13**
Cuba	CUB	3.0	27.9	2.8	-6.7	0.016	0.3
Cyprus	CYP	1,814.4	-28.5	672.6	-62.9	-17.424	6**
Czech Republic	CZE	8,697.6	-13.6	5,628.4	-35.3	-35.815	4.1**
Denmark	DNK	7,851.1	-12.9	5,304.4	-32.4	-31.225	3.33**
Djibouti	DJI	82.0	-7.6	75.1	-8.4	-0.223	0.27
Dominica	DMA	0.0	0.0	0.0	0.0	0.000	
Dominican Republic	DOM	0.0	0.0	0.0	0.0	0.000	
Ecuador	ECU	9.1	-24.0	9.4	3.3	-0.159	0.68
Egypt, Arab Rep.	EGY	1,814.1	-12.8	1,461.0	-19.5	-8.470	2.38*
El Salvador	SLV	0.0	0.0	0.3	0.0	0.004	1.78
Equatorial Guinea	GNQ	0.0	0.0	0.0	0.0	0.000	
Eritrea	ERI	253.7	-34.6	74.1	-70.8	-3.793	3.86**
Estonia	EST	10,288.1	-9.2	7,710.9	-25.1	-28.826	2.63**
Ethiopia	ETH	1,472.1	-18.7	966.4	-34.4	-10.115	3.84**
Faeroe Islands	FRO	7,206.7	-7.8	6,011.5	-16.6	-18.382	4.04**
Fiji	FJI	0.0	0.0	0.0	0.0	0.000	
Finland	FIN	10,906.9	-9.9	8,217.3	-24.7	-33.742	3.04**
France	FRA	6,393.7	-14.0	4,172.8	-34.7	-27.432	4.52**
French Polynesia	PYF	0.0	0.0	0.0	0.0	0.000	
Gabon	GAB	0.0	0.0	0.0	0.0	0.000	
Gambia, The	GMB	7.5	-71.0	0.0	-100.0	-0.228	1.72
Georgia	GEO	9,804.0	-10.3	7,763.7	-20.8	-33.790	4.41**
Germany	DEU	8,524.5	-10.8	6,169.5	-27.6	-28.330	3.41**
Ghana	GHA	0.3	0.0	0.3	0.0	0.000	
Greece	GRC	2,897.7	-19.7	1,593.3	-45.0	-18.201	5.28**
Greenland	GRL	14,949.2	-10.2	12,559.2	-16.0	-53.399	3.69**
Grenada	GRD	0.0	0.0	0.0	0.0	0.000	
Guam	GUM	0.0	0.0	0.0	0.0	0.000	
Guatemala	GTM	0.0	0.0	7.4	0.0	0.103	2.37*
Guinea	GIN	8.3	-43.9	0.1	-98.8	-0.128	0.86
Guinea-Bissau	GNB	5.3	-64.6	0.0	-100.0	-0.132	1.46
Guyana	GUY	0.0	0.0	0.0	0.0	0.000	
Haiti	HTI	0.0	0.0	0.0	0.0	0.000	
Honduras	HND	0.0	0.0	1.8	0.0	0.023	1.25
Hong Kong SAR, China	HKG	281.8	-2.7	250.6	-11.1	-0.236	0.22
Hungary	HUN	7,639.0	-15.7	4,729.0	-38.1	-37.256	5.09**
Iceland	ISL	8,859.6	-9.3	7,192.9	-18.8	-27.345	6.39**
India	IND	868.6	-10.1	702.2	-19.2	-2.976	2.13*
Indonesia	IDN	0.0	0.0	0.0	0.0	0.000	
Iran, Islamic Rep.	IRN	5,051.9	-17.5	3,281.4	-35.0	-30.720	6.26**
Iraq	IRQ	2,785.9	-14.9	2,009.9	-27.9	-14.554	3.19**
Ireland	IRL	5,823.2	-10.5	4,435.4	-23.8	-19.646	3.68**
Israel	ISR	3,229.2	-10.1	2,752.9	-14.7	-11.584	2.29*

Country	ISO3	HDD 1980	% Chg. 1980 - 2011	Pred. HDD 2050	% Chg. 1980-2050	Annual Change	T-Stat
Italy	ITA	4,053.2	-16.0	2,373.3	-41.4	-19.105	5.11**
Jamaica	JAM	0.0	0.0	0.0	0.0	0.000	
Japan	JPN	3,098.3	-8.2	2,461.9	-20.5	-7.955	1.94
Jordan	JOR	3,536.3	-8.9	3,138.0	-11.3	-11.285	1.99*
Kazakhstan	KAZ	11,286.9	-5.2	9,938.8	-11.9	-19.018	2.66**
Kenya	KEN	1,075.6	-22.6	586.0	-45.5	-8.722	3.73**
Kiribati	KIR	0.0	0.0	0.0	0.0	0.000	
Korea, Dem. Rep.	PRK	6,967.2	-7.6	5,595.0	-19.7	-16.467	2.77**
Korea, Rep.	KOR	4,932.5	-5.2	4,121.8	-16.4	-7.897	1.51
Kuwait	KWT	787.5	-23.4	431.9	-45.2	-6.912	2.36*
Kyrgyz Republic	KGZ	14,387.2	-5.7	13,094.6	-9.0	-27.446	3.12**
Lao PDR	LAO	289.2	-15.9	259.6	-10.2	-2.083	1.28
Latvia	LVA	9,957.7	-7.4	7,783.0	-21.8	-22.330	2.14*
Lebanon	LBN	3,664.2	-13.4	2,700.3	-26.3	-16.701	3.51**
Lesotho	LSO	2,734.3	-0.9	2,599.3	-4.9	-0.807	0.27
Liberia	LBR	0.3	-11.6	0.2	-33.3	-0.001	0.09
Libya	LBY	1,811.0	-15.1	1,244.2	-31.3	-9.191	3.81**
Liechtenstein	LIE	8,254.3	-12.1	5,641.7	-31.7	-30.334	4.67**
Lithuania	LTU	9,655.3	-8.5	7,304.3	-24.3	-24.749	2.41*
Luxembourg	LUX	8,560.4	-10.3	6,366.5	-25.6	-27.423	3.59**
Macedonia, FYR	MKD	5,727.2	-11.5	4,163.1	-27.3	-20.876	4.24**
Madagascar	MDG	365.2	-17.4	240.4	-34.2	-2.218	2.89**
Malawi	MWI	561.1	-15.0	402.6	-28.2	-2.931	1.8
Malaysia	MYS	0.0	0.0	0.0	0.0	0.000	
Mali	MLI	30.3	-10.5	40.2	32.7	-0.179	0.29
Malta	MLT	1,258.6	-21.6	564.5	-55.1	-7.651	3.25**
Mauritania	MRT	66.3	-25.0	41.8	-37.0	-0.773	0.96
Mauritius	MUS	0.4	3.0	1.2	200.0	0.001	0.04
Mayotte	MYT	2.7	-81.2	0.0	-100.0	-0.280	2.39*
Mexico	MEX	244.0	-5.8	207.9	-14.8	-0.446	0.6
Micronesia, Fed. Sts.	FSM	0.0	0.0	0.0	0.0	0.000	
Moldova	MDA	6,672.7	-17.1	4,000.2	-40.1	-35.976	4.89**
Mongolia	MNG	14,805.8	-4.2	13,205.3	-10.8	-19.976	2.46*
Montenegro	MNE	6,247.8	-10.3	4,635.4	-25.8	-20.102	3.98**
Morocco	MAR	3,005.5	-1.1	2,731.2	-9.1	-0.998	0.19
Mozambique	MOZ	133.9	-0.2	136.3	1.8	-0.011	0.02
Myanmar	MMR	644.0	-40.3	61.6	-90.4	-8.919	6.72**
Namibia	NAM	2,037.4	-15.6	1,120.9	-45.0	-8.667	2*
Nepal	NPL	3,612.8	-9.4	2,930.3	-18.9	-11.236	3.81**
Netherlands	NLD	7,080.0	-11.9	5,086.2	-28.2	-26.764	3.15**
Netherlands Antilles	ANT	0.0	0.0	0.0	0.0	0.000	
New Caledonia	NCL	3.8	-54.0	0.0	-100.0	-0.099	1.48
New Zealand	NZL	3,303.0	4.7	3,638.0	10.1	5.026	1.01
Nicaragua	NIC	0.0	0.0	0.1	0.0	0.001	1.78
Niger	NER	107.7	17.1	183.5	70.4	0.729	0.76

Country	ISO3	HDD 1980	% Chg. 1980 - 2011	Pred. HDD 2050	% Chg. 1980-2050	Annual Change	T-Stat
Nigeria	NGA	18.7	32.4	36.6	95.7	0.221	0.79
Northern Mariana Islands	MNP	0.0	0.0	0.0	0.0	0.000	
Norway	NOR	10,153.4	-9.4	7,787.6	-23.3	-30.140	3.03**
Oman	OMN	133.3	-47.8	0.0	-100.0	-1.905	3.51**
Pakistan	PAK	2,654.6	-9.7	2,179.3	-17.9	-8.732	2.69**
Palau	PLW	0.0	0.0	0.0	0.0	0.000	
Panama	PAN	0.5	-63.2	0.0	-100.0	-0.014	3.56**
Papua New Guinea	PNG	0.2	331.0	0.1	-50.0	0.002	0.69
Paraguay	PRY	632.0	19.0	895.9	41.8	3.846	1.82
Peru	PER	2,665.7	11.2	3,167.8	18.8	9.165	2.62**
Philippines	PHL	0.0	0.0	0.0	0.0	0.000	
Poland	POL	8,966.8	-13.4	5,824.1	-35.0	-36.264	3.87**
Portugal	PRT	3,421.9	-0.5	3,194.9	-6.6	-0.471	0.11
Puerto Rico	PRI	0.0	0.0	0.0	0.0	0.000	
Qatar	QAT	338.8	-38.7	45.0	-86.7	-4.417	2.79**
Romania	ROM	7,023.6	-16.1	4,387.2	-37.5	-35.907	5.57**
Russian Federation	RUS	11,352.7	-7.6	9,101.7	-19.8	-26.788	3.35**
Rwanda	RWA	454.9	-52.7	0.0	-100.0	-8.787	6.24**
Samoa	WSM	0.0	0.0	0.0	0.0	0.000	
Sao Tome and Principe	STP	0.0	0.0	0.0	0.0	0.000	
Saudi Arabia	SAU	900.9	-10.9	796.5	-11.6	-3.737	1.45
Senegal	SEN	8.2	-49.0	0.0	-100.0	-0.174	1.27
Serbia	SRB	7,666.0	-11.7	5,552.6	-27.6	-28.380	4.55**
Sierra Leone	SLE	0.9	-27.6	0.4	-55.6	-0.009	0.38
Singapore	SGP	0.0	0.0	0.0	0.0	0.000	
Slovak Republic	SVK	8,025.7	-16.1	4,826.0	-39.9	-39.479	4.91**
Slovenia	SVN	6,217.1	-15.4	3,775.0	-39.3	-28.840	4.9**
Solomon Islands	SLB	0.0	0.0	0.0	0.0	0.000	
Somalia	SOM	19.8	-66.8	0.0	-100.0	-0.468	2.88**
South Africa	ZAF	2,405.9	-8.2	1,887.3	-21.6	-6.104	2.41*
Spain	ESP	3,664.3	-9.0	2,703.4	-26.2	-9.892	2.44*
Sri Lanka	LKA	0.0	0.0	0.0	0.0	0.000	
St. Kitts and Nevis	KNA	0.0	0.0	0.0	0.0	0.000	
Sudan	SDN	161.9	-26.2	79.7	-50.8	-1.642	2.36*
Suriname	SUR	0.0	0.0	0.0	0.0	0.000	
Swaziland	SWZ	552.4	-19.8	311.0	-43.7	-3.593	2.47*
Sweden	SWE	8,606.7	-12.7	5,883.4	-31.6	-33.692	3.54**
Switzerland	CHE	8,357.1	-12.8	5,602.3	-33.0	-32.681	5.03**
Syrian Arab Republic	SYR	3,731.6	-17.6	2,401.4	-35.6	-22.655	4.45**
Tajikistan	TJK	12,361.5	-6.4	11,026.5	-10.8	-26.593	2.52*
Tanzania	TZA	562.8	-17.4	414.2	-26.4	-3.823	2.13*
Thailand	THA	75.1	-36.6	22.6	-69.9	-1.539	2.38*
Togo	TGO	1.4	2.3	0.7	-50.0	0.001	0.03

Country	ISO3	HDD 1980	% Chg. 1980 - 2011	Pred. HDD 2050	% Chg. 1980-2050	Annual Change	T-Stat
Trinidad and Tobago	TTO	0.0	0.0	0.0	0.0	0.000	
Tunisia	TUN	1,907.6	-8.5	1,394.6	-26.9	-4.703	1.99*
Turkey	TUR	6,084.0	-13.1	4,448.4	-26.9	-26.560	4.24**
Turkmenistan	TKM	5,908.7	-5.3	5,327.2	-9.8	-10.240	1.64
Turks and Caicos Islands	TCA	0.0	0.0	0.0	0.0	0.000	
Uganda	UGA	744.6	-43.4	15.6	-97.9	-10.921	7.67**
Ukraine	UKR	7,984.1	-12.8	5,440.0	-31.9	-31.603	4.01**
United Arab Emirates	ARE	402.0	-38.7	47.0	-88.3	-4.700	3.25**
United Kingdom	GBR	5,912.8	-13.3	4,081.0	-31.0	-25.043	4.05**
United States	USA	3,659.8	-12.8	2,501.7	-31.6	-14.473	4.47**
Uruguay	URY	1,991.1	-1.3	1,952.7	-1.9	-0.840	0.26
Uzbekistan	UZB	10,262.9	-4.7	9,521.4	-7.2	-16.316	1.95
Vanuatu	VUT	0.0	0.0	0.1	0.0	0.002	1.22
Venezuela, RB	VEN	0.0	0.0	0.0	0.0	0.000	
Vietnam	VNM	134.5	0.3	172.1	28.0	0.014	0.02
Yemen, Rep.	YEM	278.3	2.3	343.3	23.4	0.239	0.25
Zambia	ZMB	1,116.6	-17.8	653.9	-41.4	-6.300	2.81**
Zimbabwe	ZWE	1,464.4	-11.6	990.1	-32.4	-5.027	1.56

Table B2: Cooling Degree Days: Fitted Trends and Projections

Country	ISO3	CDD 1980	% Chg. 1980-2011	Pred. CDD 2050	% Chg. 1980-2050	Annual Change	T-Stat
Afghanistan	AFG	532.0	29.7	756.2	42.1	4.339	3.39**
Albania	ALB	387.6	70.6	1,173.9	202.9	10.304	5**
Algeria	DZA	1,485.5	12.8	2,158.9	45.3	6.905	2.09*
Angola	AGO	850.3	52.5	1,757.7	106.7	13.617	6.42**
Antigua and Barbuda	ATG	5,142.0	6.8	5,720.7	11.3	10.840	2.84**
Argentina	ARG	1,660.4	7.6	1,821.3	9.7	3.793	1.51
Armenia	ARM	63.7	161.7	179.6	181.9	2.014	3.61**
Australia	AUS	834.6	12.7	947.9	13.6	3.011	1.78
Austria	AUT	85.4	154.2	458.4	436.8	5.087	4.74**
Azerbaijan	AZE	544.8	76.0	1,342.2	146.4	12.115	5.3**
Bahamas, The	BHS	4,247.4	4.1	4,630.1	9.0	5.653	1.52
Bangladesh	BGD	2,593.5	10.0	2,983.5	15.0	7.858	3.12**
Barbados	BRB	5,263.0	12.8	6,435.3	22.3	20.628	5.43**
Belarus	BLR	16.4	607.7	226.3	1,279.9	3.013	3.54**
Belgium	BEL	20.9	100.9	160.8	669.4	1.596	2.15*
Belize	BLZ	4,646.3	-6.4	3,701.2	-20.3	-8.932	2.03*
Benin	BEN	4,327.8	15.0	5,673.6	31.1	20.516	9.02**
Bhutan	BTN	985.3	6.4	1,051.5	6.7	1.905	1.2
Bolivia	BOL	1,520.1	8.7	1,860.1	22.4	4.353	2.54*
Bosnia and Herzegovina	BIH	166.5	124.5	795.1	377.5	8.378	4.97**
Botswana	BWA	636.1	12.0	832.3	30.8	2.528	1.02
Brazil	BRA	2,948.2	7.3	3,293.5	11.7	6.652	2.52*
Brunei Darussalam	BRN	2,983.7	-2.0	2,796.9	-6.3	-1.886	0.93
Bulgaria	BGR	366.7	99.8	1,024.0	179.2	10.132	5.97**
Burkina Faso	BFA	5,489.2	5.7	6,055.1	10.3	9.896	2.96**
Burundi	BDI	443.8	112.5	1,330.8	199.9	13.640	6.32**
Cambodia	KHM	4,317.8	1.3	4,350.7	0.8	1.807	0.69
Cameroon	CMR	2,361.5	26.2	3,515.3	48.9	18.668	7.24**
Canada	CAN	521.5	18.9	744.8	42.8	3.187	1.63
Cape Verde	CPV	3,547.3	13.7	4,398.4	24.0	14.829	3.35**
Central African Republic	CAF	2,639.4	27.2	4,076.5	54.4	22.182	8.35**
Chad	TCD	4,142.5	14.6	4,979.8	20.2	17.611	4.83**
Chile	CHL	432.3	-35.7	93.3	-78.4	-5.569	4.13**
China	CHN	955.3	18.7	1,387.0	45.2	5.884	5.27**
Colombia	COL	2,342.5	16.0	2,941.8	25.6	11.158	3.55**
Comoros	COM	5,070.4	10.6	5,995.0	18.2	16.496	5.63**
Congo, Dem. Rep.	COD	1,486.6	43.9	2,696.5	81.4	19.179	8.83**
Congo, Rep.	COG	2,358.5	30.6	3,925.7	66.4	22.937	8.92**
Costa Rica	CRI	4,744.5	-1.1	4,460.2	-6.0	-1.572	0.33
Cote d'Ivoire	CIV	4,072.3	17.4	5,618.2	38.0	22.658	9.08**

Country	ISO3	CDD 1980	% Chg. 1980-2011	Pred. CDD 2050	% Chg. 1980-2050	Annual Change	T-Stat
Croatia	HRV	208.2	118.4	911.9	338.0	9.481	5.25**
Cuba	CUB	5,368.4	2.4	5,476.1	2.0	4.036	1.2
Cyprus	CYP	1,155.3	39.8	2,156.2	86.6	14.583	7.11**
Czech Republic	CZE	27.3	283.0	306.6	1,023.1	3.787	4.75**
Denmark	DNK	7.8	158.3	129.5	1,560.3	1.445	2.5*
Djibouti	DJI	2,938.6	11.3	3,440.0	17.1	9.970	2.43*
Dominica	DMA	5,154.0	9.2	5,957.4	15.6	14.590	3.82**
Dominican Republic	DOM	5,163.0	5.3	5,494.7	6.4	8.401	2.25*
Ecuador	ECU	1,787.1	-0.3	1,581.9	-11.5	-0.178	0.05
Egypt, Arab Rep.	EGY	1,498.4	30.5	2,149.3	43.4	12.522	5.37**
El Salvador	SLV	5,408.6	0.5	5,293.8	-2.1	0.808	0.16
Equatorial Guinea	GNQ	2,371.2	32.3	3,941.2	66.2	23.742	8.81**
Eritrea	ERI	3,104.4	19.3	4,013.6	29.3	17.411	5.41**
Estonia	EST	16.0	2,189.8	134.4	740.0	1.882	2.95**
Ethiopia	ETH	727.6	41.8	1,156.1	58.9	8.019	4.93**
Faeroe Islands	FRO	0.0	0.0	0.0	0.0	0.000	
Fiji	FJI	4,632.8	6.0	5,083.0	9.7	8.671	1.88
Finland	FIN	13.3	0.0	78.9	493.2	1.136	2.91**
France	FRA	103.7	73.3	413.2	298.5	3.680	2.9**
French Polynesia	PYF	4,657.6	15.0	6,073.3	30.4	21.993	8.06**
Gabon	GAB	2,499.7	28.5	4,062.4	62.5	22.737	8.68**
Gambia, The	GMB	4,673.7	13.9	5,956.3	27.4	20.365	5.26**
Georgia	GEO	29.4	119.1	86.9	195.6	0.905	2.75**
Germany	DEU	10.9	303.7	159.9	1,367.0	1.993	3.9**
Ghana	GHA	4,764.6	10.0	5,793.5	21.6	15.260	6.85**
Greece	GRC	911.4	43.0	1,798.4	97.3	12.653	5.88**
Greenland	GRL	0.0	0.0	0.0	0.0	0.000	
Grenada	GRD	5,071.0	13.1	6,293.3	24.1	20.532	5.88**
Guam	GUM	5,996.0	5.0	6,615.6	10.3	9.659	3.07**
Guatemala	GTM	5,002.8	-4.8	4,350.8	-13.0	-7.532	1.68
Guinea	GIN	3,743.7	7.6	4,328.5	15.6	9.099	3.19**
Guinea-Bissau	GNB	4,516.3	14.4	5,841.4	29.3	20.435	5.8**
Guyana	GUY	3,823.0	4.7	4,178.9	9.3	5.681	1.34
Haiti	HTI	5,114.2	4.4	5,351.2	4.6	6.878	1.92
Honduras	HND	4,379.3	0.8	4,216.0	-3.7	1.117	0.24
Hong Kong SAR, China	HKG	3,822.4	2.1	4,029.7	5.4	2.556	0.92
Hungary	HUN	77.6	229.2	578.8	645.9	6.930	5.94**
Iceland	ISL	0.0	0.0	0.0	0.0	0.000	
India	IND	2,891.0	4.3	3,052.6	5.6	3.836	1.71
Indonesia	IDN	4,780.5	-0.9	4,640.4	-2.9	-1.311	0.38

Country	ISO3	CDD 1980	% Chg. 1980-2011	Pred. CDD 2050	% Chg. 1980-2050	Annual Change	T-Stat
Iran, Islamic Rep.	IRN	721.7	78.9	1,754.0	143.0	16.047	10.04**
Iraq	IRQ	2,487.8	29.9	4,072.3	63.7	23.427	7.17**
Ireland	IRL	0.0	0.0	0.0	0.0	0.000	
Israel	ISR	475.7	74.5	975.1	105.0	8.736	4.45**
Italy	ITA	470.3	46.0	1,264.7	168.9	9.205	4.23**
Jamaica	JAM	5,783.6	2.9	5,944.1	2.8	5.212	1.4
Japan	JPN	1,270.8	5.1	1,423.1	12.0	2.108	0.92
Jordan	JOR	547.3	65.6	1,030.8	88.3	8.791	3.73**
Kazakhstan	KAZ	152.4	16.2	208.3	36.7	0.796	1.17
Kenya	KEN	1,031.4	20.5	1,387.2	34.5	6.268	5.66**
Kiribati	KIR	5,395.2	0.2	5,333.5	-1.1	0.362	0.05
Korea, Dem. Rep.	PRK	223.6	13.8	539.9	141.5	1.835	0.88
Korea, Rep.	KOR	585.7	2.3	823.2	40.5	0.583	0.26
Kuwait	KWT	4,511.8	23.5	6,461.4	43.2	31.986	7.04**
Kyrgyz Republic	KGZ	9.0	2.0	10.0	11.1	0.006	0.11
Lao PDR	LAO	2,228.2	16.9	2,815.6	26.4	11.129	3.71**
Latvia	LVA	4.7	820.1	130.0	2,666.0	1.762	2.93**
Lebanon	LBN	464.0	67.7	1,036.8	123.4	8.956	4.45**
Lesotho	LSO	272.3	12.0	358.4	31.6	1.088	1.55
Liberia	LBR	3,894.2	17.5	5,354.1	37.5	21.680	7.81**
Libya	LBY	1,335.2	23.3	2,113.3	58.3	10.402	4.56**
Liechtenstein	LIE	41.0	179.8	225.9	451.0	2.590	3.2**
Lithuania	LTU	3.8	615.0	151.3	3,881.6	2.016	3.12**
Luxembourg	LUX	7.3	273.0	129.6	1,675.3	1.592	3.04**
Macedonia, FYR	MKD	289.4	101.4	921.2	218.3	9.159	5.21**
Madagascar	MDG	1,870.8	14.1	2,396.6	28.1	8.279	3.86**
Malawi	MWI	1,470.8	20.3	1,926.0	30.9	8.645	3.1**
Malaysia	MYS	3,993.2	1.9	4,145.7	3.8	2.478	0.97
Mali	MLI	5,050.3	9.6	5,696.6	12.8	14.510	3.74**
Malta	MLT	1,125.0	28.4	2,272.1	102.0	12.682	4.59**
Mauritania	MRT	5,069.6	10.7	6,053.7	19.4	16.833	3.63**
Mauritius	MUS	3,287.6	2.3	3,316.1	0.9	2.331	0.59
Mayotte	MYT	3,617.0	15.8	4,638.9	28.3	17.446	6.1**
Mexico	MEX	3,248.4	3.5	3,236.9	-0.4	3.394	1.06
Micronesia, Fed. Sts.	FSM	6,217.7	3.7	6,649.4	6.9	7.348	2.71**
Moldova	MDA	158.2	241.7	1,220.5	671.5	14.736	7.69**
Mongolia	MNG	72.5	132.8	165.7	128.6	1.775	3.28**
Montenegro	MNE	182.8	107.9	796.9	335.9	8.072	4.96**
Morocco	MAR	1,632.2	9.8	1,761.8	7.9	4.576	1.5
Mozambique	MOZ	2,822.1	7.6	3,179.8	12.7	6.638	2.26*
Myanmar	MMR	2,709.8	18.8	3,391.3	25.1	14.440	5.07**
Namibia	NAM	1,139.2	13.9	1,578.3	38.5	5.385	1.72

Country	ISO3	CDD 1980	% Chg. 1980-2011	Pred. CDD 2050	% Chg. 1980-2050	Annual Change	T-Stat
Nepal	NPL	1,320.9	2.8	1,393.8	5.5	1.187	0.79
Netherlands	NLD	14.7	96.9	135.9	824.5	1.333	2.07*
Netherlands Antilles	ANT	5,502.0	2.4	5,563.1	1.1	4.038	0.83
New Caledonia	NCL	2,905.4	13.5	3,826.2	31.7	12.752	2.69**
New Zealand	NZL	128.1	-34.4	31.3	-75.6	-1.550	2.03*
Nicaragua	NIC	4,629.2	2.9	4,666.2	0.8	4.082	0.86
Niger	NER	4,455.9	8.1	4,908.3	10.2	10.827	2.45*
Nigeria	NGA	3,515.4	16.7	4,633.3	31.8	18.113	6.75**
Northern Mariana Islands	MNP	5,973.0	5.0	6,583.2	10.2	9.593	3.06**
Norway	NOR	1.0	117.8	20.6	1,960.0	0.214	1.34
Oman	OMN	3,938.4	13.7	4,999.4	26.9	16.878	5.38**
Pakistan	PAK	2,162.0	9.0	2,518.4	16.5	6.104	2.44*
Palau	PLW	6,082.0	3.0	6,517.2	7.2	5.856	1.68
Panama	PAN	4,814.2	0.4	4,709.9	-2.2	0.615	0.14
Papua New Guinea	PNG	3,833.6	1.8	4,091.7	6.7	2.327	0.69
Paraguay	PRY	2,333.2	7.9	2,665.6	14.2	5.756	1.42
Peru	PER	473.2	24.8	684.0	44.5	3.508	3.33**
Philippines	PHL	5,148.9	-2.1	4,987.8	-3.1	-3.623	1.51
Poland	POL	13.2	276.0	245.1	1,756.8	3.018	4.4**
Portugal	PRT	466.9	9.0	583.5	25.0	1.412	0.66
Puerto Rico	PRI	5,299.4	5.1	5,685.4	7.3	8.369	2.22*
Qatar	QAT	5,106.0	23.9	7,379.9	44.5	36.905	6.91**
Romania	ROM	141.3	226.1	815.0	476.8	9.735	7.51**
Russian Federation	RUS	62.7	114.9	251.8	301.6	2.596	2.99**
Rwanda	RWA	301.7	154.4	1,172.6	288.7	13.018	6.83**
Samoa	WSM	5,760.1	11.2	6,873.3	19.3	19.757	6.44**
Sao Tome and Principe	STP	4,405.1	15.1	5,920.4	34.4	21.458	5.05**
Saudi Arabia	SAU	3,162.5	20.9	4,250.9	34.4	19.467	6.01**
Senegal	SEN	4,702.5	12.8	5,891.2	25.3	18.917	4.76**
Serbia	SRB	101.0	180.6	485.0	380.2	5.564	4.81**
Sierra Leone	SLE	3,781.7	14.1	4,998.6	32.2	17.271	6.29**
Singapore	SGP	5,245.0	-0.7	5,169.7	-1.4	-1.163	0.36
Slovak Republic	SVK	54.8	220.1	506.6	824.5	6.025	5.4**
Slovenia	SVN	188.3	119.3	797.0	323.3	8.304	4.89**
Solomon Islands	SLB	5,815.0	2.1	6,059.6	4.2	4.002	0.98
Somalia	SOM	3,776.7	20.5	5,178.8	37.1	23.395	6.62**
South Africa	ZAF	609.2	16.0	821.4	34.8	3.113	2.99**
Spain	ESP	643.4	25.6	1,091.3	69.6	5.717	2.85**
Sri Lanka	LKA	5,009.6	1.1	4,958.2	-1.0	1.685	0.58
St. Kitts and Nevis	KNA	5,175.0	6.2	5,702.6	10.2	10.073	2.72**
Sudan	SDN	3,399.3	20.9	4,551.6	33.9	20.864	6.56**
Suriname	SUR	3,724.1	17.4	5,059.7	35.9	20.360	6.34**

Country	ISO3	CDD 1980	% Chg. 1980-2011	Pred. CDD 2050	% Chg. 1980-2050	Annual Change	T-Stat
Swaziland	SWZ	1,313.0	15.9	1,700.7	29.5	6.414	2.79**
Sweden	SWE	3.9	210.7	85.2	2,084.6	1.006	2.21*
Switzerland	CHE	24.6	218.2	190.6	674.8	2.263	2.89**
Syrian Arab Republic	SYR	1,036.3	50.9	2,076.5	100.4	15.870	6.89**
Tajikistan	TJK	5.5	98.5	13.2	140.0	0.130	1.87
Tanzania	TZA	1,302.4	24.3	1,826.5	40.2	9.244	5.15**
Thailand	THA	3,442.9	13.6	4,214.6	22.4	14.159	4.8**
Togo	TGO	4,368.0	12.8	5,579.9	27.7	17.919	8.05**
Trinidad and Tobago	TTO	4,603.7	11.6	5,659.2	22.9	16.812	4.74**
Tunisia	TUN	1,106.6	16.7	1,952.8	76.5	7.625	2.39*
Turkey	TUR	383.4	72.8	864.3	125.4	7.676	7.47**
Turkmenistan	TKM	691.8	23.9	1,091.7	57.8	5.465	2.75**
Turks and Caicos Islands	TCA	4,967.0	2.6	5,086.6	2.4	4.098	1.21
Uganda	UGA	253.5	181.3	1,108.0	337.1	12.721	9.08**
Ukraine	UKR	137.3	234.5	829.7	504.3	9.970	6.16**
United Arab Emirates	ARE	4,121.9	17.1	5,386.6	30.7	21.462	6.14**
United Kingdom	GBR	10.6	18.6	51.6	386.8	0.218	0.41
United States	USA	2,134.7	12.1	2,446.0	14.6	7.496	3.81**
Uruguay	URY	956.5	0.4	807.7	-15.6	0.113	0.07
Uzbekistan	UZB	192.1	21.2	279.8	45.7	1.295	1.61
Vanuatu	VUT	4,394.4	3.5	4,743.9	8.0	5.018	1.06
Venezuela, RB	VEN	5,007.1	1.3	4,944.9	-1.2	2.045	0.38
Vietnam	VNM	4,108.7	2.4	4,213.1	2.5	3.138	1.14
Yemen, Rep.	YEM	3,468.8	8.3	3,950.1	13.9	8.870	2.88**
Zambia	ZMB	929.7	31.2	1,309.0	40.8	7.730	3.25**
Zimbabwe	ZWE	788.2	27.9	1,181.5	49.9	6.527	2.96**