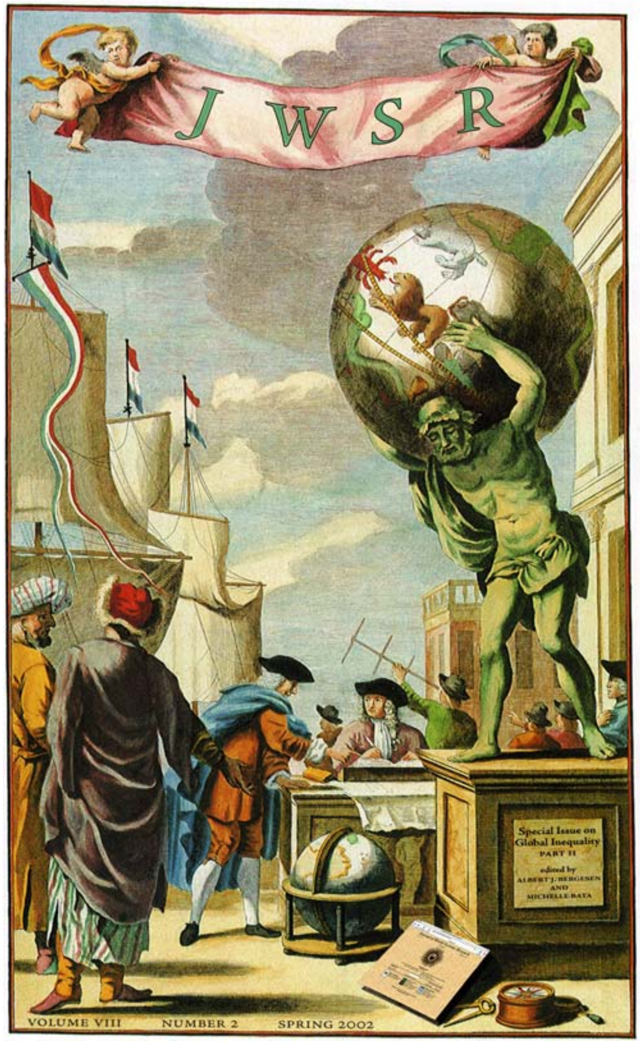


ABSTRACT

This study examines the evolution of global energy inequalities over the modern period, with particular attention paid to the years 1958–1998. The analysis reveals that global energy inequalities were modestly reduced in the 1970s, as semi-peripheral nations increased their consumption of modern energy resources. However, an intensification of inequalities re-asserted itself in the 1980s and 1990s, as the semi-periphery lost ground in relation to resurgent consumption in core nations such as the United States. The study argues that, in an increasingly bounded energy system, geopolitical, commercial, and social tensions will rise if fundamental inequalities in energy consumption are not addressed. Prospects for achieving reforms in the system over the medium term are evaluated at the conclusion of the study.

# Global Energy Inequalities: Exploring the Long-Term Implications

*Bruce Podobnik*

## INTRODUCTION

Mainstream energy studies have paid insufficient attention to the unequal levels of energy consumption that have become embedded in the foundations of the world-system. This inattention is problematic, given that these energy inequalities pose increasingly severe environmental and human challenges. In a world characterized by strikingly unequal rates of energy consumption, for instance, it will be difficult to develop collectively rational responses to global climate threats. Furthermore, energy inequalities increase the potential for resource-based geopolitical conflicts. And they foster unhealthy consumption habits throughout the developed world, while preventing entire generations of men, women, and children in the developing world from fully realizing their potential as citizens of the modern world.

Faced with these multiple threats, it is not unreasonable to suggest that energy-related difficulties will begin undermining stability in the world community in coming decades. Indeed, an analysis informed by the world-systems approach highlights contradictions that are likely to generate multiple kinds of energy-related crises in the medium to long term.

In recent years, a variety of researchers working within the world-systems tradition have shed important light on the ways in which the expanding capitalist world-economy intensifies processes of environmental degradation.[1] By

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1. Of particular note are Bunker (1985), Burns, Kick & Murray (1994), and the studies presented in the volume edited by Goldfrank, Goodman, and Szasz (1999).

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focusing on the material consequences of capital accumulation and the enduring inequalities fostered by the world-system, these researchers have developed novel analyses of long-term, problematic patterns of evolution in the human/nature nexus. In the analysis that follows, I draw on this research tradition in order to bring a greatly under-examined characteristic of the global energy system into sharper focus—and to examine prospects for reforming inequalities in this energy system.

## GLOBAL ENERGY INEQUALITIES

Debates have long raged as to whether or not the world-economy operates as a zero-sum, bounded system in which gains by one country imply losses by another. In the case of the energy foundations of the world-economy the zero-sum, bounded nature of the world-system is quite clear. The fact that 90 percent of the commercial energy consumed in the world derives from non-renewable resources provides one important boundary.[2] And the fact that global ecological constraints are tightening provides another. Although some elasticity in these boundaries is offered by changing technologies, in fundamental terms the consumption of commercial energy resources by one group implies a future inability to consume for other groups. This zero-sum feature of the world energy system raises particularly severe dilemmas, as highlighted in a global analysis of patterns of energy consumption.

As with most cross-national research, when examining large-scale patterns of energy consumption we are forced to rely on nationally-aggregated data. The limited amount of research that has been conducted at local levels reveals that lower-class citizens, rural residents, women, and minority populations are often forced to rely on traditional, highly-polluting, and labor-intensive forms of energy to meet their basic needs.[3] As more research is conducted at the within-country level, our understanding of local and regional inequalities will be strengthened.

2. The non-renewable energy resources of coal, petroleum, and natural gas currently provide around 90 percent of the world's commercial energy, while nuclear and hydro-electricity provide most of the rest. It should be noted that the data analyzed in this paper relates exclusively to commercial forms of energy, and does not include traditional resources such as wood (which are estimated to provide under five percent of the world's energy). Consult Appendix A for further information on data sources and methods.

3. See Alam, Sathaye, & Barnes (1998) and Komives, Whittington, & Wu (2000) for examples of these within-country studies.



The present analysis, however, is forced to utilize national data that undoubtedly underestimates true levels of inequality in energy consumption. Given this likely distortion, it is quite remarkable how stark the inequalities are that are registered in nationally-aggregated data.

Let me start with a couple of observations regarding relatively long historical trends in the global energy system. As shown in Figure 1, through the end of WWII the developed world was almost totally self-sufficient in energy.[4] Since then, however, nations of the global south have been transferring energy resources to nations in the global north at a steady rate. A number of oil-exporting countries have achieved impressive levels of economic growth on the basis of this trade. However, the main effect has been to intensify long-standing global inequalities in levels of energy consumption. As indicated in Figure 2, throughout the modern period core states have attained much higher levels of per capita commercial energy consumption than their semi-peripheral or peripheral counterparts. While there was a slight closing of the gap between core and semi-peripheral regions during the 1970s,[5] by the mid-1980s long-term patterns of intensifying inequality had reasserted themselves.

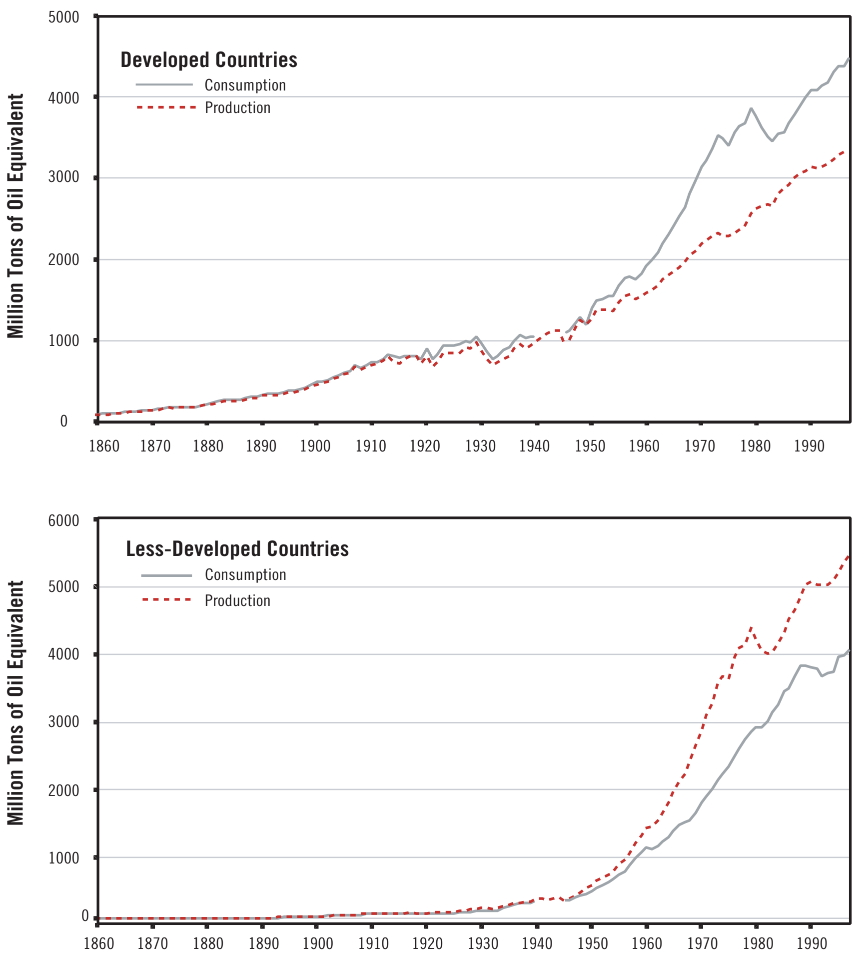
If we focus our attention on the post WWII period, and examine world regions in more detail, we again see enduring patterns of inequality. As shown in Figure 3, North America (the US and Canada) has persistently outstripped all other regions in terms of commercial energy consumption. After seeing substantial gains in the three and a half decades following WWII, meanwhile, countries in Eastern Europe have undergone a significant decline in consumption. Western Europe, which saw a slight pause following the shocks of the 1970s, has reasserted moderate growth. The Pacific region, which includes Japan, East Asia, and Australia, has seen steady growth. Africa and Asia, meanwhile, have seen little increase in per capita consumption of commercial energy since the 1970s.[6]

4. Consult Appendix A for information on data sources and methods. It should be noted that the energy data examined in this paper is commercial energy (coal, petroleum, natural gas, nuclear, and hydro-electricity), and does not include traditional resources such as wood.

5. Chase-Dunn (1989: 265-266) correctly highlighted the growing share of energy that flowed to certain semi-peripheral states in the pre-1980 period. This pattern reversed itself in the post 1980 period, however, as Eastern Europe declined and core states once again expanded their consumption.

6. Consult Table 1 for data on the evolution of per capita consumption rates for selected countries over the period 1958–1998.

**Figure 1 – Commercial Energy Production and Consumption, 1860–1998**

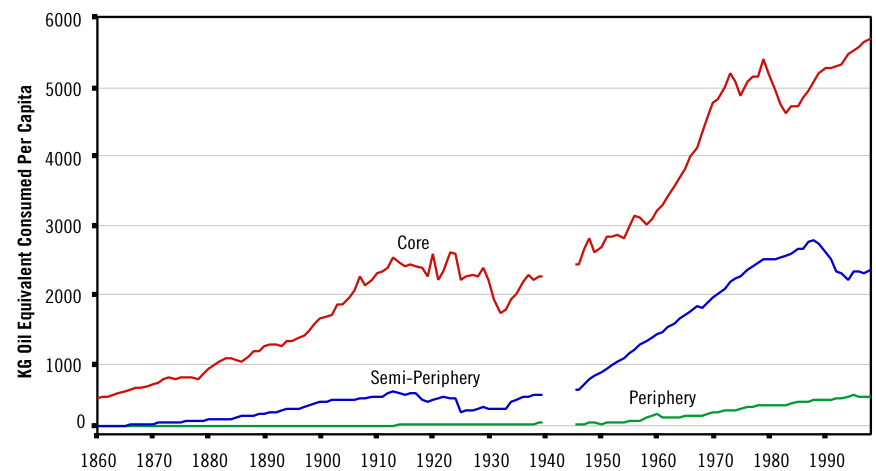



Sources: See Appendix A

Turning to a more focused analysis of the present situation, we again find that countries exhibit very divergent patterns of energy consumption. As shown in Figure 4, the average citizen in the United States consumes five times as much as the world average, ten times as much energy as a typical person in China, and over thirty times more than a resident of India. Even in such major oil exporting nations as Venezuela and Iran, per capita consumption of commercial energy resources is less than one half and one quarter of the US average, respectively. A

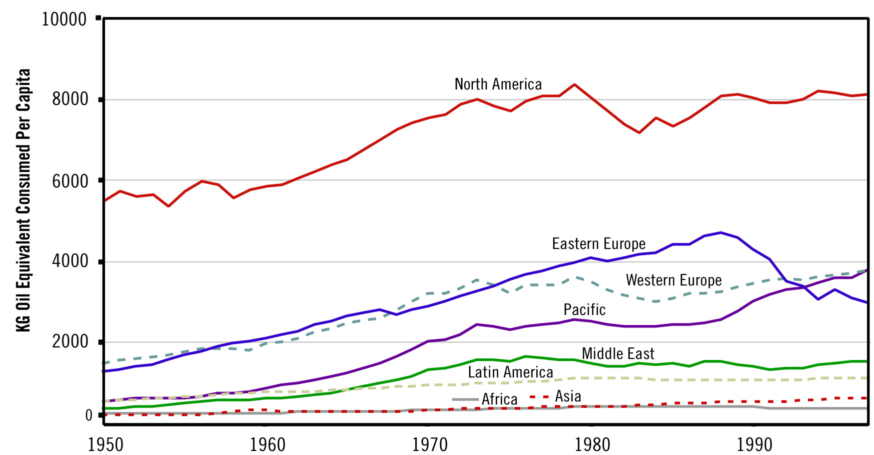


**Figure 2 – Per Capita Commercial Energy Consumption, 1860–1998**




Sources: See Appendix A.

**Figure 3 – Per Capita Commercial Energy Consumption, 1950–1998**




Sources: See Appendix A.

starker illustration of these inequalities is captured in the estimation that around 40 percent of the world's population—over 2 billion people—still has no regular access to commercial energy products in their homes (World Energy Council 2000).

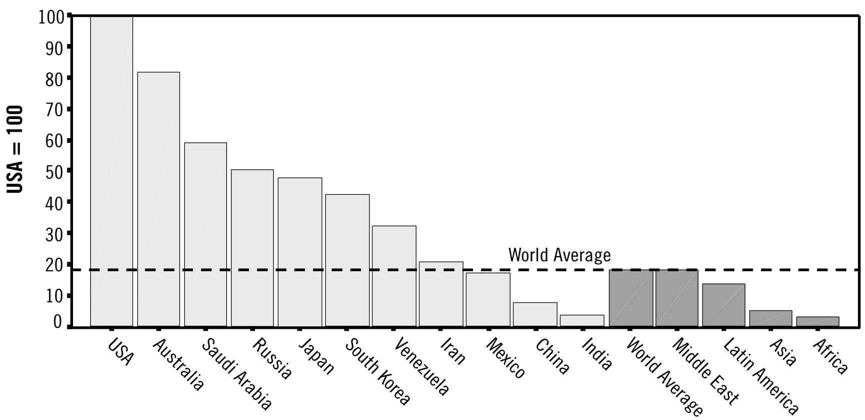
## Table 1 – Per Capita Commercial Energy Consumption for Selected Countries

| | KG of oil equivalent, commercial energy consumed per capita | | | | |
|---|---|---|---|---|---|
| COUNTRY | 1958 | 1968 | 1978 | 1988 | 1999 |
| UAE | 352 | 3356 | 16450 | 19314 | 15188 |
| CANADA | 4110 | 6084 | 8041 | 8445 | 8877 |
| SINGAPORE | 563 | 3748 | 5735 | 5338 | 8700 |
| KUWAIT | 7085 | 6104 | 4293 | 3525 | 8407 |
| USA | 5583 | 7239 | 7970 | 7890 | 7960 |
| NETHERLANDS | 2511 | 4418 | 7123 | 6081 | 6801 |
| AUSTRALIA | 2599 | 3551 | 4457 | 4607 | 6480 |
| BELGIUM | 2653 | 4218 | 5693 | 4855 | 5914 |
| SWEDEN | 2980 | 4830 | 3919 | 5099 | 5822 |
| NEW ZEALAND | 1174 | 2333 | 2585 | 3605 | 4769 |
| SAUDI ARABIA | 1808 | 6171 | 8503 | 6166 | 4715 |
| RUSSIA/USSR | 2001 | 2291 | 3743 | 4740 | 4026 |
| FRANCE | 1806 | 2661 | 3474 | 3137 | 3857 |
| JAPAN | 557 | 1721 | 2735 | 2463 | 3821 |
| UK | 3026 | 3499 | 3818 | 3671 | 3753 |
| TAIWAN | 288 | 569 | 1421 | 2035 | 3448 |
| DENMARK | 786 | 2102 | 2404 | 3217 | 3426 |
| SKOREA | 119 | 428 | 847 | 1675 | 3388 |
| ITALY | 846 | 2311 | 2702 | 2417 | 3156 |
| ISRAEL | 642 | 1071 | 2232 | 1830 | 2890 |
| VENEZUELA | 6949 | 5557 | 3504 | 2845 | 2569 |
| SAFRICA | 1161 | 1283 | 1753 | 2269 | 2279 |
| HONG KONG | 43 | 21 | 583 | 1354 | 2273 |
| POLAND | 1622 | 2263 | 3392 | 3447 | 2060 |
| MALAYSIA | 236 | 279 | 606 | 1000 | 1846 |
| ARGENTINA | 630 | 1124 | 1437 | 1593 | 1709 |
| IRAN | 1165 | 1724 | 2361 | 1312 | 1642 |
| CHILE | 534 | 1327 | 1073 | 930 | 1394 |
| MEXICO | 639 | 796 | 1217 | 1410 | 1366 |
| NKOREA | 390 | 1046 | 1416 | 2104 | 1331 |
| JAMAICA | 93 | 680 | 491 | 912 | 1300 |
| IRAQ | 345 | 918 | 1578 | 2049 | 1104 |
| BRAZIL | 154 | 302 | 628 | 679 | 1080 |
| THAILAND | 40 | 159 | 196 | 296 | 877 |
| TURKEY | 146 | 335 | 481 | 721 | 876 |
| CUBA | 580 | 473 | 680 | 765 | 857 |
| COLOMBIA | 495 | 571 | 600 | 615 | 706 |
| EGYPT | 165 | 248 | 447 | 614 | 681 |
| CHINA | 215 | 168 | 430 | 564 | 614 |
| PERU | 258 | 366 | 535 | 486 | 485 |
| ZIMBABWE | 641 | 331 | 329 | 387 | 473 |
| INDONESIA | 151 | 127 | 216 | 338 | 402 |
| BOLIVIA | 102 | 153 | 298 | 205 | 374 |
| ELSALVADOR | 105 | 157 | 268 | 244 | 357 |
| PHILIPPINES | 109 | 233 | 238 | 281 | 333 |
| INDIA | 64 | 103 | 126 | 201 | 292 |
| HONDURAS | 107 | 142 | 157 | 183 | 266 |
| IVORY COAST | 36 | 141 | 222 | 318 | 252 |
| ZAMBIA | 58 | 516 | 315 | 168 | 242 |
| GUATEMALA | 103 | 144 | 127 | 96 | 236 |
| NIGERIA | 11 | 53 | 178 | 171 | 183 |
| GHANA | 71 | 117 | 129 | 111 | 142 |
| KENYA | 39 | 184 | 192 | 118 | 121 |
| ZAIRE | 26 | 48 | 67 | 39 | 12 |

| | Percent change in per capita consumption | | | |
|---|---|---|---|---|
| COUNTRY | 1968 | 1978 | 1988 | 1999 |
| UAE | 852 | 390 | 17 | -21 |
| CANADA | 48 | 32 | 5 | 5 |
| SINGAPORE | 566 | 53 | -7 | 63 |
| KUWAIT | -14 | -30 | -18 | 139 |
| USA | 30 | 10 | -1 | 1 |
| NETHERLANDS | 76 | 61 | -15 | 12 |
| AUSTRALIA | 37 | 26 | 3 | 41 |
| BELGIUM | 59 | 35 | -15 | 22 |
| SWEDEN | 62 | -19 | 30 | 14 |
| NEW ZEALAND | 99 | 11 | 39 | 32 |
| SAUDI ARABIA | 241 | 38 | -27 | -24 |
| RUSSIA/USSR | 15 | 63 | 27 | -15 |
| FRANCE | 47 | 31 | -10 | 23 |
| JAPAN | 209 | 59 | -10 | 55 |
| UK | 16 | 9 | -4 | 2 |
| TAIWAN | 97 | 150 | 43 | 69 |
| DENMARK | 167 | 14 | 34 | 7 |
| SKOREA | 259 | 98 | 98 | 102 |
| ITALY | 173 | 17 | -11 | 31 |
| ISRAEL | 67 | 108 | -18 | 58 |
| VENEZUELA | -20 | -37 | -19 | -10 |
| SAFRICA | 11 | 37 | 29 | 0 |
| HONG KONG | -51 | 2670 | 132 | 68 |
| POLAND | 40 | 50 | 2 | -40 |
| MALAYSIA | 19 | 117 | 65 | 85 |
| ARGENTINA | 78 | 28 | 11 | 7 |
| IRAN | 48 | 37 | -44 | 25 |
| CHILE | 149 | -19 | -13 | 50 |
| MEXICO | 25 | 53 | 16 | -3 |
| NKOREA | 168 | 35 | 49 | -37 |
| JAMAICA | 632 | -28 | 86 | 42 |
| IRAQ | 166 | 72 | 30 | -46 |
| BRAZIL | 96 | 108 | 8 | 59 |
| THAILAND | 303 | 23 | 51 | 196 |
| TURKEY | 130 | 44 | 50 | 22 |
| CUBA | -18 | 44 | 13 | 12 |
| COLOMBIA | 15 | 5 | 3 | 15 |
| EGYPT | 50 | 80 | 37 | 11 |
| CHINA | -22 | 156 | 31 | 9 |
| PERU | 42 | 46 | -9 | -0 |
| ZIMBABWE | -48 | -1 | 18 | 22 |
| INDONESIA | -16 | 70 | 57 | 19 |
| BOLIVIA | 50 | 95 | -31 | 82 |
| ELSALVADOR | 49 | 71 | -9 | 46 |
| PHILIPPINES | 114 | 2 | 18 | 18 |
| INDIA | 61 | 22 | 60 | 45 |
| HONDURAS | 33 | 11 | 17 | 45 |
| IVORY COAST | 295 | 57 | 43 | -21 |
| ZAMBIA | 788 | -39 | -47 | 44 |
| GUATEMALA | 41 | -12 | -25 | 147 |
| NIGERIA | 402 | 236 | -4 | 7 |
| GHANA | 65 | 10 | -14 | 28 |
| KENYA | 366 | 5 | -39 | 3 |
| ZAIRE | 87 | 39 | -41 | -71 |

Sources: See Appendix A.

**Figure 4 – Per Capita Commercial Energy Consumption Relative to USA, 1998**




**Sources: See Appendix A.**

It must also be observed that these unequal patterns of consumption show little sign of easing. This can be demonstrated through two related techniques: a gini-style analysis, and a quintile-based analysis.

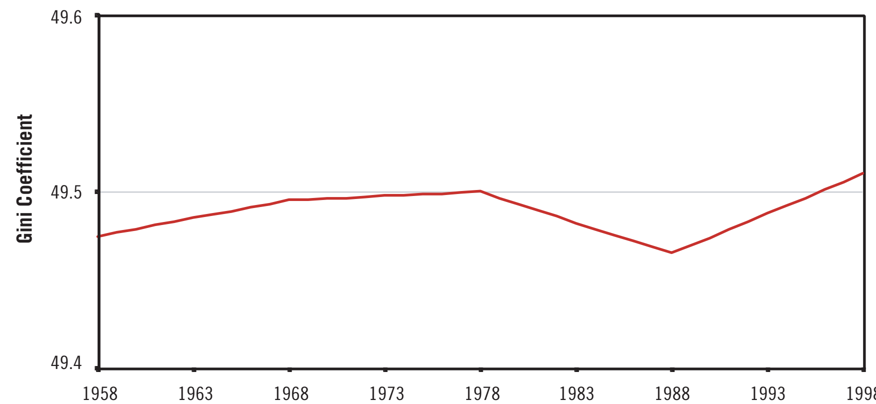
The gini-style analysis has the advantage that it compares the relationship between every individual country's per capita energy consumption and its population size. It therefore makes full use of country-level information. It has one disadvantage, however, in that the scale of the graph used largely determines the image conveyed. Take Figure 5, for instance. Here the evolution of the world energy gini coefficient over the period 1958-1998 is charted, focusing in on a very small band on the y-axis.[7] As shown at this very focused scale, during the period 1978-1988 the gini coefficient got slightly smaller—meaning that world commercial energy consumption was becoming slightly more equitable. The post-1988 period, however, saw a relatively rapid return to a longstanding pattern of inequality.

While serving the useful purpose of highlighting a modest pause in the overall trend, the gini analysis has the potential to over-emphasize quite minor changes. Changing the y-axis to cover a range from 49.0 to 50.0, for instance,

[7] That is to say, the gini coefficient range from 49.4 to 49.6 is extremely small. See Appendix A for a description of exactly how the world energy gini coefficient was calculated.

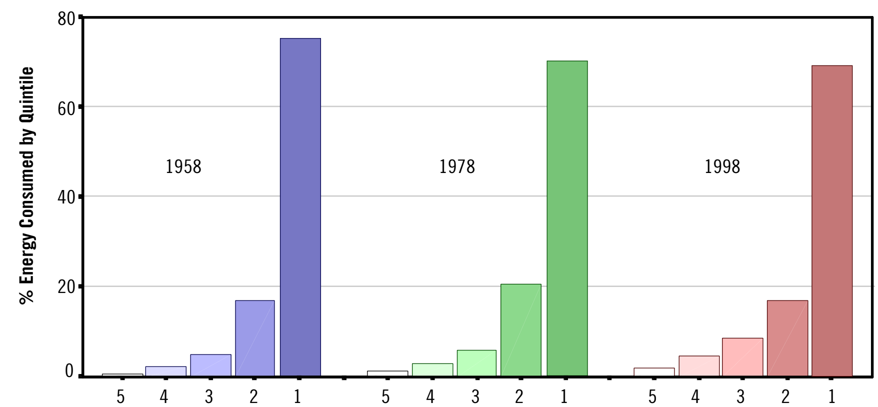


**Figure 5 – World Energy Gini Coefficient, 1958–1998**




Sources: See Appendix A.

**Figure 6 – World Commercial Energy Consumption by Quintiles**

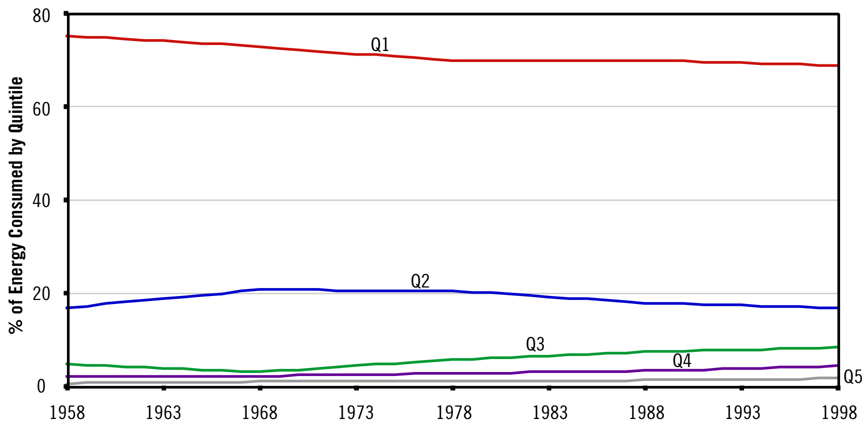



Sources: See Appendix A.

results in a largely horizontal line (which would emphasize an unchanging distribution of energy consumption). It is possible to guard against an overly-sensitive gini analysis by performing a breakdown by quintile groups. This method is based on a five-category aggregation of countries, and so it makes less full use of individual country-level data. Nevertheless, by providing a more structured set of categories to compare over time, it is less sensitive to presentational decisions.

So, what does the quintile analysis show us? As shown in Figure 6, in 1998 the top quintile (containing the wealthiest 20 percent of the world's population)

**Figure 7 – World Commercial Energy Consumption by Quintiles**




**Sources: See Appendix A.**

consumed about 68 percent of the world's commercial energy, while the lowest quintile consumed under 2 percent of these resources. Figure 7 shows how these categories have evolved over time. The following patterns can be identified: the proportion of energy consumed by the top quintile fell slightly during the period 1958-1978, and then largely remained steady; the second quintile saw gains up to 1978, then fell slightly; the third quintile has seen some growth in the post-1968 period; and the fourth and fifth quintiles have seen very limited growth in the post-1958 period.

There are a couple of noteworthy points to make about this quintile analysis. First, the overall endurance of inequality is again remarkable. Within this overall continuity, however, we can again identify slight modulations. Specifically, the upper middle group (the upper end of the semi-periphery) has seen its share of commercial energy consumption decline since the late 1960s. At the same time, the middle group (the lower end of the semi-periphery) has seen its share increase slowly but steadily. This reflects the fact that part of the semi-periphery (mainly Eastern Europe) has seen its energy consumption rates slip, while another part (East Asia) has increased its proportional energy consumption in the post-1968 period. This suggests that the semi-peripheral pattern identified by Chase-Dunn (1989: 265) may need to be slightly modified, to take into account diverging fortunes within that category of countries in the post-1970 period.

In sum, though there has been a slight change in the relative share of the world's commercial energy resources going to the second and third quintiles, the overall distribution has remained fundamentally unaltered in the post-1958 period. One of the central challenges facing the world community in this century will be to begin to alter these embedded patterns of inequality in the global energy system.



## ENVIRONMENTAL IMPLICATIONS

While many people in the developing world struggle to gain access to modern energy technologies, citizens and companies in the global north are generally consuming energy resources at an unsustainable rate. The high levels of energy use found in wealthy countries are the source of most of the greenhouse gases emitted into the atmosphere today.[8] In contrast, most citizens in the global south produce relatively modest energy-related greenhouse emissions. Since these gases remain in the atmosphere for long periods of time, it should also be noted that nations of the developed north have emitted most of the total anthropogenic greenhouse gases that have accumulated in the atmosphere over the last two centuries.

Scientific evidence continues to mount that greenhouse gases generated by human activities are having detrimental impacts on local, regional, and global eco-systems. For instance, the most recent report of the Intergovernmental Panel on Climate Change (IPCC 2001) concludes that most of the global warming observed over the last 50 years can be attributed to human activities. The report also provides evidence to suggest that this warming trend is likely to have more severe environmental and human consequences than had been predicted only a few years ago. In short, the ecological boundary surrounding the global energy system is turning out to be much tighter than expected.

With the scientific consensus suggesting that dangerous climatic dynamics are already being triggered, it becomes imperative to contain greenhouse gas emissions on a global scale at the earliest opportunity. Unfortunately, the difficulties inherent in achieving such a policy objective are exacerbated by the inequalities embedded in the world energy system. Let us pause to examine the startlingly unequal emissions rates that derive from these unequal patterns of consumption.

It has been suggested that the most equitable approach to addressing the problem of global climate change would be to define a standard per capita emissions rate, and then levy penalties on nations that exceed the standard (Meyerson

8. Greenhouse gases primarily include carbon dioxide, methane, and nitrous oxide—all of which are by-products of fossil-fuel consumption (though there are other sources of these gases as well). See IPCC (2001) for a recent summary on greenhouse gases and global climate change.

**Table 2 – Comparison of 1990 Target Carbon Emissions Rates to Actual 1998 Carbon Emissions.**

| Country | 1990 Target | 1998 Actual | Ratio |
|---|---|---|---|
| UAE | 2 | 31 | 15.16 |
| BAHRAIN | 1 | 5 | 8.97 |
| SINGAPORE | 3 | 25 | 8.34 |
| USA | 277 | 1494 | 5.38 |
| KUWAIT | 2 | 12 | 5.09 |
| CANADA | 31 | 138 | 4.48 |
| AUSTRALIA | 19 | 83 | 4.39 |
| NETHERLANDS | 17 | 65 | 3.92 |
| SAUDI ARABIA | 18 | 63 | 3.60 |
| BELGIUM | 11 | 38 | 3.44 |
| ISRAEL | 5 | 15 | 2.91 |
| DENMARK | 5 | 16 | 2.81 |
| TAIWAN | 22 | 58 | 2.65 |
| GERMANY | 89 | 227 | 2.55 |
| SOUTH AFRICA | 41 | 101 | 2.46 |
| FINLAND | 6 | 13 | 2.35 |
| NORWAY | 5 | 11 | 2.34 |
| UK | 64 | 147 | 2.30 |
| SOUTH KOREA | 48 | 107 | 2.25 |
| GREECE | 11 | 25 | 2.22 |
| NEW ZEALAND | 4 | 8 | 2.15 |
| JAPAN | 137 | 288 | 2.10 |
| HONG KONG | 6 | 12 | 1.90 |
| ITALY | 63 | 119 | 1.89 |
| AUSTRIA | 9 | 16 | 1.87 |
| POLAND | 42 | 77 | 1.82 |
| SPAIN | 43 | 75 | 1.74 |
| VENEZUELA | 21 | 37 | 1.73 |
| FRANCE | 63 | 106 | 1.69 |
| SWITZERLAND | 7 | 12 | 1.61 |
| SWEDEN | 9 | 15 | 1.58 |
| BULGARIA | 9 | 14 | 1.45 |
| MALAYSIA | 20 | 28 | 1.41 |
| HUNGARY | 11 | 15 | 1.31 |
| IRAN | 62 | 79 | 1.28 |
| PORTUGAL | 11 | 14 | 1.28 |
| RUSSIA | 339 | 405 | 1.19 |
| MEXICO | 93 | 95 | 1.03 |

**Countries Equal to or Under IPCC Recommended Threshold**

| Country | 1990 Target | 1998 Actual | Ratio |
|---|---|---|---|
| ARGENTINA | 36 | 36 | 1.00 |
| CHILE | 15 | 14 | .96 |
| IRAQ | 20 | 19 | .95 |
| TURKEY | 62 | 47 | .76 |
| THAILAND | 62 | 42 | .68 |
| CHINA | 1259 | 740 | .59 |
| EGYPT | 58 | 31 | .53 |
| BRAZIL | 164 | 84 | .51 |
| COLOMBIA | 37 | 17 | .46 |
| ZIMBABWE | 11 | 4 | .37 |
| INDONESIA | 198 | 67 | .34 |
| INDIA | 942 | 252 | .27 |
| NIGERIA | 107 | 27 | .25 |
| PHILIPPINES | 68 | 17 | .25 |
| PAKISTAN | 125 | 26 | .21 |
| BANGLADESH | 122 | 6 | .05 |

See Appendix A for sources.



1998). Enshrined within the United Nations Framework Convention on Climate Change is one such standard that could be applied in this kind of calculation. Specifically, the Framework Convention states that anthropogenic carbon dioxide emissions should be stabilized at 1990 levels. This 1990 target level is largely symbolic, since it is not assumed to be capable by itself of forestalling significant global warming. Furthermore, it has not been formally ratified by anything approaching a majority of the world's governments. It has nevertheless come to represent the first widely promulgated threshold relating to a major greenhouse gas. As such, it provides one standard upon which to compare the behavior of countries across the world.

Table 2 carries out an analysis designed to show how actual 1998 carbon emission rates for each country compare to their 1990 target levels. The calculations involved are quite simple. First, note that estimated world anthropogenic carbon emissions totaled 5.832 billion metric tons of carbon dioxide in 1990 (US EIA 1999). The world's population, meanwhile, totaled 5.260 billion people in 1990. The UNFCCC target rate, therefore, theoretically allows every person on the planet to emit roughly 1.12 metric tons of carbon per year. Given this per-person theoretical emission allowance, each country's cumulative target rate can be calculated by multiplying its population by 1.12. Carrying these multiplications out for the year 1990 then gives us the population-weighted target levels for each country, consistent with the UNFCCC threshold. In the case of the United States, for example, we multiply 1.12 by 249.8 million (the US population in 1990) to get a 1990 carbon target level of 277 million metric tons. This is the amount of carbon the US population could emit, consistent with the UNFCCC target, on a yearly basis for an interim period.

Of course, few countries emit the amount of carbon dioxide suggested by the 1990 target. Many poor countries emit less than their population-weighted theoretical allowance, while many wealthy countries emit much more than their population-weighted allowance. A ratio can be computed to reflect precisely how far any country is from their UNFCCC theoretical allowance for any given year (remembering that the 1990 level is supposed to be fixed over time). To calculate the ratio we just take the actual carbon emission level of a country for a particular year and divide it by that country's 1990 target rate.[9] The higher the ratio, the more severely a country is exceeding its population-weighted 1990 theoreti-

9. In Table 2, the numbers in the '1990 Target' and '1998 Actual' columns have been rounded. However, the ratio numbers were calculated on un-rounded numbers.

cal allowance. A ratio of 1 (attained only by Argentina in 1998) signifies that a country is emitting at exactly its theoretical allowance. And a ratio of less than one signifies that a country is emitting less than its population-weighted 1990 theoretical allowance.

As can be seen in Table 2, energy consumption inequalities translate into substantially different rates of greenhouse gas emissions across the world. Just as the United States consumes 5 times the global average, it also emits over 5 times more carbon than theoretically allowed for by the UNFCCC threshold. Canada and Australia exhibit quite elevated carbon emission rates, while even Japan emits twice its theoretical allowance. Overall, a broad band of West European countries emit 2 or 3 times more carbon than suggested by the UNFCCC guidelines. Interestingly, though, a handful of core nations (Italy, Austria, France, Switzerland, and Sweden) come close to attaining their symbolic emissions allotments. Broadly speaking, semi-peripheral nations generally approximate the UNFCCC threshold, while peripheral nations (including China and India) emit far below their symbolically allotted rates.

The data presented in Table 2 suggest how politically difficult it would be to implement an equitable approach to global carbon reduction. In order for most core nations to approach their per capita global emissions norm, they would have to reduce their commercial energy consumption levels by factors of 3, 4, or 5. Moreover, these reductions would have to be achieved in a context in which per capita emissions from peripheral nations were allowed to rise towards the global threshold. In other words, the historically-ingrained transfer of resources characteristic of the world energy system would have to be reversed. Nothing short of a fundamental change in the material structures and political culture of the world-system itself would be required to attain an equitably distributed allotment of energy consumption rights.

In the absence of significant reform, the contradictions originating from unequal patterns of energy consumption in this zero-sum, ecologically-bounded system promise to heighten tensions in coming years. These tensions are already manifesting themselves in increasingly acrimonious negotiations at global climate conferences. But they will surely manifest themselves as heightened political, commercial, and social competition as well, as discussed in the next section of this paper.

## LONG-TERM GEOPOLITICAL, COMMERCIAL, AND SOCIAL IMPLICATIONS

Though prone to neglect dimensions of inequality, mainstream energy analyses have paid a great deal of attention to the ways in which competition for access to energy resources has influenced dynamics of geopolitical rivalry in the modern era.[10] Additionally, there is a well-developed literature which describes the competitive struggles pursued by private energy corporations in the twentieth century.[11] Even given these extensive bodies of research, however, it is important to note that world-systems researchers have still been able to shed new light on geopolitical and commercial dynamics surrounding extractive industries.



By engaging in comparative historical research, for instance, Stephen Bunker and his colleagues[12] have shown that the tendency of ascendant core states to engage in competitive struggles for access to raw materials has been a central feature of the world-economy since at least the sixteenth century. They have also drawn attention to the fact that attempts to achieve national economic ascent involve the extraction of natural resources in processes that are disrupting fragile eco-systems across the world. Far from reflecting any widespread process of dematerialization, these national development efforts continue to involve the appropriation of tremendous volumes of raw materials by specific social groups—most often to the detriment of other segments of society.

The operation of these extractive dynamics has taken on particularly severe forms in the case of modern energy sectors. For instance, it is widely acknowledged that competition for access to South East Asian oil resources was a fundamental cause of warfare between the US and Japan in WWII. Similarly, the largest military conflict in the post-Cold War era—the Persian Gulf War—was motivated primarily by competition for control over one of the world's key reserves of petroleum. And every indication is that competition for petroleum will generate renewed geopolitical tensions on both regional and global levels in the coming decades, as resource and ecological boundaries draw tighter.[13]

It is important to note that over 70 percent of the world's proven reserves of petroleum, and over 75 percent of known natural gas reserves, are located in the Middle East and Central Asia.[14] As petroleum and natural gas reserves in other parts of the world become depleted during the coming decades, developing

10. For particularly useful studies on the geopolitical dimensions of energy issues, see Vernon (1983), Bromley (1991), and Yergin (1991).

11. See Penrose (1968) and Moran (1987), for instance.

12. Bunker and Ciccantell (1999) contains a list of additional studies completed by this group of researchers.

13. See Podobnik (2000: chapter 3) for a more detailed examination of the ways in which competition for access to energy resources have influenced dynamics of geopolitical rivalry in the modern era.

14. These estimates of proven petroleum and natural gas reserves come from British Petroleum (1998) and World Energy Council (1999).

nations such as China will be forced to turn towards Middle Eastern and Central Asian oil and gas resources to satisfy their growing domestic demand (Ogutcu 1998; Xu 2000). This will bring large nations in the global south, which have historically consumed very small quantities of petroleum, into direct competition with nations of the global north. Though there is uncertainty as to exactly when depletion effects will begin hitting Middle Eastern and Central Asian reserves, it appears likely that, under rising demand pressure from both core and peripheral nations, the pools of low-cost oil and gas located in these regions will themselves begin to run dry sometime during the 2030-2070 period. As resource constraints tighten, the material inequalities embedded in the international petroleum system are then likely to become a potent source of geopolitical tension.

Growing reliance on petroleum and natural gas resources from the Middle East and Central Asia is also likely to expose the world-economy to substantial financial vulnerability. As argued in recent studies,[15] countries in these regions are likely to be convulsed by political and social unrest in the coming decades. This suggests that price volatility will regularly emanate from the world's key sources of conventional energy, at a time when depletion effects are likely to begin placing sustained upward pressure on oil and gas prices throughout most of the rest of the world (Pindyck 1999). If deregulation continues to sweep through global electricity markets, another source of market volatility will be added to this already uncertain commercial environment.

Recent experience has revealed that inflationary trends in global energy markets can rapidly undermine conditions for capital accumulation in broad regions of the world-economy. In over 35 countries energy imports exceed 10% of the value of their exports, and so even modestly elevated global energy prices can quickly generate serious trade deficits (IMF 2000). Even in core nations such as the United States, spikes in electricity prices have led to substantial commercial and political unease.

It certainly remains the case that, as world-systems researchers have repeatedly pointed out, prices of raw materials such as energy fundamentally impact rates of profit and capital accumulation in virtually all sectors (Barham, Bunker, and O'Hearn 1994: 5). In this regard, the "new economy" is not so different from the old economy. Indeed, given their high level of demand for uninterrupted electricity, information-based industries may be more acutely sensitive to the cost

15. See studies conducted by the National Intelligence Council (2000) and the Center for Strategic and International Studies (2001) for discussion of this point.



and reliability of energy inputs than many traditional industries (Feder 2000). The most advanced sectors of modern economies, in short, are not likely to be able to escape the commercial turbulence generated by tightening constraints emerging in conventional global energy industries.

In addition to the mounting possibility that geopolitical tensions and commercial instability will be generated by global energy inequalities, there are also problematic social dynamics that may kick into effect as well. Most importantly, it is not at all clear that the relatively soft constraints represented by environmental regulations can remain resilient in the face of growing supply difficulties in global energy industries.

While public support for stronger environmental regulations has been widespread in core countries during the economic upturn of the 1990s, it is unclear how strong these environmental commitments will prove to be during periods of crisis in energy sectors. Recall that, following the temporary oil price hikes of 2000-2001, protests against energy taxes swept across Western Europe. Though labor and green political representatives tried to defend the taxes on the basis of their environmental benefits, in most cases these taxes were reduced in the face of consumer anger (Barnard 2000). Similarly, in the context of the current electrical crisis that is assailing California, political and corporate leaders are calling for suspension of some federal and state regulations in order to allow for increased electricity production in conventional and nuclear-powered stations (Booth 2001).

If public commitment to environmental regulations proves to be soft in core nations during a time of relative affluence, then this has ominous implications for the viability of such regulations in developing countries throughout the world. Wallerstein's (1999) suggestion that reformist environmental regulations will prove ineffective in containing the ecologically destructive tendencies of the capitalist world-system may well end up being correct. What is certain is that a time of significant challenges to environmental achievements will come as the contemporary global economic expansion ends, competition for increasingly scarce conventional fuels intensifies, and the costs of climate change begin to mount.

## PROSPECTS FOR THE FUTURE

There are many reasons to be pessimistic about the future evolution of the global energy system. Indeed, analysts from diverse ideological perspectives argue that fundamental changes in contemporary patterns of energy use cannot be made and that catastrophe is inevitable. Still, as Bunker and Ciccantell (1999: 120) point out, it is important not to underestimate the ability of capitalist firms to innovate and adapt to new material circumstances. And, it is certainly premature to assume that concerted political and social pressures for equitable reforms would be unable to move the global energy system towards a more collectively rational trajectory.

In this last section, one possible scenario of true reform—resulting from a particular conjuncture of systemic dynamics—is described. Whether it will materialize is partly dependent on broad structural forces beyond the control of individual nations, and partly dependent on the ability of state planners, corporate leaders, and broad groups from civil society to push for reform. In this respect, we have arrived at the classically ambiguous conclusion found in most world-systems analyses: though structural processes of evolution are leading in dangerous directions, there is at least some possibility that human agency can have unusually powerful effects precisely because we find ourselves in a crisis period.[16]

As discussed in the previous section, geopolitical rivalries for dwindling conventional energy resources are likely to fuel serious conflicts between ascendant states and long-established core powers (CSIS 2001). It also appears, however, that these same dynamics of geopolitical rivalry are spurring some states to fund new energy technology development programs. State agencies in the United States, Western Europe, and Japan, for instance, have already sponsored joint projects with private corporations to commercialize a variety of new energy systems in this decade. Underlying these efforts is a pressing need to find new ways to utilize the extensive networks of government laboratories that, during the post-WWII era, specialized in the development of nuclear weapons and delivery systems.[17] One unanticipated consequence of contemporary efforts to legitimize continuing public support for military-industrial complexes may therefore be to foster more innovative patterns of state intervention in energy sectors during the coming decades.

Similarly, rising prices in petroleum and natural gas industries will stimulate a renewed wave of capital investments in conventional energy sectors—thereby partially reinforcing business-as-usual commercial dynamics. At the same time, however, rising conventional energy prices will stimulate interest in alternative energy technologies. In this context, it is important to note that a tremendous

16. See Wallerstein (1999) and Boswell and Chase-Dunn (2000: chapter 6) for particularly useful descriptions of the complexities inherent in these bifurcation points in world history.

17. See Nakaoka (1994), Sissine (1999) and US General Accounting Office (1999) for surveys of government-supported efforts to commercialize new energy technologies.



amount of innovation is occurring in a variety of alternative energy sectors. Indeed, new kinds of business ventures—which link small engineering firms such as Ballard Power with long-established automotive and petroleum corporations—are fostering rapid commercial advances in new wind, solar, and fuel cell technologies.[18] Through such cooperative, multi-firm joint efforts, resistance encountered in the market place can be more effectively countered. Historical and contemporary trends therefore suggest that competitive dynamics can indeed foster the entrepreneurial and organizational innovations required for the commercialization of a variety of new energy technologies.

There is an additional factor that is likely to enhance dynamics of innovation in global energy industries. In contrast to the global energy shifts of the nineteenth and twentieth centuries, future energy transitions may be facilitated by the existence of multilateral agencies that can assist in setting common agendas and coordinating policies undertaken by individual governments. Although organizations such as the World Bank and the International Energy Agency have long directed the bulk of their institutional support towards conventional energy systems, there are indications that these organizations are in the process of modifying their priorities. As a result of pressure from non-governmental organizations, for instance, the World Bank recently committed itself to increasing funding for environmentally sustainable energy projects (World Bank 1999). Multilateral institutions are also assisting in national efforts to reduce subsidies to conventional energy industries throughout the world. If the field of energy pricing can be leveled through these national and international policy efforts, possibilities for a shift towards greater reliance on new energy technologies will be significantly improved.

What is still missing from contemporary efforts at generating innovative changes in the global energy system, however, is any concerted attempt to reduce enduring energy inequalities by reigning in habits of over-consumption found in many core countries. It is here that groups rooted in civil society, such as consumer and environmental movements, have an important role to play. Such movements have demonstrated in practice that they have the capacity to alter the trajectories of energy sectors, by mobilizing against nuclear power and by pushing for tighter environmental regulations on conventional sectors in many regions of the world.[19] Now they must not only strengthen their defense of

18. See Srinivasan, et al. (1999) Worrell, et al. (2001), and Podobnik (2000: 254) for discussions of private-sector investments in new energy systems.

19. See Rudig (1990), Nilsson & Johansson (1994), and Podobnik (2000: chapter 5) for discussions of the impact of social movements on global energy industries.

existing regulatory controls, but they must also work to transform cultural propensities to over-consume energy resources that are found in such countries as the United States, Canada, and Australia (Nye 1999). Behind these intentional efforts at reform, meanwhile, lies what might be a more powerful source of social pressure for fundamental change in the global energy system. Escalating social tensions in the Middle East and Central Asia may in the end prove to be the key, unintended factor propelling the system in innovative directions in the twenty-first century.

There are clearly inherent uncertainties in the manner in which geopolitical, commercial, and social dynamics will interact in coming decades. What is clear, however, is that the massive inequalities embedded in the global energy system must begin to be reformed if potentially dire trends are to be avoided. Whether or not this process can be initiated soon will have a tremendous impact on determining whether the world can move in a collectively rational direction regarding energy policy, or whether we will become caught in escalating energy-related crises in this century.

## APPENDIX A: ENERGY DATA SOURCES AND METHODS

The analyses undertaken in this paper are based on data covering coal, petroleum, natural gas, nuclear, hydro, geothermal, and alternative energy industries for the period 1800-1998. The following sources were drawn upon for the production and consumption data: 1) for the period 1860-1949: Etemad and Luciani 1991, *World Energy Production 1800-1985*; and 2) for the period 1950-1997: *The United Nations Energy Statistics Database*, 1997 edition, provided in the annual volumes published by the United Nations, entitled *Energy Statistics Yearbooks*, and supplemented by updated computerized files provided by the United Nations Energy Statistics Unit. Some additional consumption data for the years 1925-1949 were taken from the United Nations publication *World Energy Supplies in Selected Years, 1929-1950* (UN 1952) and from Darmstadter et al., *Energy in the World Economy* (1971).

Where missing data has been estimated, the method of linear interpolations between specific country data points has been used. This method is judged to be reasonable, given the fact that national patterns in energy production and consumption generally follow smooth trajectories. The method of linear interpolation is widely used in the construction of other energy data sets. Because of severe missing data problems during the years 1940-1945, the series on consumption were left as missing during this period.

Reliability checks were carried out on the energy data files. Specifically, the United Nations data has been cross-checked with information provided in



International Energy Agency energy publications, the US Energy Information Administration's *Annual Energy Review*, and the *British Petroleum Survey of Energy Resources*. These comparisons reveal a very high level of reliability.

In calculating the world energy gini coefficient, each year was calculated separately. First, for each country a variable (perpop) was calculated—equal to the percent of the world's population represented by that country in that year. Second, for each country a variable (perenc) was calculated—equal to the percent of world commercial energy consumption represented by that country in that year. The gini coefficient for each year was then calculated using this formula:

$$Gini = 0.5*(\text{sum of absolute values of } (perpop - perenc) \text{ for all countries in that year}).$$

*In notational form:*

$$Gini = 0.5*(|perpop1 - perenc1| + |perpop2 - perenc2| \ldots + |perpopN - perencN|)$$

where *perpop*1 is percent of world population in country 1, and
*perenc*N is percent of world energy consumed in country N.

See Podobnik (2000) or contact author <podobnik@lclark.edu> for a more detailed discussion of data sources and methods, as well as descriptions of exactly which countries are included in global regional categories used.

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