NUCLEAR ENERGY FOR THE 21ST CENTURY TO SUSTAIN OUR CIVILIZATION

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1. FOREWORD

Since the Industrial Revolution, mankind's consumption of energy has increased as our civilization has developed and our standard of living has improved. This mass consumption of energy has naturally brought about a number of environmental problems. The first incidences of pollution were regional and even local problems involving things like dust, sulfur dioxide and nitrogen oxide. Pollution has since become an urgent dilemma in some rapidly industrializing nations, but in most so-called "advanced nations" it is well under control, with lesser significant public health threats.

The most serious environmental problem facing us today is global warming, caused by carbon dioxide and other greenhouse gases. Unlike other forms of pollution restricted to certain regions or countries, this phenomenon affects the stability of the global carbon cycle, and will require synthetic solutions based on very long-term prospect. In terms of both time and space, humanity has never before faced a challenge of such global problem.

We cannot halt the emission of carbon dioxide gas as long as we use fossil fuels, but we will not be able to solve this problem if we continue to view it in terms of shortsighted equations like "control of fossil fuel equals control of energy." In developing countries, there is a strong link between increased energy consumption and economic growth, and the ongoing population explosion in such countries more or less ensures that their energy consumption will continue to grow. In advanced nations, too, the spread of information technology is leading to greater energy consumption in homes and offices. Energy is also needed to process and recycle various kinds of waste. Even if we promote energy saving, it is realistic to expect the demand for energy to continue growing gradually. Some argue that the use of energy should be restricted, even if it affects our standard of living - but lifestyle choices are personal decisions, and this approach would be unlikely to enjoy wide spread support. We must therefore find a way to reduce energy consumption and decrease CO_2 emission while maintaining our current quality of life. This means using energy efficiently and developing "cleaner" energy sources that emit less carbon dioxide gas; the advanced nations are already moving in this direction.

In this article, we will take a look at past energy structures of advanced countries from the perspectives of efficiency and cleanness in an attempt to draw some useful lessons in energy and the environment for the coming century.

2. TRENDS IN ENERGY CONSUMPTION & CO_2 EMISSION

Primary energy structures and changes over time depend on the different conditions of each nation. In Europe, for example, coal started out as the main energy source. Consumption of petroleum increased dramatically in the 1960s, and then - in the wake of the Oil Crisis—Europeans diversified their energy sources to include nuclear power and natural gas. In North America, on the other hand, petroleum use was high from the early stages and became higher during the 50s and 60s. Since the Oil Crisis, there has been a gradual switch to natural gas and coal. Canada makes considerable use of hydroelectric power.

Japan's consumption of petroleum grew enormously in the 1960s, along with our economy. Since the Oil Crisis, we have been shifting gradually to nuclear power, natural gas and coal, but our dependence on petroleum remains high. Figure 1 shows CO_2 emission by different sources from 1950 to 1994.

Petroleum consumption in advanced nations increased dramatically from 1950 until the first Oil Crisis, but since then it has leveled off and - in some cases - even declined. Energy consumption in China and India, on the other hand, has been growing steadily since 1950, mainly in the form of coal burning. CO_2 emissions in advanced nations have declined since the Oil Crisis, but in China and India these emission yet continue to grow.

Figure 2 shows the total CO_2 emission of each country since 1950. As of 1994, China was the world's second largest generator of CO_2 gas - and if its CO_2 emission continue to grow at the present pace, it will soon surpass USA for the top position. India's CO_2 emission have grown at an annual rate of about 6% since 1950, and in 1994 even though a little less than Japan, it was still generating CO_2 more than England, France, Germany or Canada. Clearly, the problem of global warming is not confined to advanced nations. It is also a pressing issue in developing countries where population is increasing and energy needs are expanding.

3. EFFICIENCY AND CLEANNESS

To make sustainable growth possible, we must use energy more efficiently and develop cleaner sources of energy. For the sake of this paper, we will define efficiency by the total primary energy supply per GDP (TPES/GDP) and cleanness by the rate of CO_2 emission for each energy supply.

Figure 3 (a) shows changes in the TPES/GDP for each country over time. China is rapidly lowering its TPES/GDP, but its degree of energy efficiency remains very low. Energy efficiency in the former Soviet Union is just as poor, and other developing countries not shown here are similarly by low. There is still plenty of room for improvement through technical and financial aid from the advanced nations. From Figure 3 (b), we can see how energy efficiency in advanced nations has improved since the Oil Crisis. Japan and France are particularly efficient, the TPES/GDP in both of these countries being very low, but they seem to have reached their lowest limit.

Figure 4 shows the rate of CO_2 emission by nation since 1960. We can see how advanced nations moved from coal to petroleum and then - after the Oil Crisis - lowered their CO_2 emission by shifting to natural gas and nuclear power. The decline in the rate of CO_2 emission is especially notable in France, a nation that has maximized its use of nuclear power. The rate of CO_2 emission in Canada has always been low, owing to the use of hydroelectric power. In China, however, 75% of all energy comes from coal and the rate of CO_2 emission has not shown any improvement between 1970 and 1994.

Figure 5 traces advances in energy efficiency and cleanness by decennial plotting of the rate of CO_2 emission vertically and the TPES/GDP horizontally. Changes that occurred during each of the three decades between 1964 and 1994 are shown in three separate vectors.

From 1964 to 1974 (the decade before the Oil Crisis), petroleum consumption in all countries rose exponentially as economies expanded and grew. Coal consumption decreased proportionately during this time, resulting in lower CO_2 emission, but the TPES/GDP actually grew.

In the decade after the Oil Crisis (1974-1984), advanced nations worked hard to save energy and to shift to alternate sources of energy. This was the period in which nuclear power really came into widespread use and CO_2 emission decreased. A general decline in the TPES/GDP was also seen everywhere except for France, where the emphasis was given to nuclear power as an alternative energy source rather than for saving energy.

The price of petroleum remained almost constant during the last decade (1984-1994), but public awareness of environmental problems grew at this time. Use of nuclear power continued to expand, despite rising anti-nuke sentiment in the wake of the Chernobyl disaster in 1986, and this helped to lower CO_2 emission levels. France expanded its use of nuclear power even further during this period, thereby achieving

significant reductions in CO_2 emission. In USA, the use of coal increased along with nuclear power, and as a result CO_2 emission in that country remained virtually unchanged. USA and Canada have made considerable strides in energy efficiency, but they still use energy far less efficiently than Japan and France.

4. THE ROLE OF NUCLEAR POWER IN THE WAKE OF THE OIL CRISIS

After the Oil Crisis, advanced nations introduced energy saving measures and switched to alternative resources like nuclear power, and as a result the rate of CO_2 emission was greatly reduced. France, for example, expanded its use of nuclear power from 2.2% to 39.7% of total primary energy supply, and halved its carbon dioxide emissions from 0.77 to 0.38 (per ton of carbon/per ton of petroleum). Japan, too, upped its use of nuclear power from 0.8% to 15.3%, thereby improving its own carbon dioxide emission ratio by 19%. Figure 6 shows the relationship between the expanded use of nuclear power as a primary source of energy and the decrease in the rate of CO_2 emission in the years since the Oil Crisis. Though energy structures and responses to the Oil Crisis varied from country to country, there is a certain correlation between the increased use of nuclear power and decreases in CO_2 emission. From this, we may conclude that improvements in the rate of CO_2 emission in advanced nations since the Oil Crisis are due, in large part, to the increased use of nuclear power.

5. TOWARD THE 21ST CENTURY

To realize a sustainable growth, we must learn to use energy more efficiently and more cleanly.

Some countries, like Japan and France, have almost reached their limits in efficiency levels, but the vast majority of nations still have plenty of room for improvement. Developing nations, in particular, use energy inefficiently. The individual circumstances of such countries should be considered when we set targets for CO_2 emission reduction. If we ask advanced nations alone to cut back, the amount that is actually reduced would provably be insignificant. For the developing nations to reduce CO_2 emission, it is essential that we help them make their use of energy more efficient by providing them with technical and financial aid.

Expanded use of nuclear power in the wake of the Oil Crisis did much to help stabilize the price and supply of petroleum. Today, however, when public awareness of environmental problems is high, we realize that the contribution of nuclear power goes beyond this. Improvements in energy cleanness made in advanced nations are due mainly to the use of nuclear power.

If other advanced nations could achieve the same efficiency in energy use as Japan and the same level of nuclear power use as France, the level of CO_2 emission would drop to about one-third of its current level. And this is not impossible. France has proven that expanded use of nuclear power can lead to dramatic reductions in CO_2 emission. Other nations have experienced the same thing, though in varying degrees.

To reduce CO_2 emission in developing nations, it is essential that cleaner forms of energy be used. Rapidly growing nations like China and India continue to rely mainly on coal for their energy needs. Nuclear power would be an effective way to clean up energy use in such countries. The use of nuclear power, however, requires a high level of technology to ensure safety as well as strict controls to ensure non-proliferation. Once again, advanced nations must take the lead by offering technological and financial support.

The energy saving measures and alternative energy sources (especially nuclear power) developed by advanced nations after the Oil Crisis not only decreased our dependence on fossil fuels, they also contributed greatly to reducing emissions of carbon dioxide. Reaffirming these measures and implementing them in whole world including developing nations will enable us to control global warming and maintain continuous development into the next century. Nuclear power has fallen on hard times in many parts of the

world, but we would like to remind as many people as possible that it is the only way to generate energy while protecting the environment.

Finally, we would like to call your attention that it is fundamentally important to establish “society based on recycling “ for sustainable development of our civilization in next century, and that nuclear power industry cannot be the exception. Establishment of a total system composed of nuclear reactors and their fuel cycles consistently is a necessary condition for nuclear energy to support sustainable and continuous development as a main energy source.

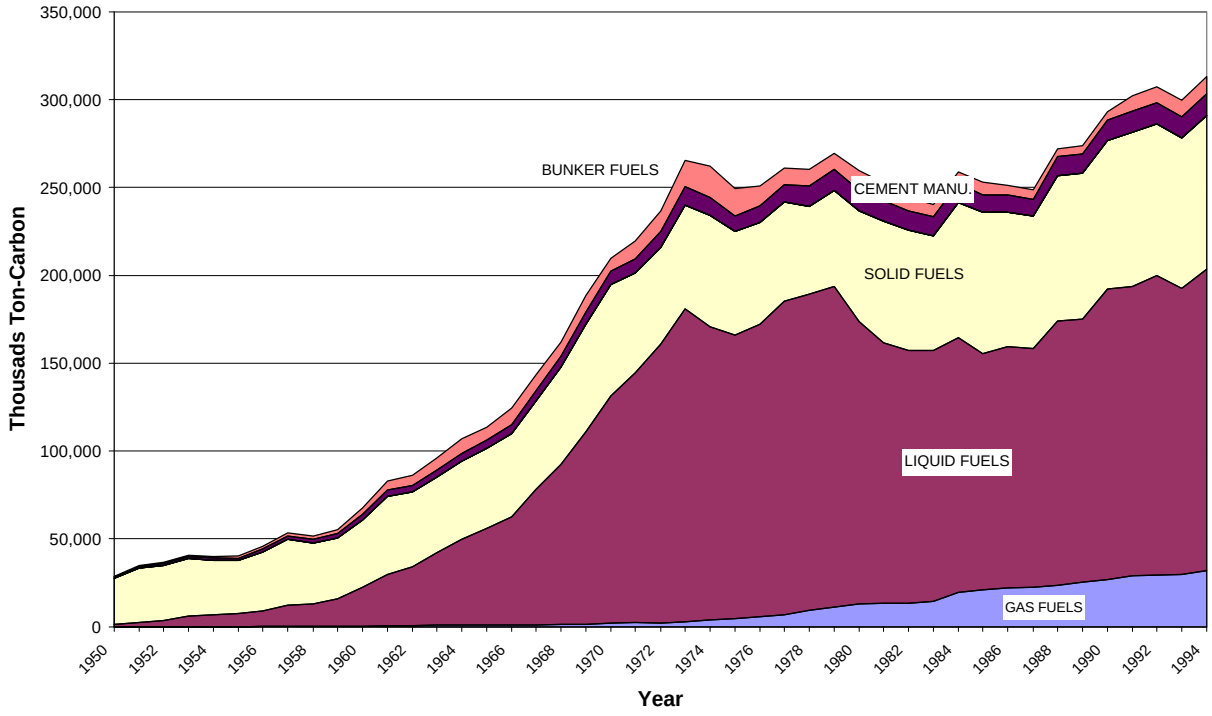


Figure 1 CO_2 Emission in Japan (from ORNL-CDIAC-NDP-030/R7)

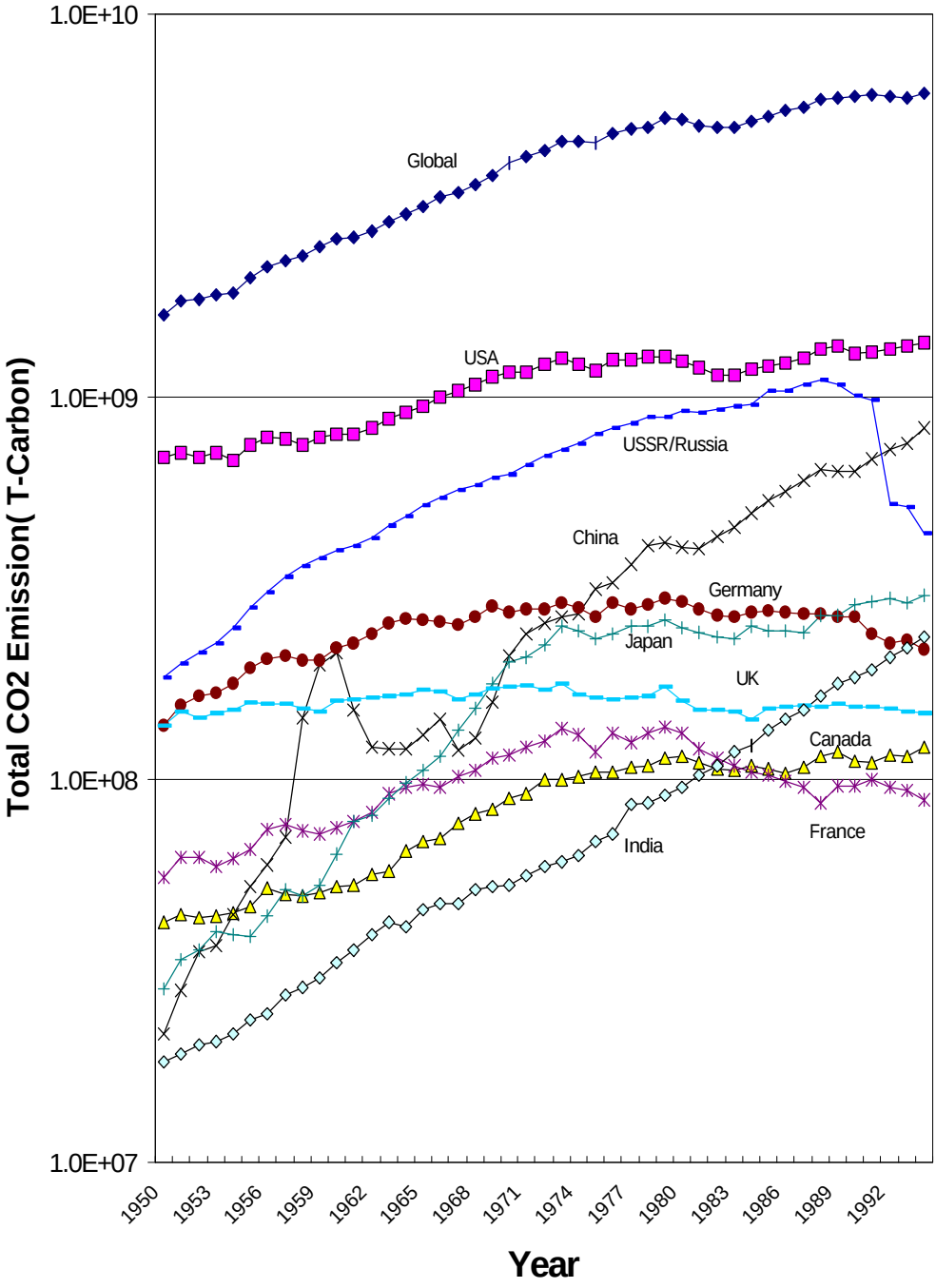
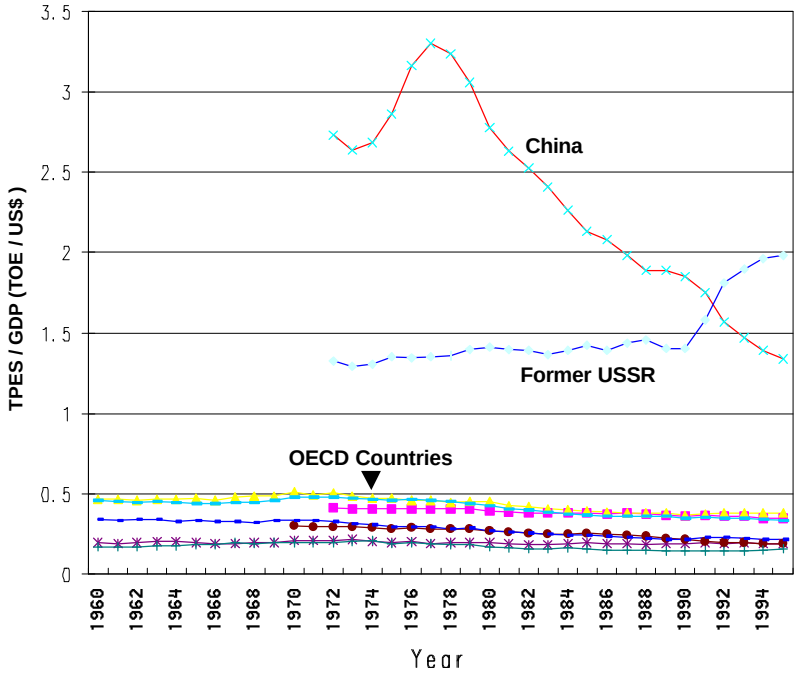
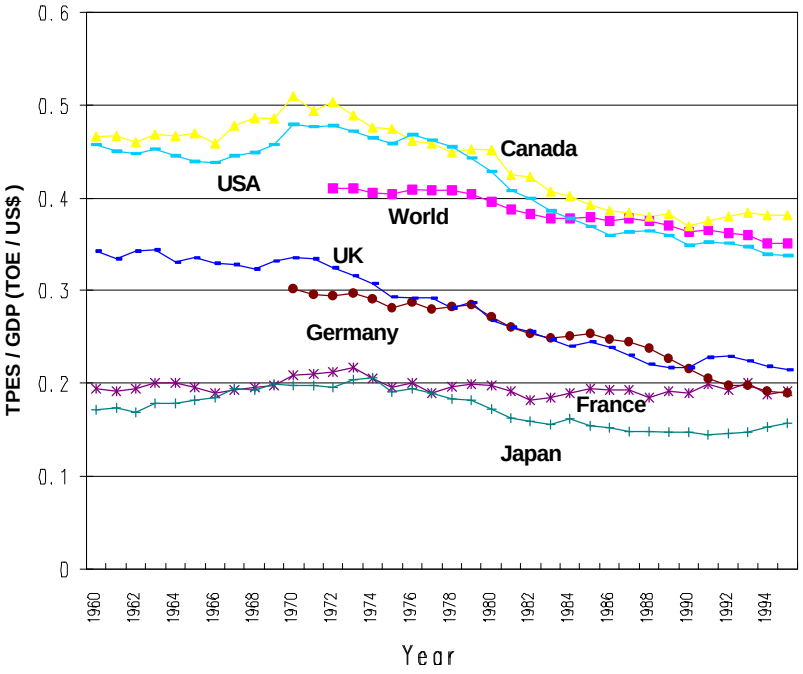


Figure 2 Total CO_2 Emissions (from ORNL-CDIAC-NDP-030/R7)



(a) TPES/GDP



(b) TPES/GDP (OECD Countries)

Figure 3 Total Primary Energy Supply per GDP

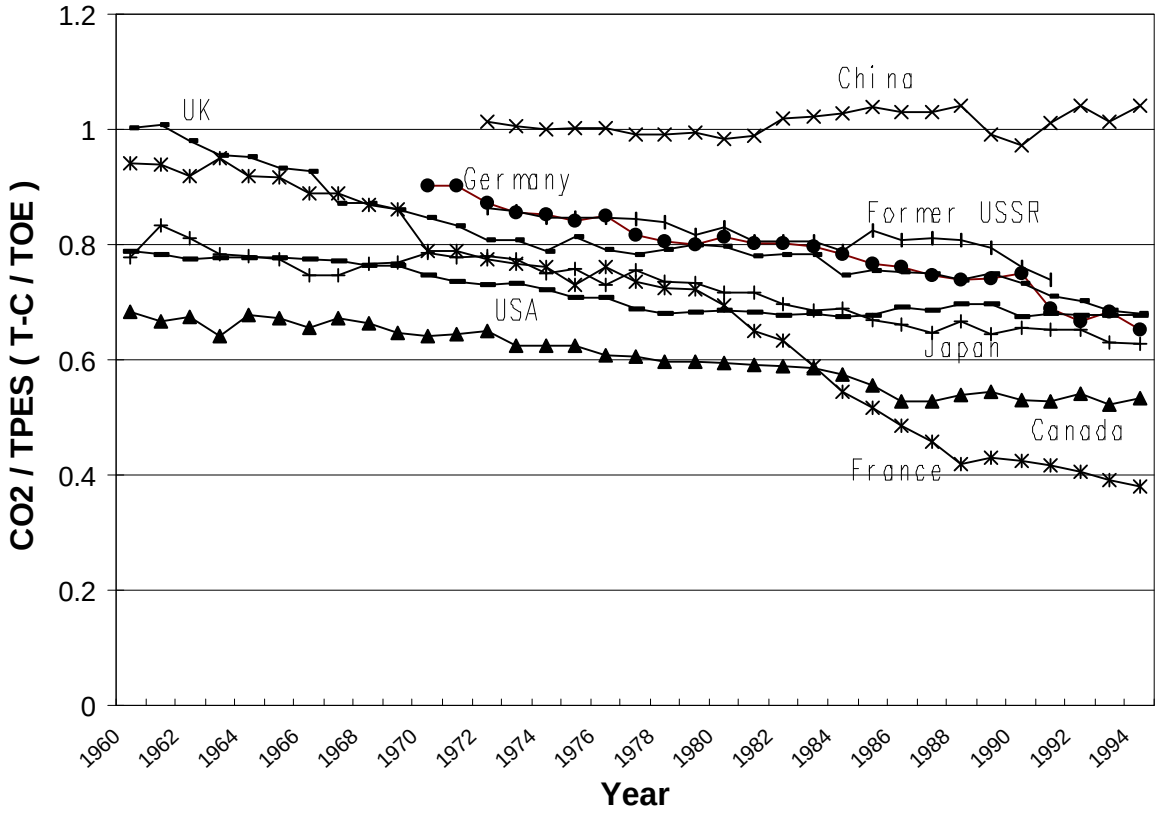


Figure 4 CO_2 Emission per Unit Energy Supply
(from "ORNL-CDIAC-NDP-030/R7" and "Energy Balances of OECD Countries, 1994-1995"

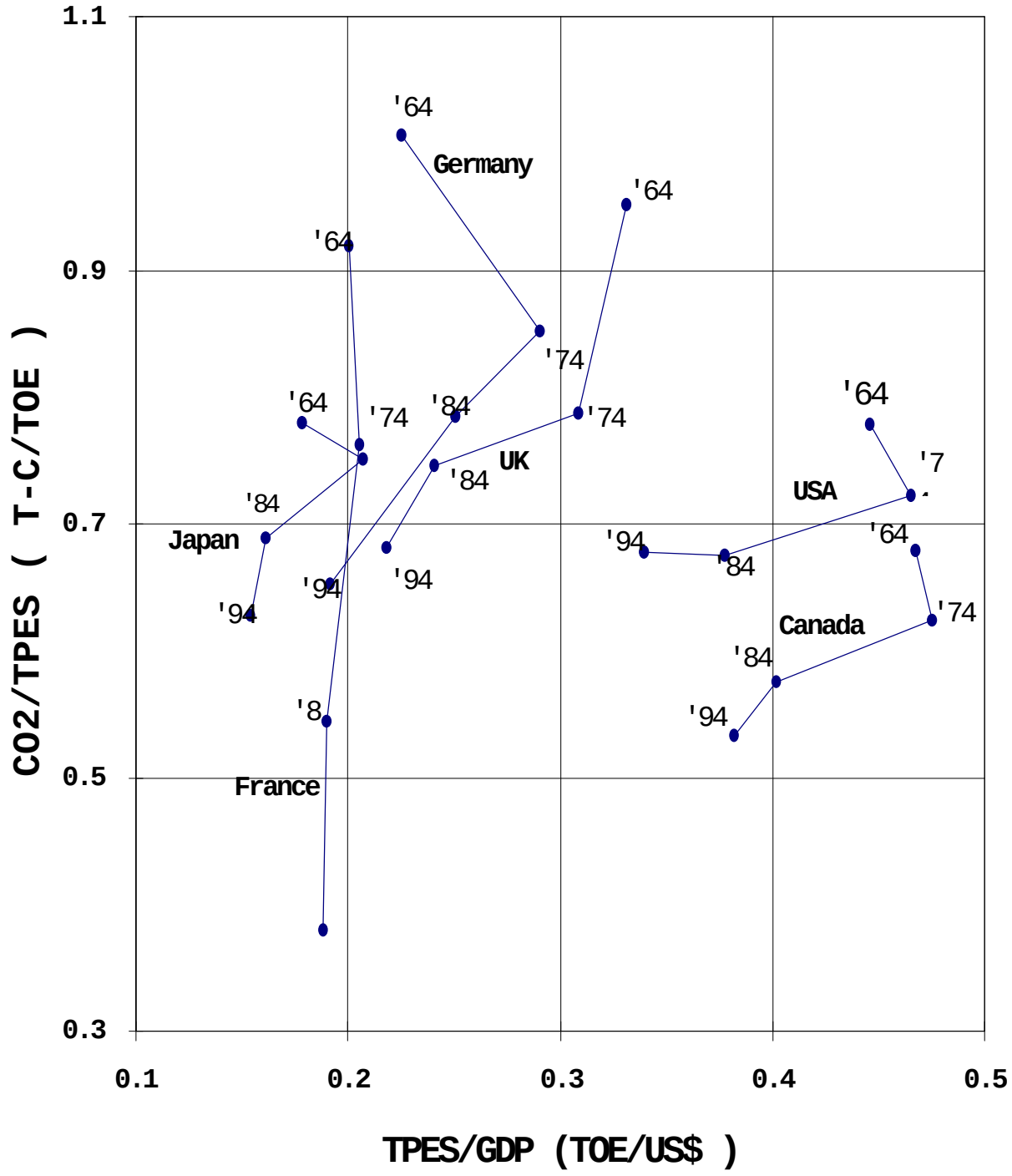


Figure 5 Improvements of Cleanness and Efficiency in 1964 - 1994

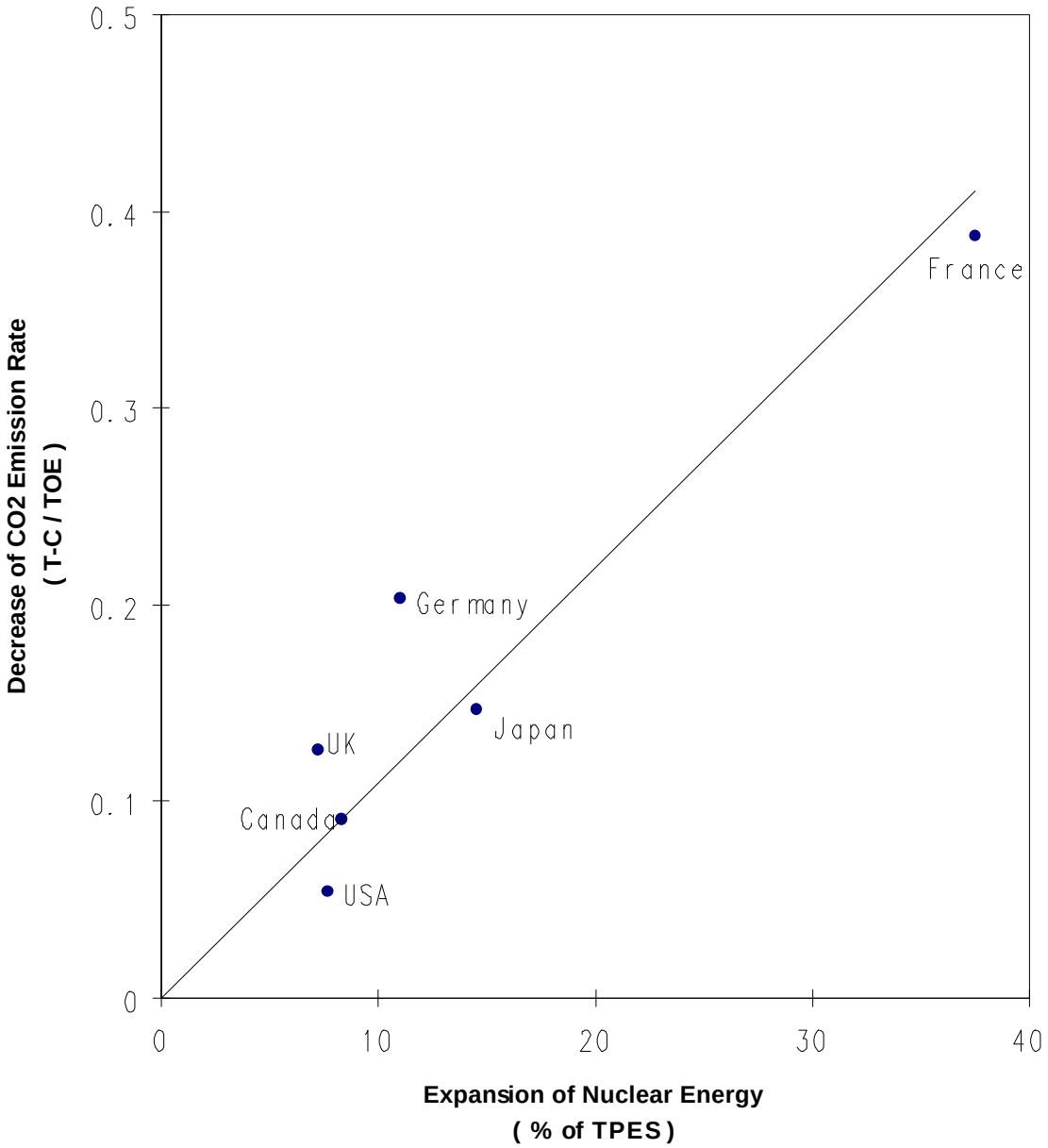


Figure 6 Expansion of Nuclear Energy vs. Decrease of CO_2 Emission Rate, 1973 to 1995