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AICGS POLICY REPORT

INTELLECTUAL PROPERTY RIGHTS AND GREEN TECHNOLOGY TRANSFER: GERMAN AND U.S. PERSPECTIVES

Robert V. Percival
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AMERICAN INSTITUTE FOR CONTEMPORARY GERMAN STUDIES THE JOHNS HOPKINS UNIVERSITY

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FOREWORD

While environmental concerns have recently taken a backseat to the economic and financial crisis, scientific projections on climate change continue to call for action. Yet, international cooperation has been hampered and a rift between developed and developing nations is increasingly evident. Developed nations charge that a reduction in emissions is not possible without a similar commitment from developing countries, whereas developing countries fear that their economic growth will be hampered by severe restrictions. Intellectual property rights also play a role in the disagreements. Companies in the developed world that spend considerable amounts of money on the research and development of energy efficient and clean energy technology are interested in recouping those investments through property rights. Developing nations as well as environmental and climate advocates contend, however, that such technology must be made available to all nations for the betterment of the developing countries and the world as a whole.

This Policy Report examines American and German views on this contentious issue. In his essay, Robert Percival from the University of Maryland School of Law first outlines various strategies for promoting the development and deployment of green energy technology. The author then turns to intellectual property laws and their influence on green energy innovation. Miranda Schreurs from the Freie Universität Berlin examines why technology transfer and intellectual property rights are key issues in climate policy and what role technology transfer has played so far, focusing especially on the German and European view on these issues. Both essays provide important insights into the climate policy debate as well as the aspect of intellectual property rights and add important policy recommendations for policymakers on both sides of the Atlantic.

This publication is an example of AICGS' commitment to furthering transatlantic discussion on the global issues of climate change and energy sustainability and builds on previous projects on those topics. AICGS is grateful to the authors for their insights, the Daimler-Fonds im Stifterverband die Deutsche Wissenschaft for its generous support of this publication, and to Jessica Riester and Kirsten Verclas for their work on the publication and project.

Jack Janes
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STRATEGIES FOR PROMOTING GREEN ENERGY INNOVATION, DEPLOYMENT, & TECHNOLOGY TRANSFER

ROBERT V. PERCIVAL[1]

Global climate change represents the most difficult environmental challenge facing the world today. The struggle to reach consensus on a global policy for responding to it has exposed sharp divisions between developed countries and the developing world. There is wide recognition that a global transformation toward a green energy infrastructure is necessary, but considerable uncertainty over the best means for bringing this about. While technological innovation can play an important role in reducing greenhouse gas emissions, developing countries fear that principles of intellectual property law will hinder the transfer of green energy innovations to them.

This paper surveys various strategies for promoting the development and deployment of green energy technologies. Governments around the globe have adopted a vast array of subsidy, tax, and regulatory policies to foster research, development, and deployment of green energy technologies. These include grants, soft loans, tax credits, portfolio standards and other mandates, feed-in tariffs, energy taxes, and other policies to make green energy innovation more rewarding and to reduce the cost of renewable energy sources compared to fossil fuels. Some of these policies seek to promote the use of particular renewable energy sources, while others seek to raise the cost of using carbon-intensive sources of energy.

After reviewing the history of these policies and studies assessing their effectiveness, the paper concludes that the principal obstacle to transformation to a green energy infrastructure is uncertainty concerning the future price of fossil fuels. Past surges in oil prices have spurred crash programs to develop renewable energy sources that later were abandoned when oil prices declined. The paper examines how carbon taxes or oil price stabilization tax schemes could create comprehensive, predictable incentives for making the necessary transition to green energy technology. It acknowledges the potent political headwinds facing such policy proposals and explores ways of overcoming them.

The paper then examines claims that intellectual property law, which is designed to create incentives for innovation, actually may inhibit the transfer to developing countries of green energy innovations. While the paper cannot find significant examples of green energy technologies whose diffusion has been hindered by existing intellectual property protections, it explores strategies, such as compulsory licensing schemes, for responding to such problems if and when they arise in the future. The paper concludes that intellectual property law need not be an obstacle to a global transformation toward a green energy infrastructure that can promote economic development while advancing new levels of international cooperation.

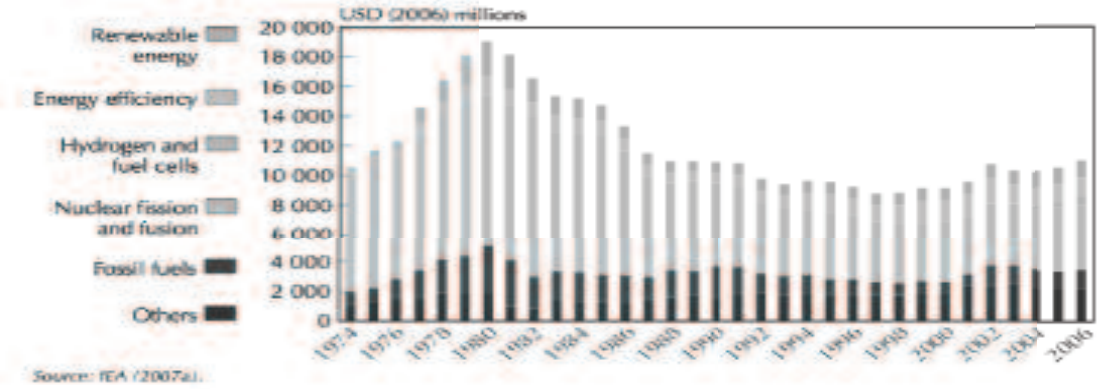
Government Policies to Promote the Green Energy Transfer

Most developed countries and many developing countries have adopted policies to encourage the development and deployment of green energy technologies. The first initiatives in this area occurred in response to crises caused by dramatic increases in the price of oil during the 1973 Arab oil embargo and following the 1979 Iranian revolution.[2] During the last decade rising concern over global warming and climate change, and another dramatic surge in global oil prices during the summer of 2008, has spawned new policies designed to reduce dependence on fossil fuels. U.S. policies are described below and the policies of the EU and thirty-four other countries are

outlined in more detail in Appendix I. These policies include a smorgasbord of subsidies, tax, and regulatory policies designed to smooth the transition to a green energy infrastructure.

Levels of funding on research to promote energy innovation also have been influenced by changing oil prices. As shown below in Figure 1, spending on energy research, development, and demonstration (RD&D) in countries who are members of the International Energy Agency (IEA) nearly doubled between 1974 and 1980 before declining throughout the next decade. In 1974, renewable energy represented only 2.7 percent of energy RD&D spending. By 1981 it had risen to 12.9 percent before declining to 6.2 percent by 1986. In 2006 it increased to 10.2 percent of such spending.

Figure 1: All IEA Member Country RD&D Spending, 1974-2006



As of 2008 renewable energy RD&D represented 10.8 percent of all energy RD&D spending.[3] Solar energy has emerged as the renewable energy sector that enjoys the "lion's share" of RD&D funding; between 1974 and 2006 it represented 25 percent of renewable energy RD&D spending.[4] Country-specific spending on renewable energy RD&D generally reflects a nation's natural resource endowments.[5] New Zealand and Turkey have substantial geothermal energy resources, and so invest the bulk of RD&D funding in this sector. Norway allocated approximately one-third of its renewable energy RD&D to the hydropower sector. Austria, Canada, Finland, Hungary, and Sweden invested large sums of RD&D funding in the biomass sector. Denmark and the United Kingdom spend approximately one-third of renewable RD&D on wind power. Global competition to export renewable technologies also has influenced RD&D spending. For example, Germany devotes nearly half of its renewable RD&D budget to the solar photovoltaic sector.[6]

Government policies to promote renewable energy have sought to make it more economical to deploy proven forms of such technology through loans, tax credits, feed-in tariffs, and taxes on non-renewable, competing sources of energy. Specific policies adopted by various countries are described in more detail in Appendix I. None of these countries has tried to stabilize the price of fossil fuels per se. However, several have levied taxes that either specifically target fossil fuels or are disproportionately higher for fossil fuels than for renewable energy sources. For example, Finland's taxes on fossil fuels are staggered according to the environmental qualities of fuels and their carbon content. The most popular measures involve initiatives that aim to encourage deployment of renewable energy technology through measures such as feed-in tariffs and preferential tax treatment.

Renewable energy technologies that several countries have specifically targeted for investment and support include carbon capture and sequestration, biomass production and use, and biofuels. Several countries have focused government investment on a particular type of renewable energy source. For example, Finland maximizes use of its vast peat bogs by continuing to promote peat biomass energy as one of the country's most competitive alternative energy sources. Brazil takes advantage of its sugarcane resources by requiring an increase in the share of sugarcane biogas energy in the country's energy portfolio.

U.S. ENERGY POLICY

Since the 1973 Arab embargo on oil exports to the United States, "energy independence" has been the central theme of U.S. policy in almost every presidential administration. After the embargo, President Richard Nixon launched "Project Independence," which established a goal of making the U.S. completely energy independent by 1980.[7] President Gerald Ford postponed this goal to 1985.[8] President Jimmy Carter established the U.S. Department of Energy and proposed a $142 billion energy plan to achieve energy independence by 1990.[9] His plan included creating a solar bank and a synthetic fuels program, which later fell victim to the steady decline in real oil prices that occurred during the 1980s. President George H.W. Bush made reducing dependence on foreign oil a cornerstone of his energy policy.

Another important theme in U.S. energy policy over the past forty years has been efforts by the federal government to encourage technological breakthroughs in the development of electric vehicles. In 1970, President Richard Nixon announced he was inaugurating a program to encourage government and private research on "pollution free" automobiles.[10] The 1975 Energy Policy and Conservation Act, signed by President Ford, set federal standards for energy efficiency in new cars. President George H.W. Bush was responsible for the U.S. Advanced Battery Consortium, jointly founded with the "Big Three" automakers, which had the goal of developing a lightweight battery system suitable for electric vehicles. President Bill Clinton launched the Partnership for New Generation Vehicles, with the "Big Three" automakers, which aimed to produce a prototype car that was three times more efficient than a conventional vehicle by the year 2004. President George W. Bush announced a $1.2 billion FreedomCar proposal to develop a hydrogen-run vehicle.[11]

President Clinton's efforts to reform U.S. energy policy stumbled in the early days of his administration when he sought to establish an energy tax based on the energy content of fuels, specifically the amount of BTUs (British thermal units) the fuel produces.[12] Released in February 1993, the energy plan aimed to foster conservation and decrease pollution, while spreading the cost in an equitable manner.[13] The BTU tax was part of a broader fiscal plan Clinton proposed; the plan put before the House of Representatives was projected to raise $72 billion between 1993 and 1998.[14]

The proposed BTU tax was to be phased in over a three-year period.[15] The tax was not to apply to renewable forms of energy, but instead to all other forms of energy production, including hydroelectricity.[16] While the tax was to be imposed on "producers, refiners, and transporters," it was anticipated that these entities would pass on the tax to consumers in the form of higher prices.[17] The Treasury originally estimated that the tax would cause a $105 annual increase in energy bills for a family of four with an income of $25,000 and having an original energy bill of $2,242.[18] The Treasury estimated that an average household using "1,000 gallons of gasoline a year" would experience increased gasoline costs of about "$25 the first year and $75 the third year."[19]

The proposed tax generated stiff opposition from affected industries who questioned its complexity, effectiveness, and economic impact.[20] On 25 May 1993, several industry leaders met together for a "joint business press conference" where they argued that the BTU tax would hurt investment, reduce jobs, diminish exports, undermine consumer purchasing power, and increase inflation.[21] Despite numerous concessions, tax breaks, and exemptions added to the plan in response to industry pressure, it ultimately failed to win enactment.

On 27 May 1993, the bill was able to squeak through the House of Representatives after heavy lobbying by President Clinton, passing by a vote of 219-213.[22] However, shortly thereafter, the bill ran into trouble in the Senate Finance Committee. Two key Democratic members of the Committee from energy-producing states, Senators David L. Boren (D-Ok.) and John B. Breaux (D-La.) opposed the BTU tax, threatening to take down the whole budget proposal unless the tax was scaled back.[23] Out of fear of losing the budget, President Clinton agreed to massively scale back the BTU tax following a private meeting with Senator Boren.[24] The official announcement was made a week later, as the President announced plans to scale back the tax to less than a third of it previous level.[25] Instead it was replaced by a small increase in the federal gasoline tax that was approved by both houses of Congress and eventually signed into law by President Clinton on 10 August 1993.[26]

Significant energy legislation was adopted during the second term of President George W. Bush. The Energy Policy Act of 2005 was passed by Congress on 29 July 2005. It was a large bill, taking up more than 600 pages, and it is widely regarded as the most important U.S. energy law in over sixty-five years.[27] The legislation is wide-reaching in scope. It requires energy conservation and management plans for federal buildings and provides incentives for the development of domestic sources of energy including renewables.[28] Many environmentalists protested the law's substantial subsidies for the oil, coal, natural gas, and nuclear power industries.[29]

A main goal of the Act was to decrease America's dependence on foreign oil by encouraging greater domestic production of conventional and alternative sources of energy.[30] Thus it provided greater incentives for the development of difficult to access oil and gas reserves. The legislation gave the Federal Energy Regulatory Commission (FERC) jurisdiction over the permitting of liquefied natural gas facilities.[31] It also encouraged domestic use of coal and research and development on new "clean coal" technology.[32] Congress also provided incentives for the construction of new nuclear power plants while taking steps to improve security of the country's existing nuclear facilities. The Act includes new security review procedures and new authority for the Nuclear Regulatory Commission (NRC).[33]

The legislation repealed the Public Utility Holding Company Act of 1935 and replaced it with similar regulations that are designed to encourage investment in the power grid.[34] This also was intended to increase competition. To ensure that the power grid

remains reliable FERC was required to establish an Electric Reliability Organization to establish and implement reliability standards.[35]

The EPAct also includes provisions to encourage the development of alternative and renewable fuel sources and to promote research on energy efficiency. The Act provides incentives for developing alternative energy sources including geothermal, hydroelectric, and biomass resources.[36] It also provides incentives for production of alternative fuels and the use of hybrid vehicles and for improving automobile fuel efficiency. The Act provides funding for research and development on the use of hydrogen as an alternative fuel source.[37] It also creates new federal programs to promote energy efficiency and the production of more energy efficient products, and the use of alternative energy sources.[38]

Two years later Congress again enacted comprehensive energy legislation when it passed the Energy Independence and Security Act of 2007 (EISA).[39] This legislation was intended to increase energy security by raising fuel economy standards[40] and mandating increased biofuel production,[41] improved standards for appliances and lighting,[42] and energy conservation in industry[43] and in government and public institutions.[44] Additionally, EISA funded accelerated research and development for solar energy, geothermal energy, marine and hydrokinetic renewable energy technologies, and energy storage,[45] as well as support for carbon capture and sequestration.[46] EISA also amended portions of the National Conservation Policy Act.

EISA's key provisions include:

■ Corporate Average Fuel Economy (CAFE). The law sets a target of 35 miles per gallon for the combined fleet of cars and light trucks by model year 2020.

■ Renewable Fuels Standard (RFS). The law sets a modified standard that starts at 9.0 billion gallons in 2008 and rises to 36 billion gallons by 2022.

■ Energy Efficiency Equipment Standards. The law includes a variety of new standards for lighting and for residential and commercial appliance equipment. The equipment includes residential refrigerators, freezers, refrigerator-freezers, metal halide lamps, and commercial walk-in coolers and freezers.

■ Repeal of Oil and Gas Tax Incentives. The law repeals two tax subsidies to offset the estimated cost to implement the CAFE provision."[47]

The new Obama administration has promoted important energy infrastructure improvements as part of the economic stimulus legislation signed into law by President Obama on 17 February 2009. The American Recovery and Reinvestment Act of 2009 (ARRA) has important provisions to promote renewable energy, energy efficiency, and electricity transmission and reliability. Federal support for renewable energy is provided through investment tax credits and production tax credits.[48] Before ARRA, solar and geothermal were the only types of renewable energy projects eligible for either an investment tax credit or a production tax credit. Now, facilities built after 31 December 2008 and before 31 December 2013 that produce energy from wind, closed- and open-loop biomass, landfill gas, municipal solid waste, incremental hydropower, and wave energy also are eligible for similar investment tax credits.[49] ARRA extended the wind production tax credit until the end of 2012. In addition, geothermal, solar, landfill gas, municipal solid waste, closed and open-loop biomass, qualified hydropower, and wave power now have placed-in-service deadlines at the end of 2013. ARRA also provides federal grants in the amount of 30 percent of the tax basis of the property to developers of projects involving wind, closed and open-loop biomass, geothermal, solar, landfill gas, municipal waste, incremental hydropower, wave energy, and fuel cells. In addition, ARRA expanded a program under the EPAct that provides $6 billion in federal guarantees for a variety of projects including renewable energy systems, electric power transmission systems, and biofuel projects.[50]

ARRA also addresses energy efficiency by pledging $16.8 billion to the Department of Energy for energy efficiency and renewable energy programs.[51] Of this amount, $5.5 billion was deposited into the Federal Buildings Fund (FBF), which is in place to ensure proper upkeep of federal buildings. A total of $4.5 billion of this $5.5 billion is available to be used for

converting General Services Administration facilities into High Performance Green buildings. The government hopes to use these buildings to cut energy consumption and cost, as well as to provide a model for the private sector. The legislation also provides another $3.2 billion for the Energy Efficiency and Conservation Block Grant (EECBG) program, which was created under the Energy Independent and Security Act (EISA), to provide federal grants to local and state governments to reduce energy use. Another $3.1 billion was given to the State Energy Program, which provides states with funding for energy efficiency and renewable energy projects. Finally, ARRA provides $5 billion to the Weatherization Assistance Program that was created by the Energy Conservation and Production Act to enable low-income families to weatherize their homes, making them more energy efficient.[52]

ARRA provides $4.5 billion to programs that aim to modernize the country's electricity grid.[53] ARRA increases the amount of matching grants under the Smart Grid Investment Program from 20 percent to 50 percent.[54] A total of $80 million of the $4.5 billion is dedicated to facilitating development of regional transmission plans.[55] ARRA dedicated $2 billion to manufacturing grants for advanced batteries to support the manufacture of advanced vehicle batteries and other technology necessary for electric vehicles.[56] Funding in the amount of $10 million also was dedicated to making local distribution systems "smarter."[57]

EFFORTS TO ENACT COMPREHENSIVE U.S. CLIMATE CHANGE LEGISLATION

The Obama administration's efforts to enact comprehensive cap-and-trade legislation to control emissions of greenhouse gases have stalled in Congress, despite the House of Representatives narrowly approving the American Clean Energy and Security Act in June 2009. Also known as the Waxman-Markey bill, this massive piece of legislation seeks to "create clean energy jobs, achieve energy independence, reduce global warming pollution and transition to a clean energy economy."[58] It includes provisions to promote the development of carbon capture and sequestration technology, improvement in technology for clean transportation, smart grid advancement, energy efficiency, and nuclear power.[59] The bill's energy efficiency provisions cover building energy efficiency, lighting and appliance energy efficiency, transportation efficiency, industrial energy efficiency, and public institutes.[60]

To combat global warming and climate change the bill requires that greenhouse gas emissions be reduced 20 percent from 2005 levels by 2020.[61] By 2050, greenhouse gas emissions are to be reduced by approximately 80 percent from 2005 levels.[62] In order to reach these goals the bill creates a cap-and-trade system, the markets of which would be regulated by the Environmental Protection Agency, the Commodity Futures Trading Commission, and the Federal Energy Regulatory Commission.[63] The bill also includes an ambitious renewable portfolio standard (RPS) that would require every region in the country to obtain a quarter of its energy from renewable sources by 2025.[64]

Representative Henry Waxman said of the bill that the "goal is to strengthen our economy by making America the world leader in new clean-energy and energy-efficiency technologies."[65] In an effort to appeal to legislators from coal-producing states, the bill provides $10 billion in financing for the development of carbon capture and sequestration technology.[66]

The House passed the bill on 26 June 2009, marking the first time either house of Congress had approved a bill that was designed to curb climate change.[67] The bill passed by 219-212, with 44 Democrats voting against it.[68] While most environmental groups supported the legislation, some, including Greenpeace and Friends of the Earth, opposed it as too weak.[69] Business leaders also were split with the National Association of Manufacturers opposing the bill, but some large corporations, including Ford Motor and Dow Chemical, supporting it.[70]

While many believed that the U.S. Senate also would approve cap-and-trade legislation, it now appears unlikely that this will happen during the current session of Congress. Senators Barbara Boxer of California and John Kerry of Massachusetts released their climate bill, the Clean Energy Jobs and American Power Act (Kerry-Boxer bill), in September of

2009.[71] It mandates that by 2020 greenhouse gas emissions will be reduced by 20 percent from 2005 levels.[72] Many details were purposely left blank, to be filled in after negotiations between Democrats and Republican moderates, including Senators Lindsay Graham (R-S.C.) and John McCain (R-Ariz.).[73] In an effort to generate bipartisan appeal, the bill purposely drops references to cap-and-trade and instead labels the greenhouse gas provisions as a "Pollution Reduction and Investment" program.[74] It was hoped that by including provisions to expand subsidies for nuclear power the bill would be able to attract sufficient support from Republicans in order narrowly to win enactment in the Senate. However, this has not happened and because there are insufficient votes to approve such legislation it is unlikely to be brought up for a vote.[75]

Assessing Policies to Promote Renewable Energy

How one assesses the cost-effectiveness of individual strategies for promoting renewable energy depends on one's goals. If "the primary goal is reducing emissions, single RES-E [electricity from renewable energy sources] policies (whether price- or quantity-based) are always less cost-effective than cap-and trade or carbon pricing policy."[76] Studies indicate, however, that if the primary goal is a general expansion of renewable energy, then renewable quotas, such as renewable portfolio standards (RPS) and tradable green certificates (TGCs), prove less expensive than price-based policies, such as feed-in tariffs (FIT).[77] Yet while TGCs may appear to be a lower-cost option, other considerations such as fostering innovation and technological development also should be considered.[78]

Effectiveness of policies promoting renewable sources of energy is most often assessed by the following criteria: effectiveness; efficiency, cost-effectiveness, and transaction costs; dynamic efficiency; and technological diversity.[79] Instrument effectiveness can involve "the extent to which [the instrument] encourage[s] deployment of renewable energy technologies," and depends on factors like the level of support, design features, grid connections, and administrative procedures.[80] Dynamic efficiency addresses "the incentive for continuous technological improvements in renewable energy technologies."[81]

Various scholars have assessed and modeled those factors that should result in effective policies and efficient incentives to encourage development of green energy sources.[82] Most seem to agree that a diverse range of factors can impact policy decisions and effectiveness; for example, Fischer and Newell note that:

"Although economists typically argue that a direct price for CO_2 (via a tax or tradable permit system) would provide the most efficient incentives for development and use of less emitting technologies, the diversity of the present policies suggests that other forces are at play. First of all, emissions pricing policies that risk significantly reducing economic activity among energy-intensive sectors have little political appeal. Second, raising the price of CO_2 can have important distributional consequences, both for owners of fossil-fueled generation sources and for consumers. Third, innovation market failures, such as spillover effects, imply that emissions pricing alone will not provide sufficient incentive to improve technologies. Credibility problems may also arise in using a promise of high future emissions prices to boost current innovation, since such high prices may no longer be desired if and when the resulting cost reductions arrive. Finally, the innovation process may occur not only through R&D investments, but also via learning through the production and use of new technologies; thus, encouraging output may spur innovation. Consequently, output support and other subsidies are often attractive to decision makers alongside emissions regulations and R&D policies."[83]

As discussed in Part I, countries apply various policies to promote the transition to a renewable energy infrastructure. Policies used by several countries are shown in Table I below and discussed in more detail in Appendix I.

CAP-AND-TRADE V. CARBON TAX

Cap-and-trade programs are considered a significant and growing category of policies.[85] These systems "set a ceiling on the emissions of covered entities, issue allowances, and allow trading to

Table 1[84]

Country	Emissions cap-and-trade system	Carbon tax	Non-renewable generation tax	Emissions performance standard	RPS/TGCs	Feed-in Tariffs	RES production subsidies	Investment /R&D incentives
Canada		x (in BC)	x		x	x	x	x
Denmark	x	x	x			x		x
Germany	x					x		x
Japan	x				x			x
Netherlands	x	x	x		x	x (considered modified FITs by IEA)		x
New Zealand	x							x
Norway	x	x	x			x		x
Spain	x					x		x
UK	x	x	x		x	x (plans to implement May 2010, but some utilities voluntarily doing)		x
U.S. Federal	Proposed				Proposed		x	x
U.S. States	x			x	x	x	x	x

generate a market price for emissions."[86] The European Union Emissions Trading System (EU ETS) constitutes the "largest existing GHG trading program, governing emissions across 30 European nations, and covering large emitters, of which 72 percent are combustion installations."[87] The EU ETS was proposed in October 2001, and a three-year trial period occurred in 2005-2007.[88] Perspectives vary on whether the EU ETS is an effective approach; for example, the environmental group Friends of the Earth termed EU ETS a "complete failure" in a 2009 report,[89] while a Pew Center on Global Climate Change report offered a cautious assessment of the system's success.[90]

The Pew report emphasizes that the initial 2005-2007 period of the EU ETS was a trial period that was not intended to significantly reduce CO_2 emissions in three years.[91] The Pew report points to the establishment of both a transparent price in tradable CO_2 emissions allowance and a functioning market as indicators of success.[92] The Pew report also lists the following as key lessons learned from the EU ETS:

- "Suppliers quickly factor the price of emissions allowances into their pricing and output behavior.

- "Liquid bilateral markets and public allowance exchanges emerge rapidly and the 'law of one price' for allowances with the same attributes prevails.

- "The development of efficient allowance markets is facilitated by the frequent dissemination of information about emissions and allowance utilization.

- "Allowance price volatility can be dampened by including allowance banking and borrowing and by allocating allowances for longer trading periods.

- "The redistributive aspects of the allocation process can be handled without distorting abatement efficiency or competition despite the significant political maneuvering over allowance allocations. However, allocations that are tied to future emissions through investment and closure decisions can distort behavior.

- "The interaction between allowance allocation, allowance markets, and the unsettled state of electricity sector liberalization and regulation must be confronted as part of program design to avoid mistakes and unintended consequences. This will be especially important in the U.S. where 50 percent of the electricity is generated with coal."[93]

The concept of cap-and-trade as a means for reducing the cost of complying with controls on greenhouse gas emissions has substantial support in the United States.[94] In the 2008 election it was embraced by both presidential candidates. State initiatives to control greenhouse gas emissions also have endorsed the concept. The Regional Greenhouse Gas Initiative (RGGI) is composed of ten Northeast states which agreed to halt and reduce growth of CO_2 emissions. The program "includes all electricity generating units with a capacity of at least 25 mega-watts and requires an allowance for each ton of CO_2 emitted."[95] The first year of mandatory compliance was 2009. Program requirements are expected to apply to 95 percent of CO_2 emissions from the region's electric power sector, and states as a group "must maintain covered emissions at a level of 188 million tons of CO_2 for the next 4 years, after which a mandatory 2.5% annual decrease in CO_2 emissions through 2018 is expected to reduce the total for covered CO_2 emissions in the RGGI states to 10 below the initial calculated budget."[96]

Many economists maintain that a carbon tax is more effective in creating incentives to reduce emissions than a cap-and-trade program. For example, Avi-Yonah and Uhlman argue that a carbon tax is a "more efficient and effective market-based approach to reduce carbon dioxide emissions" than cap-and-trade.[97] Among the advantages of a carbon tax are the inherent simplicity of a tax as opposed to the complexity of cap-and-trade, the generation of revenue, and cost certainty.[98] Disadvantages include political resistance, benefit uncertainty, tax exemptions, and coordination difficulties.[99]

TRADABLE GREEN CERTIFICATES AND FEED-IN TARIFFS

Tradable Green Certificates (TGCs) are certificates that are sold on the market and which allow producers of electricity from renewable sources to gain revenue from both the market price of electricity and the market price of TGCs.[100] Feed-In Tariffs (FITs) are "a price-based policy which set the price to be paid for renewable energy per kWh generated (in the form of guaranteed premium prices), combined with a purchase obligation on utilities (supply companies or grid systems)."[101]

FITS take two forms: "[e]ither a total payment per kWh of electricity of renewable origin is given or a payment per kWh on top of the electricity wholesale-market price is granted, which results in producers selling the power themselves."[102] Either the public budget or consumers bear the costs of FITs.[103] A

variety of forms exist for FITs, and the form chosen "reflects both national priorities and the interaction between actors with different interests and negotiating power.[104]

Feed-in Tariffs currently are "the most widespread support scheme" in Europe.[105] FITs provide different support levels depending on the technology and are, therefore, able to promote different types of technologies.[106] In contrast, other policies are more likely to prioritize the cheapest technologies.[107] Setting the level of support for FITs, though, can be problematic.[108] FITs are generally considered to be effective, particularly in the case of wind energy in Germany, Spain, and Denmark.[109]

Del Rio and Gual note that claims are often made that "quantity-based instruments (i.e., quota with TGC schemes) are superior to price-based mechanisms (FITs), because the former follow the equimarginality rule, ensuring that a specific amount of [electricity from renewable sources] is deployed at lowest costs, while there is an incentive for FITs to be set at a high level . . . and, thus, a higher cost for society than is strictly necessary. . ."[110] However, del Rio and Gual cite several studies contesting this alleged inefficiency, while also noting that different designs have different social cost implications and that perfectly competitive TGC markets with frequent transactions are often erroneously assumed.[111]

The Spanish FIT system is considered to be one of the most successful policy schemes in Europe.[112] Del Rio and Gual attempted to assess the system to identify specific criteria of success.[113] This did not prove possible, but del Rio and Gual did determine that:

"Despite the existence of several barriers, the FIT has been highly successful in encouraging the promotion of wind but not so much concerning the other technologies. But the environmental benefits from the system seem to outweigh its costs only in the case of two technologies (wind and small hydro). In turn, the costs for the consumer have not been exorbitant, although their fast increase and unequal distribution between different actors are major sources of concern. Nevertheless, caution is advisable when interpreting the results, given the uncertainty involved in some of the data used and the calculations made and, particularly, concerning the measurement of avoided externalities. Probably the two greatest challenges of RES-E support schemes in general and FIT in particular are how to achieve significant [electricity from renewable sources] deployment and encourage long-term technological changes and cost reductions, while at the same time keeping the short-term costs of the system low and allow a fair distribution of these costs across different actors. There is no magic wand to achieve this and there always be [sic] unavoidable trade-offs between assessment criteria in all promotion schemes. The assessment of support instruments should take into account these factors in specific territorial settings, and not only in abstract terms, and their design should strike a reasonable balance between the aforementioned criteria. This is especially relevant when the European Commission is considering whether or not to implement an EU-wide support scheme."[114]

ONSHORE WIND ENERGY

Non-economic barriers have "a significant negative impact on the effectiveness of policies to develop wind power, irrespective of the type of incentive scheme."[115] Examples of these barriers include "administrative hurdles (e.g. planning delays and restrictions, lack of coordination between different authorities, long lead times in obtaining authorizations), grid access, electricity market design, lack of information and training, and social acceptance."[116] The International Energy Agency (IEA) indicates that, to encourage wind power deployment, remuneration levels must encompass at least "the sum of electricity price plus any premiums and/or incentives received for every unit of renewable electricity."[117] However, "higher remuneration levels do not necessarily lead to greater levels of policy effectiveness" once some minimum threshold level is established.[118]

Germany, Spain, Denmark, and Portugal are cited as countries with a high effectiveness of wind power deployment. These countries use FITs, and "[t]heir success in deploying onshore wind stems from high investment stability guaranteed by the long term FITs, an appropriate framework with low administrative and regulatory barriers, and relatively favorable grid access conditions."[119] Remuneration levels in these

countries were an average of USD 0.09-0.11/kWh.[120] Italy, Belgium, and the United Kingdom, however, have the highest remuneration per unit generated of wind, about USD 0.13-0.17/kWh, and use quota obligation systems with TGCs.[121] However, a recent IEA study determined that none of these three countries had high effectiveness of wind power deployment in the 2000-2005 study period.[122] FITs also are used in Korea, India, Brazil, the Slovak Republic, and Switzerland.[123] While the first three appear to be demonstrating some early success, the latter two countries have seen only limited wind power deployment. The IEA suggests this might be because the level of remuneration is less attractive.[124]

The low effectiveness of the quota obligation systems with TGCs seen in Italy, Belgium, and the UK appear to be related to the short-term investment horizon of their systems.[125] The IEA suggest this investment horizon is either "insufficient to stimulate sufficient investor interest or lead to investors requiring high risk premiums."[126] The IEA also notes that policy effectiveness of these countries is impacted by "significant non-economic barriers, leading to large authorization and project development times and higher total costs."[127] However, countries like Australia and the United States also have quota obligation systems with TGCs, but with lower overall average remuneration levels and increasing effectiveness.[128]

The U.S. has both federal and state policies addressing wind power development. While the combination of federal and state policies likely contributed to the increases in wind capacity, the individual policies are unlikely to support growth in wind power.[129] Policies like tax incentives and accelerated depreciation led to initial benefits.[130]

SOLID BIOMASS ELECTRICITY

The IEA found that EU-OECD countries had the most success deploying biomass during a 2000-2005 study period.[131] The Netherlands, Sweden, Belgium, and Denmark had the "highest levels of effectiveness."[132] A minimum level of remuneration of USD 0.08/kWh was found to be necessary to start deployment.[133] Similar to other technologies, non-economic barriers can negatively impact policy effectiveness.[134] However, different types of incentives can be effective.

The Netherlands, Sweden, Belgium, and Denmark had the highest growth of deployment during a 2000-2005 study period though different systems were used by each country.[135] The Netherlands and Denmark used FITs and premium systems. Quota obligation systems for a moderate cost proved effective in Sweden, while quota obligation systems at high costs proved effective in Belgium.[136] According to the IEA, these countries succeeded "due to the availability of abundant biomass combined with the opportunity for co-firing in coal-fired boilers."[137] Other countries with "good deployment effectiveness" include Belgium, UK, Japan, Germany, Italy, New Zealand, Portugal, Poland, Brazil, Austria, and Russia.[138] Non-EU OECD countries demonstrated the largest contribution total global biomass generation. The U.S., Japan, China, and Finland contributed about 55 percent of total biomass in the IEA study. However, each of these countries except Japan had low levels of deployment effectiveness in the IEA study period.

Similar to other technologies, a minimum level of remuneration, about USD 0.08/kWh, is integral for deployment.[139] Only a few countries have successfully combined "reasonable growth of solid biomass electricity generation with moderate levels of remuneration; these countries are Sweden, the Netherlands, and Denmark. The most successful countries are those where cheap and abundant biomass, like wood residues and industrial wood wastes in Sweden.[140] IEA observes that quota obligation systems like the system in Sweden "can be much more effective than in the case of wind energy, which can be attributed to the fact that biomass deployment is typically less investment intensive and therefore less affected by high risk perception."[141] The IEA also notes that life-cycle assessment is necessary.[142]

BIOGAS ELECTRICITY

Biogas electricity is generated from different sources including agricultural, landfill, and sewage gas. Remuneration level for "financially viable projects depends on the specific fuel used as well as the size

of the project."[143] Remuneration levels[144] and installation size used in FIT systems varies depending on the biogas technology used. In IEA's 2000-2005 study period, Germany, the UK, and Luxembourg saw the greatest growth of biogas generation.[145] Germany[146] and Luxembourg use FITs and the UK uses a quota obligation system with TGCs.[147] Italy also uses a quota obligation system with TGCs; this system has demonstrated high effectiveness and growth due to the "expansion of landfill gas capacity producing methane that is cheap relative to other biogas feedstocks."[148]

According to the IEA, improved policy effectiveness in several countries was due to use or introduction of a FIT system.[149] The Czech Republic introduced a new FIT system during IEA's 2000-2005 study period, and the result was increased policy effectiveness. Similarly, Portugal changed its FIT system during this period and also saw accelerated deployment. In contrast, Denmark lowered its feed-in premium remuneration and growth in electricity from biogas stagnated.[150] Australia, which used a quota obligation system, saw some moderate growth in electricity from biogas during the same period.[151] The United States, although the "world's largest supplier of biogas," saw slow growth in the electricity from biogas market during the early 2000s.[152] The IEA bases the slow growth on two factors: (1) U.S. biogas development preceded the IEA study period, and (2) increased exploitation of landfill and sewage gas.[153] The IEA indicates that quota obligations and state grant programs instigated additional, though slow to moderate, growth in the middle of the decade.[154]

SOLAR PHOTOVOLTAICS

One barrier to photovoltaic (PV) deployment is the high investment costs of PV systems. In a study, the IEA found that during the 2000-2005 study period, "only 1% of the realizable potential had been exploited by 2005," which indicates a policy effectiveness much lower than mature technologies like wind.[155] Germany and Japan[156] have the highest absolute installed capacity in PV development, while the U.S. is a distant third.[157] These three countries accounted for about 88 percent of globally installed capacity by the end of 2005.[158] Germany used FITs supported by "easy availability of soft loans and fair grid access," which proved effective into the mid-2000s despite a high cost (USD 0.65/kWh). Germany began decreasing the FIT for solar PV in the mid-2000s, and the German parliament approved proposals to "accelerate degression rates[159] for stand-alone installations from 5% per year in 2008 to 10% in 2010 per year in 2010 and 9% from 2011 onwards" to create incentives to reduce costs.[160]

The U.S. has provided federal tax incentives for PV installations; however these incentives "have been insufficient to motivate PC installations."[161] The IEA found that the U.S. scored "poorly in terms of policy effectiveness."[162] States have attempted to be more aggressive in their policies; California, Arizona, and New Jersey "established aggressive incentive policies for PV, including tax rebates for residential and commercial installations and quota obligation systems with a solar-specific set-aside."[163] Additional policies which have stimulated PV markets include net metering, favorable retail rate structures, and streamlined interconnection rules.[164]

Other countries have varying success with implementing PV policies. India, China, and Australia are second tier PV market leaders.[165] Luxembourg, Switzerland, the Netherlands, Austria, and Spain are gaining momentum in developing solar PV.[166] IEA's study of renewable energy growth during 2000-2005 identified Luxembourg and Germany, then Japan, Switzerland,[167] the Netherlands, Australia, Austria, and the United States as demonstrating the strongest growth of PV generation.[168] Japan,[169] Australia, and the United States achieved growth through fixed FITs and investment incentives.[170] Luxembourg had "an exceptionally high feed-in tariff level," which led to "a very high market growth during 2004-2005."[171] Austria achieved its policy effectiveness through "a cap applied to the total installed capacity."[172]

HYDROPOWER

Deployment of hydropower varies worldwide. The potential for further hydropower deployment is small in most OECD countries because this power source already has been exploited or legal instruments for integrated water[173] preclude further development.[174] Public resistance to hydropower also is a

factor. The majority of growth for hydropower in EU-OECD countries occurs through repowering or upgrading existing facilities or constructing on a smaller scale. By contrast BRIC countries, such as China, India, and Brazil, have seen growth in hydropower driven by increasing electricity demands, as well as water storage and management needs.[175] For these countries hydropower deployment has not required policies to provide new development incentives.[176] Environmental impacts of large-scale development, however, can be a barrier to this type of power.

GEOTHERMAL ELECTRICITY

Geothermal power is usually exploited with conventional hydrothermal technology as opposed to enhanced geothermal electrical technology.[177] Geothermal electrical technology is "used most efficiently in co-generation, but potential is often located in regions with low population density and low heat demand."[178] Plants are built over the course of three to five years which can delay implementation of policy promoting this type of technology.[179] Iceland is the most intensive user of this type of technology and meets about one-fifth of its electricity demand through geothermal electrical technology.[180] Mexico has the second largest market for this power source.[181] However, the U.S. is the largest producer of geothermal energy.[182]

GEOTHERMAL HEAT

Deep geothermal heat, which can be competitive with conventional heating, is distinct from heat from shallow ground source heat pumps. Deep geothermal heat faces deployment barriers of "cost, complex planning and permission procedures, and distance between deep geothermal resources and centres of heat demand."[183] In contrast, ground source heat pumps can be used almost anywhere for heating and cooling but have high investment costs. "Enhanced geothermal systems from deep drilling are at an early stage of maturity and costly but widespread potential, if current cost barriers can be overcome."[184] The IEA found that, during the period from 2000-2005, Spain, Switzerland, Austria, and Turkey each increased output by 50-60 percent; the U.S. increased output by 75 percent.[185] In Iceland, geothermal heat covers about 90 percent of the heating demand for residences.[186] Sizeable geothermal heat production has also occurred at various periods in Germany, France, Italy, Hungary, Japan, and New Zealand. Between 2000 and 2005, Korea implemented a policy supporting geothermal heating and focused on energy used for baths and geothermal heat pumps for public and industrial buildings.[187]

SOLAR HOT WATER

Solar technology for heating is a relatively untapped technology.[188] China, Brazil, and Austria are progressing most quickly toward realizing their potential for solar heating. China is responsible for half of global solar thermal generation.[189] The U.S. contributes around 20 percent.[190] Solar thermal heating is cost competitive in many parts of China.[191] Consumer demand in China is driven by "poorly developed conventional heating infrastructure, a well-developed domestic manufacturing industry and changes in population demographics."[192] Brazil lacks policy support "but has high solar radiation levels."[193] Austria implemented "rather modest investments in grants, information dissemination and training programmes" which have achieved relatively high effectiveness.[194] Barriers to solar thermal heating deployment primarily include "inadequate planning guidelines, and lack of consistent economic incentives, awareness programmes and training opportunities."[195] Spain has introduced regulatory innovations to address these barriers, such as by introducing a solar heating obligation in Barcelona and other Spanish municipalities. Germany and Austria, during the 2000-2005 IEA study period, achieved "market leadership in Europe . . . with modest investment incentives, showing that major drivers for solar thermal heating development are investment incentives such as grants, coupled with targeted awareness-raising and training initiatives."[196]

BIOMASS AND COMBINED HEAT AND POWER

Worldwide deployment of combined heat and power (CHP) has been moderate despite the efficiency[197] of this technology. Most implementation of this technology has occurred in Europe. High coal prices combined with greenhouse emissions caps under the

EU Emissions Trading Scheme (ETS) resulted in increased biomass use by European industries.[198] Specific policies have promoted increased use of this energy source. As part of its renewable energy law, Germany introduced in 2005 a CHP bonus for heat generated from biomass CHP plants.[199] The IEA found policy effectiveness to be higher for this form of heating from a renewable energy source than for other forms such as solar hot water and geothermal heat. However, policies to promote its use were significantly less effective than those promoting the generation of electricity from renewable sources.[200] Scandinavian countries, particularly Denmark and Sweden, experienced the greatest growth in the use of biomass and combined heat and power technologies during the 2000-2005 period.[201] Their success was attributed in part to their "cheap and abundant biomass potentials, which may be derived from a strong forest industry combined with effective incentives for promotion of biomass electricity and biofuels for transport."[202] The density of heat demand and the feasibility of constructing new heating grids is an important factor in the success of this technology.[203]

BIOFUELS

The U.S. has extensive policies to encourage more efficient energy use in the transportation sector. These policies include tax credits for plug-in hybrid electric vehicles, electric cars, and biodiesel; low carbon fuel standards; and increased vehicle fuel efficiency standards. The Energy Independence and Security Act of 2007 (EISA 2007) required major automakers to meet an increased fuel efficiency standard of 35 miles per gallon on average by 2020 and it mandated a massive increase in biofuels use.[204] Traditionally, biofuel policy efforts have focused on tax measures such as excise taxes, eco-tax, or value added taxes (VAT).[205] Mandatory blending quotas are a more recent policy approach.[206]

Brazil and the U.S. dominate ethanol production.[207] In 2005, Brazil constituted 41 percent of total ethanol production in OECD countries, while the U.S. contributed 44 percent.[208] The U.S. focused on corn-based ethanol, and supported this approach with tax credits and agricultural subsidies.[209] These subsidies have been crucial to the increase in U.S. ethanol production.[210] The growth of biodiesel production and consumption in the EU also has benefited from high subsidies implemented through tax exemptions.[211] Germany found success focusing its policy on promoting biodiesel rather than ethanol.[212] However, as the IEA notes, this success "came at a relatively high cost, mainly through a tax exemption which made biodiesel significantly cheaper than regular fossil-based diesel."[213] China found success in increasing biofuel production by introducing a blending quota.[214] India's success is largely driven by a "tax exemption and guaranteed price for ethanol producers."[215]

In 2003, the EU passed Directive 2003/30/EC to promote the use of biofuels and other renewable fuels for transport.[216] This directive set a minimum percentage of biofuels that would replace use of diesel or gas in each member state in order to reduce greenhouse gas and other harmful emissions.[217] Each state was required to introduce appropriate legislation by 2005.[218] By 2005, seventeen of the twenty-one member states used biofuels, with an average market share of 1 percent.[219] However, Germany and Sweden were the only states to reach the stated reference values, 3.8 percent and 2.2 percent respectively.[220] A 2007 EU report[221] found that biodiesel deployment proved relatively more successful reaching 1.6 percent of the diesel market, while ethanol production achieved only 0.4 percent of the gas market.[222] This rate indicates that states are unlikely to reach the Biofuels Directive target of 5.75 percent by 2010.[223]

The Impact of Oil Price Fluctuations on Investments in Green Energy Technologies

The last forty years have been marked by large fluctuations in the global price of oil.[224] The first big oil shock took place in the 1970s, with sharp increases occurring in 1973 and 1979.[225] As noted above, following two spikes that each doubled the price of oil, energy independence became a large focus of U.S. policy.[226] The surges in oil price were widely viewed as part of a long-term trend of ever-increasing oil prices, and many investment decisions were based on this assumption.[227] Numerous policy initiatives were launched to decrease U.S. reliance on imported oil, including the CAFE standards in 1975 and public investments in alternative energy sources.[228]

However, following its peak in 1979, oil prices gradually decreased over the next seven years, a decrease that culminated with the 1986 collapse in the price of oil.[229] This drop in the price of oil rendered many private investments in alternative energy projects unprofitable, undermining government policies aimed at promoting renewable energy.[230] Oil prices, while fluctuating, remained relatively low throughout the 1990s, with a small spike in prices occurring in 1990 in response to Iraq's invasion of Kuwait.[231] The price of oil again began to climb following the turn of the century, culminating with another price spike in 2008.[232] Like the previous price spikes in the 1970s, this surge generated policy proposals to promote greater energy independence and investments in alternative energy sources. However, as occurred during the 1980s, when the price of oil sharply declined after July 2008, many of the plans for new investments in alternative energy sources no longer were economically viable.[233] If an energy alternative cannot be produced at a level that is competitive with the prices of existing sources of energy, it does not make economic sense to invest in that alternative.

Oil price fluctuations also have affected investments in energy research and development over the past forty years. Public investment in energy research and development rose during the 1970s, peaked in 1979, and decreased in the 1980s.[234] The peak is particularly sharp with respect to research and development funding for wind and photovoltaic energy;[235] it also is visible with respect to the funding of nuclear energy.[236] Lower levels of public funding for energy research and investment continued throughout the 1980s and 1990s.[237] The only interruption to this trend occurred in 1990-1991, with a small increase in investment occurring in response to the small oil price spike in 1990.[238] Even when oil prices started to increase again after the turn of the century, energy R&D investment in both the public and private realms stayed relatively low.[239]

Following the recent spike in oil prices during the summer of 2008 there has been a small increase in energy R&D funding[240] and public investment in renewable energy has increased markedly over the last five years.[241] In 2009, the U.S. government increased its investment in energy research and development by 21.4 percent.[242] Research programs involving energy efficiency, renewable energy, nuclear energy, and fossil fuels all received increases of at least 15 percent.[243] Appropriations within the fiscal stimulus further boosted investment in energy R&D, with $400 million going to the Advanced Research Projects Agency-Energy (ARPA-E).[244] The fiscal stimulus also increased funding toward individual energy areas, including renewable fuels and fossil energy.[245]

The lack of predictability in oil prices makes the markets for alternatives to oil use inherently risky for consumers and investors.[246] Without subsidies, many forms of alternative energy are not economically competitive with oil unless oil is at a higher price.[247] Ethanol does not become cost effective and a commercially viable competitor with oil until the price of oil is greater than $60 per barrel.[248] Even when oil prices are high, investors are wary to commit long-term investments in energy alternatives because of the potential for future decreases in oil prices.[249] Energy investments typically are long term—consumers buy cars that last on the road on average sixteen years, while corporate energy projects assume paybacks of twenty to thirty years.[250] Investments in renewable forms of energy are particularly long-term, as many "require substantial up-front capital expenditures before any energy is generated."[251] Fluctuations in oil prices make it difficult to attract investments in projects involving the use of alternative forms of energy. This phenomenon is visible following the 2008 price spike, as utilities now are abandoning or scaling back alternative energy investments as oil prices drop.

While subsidies toward specific areas of energy research and development promote alternative energy forms, they also interfere with selection of the most economic and efficient alternative energy sources. Moreover, subsidies are often short-term creatures of politics, and different administrations subsidize different fields—an approach that leads to inconsistent funding for several types of renewable energy.[252] On-and-off funding jeopardizes the long-term prospects for investments in renewable energy by amplifying the uncertainty of energy markets.[253]

Using Tax Policy to Overcome Obstacles to Green Technology Innovation

Instead of increasing subsidies to government-selected forms of alternative energy, a more efficient approach to promote alternative energy would be to use tax policy to increase the price of using oil and other fossil fuels. An elevated price of oil and other fossil fuels would make alternative forms of energy more competitive while enabling market forces to select the most efficient forms of alternative energy. Moreover, an increased price of oil and other fossil fuels can be justified as an effort to externalize the large social and political externalities of oil use.[254] While any policy involving taxation is likely to be politically controversial, policies can be designed to overcome some of the initially fierce political opposition.

As the Clinton administration's disastrous experience with its proposed BTU tax demonstrates, any policies likely to increase the cost Americans pay to drive their cars face prohibitive political odds.[255] Yet there is broad agreement that revenue-neutral policies to shift the burden of taxation toward polluting activities and away from labor and capital would be highly desirable and a valuable tool for reducing U.S. dependence on fossil fuels. In its report Towards A Sustainable America, released in 1999, the President's Council on Sustainable Development recognized not only the value of such a policy, but also the political obstacles to winning its enactment.[256] The boldest recommendation that the Council could make was to suggest that a commission be created to explore ways of defusing political opposition to it.

Ironically, the failure of efforts to enact a comprehensive cap-and-trade program for greenhouse gas emissions may create opportunities to renew interest in a revenue-neutral carbon tax. Two conservative Republicans, Representative Jeff Flake (R-Ariz.) and Bob Inglis (R-S.C.) have introduced a bill to impose a revenue-neutral carbon tax the revenue from which would be used to cut payroll taxes.[257] This would immediately increase the take-home pay of all American workers to help jump-start the economy while creating powerful incentives for reducing emissions of greenhouse gases, stimulating investment in alternative energy sources.

Other proposals have been made for increasing the federal gasoline tax in a revenue-neutral fashion that takes the revenue derived from the increase and redistributes it to taxpayers.[258] For example, for each $1 of tax on a gallon of gasoline, taxpayers would receive a tax credit or decrease in income tax equivalent to $14 per week.[259] In this proposal, Americans could spend their $14 per week on anything; while no revenue is created for the government, no money is taken out of the economy either.[260] The tax simply serves as "a transfer agent moving money from one activity (gasoline purchasing) to another (employment) with zero net revenue for the government."[261]

The revenue-neutral gasoline tax would have many advantages. It would be relatively easy to implement and modify.[262] History has demonstrated that gasoline is not inelastic—people will alter their driving habits if driving becomes too expensive.[263] Additionally, a revenue-neutral gas tax promotes greater energy independence without using politically-motivated subsidies to particular interest groups and without creating any large, new regulatory programs.[264]

However, an additional potential effect of a gas tax would be a decrease in the price of oil.[265] The entire aim of a gas tax is to decrease the amount of gas consumed domestically.[266] A large, widespread decrease in the United States' demand for gasoline would translate (by way of simple economics) into a decreased demand for oil and subsequent decrease in the price of oil.[267] Downward pressure on the price of oil would make it difficult for forms of alternative energy to develop into cost effective competitors with fossil fuels.

A direct method to keep the price of oil from decreasing below a certain level would be to use an oil price stabilization tax to institute a price floor on the price of imported oil. Price floors operate by setting a lower limit to the price of oil, and taxing any difference between imported oil at a price lower than that set limit.[268] For example, if a price floor is set at $75 per barrel of oil, whenever the market price of oil dips below $75, the difference between the two prices is taken by the government.[269] Such a price floor would not take effect when the price of oil increases

above the target price.[270] To make the price floor more politically palatable, the tax would probably only apply to imported oil used for fuel, with manufacturers receiving a rebate for the non-fuel oil they use.[271]

Thomas Merrill and David Schizer make a compelling case for a "petroleum fuel price stabilization plan" in an article in the January 2010 issue of the Yale Journal of Regulation.[272] Merrill and Schizer caution that while such a plan should not be viewed as creating a reliable source of revenue given the volatility of oil prices,[273] it still will have immense benefits. Institution of a price floor would create price stability for improved investment decision-making in alternative energy projects.[274] Under this plan, consumers would be protected when oil prices rise because the level of the tax would fall, but when oil prices decline, investments in alternative energy no longer would be wiped out because the price decline would generate an increase in the level of the tax to maintain the price floor. Thus, the price floor operates differently from a gas tax, cushioning market volatility to provide a ripe climate for alternative energy investment instead of directing the market.[275] As previously discussed, it does not make economic sense to make long-term investment and consumption decisions toward alternative energy without expectation of a certain degree of price stability.[276] A price floor provides a lower, stable limit upon which consumers and investors can make those long-term energy decisions without the risk of a price collapse.[277] Additionally, with a high enough target price, alternative forms of energy become effective competitors to oil, at the very least meriting increased research and development.[278] Consumers also would retain an incentive to conserve even when the price of oil declines.[279] Moreover, the plan would be politically more palatable than conventional taxes because it need not raise the price of oil to consumers at the time it is adopted and the price floor could be ratcheted upward if oil prices rise above the specified price floor.

An alternative to a price floor is a "soft floor," in which a higher target price is set, but a percentage adjustment to the price is also added.[280] For example, if the target price is $95 and the actual price of oil is $65, a soft floor with a 50 percent adjustment would equate to a $5 tax and subsequent price of $80. Additionally, the higher target price of a soft floor allows revenue to be collected even when the price of oil increases beyond what the lower target price would have been with a price floor.[281]

Soft floors provide an intermediate level of stability, keeping the price of oil around a desired level while also decreasing volatility in the amount of revenue received from the tax.[282] Moreover, under a soft floor, sellers and exporters have incentive to sell at lower prices, because consumers have "incentive to bargain for the lowest possible price."[283] Consumers also retain some of the economic benefits associated with a lower price of oil under a soft floor.[284]

Green Technology Transfer and Intellectual Property Law

The need to shift away from fossil fuels toward a green energy infrastructure has raised concerns in developing countries because entities in the developed world own most of the patents and other intellectual property rights in renewable energy and pollution control technologies,[285] as illustrated in Figure 15 in Appendix II. Intellectual property (IP) is defined by the World Trade Organization as the rights granted to people for creations stemming from their ideas.[286] A creator is typically granted an exclusive right of use over the creation for a specific time period.[287] The intellectual property rights (IPRs) relevant to development of green energy technologies are patents, trade secrets, and industrial designs.[288] The World Trade Agreement on Trade-related Aspects of Intellectual Property Rights (TRIPS),[289] to which the United States and Germany are signatories, protects many IP categories, including patents, industrial designs, integrated circuit layout-designs, and protection of undisclosed information.[290]

During negotiations on a global regime for responding to climate change, developed countries have pledged to help with technology transfer to make it easier for developing countries to green their energy infrastructures. Technology transfer is the conveyance of the knowledge of how to make, use, and apply technology, which can range from processes to inventions to ideas.[291] Often private in nature, transfer of technology can occur by both market-based and informal channels: either by way of licensing or foreign direct investment or by imitation.[292] The role of

government in the transfer of technology is to execute policy to facilitate and encourage the most effective means of technology transfer with regard to national and international needs.[293]

THE UN FRAMEWORK CONVENTION ON CLIMATE CHANGE

The United Nations Framework Convention on Climate Change (UNFCCC) is a multi-lateral environmental agreement to which the United States and Germany are signatories.[294] While the agreement neither imposes mandatory limits on greenhouse gas emissions for individual countries nor contains enforcement mechanisms,[295] parties to the UNFCCC have committed to assist in financing developing countries in their pursuit of green technology.[296] This financial assistance includes the transfer of clean energy technology from developed countries to developing country parties.[297]

Other aspects of the UNFCCC also emphasize the transfer of green technology. Article 4.5 of the UNFCCC encourages developed country parties to take whatever practicable steps possible to facilitate developing country access to environmentally sound technologies through technology transfer.[298] Article 10 of the Kyoto Protocol[299] reiterates these commitments. The Bali Action Plan of 2007 echoes these themes of developing country access to affordable, environmentally sound technology.[300] Although parties to the Action Plan disagreed over whether the current policy framework would effectively meet the Plan's goals, the Plan itself emphasizes technology development and transfer, describing a potential fund for technology transfer to least-developed countries.[301]

THE WTO AND THE TRIPS AGREEMENT

All members of the World Trade Organization (WTO), including the United States and Germany, are bound by the TRIPS Agreement.[302] The TRIPS Agreement is the most comprehensive international agreement regarding intellectual property in international trade, and establishes binding minimum standards of IP protection.[303]

Within these standards of IP protection, Article 7 of the agreement describes the purpose of IP as promoting technological innovation and dissemination toward the furtherance of "social and economic welfare."[304] The dissemination of technology in the interest of public welfare may be protected under Article 8, which states that provisions may be necessary to prevent holders of IPRs from engaging in practices which are detrimental to international technology transfer.[305] Additionally, Article 66.2 specifies that developed country members of the WTO must foster technology transfer to least-developed country members.[306]

The TRIPS Agreement allows for flexibility as to the scope of IPRs protection in certain fields and to individual country determinations of implementation of IPRs protections.[307] One flexibility within TRIPS is an exception to patentability. Under Article 27.1, WTO members must grant patents to all types of inventions that meet (undefined) basic criteria.[308] Although these undefined criteria are generally broadly applied, more narrowly defined criteria could enhance transfer of technology to low-income countries who cannot afford licensing or investment.[309]

Another flexibility under TRIPS is exceptions to patent rights. Under Article 30, WTO countries can provide limited exceptions to the rights of patent holders—countries can allow third party use of patented inventions without the consent of the holder.[310] These exceptions are often related to, though not conditioned on, public policy objectives. As applied to climate change technology, experimental use is a common exercise of this exception; through adapting technologies to local needs and environments, countries can "invent around" IP restrictions.[311]

The most controversial flexibility under TRIPS is compulsory licensing. Article 31 permits administrative or judicial authorities to grant non-voluntary licenses to third parties, even without the consent of the patent owner.[312] Some countries only use compulsory licenses in cases in which the technology is not exploited in the country or is insufficiently exploited.[313]

Article 66.1 relates to another TRIPS flexibility, in which developing countries are allowed a special transition period for the implementation of the TRIPS

agreement.[314] This exception serves as a grace period during which developing countries are allowed a certain degree of open technology transfer.

U.S. POLICY

Steven Chu, the US Secretary of Energy, spoke in 2009 of sharing all green technology IP with developing nations, stating the necessity for collaboration to mitigate global climate change.[315] However, following Chu's suggestion that IPRs be weakened, the Chamber of Commerce created the Innovation, Development, and Employment Alliance (IDEA).[316] IDEA was formed as a coalition of companies united to lobby for more restrictive patent laws.[317]

Numerous actions of Congress were put forward prior to the UNFCCC Copenhagen Conference that reiterated the adherence of the United States to the provisions in the TRIPS agreement. Three separate bills passed by the United States House of Representatives[318] and one Senate bill[319] included provisions or amendments ensuring the United States' compliance with international IP legal requirements. In the Senate, forty-two senators signed a letter advocating for intellectual property protections. Additionally, Congress passed, and the President signed, the Consolidated Appropriations Act of 2010 restating the United States' commitment to not stray from its adherence to international IP legal requirements.[320]

The passage of legislation in the U.S. reiterating the country's commitment to international IP legal standards means that technology transfer must occur within the TRIPS framework. Some parties to TRIPS have expressed doubt on whether flexibilities are sufficient to allow quick and widespread transfer of climate change technology.[321] Additionally, while application of the exceptions may be possible, there may be a danger in over-applying the TRIPS flexibilities beyond the limited, exceptional purpose for which they were originally tailored.

GERMAN POLICY

In 2004 the European Union (EU) created the Environmental Technologies Action Plan (ETAP), an overarching plan to promote sustainable development in Europe while simultaneously accelerating innovation in the field of low carbon technology.[322] To reach its goal, the EU ETAP uses a range of financial instruments to procure research and development funding and promote market uptake.[323] ETAP is intended to stimulate economic growth through climate change technology in Europe and globally, particularly in developing countries.[324] In light of the economic crisis, the EU established the European Energy Programme for Recovery (EEPR) to fund EU energy goals and endowed the program with the largest amount of funding ever for EU energy initiatives.[325]

The ETAP does not contain any provisions that explicitly promote the need for strong intellectual property rights as a prerequisite for the transfer of climate change technology to developing countries. However, the plan states that one key role of developing countries in promoting climate change technologies is to protect IPRs.[326] The ETAP also states that "IPRs are fundamental to making technological knowledge accessible and securing business partners and foreign investors,"[327] revealing the EU's concern that weak or non-existent IPRs will stand as a barrier to climate change technology transfer.

Based on ETAP reviews and assessments, the European Commission plans to transform ETAP into an Eco-Innovation Action Plan.[328] The EU predicts that small and medium enterprises (SMEs) will play a critical role in accelerating eco-innovation, both as innovators and buyers of climate change technologies.[329] To better pave the way for SMEs to contribute to climate change technology, the European Commission pledges to, among other things, improve SME access to IPRs protection and insists that member states must do the same at the national level.[330]

Germany, an international leader in environmental innovation, created an ETAP federal government/Länder network in 2006 to implement ETAP at the national level.[331] The federal ETAP recognized the importance of SMEs in driving environmental innovation by providing these entities with the "lion's share" of funding.[332] Germany was not new to promoting environmental innovation through federal planning when it incorporated the EU's ETAP into its national plan. In 2004 Germany passed the Renewable

Energy Sources Act (Erneuerbare-Energien-Gesetz, or EEG), a prominent piece of climate change legislation, to facilitate the generation and market uptake of renewable energy.[333] The EEG established feed-in tariffs, a system requiring electrical grid operators to pay for the feed-in of low carbon energy including hydropower, landfill gas, sewage treatment, mine gas, biomass, geothermal, wind, and solar radiation energies.[334]

German patent law incorporates two notable TRIPS flexibilities: exceptions to patent rights and compulsory licensing.[335] A patent may have no effect should the federal government deem that the invention must be exploited in the interest of the "public welfare."[336] The federal government also has the power to grant compulsory licenses should a patentee unreasonably refuse to exploit the invention; the invention must be exploited due to "public interest."[337] Compulsory license applicants can even request a provisional order allowing exploitation of an invention during compulsory licensing proceedings so long as public interest demands a license be granted immediately.[338]

Despite the recent economic crisis, Germany's renewable energy sector has thrived. In 2009 renewable energies accounted for more than 10 percent of total heat, electricity, and fuel consumption in Germany and more than 300,000 people worked in this sector.[339] Meanwhile, Germany's production of electricity from conventional sources has decreased.[340] Projects that drive this progress are supported by the Federal Environmental Ministry as well as the Federal Ministry of Economics, the Federal Ministry of Education and Research, and the Federal Ministry of Food, Agriculture, and Consumer Protection.[341]

The federal government and German companies also take part in numerous projects and partnerships that facilitate the transfer of German environmental technology to developing countries. For example, a consortium of German companies established the Desertec Foundation, a large-scale push to establish a network of concentrated solar power plants in the Middle East and North Africa (MENA) to produce a sustainable electricity source for Europe and the MENA region.[342] Desertec's concept has even attracted oil-rich nations who now see their deserts as a viable source of energy yet to be tapped.[343] Technology diffusion is also occurring through higher education via the Joint European-Latin American Universities Renewable Energy Project, which recently hosted a symposium in Hamburg focused on renewable energy technology transfer between Brazil and Germany.[344] German companies are also facilitating technology transfer through workshops in India focused on providing technological assistance and transfer in renewable energies and electrical grid integration.[345]

Germany has maintained its status as a European and world leader in environmental technology by implementing EU programs on a national level and taking initiative in the private sector. Though the EU has emphasized the importance of strong IPRs in spurring environmental innovation, particularly among SMEs, German patent law suggests that the option to override environmental IPRs in the interest of public welfare is still on the table, even though this option has yet to be exercised.

RESOLVING CONFLICTS BETWEEN TECHNOLOGY TRANSFER & INTELLECTUAL PROPERTY LAW

The green technology transfer debate has centered around the possibility of relaxing intellectual property rights (IPRs) to facilitate the transfer of technology from developed countries to developing countries that would not otherwise be able to afford the technology. Arguments in favor of relaxing IPRs generally stress that the ability of national governments to use strategies such as compulsory licensing is justified by a compelling public "health" or "emergency" interest. Opponents generally maintain that relaxing IPRs will discourage innovation and possibly ossify the renewable energy technology market. Meanwhile, various countries have implemented or are in the process of implementing various initiatives to facilitate and encourage renewable energy research and development.

Until recently, technology transfer has been left to shift with transnational market forces and the "foreign direct investment, licensing agreements, joint ventures, and management contracts" of transnational corporations.[346] These forces placed a premium on

IPR protection and created "supply-side restrictions" and "demand-side limitations" that in turn prevented transfers from working in practice.[347] Recently, international institutions have made efforts to establish frameworks to facilitate the transfer of green technology from developed countries to developing countries. These efforts have accelerated in preparation for the 2012 expiration of the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC).[348]

In December of 2008 the United Nations Climate Change Conference in Bali produced a draft technology transfer agreement that enumerated certain goals for future progress, "including technology needs assessment, joint R&D programs, a healthy technology transfer environment, and licenses."[349] The United States and the European Union had hoped to eliminate tariffs on climate change mitigation techniques to facilitate the flow of ideas into developing countries, but developing countries were skeptical that the proposal was merely "disguised protectionism" to boost exports. The parties also clashed over whether to relax IPRs to facilitate the smooth flow of technology.[350] Many scholars continue to advocate the notion that developing countries must "leapfrog" over dirty technologies to clean technologies.[351]

To facilitate developing country leapfrogging, Hasper recommends tapping into the market for green technology in developing countries through the use of a global technology exchange forum that brings technology holders, venture capitalists, and domestic entrepreneurs together to reduce information asymmetries and transaction costs.[352] He also urges that those participating in the developing country green technology markets not neglect the role of indigenous firms which are better aware of local needs and thus better able to implement technologies that meet the economic needs of communities.[353] Perhaps explicitly incorporating this awareness into technology transfer plans could ease developing countries' concerns that developed countries are only moving to eliminate climate change technology tariffs to increase exports.

There is a growing interest in creating a global technology exchange forum that follows the open-source operating system model; a sort of "Wikipedia" of green technology exchange.[354] One global exchange scheme already in operation is the Eco-Patent Commons.[355] Companies have offered a number of patents with environmental benefits free of charge through the Eco-Patent Commons with one limitation: defensive termination. If a non-pledger attempts to assert a patent against a pledger, the pledger has the option to defensively terminate its non-assert agreement (i.e., agreement not to sue). Since launching in 2008, the Eco-Patent Commons has received approximately 100 eco-friendly patent pledges. This year, Green Xchange will start a partnership with Creative Commons and will provide eco-friendly patents for fixed annual licensing fees.[356] Voluntary patent-sharing forums such as Eco-Commons and Green Xchange are praised as alternatives to making substantive changes to the law, which means these forums are inherently a faster means of exchanging green technology.[357]

While a significant portion of recent literature on technology transfer to developing countries has focused on resisting substantive changes to the law on the grounds that IPR protection spurs innovation and are essential for attracting foreign direct investment,[358] other studies suggest that stronger IPRs are not necessary and may in fact hinder green technology transfer. Reichman has suggested that developing countries can accommodate developed countries' standards for patent protections in a way that better facilitates technology transfer by "adopting relatively stringent eligibility standards covering subject matter, novelty, nonobviousness, and disclosure."[359] India has aggressively pursued this strategy to meet development goals in its pharmaceutical industry, establishing a strict nonobviousness standard which requires "a technical advance" or economic significance.[360] Recently passed Chinese patent law adopts a broader, more absolute novelty standard and also requires disclosure of origin for genetic resources. The United States has even recently begun to increase its patent eligibility standards, though not as much as India.[361]

Another method for circumventing strong IPR protections is to allow compulsory licensing and related measures. Compulsory licensing is permitted under TRIPS in times of "emergency" and has generally

been used for pharmaceutical products used to fight epidemics such as HIV/AIDS. Recent use of compulsory licensing has expanded the scope of its application to include pharmaceuticals used to treat long-term health problems such as heart disease and cancer.[362] Some argue that climate change is a long-term health problem or that it is an "emergency," thus justifying the use of compulsory licensing to increase access to green technology. Nevertheless, IPRs were left out of the Copenhagen Accord, to the relief of developed countries opposed to the relaxation of IPRs.[363]

In 2005 Brazil invoked compulsory licensing to break HIV/AIDS pharmaceutical patents owned by Abbot Laboratories by approving a bill suspending the patents and authorizing the production of generic versions of the drugs. This moved saved Brazil $250 million when Abbott responded by lowering the price it had changed for its antiretroviral drugs. Similarly, Thailand approved compulsory licensing for an AIDS drug in 2007 after failing in negotiations to reduce the cost of the drugs.[364] Thailand also became the first state to use compulsory licensing for chronic diseases when it granted a license for heart and lung cancer medications.[365] Chinese Patent Law allows "Bolar exceptions," which permits generic producers to reverse-engineer medicines and conduct clinical trials despite the patent. Though China's pending patent reform is set to include compulsory licensing provisions, compulsory licensing provisions are not common in developing countries.[366] The WTO upheld these exceptions as legitimate under Article 30 of the TRIPS Agreement.[367] Many European countries have codified compulsory licensing provisions into patent laws which are compatible with the TRIPS Agreement, though until recently patent authorities were reluctant to grant compulsory licenses despite these provisions.[368]

Although compulsory licenses have generally been reserved to the pharmaceutical industry, countries have taken other intellectual property avenues to promote green technology transfer. Professor Derclaye suggests several IPR incentives that could be used to promote green technology, including "accelerated examination, reduction, cancellation or waiver fees, removal of green inventions from deferred examination, earlier publication and/or priority at the opposition and infringement stages, [and] stronger protection."[369] One example of an IPR incentive in use is the United Kingdom's Intellectual Property Office fast track system for green technology, also referred to as the "Green Channel." As of 12 May 2009, patent applications for green technologies can take advantage of an accelerated procedure in which the applicant simply makes a request in writing which makes "a reasonable assertion that the invention in the patent application is one which has some environmental benefit," and "which actions [he/she] wish[es] to accelerate: Search, Combined Search and Examination, Publication, and/or Examination." The United States Patent and Trademark Office introduced a similar system in December of 2009.[370] Australia and South Korea have also launched similar programs and China, Japan, and Brazil have expressed interest in following suit.[371] Thus, although international institutions and nations have yet to strike IPRs with a heavy blow in the interest of green technology transfer, it seems as though some countries are slowly moving toward more fluid movement of green technology by making minor yet significant adjustments to patent procedures.

Intellectual property rights may foster innovation in green technology, but if too restrictive may also preclude developing countries from accessing critical technology. The United States is committed to fueling green technology, but Congress and industries are equally committed to strong IPRs protection. The European Union echoes this commitment to IPRs protection, maintaining that IPRs protection is necessary to stimulate green innovation and market uptake. German intellectual property law does not reflect staunch adherence to strong IPRs protection and instead permits the most controversial TRIPS flexibility: compulsory licenses in the interest of public welfare. Nevertheless, Germany continues as a leader of green technology and apparently has yet to exercise the power of compulsory licensing in the green technology sector.

Conclusion

Increasing concern over global warming, climate change, and other social costs of dependence on fossil fuels has spurred a vast array of initiatives to promote a transition to a green energy infrastructure. Through subsidies, taxes, and regulations, these initiatives have tried to improve the efficiency of energy use and to encourage the substitution of renewable energy sources for oil and coal. While these initiatives have generated many benefits, investment in research and deployment of green energy technologies frequently has been stymied when the price of oil declines. This paper concludes that carbon taxes or oil price stabilization tax schemes could create comprehensive, predictable incentives for making the necessary transition to green energy technology. While recognizing the potent political headwinds facing such policy proposals, the paper explores ways of overcoming them.

The paper then examines claims that intellectual property law, which is designed to create incentives for innovation, actually may inhibit the transfer to developing countries of green energy innovations. While the paper cannot find significant examples of green energy technologies whose diffusion has been hindered by existing intellectual property protections, it explores strategies, such as compulsory licensing schemes, for responding to such problems if and when they arise in the future. The paper concludes that intellectual property law need not be an obstacle to a global transformation toward a green energy infrastructure that can promote economic development while advancing new levels of international cooperation.

Appendix I: A Survey of National Strategies for Promoting the Transition to Green Energy Sources

EUROPEAN UNION 20/20/20

The EU 20/20/20 directive "represents the world's most visible, farthest reaching agreement to promote renewable energy."[372] The directive requires "member states to enact their own national RES-E policies (toward the targeted 20% increase in RES-E share by the year 2020)."[373] Rationales behind the directive include energy supply security; promoting technological development, innovation, and employment; and increasing "export prospects, social cohesion and employment opportunities."[374] The directive is considered part of a package that includes compliance with the Kyoto Protocol.[375]

DENMARK

Since 1976, the Danish government has passed a series of four energy plans that have evolved to reflect an increasing emphasis on decreasing Denmark's dependency on foreign oil and non-renewable energy sources, and increasing the development and use of alternative energy sources, particularly wind power.[376] Denmark's first energy plan, the Danish Energy Plan of 1975, focused primarily on ensuring the security of energy sources and it proposed the use of nuclear power. The nuclear power proposal sparked intense debate, which lead to the creation of an alternative energy plan that emphasized, among other goals, an increase in the use of alternative energy sources, specifically solar and wind energy.[377] Denmark supported the proliferation of wind power by using feed-in tariffs, economic subsidies, financial incentives, and other economic support systems.[378]

The second Danish energy plan, the Energy Plan of 1981, focused on reducing dependency on foreign fuel and formally recognized renewable energy as a potential energy source by providing for subsidies and feed-in tariffs for wind power.[379] Shortly thereafter, Denmark eliminated nuclear energy as part of Denmark's energy supply planning.[380]

The Danish Ministry of Energy published the third energy plan, Energy 2000, in 1990. Like the previous plan, Energy 2000 emphasized renewable energies and called for an increase in the use of biomass fuels and other environmentally friendly fuel alternatives.[381]

In 1996, the Danish Ministry of Environment and Energy published Denmark's fourth energy plan, Energy 21. Again, the plan focused on renewable energies and officially established Denmark's overarching energy policy goals: "(1) to reduce greenhouse gas emissions; and (2) to develop a sustainable energy system."[382]

Denmark instituted its Green Growth Initiative in 2009.[383] The initiative establishes a strategy for environmental policy in the agriculture sector that includes a reduction of GHG emissions, primarily from nitrogen regulation.[384]

GERMANY

Germany has supported solar energy development and use by providing federal subsidies that encourage community initiatives, such as the 1000 Roofs Program, which was launched "to provide homeowners with financial incentives to install photovoltaic systems as a means to consume power" at reduced costs.[385] The program ended in 2004 when it reached its required number of installed photovoltaic systems. Germany has also used a "feed-in-tariff" program that facilitated the integration of solar grids into existing power grids.[386]

Germany integrated the EU climate and energy policy into national policy by the Integrated Climate Change and Energy Program.[387] The program includes a variety of renewable energy initiatives. Germany plans to use €400 million from the sale of carbon credits on the EU trading market to invest in low-carbon projects such as biomass research projects.[388]

Germany has in place a Renewable Energies Export Initiative, which facilitates contact and communication between German businesses and businesses abroad.[389] Through the initiative, the Federal Ministry of Economics and Technology launched "renewables – Made in Germany," to facilitate the spread of

German technology in the renewable energy sector. The website for "renewables – Made in Germany" provides descriptions of German renewable energy companies and products,[390] and the virtual marketplace of renewable B2B, operated by the German-Greek Chamber of Industry and Commerce, facilitates renewable energy business communication.[391]

JAPAN

Japan promotes solar energy development through its New Sunshine Project, initiated in 1974. Another version of the project was launched in1993 to build photovoltaic systems and modernize infrastructure for solar energy.[392] In 2008, Japan launched the Renewable Energy Policy Platform "to study and promote renewable energy programs." Finally, in 2009 the Japanese Ministry of International Trade and Industry announced the New Purchase System for Solar-Power Generated Electricity to promote energy security by, in part, requiring power companies to purchase excess solar power electricity at specified prices.[393]

Japan drafted Cool Earth 50, an innovative technology roadmap, in 2008 to promote twenty-one different innovative technologies to reduce GHG emissions.[394] The technologies include biofuels, photovoltaics, and hydrogen production. Japan's Ministry of Economy, Trade, and Industry (METI) provides subsidies for R&D that will increase the propagation of new and renewable energy.[395] The projects funded cover a variety of sectors, including electricity, heat, and transport. METI and the New Energy and Industrial Technology Development Organization provide investment for advanced new and renewable energy technologies and facilities, including those in the photovoltaic, wind, solar heat, differential temperature energy, natural gas-cogeneration, fuel cell, wastes generation, use of waste heat, and production of wastes fuel areas.[396]

AUSTRALIA

Australia's Department of Resources, Energy, and Tourism implements the country's Clean Energy Initiative, a $5.1 billion initiative. This initiative is composed of a set of sub-programs. The Solar Flagships Program "supports the construction and demonstration of large scale, grid connected power stations . . . which may include solar, thermal, photovoltaic and energy storage technologies."[397] The Carbon Capture and Storage (CCS) Flagships Program is designed to promote CCS technologies and supports the G8's call to launch the demonstration of twenty CCS projects by 2010.[398]

The Australian Center for Renewable Energy (ACRE), a component of the initiative that seems to still be in the development stages, "will become [Australia's] central point of contact for support in the Australian Government for renewable energy and enabling technologies."[399] ACRE's supporting programs are the Renewable Energy Demonstration Program, ACRE solar projects, Second Generation Biofuels Research and Development Program, Geothermal Drilling Program, Wind Energy Forecasting Capability Program, and Advanced Electricity Storage Technologies Program. To support these projects, ACRE is charged with a variety of responsibilities for establishing and supporting mechanisms to support renewable energy R&D and proliferation.[400]

AUSTRIA

Several of the Austrian Energy Agency's current energy technology projects aim to decrease consumption and increase the efficient use of energy.[401] Notable renewable energy policy initiatives include the Green Electricity Act, the Combined Heat and Power Law, the Green Electricity Act, the Climate and Energy Fund, and the Austrian Climate Change Strategy.[402] Feed-in tariffs and direct subsidies for renewable energy sources were established under the Green Electricity Act Amendments in 2008 and 2009.[403] The Combined Heat and Power Law (CHP Law), effective as of 2009, provides for investment subsidies to CHP plants if they result in energy and CO2 emissions savings as compared to the separate production of heat and electricity.[404] The Climate and Energy Fund provides funding for research and development (R&D) in sustainable energy technologies.[405]

BELGIUM

Belgium instituted technology subsidies for new

products that improve energy efficiency by the passage of a Royal Decree in 1983. The legislation overlapped regional initiatives supporting technology, including energy technologies.[406] Since 2003 Belgium has provided federal tax deductions for individuals who invest in energy efficiency and renewable energy in their homes through the Federal Public Service.[407]

BRAZIL

In 2008 Brazil enacted the National Climate Change Plan. The goal of the plan is to reduce Amazon rainforest deforestation by over half by 2017 and to increase energy efficiency and the share of energy generated by certain renewable energy sources.[408] Sugarcane biogas plants are one notable energy source supported by the plan.

CANADA

Canada promotes renewable energy development through its Clean Energy Fund Program, a component of Canada's Economic Action Plan. The fund is investing in large-scale carbon capture and storage (CCS) demonstration projects, possibly in response to the G8's call to launch twenty CCS demonstrations by 2010, and smaller-scale projects as well. In 2009, three CCS projects in Alberta were announced.[409]

Canada promotes solar energy through "federal, provincial, and municipal initiatives involving government and academic research and development, investment programs, renewable portfolio standards, and utility programs."[410] One initiative is the Natural Resources Canada CANMET Technology Centre: "a facility which advocates for the development of solar technologies to help distribute energy throughout Canada."[411] Additionally, three federal programs are the backbone of energy policy in Canada: EcoENERGY for Renewable Heat, EcoENERGY for Renewable Power, and the EcoENERGY Retrofit Program. The EcoENERGY Renewable Heat program provides businesses with funds to purchase or adopt renewable thermal technology for heating purposes.[412] The EcoENERGY Renewable Power Program is designed to support renewable technologies by paying individuals and organizations that build solar projects for the energy used by these projects.[413] The EcoEnergy Retrofit Program promotes green technologies and provides tax-exempt grants to homeowners who have renovated their homes to be more energy efficient.[414]

Canada's Accelerated Capital Cost Allowance (CCA), implemented in 2007, provides investors with accelerated write-offs of certain equipment used for more efficient energy production and for energy produced by alternative energy sources.[415] The Trust Fund for Clean Air and Climate Change provides funding for territorial initiatives aimed at reducing GHG emissions and air pollution.[416] Funding for similar projects in the private sector is provided through Canada's Sustainable Development Technology Fund.[417]

CZECH REPUBLIC

The Czech Republic has allocated approximately CZK 8 billion for its national program for the energy management and the use of renewable sources of energy.[418] In 2005 the Czech Republic amended its 1992 Income Tax Act to allow income tax exemption for six years for owners of renewable energy equipment who produce energy for their own consumption.[419] The Czech Republic also provides subsidies for the cultivation of crops that are grown specifically for energy use.[420]

ESTONIA

In 2004 Estonia enacted a long-term national development plan for fuel and energy that set a target for the share of energy from renewable energy sources at 5.1 percent by 2010 and called for the use of renewable liquid fuels.[421]

FINLAND

Finland implemented a Long-Term Climate and Energy Strategy in 2008, which aims to, among other things, increase the share of energy generated indigenously and the use of renewable energy.[422] Biomass fuel produced by peat accounts for approximately 6 percent of Finland's energy balance and the national energy and climate strategy continues to promote peat as a competitive alternative energy source.[423]

The Housing Finance and Development Center of Finland provides energy grants for housing improvements that reduce energy consumption, reduce GHG emissions, or incorporate renewable energy sources.[424]

Finland also imposes energy taxes on transportation and heating fuels.[425] The basic tax applies only to oil products and is staggered for gasoline and diesel according to their environmental qualities. An additional tax is levied on oil, other fossil fuels, and electricity, and varies by the fuel's carbon content.[426]

FRANCE

France's Finance Law of 2009 contains provisions that provide financial incentives for undertaking energy-saving renovations and the use of biofuels.[427] Article 99 provides for 0 percent interest on eco-loans for energy-efficient renovations and Articles 16 and 17 provide for reduced consumption taxes for a variety of biofuels. To assist the agricultural sector in energy-efficient and renewable energy endeavors, France implemented a plan to provide investment support for energy-saving and renewable energy equipment.[428] Renewable energy R&D support is provided through the French National Strategy for Research and Development, with emphasis on R&D in biomass production, photovoltaic energy, and a variety of other renewable energy sources.[429] Individuals who purchase energy-efficient and renewable energy equipment for primary residences can receive tax credit under Article 200 of the General Tax Code; the percentage of credit varies based on the type of equipment or installation.[430] In 2003 the French Environment and Energy Management Agency initiated a joint program with the energy industry to fund biofuel R&D for new technologies.[431] France lends support specifically for small and medium size enterprises (SMEs) through both FOGIME, the government crediting and loan guarantee for SMEs' renewable energy investments,[432] and the French Agency for Innovation (OSEO) provides grants and zero-interest grants for SMEs' R&D activities in renewable energy.[433]

GHANA

Ghana's Strategic National Energy Plan (SNEP) was implemented in 2006 and contains national energy plans up to 2020.[434] One policy recommendation under the plan is to establish a system of feed-in tariffs to promote the uptake of renewable energy, particularly from existing biomass co-generation plants, and financial schemes such as subsidy programs and micro-financing.

GREECE

The Center for Renewable Energy Sources and Saving (CRES) is Greece's national entity responsible for promoting energy conservation and renewable energy use. The CRES has implemented several financial initiatives to promote renewable energy development and consumption.435 In 1995 Greece established the Operational Program for Energy (OPE) to provide capital cost grants to promote renewable energy production and energy conservation.[436] Greece also has technologically-specific feed-in tariffs in place and biofuels are exempt from fossil fuel taxes.[437]

HUNGARY

Under the Electricity Act 2005, Hungary has in place a feed-in tariff system, which requires large electricity suppliers to purchase electricity from renewable energy sources.[438] The tariff does not vary by energy source and is adjusted for inflation. The tariff is recovered by a charge on the electricity system. Hungary, based on a Resolution of the Parliament, created a strategy for increasing the consumption of renewable energies for 2008–2020 that sets consumption targets for various renewable energy sectors.[439]

ICELAND

Iceland adopted "Iceland's Climate Change Strategy" in 2007.[440] Among other goals, the strategy aims to introduce new technology, economic policies, and carbon sequestration. Iceland plans to prioritize carbon capture and sequestration, place a greater emphasis on renewable energy technology exportation, and determine whether it will engage in climate-friendly projects under the Clean Development Mechanism.

INDONESIA

In 2009 Indonesia created a "mandatory utilization framework in the transportation, industrial, commercial, and power generation sectors for biodiesel, bioethanol, and bio-oil from 2009 to 2025."[441] The framework prioritizes biofuel production and use by national companies, regulates the biofuel industry, and sets biofuel share targets. Biofuel use is mandated and set at certain percentages of energy consumption for different sectors.

IRELAND

Ireland's Sustainable Energy Incubator Program, managed by Sustainable Energy Ireland, was created in 2007 with the purpose of providing financial support for sustainable energy ventures.[442] This program prioritizes the bioenergy, ocean energy, wind energy, microgeneration, and fuel cells and hydrogen sectors.

ITALY

In 2000, Italy's Interministerial Committee for Economic Planning created the Biomass Fuels National Plan to promote the replacement of fossil fuels by biomass through incentive systems. Italy's Ministry of the Environment is providing funding for research projects to improve the efficiency of electricity and heat production from renewable sources, particularly solar energy, in urban areas.[443] Various types of organizations can apply for this funding and funding is distributed through a competitive selection process.

In 2008 Italy launched two project streams under its Industry 2015 program that are aimed at, among other goals, the use of renewable energy.[444] In 2009, the Industrial Energy Efficiency stream selected several projects that mobilized €500 million in renewable energy R&D. Most of the funding is going toward bioenergy, energy production from waste, wind energy, and solar photovoltaics.

REPUBLIC OF KOREA

As of 2008, South Korea provides a tax audit exemption for businesses involved in developing alternative energy.[445] Businesses covered by this exemption include businesses operating in solar cell, biomass, and nuclear power fields.

LUXEMBOURG

Luxembourg provides a variety of support measures to SMEs, one of which being a grant scheme available to enterprises of all sizes that invest in projects that promote energy conservation, renewable energy, and combined heat and power production.[446] Up to 40 percent of eligible investment costs are covered for all enterprises while SMEs can receive up to 10 percent more coverage.

Luxembourg's Framework Law of 1993 requires that electricity produced by small-scale renewable energy sources be connected to public grids and establishes feed-in tariffs for these sources.[447]

MALAYSIA

In January of 2010 Malaysia, in cooperation with the Credit Guarantee Corporation, created the Green Technology Financing Scheme (GTFS).[448] The scheme provides financing to support companies that are investing in renewable energy, sustainable energy, and green technology. Just one month after the GTFS became effective 186 companies had responded to the loan offer.

NETHERLANDS

The Dutch government in 2007 passed, and in 2009 promulgated, the Sustainable Energy Production Incentive Draft Decision, which provides grants to those who invest in renewable electricity and renewable gas.[449] The grant rate level will be adjusted annually in relation to energy prices. This scheme falls under the Economic Affairs Grants (Framework) Act. In 2001, Netherlands implemented Energy Premium (EPR), a subsidy program, and Energy Performance Advice (EPA), a free consultation "for households and social housing corporations that invest in renewable energy."[450] Energy taxes fund the program.

NEW ZEALAND

In 2010 New Zealand implemented a comprehensive

emissions trading regime that covers all sectors of the economy.[451] New Zealand helps businesses to make efficiency gains through its Energy Efficiency and Conservation Authority (EECA) Business program.[452] EECA provides financial incentives to promote investment in new technologies and information to reduce investment risks. New Zealand's low carbon energy technologies (LCET) fund supports research in second-generation biofuels, low carbon liquid biofuels, and low carbon energy technology.[453] LCET funds are used to invest in research for the scale-up and demonstration of technology, assessment of environmental impacts of technology, and technology that demonstrates the potential to reduce carbon dioxide emissions.

NORWAY

Carbon capture and storage is central to Norway's policy on energy and climate.[454] In 2006 Statoil, a Norwegian energy company, received permission from the Norwegian government to build a combined heat and power plant in Mongstad and agreed to develop CCS technology at the plant. The CCS center will capture carbon dioxide and transport the carbon dioxide by pipeline under the North Sea bed for storage. The CCS technology center should be in operation by 2011 or 2012.

Norway established two CO_2 taxes in 1991.[455] The first is a tax on mineral products such as oil except for those not used for heating purposes. The second is a tax on emissions from offshore oil and gas and, because the tax is classified as a deductible operating cost, it reduces the ordinary tax and special tax owed by offshore oil and gas companies.

Norway's R&D program Clean Energy for the Future (RENERGI), implemented in 2004, provides support for energy innovation.[456] One of RENERGI's primary objectives is to develop environmentally friendly and economically efficient energy resources. RENERGI accepts grant applications from trade and industry, independent research institutes, and universities.

POLAND

Poland's Green Investment Scheme (GIS), which became effective in 2009, guarantees that the funds generated by the sale of emissions trading Assigned Amount Units are used for projects relating to climate protection.[457]

The National Fund for Environmental Protection and Water Management provides funding through low-interest and fixed-rate loans for the investment and construction of renewable energy and high efficiency CHP facilities.[458] This fund supports biomass, thermal power generation using biomass, CHP production, CHP using sewage or other waste, wind power, geothermal power, hydroelectric power, and high efficiency CHP projects.

Poland's Long-Term Program for Promotion of Biofuels or Other Renewable Fuels for 2008 to 2014 includes provisions for excise tax exemptions, corporate income tax reduction, support for energy crop cultivation, and investment support to promote biofuel production and use.[459]

PORTUGAL

Portugal's National Energy Strategy (ENE 2020) focuses on five main axes, which includes "betting on renewable energy."[460] This axis sets as one of Portugal's goals an increase in renewable energy production and an increase in the number of renewable energy types available.

SINGAPORE

Singapore implemented the Clean Energy Research Program (CERP) in 2007 to promote R&D in clean energy technology using a competitive bidding process.[461] Institutes of higher learning, public sector agencies, and non-profit organizations can qualify for funding for projects in specific technologies including solar technologies and roof-mounted solar harvesting devices for the tropical region. The Ministry of National Development operates a fund specifically for promoting sustainable building projects, including those that incorporate the use of renewable energy.[462] The Innovation for Environmental Sustainability (IES) Fund provides support for companies investing in environmental projects, including renewable energy projects.[463] The fund will provide 100 percent of funding needed if the Ministry can directly employ the projects and

have full intellectual property rights to the final technologies.

Under the Income Tax Act, individuals can write off energy-saving equipment costs for equipment including solar heating and cooling systems and solar energy collection systems.[464]

SLOVAK REPUBLIC

The Slovak Republic passed the Act on Support of Renewable Energy Sources and High Efficiency Combined Heat and Power Generation in 2009.[465] The Act provides for preferential transmission, distribution, and delivery of electricity from renewable energy electricity producers. System operators are required to buy renewable energy electricity at a preferential fixed price for a fixed period of time.

Slovakia developed a Long-Term Strategy for the use of crop-plants for industrial purposes to promote the use of biomass as a renewable energy source.[466] Strategy measures include the creation of a market for biomass and applied research and distribution of biomass use technology.

The Biomass Action Plan highlights the importance of biomass to heat and electricity generation in Slovakia.[467] The plan provides for financial support for the production of biomass and the use of biomass for energy, and for R&D in the biomass energy sector.

Slovakia's Environmental Fund, established in 2005, provides grants and soft loans to support investment in renewable energy.[468] The fund is financed through environmental pollution fees and fines. A separate fund, the Ecological Fund, also supports renewable energy project investments through soft loans.[469]

SWEDEN

Sweden has in place a complex system of carbon and energy taxation.[470] In 1991 Sweden introduced a CO_2 tax, a reduction in the general energy tax, a tax on sulfur emissions, and value-added taxes on electricity and fuels. The three elements of the present tax structure are an energy tax, a CO_2 tax, and a sulfur tax. The energy tax applies to oil, coal, and natural gas; industry use and electricity generation are exempt. The CO_2 tax is levied on fuels based on their carbon content, with the exception of biofuels and peat. The sulfur tax is uniform across all users.

SWITZERLAND

Switzerland approved an Action Plan on Renewable Energy in 2008 that aims to increase the country's share of renewable energy.[471] Measures proposed to reach that goal include incentives for solar thermal energy, feed-in tariffs for district heating, the incorporation of biogas into the gas grid, and additional funding for R&D.

THAILAND

In 2004 Thailand implemented the Strategic Plan for Renewable Energy Development with the goal of increasing renewable energy use to 8 percent of commercial primary energy by 2011.[472] The plan calls for, among other programs, specified electricity tariffs for renewable technology, tax breaks, subsidies, and R&D.

TUNISIA

Tunisia's National Energy Efficiency and Renewable Energy Program of 2007 provides, among other initiatives, financial support for renewable energy technology R&D and investments in water pumping and desalination, rural electrification, and biogas production.[473]

UNITED KINGDOM

The United Kingdom's Low Carbon Transition Plan outlines measures to be taken to ensure that the UK meets its emission reduction targets.[474] Measures to be taken include funding demonstrations of CCS, paying individuals and businesses for using renewable energy sources for heat and electricity, and providing funding for R&D and deployment of renewable energy technology. The Renewable Energy Strategy of 2009 outlines ways in which the UK will ensure that by 2020,15 percent of energy is generated from renewable sources.[475] This strategy will invest some of its funding in emerging technologies, including wave and tidal generation, offshore wind, and advanced biofuels.

The UK's Energy Technologies Institute (ETI), funded in part by the government and in part by industry, is a limited liability partnership that focuses on investment and R&D in cost-effective low-carbon energy technology.[476] Participating industries include BP, Caterpillar, and Shell.

Appendix II

Figure 1: Inflation Adjusted Monthly Crude Oil Prices, 1974-present[480]

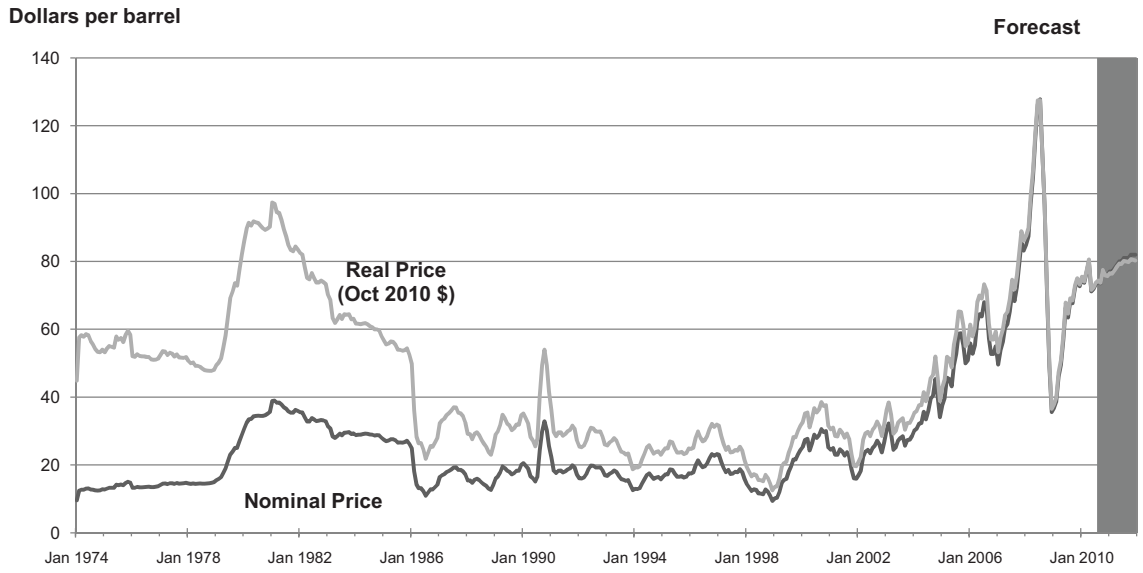


Figure 2: Annual Federal Energy R&D Investments by Major Program Area (in 2005 dollars)[481]

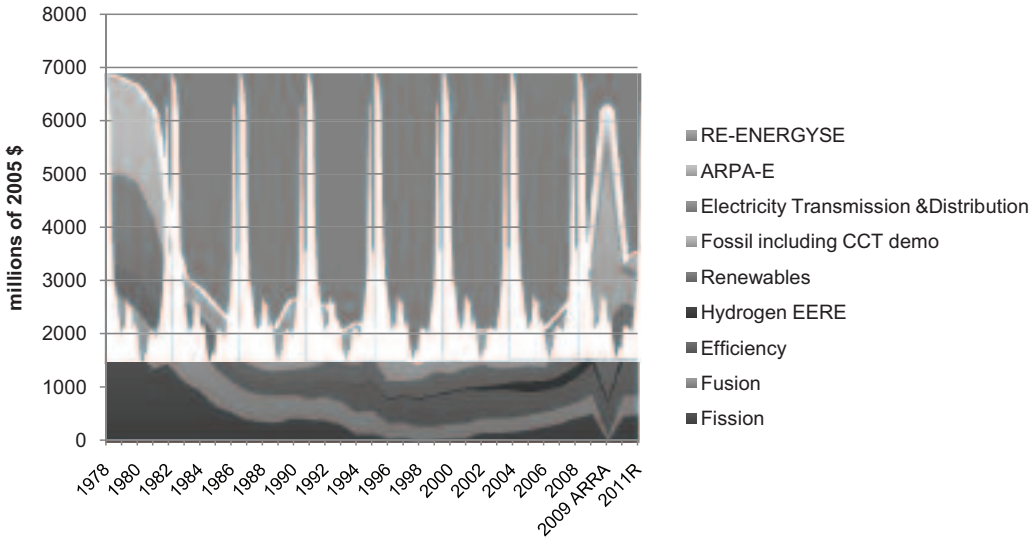


Figure 2A: Energy R&D Budgets of National Governments of Selected IEA Members, 1997-2007 (in millions of 2007 dollars)[482]

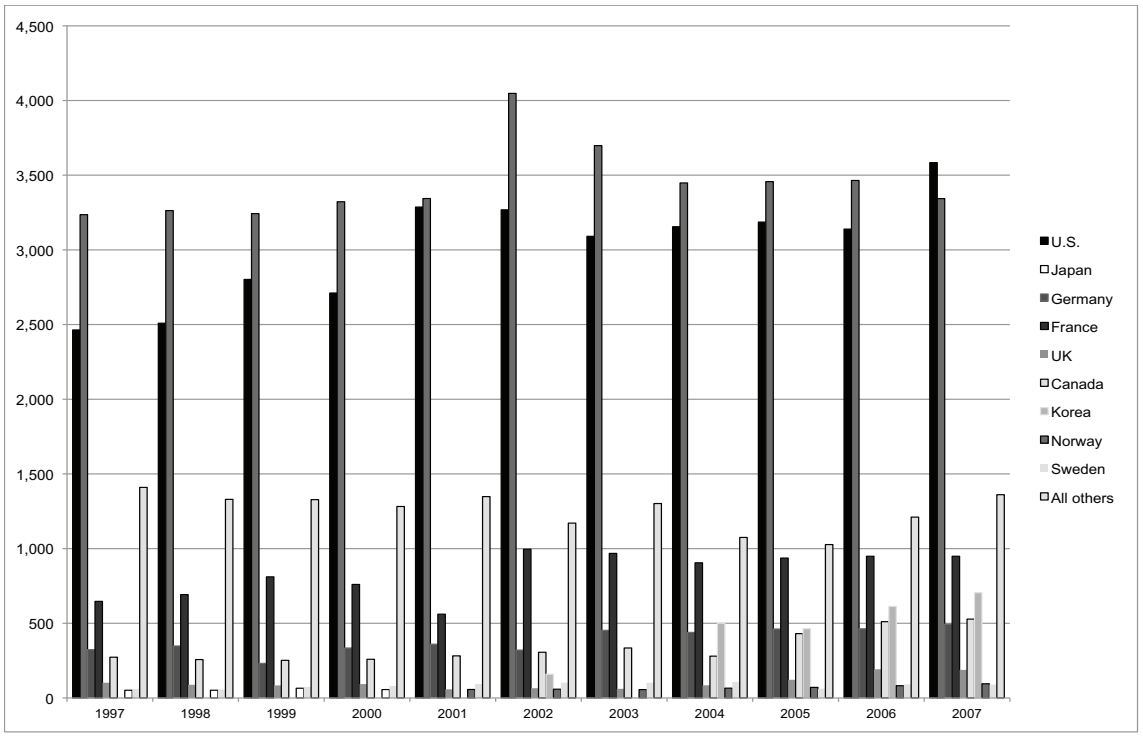


Figure 2B: Combined Energy R&D Budgets of IEA Members by Technology Type,1997–2007 (In Percentage of Totals Rreported by All IEA Members)[483]

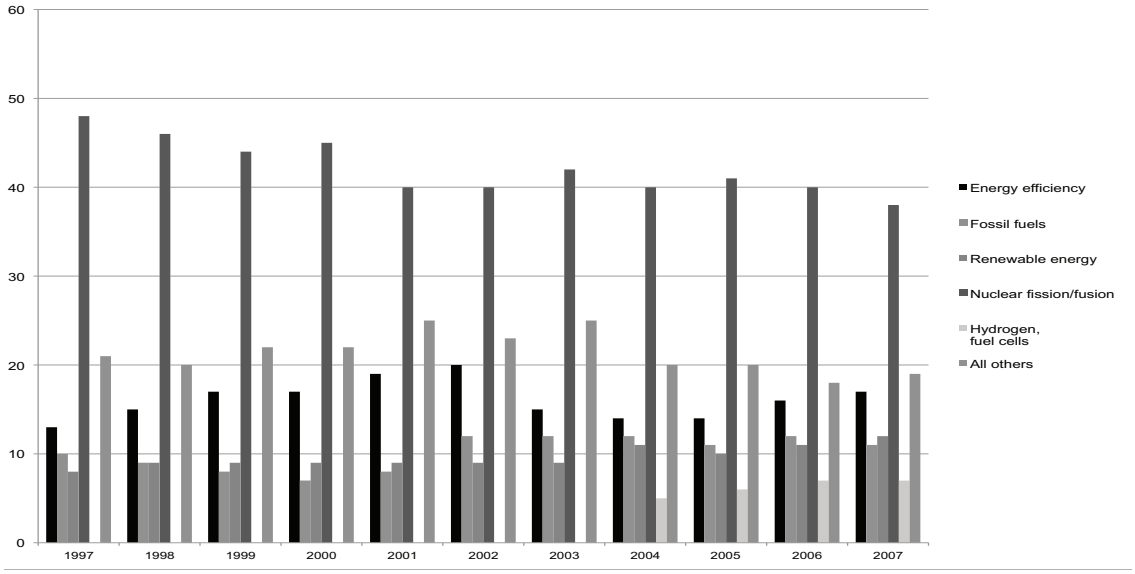


Figure 3: Energy R&D Investment by Public and Private Sectors[484]

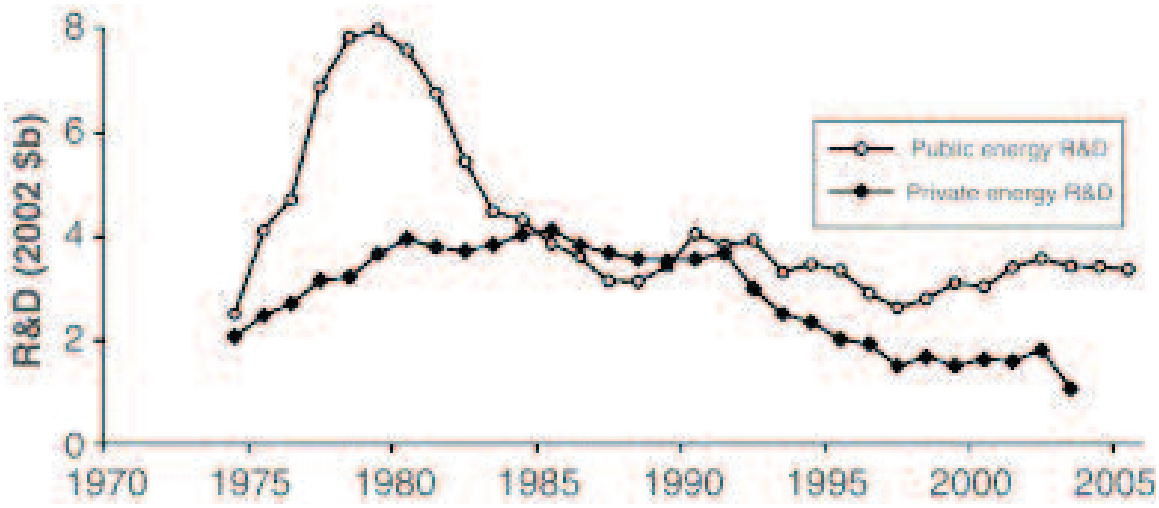


Figure 4: U.S. Department of Energy R&D Expenditures[485]

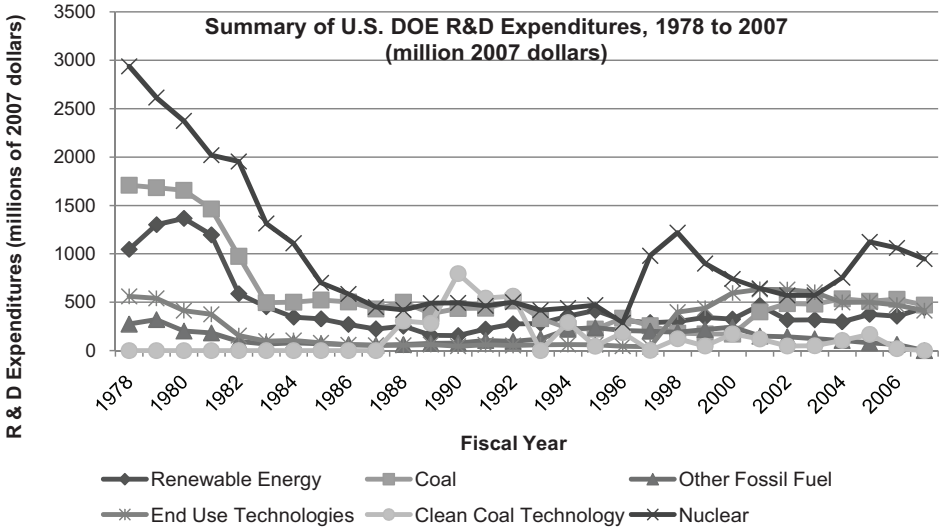


Figure 5: U.S. Department of Energy R&D Expenditures (without Nuclear R&D)[486]

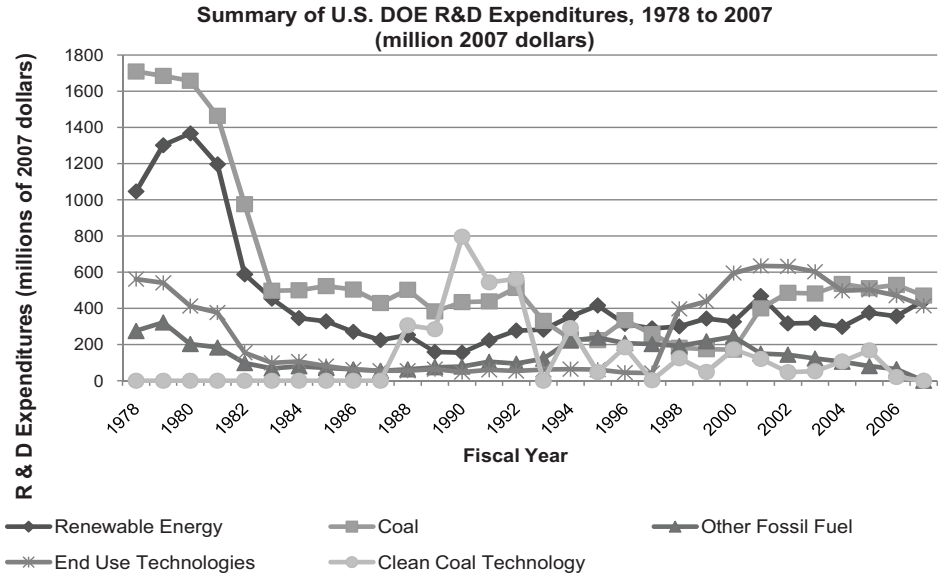


Figure 6: Patenting and Federal R&D for Wind,1973-2005 (R&D in 2002 millions of dollars)[487]

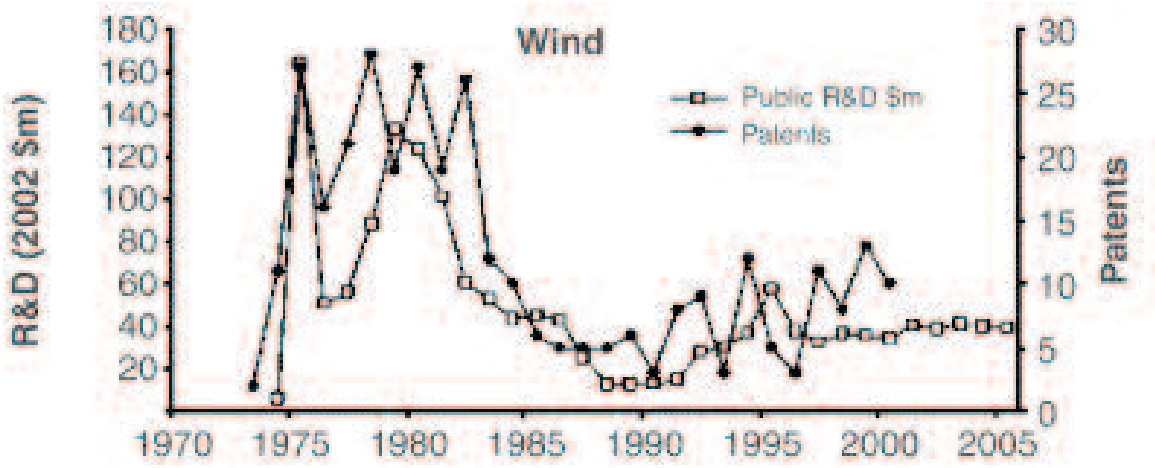


Figure 7: Patenting and Federal R&D for Photovoltaics, 1973-2005 (R&D in 2002 millions of dollars)[488]

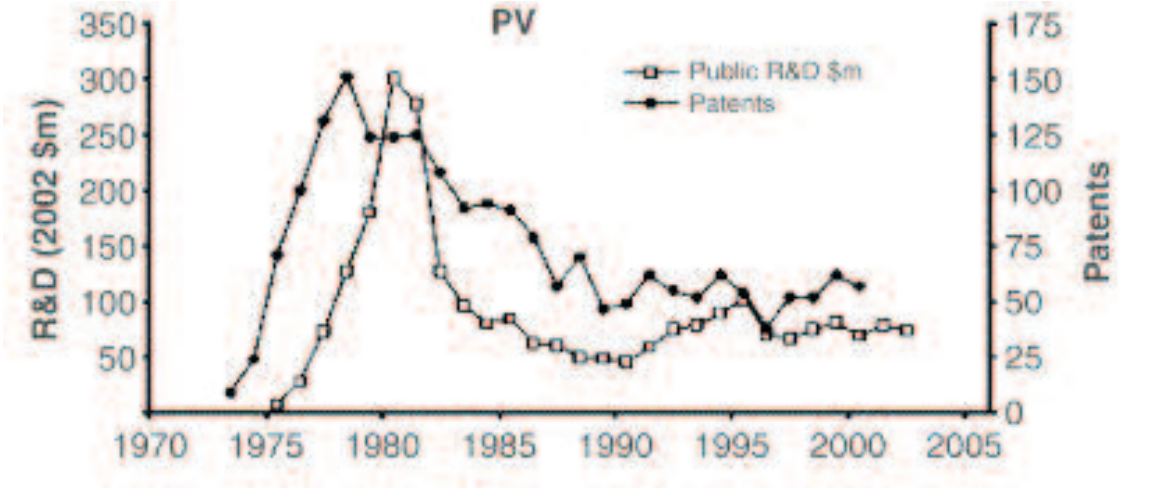


Figure 8: Patenting and Federal R&D for Nuclear Fission, 1973-2005 (R&D in 2002 millions of dollars)[489]

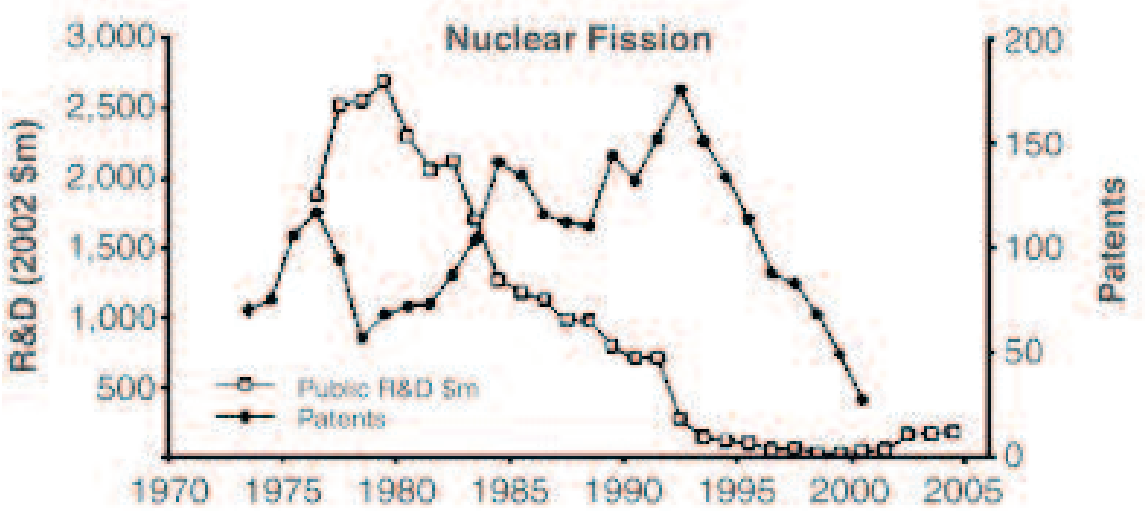


Figure 9: Patenting and Federal R&D for Nuclear Fusion, 1973-2005 (R&D in 2002 millions of dollars)[490]

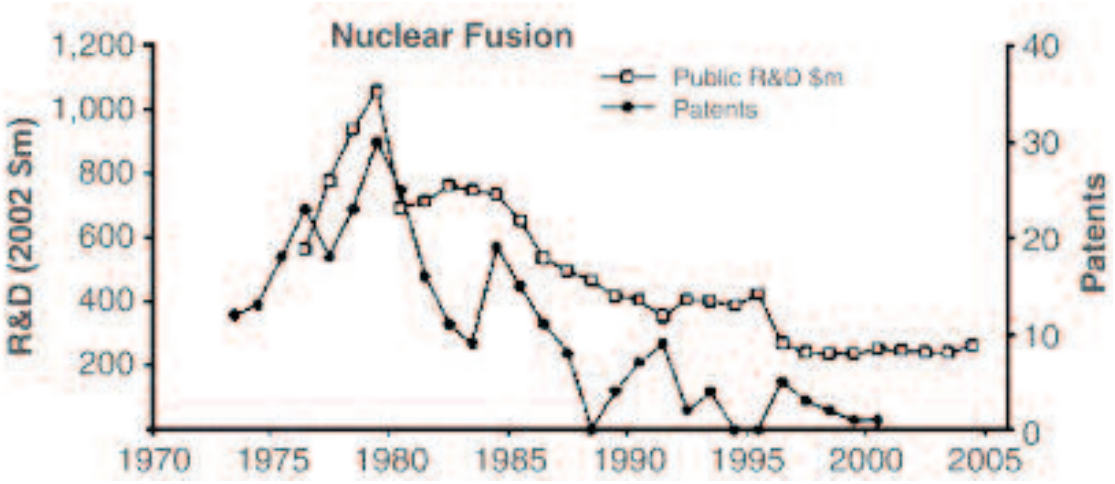


Figure 10: Private Sector R&D Investment between 1980 and 2003, Energy v. Drugs and Medicines (in 2002 millions of dollars)[491]

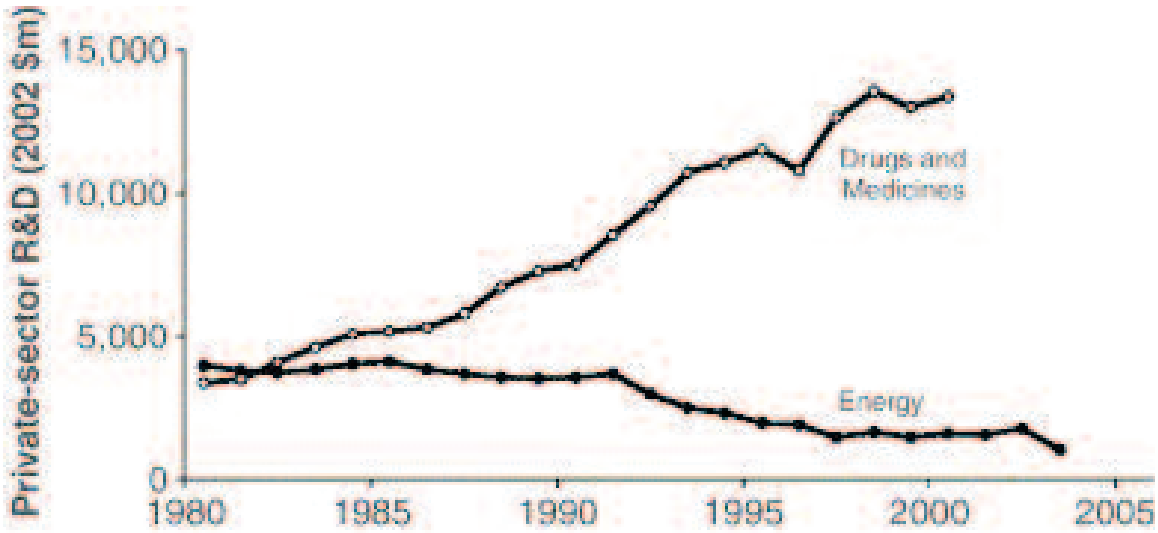


Figure 11: Department of Energy R&D Spending, Indluding Stimulus Funds (billions of 2008 dollars)[492]

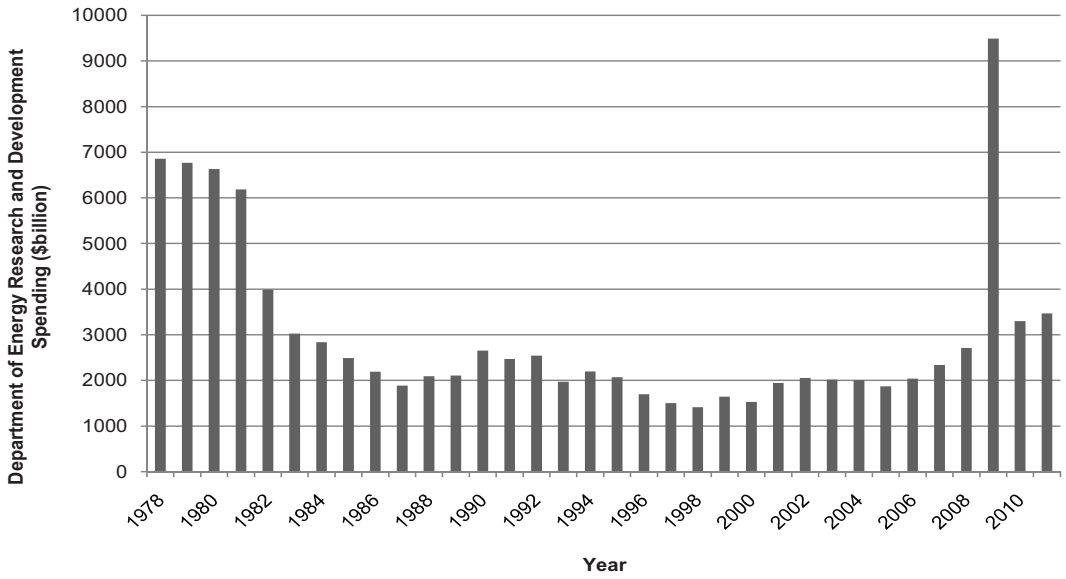


Figure 12: Historic Impact of PTC Expiration on Annual Installation of Wind Capacity[493]

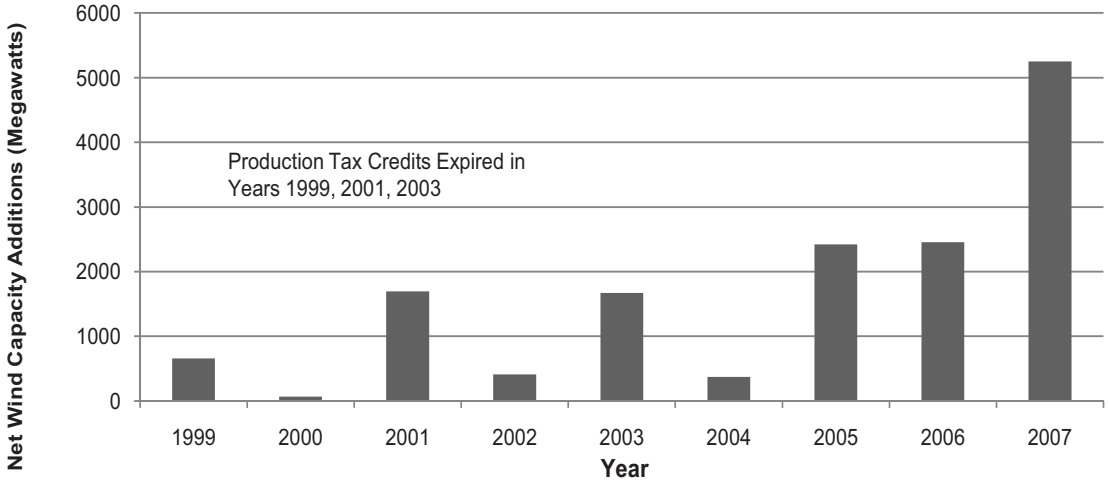


Figure 13: Approximate Retail Price Under Illustrative Alternative Fuel Price Stabilization Program (FPSP) Implementations[494]

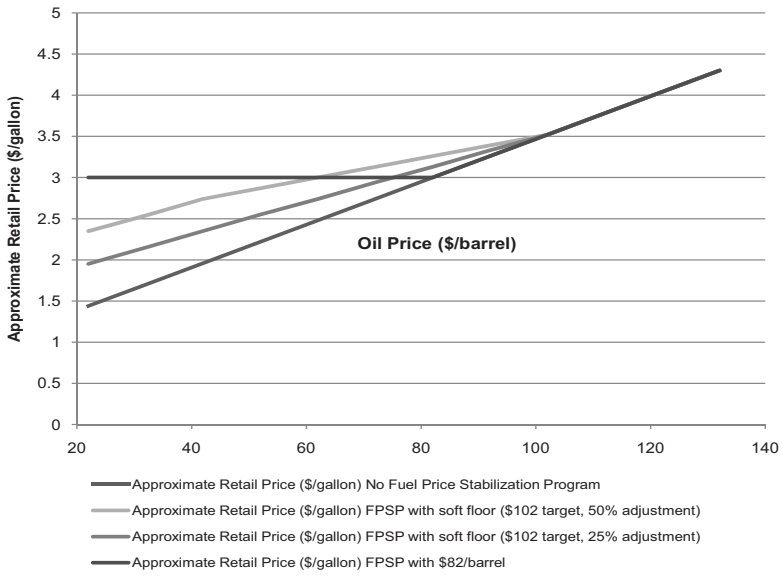


Figure 14: Approximate State Revenues from Fuel Price Stabilization Program (FPSP) Under Illustrative Alternative Implementations[495]

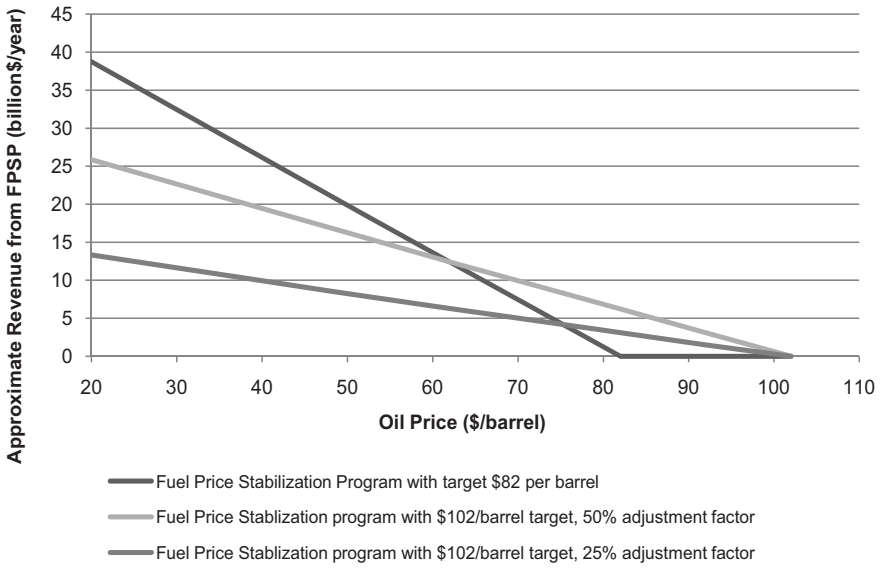
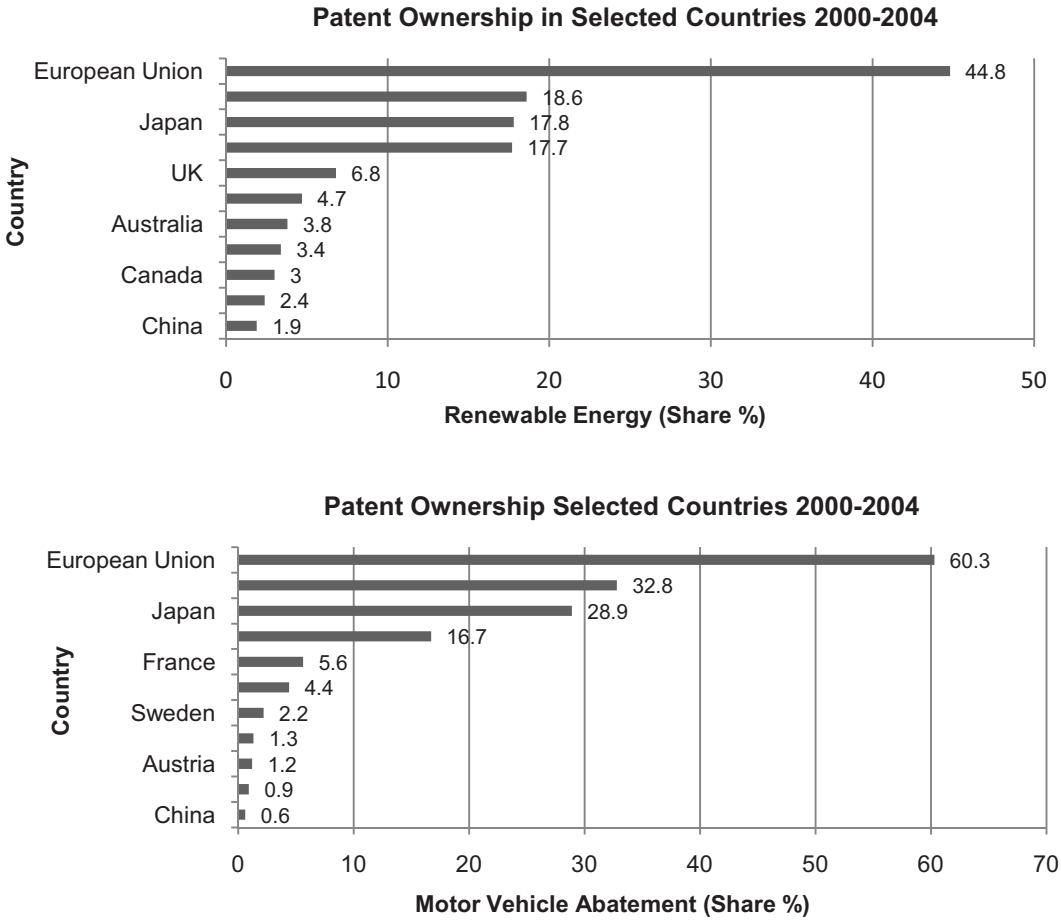


Figure 15: Patent Ownership in Selected Countries, 2000-2004[496]



Appendix III: Proposals for Revamping U.S. Energy Policy

The Environmental Transformation Fund provides financial support and the national and international levels for R&D and deployment of low-carbon technologies.[477] The Bio-Energy Infrastructure Scheme, launched in 2003, provides grants to biomass producers in England for use in heat and electricity generation in England.[478] The Bio-Energy Capital Grants Scheme awards capital grants to support the use of energy crops to generate heat and electricity.[479]

In March 2009, the National Renewable Energy Laboratory (NREL) published a comparative review of twelve national energy proposals that were considered by the Obama administration and the 111th Congress.[494] These plans are representative of many different views on how the country should address energy policy. One common theme is the urgency of increasing funding for clean energy research and development. The following is a brief summary of the twelve proposals.

1. REPOWER AMERICA

Al Gore first announced this plan in a July 2008 speech. It calls for 100 percent carbon-free electricity within ten years. In order to achieve such a rapid level of change the plan calls for improvements in energy efficiency, a rapid switch to renewable energy options, a unified national smart grid, and plug-in hybrid electric vehicles. As of late 2008 the proposal claimed to have over 2 million supporters. The plan focuses on the power and transport industries and stresses environmental protection. It is written with a top-down, goal-oriented approach.

2. THE PICKENS PLAN

T. Boone Pickens first announced this plan in July 2008. Highlights of this plan include deploying enough wind turbines in ten years to offset the need for natural gas in power generation, and the use of compressed natural gas (CNG) vehicles. The plan focuses on the power and transport industries and stresses national energy security. It is written with a top-down, goal-oriented approach.

3. THE NEW APOLLO PROGRAM

This plan is essentially a blueprint for a fundamentally new economy. It is supported by a coalition of business, labor, environmental, and community leaders. The proposal would invest $500 billion over ten years into clean energy initiatives, and by doing so create 5 million green-collar jobs. The plan covers major sectors including power, transport, buildings, and the government, and it focuses on environmental concerns and economic recovery. It was written with both goal-oriented, top-down aspects, as well as detailed bottom-up aspects.

4. A NATIONAL STRATEGY FOR ENERGY SECURITY

This plan was released in September 2008 and primarily focuses on reducing dependence on foreign oil in order to protect national security. It also recognizes that climate protection is an essential part of national security. It calls for a tenfold increase in federal energy research, and development and the extension of production and investment tax credits for renewable energy. This plan focuses on all major sectors and it focuses on national energy security. It was written with goal-oriented, top-down aspects as well as more detailed, bottom-up aspects.

5. GREEN RECOVERY

This plan was based on a 2007 report on "Progressive Growth" published by the Center for American Progress. It is a two-year plan that spends $100 billion on building retrofits, mass transit and freight rail, smart-grid systems, wind power, solar power, and biofuels. It estimates that it would create 2 million new jobs, and it would be paid for by deficit spending. Authors estimate that energy savings would offset the costs within five years. This plan focuses on the power and buildings sectors and is concerned with economic recovery and environmental issues. It was written with both top-down and bottom-up aspects.

6. A 100-DAY ENERGY ACTION PLAN

The Council on Competitiveness issued this plan in September 2008. It stresses innovation and entrepreneurism. The six key areas covered by the plan are promoting energy efficiency, fully utilizing domestic energy, promoting energy infrastructure investments, encouraging technology breakthroughs and entrepreneurship, creating a clean energy workforce, and creating a national transmission superhighway. This plan covers all major sectors and is focused on environmental concerns and economic recovery. It was written primarily with a goal-oriented, top-down approach.

7. NEW ENERGY FOR AMERICA

This is the plan of the current administration. Reducing dependence on foreign oil remains a high priority, and a cap-and-trade system that will cut greenhouse gas emissions 80 percent below 1990 levels by 2050 takes center stage. Revenues from the cap-and-trade system will be used to fund the $150 billion investment in clean energy technology that will create 5 million new jobs in the next ten years. This plan is concerned with all major sectors and is focused on economic recovery and environmental concerns. It was written with both top-down and bottom-up aspects.

8. TRANSITION TO GREEN

At 390 pages in length, this is the most detailed plan reviewed. It provides recommendations for each federal government agency and focuses on restoring environmental quality. The four priority areas under this plan are: clean energy and climate change, federal budget and stimulus legislation to achieve national environmental goals, making the White House the leader on clean energy and the environment, and "putting the right people in the right jobs." This proposal is primarily focused on the public sector and environmental concerns. It was written with a bottom-up approach.

9. A CLIMATE PLAN FOR THE NEW ADMINISTRATION

This plan was created by anonymous authors who used the name "Justinian" after a late Roman emperor. This plan focuses on what the incoming administration can do to address climate change issues, and does not address legislative action. It suggests that the EPA be given the authority to regulate greenhouse gas emissions, and discusses the role the White House can play in addressing climate change, including encouraging citizens to make more environmentally responsible individual choices. This plan is focused on the public sector and environmental concerns.

10. CLEAN ENERGY 2030

This plan was created by Google. Version 2.0 came in November 2008 as a response to public comments and the failing economy. It calls for energy efficiency and renewable energy and plug-in hybrid vehicles. This plan is given a longer time frame and says there is no need to decommission existing plants. This plan is focused on the power and transport sectors and is concerned with environmental issues. It was written with a top-down approach.

11. A TRANSITION PLAN FOR SECURING AMERICA'S ENERGY FUTURE

This plan was developed by the Chamber of Commerce, under the leadership of Retired General James Jones. Jones was appointed to head the National Security Council for the Obama administration, and he served in the position for just under two years. The plan focuses on market-based solutions and many incentives are in the form of tax credits and tax depreciation. It stresses national security concerns but focuses more on domestic energy sources including nuclear power. This plan covers all major sectors and is primarily concerned with national energy security. It was written with a bottom-up approach.

12. ENERGY EFFICIENCY AND ECONOMIC RECOVERY INITIATIVE

This plan focuses on jump-starting the economy and it calls for retrofitting 2 million buildings during the next two years. It was designed to be implemented almost immediately using existing agencies and programs. This plan is focused on buildings and is concerned with both environmental issues and economic recovery.

NOTES

1 Robert F. Stanton Professor of Law and Director, Environmental Law Program, University of Maryland School of Law. The author would like to thank Peter Hogge, Esther Houseman, Molly Madden, and Megan Marzec for their outstanding research assistance with this paper.

2 See "Inflation Adjusted Monthly Crude Oil Prices – 1946-present," Figure 1 in Appendix II.

3 International Energy Agency, Deploying Renewables – Principles for Effective Policies 158 (2008).

4 Id. at 159.

5 Id. at 160.

6 Id.

7 Andy Grove, Our Electric Future, The Journal of American Enterprise Institute, at http://www.american.com/archive/2008/july-august-magazine-contents/our-electric-future.

8 Ronald Bailey, Energy Independence: The Ever-Receding Mirage, Reason Magazine, July 21, 2004, at http://reason.com/archives/2004/07/21/energy-independence-the-ever-r/print.

9 Id.

10 Id.

11 Id.

12 Steven Greenhouse, CLINTON'S ECONOMIC PLAN: The Energy Plan; Fuels Tax: Spreading The Burden, February 18, 1993, available at http://www.nytimes.com/1993/02/18/us/clinton-s-economic-plan-the-energy-plan-fuels-tax-spreading-the-burden.html. A BTU is the "quantity of heat needed to raise the temperature of a pound of water by 1 degree Fahrenheit." Id.

13 Id. See also Dawn Erlandson, The BTU Tax Experience: What Happened and Why It Happened, Pace Environmental Law Journal, Volume 2, Number 1, Page 176, 1994, available at http://digitalcommons.pace.edu/cgi/viewcontent.cgi?article=1239&context=envlaw. (describing the initial bipartisan support and environmental enthusiasm surrounding the plan). "Three quarters of the House and Senate were visited by teams of environmentalists urging support for the plan." Id.

14 Paul F. Horvitz, Clinton Retreats on Energy Tax in Fight Over Budget, N.Y. Times, June 9, 1993, available at http://www.nytimes.com/1993/06/09/news/09iht-plan_1.html; see also CLINTON's ECONOMIC PLAN, supra note 12. (expecting revenue of "$1.5 billion from the tax in the fiscal year 1994, $8.9 billion in 1995, $16.4 billion in 1996 and $22.3 billion in 1997").

15 See CLINTON's ECONOMIC PLAN, supra note 12; see also TED Case Studies: US BTU Tax, (last viewed August 29, 2010, available at http://www.american.edu/TED/usbtutax.htm. "The tax would be imposed on coal, natural gas, liquefied petroleum gases, natural gasoline, nuclear-generated electricity, hydro-electricity, and imported electricity at a base rate of 25.7 cents per million BTUs (p/MBTU)." Id. "An additional 34.2 cents p/MBTU was to be levied on refined petroleum products, a total of 59.9 cents." Id.

16 See CLINTON's ECONOMIC PLAN, supra note 12. See also TED Case Studies, id.

17 See CLINTON's ECONOMIC PLAN, supra note 12.

18 Id. But see Mary McElveen, Business Helps Sink BTU Tax – Opposition to Clinton's Energy Tax Proposal, Nation's Business, July 1993, available at http://findarticles.com/p/articles/mi_m1154/is_n7_v81/ai_14017856/. (providing an estimate of $400 - $500 cost per family per year); National Center for Policy Analysis, Federal Budget Issue: Do We Need an Energy Tax?, Policy Backgrounder No. 127, June 4, 1993, available at http://www.ncpa.org/pub/bg127. (tracking administration estimates from an original cost per year estimate of $204, to an Energy Department estimate of $322, to a May Treasury Department estimate of $400, also citing disparate impacts in different locations around the country).

19 See CLINTON's ECONOMIC PLAN, supra note 12. "The new tax would raise the price of gasoline by 2.5 cents a gallon next year; in 1996 the tax would be 7.5 cents a gallon higher than it is now." Id.

20 See Business Helps Sink BTU Tax, supra note 7; see also S. Fred Singer, Hidden BTU Tax Horrors, The Washington Times, May 3, 1993, available at http://www.sepp.org/key%20issues/btutax/hiddenbtu.html; see also Jeff A. Taylor, Power Move – the Adverse Effects of Pres. Clinton's Energy Taxes, Reason, June 1993, http://findarticles.com/p/articles/mi_m1568/is_n2_v25/ai_14113197/; see also Do We Need an Energy Tax?, supra note 18 (explaining the regressive nature of the tax and providing an in-depth look of the effect on the tax on family budgets and varying locational effects); see also The Flaws in Clinton's Energy Tax, Backgrounder, The Heritage Foundation, No. 934, March 18, 1993, available at http://www.heritage.org/Research/Reports/1993/03/The-Flaws-In-Clintons-Energy-Tax (criticizing the White House's efforts to conceal the true nature of the tax).

21 See Business Helps Sink BTU Tax, supra note 18. "The presidents of the U.S. Chamber of Commerce, the National Association of Manufacturers, and the National Federation of Independent Business had urged the elimination of the tax from legislation pending in Congress." Id.

22 See Business Helps Sink BTU Tax, supra note 18; see also That Sinking Feeling, Time Magazine, June 7, 1993, available at http://www.time.com/time/magazine/article/0,9171,978663-1,00.html.

23 See Edwin Chen, Boren Hails Shift on Energy Tax, Los Angeles Times, May 31, 1993, available at http://articles.latimes.com/1993-05-31/news/mn-41951_1_btu-tax.

24 Id; see also John Dillin, Clinton Moves to Shore Up Support for his Fiscal Plan, The Christian Science Monitor, June 1, 1993, available at http://www.csmonitor.com/1993/0601/01013.html.

25 See Clinton Confirms Changes to Energy Tax, supra note 3. Additionally, the tax would likely be "shifted away from a heat-content tax" to a value-added tax. Id.

26 Martin A. Sullivan, Gas Tax Politics, Part I, taxanalysts, September 22, 2008, available at http://www.taxhistory.org/thp/readings.nsf/ArtWeb/5DDB79194769C2BF852574D5003C28D5?OpenDocument.

27 Environmental Law, 11.01[3], 11-18.4.

28 Id.

29 Id. at 11-18.5.

30 Energy Policy Act of 2005 1 (Kevin J. McIntyre, Martin V. Kirkwood, Jason F. Leif eds., LexisNexis 2006).

31 Id. at 2.

32 Id.

33 Id. at 2-3.

34 Id. at 3.

35 Id.

36 Id. at 4.

37 Id.

38 Id.

39 Public Law 110-140.

40 See Title I.

41 See Title II.

42 See Title III.

43 See Title IV.

44 See Title V.

45 See Title VI.

46 See Title VII.

47Congressional Research Service Report to Congress, Energy Independence and Security Act of 2007:

A Summary of Major Provisions
http://energy.senate.gov/public/_files/RL342941.pdf.

48 Production tax credits are tied to the number of kilowatt (kW) hours of electricity sold during a 10-year period after a qualified facility is in service. Currently, production tax credits are 2.1¢ per kW hour for the sale of electricity that comes from solar, geothermal, wind and closed-loop biomass, and 1¢ per kW hour for the sale of electricity that comes form open-loop biomass, landfill gas, trash combustion and certain qualified hydropower facilities. Frank P. Grad, Treatise on Environmental Law, Ch. 11 § 11.01[4][a] (Matthew Bender 2010) (1973).

49 Id.

50 Id.

51 Id. at § 11.01[4][b].

52 Id.

53 Id. at 11.01[4][c].

54 Id.

55 Id.

56 Id.

57 Id.

58 American Clean Energy and Security Act of 2009, H.R. 2454, 111th Cong. (2009).

59 Id.

60 Id.

61 John M. Broder, Democrats Unveil Climate Bill, N.Y. Times, April 1, 2009, at A19.

62 Id.

63 John M. Broder, House Passes Bill to Address Threat of Climate Change, N.Y. Times, June 27, 2009, at A1.

64 See Broder, supra note 61.

65 Id.

66 Id.

67 Id.

68 Id.

69 Id.

70 Id.

71 Darren Samuelsohn, Boxer, Kerry Launch Campaign to Pass Senate Cap-And-Trade Bill, Greenwire, September 30, 2009.

72 Id.

73 Id.

74 Id.

75 Id.

76 Carolyn Fischer and Louis Preonas, Combining Policies for Renewable Energy – Is the Whole Less than the Sum of Its Parts?, Resources for the Future 6, http://www.rff.org/documents/RFF-DP-10-19.pdf (March 2010) (citing Karen Palmer & Dallas Burtraw, Cost Effectiveness of Renewable Electricity Policies, 31 (Supplement 2) Energy Economics S235-43 (2005) and Carolyn Fischer & Richard G. Newell, Environmental and Technology Policies for Climate Mitigation, 55(2) Journal of Environmental Economics and Management 142-62 (2008)).

77 Fischer and Preonas, supra note 76, at 6. Fischer & Preonas also note that "FITs typically offer higher subsidy rates for more costly technologies, while TGCs encourage competition amongst RES-E technologies" and FITs can only achieve cost parity with TGCs by offering uniform rates across all RES-E technologies (thereby eliminating special provisions for solar and other expensive technologies)." Id. (citing Christoph Böhringer and Knut Einar Rosendahl, Green Promotes the Dirtiest: On the Interaction Between Black and Green Quotas in Energy Markets, 37 Journal of Regulatory Economics 316 (2010)).

78 Id. at 7-8 (noting that "TGC markets enable cheaper renewable (e.g. wind) to dominate expensive ones (e.g. solar)" which indicates that a "quota system alone is likely to be insufficient for ensuring long-term innovation and technological development") (citing Thomas Unger and Erik O. Ahlgren, Impacts of a Common Green Certificate Market on Electricity and CO2-emissions Markets in Nordic Countries, 33 Energy Policy 2152 (2005)); see also Christoph Böhringer & Knut Einar Rosendahl, Green Promotes the Dirtiest: on the Interaction Between Black and Green Quotas in Energy Markets, 37 J. Regul. Econ. 318 (2010) for an argument that combining black (CO2) and green (renewable) quotas can lead to higher output from the most CO2-intensive power generation, usually coal power.

79 Id. at 1368.

80 Pablo del Rio Gonzalez, The Interaction Between Emissions Trading and Renewable Electricity Support Schemes: An Overview of the Literature, 12 Mitig. Adapt. Strat. Glob. Change 1368 (2007).

81 Id.

82 See, e.g., Carolyn Fischer and Richard G. Newell, Environmental and Technology Policies for Climate Mitigation, 55 Journal of Environmental Economics and Management 142 (2008); see also Lawrence H. Goulder & Ian W. H. Parry, Instrument Choice for Environmental Policy, 2 Review of Environmental Economics and Policy 152 (2008).

83 Carolyn Fischer and Richard G. Newell, Environmental and Technology Policies for Climate Mitigation, 55 Journal of Environmental Economics and Management 143 (2008).

84 Table taken from Carolyn Fischer and Louis Preonas, Combining Policies for Renewable Energy – Is the Whole Less than the Sum of Its Parts?, Resources for the Future, 6, http://www.rff.org/documents/RFF-DP-10-19.pdf (March 2010) (citing DSIRE, IEA, and others for source materials for table).

85 Carolyn Fischer and Louis Preonas, Combining Policies for Renewable Energy – Is the Whole Less than the Sum of Its Parts?, Resources for the Future 6, http://www.rff.org/documents/RFF-DP-10-19.pdf (describing the U.S. Acid Rain Program as a "seminal example of such a policy").

86 Id.

87 Id. (citing EU Business, Iceland, Norway, Lichtenstein to Join EU Emisssision Trading System, March 5, 2010, http://www.eubusiness.com/topics/environ/1193418125.05) (noting that this includes all 27 EU member states, as well as Norway, Iceland, and Liechtenstein).

88 A. Denny Ellerman & Paul L. Joskow, The European Union's Emissions Trading System in Perspective, PEW Center on Global Climate Change, ii, May 2008, http://www.pewclimate.org/docUploads/EU-ETS-In-Perspective-Report.pdf (last visited August 23, 2010).

89 Friends of the Earth, A Dangerous Obsession 20 http://www.foe.co.uk/resource/reports/dangerous_obsession.pdf (last visited August 23, 2010) ("Phase I of the scheme is widely deemed to have been a complete failure with over-allocation leading to a collapse in the price of EUAs – the permits traded under the scheme. With price being the main driver for emissions reductions under a trading scheme, a collapse in the price of permits eliminates all incentives for firms covered by the scheme to reduce their emissions. Despite a lowering of the cap in Phase II, permits have still been over-allocated. Combined with the recent contraction of European industry, this resulted in the price of EU allowances falling to record lows for Phase II, down to €8 on 12 February 2009 – a fall of more than 70 per cent from the peak on 1 July 2008.").

9 A. Denny Ellerman & Paul L. Joskow, The European Union's Emissions Trading System in Perspective, PEW Center on Global Climate Change iii, May 2008, http://www.pewclimate.org/docUploads/EU-ETS-In-Perspective-Report.pdf (last visited August 23, 2010) ("In light of the speed with which the program was developed, the many

sovereign countries involved, the need to develop the necessary data,

information dissemination,

compliance and market institutions, and the lack of extensive experience with emissions trading in

Europe, we think that the system has performed surprisingly well.").

91 A. Denny Ellerman & Paul L. Joskow, The European Union's Emissions Trading System in Perspective, PEW Center on Global Climate Change 45, May 2008, http://www.pewclimate.org/docUploads/EU-ETS-In-Perspective-Report.pdf (last visited August 23, 2010).

92 A. Denny Ellerman & Paul L. Joskow, The European Union's Emissions Trading System in Perspective, PEW Center on Global Climate Change 45, May 2008, http://www.pewclimate.org/docUploads/EU-ETS-In-Perspective-Report.pdf (last visited August 23, 2010).

93 A. Denny Ellerman & Paul L. Joskow, The European Union's Emissions Trading System in Perspective, PEW Center on Global Climate Change iii-iv, May 2008, http://www.pewclimate.org/docUploads/EU-ETS-In-Perspective-Report.pdf (last visited August 23, 2010).

94 Reuven S. Avi-Yonah & David M. Uhlmann, Combatting Global Climate Change: Why a Carbon Tax is a Better Response to Global Warming than Cap and Trade, 28 Stan. Envtl. L. J. 5 (2009).

95 Energy Information Administration, Annual Energy Outlook - Legislation and Regulations, May 2010, http://www.eia.doe.gov/oiaf/aeo/leg_reg.html (last visited August 18, 2010).

96 Id.

97 Reuven S. Avi-Yonah & David M. Uhlmann, Combatting Global Climate Change: Why a Carbon Tax is a Better Response to Global Warming than Cap and Trade, 28 Stan. Envtl. L. J. 6 (2009) (noting the tax would be imposed on all coal, natural gas, and oil produced domestically or imported into the United States).

98 Id. at 38-43 (2009) (noting that extensive experience in taxing, as well as the fact that the tax would be level against polluters, would address upstream sources, and credits could be given to those projects which reduce CO2 emissions, such as carbon sequestration projects).

99 Id. at 43-49 (2009).

100 Pablo del Rio Gonzalez, The Interaction Between Emissions Trading and Renewable Electricity Support Schemes: An Overview of the Literature, 12 Mitig. Adapt. Strat. Glob. Change 1366 (2007).

101 Pablo del Rio & Miguel A. Gual, An Intergrated Assessment of the Feed-in Tariff System in Spain, 35 Energy Policy 995 (2007).

102 Pablo del Rio Gonzalez, The Interaction Between Emissions Trading and Renewable Electricity Support Schemes: An Overview of the Literature, 12 Mitig. Adapt. Strat. Glob. Change 1365 (2007).

103 Pablo del Rio & Miguel A. Gual, An Intergrated Assessment of the Feed-in Tariff System in Spain, 35 Energy Policy 995 (2007).

104 See, e.g., id. (describing how these systems can vary in their levels of support, time of day (base or peak load) or season (winter or summer), frequency, minimum guaranteed payments (e.g., long-term like 20 years in Germany or short-term like the minimum of four years which existed in Spain prior to 2004), who pays for the FIT, and application to new capacity).

105 Id. at 1011.

106 Id.

107 Id.

108 Id. (noting that a FIT set too high causes extra costs for consumers, while a FIT set too low might be ineffective).

109 Id.

110 Id.

111 Id. n.5.

112 Id. at 1011.

113 Id.

114 Id.

115 International Energy Agency, Deploying Renewables – Principles for Effective Policies 17 (2008).

116 Id.

117 Id. at n.33; see also id. at n.4 (noting also that "[u]ntil 2005, none of the countries that provide overall levels of remuneration below USD 0.07/kWh witnessed significant deployment effectiveness").

118 Id.

119 Id. The IEA also notes that Portugal's effectiveness increased significantly with the introduction of a new FIT, while Denmark's policy effectiveness appeared to decrease because of a 2001 elimination of its FIT and a new emphasis on offshore wind development. Id. at 104. Note that this report focuses on the 2000-2005 period; investment stability in recent years might be more questionable.

120 Id.

121 Id.

122 Id. at 102. Italy,Belgium, and the United Kingdom each had a range of average yearly effectiveness of 1-3% in the IEA study. Id.

123 Id. at 105.

124 Id.

125 Id.

126 Id.

127 Id. at 106.

128 Id. at 105.

129 Id. at 17 (noting also that "the lack of stability in the provision of the production tax credit on an ongoing basis has led to substantial boom-and-bust cycles in US wind power installations in the 2000s").

130 Id. at 106.

131 Id. at 18.

132 Id.

133 Id. Remuneration levels were found to be "quite evenly distributed between regions as well as among countries with different incentive schemes" in the IEA 2000-2005 study. Id. at 115.

134 Id. at 18

135 Id.

136 Id.

137 Id.

138 Id. at 109-12. Non-EU OECD countries demonstrated the largest contribution to total global biomass generation in IEA's study. US, Japan, Canada, China, and Finland contributed about 55% of total biomass in the IEA study, yet each of these countries except Japan had low levels of deployment effectiveness in the IEA study period. Id. IEA suggests the study start date might play a role; most of these programs began before 2000.

139 Id. at 114.

140 Id.

141 Id.

142 Id.

143 Id. at 18 (noting that "[s]trong competition for feedstocks has recently developed from agricultural markets, and affects the viability of projects in many countries").

144 The IEA does note that minimum remuneration level necessary, though depending on plant type and size, is about USD 0.08/kWh. Id. at 120. This cost "can increase significantly once low-cost biogas options like landfill gas are exploited." Id.

145 Id. at 18.

146 IEA notes that "[i]n Germeny, the FIT incentive scheme has shown relatively high costs compared with other countries due to the small-to-medium scale and type of feedstocks used in agricultural applications." Id.

147 Id.

148 Id. at 18 (noting that the UK's growth is also based on a similar expansion of capacity).

149 Id. at 116.

150 Id.

151 Id. at 117.

152 Id.

153 International Energy Agency, DEPLOYING RENEWABLES – PRINCIPLES FOR EFFECTIVE POLICIES 117 (2008).

154 Id. at 117.

155 Id. at 19 (indicating effectiveness for PV to be "lower by a factor of ten than more mature RET such as wind energy").

156 Japan, like the US, applied investment subsidies as the main incentive scheme. Id. at 121.

157 Id. at 19.

158 Id.

159 Degression rates "refers to a predetermined (often annual) percentage decrease in the support level for a given renewable energy installation. Id. at 19 (2008).

160 Id.

161 Id.

162 Id. at 122.

163 Id. at 19.

164 Id.

165 Id. at 122.

166 Id. at 122.

167 Switzerland has a feed-in tariff with relative low remuneration level. Id.

168 Id.

169 Japan used a 50% investment incentive program. Id.

170 Id.

171 Id.

172 Id.

173 This includes watershed management efforts such as the EU's Water Framework Directive. See http://ec.europa.eu/environment/water/water-framework/index_en.html (last visited August 22, 2010).

174 Id. at 19 (noting that Canada and Turkey are exceptions to the statement that hydropower deployment in OECD countries is small).

175 Id.

176 Id. China, India, and Brazil each increased installed capacity during the 2000-2005 period. Id. at 139. China's policy is based on case-by-case investment incentives. Id. India previously had insignificant private investment, but introduced in 2003 new policies such as the 50,000 MW Hydro Initiative and Electricity Act to create a more investment friendly environment in order to realized India's full hydropower potential. Id. The impacts of these policies are still to be seen. Brazil focuses primarily on small scale projects which have seen good results since a new 2002 feed-in law. Id.

177 Id. at 135 (noting that enhanced geothermal electrical technology remains in the demonstration phase).

178 Id.

179 Id. at 136.

180 Id.

181 Id.

182 Id.

183 Id. at 20.

184 Id.

185 Id. at 138

186 Id.

187 Id. at 140.

188 Id. at 141. This technology includes a range of heat generating technology, including flat-glazed collectors, non-glazed collectors, and vacuum collectors with heat storage facilities.

189 Id. at 20.

190 Id. at 141.

191 Id. at 20.

192 Id.

193 Id. at 20-21

194 Id. at 21.

195 Id.

196 Id. at 144.

197 Efficiency is based on whether adequate heat demand is sufficiently close to the production of heat from this technology. Id. at 21.

198 Id. at 149.

199 Id.

200 Id. at 21.

201 Id.

202 Id.

203 Id. Density of heating demand and tradition of grid-connected heating deployment also are important. Id. Scandinavia's success likely is based on these factors, while Russia and China have the potential to satisfy them. Id.

204 Energy Independence and Security Act of 2007 (EISA2007) (Energy Independence and Security Act of 2007, Pub. L. No. 110-140, § 102, 121 Stat. 1492 (codified at 49 U.S.C. § 32902 (Westlaw 2008)). Note that Europe already requires an average of 40 miles per gallon. Reuven S. Avi-Yonah & David M. Uhlmann, Combatting Global Climate Change: Why a Carbon Tax is a Better Response to Global Warming than Cap and Trade, 28 Stan. Envtl. L. J. 21 (2009) (citing EISA 2007 and Peter Fairley, The New CAFE Standards: Fuel Standards Will Likely Be Achievable but Won't Encourage Innovation, Tech. Rev., Jan. 15, 2008, www.technologyreview.com/Energy/20067.]

205 International Energy Agency, DEPLOYING RENEWABLES – PRINCIPLES FOR EFFECTIVE POLICIES 22 (2008).

206 Id.

207 Id. at 21.

208 Id.

209 Id. at 22.

210 Id. at 21. See, e.g. Food, Conservation, and Energy Act of 2008 (Public Law 110-234) (specifying ethanol excise tax credit of $0.45 per gallon set to expire at the end of 2010); Emergency Economic Stabilization Act of 2008 (providing a $1.00-per-gallon tax credit for biodiesel which expired at the end of 2009 and applied to biodiesel from recycled vegetable oils or animal fats).

211 Id.

212 Id. at 22.

213 Id.

214 Id. at 21.

215 Id.

216 Europa – Summaries of EU Legislation, http://europa.eu/legislation_summaries/energy/renewable_energy/l21061_en.htm (last visited August 22, 2010).

217 Id.

218 Id.

219 Id.

220 Id.

221 Report from the Commission of 10 January 2007 – Biofuels Progress Report. Report on the progress made in the use of biofuels and other renewable fuels in the Member States of the European Union, http://europa.eu/legislation_summaries/energy/renewable_energy/l21061_en.htm (last visited August 22, 2010).

222 Europa – Summaries of EU Legislation, http://europa.eu/legislation_summaries/energy/renewable_energy/l21061_en.htm (last visited August 22, 2010).

223 Id.

224 See Inflation Adjusted Monthly Crude Oil Prices, Figure 1.

225 Id.

226 See A Historical Perspective on Energy Policy: A Time of Unusual Change and Uncertainty, prepared for the U.S. Senate Committee on Appropriations Energy and Water Development Subcommittee, pages 2-3 (2010) (testimony of Philip R. Sharp) available at http://www.rff.org/RFF/Documents/RFF-CTst-Sharp-April2010.pdf.

227 Id. at 4. The belief in long-term increased oil prices was founded both on an expectation of further OPEC coordination and a perception that global peak oil production had passed. Id.

228 Id. at 3. Paralleling this public investment were substantial levels of private investment and both private and public research and development. Id. at 3-4. See also, Figure 3, Figure 4 and Figure 5.

229 See Inflation Adjusted Monthly Crude Oil Prices, Figure 1 in Appendix II.

230 See A Historical Perspective, supra note 3 at page 4. Only a few energy regulatory programs lasted and became successful: the CAFE auto efficiency standards, other efficiency policies, and the Public Utility Regulatory Policies Act (PURPA). Many of these policies retained an element of cost effectiveness that was integral to their withstanding the collapse in oil prices. Id. at 6 and 7.

231 See Inflation Adjusted Monthly Crude Oil Prices, Figure 1, supra note 325. See William Nordhaus, Who's Afraid of a Big Bad Oil Shock?, Brookings Panel on Economic Activity, Special Anniversary Edition, page 2, September 2007, available at http://nordhaus.econ.yale.edu/Big_Bad_Oil_Shock_Meeting.pdf.

232 See Inflation Adjusted Monthly Crude Oil Prices, Figure 1, supra note 325.

233 See Gathering Clouds: Clean Technology in the Downturn, The Economist, November 6, 2008, available http://www.unep.ch/etb/events/green%20economy%20press%20covers/The%20Economist_Clean%20Technology.pdf.

234 See Annual Federal Energy R&D Investments by Major Program Area (in 2005 dollars), Figure 2.; Energy R&D Investment by Public and Private Sectors, Figure 3.; U.S. Department of Energy R&D Expenditures, Figure 4, and U.S. Department of Energy R&D Expenditures (without Nuclear R&D), Figure 5. Part of this parallelism can likely be attributed to the initial focus on energy independence and expectation of increased oil prices previously described in The Price of Oil Over the Last 40 Years. Likewise, the decrease in funding for research and development in the 1980s may correspond to the decrease in the price of oil over the same time frame.

235 See Patenting and Federal R&D for Wind – 1973-2005 (R&D in 2002 $m), Figure 6.; Patenting and Federal R&D for Photovoltaics – 1973-2005 (R&D in 2002 $m), Figure 7.

236 See Patenting and Federal R&D for Nuclear Fission – 1973-2005 (R&D in 2002 $m), Figure 8.; Patenting and Federal R&D for Nuclear Fusion – 1973-2005 (R&D in 2002 $m), Figure 9.

237 Id.

238 Id.

239 Id. Compared to other fields of research and development, private investment in energy research and development is rather low. See Gregory F. Nemet and D.M. Kammen, US Energy Research and Development: Declining Investment, Increasing Need, and the Feasibility of Expansion, January 1, 2007, available at http://dx.doi.org/10.1016/j.enpol.2005.12.012. Perhaps the spikes, dropoffs, and generally low levels in the price of oil have kept private investors from engaging too much in energy research and development. See also Private Sector R&D Investment between 1980 and 2003: Energy v. Drugs and Medicines (in 2002 $m), Figure 10. Although private investment occurred at similar levels for medicine and energy research and development in 1980, private investment in medicine research and development increased threefold between 1980 and 2000. Id. Private investment in energy research and development actually decreased in real dollars over that same time frame. Id.

240 See Annual Federal Energy R&D Investments, Figure 2, supra note.

241 Id.

242 AAAS R&D Funding Update: Congress Finalizes Omnibus Budget for FY2009: Increases Across All Major R&D Agencies, AAAS, page 12, March 20, 2009, available at http://www.aaas.org/spp/rd/FY2009update.pdf.

243 Id. at 6.

244 Id. at 6-7.

245 Id. at 7.

246 John Carey, The Real Question: Should Oil Be Cheap?, Bloomberg Businessweek, July 23, 2008, available at http://www.businessweek.com/magazine/content/08_31/b4094000658012.htm.

247 Id.

248 Philip Gordon, An Improbable Cure for Oil Addiction, Brookings Institute, Financial Times, May 12, 2006, available at

http://www.brookings.edu/opinions/2006/0512globalenvironment_gordon.aspx.

249 Richard Westin, The Case for a Crude Oil Price Stabilization Tax, 40 ELR 10328, pages 2-3, March 2010.

250 Oil Price Floors and Other Possible Solutions to the Mixed Blessings of Low Prices, Securing America's Future Energy, Intelligence Report: "Connecting the Dots on Energy Issues", Vol. 2 Issue 2, February 18, 2009, available at http://www.secureenergy.org/sites/default/files/986_SAFEIntelligenceReport2220090218.pdf.

251 Geoffrey Heal, The Economics of Renewable Energy, National Bureau of Economic Research, page 4, June 2009, available at http://gesd.free.fr/nb15081.pdf (noting that building capital intensive forms of energy production that do not have running costs equates to pre-paying for electricity produced over the next ~40 years). An additional quality of renewable energy derived from its carrying no running costs (beyond maintenance, repairs) is that the average cost of energy production depends on the amount of energy produced (more energy produced à lowered energy costs because up-front capital costs are already paid for). Id. at 5.

252 James Kanter, Producers Urge Obama to Take a Long View on Clean Energy Incentives, NYTimes.com: Green Blog, November 6, 2008,

available at http://green.blogs.nytimes.com/2008/11/06/producers-urge-obama-to-take-a-long-view-on-clean-energy-incentives/.

253 See The Economics of Renewable Energy at 10. This effect is particularly visible in investments in wind energy, both with and without the presence of Production Tax Credits. See Historic Impact of PTC Expiration on Annual Installation of Wind Capacity, Figure 12 in Appendix II.

254 Id. at 5-8. Some of these externalities include pollution (including greenhouse gas emissions), national security costs from reliance on foreign oil, and health effects from pollution. Id. at 5-8. Estimates of the actual social cost of fossil usage are wide ranging and inexact. Id. at 5-7. See also Ian Parry, Are Gasoline Taxes Too High, Resources for the Future, April 2001.; Ian Parry and Kenneth Small, Does Britain or the United States have the Correct Gasoline Tax?, American Economic Review, Vol. 95 No. 4, 2005; European Commission, External Costs: Research Results on Social-Environmental Damages Due to Electricity

and Transport, available at ec.europa.eu/research/energy/pdf/externe_en.pdf.; Stephen P.A. Brown and Hillard G. Huntington, Reassessing the Oil Security Premium, Resources for the Future, February 2010 (discussion paper).; William Nordhaus, A Question of Balance: Weighing the Options on Global Warming, Yale University Press, 2009; Nicholas Stern, The Economics of Climate Change: The Stern Review, London, H.M. Treasury. 2006.

255 Charles Krauthammer, The Net-Zero Gas Tax, January 5 - January 12, 2009, Vol. 14, No. 16, available at

http://www.weeklystandard.com/Content/Public/Articles/000/000/015/949rsrgi.asp. See also Oil Price Floors and Other Possible Solutions to the Mixed Blessings of Low Prices, Securing America's Future Energy: Intelligence Report, "Connecting the Dots on Energy Issues," February 18, 2009, Vol. 2 Issue 2, available at http://www.secureenergy.org/sites/default/files/986_SAFEIntelligenceReport2220090218.pdf. (concerning feebates). "For each class of vehicles, the government could tax the purchase of a car for each mile per gallon of fuel consumption it achieved below a pivot point and subsidize the purchase of a car for each mile per gallon of fuel consumption it achieved above a pivot point. The pivot point could be adjusted each model year to establish incentives for consistent increases in fuel economy or for alternative fuel vehicles. Similarly, the tax or rebate for each mile per gallon of fuel efficiency could be increased when oil prices fall in order to establish stronger incentives for more efficient cars and stronger penalties for less efficient ones. In fact, fees and rebates could be scaled aggressively enough to basically serve to "impose" a higher price of gasoline on consumers—say the equivalent of $75 a barrel (or higher, based on the level economists believe will change behavior)." Id.

256 President's Council on Sustainable Development, Towards A Sustainable America (1999).

257 Nina Easton, Guess Who Wants a Carbon Tax?, Fortune, Sept. 1, 2010.

258 Id.

259 Id. The average American uses 14 gallons of gas each week. Id.

260 Id.

261 Id.

262 Id.

263 Id. "A 2007 study done at the University of California, Davis, shows that during the oil shocks of the late 1970s, a 20 percent increase in oil prices produced a 6 percent drop in per capita gas consumption. During the first half of this decade, demand proved more resistant to change—until the dramatic increases of the last two years. Between November 2007 and October 2008, the United States experienced the largest continual decline in driving history (100 billion miles). Last August, shortly after pump prices peaked at $4.11 per gallon, the year-on-year decrease in driving reached 5.6 percent—the largest ever year-to-year decline recorded in a single month, reported the Department of Transportation. (Records go back to 1942.) At the same time, mass transit—buses, subways, and light rail—has seen record increases in ridership. Amtrak reported more riders and revenue in fiscal 2008 than ever in its 37-year history." Id.

264 Id. The gas tax creates pressure on consumer demand for more fuel efficient cars, decreased levels of car usage, increased public transportation, and decreased importing of foreign oil. Id.

265 Id.

266 Id.

267 Id.

268 See The Case for a Crude Oil Price Stabilization Tax at page 4, supra note 350.

269 Id.

270 Id. See also Approximate Retail Price Under Illustrative Alternative Fuel Price Stabilization Program (FPSP) Implementations, Figure 13.; Severin Bornstein, The Implications of a Gasoline Price Floor for the California Budget and Greenhouse Gas Emissions, Center for the Study of Energy Markets (CSEM) Working Paper Series, University of California Energy Institute, page 4, December 2008, available at http://www.ucei.berkeley.edu/PDF/csemwp182.pdf.

271 See The Case for a Crude Oil Price Stabilization Tax at page 5, supra note 350. Additionally, a supplementary tax against "imported refined products" would likely be necessary to protect U.S. processors and refiners from lost production. Id. See also The Implications of a Gasoline Price Floor for the California Budget and Greenhouse Gas Emissions at page 4, supra note 371. The target price depends on the desired sum of revenue the state wants, the level the state wants to promote alternatives / discourage use of fuel oil, and political saliency. Id.

272 Thomas Merrill and David Schizer, Energy Policy for an Economic Downturn: A Proposed Petroleum Fuel Price Stabilization Plan, Yale J. Regulation, January, 2010 (available online at http://findarticles.com/p/articles/mi_7780/is_201001/ai_n53078466/?tag=content;col1)

273 Id. at 6. In the course of a single day, "using a $75 floor and a $70 world price yields a daily revenue figure of $60 million." Id. However, direct revenues would be nullified by OPEC decreasing production to increase the price of oil. Id. at 20. See also Approximate State Revenues from Fuel Price Stabilization Program (FPSP) Under Illustrative Alternative Implementations, Figure 14.

274 See The Case for a Crude Oil Price Stabilization Tax at page 6, supra note 350.

275 Id. at 10-12. The price floor is compatible with other mechanisms to reduce greenhouse gas emissions (carbon taxes, cap-and-trade). Id. See also An Improbable Cure for Oil Addiction, supra note 349 (stating that price floor alone will not work; needs to be coordinated, supplemented by other policy initiatives to promote alternatives, decrease oil consumption).

276 See An Improbable Cure for Oil Addiction, supra note 349.

277 See The Case for a Crude Oil Price Stabilization Tax at page 6, supra note 350. Long-term planning is key for the oil, alternative energy, and energy-efficiency industries and for consumer planning. Id. at 6-8.

278 Id. at 6.

279 Id. at 6-7. But see Jerry Taylor and Peter Van Doren, An Argument Against Oil Price Minimums, Washingtonpost.com, May 29, 2006 (a added to cato.org on June 1, 2006), available at http://www.cato.org/pub_display.php?pub_id=6410 (stating how a price is politically unpalatable: that even if a price floor is instituted by Congress, if there is a sustained run of low oil prices, it is probable that later Congress' will repeal this policy). Additionally, the criticism was leveled that even with a price floor, the market would adjust to just push its prices up to meet the floor (one-way elevator). The consumer preference was also stated for a price environment of generally low oil prices with occasional spikes to an environment of consistently high oil prices. Id.

280 Severin Bornstein, The Implications of a Gasoline Price Floor for the California Budget and Greenhouse Gas Emissions, Center for the Study of Energy Markets Working Paper Series, University of California Energy Institute, page 7, December 2008, available at http://www.ucei.berkeley.edu/PDF/csemwp182.pdf.

281 Id. "If the current price of oil is $62 and the target price was going to be set to $82 under (a price floor), the surcharge would be set to cover 100% of the difference between $62 and $82. Instead, under a soft floor, the surcharge could be set to cover only 50% of the difference, but the target price could be set to $102. At $62/barrel, both implementations result in gas prices around $3.00, so these two programs generate the same surcharge and revenue. But as the price of oil changes, the retail price of gasoline captures about half of the change in the price of oil, as illustrated in figure 2. As a result, revenues under the soft floor change half as much as under the original plan. In this example, if the price of oil went to $82, revenues would drop by 100% under the original plan, but would only drop by about 50% under this soft floor with a 50% adjustment. Likewise, if the price of oil dropped below $62 in this example, revenues would only expand by half as much under the soft floor as they would under the "hard floor" in the original plan." Id. See also Figures 13 and 14.

282 See The Implications of a Gasoline Price Floor for the California Budget and Greenhouse Gas Emissions, supra note 381.

283 Oil Price Floors and Other Possible Solutions to the Mixed Blessings of Low Prices, Securing America's Future Energy: Intelligence Report, "Connecting the Dots on Energy Issues," February 18, 2009, Vol. 2 Issue 2, available at http://www.secureenergy.org/sites/default/files/986_SAFEIntelligenceReport2220090218.pdf.

284 Id.

285 The concerns of developing countries are outlined in detail in K. Ravi Srinivas, Climate Change, Technology Transfer and Intellectual Property Rights, April 2009 RIS Discussion Paper (available online at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1440742).

286 World Trade Organization, Frequently asked questions about TRIPS in the WTO, available at http://www.wto.org/english/tratop_e/trips_e/tripfq_e.htm#WhatAre.

287 Id.

288 Agreement on Trade-related Aspects of Intellectual Property Rights, World Trade Organization, art. 1:2 (1994), available at http://www.wto.org/english/docs_e/legal_e/27-trips_04_e.htm.

289 Id. at sec. III.

290 Id. at art. 1:2.

291 International Centre for Trade and Sustainable Development, Climate Change, Technology Transfer, and Intellectual Property Rights, 2 (August 2008), available at www.iisd.org/pdf/2008/cph_trade_climate_tech_transfer_ipr.pdf.

292 Id. The private sector may also take initiative to disseminate environmental technology outside of typical market forces. One example of such initiative is the World Business Council for Sustainable Development's Eco-Patent Commons. The WBCSD is an international association of approximately 200 companies dedicated to sustainable development. The Eco-Patent Commons is akin to open source software in that the forum is available for companies to upload and download environmental patents free of charge. World Business Council for Sustainable Development, Eco-Patent Commons, available at http://www.wbcsd.org/templates/TemplateWBCSD5/layout.asp?MenuID=1, then go to "Eco-Patent Commons."

293 International Centre for Trade and Sustainable Development, Climate Change, Technology Transfer, and Intellectual Property Rights, 2 (August 2008), available at www.iisd.org/pdf/2008/cph_trade_climate_tech_transfer_ipr.pdf.

294 United Nations Framework Convention on Climate Change, Parties & Observers, available at www.iisd.org/pdf/2008/cph_trade_climate_tech_transfer_ipr.pdf.

295 United Nations Framework Convention on Climate Change, Essential Background, available at http://unfccc.int/essential_background/items/2877.php.

296 United Nations Framework Convention on Climate Change, art. 4.3, available at http://unfccc.int/essential_background/convention/background/items/1362.php.

297 Id. Some member countries are concerned that as the demand and need for climate change technology increases, the cost of the technology will reach levels that least developed countries cannot possibly afford. See Copenhagen Economics A/S and the IPR Company ApS, Are IPR a Barrier to the Transfer of Climate Change Technology? 35 (Jan. 19, 2009), available at http://trade.ec.europa.eu/doclib/docs/2009/february/tradoc_142371.pdf.

298 Id. at art. 4.5. Even with this mention of potential sharing of technology and the attendant intellectual property concerns associated with such sharing, there is no direct mention of IP rights in the UNFCCC. Id.

299 Kyoto Protocol to the United Nations Framework Convention on Climate Change, art. 10 (1998), available at http://unfccc.int/resource/docs/convkp/kpeng.pdf.

300 United Nations Framework Convention on Climate Change, Report of the Conference of the Parties on its Thirteenth Session, Decision 4/CP.13 (December 2007), available at http://unfccc.int/resource/docs/2007/cop13/eng/06a01.pdf#page=26.

301 Id. at Decision 1.

302 Agreement on Trade-related Aspects of Intellectual Property Rights, World Trade Organization (1994), available at http://www.wto.org/english/docs_e/legal_e/27-trips_04_e.htm.

303 International Centre for Trade and Sustainable Development, Climate Change, Technology Transfer, and Intellectual Property Rights, 3 (August 2008), available at www.iisd.org/pdf/2008/cph_trade_climate_tech_transfer_ipr.pdf.

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02

GERMAN PERSPECTIVES ON ECOLOGICAL MODERNIZATION, TECHNOLOGY TRANSFER, AND INTELLECTUAL PROPERTY RIGHTS IN THE CASE OF CLIMATE CHANGE

MIRANDA A. SCHREURS

Introduction

Climate change is an important policy issue that has been addressed by successive German governments. The German government and industry have pursued policies that link climate mitigation to the country's own economic transformation. Domestic climate policies and programs have put Germany at the forefront among large industrialized countries in tackling greenhouse gas emissions. As of the end of 2009, German greenhouse gas emissions had fallen by 28.7 percent relative to 1990 levels.[1] Germany has also been a driving force in the development of climate and renewable energy policy at the European Union level.

With the date of the end of the Kyoto Protocol nearing, efforts to form a post-Kyoto climate agreement continue. The need to bring developing countries into a post-Kyoto climate agreement are bringing issues related to technology transfer and intellectual property rights more strongly to the fore. This essay examines the issue of technology transfer as a means for addressing rising greenhouse gas emissions in developing countries. It pays special attention to the views of Germany, a global leader in green technology, climate mitigation, and environmental and energy technology exports. The essay begins with a brief overview of current greenhouse gas emissions, population, and energy trends. It then provides an assessment of why technology transfer and intellectual property rights are key issues in the climate change discussions, the role that technology transfer has played under the Kyoto Protocol, and recent developments in the international climate negotiations pertaining to technology transfer and intellectual property rights. It then considers the positions of Germany and the European Union in relation to these questions.

THE INTERNATIONAL CLIMATE NEGOTIATIONS

The international climate negotiations are being held against the backdrop of rising global greenhouse gas emissions, an expanding global population, and growing demands for energy, especially in transition economies. The past several years have seen only limited forward progress toward the establishment of a global climate change agreement. In Copenhagen in December 2009, countries agreed to establish voluntary emission targets, but no legally binding agreement was reached. Expectations are that in Cancun in December 2010 and in Cape Town in 2011, negotiators will seek to make progress on rules governing technology and financial transfers and intellectual property rights. Whether a binding international agreement can be reached remains an open question.

GREENHOUSE GAS EMISSION TRENDS

Despite close to two decades of international negotiations related to climate change, global greenhouse gas emissions continue to rise. According to the Netherlands' Environmental Assessment Agency, global greenhouse gas emissions in 2008 were 41 percent higher than in 1990.[2]

The United States, Europe, Canada, and Japan are responsible for the vast majority of the historically emitted greenhouse gases. Yet, in the years to come developing countries will contribute the majority of greenhouse gases emitted into the atmosphere. It is noteworthy that in 2008, developing countries

contributed 50.3 percent of global greenhouse gas emissions, for the first time exceeding emissions from developed countries. China, moreover, has surpassed the United States as the largest greenhouse gas emitter.[3] Among transition economies, China, India, Brazil, Russia, South Africa, and Indonesia will be particularly large contributors to future emissions.

Developing countries were not required under the Kyoto Protocol to cut emissions. Instead, the Kyoto Protocol called upon developed countries to "Cooperate in the promotion of effective modalities for the development, application and diffusion of, and take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies, know-how, practices and processes pertinent to climate change, in particular to developing countries, including the formulation of policies and programmes for the effective transfer of environmentally sound technologies that are publicly owned or in the public domain and the creation of an enabling environment for the private sector, to promote and enhance the transfer or, and access to, environmentally sound technologies."[4] It also called for cooperation with developing countries in developing training and educational programs.

While the Kyoto Protocol did result in the development of some new initiatives promoting technology transfer to developing countries, the scale of transfer has remained limited. Efforts to bring developing countries into a global climate change agreement will be heavily influenced by the kinds of technology and financial transfer mechanisms that are developed. Developed countries, however, remain reluctant to make major technology or financial transfers without protection of intellectual property rights and assurances that financial and technology transfers are used for intended climate mitigation and adaptation purposes.

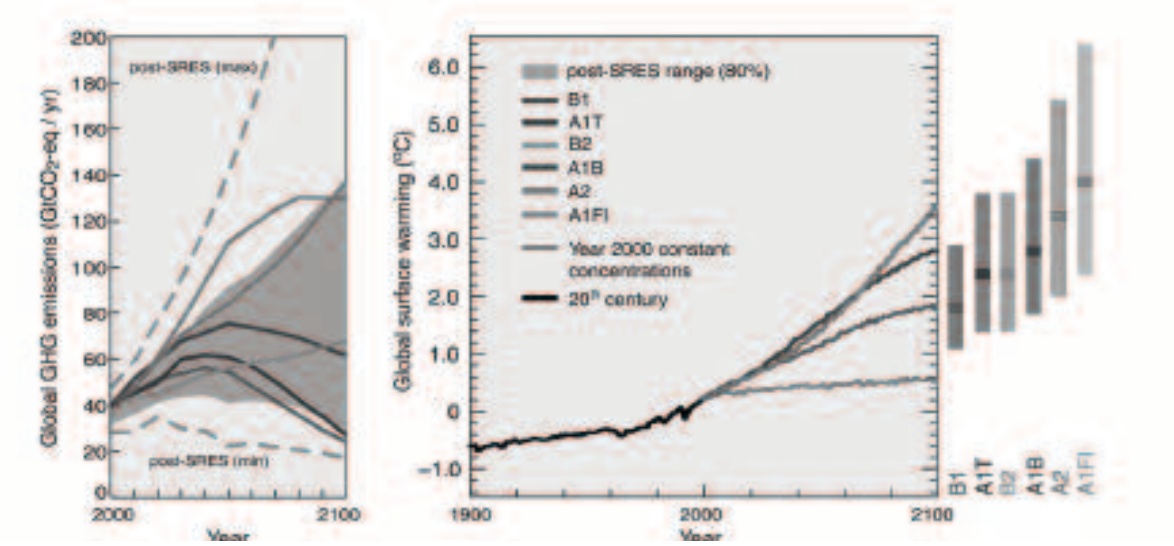
Unless especially large emitting developing economies control the rise in their greenhouse gas emissions, efforts to prevent major changes in global mean temperatures are likely to fail. Yet, from the perspective of developing countries, historic responsibility for the global warming experienced today rests largely with the developed economies. Developing countries also point to the major inequities that exist between first and third world countries in terms of their energy consumption and greenhouse gas emissions. Indeed, per capita carbon dioxide emissions in the United States (19.1 tons (2007 data)) are double those of Germany (9.7 tons), more than 17 times those of India (1.2), and approximately four times more than in China (4.6).[5]

GLOBAL TEMPERATURE CHANGE

The Intergovernmental Panel on Climate Change (IPCC) estimates that if global greenhouse gas emissions follow a business as usual growth pattern, global average temperatures could rise by several degrees Centigrade in the coming century. The IPCC's Fourth Assessment Report warns that when average global temperatures rise, the risk of severe weather events and unpredictable tipping points rises substantially. Tipping points can occur when changes in the earth system can no longer be reversed (such as when there is a change in the directional pattern of an ocean current or the extinction of species that are incapable of adapting to the rapid temperature changes). The extent of the temperature changes will be dependent upon future greenhouse gas emission levels. Sharp immediate reductions in greenhouse gas emissions could limit average temperature increases. A continued growth in emissions (a business as usual scenario) could result in temperature increases of several degrees Centigrade in the coming century. Rising average global temperatures are predicted to result in increasingly severe weather patterns, including longer droughts, heavier rainfall, and higher temperature extremes. A major concern is that the Arctic and mountainous glaciers, which store much of the world's fresh water, will begin to melt. This could cause coastal flooding, shifts in ocean currents that regulate temperatures in many parts of the world, and changes to major weather patterns.[6]

An international consensus is slowly emerging behind the importance of limiting the rise in global average temperatures. The small island states are arguing that anything above a 1.5 degree Centigrade rise threatens their survival. Internationally, however, a 2 degrees Centigrade target appears to be taking hold.

Figure 1: Predicted Greenhouse Gas Emissions, 200-2010 and Global Average Surface Warming, 1900-2010[7]



The IPCC has produced a range of different scenarios for greenhouse gas concentrations and possible temperature increases depending on future energy mixes, population trends, and socio-economic conditions. The best estimates of the scenarios range from a 1.8 to a 4 degree Centigrade increase in global average temperatures over the course of the next century although the bars on the right of the graph show that the possible range of temperature increase for each scenario varies considerably and in a worst case scenario (A1F1) could exceed a 6 degree Centigrade increase. Scenario A1F1 assumes a world that remains heavily dependent on fossil fuels.

GROWING DEMAND FOR ENERGY AND RESOURCES

The rise in greenhouse gas concentrations in the atmosphere will be exacerbated insofar as the global population is expected to increase from its current 6.5 billion to approximately 9 billion by the middle of the century. In addition, efforts are continuing to extend access to electricity to the close to 1.5 billion people who currently live without it.[8] There will be a strong growth in demand for energy, food, and natural resources in the coming decades.

Beyond this, the rapid economic development occurring in numerous transition economies means that the demand for energy and other resources will grow dramatically. China's shift in the early 2000s from being self-sufficient in its energy supply to needing to import oil, coal, and natural gas from abroad to meet its energy demand is an indication of a changing global economic order. In the future, demand for limited supplies of fossil fuels can be expected to grow. Similarly, as middle classes expand in transition economies, consumption levels grow and demand for consumer goods expands.

Given these factors, technology transfer is needed both for mitigation efforts and adaptation. In terms of mitigation, technology transfer is necessary to help developing countries use energy and resources more efficiently. Energy inefficiencies are extremely high in the developing world; it can take several times more energy to produce an equivalent unit of gross domestic product (GDP) in the developing world as it does in the developed. Improving energy and resource efficiencies is one goal of technology transfer and, as such, makes technology transfer an essential element of climate change strategies.

Figure 2: Atmospheric Concentration of Carbon Dioxide, 1958-2010[9]

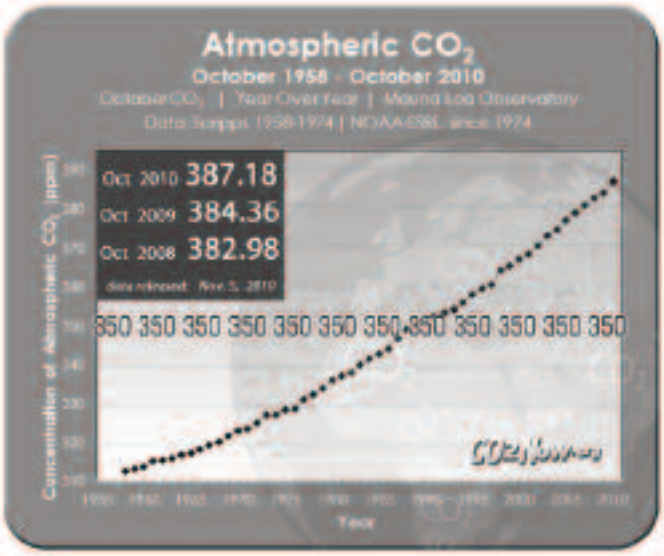
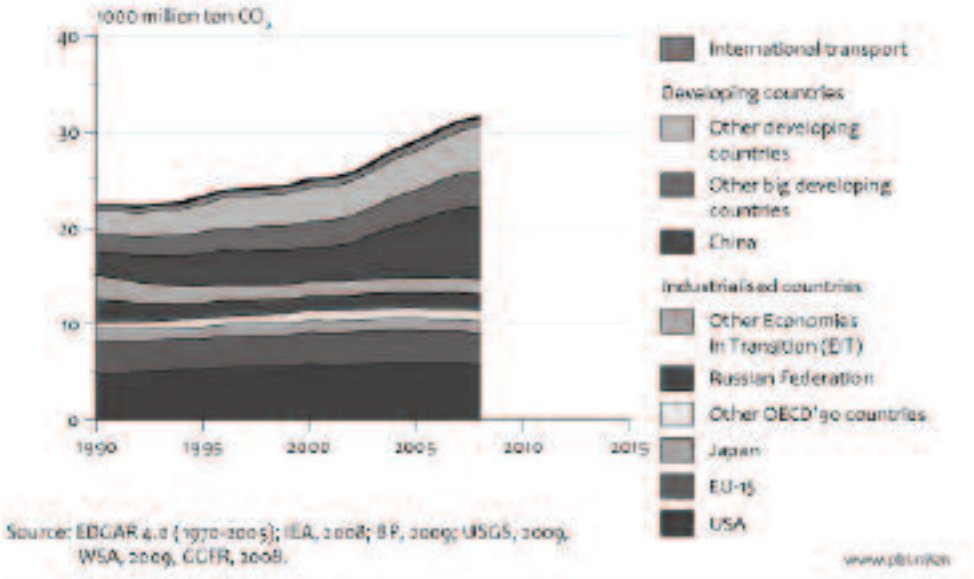


Figure 3: Global CO_2 Emission from Fuel Use and Cement Production by Region[10]



Early Considerations of Technology Transfer: The Kyoto Protocol and the Clean Development Mechanism

The Kyoto Protocol led to the development of what are known as "flexibility mechanisms" that were designed to provide Annex I (industrialized) countries with some flexibility in how they meet their emission reduction targets while at the same time assisting developing countries in improving energy efficiency or reducing reliance on fossil fuels. Three flexibility mechanisms were included in the agreement: joint implementation, the clean development mechanism, and carbon emissions trading. Joint Implementation (JI) and the Clean Development Mechanism (CDM) are variations on a theme. Joint Implementation permits developed countries to take greenhouse gas reduction measures outside of their own borders—in countries in transition that are listed in Annex 1 of the Kyoto Protocol (primarily the central and eastern European economies)—but still get credit toward their own emission reductions. The clean development mechanism follows the same principle, but is between developed and developing countries. The clean development mechanism (CDM) was conceptualized as well as a means to assist developing countries to develop more sustainably by the transfer of climate change technology and know-how from industrialized to developing countries. In order for a project to qualify for certified emission reduction credits, that is, for approval as a project that can be counted toward a developed country's domestic emission reduction requirements, projects have to be certified by the UNFCCC secretariat and must fulfill "additionality" criteria. In other words, they are only to be certified by the CDM Executive Board if the projects can be shown to reduce greenhouse gas emissions (e.g., energy efficiency improvements in a utility) or prevent the release of more emissions (e.g., the building of a wind park to prevent the need to build a new coal-fired power plant) and would not have occurred anyways under the normal progress of development.

The European Union Emissions Trading Scheme (EU ETS) was introduced to control emissions from big polluters—approximately 11,000 power stations and industrial plants that together are responsible for about half of all carbon dioxide emissions in Europe. Under the EU ETS installations have been allocated carbon emission allowances. Each industrial facility must have enough allowances to cover its emission levels. Excess allowances can be sold off or kept to cover future emissions. The entire number of allowances is limited by a system-wide cap that is decreased over time. Certified emission reductions achieved through the CDM or Joint Implementation also can be brought into the EU ETS.

The Clean Development Mechanism has had mixed success. On the positive side, it has involved several developing countries more actively in climate mitigation efforts, helped to raise awareness, and prevented the release of millions of tons of carbon equivalents. The CDM Secretariat claims that the over 2,300 projects approved as of September 2010 contributed 1.82 billion certified emission reduction credits.[11]

In the early days, many Clean Development Mechanism projects targeted the elimination of hydrofluorocarbons, chemicals that were introduced as substitutes for chlorofluorocarbons. Chlorofluorocarbons were banned under the Montreal Protocol because they destroyed ozone in the stratosphere (the Ozone Layer. Ozone is naturally found in the stratosphere and provides protection from the sun's ultraviolet radiation). The introduction of hydrofluorocarbons, however, turned out to be a case of replacing one bad with another. Hydrofluorocarbons have an extremely high global warming potential. Global warming potential refers to the heat absorbing capacity and longevity of a greenhouse gas in the atmosphere relative to carbon dioxide. The higher the global warming potential of a gas relative to carbon dioxide, the more potent it is as a greenhouse gas. Carbon dioxide is the most abundant greenhouse gas, but there are in fact many greenhouse gases (e.g., including methane, nitrous oxide, and various hydrofluorocarbons and perfluorocarbons). All have global warming potentials that are many times and often several hundred to several thousand times higher than carbon dioxide.[12] Thus, the elimination of the development and use of these potent greenhouse gases was an early target of the CDM.

Over time, CDM projects expanded to include a wide variety of renewable energy and energy efficiency projects. Now many CDM projects are focused on

development of hydro, wind, photovoltaic, and biomass energy projects and the capturing of greenhouse gas emissions, e.g., from gas flaring and landfills or in chemical plants.

More critically, the CDM has had trouble taking hold in many countries that are not seen as attractive by developed countries. Thus, the vast majority of all CDM projects went to China and India while Africa obtained only a handful of projects in total. As of September 2010, of the 2,365 registered projects, 1,828 had gone to the Asia Pacific region, 478 to Latin America and the Caribbean, and only 46 to Africa and 13 to eastern Europe.[13] There are also concerns that some of the projects that were approved as CDM projects are not really additional[14] and that the scale of the CDM, which is project-based, is too small to lead to the kinds of large scale transitions that are needed.

The CDM mechanism has been heavily used by the United Kingdom, accounting for 28.49 percent of all registered projects. Switzerland (19.67 percent), the Netherlands (11.46 percent), Japan (11.42 percent), and Sweden (7.14 percent) all follow. Germany was slower than these countries to focus attention on the CDM but has become more actively involved in recent years, including with CDM capacity building projects in developing countries. Germany was responsible for 5.46 percent of all registered CDM projects as of September 2010.[15]

Carbon emissions trading represents the third, and most important flexibility mechanism from a German and European perspective. Initially resisted strongly by Germany, it has became one of Europe's central tools for achieving emission reductions and has played a substantial role in helping Germany reduce emissions.[16] Approximately 75 percent of German companies covered by the EU Emissions Trading Scheme were actively participating in emissions trading or planning to do so as of 2009.[17] German companies are also trading emission reduction credits achieved with CDM and JI projects under the EU ETS.

Technology Transfer in a Post-Kyoto Climate Regime

Efforts to develop a post-Kyoto climate agreement focus on the importance of broad participation by both developed and developing countries. Unlike the Kyoto Protocol, which only mandated action by Annex I (developed) countries, a post-Kyoto climate agreement will require participation by both developed and developing economies. With developing countries accounting for an expanding percentage of global greenhouse gas emissions, gaining developing country support for joint action is crucial. Technology transfer will be a critical component of helping developing countries to address climate mitigation and adaptation challenges and winning their cooperation. It is widely agreed that the CDM and JI mechanisms are not adequate to meet the scale of the problems found in developing countries. Thus, reform (or replacement) of the mechanisms is being actively discussed internationally.

TECHNOLOGIES FOR GREENHOUSE GAS MITIGATION IN DEVELOPING COUNTRIES

As the ability to buy scooters, motorbikes, and automobiles expands, transportation-related emissions are soaring in many developing countries. Urban areas have mushroomed, roads have proliferated, and traffic congestion has become a reality of life. Few developing countries, however, have developed adequate public transportation structures to reduce dependence on automobiles. Aiding urban communities to introduce subways, bus-rapid transit (as in Bogota, Colombia), car-sharing, and other strategies will be an important goal of technology transfer in the years to come. Technologies are also needed that are more effective at heating and cooling, at capturing pollutants, and at limiting resource inputs. Assisting developing countries in reducing their dependence on highly polluting fossil fuels and encouraging the development of renewable energy and energy efficiency technologies will be important if the global rise in greenhouse gases is to be controlled.

In less developed countries there are few automobiles and motorbikes and per capita greenhouse gas emissions are low; nevertheless, there are many challenges that need to be addressed. Small scale boilers

and wood or coal-burning cooking stoves are common. These tend to be very energy inefficient, highly polluting, and dangerous to human health. In any future global agreement, means to aid least developed countries to develop in sustainable directions needs to be considered. For example, helping developing countries to transition to alternative cooking and heating technologies will not only reduce greenhouse gas emissions, it can reduce the pressure on forests and improve the quality of life, especially for women. Open landfills, which are also common in less developed countries, can produce large amounts of methane, a greenhouse gas with a very high global warming potential. This methane can either be captured or alternative waste management structures can be introduced.

TECHNOLOGIES FOR CLIMATE ADAPTATION

At the time the Kyoto Protocol was formulated the main focus of discussion and action was on mitigation. Internationally, climate change discussions are increasingly expanding to include discussions of adaptation. In terms of adaptation, technologies are needed that can help developing countries address new climatic realities. One particularly important area for adaptation work is in relation to water. Water scarcity is emerging as one of the most dire environmental threats of the century. Climate change could exacerbate water shortage problems. This makes it important to help developing countries reduce water loss in agricultural production and adapt their agricultural production to increasingly saline soils.

At the same time, for other regions, water excess is the problem (note the 2010 floods in Pakistan that affected over one million people). Helping countries introduce flood control technologies and strategies will become increasingly important and is the kind of project expected to be carried out with developed country assistance.

DEVELOPMENTS IN THE INTERNATIONAL CLIMATE NEGOTIATIONS

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC), negotiated in 1997, covers the period through 2012. Efforts to establish a successor agreement have proved problematic. At the 15th Conference of the Parties to the UNFCCC in Copenhagen in December 2009, no mandatory targets or timetables for emission reductions were established and no agreement on a binding international agreement could be reached.

Instead, a group of fifteen countries hammered out a non-binding accord that was later adopted by the General Assembly. The Copenhagen Accord sets a goal of keeping global warming temperature increases to no more than 2 degrees Centigrade. Individual nations have made voluntary pledges indicating what they will do to try to make achieving this goal possible. The European Union, for example, pledged a 20 percent carbon dioxide emission reduction relative to 1990 levels by 2020 or 30 percent if other countries take comparable action. The United States announced a target "in the range of 17%, in conformity with anticipated U.S. energy and climate legislation, recognizing that the final target will be reported to the Secretariat in light of enacted legislation."[18] Canada aligned itself with the U.S. position. Australia announced an unconditional 5 percent emission reduction target on a 2000 base year moving to 15 to 25 percent reduction if other countries take comparable action.[19] China announced its plans to pursue a 40 to 45 percent improvement in carbon intensity (amount of carbon dioxide emissions per unit of GDP) by 2020 relative to 2005 levels, increase the share of non-fossil fuels in its primary energy mix to around 15 percent by 2020, and expand forest coverage. India announced its plans for a 20 to 25 percent carbon intensity improvement. Brazil has pledged to work to improve its energy efficiency, expand renewable energies, and slow deforestation with a goal of a 36.1 to 38.9 percent reduction in business as usual emissions growth by 2020.[20] There are currently over 120 states that have associated themselves with the Copenhagen Accord.

In addition, agreement was reached on fast-track climate funding of $30 billion until 2012 to be paid into a Copenhagen Green Climate Fund to aid developing countries in addressing climate change. Payments by developed countries into the fund are to rise to $100 billion per year by 2020. Many details on how these funds are to be allocated and distributed remain open. The EU committed to paying €2.4 billion annually through 2012 but has also indicated that

future funding will be contingent on there being some kind of international deal.[21] Germany pledged €350 million for 2010, €410 million for 2011, and €500 million for 2012.[22]

Beyond the adaptation fund, a new instrument known as REDD+ (Reduction of Emissions from Deforested and Degraded areas) began to be seriously discussed. REDD+ looks at ways of establishing sustainable forest projects financed by developed countries to provide incentives for developing countries to protect their forests in ways that are somewhat analogous to the CDM but focused on forest protection as a climate mitigation measure.

The future of the international climate negotiations is rather uncertain at this moment in time. Expectations are extremely low for the 16th COP to the UNFCCC that will take place in Cancun, Mexico in December 2010. Little progress on moving toward a post-Kyoto treaty with binding emission targets is expected. Instead, delegates are expected to focus their attention on making progress on technical details associated with the emerging frameworks for financial and technology transfer for climate mitigation and adaptation in developing countries and on the REDD+.

The Copenhagen Accord can be seen as a small step forward, but it has been widely assessed as weak and far from what is needed to reduce global greenhouse gas emissions by the amount scientists warn is necessary. According to a report prepared by German Watch and WWF International, the pledges are too small to have much effect, and put the globe on a trajectory toward a minimum 3 degree C global warming.[23]

There are numerous conflict points that have made progress in the international negotiations difficult but several are related to the north-south divide.

Developing countries are quick to point out the responsibility of North America, Europe, and Japan for causing the accumulation of greenhouse gas emissions in the atmosphere today. They argue that developed countries must take major steps to reduce their greenhouse gas emissions (going into the Copenhagen meeting, for example, the G77, a block of 130 nations, was calling on the Annex I countries to commit to an aggregate 40 percent emission cut relative to 1990 levels by 2020).[24] In contrast, developed countries are wary of taking on major emission reduction goals unless developing countries also agree to take on emission improvement strategies. This call has emanated most strongly from the United States ever since the U.S. Senate passed the Byrd-Hagel Resolution, which sent a strong message to the president that the Senate would not support any climate agreement that did not also require meaningful action by developing countries. Similar sentiments continue to prevail.

Countries in Europe have expressed similar concerns fearing that their industries might shift their manufacturing base to countries with lower emission standards (a kind of carbon leakage) if developing countries are not expected to take action to cut emissions as well. There is a fear of "unfair" competition from developing countries that can produce products at lower costs, especially if they are not bound by the same kinds of environmental restrictions being asked of developed countries. In Germany, such concerns are voiced by the cement, iron and steel, and metal work industries, among others. There are also concerns about developing countries winning manufacturing jobs in industries where in the past European companies have been strong. This has been the case, for example, with a growing number of developing country firms involved in the manufacturing of photovoltaic cells and wind turbines, for example.

Four leading transition economies (China, India, South Africa, and Brazil) that form the BASIC Group announced their determination to cooperate on climate science and pledged to assist the least developed countries with climate technology. They also are calling for the development of a legally binding climate agreement and demanding that developed countries follow through on the financial pledges of support made for developing countries in Copenhagen.[25]

The very different perspectives and interests of countries have complicated the global climate negotiations. This is visible in relation to intellectual property rights and technology transfer as well.

Intellectual Property Rights and Technology Transfer

There are several major debates regarding intellectual property rights and technology transfer as it pertains to climate change. Developing countries frequently argue that intellectual property rights (IPR) are a barrier to technology transfer, citing the expense and restrictions imposed by patents. Intended to protect the research and development investments made by individuals and companies involved in product and process development, patents give developers the right to sell licenses for the use of their inventions by third parties for a designated period of time (often twenty years). In the climate change area, the need for a scaling-up of the rate and level of clean technology transfer would argue for a system that would simplify access to new technologies for developing countries.

The developers of technology, on the other hand, argue for strengthened IPR protections. They argue that they have few incentives to invest in clean technology R&D if their inventions are not adequately and fairly protected. They argue that to stimulate climate technology research and development, stricter IPR protections are needed globally.

A 2009 Chatham House report on IPR and technology transfer for climate change reached several important findings and conclusions. First, the rate of approval, introduction, and wide-scale dissemination of clean technologies is taking too long (on average twenty-four years). The report found that clean technology patents are dominated by the United States, Japan, and Germany. No Chinese, Indian, or Brazilian firms were among the top ten patent producers in the fields examined (wind, solar photovoltaic, concentrated solar power, biomass-to-electricity, cleaner coal, and carbon capture) although some were among the top twenty.[26]

Patent holders and manufacturers are not always the same. In the wind power sector there were more manufacturers that were also patent holders than in the case of photovoltaics. In general, the study found that major industrial corporations held the largest share of patents and that their perception of market conditions and intellectual property protection in the target economy greatly influences their rate of roll-out of new clean energy technologies.

To foster the diffusion of clean technologies, the report made several recommendations: public support in the form of grants, loans, and risk guarantees for global demonstration projects for high-risk technologies (such as carbon capture and sequestration (CCS) and concentrated solar power (CSP)); strengthening technology standard bodies to promote the diffusion of higher technology standards; innovation support schemes (such as technology prizes); development of schemes to enhance international cooperative R&D; and patent pools (such as can be found with the European Union's European Platform for Zero Emissions Fossil Fuel Power Plants).

Domestic Leadership in Climate Change Policies: The Case of Germany

Germany is a global leader in clean technology export, the development of green jobs, and promotion of development toward a green economy.[27] This is in large part due to the federal government's strong climate policies and the embrace of the concept of ecological modernization. There is a generally robust consensus in Germany that the country's long-term economic competitiveness must be linked to the restructuring of the economy in a resource and energy efficient and climate-friendly direction. Germany has set ambitious greenhouse gas emission targets to signal to industry and society the direction that change must take. For Germany, it is critical that other EU member states also take action on climate change, that the European Union be a global leader on this issue, and that support be provided to developing countries to meet their mitigation and adaptation needs.

GERMAN INFLUENCE ON EUROPEAN POLICY

The Kyoto Protocol was negotiated in Japan in December 1997. It was ratified by the European Union in 2002, one year after the United States withdrew from the agreement. The Kyoto Protocol finally came into force in 2005 after a sufficient number of countries had transposed the agreement into national law. Under the Kyoto Protocol, the European Union agreed to an 8 percent reduction of its greenhouse

gas emissions by 2008-2012 relative to 1990 levels. This target applied only to the fifteen member states that were part of the European Community at the time the Kyoto Protocol was agreed upon.

Differences in the greenhouse gas emission levels, economic strength, and reduction potentials of the EU-15 were factors in the political decision that was reached in 1998 to distribute the responsibility for meeting the 8 percent reduction target differentially among the member states. Under the burden-sharing agreement, some countries, like Ireland, Greece, Portugal, Spain, and Sweden, were allowed to increase their emissions. France and Finland agreed to stabilize them at 1990 levels. Austria, Denmark, Germany, Italy, Luxembourg, the Netherlands, and the United Kingdom agreed to reductions. Germany agreed to reduce its emissions by 21 percent.

In 2010, the European Environment Agency reported that the European Union was on track to meeting its emission reduction requirements; 2009 emissions were 6.9 percent below 1990 levels.[28] Germany has surpassed its original target: At the end of 2008 greenhouse gas emission levels were 23.3 percent below 1990 levels (Figure 4).[29] Germany's (and the United Kingdom's) overachievement in obtaining their burden-sharing targets has helped make it possible for the European Union to be on track to meet and possibly surpass its Kyoto target (Figure 5).

Figure 4: Greenhouse Gas Emissions in Germany (1990-2009 compared to 2008-2012 Kyoto Target)[30]

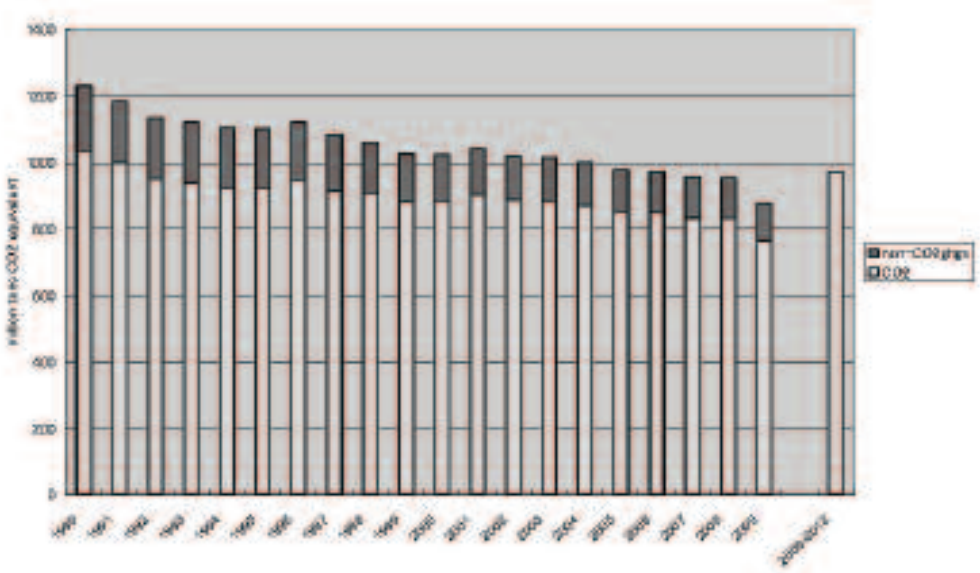
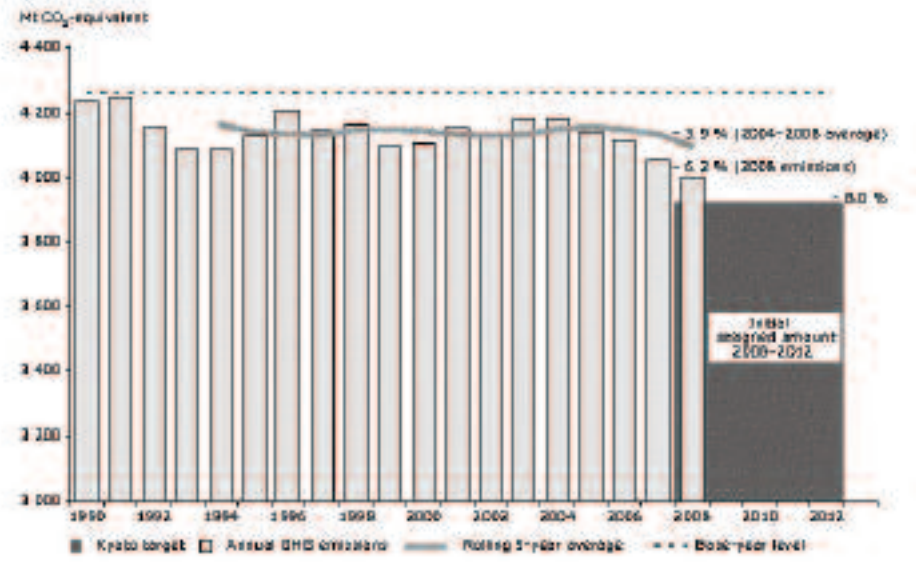


Figure 5: Greenhouse Gas Emissions in the European Union (1990-2008 compared to Kyoto Protocol Target)[31]



The Kyoto Protocol only covers the period through the end of 2012. Internationally, there have been a series of contentious negotiations to try to work out a successor agreement. With this in the background, work began within the EU on the development of a Climate and Energy Package that would provide European industry and society with signals about the future and hopefully, prompt the international negotiations forward. The Climate and Energy Package that came into effect in the spring of 2009, calls for a reduction of combined greenhouse gases by 20 percent of 1990 levels by 2020, an improvement of energy efficiency by 20 percent, and an increase in the share of renewables to 20 percent of total energy consumption by 2020. In addition, the plan calls for an increase in the share of biofuels to 10 percent of the fuel mix by 2020.[32] In reaction to the plan, the Federal Environment Ministry stated: "Implementing these decisions will call for a quantum leap in the development of industrial societies. The objective is no less than a fundamental restructuring of industrial societies to ensure that appropriate goods and services can be provided in 2050 for a world population that has grown from 6.5 billion to over 9 billion, while at the same time reducing emissions by 50 percent."[33]

Developments at the EU level built in part on domestic developments in Germany. In 2007, the German government announced plans to cut domestic emissions by about 40 percent below 1990 levels by 2020. Then, in the lead up to the G8 Summit in Heiligendamm in July 2007, Chancellor Angela Merkel called for limiting the warming of the planet to 2 degrees Celsius by 2050 to reduce the risks of extreme weather events and rising sea levels associated with anticipated alterations in the climatic system.[34] This basically equates to limiting the increase in carbon dioxide concentrations in the atmosphere from its pre-industrial level of 280 parts per million (ppm) to 450 ppm. Preventing a rise in global average temperatures above a 2 degree Celsius level will require drastic cuts in greenhouse gas emissions levels in the industrialized countries in the coming decades and eventual cuts in developing countries' emissions as well.

In April 2007, the German Federal Ministry for the Environment (*Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit*, BMU) issued "Climate Agenda 2020," a plan for achieving a 40 percent CO_2 emission reduction without relying on nuclear energy. The plan included a package of measures for increasing the share of renewables in elec-

tricity to 27 percent by 2020, doubling combined heat and power, modernizing power plants, and improving energy efficiency by 11 percent. In December 2007 Merkel's cabinet endorsed the Integrated Climate and Energy Program that called for a 40 percent emission reduction target by 2020 (compared with 1990 levels) and spelled out measures for meeting this goal.

Germany's renewable energy target was further strengthened under the amended Renewable Energy Law (*Erneubaren Energie Gesetz*, EEG) that took effect in January 2009. The goal of the EEG is to increase the share of renewables in total electricity to 30 percent by 2020 and to around half of electricity consumption by 2030.[35] The Renewable Energy Law (as amended) establishes fixed feed-in tariff rates for twenty year remuneration periods (with rates declining over time for new entrants). Particularly favorable rates were introduced for photovoltaics, offshore wind, and biomass. Utilities are required to buy the higher priced renewable power regardless of whether it is generated by commercial, industrial, or residential producers.[36]

The formation of the coalition between the CDU/CSU and the FDP in 2009 has brought some changes to Germany's climate and energy policies. In the fall of 2010, the CDU/CSU-FDP government issued a new Energy Concept for Germany. The concept builds on the decisions of earlier governments but also introduces important new elements.

The Energy Concept focuses on renewable energy as the energy of the future, development of a new grid structure, energy efficiency, research and development in energy, new mobility structures, and controversially, the extension of the running life time of Germany's remaining nuclear power plants.[37]

The cabinet decision to extend the running life time of Germany's nuclear power plants between eight and fourteen years depending on the age of the reactor is raising considerable opposition but was approved by the Bundestag in late October 2010. A tax on fuel rods is to be introduced, a portion of which is to go into a renewable energy investment fund.

In addition, the plan establishes medium-term targets for renewable energy (a 35 percent share by 2020, 50 percent by 2030, 65 percent by 2040, and 80 percent by 2050 in the electricity sector and 60 percent by 2050 for primary energy). It also outlines plans for energy efficiency improvements:

- 20 percent reduction in primary energy use by 2020 compared to 2008 levels and 50 percent reduction by 2050 (an improvement of 2.1 percent in energy productivity on average per year).

- Electricity use to be reduced by 10 percent of 2008 levels by 2020 and 25 percent by 2050.

- Energy efficiency improvements in the building sector shall increase from 1 percent to 2 percent of all buildings per year.

- In the transportation sector, energy use shall be reduced by 10 percent by 2020 and 40 percent by 2050 relative to 2005 levels.

A long-term 2050 CO_2 emission reduction target of 80 percent has also won approval. What one sees is an incremental tightening and ratcheting up of support for a clean energy economy.

Germany: A Global Leader in Clean Technology Export

Germany's green push has paid off in the form of jobs. A report prepared by the United Nations, entitled *Green Jobs: Can the Transition to Environmental Sustainability Spur New Kinds and Higher Levels of Employment*?, argues that in Germany environmental technology will quadruple over the coming years, reaching 16 percent of manufacturing output by 2030 and employing more people than the auto and machine tool industries.[38] Already, according to the German Environment Ministry, the renewable energy sector employs close to 250,000 people and generates over $240 billion in annual revenue. In 2007, it was estimated that roughly 1.5 million Germans work in environment-related jobs.[39] For Germany, investment in renewables has become more than an environmental strategy,; it is also a job strategy.

Beyond this, Germany is betting on clean technology as a means for maintaining export dominance. As Martin Jaenicke and others have argued, a country's ability to establish itself as a lead market in the development of new technological innovations can put it in a powerful position to set international product standards and become a major exporter.[40] Many of Germany's largest companies have determined that their future competitiveness will be tied to their ability to be energy and resource efficient and to develop as global market leaders in clean technologies. Building on the technological successes that were demanded in part by regulatory requirements in the climate and renewable energy areas, German industry has been able to capitalize on its domestic successes and start to export them internationally.

Germany's sustained efforts on climate change and other environmental issues over the past two decades has made it a world leader of clean technology exports. Germany surpassed the United States as the world's largest exporter of environmental technologies in 2004.[41] According to a study conducted by the *Niedersächsische Institut für Wirtschaftsforschung* (Institute for Economic Research of Lower Saxony) for the Federal Environment Agency, Germany accounted for 16 percent (€56 billion) of global environmental technology exports in 2006, compared with 15 percent for the United States and 9 percent for Japan. Particularly successful areas internationally have been with measuring, controlling, and regulating water and waste water technologies and technologies for clear air, noise protection, and recycling. Germany is particularly strong in exports of measuring and control technologies, such as instruments for measuring heat volumes. The fastest growing export area has been in the renewable energy sector with an annual growth rate of close to 25 percent in the mid-2000s. In 2007, the export volume for "potential environmental goods" was close to €60 billion, about the same level as the electrical engineering industry.[42]

The German Environment Ministry established a program in 2006 to further aid German firms' penetration of the international market through its Export Initiative Recycling and Efficiency Technologies.[43] The German BMU and the Federal Ministry of Economics and Technology (*Bundesministerium für Wirtschaft und Technologie*, BMWi) have jointly established a portal, www.cleaner-production.de, to promote German environmental technologies globally. The Federal Ministry for the Environment and the Federal Ministry of Education and Research (*Bundesministerium für Bildung und Forschung*, BMBF) worked together to push through a cabinet decision for an "Environmental Technologies Master Plan" in November 2008. The master plan highlights how policymakers can support German environmental industries to export their successes. Three areas are to be focused on first: water, raw materials, and climate change. The core elements of the master plan include research funding, the transfer and dissemination of new technology applications, enhancements in education and training, and the support of innovative small and medium-sized companies, especially in the area of international cooperation.[44]

One quite successful export area has been with waste recycling. Germany has developed advanced waste recycling and disposal systems and now has one of the world's highest recycling rates, recycling 75 percent of its waste domestically. Over 6,000 companies, employing 200,000 people are in this sector. Germany already accounts for about 25 percent of the international market in these products.

Another is in the renewable energy sector. In 2007, this sector had a turnover of about €25 billion, with the largest shares coming from biomass and solar and wind energies. By 2007, 14.2 percent of German gross electricity consumption and over 8 percent of total energy use was from renewable energy sources. There were around 19,460 wind turbines for electricity generation in Germany, with a capacity of around 22,247 megawatts.

Statistics produced in a report for the German Environment Ministry released in March 2008 suggest a strong growth in green jobs.[45] The number of jobs in the renewable energy sector jumped from 160,500 jobs in 2004 to 249,300 jobs in 2007 and 300,500 jobs in 2009. Of these about 109,000 were in biomass, 87,100 in wind power, and 79,600 in the solar sector.[46]

CLEAN TECH PATENTS

According to the Chatham House report mentioned above, the United States, Japan, and Germany are the top three countries producing patents in the fields of wind, solar photovoltaic, biomass, concentrated solar power, cleaner coal technology, and carbon capture. The United States is the top patent producer in all fields with Japan and Germany competing for second place. When the location of the parent company of the patent assignee is taken into consideration, Germany ranks in top place in the wind sector. Interestingly, patent filings in targeted export markets are also increasing. German firms are actively filing patent applications not only in the European Patent Office, but also in China.

VOICES OF CONCERN

Germany's strong domestic policies and programs for mitigating climate change are not embraced equally enthusiastically by all. There is growing fear among some energy-intensive German industrial sectors of both carbon leakage and international competition from developing country markets. Fossil fuel dependent industries regularly argue that the stringency of German climate policies relative to those of competitors in North America and Asia is driving up the costs of doing business in Germany and pushing firms to relocate outside the country. There is also growing concern about the competition that is coming from emerging economies that are moving into clean technology industries. This is particularly visible with such technologies as photovoltaics and wind power. This suggests the need for greater attention in the international negotiations to the development of strategies and institutions that support fair rules and procedures.

At the same time, the level of actual competition from developing countries needs to be put into an empirically-based perspective. According to a study released by the European Patent Office and the United Nations Environment Program, Japan, the United States, Germany, the Republic of Korea, France, and the United Kingdom together hold 80 percent of all patents in combating climate change. Japan is by far the leader, with the United States and Germany close together for second place. Germany leads in wind technology and solar thermal patenting. It comes in second rank for hydro/marine, biofuels, and geothermal, and third rank for solar PV, carbon capture, and integrated gasification combined cycle.

The study shows a surge of patenting since the formation of the Kyoto Protocol in 1997 and a continued heavy dominance by OECD countries in clean energy technology patenting. In specific technologies, some developing countries are starting to be more visible players in clean energy technology patenting. The study found that the top patent holders file patent claims in the other top patent holding countries. They also are likely to seek patent claims in China, which they increasingly view as an up-and-coming competitor. Interestingly, the study also found that the majority of organizations surveyed favored collaborative R&D activities with developing countries, patent out-licensing and joint ventures rather than patent pooling and cross-licensing.[47]

The evidence from these studies suggests that concerns raised by some companies and countries that a weak Intellectual Property Regime threatens innovation in developed countries is exagerated. While there are a growing number of countries pursuing patents in clean energy technologies and in some specific areas developing countries are becoming players, the real competition for Germany is still primarily from other OECD countries, and in particular, Japan and the United States. For these top inventors, future competitiveness is likely to be dependent on levels of private investment in and public support for research and development in clean energy technologies. This is an area where German companies can be concerned as both Japan and the United States are investing more heavily into energy-related research and development than is Germany.[48]

Conclusion

Internationally, Germany has become a leader in promoting ecological modernization and continues to pursue an energy policy domestically and within the European Union to promote a shift toward a low carbon energy future. Germany has been heavily involved in exporting clean energy and environmental technologies and has also engaged in technology transfer through the clean development mechanism.

The biggest competition for Germany as an innovator in clean energy and environmental technologies comes most strongly from Japan and then from the United States. While China, India, Brazil, and other developing countries are showing more interest in clean energy and environmental technologies, they still trail far behind Europe and North America in the acquisition of patents.

German involvement in shaping plans for the development of sound mechanisms for the promotion of clean technologies to developing country economies in the future will be important given Germany's leading role as a clean technology innovator. Rapidly rising global greenhouse gas emissions suggest that this is a policy area that must be given far more attention in the years ahead. Further progress in the international climate negotiations is likely to be closely tied to the strategies developed for cooperating with developing countries in the development and deployment of appropriate greenhouse gas mitigation and climate adaptation technologies. This is an area where Germany has much to offer other countries in terms of technology and know-how.

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