14. ENERGY SUBSIDIES AND THE ENVIRONMENT

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Overview

Many nations pursue policies that result in subsidising natural resource depletion and environmental degradation. These polices are sometimes inadvertent; other times, environmental harm is an incidental side-effect of policy objectives such as national defence, regional (often rural) development, or industrial competitiveness. The central role that energy plays in virtually every developed economy means that energy subsidies not only harm the environment directly, but increase environmental degradation associated with industrial production, agricultural production, and transportation as well. This paper illustrates the many energy subsidies that harm the environment; documents how subsidies in the US have favoured established, polluting energy sources; and identifies leverage points that OECD and their Member governments can use to reduce the impact that these subsidies have on environmental quality.

Energy subsidies encourage environmentally detrimental industrial structures

Energy subsidies influence the structure of consuming industries, as well as the structure of the energy industry itself. Subsidised energy can attract energy-intensive industries to locate in particular regions of the world, yielding industrialisation based on an artificial competitive advantage. Energy subsidies are also important in the agricultural systems of many industrialised nations, reducing the cost of key energy-intensive inputs. Transportation systems, as well, can be altered by both the magnitude of energy subsidies and their distribution across fuels.

Energy subsidies and industry

Governments have regularly attracted or retained energy-intensive industries through concessions on energy prices. One of the best examples of the use of energy subsidies as a core component of industrial policy is the primary aluminium industry. Electricity represents between 25 and 30 percent of total primary aluminium production costs[1], and primary aluminium production around the world receives heavily subsidised electricity.[2] These subsidies have led to "subsidy clusters," where

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decisions regarding industrial location are driven as much by government subsidies as by any inherent competitive advantage that a region may possess.[3]

The adverse environmental impacts of these subsidies include increased energy consumption, increased pollution from consuming industries, and the construction of unneeded power projects. Each of these repercussions can be seen in the primary aluminium sector. As increased "wheeling" makes electrical services more and more fungible, utilities that now sell subsidised electricity to smelters will be able to earn higher revenues by selling power to different customers in neighbouring markets. Unless power subsidies are stopped, the aluminium sector will continue to consume too much electricity, reducing the ability of their power suppliers (often hydroelectric) to displace the fossil-based electricity now being produced in surrounding utility districts. Low-cost electricity may also allow aluminium prices to be artificially low, impeding market substitutes such as plastics or steel that may be less energy-intensive.

Since materials recycling often saves prodigious amounts of energy (95 percent in the case of secondary versus primary aluminium), energy subsidies diminish the value of the energy embedded in the recycled commodity, hindering the substitution of recyclables for primary materials as well. For example, incremental energy subsidies to primary aluminium in 1989 were equal to between 6 and 17 percent of the then market price for scrap.[4] If energy subsidies were removed, the price of scrap would likely rise some portion of this amount to reflect the increased value of the energy savings through recycling.

Where energy subsidies are linked directly to long-term baseload power contracts, the viability of the power project itself comes into question. In some cases, if the plant had been required to charge customers the true cost of providing the electricity, it would not have been built. Consider the three dams built on the Asahan River in Indonesia to feed the P.T. Intalum aluminium smelter. The dams were ostensibly part of a regional development effort to bring residential electricity and industry to an undeveloped part of the country. However, the bulk of the project was financed through subsidised loans from the Japanese government, and the smelter alone utilises 98 percent of the dams' firm power. This leaves little for the residents or other industries.[5] Without subsidies that reduce the cost of the electricity from the dams, the smelter would not have been viable, and the dams themselves would most likely not have been built.

Energy subsidies and agriculture

In terms of the sheer quantity of output, the US agricultural system is one of the most prolific in the world. Productivity in terms of output per unit labour input is extremely high. When viewed in terms of energy input per food energy output, the US system is one of the world's least efficient, using about 9 calories of fossil fuel energy to put 1 calorie of food energy on the table.[6] This statistic demonstrates how reliant US agriculture is on cheap energy. Energy subsidies lead the farm sector to under-price synthetic chemical fertilizers and pesticides; the pumping of irrigation water (the water itself is subsidised in other ways as well); and the cost to till fields and harvest and ship produce to market. Energy subsidies also help to explain how the farm sector in the United States can continue to produce ethanol that requires 72 percent more energy to produce than it contains.[7]

Energy subsidies and transport

The energy profiles of various modes of transport vary significantly. While most systems rely on petroleum-based fuels, the consumption per passenger- (or freight-) mile vary. Subsidising energy reduces incentives to shift to less fuel-intensive transport. Energy prices can also be a significant factor in the size of market service areas for industrial commodities.

In describing the managerial revolution that so dramatically altered the shape of business in the United States during the last part of the 1800s, Alfred Chandler noted that *the railroad and the telegraph provided the fast, regular, and dependable transportation and communication so essential to high-volume production and distribution -- the hallmark of large modern manufacturing or marketing enterprises.*[8]

More generally, without reliable and efficient transportation for huge volumes of production inputs and outputs, many industries would not have been able to fully utilize the economies of scale that existed in their production processes. The utilization of economies of scale continues to be influenced by the cost of transport: as transportation costs rise, especially on land, the market area for large-scale centralised industries begins to contract. Lower-value bulk commodities, such as cement and steel, are most sensitive to these forces. Subsidised energy, by reducing the cost of transport, contributes to a greater degree of industrial centralisation than would occur in a free market.

Subsidies distort energy markets in environmentally-detrimental ways

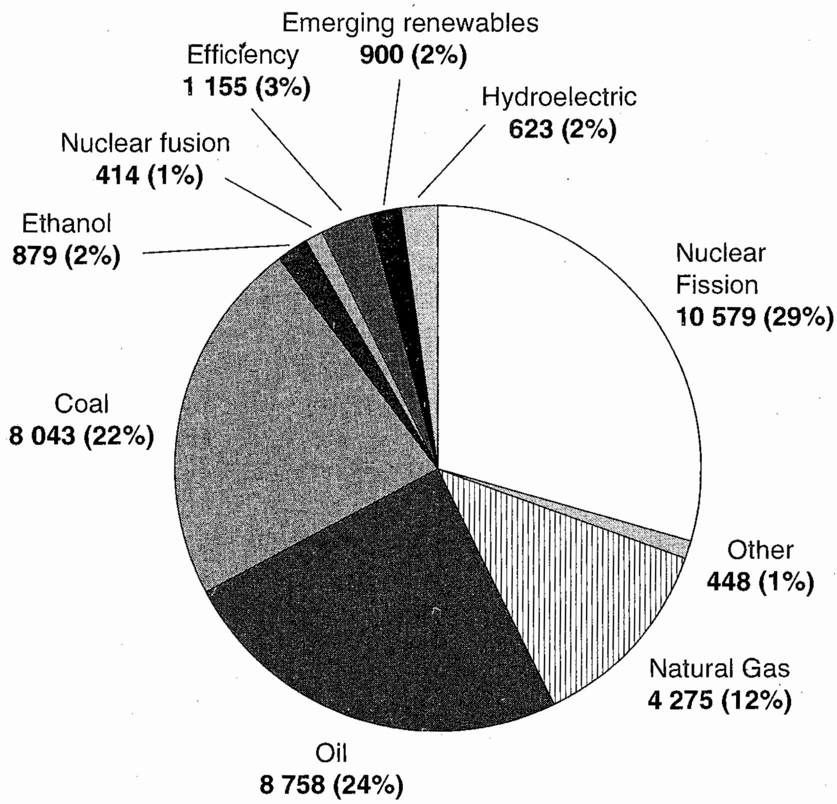
The extraction, refinement, transport, and consumption of energy create significant environmental problems in all media. Energy subsidies can exacerbate these impacts. Air emissions from vehicles, utilities, and industrial boilers generate particulate matter, metals, carbon monoxide, NO_x and SO_2. The combustion of fossil fuels is estimated to contribute to over 65 percent of all air pollution-related cancer cases.[9] NO_x and SO_2 contribute to acidic deposition, and NO_x is a contributing factor to ground-level ozone, a respiratory irritant.[10] Energy is also a major source of greenhouse gases, comprising roughly 55 to 60 percent of all anthropogenic emissions.[11]

Energy impacts on land and water include spills from oil tankers, pipelines, or storage tanks; acidification of lakes, streams, and soil; and land degradation from drilling or mining operations. Boiler cooling water can harm fisheries by raising stream temperatures, and hydroelectric dams disrupt many of the stream characteristics necessary to support vibrant aquatic life. Policies that encourage (or at least don't discourage) energy conservation and the transition to cleaner, renewable energy sources, can yield large environmental dividends.

US energy subsidy pattern detrimental to the environment

Unfortunately, the existing pattern of energy subsidies, at least in the United States, favours established, polluting energy sources. These subsidies slow the transition to increased energy efficiency and reliance on cleaner, renewable energy resources. In 1989, quantified federal energy subsidies were worth over $36 billion to recipient sectors.[12] As shown in Figure 1, conventional, established energy resources such as coal, oil and nuclear received nearly 90 percent of this amount, leaving less than 11 percent for non-conventional energy sources, such as emerging renewables (solar, wind, geothermal, and non-ethanol biomass) and efficiency. Subsidies also favoured dirty fuels over clean ones: coal and oil received nearly 80 percent of the $21 billion in subsidies to fossil fuels. Improved end-use efficiency was virtually ignored in federal programmes: supply-side energy resources received $36 in federal subsidies for every $1 received by end-use efficiency.[13] Nuclear fission was also a large beneficiary of federal largesse, receiving nearly one-third of all federal energy subsidies.

Figure 1. Shares of total subsidies in 1989 (millions of 1989$)[a]



Notes: *a.* "Other" category includes waste-to-energy and subsidies to general electricity. Percentages do not add due to rounding.

Source: Koplow (1993).

Equally important, the federal government continued its decades-long programme of subsidising the expansion of electrical power grids. The Rural Utilities Services (formerly the Rural Electrification Administration) is a large source of these subsidies domestically, as are tax-exempt public power bonds in general. Grid expansion internationally is financed through foreign lending agencies, such as the Export-Import Bank. Subsidising transmission lines erodes important niche markets for non-grid power, where the cost of generation plus the incremental cost of transmission extension can often exceed the current prices for off-grid solar or wind.[14] It is these niche markets that, for many new technologies, provide a testing area for production techniques and iterative technical improvements. This cumulative experience brings costs down over time so that the niche can be expanded to new customers and markets. The loss of these niches for emerging renewables is perhaps one of the most pernicious effects of energy subsidies. The environmental costs are large as well: a lengthened time to commercialise the renewable technologies, and an expansion of electric transmission lines into ever more remote areas.

The existing pattern of subsidies does little to promote cleaner energy technologies or to protect the environment. Yet, the patterns have persisted for long periods of time due to the substantial political power of recipient sectors and to a lack of timely, standardised, information on the scope and magnitude of the subsidies.

Federal support in R&D and lending programmes has been biased against renewable energy

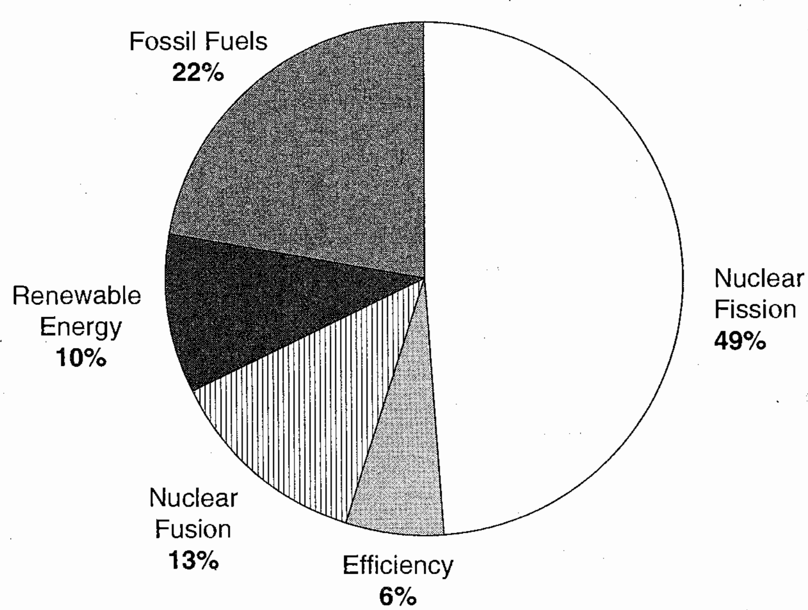
Significant shifts in energy markets take decades to occur. New technologies must be researched and developed. Much of the capital equipment used in energy markets (e.g. refineries and electricity generating and transmission assets) are both extremely expensive and long-lived. Once installed, owners are loath to replace them prematurely. In both its research and development support and lending patterns, the US federal government has favoured polluting sources such as coal and oil, large-scale hydro, and nuclear fission. The legacy of this pattern of support will last well into the next century.

(i) Research and development

While research and development (R&D) spending is often justified on the grounds that private entities under-invest, the distribution of R&D funds across sectors can become *de facto* an element of industrial policy. Governments attempt to pick the market winners and then to place their bets in the form of R&D support. This approach has three problems. First, governments may invest in applied, as well as basic, R&D where there is a weaker case for private sector under-investment.[15] Second, the US government does not have a particularly good track record picking winning technologies in energy markets (e.g. the synfuels and breeder reactor programmes). Third, by heavily favouring particular energy types with financial support, the government can create barriers to entry for competing fuels and conservation services.

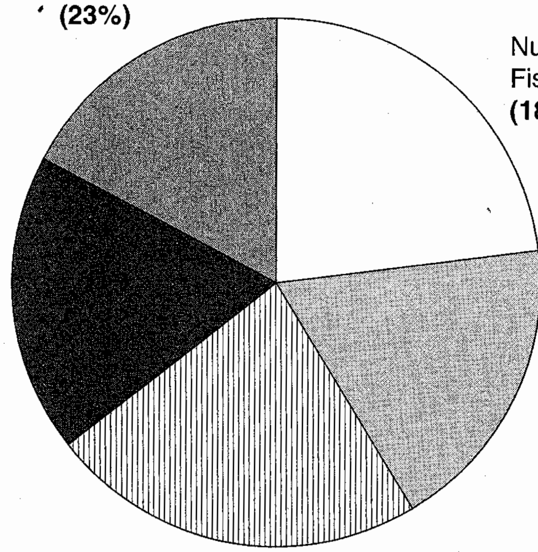
Historical support for energy R&D has heavily favoured nuclear fission and fossil energy, to the detriment of improved efficiency and renewable energy. As shown in Figure 2, between 1950 and 1993, nearly half of all R&D support went to nuclear fission. Nuclear fusion, which experts agree is still many decades away from commercialisation, received nearly as much R&D support as efficiency and all renewable energy combined during this period. Over twenty percent of federal R&D support went to fossil fuels.

Figure 2. Federal support for energy R&D, 1950-1993



Sources: Sissine (1992); Bowring (1980); Cone *et al.* (1980); and National Science Foundation.

Figure 3. Federal support for energy R&D in 1995



Source: U.S. DOE (1995).

In recent years, spending has at last begun to shift to a more favourable mix from an environmental perspective. Figure 3 illustrates the substantially larger shares of R&D support that went to renewables and efficiency during 1995 than during the 1950 to 1993 period. While this shift brings R&D support more in line with improved environmental quality, it will take many years to overcome the advantages now embedded in the various fuel cycle cost structures that the long-term R&D subsidies have provided.

(ii) Federal lending programmes

Since energy infrastructure remains in place for many years once it is installed, policies that subsidise the installation of polluting capital can generate decades of negative externalities. Nonetheless, US-subsidised lending, both domestically and internationally, has favoured polluting fuels and large scale hydroelectricity.

Most subsidised loan and loan guarantee programmes within the United States go to co-operatives or to publicly-owned power (such as municipal power plants or the federal Power Marketing Administrations). Of this recipient sector (Figure 4), fossil comprises approximately 59 percent of capacity; hydroelectric (most of it large scale) an additional 34 percent; and fission about 7 percent. Nearly all of the fossil capacity is polluting oil and coal, rather than natural gas.[16] Since the size of DSM or renewable energy capacity in this sector is quite small, the flow of these subsidies to DSM or renewable capacity is insignificant on a national scale.

Figure 4. Lending programmes have been biased against renewable energy

Loan/Loan Guarantee Recipients, by Energy Type

	Fossil Total	Fossil Coal/Oil Only	Fission	Hydro	Non-Hydro Renewables /Efficiency	Data Year(s)
U.S. Lending Mix of Capacity[1]	59%	55%	7%	34%	0%	1989
Export-Import Bank						
Direct Loans, (80-89)[2]	77%	N/A	11%	12%		1980-89
Loan Guarantees, (80-89)[2]	70%	N/A	13%	18%		1980-89
Multilateral Development Banks[3]	48%	37%	0%	50%	1%	1980-88

Sources and Notes:

1. Data represent installed shares of operating capacity in 1989; the distribution of subsidized loans and loan guarantees is unlikely to follow this distribution exactly. Capacity includes cooperatives, power districts, state projects, municipal and federal facilities. These sectors benefit from a variety of tax subsidies, as well as programmes run by the Power Marketing Administrations, the Tennessee Valley Authority, Rural Utilities Services (formerly REA), and the Bureau of Reclamation. Data are from Edison Electric Institute (1990), Table 2; and Rural Electrification Administration (1991), p.41.
2. Lending data for electric generation are not always broken out into fossil-source fuels. For this reason, the coal and oil fraction of total fossil loans could not be presented. Data are from Export-Import Bank (various years -- 1980 to 1990).
3. Data are from Philips (1991), p. 51. World Bank; Industry and Energy Department (1992); and World Bank, Industry and Energy Department (1990).
4. Totals may not add, due to rounding.

International lending for energy occurs primarily through the Export-Import Bank and through Congressionally-funded contributions to the Multilateral Development Banks (MDBs).[17] Both the Export-Import Bank and the MDBs provide subsidies to the energy sector through concessional interest rates, mediation in financial markets, and defaults on loans or loan guarantees.[18] Figure 4 illustrates that these lending activities subsidised the installation of fossil and hydro capacity; virtually none of the subsidies encouraged non-hydro renewables or improved efficiency. While these international lending patterns have hopefully begun to change in recent years, the remaining service lives of the subsidised fossil investments ensure emissions for many years to come. Similarly, the massive dislocations to human populations and ecosystems spawned by the large subsidised hydroelectric projects have already been incurred and are irreversible.

Subsidies impede the transition to cleaner energy sources

Price signals play an extremely important market function, by rationing scarce supply and encouraging the conservation of resources that rising prices suggest are becoming more dear. Market interventions alter these price signals, influencing the behaviour of producers and/or consumers.

However, with one or two policy interventions, policy analysts can generally deconstruct the effects that these interventions have on the underlying market economics.

In sectors such as energy, however, market interventions have been layered on top of market interventions for decades. Today, the many different layers and types of interventions greatly obscure the underlying economic trade-offs between energy types, and between consumption and increased conservation. Policy analysts often justify new market interventions on the grounds that they are needed to ensure fair competition between energy options (frequently referred to as "levelling the playing field"). As shown above, claims that the energy market playing field, at least in the United States, is biased against renewable energy and energy efficiency have some validity. However, even where this bias is clear, offsetting it is no easy task because:

- There is no clear picture of the many different interventions affecting a particular fuel cycle, let alone for energy markets overall.
- Earlier subsidies are often not removed when new subsidies are put in place, but remain to influence market behaviour.
- Even when removed, the distortions from earlier subsidies can take many years to subside.[19]

It is into this environment that tools such as broad-based energy taxes have been proposed as one way to help shift energy markets away from polluting fuels. Energy taxes are a good example of the multi-level nature of market interventions. First, numerous policies subsidise various fuels, encouraging more energy use. Then, an energy tax is proposed to increase the price of energy from these very same sources to encourage less energy use.[20] Simply removing the energy subsidies could accomplish many of the same ends and leave the energy markets more transparent as well.

A comparison of subsidy levels to proposed Btu and optimal carbon taxes illustrates this point (see Figure 5). Were the Btu tax proposed early in the Clinton administration to have passed, tax levels for all energy sources other than oil would have barely offset the level of federal subsidies in place during 1989. Substantial net subsidies to both coal and fission would have remained. Even in the case of oil, if a portion of the cost of defending Persian Gulf oil shipping lanes were attributed to oil consumers and included in the estimate for federal subsidies to oil, the proposed tax would probably not have covered existing subsidies.[21] A similar point can be made comparing subsidy levels per ton of carbon to the estimated optimal carbon tax needed to offset the expected impacts of global climate change.[22] Subsidy levels in 1989 were equal to over 60 percent of the proposed tax.

In both of these cases, the exact ratios between the subsidy level and proposed tax may not be as high if federal subsidy levels for 1995 (rather than 1989) were available. However, the basic point remains that subsidy removal can be an effective mechanism to achieve the environmental goals underlying many energy tax proposals. In most cases, de-subsidization is preferable because it clarifies the underlying economics of inter-fuel competition, while simultaneously achieving environmental improvement objectives.

Figure 5. Energy subsidy intensity in 1989 versus BTU and carbon tax proposals (1994$)[1]

	1989 Subsidy ($/mmBtu Input)[3]	Clinton Btu Tax Proposal ($/mmBtu)	Ratio of Subsidy to Proposed Tax Rate
Coal	$0.49	$0.26	1.9:1
Oil	$0.30	$0.61	0.5:1
Natural Gas	$0.26	$0.26	1.0:1
Nuclear Fission	$2.16	$0.26	8.3:1
Hydroelectric	$0.25	$0.26	1.0:1
	1989 Subsidy ($/ton)	**Est. Optimal Carbon Tax[2] ($/ton)**	**Ratio of Subsidy to Optimal Tax**
Carbon	$3.94	$6.15	0.6:1

Notes:

1. Subsidies to electricity are allocated back to source fuels. Subsidy intensity per mmBtu of delivered energy is higher, due to conversion and transmission losses in the electricity sector.
2. The optimal carbon tax rate varies over time. The value shown above applies during the first control period, (1990-00).
3. Subsidy intensities for 1995 are likely somewhat lower than 1989, due to the continued phase-out of large subsidies for capital infrastructure. During the 1980s, the energy sector comprised over 20 per cent of total private sector capital spending.

Sources: 1. 1989 subsidy data are derived from Koplow (1993).
2. Optimal carbon tax values are taken from Nordhaus (1994).

Few energy subsidies improve environmental quality

If the existence of energy subsidies is taken as a fact of the existing political economy, one must ask whether it is possible to differentiate between "good" and "bad" subsidies from an environmental viewpoint. While drawing this distinction is possible, available evidence suggests that only a small fraction of federal subsidies in the United States can be classified as helping the environment.

"Good" versus "bad" subsidies

Government subsidies that reduce the costs and/or risks of clean, renewable fuels or improve the energy efficiency of the economy, can be classified from an environmental (although not necessarily from an economic) perspective as "good." The presence of such subsidies may accelerate the transition to cleaner fuels or a more energy-efficient economy. This classification can include research and development into renewable energy and energy efficiency, support for DSM programmes, and regulatory interventions such as energy efficiency standards.

In contrast, "bad" subsidies reduce the costs and/or risks associated with polluting fuels. Consumption of polluting fuels may rise as a result, or the transition to substitutes may be slowed. Examples of such subsidies include percentage depletion allowances for oil and gas; subsidised maintenance of waterways heavily used to transport oil and coal; and the protection against supply

Improved information on environmentally-detrimental subsidies

Good decisions by Member governments require good information on natural resource subsidies, data that are now often fragmented across agencies, incomplete, and sometimes non-existent. OECD can help provide such information by gathering, standardizing, and disseminating information on environmentally-detrimental subsidies on a routine basis. In addition to providing Member governments with better information, this step would create pressure on Member states with high subsidies overall, or that are subsidising particularly environmentally-detrimental activities. Improved information on subsidies is a prerequisite to many of the other leverage points presented below.

Highlight R&D and lending bias across Member states

By tracking subsidies on a routine basis, OECD would be able to highlight R&D or lending programmes that support polluting fuels, to the detriment of energy efficiency or renewables. Even where programmes cannot be eliminated (for example, the Rural Utility Services may continue to subsidise rural electricity, in the belief that this remains the critical barrier to rural economic development), the subsidies can at least be better-targeted towards cleaner energy services.

Promote user fees where appropriate

OECD may wish to encourage additional government support of activities that improve environmental quality, such as site remediation or accelerating the transition to cleaner energy sources. However, within these activities, OECD can identify interventions that are likely to reduce the cost of current energy services from polluting sources (such as research on energy-related externalities) and encourage Member states to finance such spending with user fees on the relevant fuels rather than through general tax revenues.

Promote improved cost accounting for power grid expansion

The loss of niche markets for off-grid renewable energy through transmission subsidies is an important barrier to developing vital operating experience for these emerging technologies. By identifying power systems that do not have adequate cost accounting systems in place, and by helping Member countries to establish such systems, OECD could greatly enhance the long-term prospects of certain renewable technologies. It could also help Member countries make such cost accounting systems a requirement in their lending programmes to the developing world.

Inform electricity deregulation to promote enhanced environmental quality

The potential deregulation of electricity markets holds both promise and risk for improving environmental quality, depending on implementation. Increased "wheeling" will reduce the need to build new regional capacity. As regional variations in electricity pricing begin to disappear, economic activities such as aluminium smelting that rely heavily on regionally-subsidised power will find their subsidies much harder to hold onto. This could help rationalise energy-intensive industries throughout the world, yielding significant environmental benefits.[28]

Nonetheless, some aspects of the deregulatory process could harm environmental quality as well. OECD (and IEA) involvement with these issues could help to ensure that the environmental benefits of deregulation are obtained, but not the costs. This involvement should be focused in four main areas:

- *Incorporation of environmental externalities into market prices.* Without externality "adders", electricity from polluting sources can have a market advantage through avoided pollution control costs.[29] Expanded "wheeling" can greatly increase the market impact from these advantages, as polluting sources can displace cleaner alternatives, both domestically and internationally. With appropriate "adders", competition can encourage efficient and clean energy sources.[30]

- *Mediate conflicts between public and private power providers.* Existing differential subsidies and policies between public and private electricity sectors can distort market choices regarding least-cost energy sources. This could potentially increase the reliance on older, more polluting plants, or encourage inappropriate new construction.[31] OECD could work with Member states to avoid environmentally-detrimental choices of generating capacity driven only by differential subsidies.

- *Evaluate market impacts of differential environmental regulations for older facilities.* Differential environmental regulations (such as exempting many old plants from new requirements) can disadvantage newer, cleaner plants in the deregulated market.

- *Carefully monitor proposals regarding recovery of "stranded" assets in the deregulated market.* Recovery of "stranded" assets is a transitional proposal that would allow investors who own high-cost generating capacity to recover their investments through power surcharges even after deregulation. Oversight is necessary to ensure that enough funds are accrued to finance post-closure care, such as nuclear plant decommissioning.

Highlight "subsidy clusters" in OECD Member countries within the energy sector and beyond

The primary aluminium industry was presented earlier in this paper as an example of "clustering" of energy-intensive industries around large sources of subsidised electricity. Such clustering need not be driven only by electricity, but rather by low costs for any critical production input(s). Subsidised water may lead to a clustering of water-intensive crops, such as alfalfa or rice production in California. Subsidised timber can lead to the perpetuation of uneconomic pulp mills, such as in the Tongass National Forest in Alaska. Other subsidies also continue to exist, such as those from Quebec which allow that Province's anachronistic asbestos industry to survive. In every case, the subsidies lead to environmental degradation that far surpasses that which would occur in a more free market. By highlighting such "subsidy clusters", and by identifying alternative means by which the Member governments can achieve the same policy aims as represented by the existing subsidies (e.g., regional development), the OECD could help eliminate these extremely perverse subsidies and their associated environmental harm.

Summary

Federal energy subsidies in the United States have historically favoured polluting forms of energy over less-polluting renewables, and new energy supply options over increased energy efficiency. Subsidization of energy has increased environmental degradation from energy-intensive industries as well as from the energy sector itself. While there is some evidence that patterns of federal support are beginning to change, such as the increased share of R&D funds supporting renewables and efficiency, many programmes continue to subsidise environmentally-detrimental practices. In addition, decades of past subsidies to polluting fuels are now embedded in the cost structure of many of these sectors today, slowing the transition to newer energy alternatives. By providing information on the scope and magnitude of environmentally-detrimental subsidies on a regular basis, international organizations such as OECD can serve an important role in encouraging the discontinuation of these policies. These organizations can also help Member states to identify and pursue alternative, less destructive, means to achieve the regional development goals that often underlie natural resource subsidization.

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NOTES

1. Humphries *et al.* 1989).
2. Gitlitz (1993).
3. Note that primary aluminum is not the only industry for which energy subsidies play an important role. For example, Quebec's heavily subsidized industrial tariffs for hydroelectricity have also attracted magnesium smelters, pulp and paper production, and chemicals. See Gitlitz, *op. cit.* p. 92.
4. Koplow (1994).
5. Gitlitz, *op. cit.*, pp. 48-53.
6. Miller (1982), p. 161.
7. Allowing for energy credits for the use of by-products as animal feed reduces the net energy loss somewhat, although in all cases, the energy balance is still negative. See Pimental (1991).
8. Chandler (1977), p. 79.
9. US EPA (1989).
10. Highway vehicles alone contribute approximately one-third of ozone precursors such as nitrous oxides and non-methane VOCs, and nearly two-thirds of carbon monoxide. See DRI/McGraw-Hill (1994).
11. Holdren (1990) and (1991); and Shelby *et al.* (1995).
12. See Koplow (1993). This study uses 1989 as a base year, due to informational lags; the pattern today is unlikely to be significantly different, although the overall magnitude is probably somewhat smaller.
13. Additional spending on efficiency *does* occur at the more localized public utility commission (PUC) level. EIA estimates that national spending on DSM programmes rose from $872 million in 1989 to $2.8 billion in 1993 [see EIA (1993), p. 108]. If all PUC-level DSM spending were counted as a subsidy in 1989, the ratio of support for demand- versus supply-side options would have increased only from 36:1 to 36:2. However, where such demand-side management programmes procure conservation savings at a cost lower than the utility's cost of new supply, it would be improper to classify such spending as a subsidy to efficiency.
14. Transmission extensions may also displace highly polluting fuels, such as residential burning of peat or dung. However, the point is that governments providing energy services to these communities should consider off-grid and DSM alternatives to grid expansion.
15. Public support for R&D is often predicated on the grounds that the specific firms investing in innovation are unable to fully capture the market value of their successful developments. Even with patent law, many concepts can be copied or applied in new areas without compensating those who made the original discovery. As a result, private entities may invest in R&D at a level below the societal optimum. In general, basic research is both more risky (in that it may not lead to any market applications for decades) and more susceptible to uncompensated appropriation (because basic research is often general knowledge that is broadly applicable and extremely difficult to patent). As innovation becomes more and more "applied", the ability for the innovator to capture the market value of his development increases, and the rationale for public support decreases.

16 Subsidies to transmission were pro-rated to fuels based on installed generating capacity.

17. While the Export-Import Bank lends to a variety of sectors, energy loans have comprised a significant portion of their loan portfolio. During the 1980s, energy loans comprised nearly one-third of loans outstanding and about 18 percent of loan guarantees. See Koplow (1993), pp. B4-141 — B4-143, and associated tables.

18. Financial mediation, in which the government acts as the borrowing agent for another entity, can provide substantial economic benefits to the ultimate borrower by providing access to capital at far lower interest rates than that borrower could obtain from markets directly.

19. For example, the average costs of electricity generation have been reduced through many subsidies to power plant construction (e.g. investment tax credits and highly accelerated depreciation provisions) that expired years ago. Yet, because consumers pay prices based on these average costs rather than on marginal costs (as occurs in an unregulated market), these past subsidies continue to affect energy consumption decisions.

20. The United States does have a number of fuel-specific taxes on energy in place that are used for highway construction, mine reclamation, underground storage tank removal, etc., rather than to encourage less consumption of particular fuels.

21. Estimates of the cost of defending oil shipping lanes range from $1 billion (Department of Defence) to $70 billion (Cato Institute) per year. This wide range reflects the difficulty in obtaining detailed information on defence spending in particular regions, as well as widely differing assumptions regarding the degree to which military expenditures in the region would drop if oil protection were no longer needed. Because the range was so broad, this cost item was excluded from the subsidy totals on which Figure 5 is based. See US Congressional Research Service (1992).

22. The optimal tax value represents the level that would achieve the desired control rate of carbon emissions during the 1990s. The optimal tax rate rises over time. See Nordhaus (1994), pp. 93-97.

23. A small fraction of the subsidies to biomass fuels support reforestation, and have been classified under the remediation section of Figure 6.

24. Most of the receipts of the Black Lung Trust Fund are from an excise tax on coal. However, between October 1985 and September 1990, the Fund received an interest holiday on large borrowing from the US Treasury under provisions of the Consolidated Omnibus Budget Reconciliation Act of 1985.

25. At least with the Clean Coal Programme, DOE requires substantial cost-sharing with private participants. This greatly reduces the likelihood of the government investing in projects with little or no chance of commercial success.

26. As with all subsidies to the energy sector, private industry may already be financing a portion of the cost of a particular programme. For example, the Electric Power Research Institute is actively researching global climate change using private funding. In all of these areas, the relevant issue is whether large amounts of public funds are also being used to underwrite such programmes.

27. This line of reasoning has important implications for corporate accountability. If corporations find it easy to shift responsibility for past activities (e.g. worker health problems or polluted sites) to the state through corporate shells or other methods, they will have little incentive to avoid creating these problems in current operations.

28. Industrial rationalization, by definition, yields plant closures, job losses, and regional dislocation. OECD can also help Member governments to plan for this difficult transition.

29. Whether this advantage is sufficient to alter the choice of generating technologies depends on the comparative costs of the options, and varies as well by location and application (e.g. baseload versus peaking power). For example, clean natural gas-powered combined cycle turbines may be less expensive than coal in certain markets, regardless of whether externality "adders" are included.

30. In a competitive market, emissions taxes or permits are the most likely mechanisms to accomplish this goal.

31. Approximately 25 communities in the United States are actively pursuing the replacement of their existing private power supplier by constructing a new municipal utility. For Clyde, OH, one of these communities, the benefits of municipalization were clear: "a municipal utility can shop around for cheap power, does not have to pay taxes or dividends to stockholders, and can raise money cheaply by issuing tax-free bonds." The new municipal utility also appears to benefit from rent-free office space [see Salpukas (1995), p. D1].

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Exploring the Linkages

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