PART III:
OPTIONS FOR AND DISCUSSION OF IMPLEMENTING FULL SOCIAL COST ENERGY PRICING

Prices of energy resources can be restored to their full social costs by adopting an optimal taxation schedule. Part II of our report--The Full Social Cost Energy Pricing Approach to Greenhouse Warming Policy--estimated optimal tax levels reflecting air pollution-related costs incurred by society in the consumption of energy from fossil fuels. This part raises issues associated with tax implementation, and discusses some of the approaches available for implementing energy taxes. Options discussed will include different tax approaches which could be undertaken, and the various administrative levels at which taxes could be implemented. These administrative issues also raise related concerns, such as the role of regional pollution variations. The extent to which each approach fulfills the goal of full social cost pricing of energy sources is addressed at length.

3.1 TAXATION OPTIONS

A number of different taxes could be used to reflect social costs in energy prices. Pertinent issues associated with each tax are addressed in the accompanying tables. In all cases, the objective of the tax is to link the tax as closely as possible to the damage being caused. Energy sources that are being used in a manner that is less polluting should be taxed less. Incorporating a tax mechanism that will provide incentives for pollution reduction will remain a major challenge.

A consumption tax could be assessed at the retail sale of the appropriate fuels. In some cases, primarily electric utilities, the tax would apply to the sale of the resulting energy rather than the retail sale of the fuel itself. A production/import tax would fall on the producer or importer of the fuel at the point of production or at the time that the fuel was imported into the United States. These two tax approaches, consumption taxes and production taxes are the broadest tax approaches which will be addressed.

A carbon tax assessed on different fuels based on the carbon content of each fuel type also entails broad coverage of all fuel types while playing a second role introducing incentives to reduce consumption of the highest carbon content fuels--those fuels that contribute most to potentially damaging climate change. This should not, however, be interpreted as a tax designed to account for the environmental damages of global warming. As discussed in The Full Social Cost Energy Pricing Approach to Greenhouse Warming Policy (hereafter, Full Social Cost Energy Pricing), this analysis follows a "no regrets" approach to achieving efficient energy prices which is designed to reduce the burden of environmental damages of pollution. These taxes stop short of addressing global warming damages directly due to the current uncertainty in the magnitude--and even the direction--of the effects of climate change. The carbon tax examined in the study uses carbon content-based tax rates to incorporate social costs of conventional air pollutants into energy prices.

Several more narrow taxes could be imposed. A coal output tax would fall on producers and importers of coal. Similarly, a gasoline and diesel fuel tax would be imposed on consumers at the retail pump. An electricity tax could be collected by electricity generating utilities, much as local and state taxes are collected today. These tax approaches are more narrowly targeted at specific segments of the energy market, but could be implemented in combination to provide broader coverage.

An alternative approach to any of these tax schemes is imposing a fee on pollution emissions. The revenues collected under an emissions fee approach would be equivalent to collections using the traditional tax approach, but such fees introduce new administrative demands on pollution emitters and regulators. Their advantage is that there will be a close link between the tax and the environmental costs.

Each of these tax approaches could be administered at any level of government, from local governments to the federal level. The greatest advantage of nationwide implementation is ease of coordination and refinement of the appropriate tax levels. At more localized administrative levels, taxes could be adjusted to account for the particular characteristics of that jurisdiction, enhancing fuel resource allocation, but coordination across jurisdiction may become unmanageable.

Local taxes may also induce inefficiencies. A tax levied by the state of Virginia may lead Northern Virginia residents to buy their gasoline in Maryland or the District of Columbia.

3.2 CRITERIA FOR EVALUATING TAX APPROACHES

A number of questions should be asked of each social cost pricing implementation strategy. Perhaps the most important issue is the extent to which the tax scheme fulfills the goal of incorporating unpriced social costs specifically attributable to use of an energy source use in the market price of each fuel.

The implementing jurisdiction and the effects of that level of control should be considered for each tax approach. If taxes implemented at the local level preclude updating the tax rates, then more broadly based implementation would be advantageous. On the other hand, local control would be more desirable if more sensitive, localized, information was incorporated in tax rates. As an example, pollution levels in Los Angeles may merit quite different taxes than pollution in Sacramento.

Ease of tax collections is also a pertinent factor. For some tax approaches, tax collection mechanisms already exist. For example, gasoline and diesel taxes levied nationally as well as by states and localities are collected at point of sale. State severance taxes are collected at the wellhead for petroleum production, and utilities commonly collect taxes through their customers' regular billing. No systems currently exist for collecting fees from pollution emitters at the emissions point.

The degree of difficulty associated with updating the tax rates may also vary depending on the tax approach.

One final issue which will be identified is the end use marketplace effects of each tax type. While appropriately calibrated taxes would cause fuel consumption to adjust optimally, divergences from optimal taxes may have nonoptimal distortionary effects in end product markets.

3.3 OBJECTIVE OF FULL SOCIAL COST PRICING

Prices act as the marketplace signal to allocate goods and services among producers/sellers and consumers. To achieve the efficient allocation, market prices should reflect the full cost of supplying a good. The adverse marketplace implications of pollution arise because pollution damages, and the true costs of the production of a commodity such as energy, are often not reflected in market prices. In the case of energy consumption, market prices reflect the private costs of consumption, but not the environmental consequence.

Air pollution, the subject of this research effort, is shown in Full Social Cost Energy Pricing to be a substantial cost of energy consumption. Excluding pollution costs from energy prices creates inadequate incentives for optimal resource allocation. It has been shown by economists since the time of Pigou that incorporating an appropriate tax in the price of a commodity priced below its full social cost can create a signal leading buyers and sellers to optimal resource allocation. One of the purposes of this research effort has been to calculate the appropriate tax rates on energy resources incorporating the full social costs of energy production and consumption in the market price signal.

3.4 LIMITATIONS ON THE OBJECTIVE OF OPTIMAL TAXES

In practice, due to data limitations, technological and scientific uncertainty, and resource constraints, computing the precise tax rates to restore optimal resource allocation is an impossible task. A number of different sources of underlying uncertainty are discussed in the appendices to Full Social Cost Energy Pricing. The issue of regional variation is of particular concern with respect to the choice of the tax implementation approach. Truly optimal tax rates should vary on a regional or even localized level when environmental and/or health damages vary.

Regional variation involves two classes of issues. First, different regions suffer varying degrees of environmental damage and health degradation from pollutants related to energy consumption. Differences may occur in different regions of the country such as East and West, urban versus rural environments, and even across local areas with differing microclimates. Some environmental pollutants may be of great concern in one area but not as significant in other areas. Ozone is of greatest concern in urban areas, most especially the Los Angeles Basin, while sulfur dioxide pollution--the main precursor to acid precipitation--is of greater concern in the Midwest and Northeast, often in less populated areas.

A second dimension of the regional nature of pollution is that the source of pollution may not be the area that incurs the adverse consequences. Ozone pollution from urban areas may blow across rural areas reducing agricultural output. The sulfur dioxide emissions of a few electricity generating power plants in the Midwest may be responsible for acid precipitation over a much broader area.

Optimal taxes should take both of these considerations into account. Localized tax rates should account for the specific health and environmental damages of the emissions in the local area and any downstream consequences of those emissions. Relative to the single tax rates computed in Full Social Cost Energy Pricing, taxes in Los Angeles, for example, are probably too low for ozone pollution and may be too high for sulfur oxides. Ozone pollution from Los Angeles blows across a wider region, threatening both agricultural output and human health. But because the damages from sulfur oxides are greatest in the Midwest and Northeast, the single tax rate for sulfur oxides may be higher than is optimal for Los Angeles. In contrast, in large portions of the country, especially rural areas, energy consumption may be responsible for de minimus health and environmental damages from airborne pollutants, and the single tax rates imposed on energy in those areas maybe higher than optimal resource allocations call for.

The above discussion of the direction of regional divergences from optimal tax rates is necessarily inconclusive. Herein lies the difficulty in incorporating full social costs in market prices. Determining the desirable tax rate for a region or locality to reflect the health and environmental damages due to energy consumption in that area places an enormous information burden on policy makers. For the Los Angeles area, several studies have examined the consequences of ozone pollution. Other studies have identified the differences in adverse consequences of ozone exposure in rural versus urban areas. These studies are time consuming, data intensive, and subject to scientific uncertainty.

The tax rates computed in Full Social Cost Energy Pricing are subject to similar constraints. Due to resources limitations and data availability, national emissions estimates and nationwide damage estimates underlie the social cost calculations. Before implementing such a tax approach, however, it would be necessary to conduct a more detailed analysis of the factors influencing variations to reflect more localized conditions.

The practical application of incorporating health and environmental social costs in energy pricing necessitates the balancing of achieving optimality and effectively implementing the tax policy. Some tax approaches may be easier to implement, but with the disadvantage that regional variation may be more difficult to incorporate. Others may be appealing because of local flexibility, but tax refinement maybe more difficult to coordinate. Each of the tax approaches will be discussed below.

3.5 BROAD-BASED IMPLEMENTATION OPTIONS

The broad-based tax alternatives come closest to achieving social cost pricing because all fuel types fall under the tax. Some broad-based taxes inhibit flexibility because incorporating localized information may be impractical. Broad-based taxes are summarized in the first three columns of Table A3. 1.1 and for emissions fees, in Table A3.1.2.

Consumption Tax

A consumption tax would fall on fuel consumers at the point of purchase of the fuel or in some cases for purchase of the energy produced from the fuel. The tax could be administered centrally or on a state or local basis. Fuel taxes are already collected on most consumer purchases of gasoline, diesel fuel, aircraft fuel, and heating oils. While the final buyers of most supplies of coal and substantial quantities of natural gas and heating oils are electric utilities, taxes on those fuels could be passed through to electricity customers. New tax collections would have to be introduced on sales of wood fuel in most cases.

Because taxes would be collected at the point of sale/supply, incorporating differing tax rates for different regions would be possible, but coordinating differentiated tax rates across the different fuels and local jurisdictions may be unwieldy. Updating tax rates because of new or improved scientific or emissions data may be difficult to coordinate as well. Because the tax would fall on all fuels in relation to the emissions from that fuel, consumption levels of each fuel would adjust optimally.

Production/Import Tax

A tax on producers and importers could be levied at the point of production or importation of each fuel and subsequently passed along to end users in price adjustments. Collection of such a tax would be relatively uncomplicated because of the smaller number of producers/importers and because taxes are already collected from producers in the form of severance and importation taxes. More centralized administration of the tax would be appropriate due to the smaller number of producers/importers. New collections would have to be introduced for wood fuel.

Because a production tax would be targeted toward petroleum rather than the derivative petroleum fuels, this tax is more indirectly linked to the externalities incorporated in energy prices. The market mix of petroleum derived fuels could be distorted as well.

This tax would be one of the easiest taxes to update based on new information, but at the same time is not readily adjustable for local and regional information. Because the tax is collected from only a small number of producers and importers (relative to the large numbers of retailers) and because they are further distanced from actual consumption of the fuels, a more limited information set would be required to refine tax rates. But this same distancing prevents adjusting tax rates at the local level.

Carbon Tax

The carbon tax as utilized in this approach would be used as a mechanism to incorporate the social costs of conventional pollutants in fuel prices based on the carbon loading of each fuel. As discussed in Full Social Cost Energy Pricing, this is not a tax explicitly designed to curb greenhouse gas emissions; that is, however, a secondary effect of this approach. This approach is one step removed from the socially optimal pricing schedule because taxes on each fuel are not directly established based on the health and environmental damages of that fuel, but are tempered by the carbon content of the fuel. Some carbon content-based price incentives are thereby introduced but at the cost of a suboptimal allocation of fuel resources relative to conventional air pollutants.

The carbon-based tax could be introduced as either a consumption tax or a production/importation tax with the advantages and drawbacks of each discussed above.

This is a more difficult tax to update because of the need for additional information on carbon loadings of each fuel type and the inherent variations in carbon content across different sources of the same fuel. Introducing regional or local variation is also increasingly complex because of the information requirement of the carbon content of fuels used in that region or locality.

In the marketplace for fuels, the carbon tax will introduce an incentive to reduce consumption of high carbon content fuels, especially coal and natural gas. These marketplace adjustments may not optimally account for air pollution externalities, for example, natural gas has a high carbon loading but a relatively small adverse impact on the environment or health.

Emissions Fees

Fees assessed on the emissions of pollutants are an alternative broad-based implementation method. This approach yields the closest possible linkage between the source of the externality and the assessment of the tax. Fees would be assessed on the pollutant of concern, rather than on the fuel source. Emissions fees would be passed through in the prices of fuels allowing for optimal allocation between fuels in the marketplace.

The disadvantages of emissions fees have been widely discussed in the environmental economics literature. An emissions fee program may be perceived as transferring to the polluter a pollution property right. This aspect of the fee approach has made fees politically unattractive to groups concerned with whether pollution victims are compensated. Collecting the taxes may be more difficult as well because of the need to collect specific data on emissions from each facility. Collecting emissions data from individuals--for example, for their home furnaces and woodstoves--could be unmanageable. Some estimated level of emissions charges would probably be required from homeowners.

To some extent, emissions fees already incorporate local and regional circumstances because the fees adjust to the emissions in that locality if the fee levels properly incorporate the resulting adverse health and environmental impacts. Some local adjustments could still be incorporated taking into account background levels of each pollutant, dispersion patterns, etc.

Targeted Taxes

Targeted taxes are more narrowly focused than the consumption and production tax approaches, but may be more easily implemented by local authorities. Some targeted taxes may be more readily adjusted on a regional basis compared to a more general tax. These taxes are however, further removed from the notion of optimal resource allocation because only a limited number of pollution sources are targeted by the tax. Marketplace adjustments among fuel types may be undesirable. Targeted taxes are summarized in the final three columns of Table A2. 1.1.

Gasoline and Diesel Fuel Tax

A tax on purchases of motor fuels would address only a limited amount of total pollutants from energy consumption. Taxes would be collected at the retail level much as federal, state, and local excises are collected today. Current tax collection would allow for ease of implementation at either a centralized or local level and ready adjustment on a local or regional level. Updating taxes would be relatively simple as the required information set is restricted to motor fuels, only.

A significant drawback to relying strictly on a motor fuels tax is that the greatest quantity of externalities resulting from fuel consumption is not covered. As discussed in the appendices to Full Social Cost Energy Pricing, sulfur oxides pollutants from burning fossil fuels account for the greatest quantity of adverse health effects and for acid precipitation. Only a small amount of sulfur oxides emissions are addressed by a gasoline tax. The same drawback holds for particulate pollution. Limited benefits will be achieved by focusing only on motor fuels. On the other hand, taxing motor fuels will address substantial amounts of air toxics resulting from motor fuels, residual lead remaining in gasoline, and the precursors to ozone pollution, volatile organic compounds and nitrous oxides.

Coal Output Tax

Like the gasoline tax, a coal output tax addresses a restricted set of sources of conventional pollutants. In that sense, a coal output tax will result in a less than optimal resource allocation. This tax does, however, address the largest single polluting fuel source. Consumption of coal for fuel accounts for the greatest portion of acid precipitation and health effects of sulfur oxides. Substantial amounts of the precursors to ozone are also products of coal consumption.

As with the production tax discussed above, taxes could be collected from a limited number of suppliers providing for ease of implementation. These suppliers are somewhat removed from local fuel consumption, making local administration of the tax and adjustment of the tax rates unworkable.

Much like the case for the gasoline tax, updating the tax rates would be relatively simple because of the more narrow focus of this approach. Also as is the case with the motor fuels tax, there will be marketplace incentives to reduce coal consumption which may not yield an optimal resource allocation.

Electricity Tax

A tax on electricity would be one step removed from a more direct tax on fuel consumption. In this case, electricity generators would tax consumers for their electricity use, electricity which could be generated from a number of different combinations of coal, heating oils, and natural gas.

An electricity tax shares many of the same advantages and disadvantages of the motor fuels and coal output taxes discussed above. This tax focuses on a restricted set of the fuels that create conventional air pollutants, but significant environmental and health endpoints are addressed. Electric utilities are primarily responsible for the emissions of pollutants which lead to acid precipitation, and the large quantities of coal and heating oils consumed by electric utilities account for a substantial portion of the health and environmental effects of sulfur oxides.

Administering an electricity tax at the local level provides a substantial opportunity to readily adjust tax rates for the health and environmental effects specific to that region's facilities. Supervisory and administrative boards overseeing public utilities already exist in most areas. Some broader coordination would probability be required to insure that the adverse impacts occurring downstream from the facilities, as is the clearly the case with acid precipitation which may occur far from the generating facilities, are properly incorporated in local tax rates.

Taxing electricity would create incentives for utility customers to consume fuels directly. Large customers like factories and businesses may wish to bum fuel on-site while homeowners may rely more heavily on furnaces for heat. These incentives may lead to undesirable emissions being shifted from electricity-generating facilities to homes and businesses.

Combinations of Targeted Trees

Implementing some combination of targeted taxes could be used as a means to achieve broad coverage, incorporate local control, and take advantage of administrative simplicity. For instance, a coal output tax could be easily implemented and operated at the federal level while a tax on electricity generation is used to adjust tax rates based on local circumstances. Additional research would be required to address the different combinations of taxes possible and the consequences for approaching an optimal resource allocation of each different approach.

APPENDIX 3.1

Table A3.1.1

Alternat ive Tax Structures

	Consumption Tax	Production/ Import Tax	Carbon Tax	Coa l Output Tax	Electricity Tax	Gasoline and Diesel Fuel Tax
Description of Tax	Tax assessed at retail level for all fuel types .	Tax assessed at producer/ importer level. PrimSri ly assessed on coal, petroleum and natural gas.	Tax assessed at retail level for all fuel types. Tax amount determined by carbon content of each fuel.	Tax assessed at producer/ importer level for al 1 coal except coal used in coking process.	Tax assessed at electricity generating uti l ity.	Tax assessed at retail gasol ins outlets.
Level of Tax'						
Gasol ine	S O. 28/gal		$ 0.25/gal[4]			S 0.28/gal
Diesel	0.61/gal		2.81/gal			0.61/gal
Aircraft	0.12/gal		NA			
C o a l	232.71/ton	$232.71/ton	142.30/ton	$232.71/ton		
Heat i ng Oils	0.58/gal		1.43/gal			
Natural Gas	0.06/1000 CU. ft.	0.06/1000 cu. ft.	0.06/1000 cu. ft.			
Wood	134.11/ton	134.11/ton	NA			
Petroleum		11.25/bbl[3]				
Electricity					s 0.0665/KWh[5]	
Total Tax Revenue for 1989 estimated consumption volumes (in billions S)[2]	284.99	288.34	259.38'	197.37	184.92	44.31
Range of Tax Revenue: lower and upper bounds (in billions S)	21.41 - 548.36	22.45 - 554.03	21.51 - 497.53	7.06- 387.68	6.67- 363.45	12.50 - 75.91

Table A3.1.1(continued)

Scope of Coverage	Broadest coverage.	Broadest coverage.	Broad coverage. Addresses especi ally fuels linked to cl imste change, acid rain and sulfur oxide-related effects.	Narrow coverage. Addresses only one fuel source, though most polluting source.	Narrow coverage. Addresses only one set of emissions sources.	Narrowest coverage. Motor vehicles only.
Linkage to External i ty	Taxes assessed on each fuel based on contribution to total externality. Closest possible linkage.	Taxes on petroleum based fuels linked to externali ty indirect ly.	Taxes linked to air pollution externalities only indirectly. Extent of external i ty based on contribution of each fuel type, while tax is based on carbon content .	Close linkage for a narrow set of external i ties. Addresses the single most polluting fuel.	Upstream link to external i ty. PrimSri ly dresses acid rain and other sulfur oxide- related effects.	Close l inkage for a narrow set of external i ties.
Ease of Collection	Tax collected through existing channels (in most cases). New collections instituted for wed.	Tax collected through a limited number of producers importers. Easiest possible collection. New col lect i ons instituted for wood.	Tax col lected through existing channels, however, tax wil 1 be based upon fuel composi t ion rather than sales volume.	Tax collected at producer/ importer level. Easiest possible collection.	Tax collected at electric utilities, a readily identifiable selection of facilities with existing tax collection mechanisms.	Tax co1 lected through existing charnels.
Ease of Ref inement[7]	Requires updated information on consumption volumes.	Requires updated information on consumption volumes.	More difficult tax to update. Requires continual updating of carbon content of each fuel typa and information on consumption volumes.	Requires updated information on coal consumption volume.	Requires updated information on electricity generation, fuel consumpt i on va l ues and fuel mix by electric utilities.	Requires updated information on gasol ine/ diesel consumption volume.
Effects in Fuel Markets	Fuel consumption will adjust optimally to account for externalities.	Could distort market mix of petroleum derived fuels.	In long-run should drive market toward lower carbon-containing fuels, but will not optimally account for air pollution externalities.	Could distort fuel input use away from coal.	In long-run could (cad to lower demand for electricity or fuel witching by utilities toward less polluting fuels.	Hay lead consumers to travel less, switch fuels, or switch transit mode.

Table A3.1.1 (continued)

Institutional Issues	Federal implementation allows easiest coordination. State or local more difficult to coordinate, but could take advent age of existing programs. Collection processes current 1 y exist at Federal level for motor fuels taxes and black lung tex on coal, at state and local level for motor fuels excises and electric utilities.	Federal implementat ion easiest. State possible. Because production tax could be collected from many fewer perties capered to a consumpt i on tax, state implementation more feasible. Severance tax collect ion processes exist in many states for these fuels.	Federal implementation easiest. State or local possible but more difficult to coordinate. May be too unweildy for state or local, especially due to continual updating of optimal tax based on carbon content.	Federal, State possible. At state 1 evel, severance tax collection mechani sms a l ready exist. At Federal level, black lung tax is currently assessed on coa 1.	Federal, state, o r local implementation possible. Utility taxes current 1 y collected by states and locally. No current Federal tax cot lection from utilities.	Federal implementation easiest. State/local possible. Existing tax collection mechanism at Federal level for highway trust fund. States and totalities have collection systems for motor fuels taxes.

Footnotes for Table A3.1.1

1. Consumption tax estimates from appendix table 17, column 4. Represents midpoint of estimated range assuming current regulations reduce emissions by 25% (for SOX and particulate). Estimates of other tax approaches use the consumption tax values as a baseline. Adjustments to the baseline are explained in the appropriate footnotes.

2. Sum over all fuel types of optimal tax (midpoint estimate) for each fuel multiplied by most recent estimate of consumption of that fuel.

3. Per barrel tax on petroleum calculated as tax constraint divided by 1986 petroleum consumption. Tax constraint calculated as sum of optimal tax on gasoline, diesel fuel, aircraft fuels, and heating oils multiplied by base year (1986) consumption volumes.

4. Tax constraint calculated as sum of optimal tax on gasoline, diesel fuel, coal, heating oils, and natural gas multiplied by 1986 consumption volumes for each fuel. Aircraft fuel and wood fuel were deleted due to insufficient carbon content data. Tax constraint was reallocated based upon relative carbon tax weights from appendix table 14.

5. Tax constraint divided by total electric utility industry output for 1986 (source: U.S. Bureau of the Census, Statistical Abstract of the United States, Washington, D.C. (1989), Table 952), Tax constraint calculated as sum of optimal tax on coal, natural gas, and heating oils times volume of each fuel consumed in electricity generation in 1986. Fuel consumption values drawn from (coal and natural gas) or calculated from (heating oils) Annual Energy Review, 1987, Tables 70, 76, and 86.

6. Excludes carbon taxes on aircraft fuels and wood fuel.

7. Based on underlying linearity of benefits models, unit value of benefits (hence, optimal tax values) will be constant for any level of fuel consumption. If, however, linearity does not hold, optimal tax values must be reassessed as fuel consumption values change.

Table A3.1.2

Emissions Fee

	Emissions Fee
Description of Fee	Fee charged to emitters for each unit of pollutant emitted.
Level of Tax[1]	
Lead in Gasoline	$284.82/kilo
Particulates	18.09/kilo
SO_x	11.13/kilo
NO_x	0.09/kilo
VOC's	0.71/kilo
Total Tax Revenue for 1988 Emissions Levels[2]	$246.83 billion
Range of Tax Revenue: lower and upper bounds (in billions $)	10.25 - 483.30
Scope of Coverage	Broad coverage.
Linkage to Externality	Closest Possible linkage. Fees assessed on each pollutant.
Ease of Collection	Tax collected from each emitter based upon pollutant output. Will require plant-specific monitoring or estimation. New methods will be required for fee collection from auto use.
Ease of Refinement	Requires updated information on national emissions of each pollutant from each fuel type.
Effects in Fuel Markets	Fuel consumption will adjust optimally to account for externalities.
Institutional Issues	Federal implementation. May be too unweildy for state or local given requirements for monitoring/estimation. Implies giving pollution property right to emitters; hence, may be politically unpopular.

Footnotes for Table A3.1.2

1. Emissions fee calculated as midpoint of range of total benefits for each pollutant type from appendix tables 4 and 7 divided by base year emissions. Base year 1986 except 1984 for lead in gasoline.

2. Total tax revenue calculated as sum over each pollutant type of optimal fee (midpoint) times emissions for most recent year, 1989.

PART IV
RESIDENTIAL ENERGY DEMAND AND THE TAXATION OF HOUSING

The primary author of this section was William M. Gentry, Economics Professor, Duke University.

Increased concern about the environment has increased interest in policies aimed at reducing energy demand. To address environmental externalities associated with energy consumption, economists often suggest targeting corrective energy taxes.[1] While narrowly focused energy taxes are powerful instruments for reducing energy demand, optimal tax theory suggests that the taxation of substitutes and complements can play an important role in commodity tax design: taxes on complements to energy and subsidies on substitutes for energy reduce energy demand. This paper analyzes the effect of the tax treatment of housing on the demand for energy.

With almost 50 percent of the U.S. capital stock devoted to housing, even a small interaction between the tax treatment of housing and energy demand could induce a large change in energy use. The link between the housing stock and energy demand is direct: housing services are produced by combining houses and residential energy. Estimates from Quigley (1984a) suggest that utility expenditures are about 17 percent of the total annual cost for housing services.[2] In turn, residential energy demand is an important component of total U.S. energy demand: in 1988, residential space heating and cooling, water heating, and other household appliances accounted for 16.4 quadrillion BTUS of energy --20 percent of the total energy consumed in the U.S.[3]

If consuming more housing increases residential energy demand, then reducing the demand for housing reduces energy demand. Rather than discouraging housing consumption, however, U.S. tax policy encourages consumption of and investment in housing. The tax code favors housing in three ways: (1) for homeowners, imputed rents are not taxed and mortgage interest and property taxes can be deducted from income; (2) for rental property, landlords benefit from provisions such as accelerated depreciation; and (3) the corporate income tax induces investment in non-corporate assets, such as housing, rather than the corporate sector. Section 1 of the paper reviews the public finance literature on the taxation of housing and estimates the size of the subsidy to housing from the tax system.

While the tax-treatment of housing may increase housing expenditures, it is less clear whether this increase translates into an increase in residential energy demand. Housing expenditures purchase a bundle of housing attributes: size, location, vintage, design, quality of construction are but a few. Some of these attributes increase energy demand (e.g., size); others, such as energy-efficient design, decrease energy demand. However, both increased size and energy efficiency increase the value of a house. Moreover, residential energy consumption encompasses a variety of end uses: the most important are space heating, water heating, air conditioning and kitchen appliances. Some of these uses of energy are more related to the amount of housing than others. For example, energy for space heating depends directly on the size of the house, but energy for water heating depends more on the number of residents than the size of the house. Section 2 explores the relation between the components of energy demand and house characteristics.

In order to analyze whether changing the tax treatment of housing would affect energy demand, it is necessary to abstract from the intricacies of different house characteristics and uses of energy. Section 3 models housing services as being produced from housing capital (land plus structures) and energy. Changing the tax treatment of housing raises the cost of housing services and increases the price of housing capital relative to the price of energy. This change in relative price reduces the level of housing services consumed and, for a given level of housing services, induces a substitution of energy for capital. The total effect on residential energy demand is the sum of the reduction in energy caused by lower housing consumption and the increase in energy caused by the substitution of energy for capital. The model and estimates draw heavily from Quigley's (1984) estimates on how changes in energy prices affect housing consumption. The estimates suggest that eliminating the tax differential between housing and corporate capital would reduce residential energy demand by 6.8 percent.

Section 4 places the change in residential energy caused by changing the taxation of housing in a broader context. Less consumption of housing services might reduce residential energy, but energy policy is more concerned with total energy demand. Less investment in housing capital might increase investment in other sectors; less consumption of housing services might increase consumption of other goods. This shift from housing to other goods would increase energy used to produce these other goods. Section 4 discusses the implications of changes in residential energy demand on total energy demand and other issues that are not addressed by the model of housing services. Section 5 offers concluding remarks.

4.1 THE TAX SYSTEM AS A SUBSIDY TO HOUSING

The tax subsidy to housing in the U.S. has three main components: (1) preferential treatment of owner-occupied housing from the personal income tax system; (2) tax provisions for rental property such as accelerated depreciation allowances; and (3) general equilibrium effects from corporate taxation. This overall subsidy suggests that, relative to a tax system that is neutral towards housing, the US. invests more in housing, invests less in other assets (e.g., less manufacturing) and consumes less of other goods. This section discusses the three components of the tax treatment of housing and summarizes the overall effect of the tax system.

Tax Incentives&r Owner- Occupied Housing

Because of the importance of housing as a commodity and the magnitude of the revenue costs of the special tax Provisions, an extensive literature details how taxes affect housing prices and demand (see Rosen (1985) for a review). Following Poterba (1984, 1990), for taxpayers who itemize deductions, the after-tax user cost of capital for owner-occupied housing is:

$$\frac{c_o}{P_o} = (1 - \Theta)(i + \tau_p) + \delta + \alpha + m - \pi_e \quad (1)$$

where CO is the after-tax user cost of owner-occupied housing, Θ is the individual's marginal tax rate, i is the nominal interest rate, τ_p is the property tax rate as a fraction of the value of the house,' δ is the physical depreciation rate for the house, **a is** the risk premium for housing investments, m is the cost of home maintenance as a fraction of the house value, π_e is the expected rate of house appreciation, PO is the price of owner-occupied housing.

At first glance, the tax system only appears to affect the user cost by reducing the cost of homeownership through the deductibility of mortgage interest and property taxes. While the deductibility of mortgage interest and property taxes are among the most visible parts of the tax subsidy for housing, many other tax provisions affect housing. First, implicit in equation (1) are the assumptions that individuals can borrow or lend at the nominal interest rate, i, and that interest income is taxed at the rate, Θ. Under these assumptions, the user cost does not depend on the percentage of the house that is financed by borrowing: housing is a tax- advantaged investment even if it is 100 percent equity financed. This invariance between debt and equity finance highlights the source of the tax incentives for homeownership: imputed rent (implicit income from consumption flows) is not taxed. Instead of creating a tax advantage for housing, mortgage interest deductibility merely extends the tax advantage of equity-financed housing to homeowners who borrow (see Woodward and Weicher (1989)).

Second, this user cost expression does not hold for households who do not itemize. Although the after-tax interest rate is still appropriate for the equity position of the non-itemizer, since the return on alternative investments is taxed, non-itemizers pay the before-tax interest rate and the full value of property taxes ($\Theta = 0$).[5] Third, the user cost depends on the household's marginal tax rate which varies across households. Therefore, the user cost depends on the other characteristics (mainly, income) of the household that affect tax rates. The dependence of the user cost on household tax rates makes it difficult to separate income and tax effects in empirical work since the tax rate varies directly with income. Fourth, this user cost formula assumes that the price appreciation for houses is not taxed. Given the rollover provision (capital gains from house sales that are reinvested in housing are tax-deferred) and the one-time exclusion of $125,000 for people over age 55, this assumption is realistic.[6] These capital gains rules provide another tax incentive for housing.

Changing the taxation of housing would change the user cost of homeownership. Table 4.1 examines the user cost of homeownership under several potential policy reforms using plausible parameters taken from Poterba (1990). The first line in the table is the user cost under the current policy with deductible mortgage interest and property taxes, untaxed imputed rents and lightly taxed housing capital gains (equivalent to equation (l)). For a high income taxpayer, the user cost of homeownership is 0.114. This user cost can be interpreted as the annual consumption flow from the house be worth 11.4 percent of the value of the house to cover the after-tax cost of capital, property taxes, depreciation, maintenance and risk. The second row of Table 4.1 has the user cost of homeownership with no income tax. Without an income tax, the consumption flow from the house must cover the gross interest rate and the full cost of property taxes. Thus, the user cost increases by 22 percent: relative to not having an income tax, the current personal tax system provides a 22 percent subsidy to homeownership. An alternative interpretation for the user cost without a tax system is that it represents the user cost with an income tax on economic income from owner-occupied housing in a housing market where competition drives economic profits to zero.'

Since abolishing the income tax is unrealistic, it is important to consider alternative policies that would increase the conformity between housing and other goods. The third and fourth rows of Table 4.1 have two incremental reforms of the tax treatment of housing. The third row has the user cost if mortgage interest and property taxes were not deductible. The user cost increases by 11.6 percent but is less than the user cost without an income tax. Eliminating the deductibility of interest and property taxes does not eliminate the tax subsidy to housing since the return to equity-financed homeownership is not taxed. The portion of an owner-occupied house that is equity financed is the value of the house that is clear of the mortgage. This policy favors equity finance over debt (mortgage) finance, since the cost of equity finance is $(1 - \Theta)i$ but the cost of debt finance is the gross interest rate, i. If homeowners increased their reliance on equity finance by borrowing less in response to eliminating mortgage interest deductibility, then this policy would increase the user cost by less than 11.6 percent.*

The fourth row eliminates the rollover and exclusion provisions that virtually eliminate taxes on housing capital gains: housing capital gains are taxed upon realization like gains on other assets. The current deferral option of realization-based taxation lowers the effective tax rate on all capital gains. This option is assumed to reduce the statutory tax rate by 50 percent (see King and Fullerton (1984)), so the effective tax rate on housing capital gains is 14 percent? Increasing the conformity between capital gains on housing and other assets would only increase the user cost by 3.5 percent. Thus, the special capital gains provisions do not appear to play a large role in the tax subsidy to housing.

The last policy alternative addresses taxing the return on equity-financed housing by taxing the imputed rent from homeownership. It treats homeownership as a small business: the income from homeownership (imputed rent) is taxed but costs (interest, property taxes, depreciation allowances and maintenance) are deductible. Unlike eliminating interest deductibility, taxing the imputed rent favors neither equity nor debt finance. One problem with this policy is that designing depreciation allowances for personal residences would be complicated. Furthermore, depreciation rules can often be exploited to reduce taxes.’” Under the assumption that the present value of depreciation allowances is fifty cents for every dollar invested, treating homeownership as a small business increases the user cost by 19 percent.” With this set of parameters, this user cost approximately equals the user cost without an income tax. More generous depreciation allowances would decrease the user cost of homeownership.[12]

Since the user cost depends on the homeowner’s marginal tax rate, the subsidy from the tax system varies with a household’s income. For a household with a marginal tax rate of zero, the tax system does not affect the user cost. For a household with a 15 percent marginal tax rate, the tax subsidy to housing relative to not having an income tax is 9.7 percent rather than the 21.9 percent subsidy for households with a 28 percent tax rate. The overall subsidy to homeownership depends on the distribution of homeownership across income groups. Table 4.2 presents the weighted average tax subsidy for owner-occupied housing using data from the 1989 Consumer Expenditure Survey. Column (1) reports the income distribution of homeowners. More than half of homeowners are in the middle income group ($15,000 to $50,000 of income) that roughly corresponds to the 15 percent marginal tax rate bracket. While only one-quarter of homeowners have incomes above $50,000, this high income group owns 41 percent of the value of owner-occupied housing. Weighting the tax subsidy for homeownership for each income class by the share of the housing capital stock owned by the income class produces a weighted average tax subsidy for the total stock of owner-occupied housing of 13.3 percent.

Along with the previously mentioned caveats on the user cost formula, these changes in the cost of homeownership are imprecise for a number of reasons. First, the calculation of the change in the long-run after-tax cost of homeownership assumes that the supply of housing is perfectly elastic. This incidence assumption implies that a reduction in the subsidy is borne by future homeowners rather than the builders or current owners. While this assumption follows previous analyses of the tax subsidy (e.g., Aaron (1972)), White and White (1977) show that both the distributional effects of the subsidy and the change in the quantity of housing depends critically on the supply elasticity of housing. In contrast to the case of perfectly elastic supply, if the supply of housing was perfectly inelastic, then changes in the tax subsidy would be capitalized into current house prices and the incidence of the changes would be entirely on current homeowners. Since the quantity of housing does not change in this case, the tax subsidy would be expected to have little effect on energy demand. Intermediate values of the supply elasticity cause a mixture of these two cases. However, since the perfectly elastic supply case has the largest changes in the cost of homeownership and the quantity of housing, it produces the largest possible interaction of the tax subsidy and residential energy demand.

Second, the changes in the user cost depend on the choice and stability of the parameters (e.g., the interest rate) in the user cost. For example, lower interest rates or property tax rates would reduce the effect of eliminating deductibility of mortgage interest or property taxes. Moreover, changes in tax policy towards housing might affect the gross interest rate or the reliance on property taxes by local governments. The implicit incidence assumption is that tax policy towards housing does not affect the interest rate or other components of the user cost.

Third, although analyzing these tax reforms is easy, implementing them is difficult. The most comprehensive reform of treating homeownership requires measuring imputed rents, calculating depreciation allowances, and recording maintenance expenses. In part, this policy would increase the cost of tax compliance for homeowners. However, valuing the imputed rents from owner-occupied housing creates bigger problems than just recordkeeping: for many houses, a market rental value is hard to estimate. In addition to the economic complications of these reforms, increasing the tax burden on homeownership would face political obstacles: since the mortgage interest deduction has long been a "sacred cow" in tax policy, the political possibility of taxing imputed rent seems remote.

Overall, eliminating the tax subsidy to homeownership in the personal tax code by taxing imputed rents would raise the user cost of homeownership by about 20 percent. These estimates of the size of the tax subsidy roughly conform to those in the previous literature (e.g., Aaron (1972) and White and White (1977)). Incremental reforms, such as eliminating mortgage interest deductibility, would increase the user cost by less than 12 percent. Given the assumptions underlying these estimates, they provide upper bounds on the effect of tax policy on the cost of homeownership. These policies would directly effect the two-thirds of Americans who own their homes; however, as discussed in the next section, these policies should be analyzed in conjunction with the tax treatment of rental property.

Tax Incentives&r Rental Property

Since individuals choose whether to rent or own their homes, tax policies that affect the user cost of homeownership cannot be completely separated from the tax treatment of rental property. For renters, rents depend on the user cost of rental property. Raising the cost of homeownership but not the user cost of rental property would induce individuals to switch from owning to renting their homes.[13] For individuals who switch from owning to renting, the cost of rental housing is greater than the user cost before the change in policy but less than the cost of homeownership after the policy change. Thus, the endogeneity of tenure status would dampen the reduction in housing investment induced by raising the user cost of homeownership.

This endogeneity complicates analyzing the interaction between the tax treatment of housing and residential energy demand. Ignoring the shift from owning to renting that would occur with the elimination of the tax subsidy for owner-occupied housing would overstate the policy's effect on energy demand. Adjusting for the changes in tenure status would require simultaneously estimating changes in tenure status and amounts of residential energy. Another option for the analysis is to simultaneously change the tax treatment of rental property such that rents would increase by the roughly the same proportion as the user cost of homeownership. This option allows for the aggregation of rental and owner-occupied housing. The advantage of aggregating rental and owner-occupied housing is that the general equilibrium tax effects discussed below do not distinguish between rental and owner-occupied housing. Section 3 analyzes energy demand by owner-occupiers ignoring the tenure decision and energy demand by all households.

The user cost of rental property depends on the tax treatment of landlords.” The user cost for rental property depends on the landlord’s tax rate rather than the residents. The landlord’s tax rate could differ from the tenant’s either because tax rates are graduated or because only the landlord itemizes deductions. With competition between landlords, rents depend on the tax code. Unlike owner-occupied housing, the rents from rental property are taxed: the renter pays with income that is subject to the income tax and the landlord pays taxes on rents received. While this provision increases the tax burden on rental housing, rental property has a number of tax advantages relative to owner-occupied housing. As a business, the landlord can deduct maintenance expenses, property taxes, interest payments and depreciation allowances from income. The resulting user cost of rental property is:

$$\frac{c_r}{P_r} = [(1 - T)i + \delta + \alpha + - \pi_e]\frac{1 - zT}{1 - T} + \tau_p + m \qquad (2)$$

where T is the landlord’s marginal tax rate, z is the present value of depreciation allowances for $1 of investment, c_r is the value of consumption from the rental property, P_r is the price of rental property, and other terms are defined as in equation (1).

The tax treatment of rental property as a business is similar to the policy proposed in the fifth row of Table 4.1: taxing rents but allowing deductions raises the user cost of homeownership by 19 percent. However, separating who owns the home from who lives there creates a possible tax advantage for renting. An individual can choose between being an owner-occupier without the taxation of imputed rents or renting from a landlord who values depreciation deductions highly because of a high marginal tax rate (see Gordon, Hines and Summers (1987)). This tax arbitrage opportunity between high tax bracket landlords and low tax bracket renters could exist even if homeownership is taxed as a small business. Depending on the parameters (e.g., generosity of depreciation allowances), the effective tax rate on housing can either rise or fall with the marginal tax rate. The effective tax rate is the percentage difference between the user cost with the tax system and the user cost without a tax system. For example, if investing one dollar generates depreciation allowances with a present value of one dollar, then increasing the tax rate decreases the user cost (and the effective tax rate) because high tax rate investors have a higher value of the interest deductions (i.e., a lower after-tax opportunity cost of capital).

As an example of why some people might prefer to rent for tax reasons, consider a person with a tax rate of zero who can rent from a landlord with a tax rate of 45 percent and depreciation allowances with a present value of 70 cents for each dollar of investment. These parameters roughly correspond to U.S. tax policy before 1986 (see Gordon, Hines and Summers). The person with the zero tax rate has a user cost of homeownership of 0.139. In contrast, for the landlord, the user cost of rental property is 0.126. The low tax rate person has an incentive to rent because the landlord has a lower after-tax opportunity cost of capital. Relative to homeownership, renting lowers the individual's cost of housing by 9.4 percent ((0.139 - 0.126)/0.139).

In analyzing the effect of the tax treatment of housing on energy demand, one needs to know whether to apply the tax subsidy to only owner-occupied housing or to a broader measure of the housing stock. As this example demonstrates, the tax treatment of landlords can lower rents. In section 3, I use two measures of the size of the housing capital stock affected by the tax code: (1) assuming that the tax policy only addresses the personal tax code subsidy to homeownership and that tenure choices do not change, I analyze the effect only on the current stock of owner-occupied housing; and (2) assuming that the policy change simultaneously addresses the tax treatment of landlords, I analyze the effect of the subsidy on the entire housing capital stock.

In terms of changing the user cost formula, policy reforms aimed at rental property are more subtle than those aimed at owner-occupied housing. Slower depreciation allowances, stricter anti-tax shelter provisions, and a narrower spread between the tax rates of landlords and tenants would all increase the user cost of rental property. The Tax Reform Act of 1986 included all three of these changes to some degree (see Poterba (1990)). The user cost of rental property after 1986 is much closer to the user cost without a tax system. Assuming that the present value of depreciation allowances fell to 50 cents per dollar invested and that the marginal landlord has a tax rate of 28 percent, the user cost of rental property is 0.136 or a subsidy of 2.2 percent relative to not having an income tax.[15]

In considering changes in the tax treatment of owner-occupied housing, treating homeownership as a small business serves as a natural benchmark if imputed rents are taxed, then housing faces the same level of taxation as nondurable consumption. For rental property, however, there is not an obvious benchmark policy. The calculation of the 2.2 percent subsidy uses the user cost without a tax system as a benchmark. Another comparison is between the tax treatment of rental property and other investments: does rental housing have a higher or lower effective tax rate than other uses of capital? However, comparisons with other investments introduce concerns regarding corporate level taxation of many alternative investments. The next section compares the level of taxation of housing and other capital.

General Equilibrium Effects

While the decision between renting and owning depends on the difference between the user costs for owner- and renter-occupied housing, the effect of the tax system on the amount of housing depends on the levels of the two user costs relative to the after-tax cost of other consumption goods and the returns to other investments. As shown above, relative to nondurable consumption, the weighted average tax subsidy from the personal tax code for owner-occupied housing is 13.3 percent and the subsidy for rental housing is 2.2 percent.”

Comparing housing with other investments is more complicated than comparing housing with other consumption because of the variation in the taxation of alternative investments. One simple breakdown is to compare investments in non-corporate and corporate capital. Residential structures are 46 percent of the total private capital stock.” Non-corporate residential structures account for 79 percent of noncorporate capital and corporate residential structures are less than 1.5 percent of total residential capital. Hence, dividing the private capital stock into two groups, corporate nonresidential capital and noncorporate residential capital, is a fairly accurate simplification.

Even with this simple division of capital, calculating the tax differential between the two groups is difficult. The statutory corporate income tax rate might differ greatly from a true measure of the extra tax burden imposed by the corporate tax system because of complicated interactions between depreciation rules, financial structure (e.g., the choice between debt and equity finance), inflation and the tax rate schedule.” To include these interactions, economists typically calculate effective tax rates to measure the tax burden on capital. Effective tax rates measure the difference between the marginal product of capital and the after-tax return to the owner of capital. The difference between the effective tax rates on corporate and noncorporate capital measures the extra tax burden imposed by the corporate tax system.

Estimating effective tax rates is an imprecise science. I rely on two previous measures of the difference between the effective tax rates on corporate and noncorporate assets. First, Fullerton, Gillette and Mackie (1987) calculate an effective tax rate of 44.4 percent on corporate assets and 33.9 percent (excluding owner-occupied housing) on noncorporate assets. These effective tax rates suggests that the corporate tax system increases the tax burden on capital by 10.5 percentage points relative to the tax treatment of noncorporate capital. Second, Fullerton and Karayannis (1992) estimate an effective tax rate on corporate capital of 42.3 percent and an average tax rate on income from rental property of 26.0 percent. The difference between these two tax rates, 16.3 percentage points, measures the extra tax burden on corporate assets that accounts for the mix of assets, financial choices and depreciation rules. These estimates suggest that housing (noncorporate) capital faces tax rates that are about 13 percentage points less than the tax rates on corporate capital.

This difference is in addition to the tax advantages of housing that arise from the personal tax system.

Total Tax Subsidy on Housing

The tax treatment of homeownership, rental property and corporate capital combine to create a wedge between the pre-tax marginal product of corporate capital and the after-tax return to housing. This wedge is the total subsidy to housing from the tax system. The previous sections have given some of the details on each component of this wedge; however, these different tax provisions can be summarized as a subsidy at a rate s on the return to housing relative to the pre-tax return to corporate capital:

$$r_c = (1 + s)\, r_h \qquad (3)$$

where r_c is the pre-tax return to corporate capital and r_h is the rate of return to housing before taxes (price appreciation plus consumption value as a fraction of the total value of the house). This simple formula averages across rental and owner-occupied housing and across individuals with different tax rates.

Table 4.3 aggregates the different elements of the favorable tax treatment of housing into a single measure ofs. Column (1) of the table summarizes the personal tax advantages to owner-occupied and rental housing. The personal tax advantage is the difference between the tax treatment of housing and other non-durable consumption goods. To aggregate to the tax subsidy on all residential capital, the tax advantages to owner-occupied and rental housing are weighted by their shares in the housing stock. Column (2) is a rough estimate of the difference the taxation of noncorporate and corporate capital. This difference is the relative taxation of corporate capital and noncorporate capital that is subject to the personal income tax. Column (3) is the total tax advantage of housing relative to corporate assets, the sum of columns (1) and (2).

Table 4.3 suggests that the tax system reduces the price of residential capital by 23 percent relative to corporate capital. Much of this price reduction is concentrated on owner-occupied housing because of the favorable personal tax treatment of homeownership. The subsidy for owner-occupied housing is 26.3 percent relative to 15.2 percent for rental housing. About half of the subsidy for owner-occupied housing and the majority of the subsidy for rental property come from the difference in taxation of corporate and noncorporate assets.

While these parameters combine to yield a best guess of the magnitude of the favorable tax treatment for housing, the exact size of the subsidy is uncertain. Both the user cost calculations and the effective tax rates between corporate and noncorporate capital are sensitive to assumptions about parameters. These parameters, such as interest rates and tax rates, change over time. Furthermore, some of the favorable tax treatment depends on specific financing arrangements that may be endogenous to tax policy. For example, if mortgage interest rates are higher than the return to savings for individuals, then the user cost of homeownership depends on the amount of borrowing which depends on tax rules for deductibility. Despite these uncertainties, the estimates in Table 4.3 roughly approximate the tax subsidy to housing.

4.2 THE COMPOSITION OF RESIDENTIAL ENERGY USE

The size of the subsidy to housing from the tax system is one of two main elements in the interaction of the tax treatment of housing and energy demand. The other main element is the nature of residential energy demand. Residential energy consists of electricity (61%), natural gas (29%), oil (7%) and other sources (3%)." Residential energy encompasses a variety of end uses: space heating, air conditioning, water heating, kitchen appliances, lighting, and other miscellaneous energy needs. Table 4.4 reports the breakdown of residential energy demand by end use, by region of the country, and house size for 1987. These data are from the Residential Energy Consumption Survey. The average U.S. household consumes 162 million BTUS of energy.[20] Space heating is the largest component of residential energy demand covering 38 percent of the total. Air conditioning accounts for another 9 percent of residential energy demand. Energy use for heating and cooling varies greatly by region indicating the importance of climate for residential energy demand.

Miscellaneous energy demand, a broad category that includes such items as kitchen appliances and lighting, is the second largest category. Table 4.5 details the main categories of miscellaneous demand for electricity. Electricity accounts for over 93 percent of the total miscellaneous energy demand.[21] Kitchen appliances are the most important group within the miscellaneous category using 48 percent of miscellaneous electricity. Other than refrigerators, which use almost one-third of all miscellaneous electricity, no single appliance accounts for over 10 percent of the miscellaneous electricity demand.

While these statistics provide a useful summary of residential energy demand, the question remains whether they help in assessing the interaction between the tax subsidy and energy demand. How do the changes in housing capital induced by the tax subsidy affect these different categories of energy demand? One obstacle in answering this question is that increased expenditures on housing can purchase many different positive characteristics: more rooms, a better location, a larger yard, more modem appliances are just a few of the dimensions of house quality.[22] Some house characteristics, such as location and yard size, have little to do with energy demand. Other characteristics can either increase or decrease energy demand: for example, size is positively related with energy demand but newer (or more recently renovated) houses use less energy than older houses.

Of the characteristics that increase energy demand, size is the easiest to compare with energy use. Table 4.2 shows a strong positive relation between size and total energy use: increasing from the 1000- 1600 square foot range to the 2000-2400 square foot range increases average energy demand by about 30 percent. However, the relation between energy use and house size depends critically on the end use: energy for space heating and miscellaneous uses increase considerably with house size, but water heating displays a much weaker relation with house size. Also, this comparison does not control for other determinants of energy demand that are correlated with house size, such as the number of people in the household. For example, even though larger houses are associated with using more energy to heat water, the relation between number of people in the household and energy for hot water is much stronger than the relation with size: the typical 4 person household uses 48 percent more energy for hot water than the typical 2 person household.[23] Within the miscellaneous category energy for some appliances, such as televisions, might have little relation with house size but be strongly related to the characteristics of the occupants.

Another house characteristic that might increase both house prices and energy demand is the number of miscellaneous appliances. Adding an appliance such as a dishwasher increases the value of the house but also increases the demand for energy. By subsidizing consumer durables, the tax system encourages individuals to increase the number of appliances in their homes. However, it is difficult to distinguish between the tax subsidy to homeownership and the tax subsidy to other durables. Consumer durables other than housing receive the same type of subsidy as owner-occupied homes: the implicit rental income from durables is not taxed. The distinction between the imputed rents from owner-occupied housing and durables within the house highlights a major problem in taxing imputed rents from owner-occupied housing: does the imputed rent include the contents of the house? If not, then a bias arises in favor of appliances rather than structures.[24] If imputed rents from household durables are taxed, then logically the tax on imputed rents should extend to other durables, such as cars.

At least two positive housing characteristics reduce, rather than increase, energy demand: energy efficiency and vintage. Dinan and Miranowski (1989) find a positive relation between house prices and energy efficiency. Their estimates imply that the housing market capitalizes improvements in energy efficiency at a 10 percent real discount rate.[25] Since the tax subsidy reduces the cost of housing capital including any efficiency improvements, the tax treatment of owner-occupied housing encourages investments in energy efficiency. Similarly, hedonic models of house prices reveal that, holding other characteristics fixed, newer houses are more valuable. Newer houses also use less energy than older houses: houses built after 1980 use one-third less energy for heating (controlling for climate and house size) than houses built between 1950 and 1969.[26] This statistic suggests that the to the extent that tax subsidy encourages a newer housing stock, it reduces residential energy demand.

The net effect of the interaction between these different housing characteristics, the tax subsidy and energy demand is ambiguous. The model discussed in the next section treats housing capital as a substitute for energy in producing housing services. As will be discussed below, previous estimates of the substitutability between housing capital and residential energy suggest that there can only be limited substitution between capital and energy.

4.3 JOINT DEMAND FOR HOUSING AND RESIDENTIAL ENERGY

The amount of housing capital is directly tied to the amount of residential energy consumed. In modeling the relation between housing and residential energy, Quigley (1984a) posits a production function for housing services with two inputs: housing capital (real estate) and energy. In turn, housing capital is a function of land and structures. Quigley is mainly interested in how the increases in energy prices in the 1970s and 1980s affected the demand for residential energy, real estate and housing services. However, the estimated parameters can also be used to predict how tax policies that change the price of housing capital would affect residential energy.

Quigley models the supply of and demand for housing services in a competitive market. Housing services are produced from a nested constant elasticity of substitution (CES) production function combining land, structures and operating inputs?’ First, land and structures combine through a CES production function to produce housing capital. Second, housing capital and operating inputs (energy) combine through a CES production function to produce housing services. The production function has constant returns to scale, so competition implies a perfectly elastic supply of housing services. With competition, the supply price of housing depends on input prices. Increasing the price on an input causes a substitution away from that input (for a given level of housing services) and increases the price of housing services.

Quigley estimates the quantity of housing services with a log-linear demand curve that depends on household income and the price of housing services implied by the production function. The model is estimated using 7378 observations on new home sales from Federal Housing Administration insurance records for 5 metropolitan areas from 1974 through 1978. The advantage of using data from 1974 through 1978 is that relative input prices changed dramatically over the period: real energy prices rose by almost 40 percent. Only having data on new homes is a mixed blessing. The disadvantage is that the results might not reveal changes in the value of existing homes. The advantage is that new house designs are more likely to be affected by changes in relative input prices. Since the estimates capture how house designs reflect relative prices, they are long-run estimates of changes in the housing stock. The estimated income elasticity for housing services is 0.34 and the estimated price elasticity is -0.72.[28]

Unlike previous studies, Quigley also estimates an elasticity of substitution between capital and energy. This elasticity of substitution is estimated as 0.32 suggesting some latitude for trading between capital and energy in producing housing services.[29] Based on the estimates of the substitutability of capital and energy and the demand parameters, a 10 percent increase in energy prices is associated with a 0.9 percent decline in the demand for housing services, 0.6 percent decline in the demand for real estate and a 2.8 percent decline in the demand for residential energy. This result suggests that policies targeted at changing the price of energy (i.e., corrective energy taxes) would reduce energy demand without greatly affecting the amount of housing capital.

The effect of eliminating the tax subsidy to housing on residential energy demand requires asking the opposite question from Quigley: instead of estimating how increases in energy prices affect the demand for housing services, removing the tax subsidy increases the price of housing capital which lowers demand for housing services which includes residential energy. For various changes in the price of housing capital (real estate), Table 4.6 reports the change in demand for housing services, real estate, and residential energy. For the 23 percent increase in housing prices implied by eliminating the tax advantage to housing (see Table 4.3), the demand for housing services would fall by 11.8 percent, the demand for real estate by 12.7 percent and the demand for residential energy by 6.8 percent. Thus, changing from the current tax system to one with neutral treatment between corporate and residential capital would reduce residential energy demand, though the effect might not be especially large. In comparison, a tax on residential energy that increased the price by 20.0 percent would induce the same reduction in residential energy demand. While a 20.0 percent tax on residential energy would induce the same reduction in energy demand, this tax is not a perfect substitute for eliminating the tax advantage of housing capital because the tax subsidy to housing varies with income (since marginal tax rates depend on income) but the energy tax would not vary by income.

The various entries in Table 4.6 correspond to alternative changes in the tax system that increase the relative price of housing capital and energy by more or less than 23 percent. Table 4.7 summarizes the effects on residential energy demand of the aforementioned policies and several alternatives. Addressing the personal tax advantage to housing without raising the tax on houses to the level of the tax on corporate capital would increase the price of housing capital by 10 percent and reduce the demand for residential energy by 3.2 percent. Only raising the tax on owner-occupied housing to the level of taxation on corporate capital would increase the price of owner-occupied housing by 26 percent. Ignoring the endogeneity of tenure choice, this policy would reduce the demand for residential energy by owner-occupiers by 7.5 percent.[30] However, since owner-occupiers " only account for 74 percent of total residential energy demand, the total reduction in residential energy demand would be only 5.6 percent.[31]

Eliminating the deductibility of mortgage interest and property taxes -- a reform that only addresses part of the tax advantage of homeownership -- would have little effect on residential energy demand. Assuming that 70 percent of middle income homeowners itemize deductions and 100 percent of high income homeowners itemize deductions, eliminating the deductibility of mortgage interest and property taxes would increase the weighted average price of housing by 6.7 percent. This increase in the price of housing capital would lower the demand for owner-occupied housing by about 4.3 percent (ignoring any effects on tenure choice) and the demand for residential energy by homeowners by 2.9 percent or a 2.1 percent reduction in total residential energy demand.

The change in residential energy demand induced by a change in the price of housing capital can be decomposed into two parts. The first effect is the change in energy demand for a change in the level of housing services with relative input prices constant. If the demand for housing services fell by 11.8 percent without the change in relative prices, the demand for residential energy would also fall by 11.8 percent.[32] The second effect is a substitution effect from the change in relative prices. Given a decrease of housing services by 11.8 percent, the substitution of energy for capital induced by the increase in the price of housing capital increases the demand for residential energy by 5.0 percent (relative to energy demand before the decrease in housing services). The net effect of eliminating the favorable tax treatment of housing would be a 6.8 percent decrease in residential housing. However, this effect is much smaller than would be the case if one ignored the substitutability between housing capital and residential energy.

4.4 FURTHER ISSUES IN HOUSING AND ENERGY DEMAND

Increasing the level of taxation on housing to approximately the same as the taxation of other consumption goods and corporate investments lowers the demand for housing services and, consequently, lowers the demand for residential energy. The 6.8 percent reduction in residential energy demand from eliminating the tax differential between housing and corporate capital is a 1.4 percent reduction in total U.S. energy consumption if energy used in other sectors of the economy does not change. However, this assumption -- that energy demand in other sectors is constant -- is suspect. A 11.8 percent reduction in housing services would probably be accompanied by increased investment in other activities and increased consumption of other goods. The net effect on total energy demand depends on the increased energy demand associated with this increased investment and consumption.

The changes in investment and consumption induced by the increased taxation of housing create a labyrinth of general equilibrium effects. While a many-sector full general equilibrium model of the economy might provide a rough estimate of these energy effects, tracing the exact change in total energy use from these effects is beyond the scope of this paper.[33] However, it is possible to put the potential reduction in residential energy in the context of the energy required for other consumption goods.

Energy required for final consumption of a good takes two forms: (1) energy used by individuals in consuming the good (e.g., gasoline for a car) and (2) energy used to produce goods and services. Input-output analysis measures the energy used introducing goods and services. This analysis measures both the energy used directly introducing a good and the energy used in producing the inputs to the goods. Hannon, Blazeck, Kennedy and Illyes (1983) calculate energy intensities for 88 sectors in the economy. Compared to other goods, construction only uses a moderate amount of energy. The most energy intensive goods are chemicals, road construction, metal manufacturing,' and transportation services.[34] Food, wood products (except paper), office machinery, and services (e.g., communications) are among the least energy intensive commodities. In terms of energy contained in different goods, it is unlikely that consuming less housing and more of other goods would greatly influence total energy demand. In general, changes in the product mix in the economy probably have only marginal effects on total energy used in production of goods.[35]

The analysis of the tax treatment of housing in sections 1 and 3 ignores tax incentives targeted at improving energy efficiency. The user cost and general equilibrium models focus on the traditional public finance arguments of why housing is tax-favored. However, in the past, the Federal tax code and many state tax codes have had specific incentives for investment in energy efficient housing. The Energy Tax Act of 1978 provided a tax credit of 15 percent of the investment (with a maximum credit of $300) for energy conservation measures such as adding insulation.[36] The credit was in effect from 1979 through 1985. Previous research on the effectiveness of energy tax credits has been inconclusive (for a summary, see Hassett and Metcalf (1992)). Hassett and Metcalf (1992) analyze the effect of energy conservation tax credits allowing for uncertainty in energy prices and irreversibility of conservation investments. They find that while uncertainty in energy prices and irreversibility of investment lead to low level of conservation investment, the tax credit programs have a statistically significant positive effect on the amount of investment. These programs increase the tax subsidy to housing, but their targeted design results in increased energy conservation and possibly decreased energy use.

The model of the tax treatment of housing and residential energy demand increasing the price of capital in a constant elasticity production function between housing capital and energy abstracts from a wide variety of potential side-effects from changing the tax treatment of housing. Building codes may prevent free substitution between energy and capital implied by the unconstrained constant elasticity of substitution production function. If building codes prevent this substitution, then the model overstates the substitution effect of the increased price of capital and residential energy demand might decrease by more than 6.8 percent. Quigley (1984b) finds that the standards adopted by the California Energy Commission in 1980 would result in a larger reduction in energy consumption in response to a 10 percent increase in energy prices than would be implied by the substitution effect in the CES production function. The binding housing standards decrease individual welfare since the individuals are forced to alter their choice of housing capital and energy however, this policy is justifiable if the market price of energy does not fully reflect society's value of energy.

Another side-effect that the model does not quantify is the possible effect on the organization of the housing market. Increasing the price of housing capital might have two effects on the organization of housing markets that indirectly decrease total energy demand. First, decreasing housing consumption might result in more centralized cities which would decrease energy used in transportation, especially commuting. Second, the smaller housing stock might correspond to fewer single family detached houses and more multifamily housing units that are more energy efficient. Assessing the importance of these indirect effects would be mere speculation.

4.5 CONCLUSION

This paper analyzes the effect of eliminating the favorable tax treatment of housing on the demand for residential energy. Residential energy is used for heating, cooling, cooking and many other appliances. Despite the wide variety of end uses, energy is a substitute for housing capital in producing housing services. Equalizing the taxation of noncorporate housing capital and corporate capital would increase the price of housing capital by 23 percent which would reduce residential energy demand by 6.8 percent. While eliminating all of the tax advantages of housing would substantially decrease residential energy use, it would not substantially affect total energy demand: residential energy is only 20 percent of total energy use and increased energy demand caused by the substitution to goods other than housing would offset, to some degree, the reduction in residential energy.

Analyzing the interaction between the tax treatment of housing and energy demand is important for tax policy for two reasons. First, although it is unlikely that the U.S. will revoke the tax advantages of housing by reforming the income tax system in the near future, the tax differential between housing and other goods could be eliminated through a number of other policy reforms. Examples include: (1) integrating the corporate and personal tax systems which would eliminate the tax differential between corporate and noncorporate capital; and (2) replacing the personal income tax with a a consumption tax that taxes imputed rents from owner-occupied housing.[37] Second, the interaction between housing and energy highlights the importance of the tax treatment of substitutes and complements in designing tax policies aimed at reducing externalities. Eliminating the favorable tax treatment of housing has roughly the same effect on residential energy demand as a 20 percent tax on residential energy.

Table 4.1: User Cost of HomeOwnership Under Various Tax Policies		
Description of policy (User cost formula)	Implied user cost for high income taxpayer	Percentage change from current policy
1. Current policy (equation 1 in the text) $(1 - \Theta)(i + \tau_p) + \delta + m + \alpha - \pi_e$	0.114	--
2. User cost without an income tax $i + \tau_p + \delta + m + \alpha - \pi_e$	0.139	+21.9%
3. Eliminate deductibility of mortgage interest and property taxes $(1 - \Theta)Ei + (1 - E)i + \tau_p + \delta + m + \alpha - \pi_e$	0.127	+11.6%
4. Eliminate rollover and exclusion provisions for nominal capital gains on housing $(1 - \Theta)(i + \tau_p) + \delta + m + \alpha - \pi_e + \tau_{cg}\pi_e$	0.118	+3.5%
5. Tax imputed rents, allow deduction for mortgage int., prop. tax, dep'n and maintenance $[(1 - \Theta)i + \delta + \alpha - \pi_e](1 - z\Theta)/(1 - @) + \tau_p + m$	0.136	+19.3%

The following parameters are taken from similar calculations in Poterba (1990): a nominal interest rate, i, of 7 percent; a property tax rate, τ_p, of 2 percent of the property value; a depreciation rate, δ, of 2.5 percent; maintenance costs, m, of 1.4 percent; a risk premium for housing, α, of 4 percent; and an expected inflation, π_e, of 3 percent. The marginal tax rate on ordinary income, Θ, is assumed to be 28 percent. In the case that eliminates the rollover and exclusion provisions, the accrual equivalent effective tax rate, τ_{cg}, is assumed to be one-half of the ordinary income tax rate (14 percent) to reflect the value of deferral. When the user cost depends upon the size of the mortgage, the equity-to-value ratio, E, is taken as 60 percent which roughly corresponds to the average value for the 1980s from the Federal Reserve Board's Flow of Funds and Savings Section, 1988 (see Manchester and Poterba (1989)). The parameter z accounts for the present value of the depreciation allowances for $1 of investment. Following Gordon, Hines and Summers (1987), z is approximated as 0.5.

These calculations are made under two assumptions. First, the supply of housing is infinitely elastic, so the tax (subsidy) falls on the consumer. Second, the changes in tax policy do not affect the nominal interest rate, the risk premium, or the property tax rate.

Table 4.2: Weighted Tax Subsidy for Owner-occupied Housing					
Income Class:	% of owner-occupiers (1)	$ billion (2)	% of owner-occupied housing stock **(3)**	Tax subsidy for income class **(4)**	**Weighted average tax subsidy (3) x (4)**
Low income (tax rate = O%) Income **<** $15000	22.5%	788.00	15.3%	0.0%	0.0% -
Middle income (tax rate = 15%) $15000-$50000	52.1%	2231.25	**43.4%**	9.7%	4.2%
High income (tax rate = 28%) Income **>** $50000	25.3%	2123.20	41.3%	21.9%	9.1%
Total for all income groups	99.9%	5142.45	100.0%	---	133%

Source: Consumer Expenditure Survey (CES) for 1989 for income distribution of tenure status and house values. Column(1) is the percentage of households in the income class that own their homes. Column (2) is the estimated value of homes owned by households in the income class from the CES. Column (3) is the percentage of the total value of the owner-occupied housing stock owned by households in the income class (the entry in column (2) divided by $5142.45 billion). Column (4) are the tax subsidies for homeownership for the income class. These subsidies are from author's calculations using user cost formula similar to table 1. For owners, the percentage subsidy is the percentage increase in the user cost of moving from line 1 of table 1 to line 2 of table 1 for different marginal tax rates.

Table 4.3: Total Tax Subsidy to Housing Relative to Corporate Assets			
	Personal Tax Advantage (1)	Corporate Tax Advantage (2)	Total Tax Advantage (1) + (2) = (3)
Owner-occupied Housing	13.3%	13.0%	26.3%
Rental Housing	2.2%	13.0%	15.2%
Weighted Average for all Residential Capital	10.0%	13.0%	23.0%

Weights for owner-occupied (70%) and rental housing (30%) are from the Survey of Current Business, August 1990, Table 9, page 101. The personal tax advantage for owner-occupied housing is from the calculations in Table 2 (and described in the text). The personal tax advantage for rental housing is described in section I.B. The corporate tax advantage is the an average from the difference in the effective tax rates on corporate and noncorporate capital taken from Fullerton, Gillette and Mackie (1987) and Fullerton and Karayannis (1992) (described in section I.C).

Table 4.4 Composition of Residential Energy Use, By Region and Size of Unit, 1987										
	Housing units	BTUS per housing unit	Space Heat		Water Heat		Air Cond.		Misc.	
			BTUS	%	BTUs	%	BTUS	%	BTUS	%
National	90.5	161.9	60.7	38	233	**1s**	**14.4**	**9**	**61.1**	**38**
By Region:										
Northeast	19.0	162.7	83.9	52	18.2	11	6.0	4	54.7	33
Midwest	22.3	170.0	73.8	44	23.8	16	11.7	7	60.7	36
South	30.9	163.0	45.2	28	25.1	15	26.7	16	65.7	40
West	18.3	131.2	39.2	29	24.5	19	6.0	5	61.1	47
By sq. footage:										
<999	32.3	114.3	42.9	38	20.1	18	9.2	8	42.1	37
1000-1600	25.6	155.8	54.1	35	24.4	16	15.1	10	62.1	40
1600-2000	11.2	183.9	70.6	38	24.2	13	18.4	10	70.6	38
2000-2400	8.4	201.7	79.5	40	25.9	13	17.7	9	78.6	39
>2400	13.0	233.8	98.9	42	26.1	11	23.8	10	85.1	36

Housing units are in millions. BTUS are in millions. Housing units include houses, apartments, mobile homes for both owner-occupied and renters. For comparability between site electricity BTUS and fossil fuel BTUS, site electricity BTUS are multiplied by three.

Source: Household Energy Consumption and Expenditures 1987, Part 1: National Data, Energy Information Administration, U.S. Department of Energy (1989), pages 89, 93, 95, and 98.

Table 4.5: Miscellaneous Electricity Use, By Appliance, 1987		
Appliance:	**Energy Use as a Percentage of Miscellaneous Electricity**	**Energy Use as a Percentage of Total Electricity**
Kitchen:	48.4	30.2
Refrigerators	31.8	19.8
Freezers	8.1	5.1
Range/Oven .	6.1	3.8
Microwave Ovens	1.1	0.7
Dishwashers	1.3	0.8
Clothes Dryers	9.0	5.6
Clothes Washers	1.4	0.8
Televisions	9.2	5.7
Furnace Fans	6.0	3.8
Water-Bed Heaters	4.0	2.5
Other	22.9	13.2

Miscellaneous electricity use accounts for 62,4 percent of total electricity use.

The other category includes lighting, small cooking appliances, computers, electric tools, ceiling fans, electric blankets and other electric appliances.

Source: Household Energy Consumption and Expenditures 1987, Part 1: National Data, Energy Information Administration, U.S. Department of Energy (1989), page 10.

Table 4.6: The Effects" of Increasing the Price of Housing Capital			
Increase housing capital price from a change in the tax treatment of housing	Associated Change in the Demand for:		
	Housing Capital	Housing Services	Residential Energy
5%	-3.1%	-2.9%	-1.6%
10%	-6.0%	-5.6%	-3.2%
13%	-7.7%	-7.1%	-4.0%
15%	-8.7%	-8.1%	-4.6%
20%	-11.2%	-10.4%	-6.094
23%	-12.7%	-11.8%	-6.8%
25%	-13.6%	-12.6%	-73%
26%	-14,0%	-13.0%	-7.5%
30%	-15.8%	-14.7%	-8.5%
35%	-17.8%	-16.7%	-9.7%

Source: Author's calculations based on parameters estimated by Quigley (1984a).

Table 4.7: The Effects of Alternative Policies on Residential Energy Demand	
Policy Alternative:	Change in Residential Energy Demand
1. Raise the level of taxation on housing (owner-occupied and rental) to the level of taxation of corporate capital (A 23.0% increase in the cost of housing capital)	-6,8%
2. A 20% increase in the price of residential energy	-6.8%
3. Eliminate the personal tax advantage owner-occupied and rental housing with addressing the advantage created by the corporate tax (A 10% increase in the cost of housing capital)	-3.2%
4. Raise the level of taxation on owner-occupied housing to the level of taxation of corporate capital without addressing rental property (A 26.0% increase in the cost of owner-occupied housing)	-5.6%
5. Eliminate the deductibility of mortgage interest and property taxes for owner-occupiers (A 6.7% increase in the price of owner-occupied housing)	-2.1%

Source: Author's calculations from tables 3 and 6, as described in the text.

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NOTES

1. For a general discussion of a carbon tax, see Poterba (1991); Goulder (1992) has an extensive general equilibrium analysis.

2. Total annual cost equals the annualized cost of land and structures plus the annual operating expenditure on utilities (Table 1, p. 558, Quigley (1984a)).

3. Source: U.S. Energy Information Administration, State Energy Data Report, 1960-1988. Other end uses for energy were: commercial, 16%; industrial, 36%; and transportation, 28%.

4. As noted by Poterba and others, under the "benefit tax" view of the property tax (i.e., the property tax is a fee for local public services), it is not clear how the property tax should be treated in the user cost.

5. Also, the user cost reflects the marginal cost of housing rather than the average cost. This distinction arises when home-ownership induces the household to switch from taking the standard deduction to itemizing. In this case, the tax savings from using the standard deduction rather than itemizing are lost inducing a fixed cost to homeownership. This distinction is mainly important for the tenure decision, so it may not be important for energy demand.

6. For a sample of homebuyers who owned their previous home, Hoyt and Rosenthal (1990) report that 15 percent of the sample bought houses that were less valuable than their previous homes, so that they would not be completely covered by the rollover provision.

7. The nature of owner-occupied housing makes it somewhat difficult to distinguish between producer and consumer surplus. While competition drives the producer surplus to zero, the consumer surplus from owner-occupied housing may still be large.

8. For example, if the equity-to-value ratio increased from .6 to .7, then the user cost would only increase by 9.9%.

9. Two other tax provisions influence the effective capital gains tax on housing. First, the U.S. tax code allows a step-up in basis for assets that are inherited (constructive realization at death) that eliminates the capital gains tax on any appreciation of assets before inheritance. This provision lowers the effective tax rate on capital gains. Second, unlike other capital assets, individuals cannot deduct capital losses from the sale of property (e.g., houses or cars). This asymmetric treatment of housing capital losses and gains increases the effective taxation of housing capital gains. The justification for this tax rule is that the current tax code does not allow individuals to deduct depreciation on houses. Depreciation allowances would lower the basis of the house which would increase the size and frequency of housing capital gains. The current policy of not

allowing depreciation allowances is consistent with the policy of not taxing the imputed rents from homeownership.

10. Depreciation allowances create two tax-minimizing strategies: (1) borrowing to increase the sum of interest and depreciation deductions, a tax sheltering strategy often associated with partnerships (see Cordes and Galper (1985)); and (2) "churning" by which assets are sold frequently to increase the total value of their depreciation allowances when the tax system allows accelerated depreciation (see Gordon, Hines and Summers (1987)).

11. Depreciation allowances with a present value of fifty cents for every dollar invested roughly correspond to the present value of current depreciation allowances for business structures (using a discount rate of 6 percent). Currently, for tax purposes, business structures can be depreciated using straight-line depreciation over 27.5 years.

12. If the taxpayer received depreciation allowances with a present value of $1 for each dollar invested (z = 1, in the formula in table 1), the user cost would only rise by 5%. The tax system would still provide a generous subsidy because the opportunity cost of capital is the after-tax return on bonds that are assumed to be taxed at the marginal tax rate for ordinary income. In contrast, if the taxpayer cannot deduct depreciation (z = O), the user cost would increase by 34%.

13. Rosen (1979) estimates that taxing imputed rents for homeowners would decreases the incidence of homeownership by over 4 percentage points.

14. I implicitly assume that rental property is owned by individuals or partnerships rather than corporations. See Poterba (1990) for a summary of the debate on the marginal source of investment in rental housing.

15. As with homeownership, this subsidy is the same as the subsidy relative to an income tax on economic income with a perfectly competitive housing market and constant returns to scale production.

16. As discussed below, similar to owner-occupied housing, the imputed rents from consumer durables are not taxed.

17. The comparisons for different types of capital are for 1989 from the Bureau of Economic Analysis, Survey of Current Business, August 1990, page 101, tables 5 and 9.

18. For a rich description of these interactions, see King and Fullerton (1984).

19. Source: Office of Technology Assessment, Building Energy Efficiency, 1992, p. 17. These statistics mask the heterogeneity in sources for residential energy because electricity is generated from a variety of fuels.

20. For comparability between electricity BTUS delivered to houses and fossil fuel BTUS contained in natural gas, electricity BTUS are multiplied by three throughout the paper.

See Residential Energy Consumption Survey Trends in Consumption and Expenditures, 1978-1984, DOE, Energy Information Administration, 1987, pp. 14-15.

21. Source: Calculated (site electricity BTUs are adjusted to be comparable to natural gas BTUs) from table 1, p. 4 of U.S. Department of Energy (1989).

22. Hedonic regression techniques can be used to study the contributions of specific characteristics to the overall value of a good. Palmquist (1984) and Quigley and Rubinfeld (1989) are two recent examples of studies that apply hedonic techniques to house values. The results suggest that house size, number of rooms, age and neighborhood quality are among the most important determinants of house values.

23. Source: U.S. Department of Energy (1989), p. 110.

24. An analogous tension arises between the tax treatment of business equipment and structures: depreciation rules sometimes favor one type of investment over the other.

25. Johnson and Kasserman (1983), Longstreth, Coveney and Bowers (1985), and Khazzoom (1987) also report that energy efficiency increases house value. In contrast, the literature on energy savings in appliances suggests that consumers are myopic (see Ruderman, Levine and McMahon (1987) and Hausman (1979)). Hausman's estimates suggest that consumers discount appliance efficiency using a 30 percent discount rate.

26. Source: U.S. Department of Energy (1989), figure 6, page 12.

27. Operating inputs exclude maintenance expenses which are classified as a cost of capital.

28. These estimated elasticities are somewhat different than those found by Rosen [1979] who concentrates on the tax aspects of housing choice and finds an income elasticity of 0.76 and a price elasticity of -1.0. However, two differences in methodology might explain the variation in elasticities: (1) Quigley only uses data on new houses but Rosen uses a cross-section of existing homes; and (2) Rosen does not allow for a production function that combines housing capital and operating inputs. Using data on new houses, MacRae and Turner (1981) estimate an income elasticity of 0.25 and a price elasticity of -0.89 allowing for a production function that combines housing capital and operating inputs.

29. As noted by Quigley, this elasticity of substitution between capital and energy is lower than the elasticity of substitution between land and structures for producing housing capital.

30. Ignoring the endogeneity of tenure choice overstates the effects of the policy change on the demand for housing capital and residential energy.

31. The division of residential energy demand by tenure status is calculated from U.S. Department of Energy (1989), page 26, table 7.

32. If relative input prices are constant, the percentage decrease in residential energy demand equals the percentage decrease in housing services because the estimated production (constant elasticity of substitution) has constant returns to scale.

33. Constructing a general equilibrium model that adequately captures the interaction between housing capital, residential energy, the demand for other goods and investment in alternative investments would be a difficult task. Among the more complex features of the model would be knowing the degree to which lower consumption of housing increases consumption of other goods as opposed to investment in alternative assets. Furthermore, individuals could switch to investing abroad which would complicate the effects on energy demand since the problem would expand to include foreign and domestic energy use.

34. The input-output analysis only includes commercially-produced transportation services. Energy used by individuals to produce transportation is recorded as direct household consumption.

35. See Krenz (1976), page 387.

36. In addition, the Energy Act of 1978 provided larger credits for investment in solar, wind and geothermal energy equipment.

37. For a full explanation of the integration of personal and corporate taxation, see U.S. Department of Treasury (1992). For a discussion of the options of taxing consumption rather than income and the tax treatment of housing under different consumption tax plans, see Bradford (1986).