SUPPLEMENTAL ECONOMIC IMPACT STATEMENT FOR VERMONT'S PROPOSED RULE ON OUTDOOR WOOD-FIRED BOILERS

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August 2006

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INTRODUCTION CHAPTER 1

The Vermont Agency of Natural Resources' (ANR) Air Pollution Control Division (APCD) is currently revising and expanding regulations governing the installation of and emissions from outdoor wood-fired boilers (OWBs). First proposed in August 2005, the new regulations would establish a specific emission limit for particulate matter (PM) and would require that a manufacturer demonstrate compliance before retailers are allowed to sell the manufacturer's product in Vermont. This rule is being proposed as § 5-205 ("Control of Particulate Matter from New Outdoor Wood-Fired Boilers") of Vermont's Air Pollution Control Regulations (APCR). The ANR is also proposing several minor revisions to the current regulation entitled "Siting and Stack Height Standards for Outdoor Wood-Fired Boilers" (§ 5-204).

BACKGROUND

The APCD began receiving complaints about OWB smoke in the late 1980s and early 1990s. In 1997, the state set standards that prohibited new OWBs from being located closer than 200 feet from a neighboring residence. The rule also required that any OWB located within 500 feet of a neighboring residence be equipped with a stack of a specified minimum height.

Despite the location and stack height standards, the APCD has continued to receive complaints about OWBs. In response to these complaints and to evidence of potential adverse health effects related to the operation of OWBs, the proposed regulations would establish a PM emission standard for OWBs to reduce exposure to particulate matter as well as toxic pollutants produced during wood burning (e.g., carbon monoxide, dioxins, and polycyclic aromatic hydrocarbons). Specifically, the rule would require that OWBs sold for use in Vermont limit PM emissions to 0.20 grains per dry standard cubic foot (gr/dscf) of exhaust gas corrected to 12 percent CO^2, or an equivalent rate of 0.44 pounds per million BTUs of heat input.

Numerous studies have linked ambient PM exposure to health endpoints, including pulmonary function decrements, respiratory symptoms, hospital and emergency department admissions, and mortality. While epidemiological studies originally focused on PM_{10} effects, more recent studies have examined the impact of fine-fraction particles (e.g., $PM_{2.5}$) which have the ability to lodge deep in the lung (EPA, 2004). The proposed emission limitation would deliver health benefits for residents of homes neighboring OWBs, particularly sensitive populations such as the elderly, children, and individuals with pre-existing heart and respiratory conditions. In addition, the regulations would provide secondary benefits such as elimination of nuisance conditions and aesthetic disamenities (e.g., visibility).

Concern over OWB emissions has increased as OWB sales have grown. Nationwide, sharp increases in fossil fuel prices have encouraged homeowners to seek alternative heating options. According to data provided by manufacturers, approximately 156,000 OWBs have been sold in the U.S. since 1990, with sales concentrated in the Northeast. The rate of sales has increased substantially since 1999; manufacturers expected sales increases of 200 to 350 percent in 2005.

While data are sparse, Vermont appears to reflect these same sales patterns. Since 1990, roughly 2,000 OWBs have been sold in Vermont (NESCAUM, 2006). Sales grew from 64 units in 2000 to 142 units in 2003 (APCD, 2005). The number of units in operation may be greater than indicated by Vermont sales data given that many sales, occurring both inside and outside of the state, have probably not been reported to the APCD as required.

PEOPLE, ENTERPRISES, AND GOVERNMENT ENTITIES POTENTIALLY AFFECTED

In accordance with 3 VSA § 838, this Economic Impact Statement (EIS) focuses on the enterprises and entities potentially affected by the proposed OWB rules, characterizing the costs and benefits anticipated for each:

- **OWB Manufacturers**: Approximately 28 firms manufacture OWBs; one of these firms is located in Vermont. The proposed rule would require that manufacturers meet the PM emission limit as a precondition of selling their OWBs in Vermont. Therefore, manufacturers will incur the costs of modifying OWBs, e.g., through reconfiguration or addition of emission control devices. Chapter 2 examines potential economic impacts on manufacturers.

- **Prospective OWB Users**: The proposed regulation would require that future OWB units sold for use in Vermont meet the emission standard. Therefore, another potentially affected group is prospective OWB buyers (current owners would be unaffected). Specifically, buyers may face higher prices for OWB units or, if emission controls are prohibitively costly, may need to use alternative heating systems. In addition, OWB users may realize health benefits if they use heating systems with lower emissions. Chapter 3 considers the range of possible impacts on OWB users and their economic implications.

- **OWB Retailers**: To the extent that emission controls increase the cost of OWB production, retailers may realize reduced profits or reduced sales.

The ultimate effect on retailers (and the regional economy) depends on whether OWBs represent a major or minor component of sales and profits. Chapter 4 examines these issues.

- **Residents Neighboring OWB Users**: The primary benefit of the rule would be reduced health risks for individuals neighboring prospective OWB users. In addition, some neighbors would realize benefits associated with reductions in nuisance impacts such as odors. Chapter 5 reviews the health impacts associated with PM exposure and the economic benefits of reducing these exposures.

- **Government Entities**: Chapter 6 briefly considers the resources that the Agency of Natural Resources will devote to enforcement of the OWB emission standard and secondary implications for state and local health officials.

This report concludes with a summary of the economic impacts on these groups as well as a discussion of potential burdens for small businesses (see Chapter 7).

OTHER POTENTIAL ALTERNATIVES

Provisions in 3 VSA § 838 require that the EIS compare the economic impact of the rule with other regulatory alternatives. While a variety of options exist, the Agency of Natural Resources has focused on three alternatives:

- **No Action**: One option simply involves maintaining the status quo regulations governing siting and stack height, introducing no new protective measures.

- **Interim OWB Ban**: Another alternative involves prohibiting the sale of OWBs in Vermont until the U.S. Environmental Protection Agency has developed nationwide regulatory standards for OWBs.

- **OWB User Compliance**: This alternative would limit emissions similar to the proposed regulation; however, it would shift the burden of compliance onto purchasers of OWBs, requiring that they demonstrate that their units meet emissions requirements (as opposed to placing this burden on manufacturers).

The summary chapter (Chapter 7) returns to these alternatives and compares their economic impacts to the rule under consideration.

IMPACTS ON OWB MANUFACTURERS CHAPTER 2

The proposed emission limit would apply to the sale of new OWBs for installation in Vermont. Therefore, to ensure continued sales in Vermont, OWB manufacturers would have primary responsibility for designing units to meet the emission standard. This chapter provides an overview of the OWB manufacturing sector, examines the potential changes that would be needed to meet the emission limit, and frames the potential cost of these changes.

OWB MANUFACTURERS

A recent study by the Northeast States for Coordinated Air Use Management (NESCAUM) identified 27 OWB manufacturers in North America (NESCAUM, 2006). The study found that manufacturers are distributed across 10 states and Canada: eight in Minnesota; three in Pennsylvania; two in Wisconsin; two in North Carolina; six in Canada; and one each in Missouri, Nebraska, New Hampshire, New York, Tennessee, and Washington. The companies range widely in size, employing between one and 140 individuals.[1]

While none of the manufacturers identified in the NESCAUM report are located in Vermont, APCD staff indicate that one in-state manufacturer does exist. The business is a one- to three-person operation located in West Burke in northern Vermont. This firm reported selling 10 OWBs in 2004 and four in 2005.

REVIEW OF EMISSIONS DATA

The cost of meeting the proposed emission standard is related to the control approach used and the gap between current OWB PM emission rates and the standard. Therefore, this section briefly reviews existing data from OWB emissions testing. Exhibit 2-1 summarizes the studies, noting the characteristics of the OWB tested and the PM emission levels recorded.

[1] In at least one case, an American firm serves as a distributor for OWB units manufactured outside the U.S. Specifically, Tarm-USA markets OWB models manufactured in Denmark. It is unclear whether this is true for any of the other manufacturers identified in the NESCAUM study.

Exhibit 2-1

SUMMARY OF OWB AND INDOOR WOOD FURNACE EMISSION RATE STUDIES

Study	Unit and Operation Description	Fuel	PM Emissions Reported	Emissions in lbs./mmBTU Heat Input
Valenti and Clayton, 1998	Single pass furnace (A); range of heat removals	Oak cordwood	38.5-143.2 g/hr 1,048 mg/MJ input	2.438 lbs./mmBTU
	Double pass furnace (B); range of heat removals	Oak cordwood	14.3-37.6 g/hr 681 mg/MJ input	1.584 lbs./mmBTU
McCrillis, 1995	Indoor wood furnace, intermittent firing	Cordwood	1,862 mg/MJ input	4.331 lbs./mmBTU
	Indoor wood furnace, continuous firing	Cordwood	182 mg/MJ input	0.423 lbs./mmBTU
	Indoor wood furnace	Dry woodchips	45.3 mg/MJ input	0.105 lbs./mmBTU
Central Boiler	Central Boiler Model CL-7260	Cordwood	93.76 g/hr[a]	N.A.[c]
Johansson, 2004	Conventional design (water cooled, up-draft combustion)	Dry cordwood	87-2,200 mg/MJ	0.202 – 5.117 lbs./mmBTU[d]
	Modern design (ceramic boiler, flue gas fan, down-draft combustion, large water tank)	Dry cordwood	27-32 mg/MJ	0.063 – 0.074 lbs./mmBTU[d]
	Modern design (ceramic boiler, flue gas fan, down-draft combustion, large water tank)	Wet cordwood	23-89 mg/MJ	0.053 – 0.207 lbs./mmBTU[d]
Manufacturer Test Data Reported in Schrieber et al., 2005[b]	N.A.	Cordwood	84 g/hr	N.A.[c]
	N.A.	Cordwood	60 g/hr	N.A.[c]
	N.A.	Cordwood	108 g/hr	N.A.[c]
	N.A.	Cordwood	18 g/hr	N.A.[c]
	N.A.	Cordwood	49 g/hr	N.A.[c]
	N.A.	Cordwood	33 g/hr	N.A.[c]
	N.A.	Cordwood	147 g/hr	N.A.[c]
	N.A.	Cordwood	118/g/hr	N.A.[c]
Intertek, 2006	DECTRA/Garn 1350 solid fuel boiler; two-stage combustion with ceramic-lined chamber	Cordwood (oak)	0.17 g/MJ output	0.29 lbs./mmBTU[e]

Notes:

a. Central Boiler and VT DEC disagreed over the proper interpretation of the test. The figure reported is that recommended by VT DEC.

b. Data provided in this table exclude the Intertek Laboratories study that focused on testing methods using an unidentified wood boiler. Schrieber et al. excluded these data from their calculation of average emissions.

c. Converting these figures to lbs./mmBTU requires information on the output of the OWB unit; this information is not readily available.

d. Figures are assumed to be on a heat input basis, although Johansson does not explicitly address whether emissions are stated on a heat input or output basis.

e. Converted to heat-input basis using reported efficiency of 75 percent.

Emissions are influenced by testing conditions, test methods, OWB design, OWB operating methods, fuel used, and other factors, making it difficult to compare results definitively. However, the studies suggest several key conclusions:

- Overall, concentrations of PM in OWB emissions are high. Several studies have placed OWB emissions in context by comparing them with other heat sources. Most notably, fine PM emission rates from OWBs are estimated to exceed those of wood stoves by a factor of between four (relative to a conventional woodstove) and 12 (relative to an EPA-certified catalytic woodstove); emission rates exceed gas and oil furnaces by a much greater degree (Schrieber, et al., 2005).

- While emission test results vary widely, OWBs with conventional designs generally would not meet the proposed emission standard.

- Available data suggest that properly designed OWBs can meet the proposed emission standard (0.44 lbs./mmBTU). The modifications and operational changes that appear to reduce emissions include a down-draft combustion design; two-stage combustion; a ceramic chamber; a large water tank to allow continuous firing; and use of woodchips rather than cordwood. These issues are discussed further below.

COMPLIANCE WITH EMISSION LIMIT AND ULTIMATE INDUSTRY IMPACTS

In analyzing the impact of any regulation, it is essential to anticipate the ways in which the regulated parties could respond. Available information and conversations with industry experts suggest several possible approaches that OWB manufacturers could take in response to the Vermont OWB emission requirements:

- **No Change**: Some manufacturers may already be producing OWB units that comply with the Vermont standard. For example, the Garn unit analyzed in Intertek (2006) appears to be capable of meeting the 0.44 lb/mmBTU standard. In contacts with APCD, other manufacturers have expressed confidence that their units will meet the standard once tested.[2]

- **Cease Sales in Vermont**: Some manufacturers who find compliance with the standard to be cost prohibitive may simply discontinue sales in Vermont and sales of units to be installed in Vermont. Sales in Vermont represent a very small portion of national sales (about one percent), so the impact on manufacturers would be minimal.

[2] Personal communication with Phillip Etter, APCD, May 26, 2006; and Lloyd Nichols, Tarm-USA, June 7, 2006.

- **OWB Redesign**: Existing manufacturers may redesign their OWBs to reduce emissions. Meeting the standard would likely require fundamental re-engineering to introduce features such as down-draft combustion design, two-stage combustion and/or a ceramic chamber. New manufacturers could incorporate such design features into new units brought to the Vermont market.

It is difficult to determine the relative balance of these different options since companies face different baseline circumstances. With respect to Option 1, at least one major manufacturer (Garn) appears to have units that will meet the standards. However, others that make this claim have yet to perform emission testing and in some cases are new entrants to the OWB market.

Option 2 (abandoning the Vermont market) may be an attractive interim measure for manufacturers of non-compliant units. However, Vermont is not the only state enacting or considering OWB emission controls. Washington State already limits emissions from all solid fuel-burning devices rated lower than one million BTUs per hour (NESCAUM, 2006). Indiana is considering regulatory alternatives ranging from emission limits to an outright ban on OWBs (Indiana Register, 2006). The American Lung Association of Maine is calling for increased OWB emissions controls; in response, the Maine Department of Environmental Protection is developing a regulatory strategy in coordination with relevant legislative committees (MPBN, 2006). Local governments are actively regulating stack heights and other design parameters, and in some cases have introduced OWB bans. In New York State alone, 11 municipalities have banned OWBs (Schreiber, 2005). In Vermont, the town of Salisbury is also proposing an OWB ban. Considering these trends, manufacturers may soon find it difficult to remain competitive in key markets without introducing new models with lower emissions.

Manufacturers who choose to redesign non-compliant units to meet the emission standard (Option 3) will face significant engineering and economic challenges. While a technical discussion of the re-engineering options is beyond the scope of this study, it is unlikely that the standard could be met through simple addition of conventional emission control devices. Experts suggest that the costs of a catalytic abator or other “add-on” emission reduction device are prohibitive and would render the OWB product uncompetitive in the marketplace.[3] Instead, emission tests suggest that fundamental design elements such as two-stage combustion, down-draft combustion, a ceramic chamber, or an enlarged water tank offer the greatest emission control benefits. One manufacturer acknowledged that such elements add to the cost of producing the unit and indicated that conversion from a conventional to a low-emissions design could increase the price of a $7,000 OWB to $10,000, an increase of over 40 percent. This is, however, a very rough estimate and likely represents an upper bound; actual results will depend on numerous factors, including the size and starting design of the unit; research and development costs; the cost of production inputs (labor, materials); and market demand for the redesigned unit.

[3] Personal communication with Martin Lunde of Garn Furnaces, distributed by DECTRA Corporation, June 1, 2006.

Because of the small size of the Vermont OWB market, the proposed emission standard is unlikely to significantly affect the manufacturing sector. The ultimate effect of the Vermont standard in combination with other state, local, or Federal OWB regulations could be a consolidation of the manufacturing sector that favors companies already producing compliant units as well as larger companies with sufficient research and development budgets to pursue redesign. Competition and regulatory changes may force smaller operations out of business. However, it is essential to consider the full suite of baseline market forces at work in producing this consolidation. One scenario is that, as state and municipal regulations prompt redesign efforts, the price of OWBs will rise to the point that residential use is no longer cost-effective or feasible. Indeed, analysis presented in the following chapter suggests that OWBs may already be an economically inferior option for residential heating. Manufacturers may focus on larger OWBs for commercial buildings, prompting further market consolidation. Overall, however, the proposed emission standard in Vermont would be a minor contributor to these changes.

IMPACTS ON PROSPECTIVE OWB OWNERS CHAPTER 3

As noted earlier, sales of OWBs in Vermont have increased in recent years, with approximately 142 units sold in 2003. Manufacturers of OWBs have expressed the concern that the proposed regulations may eliminate a cost-effective home heating option for potential buyers, forcing them to rely on more expensive heating options (Central Boiler, 2005). The relative cost-effectiveness of different heating options will in turn influence the overall economic impacts of the emission control regulations.

This chapter examines this assertion in greater detail, characterizing the baseline cost-effectiveness of various home-heating options and discussing whether the proposed emission limit would influence the relative desirability of these options.

BASELINE COST-EFFECTIVENESS OF HEATING OPTIONS

Prospective OWB buyers will generally have several options for heating their homes and domestic water. A valid assessment of heating options must standardize the comparison on two important levels:

- First, while some discussions of OWB advantages have focused on the cost of wood fuel relative to other fuels (see DRM, 2005), a valid comparison must consider both operating costs (e.g., fuel, maintenance) as well as capital costs (i.e., the cost of the combustion unit and its installation).

- Second, fuel costs must be standardized by energy content, expressing the cost per BTU of energy provided.

This section discusses a simple spreadsheet model that yields total annual costs associated with different heating systems, prior to introduction of the proposed OWB regulations. It is important to note that this comparison is very generalized; the cost-effectiveness of any heating option is house- and location-specific and will depend upon many factors, including the age of the home, how well the home is designed, construction materials (e.g., windows), insulation type, and the availability and price of different fuels in the local market.

Operating Costs

Exhibit 3-1 summarizes the inputs and results of the model, comparing heating option costs for several different systems: (1) a representative OWB; (2) indoor wood stoves; (3) natural gas systems using forced air; (4) natural gas systems using hot water; (5) oil systems using forced air; and (6) oil systems using hot water. The first component of the model develops annual fuel cost estimates for these systems. Fuel costs are derived by standardizing the fuel by its BTU value to yield a fuel price per million BTUs (MM BTUs). The price per MM BTU is multiplied by 100 (the approximate average MM BTU usage per U.S. household) and divided by the percentage efficiency of the system, i.e., the heat output of the system in comparison to the energy content of the fuel.

The efficiency assumption is an important element in the calculation and should be examined closely. In particular, estimates of OWB efficiency vary widely. Based on a series of testing studies, Schreiber et al. (2005) report an average efficiency of 43 percent. Other sources identify an estimated efficiency of 50 percent (Valenti and Clayton, 1998; Indiana Register, 2006). However, the efficiency of any given OWB unit will depend on the unit's design. OWB manufacturers frequently claim efficiencies much higher than 50 percent, although many observers dispute these claims.[4] A recent engineering study estimated an efficiency of 75 percent for a unit with modern design features such as two-stage combustion and a ceramic-lined chamber (Intertek, 2006). The analysis presented here uses an efficiency estimate range of 40 to 50 percent, recognizing that higher efficiencies may be achieved by some cutting-edge OWB units.

The resulting operating cost estimates highlight the importance of the efficiency assumption. As shown in the exhibit, while wood is relatively inexpensive on a dollars-per-BTU basis, the lower efficiency of OWBs makes them among the most expensive heating options on an annual fuel cost basis. Only lower-efficiency oil burning units have annual fuel costs that approach those of OWBs.

Two caveats should be considered when assessing relative fuel costs. First, due to a variety of macroeconomic and political factors, prices for home heating fuels are currently volatile. The analysis presented here attempts to integrate the most recent information on prices. Future changes in fuel prices may influence the cost-effectiveness comparison. However, forecasting oil and gas prices is extremely complex. Furthermore, forecasts are probably not essential to this comparative analysis since wood demand and wood prices generally keep pace with fluctuations in the prices of conventional fuels over time.

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[4] For example, see the arguments made by the Wood Heat Organization, at http://www.woodheat.org/technology/outboiler.htm. One source of disagreement in interpretation of efficiency tests concerns testing methods. Specifically, heating efficiency is measured at the test unit, which does not account for potential losses in delivering heat through piping between the OWB and the home. As such, laboratory tests may overstate heating efficiency.

Exhibit 3-1

COST-EFFECTIVENESS COMPARISON FOR OWBs AND CONVENTIONAL HEATING SYSTEMS

	Operating Costs						Capital Costs					Total Annual Costs	
System	**Fuel Unit**	**Price per Unit**	**BTU Value per Unit**	**Price per MM BTU**	**Effi-ciency**	**Annual Fuel Cost**	**Purchase and Installation**	**Useful Life**		**Annual Capital Cost**		**Lower Bound**	**Upper Bound**
Outdoor Wood Boiler	Cord	$225.00	22,000,000	$ 10.23	40-50%	$ 2,045 - $ 2,557	$ 5,500 - $ 8,000	15	20	$370	$878	$2,415	$3,435
Indoor Wood Stove (non-cat., 68% efficiency)	Cord	$225.00	22,000,000	$ 10.23	68%	$ 1,504	$ 2,075	18	22	$130	$206	$1,634	$1,710
Indoor Wood Stove (cat., 72% efficiency)	Cord	$225.00	22,000,000	$ 10.23	72%	$ 1,420	$ 2,425	18	22	$152	$241	$1,573	$1,662
Gas Forced Air (80% efficiency)	1,000s cf	$ 12.20	1,000,000	$ 12.20	80%	$ 1,525	$ 1,860	17	20	$125	$191	$1,650	$1,716
Gas Forced Air (90% efficiency)	1,000s cf	$ 12.20	1,000,000	$ 12.20	90%	$ 1,356	$ 2,690	17	20	$181	$276	$1,536	$1,631
Gas Hot Water (80% efficiency)	1,000s cf	$ 12.20	1,000,000	$ 12.20	80%	$ 1,525	$ 3,320	17	20	$223	$340	$1,748	$1,865
Gas Hot Water (90% efficiency)	1,000s cf	$ 12.20	1,000,000	$ 12.20	90%	$ 1,356	$ 4,260	17	20	$286	$436	$1,642	$1,792
Oil Forced Air (80% efficiency)	Gallons	$ 2.42	139,000	$ 17.41	80%	$ 2,176	$ 1,860	17	20	$125	$191	$2,301	$2,367
Oil Forced Air (90% efficiency)	Gallons	$ 2.42	139,000	$ 17.41	90%	$ 1,935	$ 2,690	17	20	$181	$276	$2,115	$2,210
Oil Hot Water (80% efficiency)	Gallons	$ 2.42	139,000	$ 17.41	80%	$ 2,176	$ 3,320	17	20	$223	$340	$2,400	$2,516
Oil Hot Water (90% efficiency)	Gallons	$ 2.42	139,000	$ 17.41	90%	$ 1,935	$ 4,260	17	20	$286	$436	$2,221	$2,371

Data Sources:

Fuel Prices:

Wood – Personal communication with Adam Sherman, Biomass Energy Resource Center, June 5, 2006; and Thom McEvoy, Vermont Extension Service, May 19, 2006.

Natural Gas – Vermont price from Energy Information Administration, Natural Gas Monthly, March 2006, Table 21.

Oil – New England price from Energy Information Administration, Weekly Petroleum Status Report, 2005-2006 Heating Season, Table C1.

Wood BTU Value: Air-dry wood value of 15.36 million BTUs per cord (Bioenergy Conversion Factors provided at http://bioenergy.ornl.gov). Bone-dry value (20 million BTUs per cord (USDA Forest Products Laboratory, Fuel Value Calculator). Commonly burned Vermont hardwoods (e.g., oak and maple) have somewhat higher BTU content, ranging from 20 to 24 million BTUs per cord (see Heat Values of Wood at http://hearth.com). Average figure of 22 million BTUs assumed.

OWB Efficiency: Valenti and Clayton, 1998; Indiana Register, 2006; Intertek, 2006; Schreiber et al., 2005.

Purchase and Installation Cost:

OWB – Schreiber et al., 2005; NESCAUM, 2006; personal communication with Martin Lunde, Garn Furnaces, June 1, 2006.

Wood Stove – Houck and Tiegs, 1998; EPA Woodstove Changeout Campaign, at http://www.epa.gov/woodstoves/changeout.html.

Gas Furnace – Consumer Energy Council of America, 2001

Oil Furnace – Consumer Energy Council of America, 2001

Useful Life:

OWB/Wood Stove – Personal communication with Cal Willis, The Wood Heat Organization, Inc., May 20, 2006.

Gas/Oil Furnace – Propane Council, at http://www.propanecouncil.org/trade/residConstruct/heating.htm.

Second, some observers point to the availability of on-site wood when stressing the advantages of wood as a heating fuel. If a landowner has a supply of cordwood, it is true that out-of-pocket expenses will be reduced. Such a scenario is particularly feasible in a rural state such as Vermont. However, wood should not be viewed as "free." The wood is a resource with a well-established market value; hence, there is an opportunity cost to burning the wood rather than selling it. Furthermore, the landowner pays an intrinsic price for the labor devoted to harvesting, cutting, and splitting the wood. For these reasons, the comparative analysis presented here does not include a scenario in which OWB (or wood stove) fuel costs are zero.

Capital Costs

Capital costs must also be considered in a comparative cost-effectiveness assessment. The purchase and installation costs of different heating systems are listed in the exhibit. The prices for gas and oil systems are from a 2001 report by the Consumer Energy Council of America (CECA, 2001) and were also reported in Schreiber et al., 2005.[5] The prices for wood stoves are taken from a 1998 report (Houck and Tiegs, 1998) and are consistent with more recent information compiled for EPA's wood stove changeout campaign which estimated a purchase/installation cost for a new wood stove of between $1,000 and $3,000. Finally, the assumed lower-bound OWB unit price is based on a figure reported in Schreiber et al., 2005. The price includes the unit and installation materials and is based on information provided by the five largest OWB manufacturers. This figure may be low; other sources suggest a capital cost of $5,000 before installation, with total costs ranging between $8,000 and $10,000 (NESCAUM, 2006). Therefore, the analysis uses an upper-bound OWB capital cost of $8,000.

To refine the comparison, it is useful to estimate *annual* capital costs that can be added to fuel costs to yield an overall annual cost figure for each heating system. Annualization means that capital costs are not simply depreciated but that the foregone interest on the initial investment is taken into account. Annual capital costs are derived by incorporating two parameters: (1) a useful operating life for the unit; and (2) a discount rate that reflects the time value of money.[6] While the discount rate applied is the same for all systems (thereby rendering it moot in the comparative assessment), systems may vary in terms of their useful life. Available information suggests that the typical life of an oil or gas-fired furnace is about 17 to 20 years (PERC, 2006; EPA Energy Star, 2005). Experts suggest that 20 years is a reasonable useful life

[5] While general price information on furnaces is difficult to locate, the CECA figures are reasonably consistent with price information available at retailer websites and in other comparative cost models; see, for example, EPA Energy Star energy savings calculator available at http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Furnaces.xls. This model assumes a range of $2,700 to $4,000 for gas furnaces with a range of efficiencies.

[6] The formula used to annualize capital costs is analogous to an annuity calculation: Annualization Factor = $[r(1+r)^n]/[(1+r)^n - 1]$, where r is the assumed discount rate and n is the useful life. Discount rates of 3 and 7 percent are used in the lower and upper bound estimates, respectively.

assumption for wood stoves, although results vary with usage and maintenance patterns; therefore, the analysis applies a range of 18 to 22 years.[7] Although reliable information is lacking, the analysis assumes an OWB useful life of 15 to 20 years. The lower bound recognizes that OWBs may not last as long as wood stoves given their exposure to weather. At the same time, some manufacturers offer 20-year warranties on OWBs, suggesting that 20 years may be a reasonable upper bound.[8]

As shown, the annualized capital costs of OWBs is greater than all other heating systems considered.

Overall Baseline Cost-Effectiveness

Considering annual operating costs and annualized capital costs together, OWBs appear to be the least cost-effective heating system of those considered, with total annual costs roughly one to 37 percent greater than the next closest option (a lower-efficiency oil burning unit).

ECONOMIC AND ADVERSE HEALTH IMPACTS ON PROSPECTIVE OWB USERS

Direct Economic Impacts on OWB Buyers

To assess the impacts of the proposed emission standard on prospective OWB users, a typical economic analysis would examine potential OWB price increases resulting from increased manufacturing costs. As noted, estimation of manufacturing cost increases is complex and will vary by OWB model; however, the cost of manufacturing conventional OWBs could increase by as much as 40 percent given fundamental redesign requirements.

In a traditional supply and demand framework, the OWB price increase would have two effects. First, fewer consumers would purchase OWBs and would instead purchase other types of heating systems. These individuals would essentially be performing a personal cost-effectiveness calculation like the one presented above, determining that substitute heating systems are more attractive now that OWB prices have risen. Second, individuals who still choose OWBs would experience consumer surplus losses. That is, while they are still willing to pay the going price for an OWB unit, the difference between their maximum willingness to pay and the actual price paid has decreased, so they enjoy less "surplus" value from the purchase.

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[7] Personal communication with Cal Wallis, The Wood Heat Organization, Inc., May 18, 2006.

[8] For example, see Alpha American website at http://www.yukon-eagle.com/thankyouletter.htm. OWB lifetimes could be even shorter than the 15-year lower-bound assumption if the unit is operated contrary to manufacturer recommendations, e.g., if the owner burns lumber, garbage, or other non-cordwood materials.

A rigorous analysis of consumer surplus losses associated with an OWB price increase requires data not readily available. Specifically, a demand curve would be constructed from time series data showing OWB price fluctuations in Vermont and the associated variation in the number of OWBs sold. From these data, a demand curve could be constructed, showing how the number of OWBs purchased changes in relation to price. The demand curve would allow estimation of consumer surplus losses resulting from the OWB price increase.

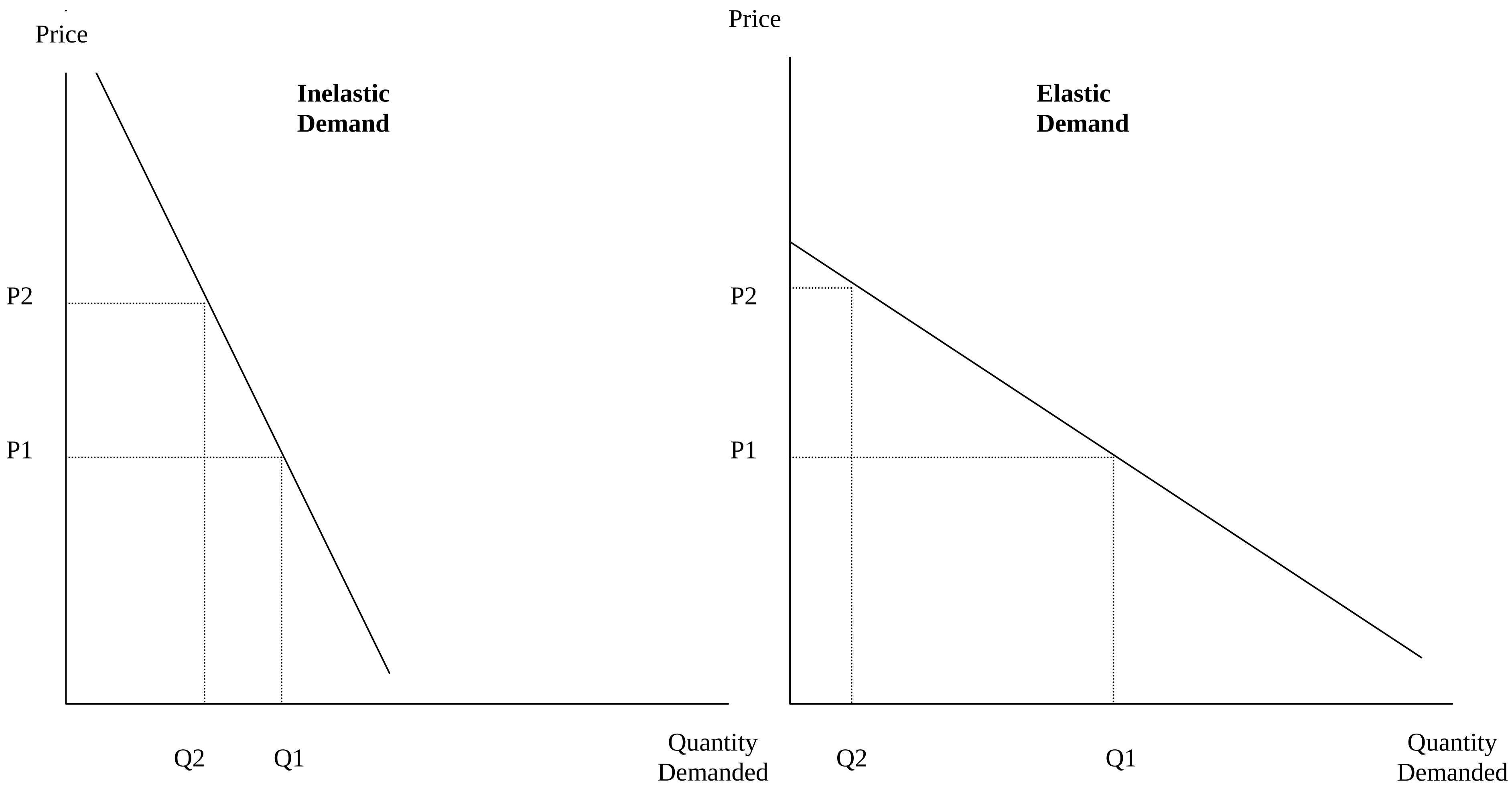
Although the necessary data are not readily available, it is possible to draw basic conclusions about likely consumer impacts by focusing on demand elasticity. Exhibit 3-2 contrasts two different demand curves, one representing highly inelastic demand and the other representing highly elastic demand. Inelastic demand exists when a given price increase (from P1 to P2) leads to only a small decrease in the quantity demanded (from Q1 to Q2); i.e., consumers generally continue buying the product despite the price increase. One key reason for inelastic demand is a lack of viable substitutes.

The second depiction of demand elasticity is likely to be more representative of OWB consumers. The availability of substitute heating systems will allow prospective OWB owners to seek out other options. Although much of Vermont is rural and lacks residential natural gas supplies, oil and propane are viable options, as is use of a wood stove or a pellet stove. The availability of substitutes and the resulting elasticity of demand suggest that manufacturers will not be able to pass through cost increases associated with the emission control requirements, but will instead have to absorb cost increases if they hope to maintain OWB sales in Vermont. The potential for consumer-level impacts is especially unlikely given the baseline cost-competitiveness issues discussed above. To the extent that OWBs are already a less cost-effective heating option, prospective owners should be even more sensitive to price increases.

Despite these arguments, some consumers may still realize losses in economic welfare if OWB prices increase or if manufacturers choose not to sell OWBs in Vermont. Although heating substitutes exist, some individuals may derive utility from the self-sufficiency associated with wood heat, especially if they harvest timber on their own property. If a homeowner wishes to use wood to heat both his or her home *and* hot water, OWBs (and some indoor wood boilers) represent the only realistic option. These individuals may experience a loss in consumer surplus when their desire for self-sufficiency is unmet. However, this loss is fundamentally different from the industry claims that the proposed regulation could deprive consumers of a cost-effective heating option.

Exhibit 3-2

ILLUSTRATION OF DEMAND ELASTICITY



Adverse Health Impacts on OWB Users

Improved OWB emission control may have an indirect economic impact on consumers through subsequent health benefits. Depending on the design of the OWB and its location relative to the owner's home, reduced emissions may decrease exposure and health risk at the residence. The nature and magnitude of these health benefits is the subject of Chapter 5, which focuses on health impacts to neighboring residents. However, these same principles apply to residents of the OWB owner's home. Key health endpoints include hospitalization for acute cardiovascular symptoms; respiratory hospital admissions; premature mortality; aggravation of asthma; and miscellaneous respiratory symptoms such as eye irritation, cough, and congestion. As discussed later, the economic costs associated with these endpoints can be characterized using cost-of-illness approaches or willingness-to-pay methods.

IMPACTS ON OWB RETAILERS AND OTHER VERMONT BUSINESSES — CHAPTER 4

Retail distribution represents the link between OWB manufacturers and potential OWB buyers. This chapter examines how OWBs are distributed in Vermont and how the emission standard could potentially affect retail establishments.

OWB DISTRIBUTION IN VERMONT

OWBs are marketed and sold through a variety of methods, including:

- **Direct Sales**: Some manufacturers (e.g., Charmaster Products of Grand Rapids, Minnesota) encourage buyers to purchase directly, using order forms at the manufacturers' websites.

- **Trade Fairs**: Some manufacturers (e.g., Hardy Manufacturing of Philadelphia, Mississippi) market and sell OWBs at trade fairs, home and garden shows, and other events featuring innovative heating products and renewable energy products.

- **Conventional Retailers**: Some OWBs are sold through hardware stores and other conventional retail establishments. In general, indoor woodstove dealers see OWBs as a competing product and therefore do not carry or promote OWBs (NESCAUM, 2006).

- **Sales Representative Network**: Some manufacturers build a network of distributors by enlisting customers as sales representatives. These distributors generally have little direct experience in the installation or maintenance of OWBs, but participate as a form of supplementary income.

- **HVAC Contractors**: Some manufacturers market their products through relationships with professional heating, ventilation, and air conditioning (HVAC) contractors to ensure proper design and installation. This approach is most common in commercial and agricultural markets as opposed to residential heating.[9]

The balance of these distribution methods in Vermont is difficult to discern based on available data. Information submitted to the Vermont ANR for the original EIS indicates that 17 "part-time" OWB dealers exist in the state (ANR, 2005); these dealers are likely to be independent sales representatives. Other OWB dealers likely exist in Vermont as part of larger hardware or HVAC operations.

POTENTIAL IMPACTS ON OWB RETAILERS

The nature of OWB distribution has important implications for potential retail-level impacts resulting from the proposed emission standard. It is useful to consider the worst-case scenario first, and then examine factors that mitigate this scenario. In 2003, 142 OWB units were sold in Vermont or for installation in Vermont. Assuming an average unit price of $6,750, retailers in Vermont could potentially lose roughly $958,000 in sales per year. Markup or profit at the retail level is highly uncertain, but a range of 5 to 15 percent is a reasonable estimate; therefore, lost net income to Vermont businesses could be on the order of $48,000 to $144,000 annually. Spread across a significant number of establishments, the impacts are likely to be minor. Therefore, even if the proposed regulations were to eliminate OWB sales in Vermont, the worst-case retail losses would be modest.

Several factors further mitigate this worst-case scenario. First, because many conventional OWB retailers are hardware stores, HVAC contractors or other establishments that do not specialize in OWB sales, the loss of OWB sales is unlikely to affect the viability of their business or cause job losses. Furthermore, the worst-case scenario assumes that all sales are through retailers. In fact, many OWBs are sold directly by manufacturers or through their representatives at fairs and other events. Lastly, an unknown portion of the OWBs purchased for use in Vermont come from out-of-state retailers, further limiting losses to Vermont businesses. As such, impacts on the Vermont retail sector could be further minimized.

Nonetheless, some of the small, part-time dealers specializing exclusively in OWB sales may be forced to cease operation. This is especially true for those dealing exclusively in OWB models that do not meet the proposed emission standard and which cannot be cost-effectively redesigned. As noted, ANR estimates that about 17 small dealers may exist in Vermont; however, it is unclear which OWB models these dealers offer.

[9] Personal communication with Martin Lunde of Garn Furnaces, distributed by DECTRA Corporation, June 1, 2006.

POTENTIAL SECONDARY IMPACTS ON LOCAL BUSINESS

Several findings presented thus far – OWB redesign costs, relative cost-effectiveness of OWB heating – suggest the potential for a contraction in residential OWB sales in Vermont. To the extent that this occurs, minor economic benefits may accrue to other sectors that compete in the home heating market. First, the most direct competitors may be manufacturers and retailers of wood stoves (including pellet stoves) and indoor wood furnaces. At least three manufacturers of indoor wood heating systems operate in Vermont:

- Vermont Castings is a major manufacturer of fireplace and wood stove products. While headquartered in Canada, Vermont Castings has production facilities in Randolph, Vermont (employing between 250 and 500 individuals) as well as a large network of retailers in Vermont.[10]

- Hearthstone wood stoves are manufactured in Morrisville, Vermont at a facility employing 75 people.[11]

- The Sam Daniels Co. specializes in hand-assembled indoor wood furnaces. Their Montpelier facility includes a manufacturing plant, offices, and a showroom, and employs six full and part-time individuals.[12]

Second, suppliers of conventional heating fuel and equipment (e.g., oil burners, home heating oil dealers) may realize modest sales increases if future OWB usage in Vermont is reduced.

[10] Information obtained online at www.randolphvt.com.

[11] Personal communication with Paul Bartlett, Hearthstone Q.H.H.P., July 27, 2006.

[12] Personal communication with Donna Daniels, Sam Daniels Co., July 27, 2006.

IMPACTS ON RESIDENTS NEIGHBORING OWB USERS CHAPTER 5

The focal concern of the proposed emission standard is the health and safety of the general public, particularly individuals living near OWBs. Health impacts range from exacerbation of respiratory and cardiac illnesses (for PM exposure) to possible carcinogenic effects (for volatile organic constituents). While the standards would not affect OWBs currently in use, they would offer potential health benefits for residents neighboring newly installed OWBs.

The remainder of this chapter is divided into four sections:

- First, the analysis examines the results of ambient monitoring studies conducted near OWBs and considers the qualities of OWB smoke that influence health risks and aesthetic concerns;
- Second, the analysis identifies key health effects associated with exposure to elevated particulate matter concentrations as well as other wood smoke pollutants;
- Third, the analysis characterizes the economic benefits of reduced PM exposures; and
- Finally, the analysis characterizes other potential benefits of reduced OWB emissions.

EMISSIONS CHARACTERISTICS AND AMBIENT MONITORING STUDIES

Many studies critical of OWBs highlight how OWB design and operation influence the characteristics of OWB emissions and human exposures (NESCAUM, 2006; Wisconsin Division of Public Health, 2005; Connecticut DEP, 2005; Vermont APCD, 2006). In particular, studies highlight how the combustion cycle in a typical OWB contributes to excessive emissions. Wood burns completely only at temperatures exceeding 1,000^{o}F. OWBs are designed to produce a slower, cooler fire to maximize the length of the burn. The result is less efficient combustion, creating more smoke and creosote. The pattern of emissions is exacerbated when the OWB cycles between combustion and “idle” mode. During the periods when no heat is needed, the OWB damper closes and the fire smolders; when heat is again needed, the start-up procedure volatilizes the condensed organics (creosote) and sends smoke out of the unit’s stack.

Other factors may aggravate the quality of OWB emissions and raise exposure concerns. Many OWBs are operated with short "stub" smokestacks that do little to disperse smoke. As noted, 1997 Vermont rules include minimum stack heights for newly installed OWBs. In addition, health officials are concerned that OWB owners may burn materials – such as green wood, brush, lumber, and household refuse – that contribute to high PM concentrations. Finally, OWBs supply domestic hot water for showering, etc.; therefore, they operate year-round, increasing the potential for longer-term exposures.

Few ambient air studies have tested pollutant exposure levels in the vicinity of OWBs. The most thorough study to date was conducted last year by researchers at NESCAUM and is currently in press for publication in the *Journal of Human and Ecological Risk Assessment* (Johnson, 2006). Exhibit 5-1 summarizes key aspects of the testing procedure and findings. As shown, the study measured average $PM_{2.5}$ concentrations of about 130 ug/m^3 when testing at 150 feet from the OWB.[13] The variation in the concentrations is the result of many factors, most notably the time since the last wood loading and the heat-calling conditions (i.e., damper closed versus damper open).

Exhibit 5-1

JOHNSON (2006) AMBIENT AIR MONITORING PROCEDURES AND RESULTS

OWB Characteristics	• Hardy H5-1-07 Economy model • Capacity = 180,000 BTU/hr • Stack height = 10 feet
Field/Testing Conditions	• Monitoring performed in March on unit located in New York State • Dry oak and other seasoned hardwood used for fuel • 50-150 foot distance between OWB and monitoring device • Calm/variable winds, light snow
Sampling Procedure	• Thermo Electron DataRAM 4000 (light scattering unit) monitored PM • 15-second averaging time over 4.3 hours
Results at 150-Foot Monitoring Distance ($PM_{2.5}$ in ug/m^3)	• Minimum: 16-17 ug/m^3 • Maximum: 810-3,328 ug/m^3 • Mean: 130-133 ug/m^3
Source: Johnson (2006) and NESCAUM (2006)	

The average recorded PM concentrations significantly exceed existing ambient PM standards. The current 24-hour National Ambient Air Quality Standard for $PM_{2.5}$ is 65 ug/m^3; EPA has proposed a revised standard of 35 ug/m^3.[14] While the monitoring in the Johnson study was performed over a shorter time period (4.3 hours), the concentrations recorded strongly suggest the potential for exceeding the 24-hour standard.

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[13] Concentrations measured at 150 feet are the most relevant to consider since existing Vermont standards require that OWBs be located a minimum of 200 feet from the nearest neighboring residence.

[14] See http://www.epa.gov/oar/particlepollution/standards.html.

POTENTIAL HEALTH IMPACTS ASSOCIATED WITH OWB SMOKE

A comprehensive assessment of the health risks associated with OWB smoke is beyond the scope of this economic impact study. However, to properly frame the potential economic benefits of reduced OWB emissions, it is essential to highlight the range of adverse health effects that might be attributable to OWBs. The following discussion examines adverse health effects associated with particulate matter exposure and effects associated with other woodsmoke pollutants.

Adverse Health Effects of PM Exposure

Exhibit 5-2 provides a brief summary of several recent studies linking particulate matter exposure to key health outcomes. As shown, major health effects of concern include hospitalization for cardiovascular symptoms; hospitalization for chronic respiratory illness; premature mortality; aggravation of asthmatic conditions (no hospitalization); and miscellaneous respiratory symptoms (e.g., sneezing, coughing, runny nose). Studies have focused on effects of both PM_{10} and $PM_{2.5}$. All of the listed studies concentrate on acute effects from short-term PM exposure.

The modeling in these studies generally yields a statistical association between PM exposure and the likelihood of the given health outcome. For example, a study may find a five percent increase in the risk of hospitalization for heart failure per each 25 ug/m^3 increment of $PM_{2.5}$. As such, the studies posit linear relationships between ambient PM and health risk without specifying threshold PM concentrations at which effects occur. Nonetheless, the baseline PM levels in these studies, when noted, are below the average ambient concentrations found by Johnson (2006). Therefore, the findings strongly suggest that ambient PM concentrations around OWBs increase the likelihood of a variety of health conditions.

A much more comprehensive review of the epidemiological literature associated with PM can be found in the criteria document produced by EPA in support of the National Ambient Air Quality Standard for PM (EPA, 2004). In this document, EPA concludes that "there is substantial strength in the epidemiological evidence for association between PM_{10} and $PM_{2.5}$ and mortality…" Likewise, EPA notes that "all associations with hospitalization for cardiovascular and respiratory diseases are positive and many are statistically significant."

The potential for adverse health impacts from OWB PM emissions also is supported by enforcement investigations performed by the Air Pollution Control Division of Vermont ANR. As described in more detail below, residents neighboring OWBs have filed numerous complaints about OWB smoke. In one instance, a complainant was treated in the emergency room for chest pains and difficulty breathing, symptoms consistent with PM exposure. In another instance, a complainant suffering from chronic asthma indicated that the smoke from the OWB exacerbates the condition.

Exhibit 5-2

RECENT STUDIES OF PARTICULATE MATTER HEALTH EFFECTS

Health Effect	Study	Findings
Hospitalization for Cardiovascular Symptoms (e.g., congestive heart failure, myocardial infarction)	Peters et al., 2001	Found moderately elevated PM levels (one-hour average of 12.1 ug/m^3) to be associated with an elevated risk of acute MI.
	Zanobetti and Schwarz, 2005	Found a 0.65% increased risk of hospitalization for MI per 10 ug/m^3 increase in ambient PM.
	Lippmann et al., 2000	Estimated a 9.1% increase in the risk of heart failure per 25 ug/m^3 increment of $PM_{2.5}$, focusing on individuals 65+ years of age.
	Linn et al., 2000	Measured percent increase in hospitalization for cardiovascular diseases in individuals over 30 years old. Found a 3.04% increase in MI hospitalization and a 2.02% increase in CHF hospitalization for each 50 ug/m^3 increment in PM_{10}.
Respiratory Hospital Admissions	Samet et al., 2000	Estimated excess risk of hospital admissions for respiratory conditions in elderly (65+); per 50 ug/m^3 PM_{10} increment, found 7.4% increase for chronic obstructive pulmonary disease (COPD) and 8.1% increase for pneumonia (no lag in modeling).
	Moolgavkar et al., 2000	Estimated excess risk of hospital admissions for COPD; per 25 ug/m^3 increment of $PM_{2.5}$, found 6.4 % risk increase.
Premature Mortality	Murakami and Ono, 2006	Found increased incidence of MI-related deaths for individuals exposed to one-hour PM levels in the range of 100-149 ug/m^3.
	Samet et al., 2000	Estimated excess death rate per 10 ug/m^3 of PM_{10} to be about 0.5% in elderly population (>65 years). Excess death rate highest in Northeast U.S., with an increase of 4.6% per 50 ug/m^3 PM_{10} increment.
	Dominici et al., 2000	Estimated total percent change in excess deaths due to PM exposure in major U.S. cities; found 1.8% increase per 50 ug/m^3 PM_{10} increment overall, with results varying by city.
	Ostro et al., 2003	Found a 10.2% increase in excess cardio deaths per 25 ug/m^3 increment of $PM_{2.5}$.
Asthma (no hospital admission)	Delfino et al., 2002	Reported same-day associations between PM_{10} levels and children's asthma episodes; effects occurred at one-hour maximum concentrations of 38 ug/m^3.
	Mar et al., 2005	Reported association between hourly exposures to $PM_{2.5}$ and exhalation of a marker of airway inflammation/injury in children with asthma; effects occurred at one-hour averaged concentrations of 8.3 ug/m^3 (at three-hour lag).
	Mortimer et al., 2002	Established association between ambient PM_{10} concentrations and symptoms in asthmatic children in urban areas with average PM concentrations of 53 ug/m^3.
Miscellaneous Symptoms	Schwartz and Neas, 2000	$PM_{2.5}$ found to be significantly correlated with coughing and lower respiratory symptoms in non-asthmatic elementary school children.
	Zhang et al., 2000	Runny nose symptoms in adult women found to be correlated with levels of PM.

Adverse Health Effects of Other Wood Smoke Pollutants

Although much of the economic benefits discussion in this report focuses on particulate matter, wood smoke contains a variety of other pollutants. Since adherence to the proposed PM standard may reduce emissions of these pollutants, a variety of other health risks may be reduced. The following pollutants are most relevant:

- **Carbon Monoxide**: Carbon monoxide (CO) is released when any carbon-based fuel is burned. Inhalation of CO reduces the ability of the blood to carry oxygen, causing effects ranging from chest pain to death (Schreiber, 2005).

- **Polycyclic Aromatic Hydrocarbons**: PAHs are formed through the incomplete combustion of coal, gas, wood and other organic fuels and typically adhere to particulates in emissions. More than 100 PAHs exist, and generally occur as mixtures rather than single compounds. Several PAHs emitted from wood burning (e.g., benzo(a)pyrene) are suspected carcinogens and laboratory experiments have linked some PAHs with reproductive effects and birth defects (ATSDR, 1995).

- **Dioxins**: Dioxins are a group of several hundred complex compounds produced during combustion. Workplace and laboratory studies provide evidence linking dioxin exposure and cancer. There is also some evidence linking dioxin to reproductive and developmental effects (Dioxin IWG, 2004).

- **Irritants**: Irritant chemicals in wood smoke include phenols, aldehydes, quinones, nitrogen oxides, and sulphur oxides. These compounds may exacerbate PM inhalation by interfering with the cilia and disrupting mucus flow. Exposure can lead to swelling of the lung tissue and cause allergic reactions (Washington State Department of Ecology, 2004).

ECONOMIC BENEFITS OF REDUCED PM EXPOSURES

To the extent that the proposed OWB emission standard reduces adverse health outcomes associated with PM exposure, economic benefits will be realized. Economists typically frame these economic benefits in two distinct ways:

- **Cost of Illness**: The cost-of-illness (COI) approach values health outcomes according to the direct cost of evaluation and treatment, medicine, and extended hospital care. Some studies also include the value of lost wages or productivity that accrue when the individual is incapacitated. The data for such studies typically come from hospital or insurance records.

- **Willingness to Pay**: Willingness to pay (WTP) focuses on the individual's assessment of what they would pay to avoid the health effect in question. Economists typically estimate WTP figures through a variety of stated preference methods that elicit information through surveys of relevant populations. While costly, economists generally prefer these methods because they allow measurement of direct costs as well as subjective assessment of discomfort, pain, anxiety, and other forms of suffering that may accompany illnesses.

Exhibit 5-3 presents findings from studies assessing the economic cost of the PM-related health impacts reviewed above.[15] In many cases, the study cited is itself a survey of existing literature; hence, numerous individual estimates exist beyond those cited in this table. As shown, the values for each health effect category range widely, depending upon the methods used, the specific health endpoint valued, and other factors.

The value cited for premature mortality warrants specific discussion. Based on an extensive literature review, the U.S. EPA estimated an average value of statistical life (VSL) of $5.5 million with a confidence interval of plus or minus $2.3 million (in 2000 dollars). The source studies derive willingness to pay in two ways. First, some used the contingent valuation method, directly surveying individuals on their WTP for mortality risk reductions. Other studies estimated the value of risk reductions based on workers' willingness to accept riskier jobs in return for higher wages. The resulting VSL estimates have been applied in a variety of regulatory contexts (see Dockins et al., 2004).

The per-case estimates of the value of health impacts suggest that the OWB emission standard may deliver significant economic benefits. However, development of a statewide benefit estimate is complex. Such an analysis would require estimation of the number of health incidents avoided as a result of the proposed rule. This population risk analysis would in turn require detailed data such as the following:

[15] Unless otherwise noted, the analysis uses the Gross Domestic Product Implicit Price Deflator to convert all figures to 2005 dollars.

Exhibit 5-3

ECONOMIC VALUE OF PREVENTING PARTICULATE MATTER HEALTH EFFECTS

Health Effect	Study	Economic Value Estimate*		Notes
		Cost-of-Illness	Willingness to Pay	
Hospitalization for Cardiovascular Symptoms (e.g., congestive heart failure, myocardial infarction)	Chestnut et al., 2006	\$22,000-\$39,000	\$2,400	Study examined both respiratory and cardiovascular hospitalizations. WTP to prevent a five-day hospitalization.
	Russell et al., 1998	\$24,662		Direct medical costs over five-year period following non-fatal MI.
	EPA, 2004a	\$72,865-\$158,000		Average of Russell et al. (1998) and other studies reflects direct medical costs and lost earnings in five-year period following non-fatal MI. Range reflects variation by age group and discount rate applied.
Respiratory Hospital Admissions	Chestnut et al., 2006	\$22,000-\$39,000	\$2,400	Study examined both respiratory and cardiovascular hospitalizations. WTP to prevent a five-day hospitalization.
	EPA, 2004a	\$13,875		Direct medical costs and lost earnings for chronic obstructive pulmonary disease.
	EPA, 2004a	\$16,470		Direct medical costs and lost earnings for pneumonia.
	Saint et al. as reviewed in Halpern et al., 2003	\$6,623		Hospitalization cost for acute exacerbation of chronic bronchitis.
Premature Mortality	EPA, 2004a		\$5.5 million	Average figure with confidence interval of plus or minus \$2.3 million; based on multiple studies applying survey-based and risk-tradeoff methodologies.
Asthma (no hospital admission)	EPA, 2004a	\$320	\$47	COI reflects direct medical cost for emergency room visit. WTP reflects mean estimate of several studies valuing avoidance of a "bad asthma day."
	EPA Cost of Illness Handbook	\$185		Cost of office visit for treatment of acute asthma attack.
Miscellaneous Symptoms	EPA, 2004a		\$18-\$28	WTP to avoid upper and lower respiratory symptoms.
	Berger et al., 1987	\$7	\$145	Average figures across range of symptoms, including cough, congestion, headache, itchy eyes, and drowsiness.
	EPA Cost of Illness Handbook	\$97-294		Direct medical costs for eye irritation (lower bound) and sore throat (upper bound), assuming office visit and medication. Figures reflect average of multiple sources.

* The analysis uses the Gross Domestic Product Implicit Price Deflator (as reported in the 2006 *Economic Report of the President*) to convert all figures to 2005 dollars.

- the baseline number of OWBs that would be installed in Vermont absent the regulation;

- the proximity of receptors around these units; and

- the prevalence of pre-existing health conditions (e.g., asthma) in the receptor population.

The analysis would also require effects thresholds for the health endpoints; epidemiological evidence is mixed regarding the existence of such thresholds (EPA, 2004). For all these reasons, an aggregate benefits estimate is not feasible within the scope of this EIS.

As a proxy for a population risk/benefits analysis, it is useful to consider the benefits required to exceed the estimated costs of the proposed emission standard. Manufacturer costs are highly uncertain given the diverse options available to manufacturers, i.e., some are already producing compliant units, some may abandon the Vermont market, and some may redesign their units. For the purposes of estimating costs, this illustration assumes that the cost of each unit sold in Vermont is increased by $2,000, yielding annual costs of $284,000 ($2,000 multiplied by 142 units). Adding profit losses for retailers ($96,000 assuming a 10 percent profit margin) yields total annual costs of $380,000. The cost-of-illness figures vary widely, but the following changes in health outcomes would roughly equate to the estimated annual costs expected to be incurred by manufacturers and retailers:

- elimination of three to 15 cardiovascular hospitalizations;
- elimination of 10 to 50 respiratory hospitalizations; or
- a seven percent decrease in the risk of premature mortality for an individual.

The potential for realizing these changes would increase over time as a larger number of compliant OWBs are put in operation.

NUISANCE EFFECTS OF OWB SMOKE

Staff in the Air Pollution Control Division (APCD) of Vermont DEC receive and investigate complaints on air pollution sources such as OWBs. APCD provided a listing and description of OWB-related complaints received since March 2004. As summarized in Exhibit 5-4, 20 complaints have been received in the last two and one-half years. In some instances, multiple neighbors will file complaints about the same OWB (as shown by the Number of OWBs figure), but most complaints apply to unique units. The complaints are distributed throughout the year, consistent with the year-round operation of OWB units.

Exhibit 5-4 SUMMARY OF COMPLAINTS RECEIVED ON OWB SMOKE		
Year	**Number of Complaints**	**Number of OWBs**
2004	7	4
2005	10	10
2006*	3	3

* Partial data through April, 2006.
Source: Vermont Agency of Natural Resources, Department of Environmental Conservation, Air Pollution Control Division.

While some of the complainants mentioned specific health effects (e.g., difficulty breathing), most of the complaints focus on the aesthetic impacts or inconveniences of living near the OWB. For instance, several complaints focus on the smell of smoke and concerns that the OWB owner may be burning materials other than cordwood. Complainants also mention the appearance of the smoke (e.g., color, thickness) and impacts on local viewsheds.

While the economic implications of PM-related nuisance impacts are difficult to characterize, economists have developed methods for certain categories of non-health impacts:

- **Soiling and Materials Damage**: Particle pollution may contribute to the soiling of painted surfaces and other building exteriors. Such soiling generally requires cleaning, an intrinsic economic cost of the pollution.

- **Visibility**: Airborne particles can degrade visibility by scattering and absorbing light. Studies have demonstrated the public's willingness to pay for visibility improvement or conservation (Chestnut and Rowe, 1990).

- **Effects on Vegetation**: Ecologists believe that PM deposition may indirectly contribute to inputs of compounds associated with negative ecological conditions such as increased nitrogen deposition and acidification. These changes may have large-scale economic implications for resource-based commercial enterprises (e.g., agriculture and forestry) as well as non-market, recreational enjoyment of natural resources such as forests.

These impacts generally are associated with long-term, regional changes in ambient PM concentrations. For example, considered individually, or even collectively, OWBs in Vermont probably will not influence regional PM concentrations at a level that produces vegetation effects. However, it may be possible for OWBs to contribute to local soiling or visibility impacts.

A more tangible and location-specific reflection of nuisance impacts may be found in housing markets. Property valuation studies typically assess how proximity to various amenities (e.g., a bathing beach) or disamenities (e.g., a municipal landfill) influence the amount individuals are willing to pay for real property. It is well understood that a house will sell for more or less depending on the attributes of the area in which it is located. However, the degree to which amenities and disamenities affect prices is highly variable and is the subject of extensive research.

Many property value studies have examined the effect of environmental factors such as air quality or water quality on house value. Specifically, several studies have examined how particulate matter concentrations can influence home values. The statistical models in these studies have consistently shown a negative relationship between particulate concentrations and house price, relationships that are statistically significant in most cases (Kiel, 2006). While such studies demonstrate the potential for OWBs to affect the value of neighboring residences, they are regional in nature, i.e., none of the research specifically addresses the impact of small, stationary air pollution sources such as OWBs on a single residence.

Anecdotal evidence suggests that OWB emissions may affect the market value of residential properties. In an ongoing APCD investigation, a complainant sold their home and moved out at a financial loss, allegedly the result of smoke impacts from an OWB at a neighboring residence. Since it is part of an ongoing enforcement investigation, details of the complaint are confidential.

To the extent that the value of a residence was negatively affected by OWB emissions, the property value impact would be a market manifestation of the various benefit categories discussed above. That is, the market value of the residence would be decreased because of the real or perceived health risks associated with the emissions, as well as aesthetic concerns. Consequently, it is redundant to consider the property value impacts in addition to other benefits (e.g., health care costs and willingness to pay to avoid health effects) when analyzing economic welfare impacts. However, from the standpoint of regional economic implications, property value impacts and associated effects on property tax collections may be legitimate concerns.

IMPACTS ON GOVERNMENT ENTITIES CHAPTER 6

Vermont's law regarding the adoption of administrative rules requires consideration of costs and benefits accruing to "government entities" (see 3 V.S.A. § 838(c)(1)). This chapter briefly discusses impacts on the Vermont ANR, as well as on state and local health officials and municipalities. Given the modest commercial economic impacts discussed in previous chapters, the proposed regulations would have a negligible effect on economic development and social welfare agencies.

IMPACTS ON AGENCY OF NATURAL RESOURCES

The Agency of Natural Resources would likely realize two offsetting impacts as a result of the OWB emissions controls. First, APCD staff and the ANR Enforcement Division would be responsible for enforcing the regulations. The proposed rule places the primary administrative burden on OWB manufacturers; they are expected to test their products and demonstrate compliance as a precondition to selling units in Vermont. As such, the ANR enforcement responsibilities would be limited to ensuring the legitimacy of the emission testing procedures and possibly notifying retailers of changes in the list of approved OWB manufacturers and units. As noted, the retail system for OWBs is diverse and includes hardware stores, HVAC contractors, and individual agents working under agreement to manufacturers. At the very least, ANR would need to inform retailers of the rules and advise them to request emissions certification from manufacturers before selling a particular OWB unit.

These enforcement costs would be at least partially offset by reduced investigative burden on APCD staff. Currently, APCD staff field complaints from OWB neighbors and concerned citizens, visit OWB locations to verify that installations meet the requirements of existing regulations (at § 5-204), and mediate disputes between OWB owners and neighbors. The proposed regulations would likely reduce or eliminate the need for these activities, a direct benefit to ANR.

IMPACTS ON HEALTH OFFICIALS AND MUNICIPALITIES

The proposed regulations would likely benefit state and local health officials and municipalities. Most notably, local health officers and zoning officials sometimes field complaints about OWBs. They and other municipal decision makers (e.g., selectboards, planning commissions, etc.) are beginning to develop local ordinances governing OWB design/location and possibly OWB bans. As noted, local ordinances are becoming more common nationwide, although in Vermont only one town (Salisbury) is currently developing a local ordinance. The proposed ANR regulations could save significant local resources to the extent that they preclude the need for municipal ordinances. For example, emissions controls may eliminate the future need to develop regulatory language, obtain proper legal review, educate selectboards and other decision-makers, debate ordinances at public meetings, and enforce the resulting rules.

Second, the public health benefits of the rule (see Chapter 5) may reduce the burden on programs operated by the Vermont Department of Health (within the Agency of Human Services). For instance, collaboration with and assistance to local health officials on handling of citizen complaints and drafting of ordinances could be reduced.

INTEGRATION AND SUMMARY CHAPTER 7

This chapter summarizes findings for all of the affected entities to formulate broad conclusions about the economic impact of the proposed OWB regulations. Subsequent sections also consider these impacts relative to those of the other regulatory options introduced in Chapter 1 and characterize potential impacts on small businesses.

SUMMARY OF FINDINGS

Exhibit 7-1 summarizes the key research findings for each of the entities potentially affected by the proposed OWB emission standard. As shown, the standards are likely to have minor effects on the commercial economy in Vermont. First, only one very small manufacturer exists in Vermont. While ANR intends to work closely with this business to minimize impacts (e.g., by allowing out-of-state sales), the operation employs only one to three individuals. Second, the retail network for OWBs includes few businesses whose viability depends on OWB sales. Current OWB sales are spread across a diverse set of hardware stores, HVAC contractors, direct-from-manufacturer operations, and individual sales agents.

The OWB manufacturing sector may undergo significant changes in coming years, although the proposed emission standard in Vermont would play only a partial role in producing these changes. As more states and municipalities introduce regulations, residential OWBs may become more expensive as a result of redesign costs associated with meeting emission standards. This change may limit the market to larger commercial and agricultural applications, leading to a contraction in the number of OWB manufacturers.

Potential OWB buyers would realize little (if any) loss in economic welfare as a result of the emission standard. Although the standards could necessitate costly redesign of some OWB models, the impact on consumers would be mitigated by: (1) the existence of some OWB models that already satisfy the emission limit; and (2) the availability of many other residential heating options. Indeed, comparative analysis suggests that OWBs currently are among the more costly residential heating options available to consumers due to their generally lower efficiencies and higher capital costs.

Exhibit 7-1

SUMMARY OF ECONOMIC IMPACTS

Affected Entity	Impact Description	Impact Summary
OWB Manufacturers	• 28 manufacturers; one small operation in Vermont. • Generally high emissions from OWBs, although units with modern design features capable of meeting proposed standards. • For manufacturers not meeting standards, options include ceasing sales in VT and redesigning units. Redesign would significantly increase production costs and these cost increases would be difficult to pass on to consumers. • Increasing regulation (in VT and elsewhere) may produce market consolidation favoring larger firms and manufacturers of units already meeting standards.	Negative impact (minor in Vermont)
Prospective OWB Owners	• Analysis suggests that OWBs are currently among the least cost-effective heating options, largely due to lower efficiencies and high capital costs. Therefore, potential increased OWB prices associated with emission regulation would not eliminate a cost-effective heating option for the typical residential consumer. • Demand elasticity for OWBs is high due to diversity of readily available substitutes (oil, gas, wood stove). Hence, increased OWB costs will likely lead consumers to select other heating options, producing limited consumer surplus losses.	Minor impact (direction unclear)
OWB Retailers	• OWBs sold through diverse distribution network (individual agents, hardware stores, HVAC contractors, direct sales). • Worst-case sales revenue loss of approximately $958,000. Producer surplus (i.e., profit) losses range from $48,000 to $144,000 annually, based on rough estimates of retailer markup. • Nature of distribution system implies that impacts would be diffuse and would not eliminate large number of jobs. • Small dealers specializing in sales of non-compliant units would be hardest hit.	Minor negative impact
Residents Neighboring OWBs	• Ambient monitoring data near OWBs are sparse. Available data suggest average $PM_{2.5}$ concentrations of 130-133 ug/m^3, well above the existing 24-hour ambient NAAQS standard. • Epidemiological studies clearly establish relationship between PM exposure and several health endpoints, including cardiovascular hospital admissions; respiratory hospital admissions; premature mortality; aggravated asthma; and miscellaneous respiratory symptoms. • Economic cost of relevant health endpoints can be based on self-assessment (willingness to pay to avoid health effect) or on direct medical cost of illness. Economic literature offers widely varying estimates. • Data do not allow population risk assessment necessary to value aggregate health benefits; however, even limited avoidance of health impacts would likely outweigh regulatory costs.	Positive impact
Government Entities	• ANR enforcement costs at least partially offset by reduction in current investigation and mediation costs borne by APCD. • Avoid future costs of developing and implementing municipal ordinances to regulate OWBs.	Neutral impact

The proposed standard offers potential benefits to individuals neighboring OWBs. Ambient monitoring data are limited, but suggest the potential for particulate matter exposures well beyond regulatory levels of concern. While no established threshold levels exist, an extensive body of epidemiological literature links the observed ambient PM concentrations with increased risk of respiratory and cardiovascular outcomes, as well as elevated mortality risks. A variety of studies have characterized the economic cost of these health effects, applying both cost-of-illness as well as willingness-to-pay methodologies. Development of aggregate health impacts would require data that are not readily available. However, the magnitude of economic costs associated with the key health endpoints implies that only a limited number of avoided cases would be necessary for the health benefits of the rule to exceed the costs to manufacturers and retailers.

Finally, the proposed standards would likely have a neutral impact on government agencies. ANR may realize some modest enforcement costs for oversight of manufacturer emissions certification. However, these costs would likely be offset by reduced handling of complaints from OWB neighbors as well as reduced burden on state and municipal health officials who might otherwise formulate local OWB ordinances in the future.

IMPACTS OF OTHER ALTERNATIVES

The other regulatory alternatives introduced in Chapter 1 would likely involve unacceptable costs or administrative obstacles:

- **No Action**: The no-action alternative would allow high emissions of PM and other pollutants in future OWB units. The result would likely be more widespread risk of the respiratory and cardiovascular health outcomes identified in Chapter 5 and growth in the accompanying health care costs. Other impacts would include increased exposure to non-PM wood smoke pollutants, increased complaints from OWB neighbors, and continued investigation and mediation responsibilities for APCD.

- **Interim OWB Ban**: Another alternative involves prohibiting the sale of OWBs in Vermont until the U.S. Environmental Protection Agency has developed nationwide regulatory standards for OWBs. EPA has no immediate plan to regulate OWBs, so the ban would be open-ended and potentially lengthy. While OWB neighbors would realize future health benefits, the ban would unfairly impact manufacturers who have chosen to test emissions and implement low-emission designs, as well as retailers who wish to carry these units.

- **OWB User Compliance**: This alternative would shift the emissions-testing burden onto OWB purchasers, rather than manufacturers. This approach would theoretically yield the same health benefits as realized under the proposed approach. However, consumers would pay for a portion of the cost increase associated with producing low-emission OWBs *and* would incur the cost of the emission testing. This approach would be highly inefficient since it would involve individual testing of each OWB rather than centralized certification of OWB models through manufacturer testing. The approach could also produce a significant enforcement burden, with ANR staff reviewing a large number of individual emission tests. Over time, it is likely that the user compliance approach would approximate a ban on OWBs, as consumers shun the uncertainty of purchasing and testing an OWB unit in favor of more established heating options.

SMALL BUSINESS IMPACTS

Impact Description

Many of the commercial economic entities affected by the proposed emission standard are small businesses under Vermont size standards. Vermont has a blanket small business definition of 20 or fewer full-time employees (see 3 VSA § 801). By this standard, some OWB manufacturers are small businesses while others are not. For instance, the single Vermont manufacturer certainly satisfies this definition. However, the major manufacturers who account for the majority of OWB sales (e.g., Central Boiler) are not small businesses under the Vermont definition. As discussed, the retail sector comprises a diverse set of entities. In Vermont, most (if not all) of these operations are likely to be small businesses under the 3 VSA § 801 definition. Since the majority, if not all, Vermont businesses impacted by the rule are small businesses, it is not possible to have separate requirements for small business.

Exhibit 7-2 summarizes the impacts that the proposed alternative and other alternatives would have on small businesses. Focusing only on Vermont small businesses, the proposed standards likely pose the least cost. Under the proposed rule, Vermont retailers would be allowed to continue selling compliant OWB units in the future; in contrast, the ban would eliminate these sales for an indeterminate time and the user-based compliance option could eventually undermine the market for OWBs and eliminate all sales. The one Vermont manufacturer typifies the type of OWB maker that may find it difficult to compete when emission controls are introduced. This small operation may not have the capital to pursue redesign of its units and would likely be forced out of business.

Nationwide, the proposed rule's small businesses impacts are difficult to separate from baseline regulatory and market factors. On one level, the proposed regulations can be seen as forcing costly redesign, a direct cost to manufacturers with non-compliant units. However, as noted, a growing number of states and municipalities are exploring regulatory options for addressing OWB emissions. Furthermore, as low-emission (and higher priced) OWB models become more attractive, OWBs may be eliminated as a cost-effective residential heating option, leading to a consolidation in the manufacturing sector. All of these changes may occur regardless of Vermont's regulatory actions.

Flexibility Statement

Most, if not all, Vermont OWB retailers and dealers are small businesses, as defined in 3 VSA 801, as is the one Vermont OWB manufacturer. The Agency of Natural Resources has attempted to reduce the dealers' cost of compliance with this rule by placing the burden of demonstrating compliance on OWB manufacturers, including the costs of reporting and dealer notification. The Agency expects manufacturers to take the lead in redesigning (if necessary) and testing their units to demonstrate compliance. The Agency has attempted to reduce the compliance burden on the one Vermont manufacturer by allowing it to continue to sell non-compliant units for installation outside Vermont. In 1997, the Agency adopted another rule regulating the siting and stack heights for new OWBs. That rule had a smaller economic impact on dealers and on the one Vermont manufacturer, who could continue their sales of existing OWBs. However, the 1997 rule was not effective in preventing continuing complaints about smoke and odors from OWBs, nor in significantly reducing the risks to health and welfare caused by such units. Therefore, maintaining only the 1997 requirements would be unacceptable, since this would allow continued risk to public health and welfare relative to conditions achieved under the proposed rule. Moreover, this approach would significantly reduce the effectiveness of the rule in achieving the purposes of Vermont's Air Pollution Control Act.

Exhibit 7-2

SMALL BUSINESS IMPACTS OF REGULATORY ALTERNATIVES

Sector	**Number of Small Businesses**		**Impacts of Alternatives**		
	In Vermont	**Out-of-State**	**Proposed Emission Limit**	**Interim OWB Ban**	**OWB User Compliance**
OWB Manufacturing	1	• Unknown portion of 27 manufacturers would meet Vermont small business size standard	• Current producers of compliant units would incur no costs • Producers of non-compliant units would incur either: (1) costs of redesigning and emissions testing; or (2) loss of all VT sales • Many of these costs ongoing and independent of proposed rule	• All sales in VT eliminated for indeterminate time	• No immediate impact • Likely eventual impact of eliminating sales in VT
OWB Retail	• 17 part-time dealers • Unknown number of additional dealers (e.g., HVAC contractors, hardware stores)	Unknown	• Some manufacturers may abandon VT market; retailer profit losses spread across large number of VT establishments • Sales of compliant models could continue • Small, part-time OWB dealers hardest hit	• Eliminate all sales and retailer profits for indeterminate time	• Eventually eliminate all sales and retailer profits as consumers shun cost and uncertainty of emissions testing

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