Wood Stoves: Can We Solve the Emissions Problem Before It Goes Up In Smoke?

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WOOD STOVES: CAN WE SOLVE THE EMISSIONS PROBLEM BEFORE IT GOES UP IN SMOKE?

William Roper*

I. INTRODUCTION

Wood has warmed humankind for centuries. Until the early 1900’s, it played a major role in satisfying both domestic and industrial heating needs in the United States.1 Coal, natural gas, and oil gradually displaced wood as a primary fuel. The use of wood sharply declined in the 1940’s,2 and has only recently resurged as a source of heating fuel. It owes its rejuvenation to the dramatic price increase of oil and gas.

Between 1972 and 1980 the number of stove-type residential heating units in the United States increased 400 percent.3 In Vermont alone, the use of wood as the primary source of heat in single-family dwellings increased twofold from 1976 to 1978,4 and almost doubled again from 1979 to 1981.5 A 1981 survey conducted in Vermont indicated that “wood is used as the primary source of heat in more single-family households than electricity, natural gas, kerosene

* B.A. Williams College, 1977; J.D. cum laude Vermont Law School, 1983; Associate with Paul, Frank & Collins, Burlington, VT. The author thanks Professor J. Stephen Dycus, Vermont Law School, for his advice and encouragement.

3. Id. at 856.
5. C. SANBORN, R. POHROT, G. HEIL & M. BLANCHET, WATERBURY, VERMONT: A CASE STUDY OF RESIDENTIAL WOODBURNING 2 (2d ed. 1981) (obtained from Air Pollution Control Section, State of Vermont) [hereinafter cited as SANBORN].
and coal, and is secondary only to oil.  

Use of wood for residential heating purposes is by no means limited to the Northeast. The Southeast, for example, contains thirty-nine percent of the total wood heating devices and accounts for thirty-two percent of the wood burned.  

With the dramatic increase in the use of wood, concern over its various adverse effects has surfaced. Widely recognized are its serious impacts on forests, through the harvesting of trees to meet the demand, and on water systems, through erosion after harvesting. The scope of this paper, however, is limited to air pollution problems. Because emissions from industrial systems using wood are, at present, relatively limited and controllable, this article will focus on the more prevalent and potentially more harmful emissions from residential wood stoves. First, it will examine the composition and potential health effects of compounds produced by burning wood; it will then review possible means of private and public control and will make recommendations for change.

II. THE COMPOSITION OF WOOD STOVE EMISSIONS AND THE HEALTH HAZARDS WHICH THEY PRESENT

A. General Findings

The potentially adverse effects of wood stove emissions were first recognized in 1976. Since that time public and private research has grown rapidly; studies have been conducted in New Hampshire, Vermont, Maine, Oregon and Tennessee. These studies have all concentrated on the most common residential wood heating unit: small, airtight box stoves.

Tests have usually been conducted by loading various stove types with different kinds of wood and then measuring the emissions through detectors located in the exit flue. The air inlet or baffle set-

6. Id. at 5.
9. Id. at 153.
10. Cooper, supra note 2, at 2.
ting is closed in increments. Although the sampling techniques have varied, making the studies difficult to compare, all the studies have shared certain findings. First, most emissions occur because of the incomplete combustion of the wood. Combustion is affected by a number of variables, among which are the amount of oxygen available, the air turbulence within the stove, and the temperature of the firebox.\textsuperscript{12} Combustion efficiency increases with an increase in any of these three factors. Thus when combustion is incomplete, various particles, which should be burned within the stove, will pass up the flue, either forming a coating of creosote in the stove pipe or exiting into the air. Second, emissions are greatest at the beginning of a burn and taper off during the combustion process.\textsuperscript{13} Third, the amount of emissions is inversely related to the combustion rate: the more efficient the combustion, the fewer the emissions.\textsuperscript{14} Finally, and most importantly, each study has concluded that wood stove emissions can pose significant health hazards.

\textbf{B. Specific Determinations}

A recent study conducted in Oregon warned that, “the emissions are almost entirely in the inhalable size range and contain toxic and priority pollutants, carcinogens, cocarcinogens, cilia toxic, mucous coagulating agents, and other respiratory irritants.”\textsuperscript{15} As this statement indicates, wood smoke contains many dangerous compounds. This article however, will limit its analysis to some of the more critical compounds: particulate matter, hydrocarbons, carbon monoxide and polycyclic organic material. Emissions of the first three compounds are regulated by the Clean Air Act\textsuperscript{16} (CAA) which will be discussed in greater detail below.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Averaging Time</th>
<th>Primary Standard</th>
<th>Secondary Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate Matter</td>
<td>Annual Geometric Mean</td>
<td>45 ug/M$^3$ (micrograms/meter$^3$)</td>
<td>60 ug/M$^3$</td>
</tr>
<tr>
<td></td>
<td>24 hours</td>
<td>260 ug/M$^3$</td>
<td>150 ug/M$^3$</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>3 hours</td>
<td>160 ug/M$^3$</td>
<td>Same as Primary</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>8 hours</td>
<td>10 ug/M$^3$</td>
<td>Same as Primary</td>
</tr>
<tr>
<td>Monoxide</td>
<td>1 hour</td>
<td>40 ug/M$^3$</td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{12} SANBORN, \textit{supra} note 5, at c-35.
\textsuperscript{13} Krzeminski, \textit{The Catalytic Combuster}, 1982 NEW ROOTS 40, 40.
\textsuperscript{14} Butcher, \textit{supra} note 11, at 727.
\textsuperscript{15} Cooper, \textit{supra} note 2, at 855.
\textsuperscript{16} 42 U.S.C. §§ 7401-7706 (Supp. V 1981). The standards which have been promulgated for these three compounds are set forth below.

\footnotesize{\textsuperscript{a}40 C.F.R. §§ 50.6-50.10 (1981).}
1. Particulates

Particulates consist of all matter, up to a certain size, which, when sucked through an emission detecting air sampler, remain on the filter. They can carry heavy metals and cancer-causing compounds into the lungs, and can aggravate respiratory problems. Particulates can also impair visibility, dirty materials and corrode metals.

In a study conducted for the Department of Energy in 1980, particulate emission from wood stoves received an impact severity rating of six (ten being the worst), with only polycyclic organic material rated higher. Under the CAA standards, particulate emission is by far the most serious of the three pollutants. Particulates from residential wood combustion ("RWC") which is limited to wood stoves, contribute significantly to the overall particulate level regulated by the CAA.

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17. LEAGUE OF WOMEN VOTERS EDUCATION FUND, BLUEPRINT FOR CLEAN AIR 2 (1981) [hereinafter cited as BLUEPRINT]. These health effects are covered by the CAA primary standards. See supra note 16.

18. Id. These effects are considered "welfare effects" and are covered by the more stringent CAA standards.


20. Id.

21. INCREASES IN PARTICULATE LEVELS IN VARIOUS LOCATIONS DUE TO RWC IN MICROGRAMS/METERS$^3$ (ug/M$^3$)

<table>
<thead>
<tr>
<th>Location</th>
<th>Average Range</th>
<th>Maximum Amount</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waterbury, Vermont</td>
<td>18-39 ug/M$^3$</td>
<td>1 hr:120 ug/M$^3$</td>
<td>RWC contributing up to 40% of the seasonal particulate levels in residential areas</td>
</tr>
<tr>
<td>Maine</td>
<td></td>
<td>100 ug/M$^3$</td>
<td>For area with 700 residences/kilometer$^2$ heating primarily with wood</td>
</tr>
<tr>
<td></td>
<td>Ave max 33-75 ug/M$^3$</td>
<td></td>
<td>For three small communities at 100% wood use</td>
</tr>
<tr>
<td>Tennessee</td>
<td>4-5 ug/M$^3$</td>
<td></td>
<td>Hurts areas already in non-attainment</td>
</tr>
<tr>
<td>Portland, Oregon</td>
<td>34 ug/M$^3$</td>
<td></td>
<td>50% of respirable residential particulates</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>16% of respirable downtown particulates</td>
</tr>
</tbody>
</table>
2. Hydrocarbons

The primary source of hydrocarbons is gas vapour from automobiles; however, further research is expected to prove that RWC also contributes significantly to the presence of hydrocarbons in the atmosphere. Hydrocarbons are the second most serious emission covered by the CAA. They have received an impact severity rating of four.\(^{22}\) Hydrocarbons include a number of highly carcinogenic benzene extractables and other agents which form ozone when combined with nitrogen oxide in the presence of sunlight.\(^{23}\) Ozone irritates the mucous membranes of the respiratory system causing coughing, choking and impaired lung function. It can also aggravate chronic heart disease, asthma, bronchitis and emphysema.\(^{24}\)

3. Carbon Monoxide

Motor vehicles are also the major source of this toxic substance, which interferes with the ability of blood to absorb oxygen. Because carbon monoxide emissions from wood stoves received only a two on the impact severity chart,\(^{25}\) these emissions do not appear to present a serious health hazard. Several studies, however, disagree with this conclusion.\(^{26}\)

\(^{a}\) SANBORN, supra note 5, at D-27 (2d ed. 1981) [hereinafter cited as SANBORN].
\(^{b}\) BUTCHER, THE IMPACT OF RESIDENTIAL HEATING BY WOOD STOVES ON AMBIENT AIR QUALITY 8 (1978) (available at Maine Dep’t of Environmental Protection).
\(^{c}\) SANBORN, supra note 5, at D-28.
\(^{d}\) Cooper, Impact of Residential Wood Combustion on Urban Air Quality: First Ambient Measurement (1980) (paper presented at Air Pollution Control A. Meeting in Montreal; available at the Quebec Chamber of Commerce in Montreal, Quebec).
\(^{e}\) Cooper, Environmental Impact of Residential Wood Combustion Emissions and Its Implications, 30 J. AIR POLLUTION CONTROL 855, 856 (1980).
\(^{f}\) SANBORN, supra note 5, at D-29.

23. BLUEPRINT, supra note 17, at 2.
24. Id. at 2.
26. See Cooper, supra note 2; Butcher, supra note 12; Conversation with Cedric Sanborn, infra note 38.
4. Polycyclic Organic Material

The most serious wood smoke emission, polycyclic organic material ("POM"), is still unregulated. Although the 1977 CAA amendments recognize the potentially hazardous nature of POMs and require the Administrator to make specific determinations regarding these compounds, no such determinations have been made to date.

POM contains various toxic, irritating, and carcinogenic agents, as well as certain benzene extracts, including Benzene (a) Pyrene (BaP), which is especially carcinogenic. A direct link between POM levels and RWC has been established, and authorities agree that POM emissions from RWC represent approximately eighty percent of the total POM emissions from all sources. While certain POM testing methodologies have been criticized, the scientific community is united in its deep concern over the level of POMs which RWC pumps into the atmosphere. A recent study proposed a threshold limit of 1 ug/M³ while another reported rural POM concentrations on bad days to already be 1.2 ug/M³. Regardless of the accuracy of these particular numbers, the conclusion remains inescapable that POM emissions from RWC pose very serious threats to public health.

Several factors may contribute to the injuriousness of the compounds described above. First, all RWC emissions are highly respirable; that is, none are large enough to be screened out before reaching the lungs and yet none are small enough to exit from the body without risk of settling on the lung tissue. Second, common wintertime atmospheric conditions such as inversions can produce unusually high emission concentrations by trapping the pollutants close to the ground. Finally, because wood burning is primarily a

27. U.S. DEPT OF ENERGY, supra note 19, at 11.
29. New York State recently sought to compel this statutorily mandated action, by filing suit against the Administrator. N.Y. v. Gorsuch, No. 82 Civ. 4695 (S.D.N.Y. July 19, 1982).
30. Hewett, supra note 8, at 153.
34. Hornig, supra note 32.
35. An inversion usually occurs when a layer of cold air located in a valley is trapped by an overhead layer of warmer air. This colder air, and the pollutants it contains, is unable to escape until winds blow out the stagnant air.
residential phenomenon, the highest risk groups, including the young, the old and those with special medical problems, receive maximum exposure in their neighborhood environment.

Air pollution created by RWC emissions is already critical in some regions and may soon become serious in others. Although wood is used less than other fuels for residential heating, it produces a disproportionate share of emissions. 36

Research on RWC emissions is fairly new and must be developed further. Methodology problems must be solved and existing variations between tests must be reduced. New data concerning the interaction of various substances in the atmosphere must also be developed. Because compounds released through RWC may become neutralized or intensified by other airborne agents, the real danger of RWC emissions to public health cannot be accurately assessed until these atmospheric processes are fully understood. Despite its shortcomings, however, existing research has already identified many actual and potential adverse effects of RWC emissions. These discoveries amply justify intensive reduction efforts.

This article will now examine various means of controlling emissions. Private solutions to the problem, such as technological innovations, trade associations and fire insurance restructuring will first be scrutinized, followed by an examination of public control in the form of existing or future federal legislation and state regulations.

III. PRIVATE SOLUTIONS

Stove design directly affects combustion of the wood. To understand what changes are necessary to reduce emissions, one must first understand the combustion process. As the fire burns, gases and particulates are driven out of the wood, circulate within the chamber and, if unburned, pass up the flue, coating the stack with creosote or exiting into the atmosphere. Maximum combustion of

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Carbon Monoxide</th>
<th>Hydro-Carbons</th>
<th>Particulates</th>
<th>POM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>0.02</td>
<td>0.01</td>
<td>2.15-6.44</td>
<td>-----</td>
</tr>
<tr>
<td>Oil</td>
<td>0.04</td>
<td>0.01</td>
<td>6.02</td>
<td>-----</td>
</tr>
<tr>
<td>Coal</td>
<td>3.46</td>
<td>0.77</td>
<td>331</td>
<td>-----</td>
</tr>
<tr>
<td>Wood (stove)</td>
<td>22</td>
<td>0.28</td>
<td>215</td>
<td>80% of Total</td>
</tr>
</tbody>
</table>

these compounds requires adequate oxygen supply, high temperatures and air turbulence.

Old stoves satisfied these requirements by allowing additional air (secondary air) to leak in through cracks. These old stoves, however, were impossible to control and burned wood too rapidly, at temperatures higher than their owners desired. Newly developed airtight stoves burn wood more slowly by limiting the air supply and decreasing the turbulence. Unfortunately, emissions have dramatically increased with this new, more fuel efficient, design.

A. Technological Change

Increasing the combustion efficiency of wood stoves would benefit not only the public but also the individual stove owner. It has been estimated that five to thirty percent of the chemical energy of wood goes up in unburned smoke. If these gases could be captured and burned, less fuel would produce the same amount of heat. Moreover, the resulting decrease in creosote buildup would reduce the risk of chimney fires. Some manufacturers have made minor modifications in airtight stoves, such as the addition of secondary air inlets and the placement of a plate over the fire to interrupt straight air flows, thereby increasing turbulence. Although these changes may limit emissions, they do not reduce them to safe or satisfactory levels. Two recent innovations, however, produce significantly greater combustion efficiency. These developments, both of which resulted from efforts to reduce creosote accumulations, may revolutionize the stove industry.

The first, a design modification by Cedric Sanborn and Richard Poirot, improves the introduction of air into a stove. Some stoves presently have secondary air inlets which permit air to circulate in a space between the fire chamber and the outer casting. While this process warms the air, adequate temperatures for most efficient combustion are still not attained. The new design solves this problem by introducing secondary air through a pipe which passes through the fire itself before releasing the air into the chamber. This mechanism permits proper and complete combustion. Unfortunat-
ly, this device, which could easily be incorporated into most stove designs, is not yet publicly available.  

The second innovation, called the catalytic combuster, was first designed by Corning Glass Works. The combuster has a very thin exterior coating of precious metals which lowers the temperature at which smoke will ignite. One study estimates that the combuster can increase the overall efficiency of the stove up to eighteen percent, and another study reports that it can also reduce creosote output by ninety percent and pollutant emissions by seventy-five percent. At present, however, there are several problems which impair the combuster's viability. First, because the combuster is placed at the base of the stovepipe, it can impede airflow and produce smoke spillage. If the combuster becomes clogged, the smoke will escape into the stove owner's house. Second, the high temperatures which the combuster produces can cause premature failure of various parts of the heating system. Fortunately, these problems are not insurmountable. Several manufacturers have already designed stoves that successfully overcome these difficulties, and further refinements seem certain.

Although the combuster presently costs $150-$250 and has a limited useful life of three to five years, the mechanism pays for itself through reduced wood costs. The foregoing factors indicate that both the viability and the popularity of the combuster will increase in the future.

B. Trade Associations

Manufacturers can help control RWC emissions by incorporating into their stove designs either of the devices described above. Producers could also spur the development and marketing of these more efficient stoves by forming a trade association of stove manufacturers.

39. Each stove model requires its own individual design. After adopting the design, Mr. Sanborn first attempts to sell it to the stove manufacturer. So far he has met with limited success and, as yet, cannot afford to produce and sell the individualized devices on the open market himself.
40. Shelton, supra note 37, at 2.
41. Id. at 23.
42. Krzeminski, supra note 13, at 41.
43. Id. at 15.
44. Shelton, supra note 37, at 11.
45. Krzeminski, supra note 13, at 11.
Such an organization might use as its model the Air Conditioning and Refrigeration Institute ("ARI"),\(^{46}\) one of the most successful manufacturers' trade associations. The Institute brings together almost two hundred companies, whose dues support a staff of engineers. These technicians develop efficiency tests, measure and compare members' devices, and award a seal of certification to any manufacturer whose product meets certain prescribed standards. The Institute compiles these test results and makes them available to both consumers and retailers. This directory has spurred ARI members to increase the efficiency of their products.\(^{47}\) The association also forces manufacturers to cooperate with each other in determining the appropriate standards of performance, permits knowledgeable individuals with hands-on equipment experience to develop the standards, and demonstrates that a group of individuals can be policed more effectively by its own members than by a government agency.\(^{48}\) Thus, the formation of a stove trade association might not only benefit the public, but also forestall government regulation of the wood stove industry.

**C. Fire Insurance**

Like a trade association, fire insurance rates could also be used to promote wood stove efficiency. Premiums could vary according to correlated stove type with more efficient stoves qualifying for lower rates. Such rate differentials would encourage the use of low-creosote stoves, which not only cause fewer fires, but also produce fewer emissions.

There is precedent for this idea in other countries. In France, where there are no wood stove regulations, insurance companies increase their premiums substantially if the equipment is not inspected and serviced at least once a year.\(^{49}\) Switzerland similarly relies on fire insurance companies, although to a lesser degree.\(^{50}\)

**D. Shortcomings of Private Solutions**

These private market solutions, which contemplate design changes in new stoves, are only a partial answer to the emissions problem. A

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46. B. Greene & W. Tombleson, Institutional and Regulatory Approaches to Control Residential Burning Emissions, Int'l Conf. on Residential Solid Fuels 1226, 1232 (June 1-4, 1981) (available at the Oregon Dep't of Energy) [hereinafter cited as Greene].
47. Id.
48. Id.
50. Id. at 1191.
serious impediment to satisfactory emission reductions is the number of inefficient stoves already in use. Therefore, a successful emissions program must include retrofitting existing polluters. Sanborn estimates that his device could be inserted into an existing stove for sixty to seventy dollars, including labor.\textsuperscript{51} Retrofitting with the combuster does not presently seem feasible.

If retrofitting is to effect total RWC emission levels, government incentives or mandates may be necessary. This article will now examine public mechanisms for control and recommend necessary changes.

IV. PUBLIC CONTROL

A. Existing Federal Legislation

1. The Clean Air Act\textsuperscript{52}

The Clean Air Act ("CAA") is the only piece of federal legislation which addresses directly the problem of air pollution. Although it is federal legislation, the Act depends heavily on the states for implementation. Under the Act, the Environmental Protection Agency ("EPA") Administrator first identifies pollutants that threaten public health (criteria pollutants), and then establishes standards below which the public will not be endangered. These standards include "an adequate margin of safety."\textsuperscript{53} The states must then design a program, known as the State Implementation Plan ("SIP"),\textsuperscript{54} which will effectuate and enforce these standards. The standards established by the Administrator are only minimum requirements; the state, in its discretion, may establish more stringent ones.\textsuperscript{55}

The Act does not eliminate pollution, but merely controls it by allowing levels which pose no threat to public health. The Act contains provisions for review of established air quality standards,\textsuperscript{56} but changes are not easily made. Controversy about these standards continues, and there are currently several bills in Congress that would revise both the standards and the structure of the CAA.\textsuperscript{57} In its present form, the CAA provides minimal protection from RWC emissions. Several modifications in the list of pollutants and their

\textsuperscript{51} Conversation with Cedric Sanborn, supra note 38.
\textsuperscript{55} Id.
standards, essential for effective application of the Act, will be suggested below.

Standards for particulates are limited to material 30 μM and smaller. Health research indicates, however, that particles 10-2.5 μM and smaller are the most harmful because they are more likely to enter the respiratory tract. As a result of this research, the EPA is currently considering an “inhalable” standard which, if approved, will have a profound impact on wood stove use because virtually all RWC particulates are in this smaller range. If this source of inhalable particulates continues to grow at its present rate, it is likely to be a major contributor to any nonattainment of a new inhalable particulate standard, if such a standard is promulgated.

The EPA should also add POMs to the existing list of criteria pollutants and should promulgate POM standards. Although existing research on POMs is inconclusive, it suggests that these emissions may be a serious threat to public health. Lack of certainty concerning the danger posed by POMs does not excuse EPA inaction. A 1976 case involving the CAA authorized the Administrator to promulgate standards even though conclusive data is unavailable. The court asserted, “if the statute accords the regulator flexibility to assess risks and make essentially legislative policy judgments, as we believe it does, preventative regulation based on conflicting and inconclusive evidence may be sustained.” This pronouncement is consistent with the “adequate margin of safety” language in the statute. Furthermore, if New York succeeds in its recent suit against the Administrator, standards for POMs may soon be established.

In addition to the section regulating particulates, there are three other sections of the CAA which could cover RWC emissions if their provisions were revised appropriately. The National Emissions for Hazardous Pollutants section establishes standards for asbestos, beryllium, mercury, vinyl chloride and inorganic arsenic. This section presently applies only to industrial or commercial processes.

59. Id.
60. Cooper, supra note 2, at 860.
61. Id.
62. Id.
64. Id. at 26.
65. N.Y. v. Gorsuch, No. 82 Civ. 4695 (S.D.N.Y. July 19, 1982).
67. Mars, supra note 58, at 1261.
The EPA, however, is considering including standards on benzene, POM, BaP, and airborne carcinogens. Adding these compounds and adjusting the regulations to apply to all sources would affect RWC.

The Prevention of Significant Deterioration section currently applies only to sulfur dioxide and particulates and aims solely at individual sources, not regional contributors. This section is of limited scope because the technology or modeling techniques needed to deal with other pollutants are presently unavailable. The EPA has proposed extending the list of regulated pollutants and section 7476 of the CAA mandates that at least carbon monoxide, hydrocarbons and nitrogen oxide be considered, but no action has been taken to date. The inclusion of these compounds would affect RWC as they are all present in RWC emissions.

Finally, the CAA has a Visibility Protection section for Federal Class I lands which include wilderness areas and national parks. Because particulate emissions hinder visibility, RWC would be affected if the geographical limitations of this section were revised to include non-federal lands.

The EPA's air pollution offset policy could also affect RWC. This policy limits the ability of a major new pollution source to build its facilities in an area already in violation of CAA standards (nonattainment). The new polluter must first reduce the emissions of some other existing pollution source sufficiently to provide a greater-than-one-for-one offset for the proposed new source. As one commentator has observed, "it is not inconceivable that some major industrial sources will find it attractive to obtain emission offsets by reducing residential wood burning particulate emissions by a widespread program for the replacement of residential heating devices with cleaner burning units." Thus, unrelated industries may contribute to the reduction of RWC emissions through offset measures.

An alternative approach to revising the CAA would be to write a new section directed specifically at RWC emissions. The existing

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68. Id. at 1261.
73. This policy was first announced in a formal interpretive ruling, 41 Fed. Reg. 55,524-30 (1976) and was later implemented in the 1977 C.A.A. amendments 42 U.S.C. § 7473 (1977).
74. Greene, supra note 46, at 1237.
75. Id.
CAA section regulating motor vehicle emissions provides an interesting model for such an addition. It establishes a certification program to test engines of new cars and authorizes sporadic inspections to monitor continued compliance. It also creates an implied warranty by the manufacturer that the engine contains no defects and conforms to relevant vehicle emission regulations. Furthermore, it limits consumers' expenses for scheduled replacements necessary for compliance. Finally, this section allows the Administrator to determine that a substantial number of any class of vehicles or engines do not conform. He may then require the manufacturer to submit a plan for remedying the nonconformity at the company's expense. A similar regulatory approach to wood stove certification would greatly reduce RWC emissions.

The CAA is the primary vehicle for federal control of air pollution. With certain revisions, its impact on RWC emissions could be direct and substantial. The current administration, however, favors reducing CAA regulatory powers. Therefore, this article will examine several other federal statutes which may help control these dangerous pollutants.

2. The National Environmental Protection Act

Pollution from wood stoves falls within the scope of the National Environmental Protection Act's ("NEPA") declaration of policy, which recognizes man's "profound impacts ... on all components of the natural environment." NEPA can only be invoked, however, through the actions of federal agencies or federally funded private parties, which will cause significant environmental impacts. Thus, NEPA would only apply to situations where federal funds or offices were promoting residential wood burning. Currently, the Tennessee Valley Authority provides low-cost loans up to $800 to help homeowners buy stoves and it is expected that 100,000 homes will eventually be involved in this program. Such an increase in wood

85. Mars, supra note 58, at 1267.
86. LaFavore, Getting Wood to Burn Clean, 27 ORGANIC GARDENING 112, 114 (1980).
burning could create emission levels sufficient to trigger NEPA. The Authority would then be required to draft and file an environmental impact statement. In fact, such a statement is already being prepared. 87

3. Toxic Substances Control Act 88

The Toxic Substances Control Act ("TSCA") was primarily designed to regulate the chemical industry. It focuses its regulatory power at the point of manufacture and provides a means for tracking and screening potentially dangerous substances. 89 Although the definition of chemical substance, "any organic or inorganic substance of a particular molecular identity," 90 is sufficiently broad to cover carcinogenic and toxic compounds in RWC emissions, regulation of these pollutants under TSCA is unlikely. There are at least two major obstacles to the application of TSCA to wood stove emissions. First, manufacturers of stoves are only indirectly responsible for emissions, and second, stove owners have not traditionally been considered manufacturers.

4. The Internal Revenue Code

The federal tax system could also promote production or use of more efficient stoves. Tax credits or deductions for manufacturers could be increased as the efficiency of new stoves increased. 91 Conversely, a tax modeled after that imposed on gas-guzzling automobiles 92 could be imposed on less efficient models, thereby discouraging their production. Providing an increased rate of depreciation to businesses using the more efficient stoves could also indirectly influence production. 93 Similar incentives for stove owners could encourage replacement or retrofitting. Finally, all stove use could be discouraged by levying a stove use tax or a tax on wood.

87. Mars, supra note 58, at 1267.
89. Mars, supra note 58, at 1268.
91. A tax credit is applied directly against the income tax paid by an individual. A deduction is applied against the gross income of an individual and reduces taxes by reducing the total income taxed. The credit's impact is direct and unvariable while a deduction's significance depends on an individual's income. Thus, a deduction is less favorable than a credit.
93. This suggestion contemplates a change in existing depreciation provisions. Under the present ACRS structure, depreciation deductions are available only for equipment used in trade or business.
Taxes advancing energy conservation indirectly affect the emissions problem. Energy-saving measures, such as weather-stripping or insulating, reduce the amount of wood which a stove must burn to stay warm. When less wood is burned, fewer emissions are created. Thus, conservation efforts, stimulated by tax incentives, may help alleviate the emissions problem.

A national scheme for taxation of stove production and use would be more effective than similar state tax incentives. If neighboring states imposed differing rates, consumers could flout the law by purchasing their stoves in the state with the most favorable tax. Furthermore, state tax plans may be subject to constitutional challenges asserting interference with interstate commerce.

B. Future Federal Legislation

1. Certification Program

If manufacturers fail to organize a trade association\(^\text{94}\) which certifies its members, the federal government may wish to begin a certification program of its own. Such a program would establish emission standards and would test all stoves. Each model of stove would receive a certain rating, analogous to the EPA miles per gallon rating for automobiles.

2. Bans on Polluters

A certification program would not eliminate the sale of less efficient stoves; the ratings would simply help consumers choose the more efficient stoves. If the certification plan was not successful, however, the government could ban the production or sale of stoves which do not meet emission standards. In West Germany, the Federal Air and Noise Protection Law of 1974 specifies a set of stove design criteria that must be met.\(^\text{95}\) Were such legislation enacted in the United States, it could avoid a constitutional challenge of "taking"\(^\text{96}\) by allowing manufacturers an adjustment period. The time

\(^{94}\) Greene, supra note 46.

\(^{95}\) Werner, supra note 49, at 1186.

\(^{96}\) The Fourteenth Amendment of the U.S. Constitution prohibits the deprivation of property without due process of law. While the determination of deprivation is difficult, case law indicates that an owner of property cannot be deprived of any of the essential attributes which belong to the right of property. The label of "taking" is attached where such deprivation is established. See, e.g., J. Nowak, R. Rotunda & J. N. Young, Constitutional Law 483-85 (1978).
lag would make technological or design changes feasible and would prevent manufacturers from suffering major losses.

Some sort of regulation at the manufacturing level is attractive, not only because enforcement would be relatively simple, but also because consumers would undoubtedly prefer that the burden of regulatory compliance be placed upon the producer rather than the purchaser.

3. Research Programs

Much of the research on RWC emissions has been federally funded. The EPA designed an exhaustive, five-year research program which was barely half complete when funds were totally withdrawn through the 1982 budget cuts. Private researchers and organizations have made important contributions, but progress on emission analysis has inevitably slackened.

A major impediment to successful emissions control is the lack of an inexpensive, standardized method for testing stove emissions. Regulations cannot be enforced without a feasible means of measuring compliance. Similarly, manufacturers cannot record emission differences resulting from design modification without a sampler. The most common method of measurement, an EPA 5 test, is fairly complex and costs $1500 per test.

Two new tests are needed. The first, which manufacturers could use to test emission variations resulting from design changes, would produce only approximate results. The second, which would be more sophisticated, would compare emission rates for different units and would include a method for measuring at similar rates of heat output. This second test would be a central feature in certification programs. Emission standards for RWC could be established in conjunction with the development of these tests. If RWC emissions are to be effectively controlled, research and technological innovations must quickly surmount this obstacle to standardization.

Although federal funding and regulation would certainly speed emissions reduction, the present political climate dictates that such federal intervention is unlikely to occur in the near future. Because state action may be a viable alternative to federal activity, this article will now examine the control mechanisms available to the states.

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97. Manufacturers are easy to locate, and because the business community is reconciled to regulation, an inspection or monitoring requirement should meet with limited resistance.
98. Greene, supra note 46, at 1246.
99. Id.
100. Id. at 1246.
C. State Control

1. Nonregulatory Involvement

a. Common Law Doctrines

There are four common law doctrines that could affect RWC: nuisance, trespass, negligence and strict liability. Nuisance is defined as a substantial and unreasonable interference with a person’s right to use and enjoy his or her property.\textsuperscript{101} Private nuisance actions are generally brought by individual citizens, while public nuisance actions, which affect a greater number of people, are usually brought by the state. Nuisance theories have been successfully applied in other types of air pollution cases.\textsuperscript{102} Residential wood combustion, however, is not generally considered an “unreasonable” activity.\textsuperscript{103} Furthermore, linking one homeowner’s emissions to another’s damages can be difficult. Public nuisance suits could skirt the latter hurdle by bringing an action against all wood stove operators in a particular jurisdiction. Successful nuisance actions could not only modify, but completely halt stove use.

The second common law doctrine, trespass, requires the plaintiff to prove that his or her right to exclusive possession of property has been physically invaded.\textsuperscript{104} Establishing causation in a trespass case is even more difficult than in a public nuisance case because the invading particulates must be traced directly to a particular offender. Current emission technology does not permit this level of accuracy. Therefore, relief from RWC emissions probably could not be obtained under a theory of nuisance.

In order to sustain a negligence action, the plaintiff must show that his or her injury was caused by the defendant’s breach of a legal duty of care which he or she owed the plaintiff. Establishing a duty of care would be difficult because no emission standards presently exist, stoves vary drastically in their emissions, and few owners are trained in proper operation. In communities with air pollution emergency programs,\textsuperscript{105} however, a person failing to reduce his or her wood burning activities might be found negligent.

\textsuperscript{101} W. Prosser, \textit{The Law of Torts} § 87 (4th ed. 1971).

\textsuperscript{102} Mars, \textit{supra} note 58, at 1263.

\textsuperscript{103} Courts are reluctant to find a nuisance where the activity is common to the area. Where this is the case, the claimed nuisance must be substantial in nature. \textit{Morris On Torts} § 5 (1980). Since woodburning is common to many rural areas, establishing a neighbor’s woodburning activity as a nuisance may prove exceedingly difficult.

\textsuperscript{104} Mars, \textit{supra} note 58, at 1263.

\textsuperscript{105} \textit{See infra} text at note 110 for a discussion of Air Pollution Emergency Programs.
Strict liability applies to abnormally dangerous activities and imposes liability without proof of fault. The emission of carcinogenic and toxic substances could conceivably fall within the definition of an abnormally dangerous activity. A wood stove, however, would probably be considered an object of common usage,\textsuperscript{106} to which strict liability does not apply. Despite this limitation, sources of hazardous pollutants specified in the CAA may be covered.\textsuperscript{107}

b. Public Education

This article has discussed only stove design as the cause of RWC emissions. The method of operating a stove, however, also affects the amount of pollutants emitted. Many states have published brochures intended to reduce inefficient stove operation.\textsuperscript{108} These brochures stress the importance of burning properly dried wood, and of never burning domestic trash in the stove. They also suggest that, upon loading their stoves, operators burn a very hot fire for the first 15-30 minutes. The high temperature burns up many of the gases that would otherwise go up the stack. Some brochures even address characteristics of different types of wood. Certain woods, pine or elm, emit vastly greater quantities of pollutants than other woods. None of the brochures, however, contains information about retrofitting devices. A description of such mechanisms should be included in future pamphlets.

Because these brochures are distributed through environmental agencies and retailers rather than through manufacturers, the actual degree of dissemination is unknown. Education through these brochures could be effectively supplemented by broadcasting informational announcements about RWC on television and radio and publishing articles on the subject in local newspapers.

Among the states, the public education approach is by far the most popular means of emissions control. Even in regions experiencing severe pollution problems, these brochures are the primary vehicle for alleviating emissions.\textsuperscript{109} This may be so because public education involves no regulation, paperwork or monitoring, thereby minimizing the cost to the state.

\textsuperscript{106} W. Prosser, \textit{supra} note 101, at § 78.
\textsuperscript{107} Werner, \textit{supra} note 49, at 1183.
\textsuperscript{108} Oregon, Montana and Colorado are among the states that have already published brochures on how to burn wood more efficiently. Vermont is in the process of issuing a publication.
\textsuperscript{109} Conversation with Cedric Sanborn, \textit{supra} note 38.
c. Emergency Alerts

In conjunction with these brochures, several regions have instituted air pollution emergency programs.\textsuperscript{110} The media alerts a region when air quality falls below a certain point. During alert conditions residents voluntarily reduce their use of wood. Although people who heat exclusively with wood may be unable to comply, many homeowners have other available alternatives. If the voluntary program proves ineffective, the reductions could be made mandatory.

2. Regulatory Involvement

a. State Implementation Plans

Although the air quality standards apply to all sources of regulated pollutants, the standards have not been enforced against small residential sources.\textsuperscript{111} Industry bears the burden of most CAA regulation because it is the major contributor of several of the compounds covered by the CAA and it can be easily monitored. However, RWC’s significant contribution to various pollutant levels must also be recognized. If the CAA is amended along the lines suggested earlier,\textsuperscript{112} state regulation of RWC may be necessary. This state control would be implemented through State Implementation Plans.

b. Building Codes

Building code restrictions could reduce the number of stoves allowed in new buildings.\textsuperscript{113} Such codes could also limit installations to the more efficient stove types by specifying an emissions standard. This type of regulation, however, could apply to new sources only and would not solve problems posed by existing stoves.

c. Zoning

Zoning ordinances could provide an additional means of controlling RWC emissions. Regional studies could establish both the levels of RWC in specified locations and the prevalence of winter inversions in these areas. It would then be possible to calculate the total

\begin{footnotesize}
\begin{enumerate}
\item Vail, Colorado and Missoula, Montana are two cities that have emergency alert programs.
\item Mars, \textit{supra} note 58, at 1257.
\item See \textit{supra} text at notes 59-72.
\end{enumerate}
\end{footnotesize}
number of stoves which a region could support. These limitations could then be incorporated into local zoning ordinances. This limit could be raised as the design or use of the stove became more efficient.

d. Retrofit Programs

As noted above, a serious barrier to successful emissions control is the large number of inefficient stoves currently in use. Placing regulations on new stoves will check the growing problem but will not resolve it. Effective control may require the institution of either a retrofit program or a stove replacement program, either of which could be subsidized.

e. Enforcing Compliance

Mandatory programs would probably face public opposition and should be avoided, if possible. In several regions, however, atmospheric quality has deteriorated to a point where regulation of RWC has become imperative. Monitoring and enforcing compliance will be essential to regulatory success. However, the widespread use of wood indicates that any enforcement scheme will probably be both complex and expensive.

Monitoring new installations will not pose serious difficulties. The state could issue stove permits, and could require any prospective stove owner to file an application before installing his or her unit. This system would help enforce compliance with regulations on new installations and would aid statistical compilation.

Monitoring compliance with retrofit or replacement programs would be more difficult, but not impossible. The states might emulate Germany, which requires fossil fuel users to have their flues inspected and cleaned once a year by certified chimney sweeps. The sweep analyzes whether the unit is operating efficiently and whether excessive smoke is being produced.114 If the states adopted a similar program, the information could be reported to state officials, who could take appropriate measures to ensure compliance.

State control of RWC has several advantages. State programs contain an element of flexibility absent in federal schemes. States are often better able to identify and resolve specific emission problems. The CAA recognizes this fact by leaving to the states implementa-

114. Greene, supra note 46, at 1236.
tion of its controls. Through voluntary programs, states may be able to reduce emissions without regulation. If state regulation is required however, it will certainly meet with user opposition. Furthermore, enforcement will be difficult due to the diffused nature of wood stove use.

These problems may be alleviated by local efforts at controlling pollution. Local topography or meteorological conditions often cause RWC emissions to remain in the atmosphere near their source of origin. Localities may therefore recognize that they themselves must take action in order to prevent significant air quality deterioration in their environment. Furthermore, local education and regulation may be better received by the public than similar state action. For these reasons, localities should be encouraged to reduce emissions on their own or to participate actively in state programs.

V. CONCLUSION

RWC emissions already pose significant problems in some regions and should cause concern in others. The potential health effects are serious and, at present, are not adequately recognized by the public. More efficient stove design and operation must be actively promoted, if not mandated. Cooperative, voluntary efforts between private organizations and public agencies may successfully reduce emissions. If such efforts do not produce satisfactory results, however, government intervention at the federal, state, or local levels may become necessary. Some form of immediate action is crucial, however, if wood is to become a safe and viable alternative fuel source for American homes.