DRAFT White Paper – Residential Heating and Wood Combustion

Strategy Evaluation
Portland Air Toxics Solutions

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Introduction

The purpose of this document is to evaluate potential emission reduction strategies for residential heating and wood combustion in the PATS study area. For the residential heating and wood combustion source category, nine strategies were evaluated.

Section I describes the residential heating and wood combustion source category, the magnitude and type of emissions from each residential heating and wood combustion process (device), summarizes the modeling conclusions regarding degree of contribution of residential heating and wood combustion to times above benchmark, describes the emission reductions needed, and describes the spatial extent.

Section II summarizes existing emission reduction measures.

Section III provides three tables that summarize the strategy evaluation, provides an overview of emission reduction measures evaluated, and lists strategies that were considered, but not evaluated.

Section IV provides a detailed narrative of the strategy and describes the strategies' impact on the primary considerations as requested by the advisory committee: magnitude, timeframe, other pollutants, technical feasibility, and cost.

Attachments section contains additional details on the full range of considerations for each strategy as requested by the advisory committee.

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I. SOURCE CATEGORY: RESIDENTIAL HEATING AND WOOD COMBUSTION

A. Source Category Description

This paper addresses home heating and residential combustion in fireplaces, where the main purpose might not be to heat a home. In the PATS study area, the number of housing units is close to 700,000; this includes both single and multi-family units. Of these roughly 2% are heated by wood. The remaining 98% of the housing in the area is heated by oil, natural gas, electricity, kerosene, liquid or gas propane, coal or coke, solar, or other. Almost half of heating is done using natural gas (47%); 41% is electricity; and other fuels make up 9% or less of the total. Because residential wood combustion and home heating other than wood have very different emission characteristics, they are addressed separately where appropriate.

The actual method of delivering the heat within a home ranges from centralized heating, to heating room-by-room. The sources are area-wide and dispersed.

The residential wood combustion source category includes several different types of wood burning devices: fireplaces, uncertified wood stoves, certified wood stoves (both catalytic and non-catalytic), uncertified fireplace inserts, certified fireplace inserts (both catalytic and non-catalytic), pellet stoves, and fire log combustion in any device.

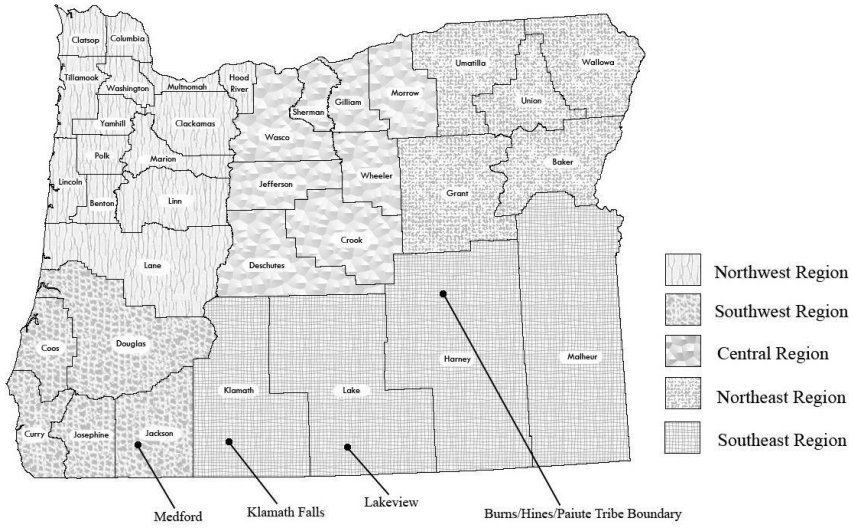
A fireplace insert is a stove designed to fit into an existing fireplace. Catalytic stoves and inserts use a ceramic catalyst inside the firebox to assist with the burning of waste-gases (smoke). Non-catalytic stoves use a combination of sophisticated baffles and air supply designs to burn waste gases efficiently. In general, catalytic stoves are a little more efficient initially than non-catalytic stoves, but ceramic catalyst inside the woodstove deteriorates over time and needs to be replaced every 2-4 years to ensure good performance. Certified devices include woodstoves or fireplace inserts certified by either DEQ or the EPA. Certified devices mean less wood smoke pollution and more efficient heating compared to a similar uncertified device. Certified woodstoves emit 50% to 60% less pollution than non-certified stoves and use 1/3 as much wood as non-certified stoves[1]. A fire log is a manufactured log, generally made from sawdust or sawdust and paraffin.

A.1. Residential wood combustion in the PATS area

In 2009, DEQ conducted a survey of residential wood combustion devices throughout Oregon[2]. The survey provides information on the northwest portion of the state, which included Benton, Clackamas, Clatsop, Columbia, Hood River, Lane, Lincoln, Linn, Marion, Multnomah, Polk, Tillamook, Washington and Yamhill counties.

[1] Source: http://www.deq.state.or.us/aq/burning/woodstoves/buysell.htm
[2] Johnson, et al. Portland State University Survey Research Lab. June, 2009. Department of Environmental Quality Residential Wood Combustion Survey: results report.

Figure 1: Residential Wood Combustion Survey Area



The survey sampled 1,298 homes in Oregon regarding residential wood burning. In this survey, respondents were asked if they owned specific wood-burning devices, and then if they used them. Table 1 on page 5 shows these results.

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Table 1: Percent Respondents Burning Wood, By Device, Northwest Region

Type of Wood Burning Device	Percent of Homes That Burn Wood
Fireplace	15.7%
Fireplace Insert Not Certified	2.0%
Fireplace Insert Certified Non-Catalytic	1.5%
Fireplace Insert Certified Catalytic	0.5%
Fireplace Insert Certified Non-Classifiable	1.0%
Woodstove Insert Not Certified	2.5%
Woodstove Insert Certified Non-Catalytic	1.5%
Woodstove Insert Certified Catalytic	3.4%
Woodstove Insert Certified Non-Classifiable	2.9%
Pellet Stove	3.9%

Source: Johnson, et al. Portland State University Survey Research Lab. June, 2009. Department of Environmental Quality Residential Wood Combustion Survey: results report

Based on these percentages for the northwest survey region and the 2000 census data, DEQ estimated the number of woodstoves that would be used in Washington, Clackamas, and Multnomah Counties in 2017 (See Table 2). The 2017 forecast also factors in expected population growth and some reduction in woodstove emissions from existing woodstove strategies. The 2017 forecast includes only the percent of devices where people actually burn wood. There are many more devices that, based on the DEQ residential wood combustion survey, are not used to burn wood.

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Table 2: 2017 Estimated Number of Wood Burning Devices in Clackamas, Multnomah and Washington Counties in which wood is burned[3]

Wood Burning Device	Clackamas County	Multnomah County	Washington County	Total
Fireplace	33,098	14,454	14,629	62,181
Certified Fireplace Insert *(Catalytic or Non-Catalytic)*	4,253	1,857	1,880	7,990
Non-Certified Fireplace Insert	5,309	2,319	2,347	9,975
Pellet Stove	8,186	3,575	3,618	15,379
Certified Woodstove *(Catalytic or Non-Catalytic)*	10,420	4,550	4,605	19,575
Non-Certified Woodstove	7,923	3,460	3,502	14,885

Source: DEQ

A.2. Residential heating and wood combustion devices

Current Heating Methods

Most often centralized heating systems use heat from combusting a fuel in a boiler, furnace or other device, to warm air that is delivered throughout the house via vents. Natural gas is the most common fuel used in the PATS study area; however oil, propane, and coal are used in the same way. Some heating is room specific with warmed air being delivered via a fan, from a stand-alone or wall mounted unit. These systems are frequently electric. Burning fuel to warm the air is the primary source of emissions. Generators are sometimes used to produce electricity: resulting pollution levels depend upon the type of fuel used, oil, diesel, gas, kerosene, etc.

Homes heated with electricity typically work like this: current is run through a resistance wire that heats up, this heats the surrounding air, and the air is dispersed via a fan. Assuming that devices are maintained in good working order, electric heat produces few emissions as a result of the process, however the manner in which the electricity is generated can be a huge source of pollution[e.g. coal fired power plants]. Electrically powered heat pumps are also utilized which recover heat from the outdoor air or from the ground using refridgerants and transfer the energy into the home using built-in fans to push warmed air into the room.

[3] This includes all existing regulations described in Section II on page 7, including removal of woodstoves at home sale required by Oregon's Heat Smart Program: http://www.deq.state.or.us/aq/burning/woodstoves/heatSmart.htm.

Passive solar heating collects the sun's energy through unshaded south facing glass during the heating season, stores the energy in strategically placed thermal mass by day, and releases it during the evening. Like electric heating, passive solar heating is emission-free, with the majority of associated pollution being emitted during construction of a building. It relies on energy efficient design and a clear solar window (minimal shading to the south of the home) as well as building eves wide enough to block the high summer sun from the south facing glass to avoid overheating in the summer.

Radiant/hydronic systems work by circulating heated water or electricity through floors or radiators. The house is heated through passive heat transfer, which can also be pollution free if the source of fuel to heat the water is solar.

For other systems, the source of pollution is the same as centralized units; emissions come from burning or combusting the fuel to heat the air or water.

For home heating other than wood, cadmium is the main driver of risk, contributing 25% of all cadmium emissions within the PATS study area.

Devices specific to residential wood combustion

Each type of residential wood combustion device emits different amounts of different pollutants on average. In addition, different amounts of wood are generally used for different devices. For example, in the Northwest region, for cordwood, 31% is burned in fireplaces, 48% in woodstoves, and 21% in fireplace inserts. For details on emission factors for each type of residential wood burning device for all pollutants, please see Attachment B on page 39.

Table 3 on page 8 shows 2017 modeled emissions from all residential wood burning devices within the PATS area. As you can see, uncertified woodstoves and fireplace inserts produce larger amounts of risk driver pollutants such as 15 PAH than other devices.

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For residential wood combustion, 15 PAH and benzene are the main drivers of risk. This section highlights emissions from wood burning devices for these two main risk driver pollutants in the PATS area. For more information on why these are the main risk drivers, see Section B1 on page 9. All pollutants are covered in the modeling.

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Table 3: 2017 Projected HAP Emissions for Residential Heating and Wood Combustion Source Category (tons/year)

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Source Category	Wood Burning Device	15_PAH	Acetaldehyde	Acrolein	Arsenic	Benzene	Butadiene	Cadmium	Diesel PM2_5	Formaldehyde	Lead	Manganese	Napthalene	Nickel
Residential Wood Combustion	Fireplace	0.03	33.7	3.9		21.6	4.9			56.4			8.3	
	Insert Not Certified	3.0	7.0	1.0		22.1	4.4	0.0003		16.5		0.002	2.0	0.0002
	Insert Certified NonCatalytic	0.7	4.1	0.3		6.2	1.1	0.0001		14.4		0.001	0.4	0.0001
	Insert Certified Catalytic	0.2	1.1	0.1		3.2	0.4			2.1			0.2	
	Woodstove Not Certified	5.5	12.6	1.9		39.6	8.0	0.0004		29.6		0.003	3.7	0.0003
	Woodstove Certified NonCatalytic	0.8	4.9	0.3		7.5	1.4	0.0002		17.3		0.001	0.5	0.0002
	Woodstove Certified Catalytic	2.0	9.4	0.6		25.8	3.4			17.3			1.7	
	Pellet Stove	0.1	1.8	0.2		0.6	0.02			6.0			8.1	
	Firelog Combustion: All device types (residential)	0.2				3.7							0.3	
	Total	**12.6**	**74.7**	**8.2**	**0.0**	**130.3**	**23.7**	**0.001**	**0.0**	**159.8**	**0.0**	**0.01**	**25.2**	**0.001**
Residential Fuel Use (other)	Distillate Oil	0.001	0.05		0.01	0.002		0.004	8.8	0.3	0.01	0.01	0.0	0.004
	Natural Gas	0.002	0.001		0.01	0.1		0.1		3.9	0.02	0.02	0.0	0.1
	Liquid Propane Gas	0.001	0.0003			0.04				1.5			0.0	
	Kerosene	0.0001	0.01		0.001	0.0002		0.0005		0.04	0.001	0.001	0.0	0.0005
	Total	**0.003**	**0.1**	**0.0**	**0.02**	**0.2**	**0.0**	**0.1**	**8.8**	**5.7**	**0.04**	**0.03**	**0.1**	**0.1**
Grand Total (All Home Heating and Wood Combustion)		**12.6**	**74.7**	**8.2**	**0.02**	**130.5**	**23.7**	**0.1**	**8.8**	**165.5**	**0.04**	**0.03**	**25.3**	**0.1**
Percent of 2017 emissions from all sources withing PATS area (not including background and secondary sources)		**75%**	**34%**	**10%**	**5%**	**23%**	**32%**	**26%**	**2%**	**39%**	**2%**	**1%**	**23%**	**4%**

B. Modeling Results: Degree of Contribution and Emission Reductions Needed.

B.1. Description of emissions/2017 modeling results from residential heating and wood combustion

Table 4 shows the various pollutants that are attributed to residential heating and wood combustion in the PATS domain and identifies the reduction targets for the specific PATS pollutants. The targets represent the reductions needed to meet ambient benchmark concentrations for residential wood combustion using reasonable worst case analysis and not considering background concentrations. The reduction targets were developed based on commensurate reductions at the top 20 percent highest receptors for this category considering emissions from all point, area, and mobile sources.

Combustion of residential natural gas contributes 25% of the cadmium emissions in the PATS study area.

Table 4: Reduction Targets for Residential Heating and Wood Combustion

Times Above Benchmark	Pollutant	Projected 2017 total emissions from residential wood combustion (tons)	Reduction Targets Percent
More than 10 times above benchmark	15_PAH	12.6	**96.8**
	Butadiene	23.8	**89.6**
	Naphthalene	25.3	**82.6**
	Benzene	130.5	**84.4**
	Formaldehyde	165.5	**88.3**
	Acrolein	8.2	**84.3**
	Cadmium	0.06	

Residential heating and wood combustion is not expected to contribute chromium, dichlorobenzene, ethyl benzene, or methylene chloride. DEQ has not developed targets for two pollutants emitted by residential wood combustion: manganese and acetaldehyde. The category contributions to manganese are extremely small. The acetaldehyde emissions from wood combustion are also very small relative to secondary formation (less than 3% vs 91%) and in general DEQ plans to handle the three secondary formation pollutants (formaldehyde, acetaldehyde and acrolein) with precursor strategies in coordination with ozone control efforts.

B.2. Main risk drivers

Cadmium is the risk driver pollutant for residential heating other than wood.

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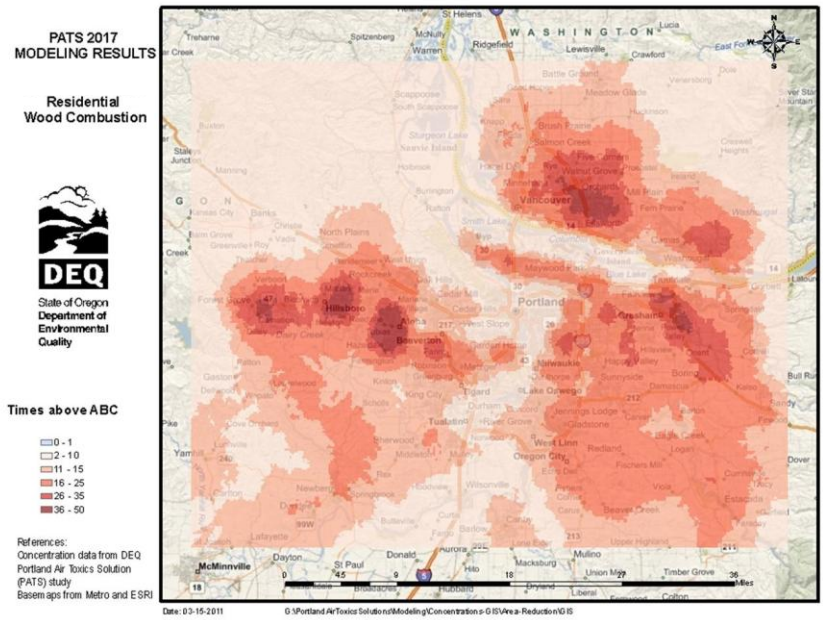
Most pollutants emitted by residential wood combustion are risk drivers for the PATS study area as a whole, but the pollutants causing at least 10% of the risk within this category are 15 PAH, 1,3-butadiene and formaldehyde. Because of the overwhelming contribution of secondary formation to formaldehyde concentrations (69%), the primary residential wood combustion pollutant capable of control is 15 PAH.

C. Source Category Effect on Distribution of Emissions

The geographic distribution of woodstove emissions and exposures is linked to land use and the location of residential housing. Older housing stock tends to have more woodstoves than new construction, and the stoves in older neighborhoods tend to have a higher percentage of older uncertified stoves from the 1970s and 80's. Low-income neighborhoods also tend to have older, higher polluting stoves, with higher rates of wood consumption because wood may be relied on more as a main source of heat and homes may not be adequately weatherized. Areas with a higher density of older, more polluting stoves and less weatherization would likely be localized impact areas for woodstove emissions. Woodstove emissions are seasonal, contributing to area wide and localized impact exposures in the fall, winter, and spring.

Below is a map of all residential wood combustion PATS pollutants totaled to show levels above benchmarks. This shows the general geographic extent of risk from residential wood combustion.



To see details on each of the pollutants, please see January 25, 2011 presentation at the advisory committee meeting, available at
http://www.deq.state.or.us/aq/toxics/docs/pats/1_25_11analysisPresentation.pdf

II. SUMMARY OF EXISTING EMISSION REDUCTION STRATEGIES

A. Emission Standards for New Wood Heating Devices

Federal

- Expected regulation: The U.S. Environmental Protection Agency (EPA) has initiated a review of the New Source Performance Standards (NSPS) for new residential wood heaters, and is planning to require lower emissions from new woodstoves and other new wood burning devices in 2013. This is a planned regulation, and has not been finalized.

B. Speed Turnover to Cleaner New Wood Heating Devices Or Cleaner Furnaces

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Local

- Incentive: Some utilities might have incentives for switching from wood heat to natural gas or electric. DEQ is not aware of any such local program. DEQ recently obtained a $2 million dollar federal Department of Energy grant to conduct stove replacement programs in communities violating or at risk of violating federal health standards for fine particulate. Such grants are rare and sporadic. In the future, DEQ would like to pursue the creation of a stable, long-term funding source for stove replacement.

State of Oregon

- Regulation: Oregon's Heat Smart Program – Requires removal of uncertified woodstoves upon home sale. As housing stock turns over, uncertified stoves will be slowly removed. This has been accounted for in the modeling of 2017 emissions. http://www.deq.state.or.us/aq/burning/woodstoves/heatSmart.htm
- Regulation: Oregon's rules also do not allow any person to sell, offer to sell or advertise to sell a used, non-certified woodstove. Uncertified stoves, including EPA-exempt stoves and outdoor wood boilers are no longer allowed to be sold in Oregon unless they are certified. Pellet stoves, fireplaces, and masonry heaters are exempt from these requirements. In addition, no building permits will be issued for the installation of a used, non-certified woodstove.
- Incentive: Statewide tax credit for premium efficiency wood and pellet stoves that qualify, the tax credit amount is 25 percent of the net cost up to $300. http://oregon.gov/ENERGY/CONS/RES/tax/HVAC-Biomass.shtml

Federal

- Incentive: Federal tax credit. Federal Energy Efficiency Tax Credit on qualifying biomass fuel stoves or woodstoves, pellet stoves, furnaces, and fireplace inserts. The tax credit amount is 10 percent of the net cost up to $300.
- Federal tax credits were previously given to homeowners to promote the purchase of more efficient furnaces, heaters, etc. These tax credits have expired. Almost all new furnaces and other heating devices are many times more efficient than older models.

C. Energy Conservation

Local

- Education: Locally weatherization programs exist that educate homeowners how to stop drafts, add insulation, and replace single pane windows to help reduce the need to continuously heat rooms. Cleaning and insulating ducts and tuning furnaces helps to reduce pollution emissions because fuels burn more efficiently and heated air can be delivered effectively. All of these actions reduce the amount of fuel used, and as a result, reduce the pollution emitted.
- Education: The City of Portland sponsors homeowner "Fix it Fairs" every year. The fairs aim to educate homeowners about the importance of maintaining their heaters, boilers, etc. properly, while teaching them how to get the most out of their equipment to keep costs low and efficiency high.

State of Oregon

- Education: The State of Oregon promotes new homes be built more efficiently for less air leakage, so that when rooms are heated, they stay heated longer using less fuel.

D. Improve User Practices

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Local

- Regulation: Vancouver, WA (Southwest Clean Air Agency). During periods of stagnant air or temperature inversions when air quality is rapidly deteriorating, the Southwest Clean Air Agency may issue Stage 1 and Stage 2 Burn Bans, which restrict wood burning. When a Stage 1 Burn Ban is in effect, the use of all fireplaces and uncertified wood stoves, pellet stoves and inserts is prohibited. When a Stage 2 Burn Ban is in effect, all wood heating is prohibited, including certified units. All outdoor burning is also prohibited in both Stage 1 and 2 Burn Bans. These Burn Bans do not apply if wood burning is the only source of heat. http://www.swcleanair.org/burninginfo.html

State of Oregon

- Education: Oregon DEQ maintains a general consumer education program on best wood burning practices. Informational materials are available on DEQ's website. DEQ will also work with select local governments on enhanced public awareness campaigns in conjunction with fine particulate reduction strategies.
- Voluntary: Curtailment of woodstove use during air pollution advisories for particulate matter. An Air Pollution Advisory is a call-to-action that DEQ issues to encourage individuals and businesses to reduce pollution-producing activities during winter air stagnation times. http://www.deq.state.or.us/aq/advisories/ Voluntary woodstove curtailment advisories are conducted periodically statewide, however mandatory woodstove curtailment programs are also used as a fine particulate reduction strategy in several Oregon communities with a history of violating federal air quality standards for particulate.

State of Washington

- Education: The state of Washington has an education program because "The purchase of certified wood stoves will not solve the problem of pollution caused by wood stove emissions; and (2) the reduction of air pollution caused by wood stove emissions will only occur when wood stove users adopt proper methods of wood burning." http://apps.leg.wa.gov/RCW/default.aspx?cite=70.94.450

- Regulation: The state of Washington has an opacity standard for smoke where no more than 20% opacity is allowed for six consecutive minutes in any one hour period. There is also an exemption for the starting of a new fire, for a period of no more than 20 minutes in any four-hour period. http://apps.leg.wa.gov/WAC/default.aspx?cite=173-433-110. An opacity standard can affect stove operator behavior, including using better quality fuel

E. Improve Wood Fuel Quality

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State of Washington

- Education: The state of Washington regulates the moisture content of wood.

III. SUMMARY OF POTENTIAL NEW EMISSION REDUCTION MEASURES

DEQ has evaluated nine strategies for reducing emissions from residential wood combustion. The strategies and results of the evaluation are summarized in this section. Detailed strategy descriptions and evaluations can be found in sections IV and V.

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A. Narrative Overview of Strategies Evaluated

Residential Heating Other Than Wood Combustion

For most home heating and wood combustion devices, existing emission reduction measures include purchasing new more efficient furnaces, heaters, boilers or woodstoves; maintaining and operating the equipment efficiently; and weatherization programs. Almost all new furnaces and other heating devices are many times more efficient than older models. Cleaning and insulating ducts and tuning furnaces helps to reduce pollution emissions because fuels burn more efficiently and heated air can be delivered effectively.

Revive Tax Credits and other Funding Assistance:
Until recently, Oregon had more tax incentives/rebates than any other state. Combined with Federal incentives, homeowners could significantly reduce their expenses for remodeling and building, as well as replace old equipment (refrigerators, dishwashers, and clothes washers) at subsidized costs through rebates and tax credits. The major appliance rebates are still in effect, however some of the tax credits, both state and federal, and other similar incentives have been discontinued. The Advisory Committee could support new or revived tax incentives, credits, and rebates. Rebates and grant programs can also be implemented by local cities, counties, and non-profits.

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Consumer Education and Outreach for Homeowners:
The Land Quality Division (of ODEQ) recently completed a study of life cycle emissions of buildings, which can be found at http://www.deq.state.or.us/lq/sw/wasteprevention/greenbuilding.htm. Significantly, the largest amount of pollution is emitted from buildings during use, rather than during construction or deconstruction/demolition. This finding underscores the need to build energy efficient, long-lived houses with non-toxic materials, and to educate the people who use the houses about their maintenance and operation.

As described above, when the heating source is changed from wood burning to oil, natural gas, electricity, and other like sources of fuel, the particulate emissions go down; however, the exchange includes moving from a renewable source of energy to a non-renewable source of energy. Mining for oil and natural gas is energy intensive and environmentally destructive. Coal-fired power plants supply the majority of the electricity in the US and 42% of that used in Oregon. Mining coal is also energy intensive and environmentally destructive [consider mountain top mining as an example]. Coal-fired power plants are the largest industrial source of all criteria pollutants, many Hazardous Air Pollutants (HAPs), greenhouse gases, and mercury.

ODEQ can also support "consumer" responsibility by encouraging homeonwers to create and use Homeowners Manuals to ensure that emissions are kept to a minimum through proper maintenance and operation of the equipment in use.

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Promotion of Existing Programs:
For references to existing programs and resources, please see Attachment C on page 45, ODEQ can partner with other nonprofit and local programs to set a goal of encouraging all new and remodeled houses (100%) to meet one of the many useful building green certification programs:

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- Living Building Challenge
- Passive House
- LEED (Leadership in Energy Efficient Design)
- ODOE Oregon High Performance Home
- Earth Advantage
- Energy Star
- Home Builder Association Green Building Guidelines

Remodels and new houses should:

- Incorporate Passive solar design
- Meet the 4 system conditions of The Natural Step
- Use day-lighting
- Use green materials that are:
  1. Local
  2. Renewable
  3. Have low embodied energy [like wood, sand, clay, and glass]
- Be integrated into the landscape
- Process storm water on site
- Be built with a durable, super-insulated air sealed envelope

ODEQ has already set the stage with the previously referenced report. It is not necessary for ODEQ to establish a separate work group for residential heating other than residential wood combustion because groups have already formed to address these issues. Promotion and use of the expertise and information already available is an appropriate strategy. Outreach and education are primary components of such an activity that will aid in "consumers" understanding of the purpose of all these requirements. ODEQ also has an untapped resource of Sustainable Building Advisors in house. A central repository such as a web page for the information and resources could ease users' ability to find and use them.

The City of Portland has a wealth of resources that include a "Green Building Hot Line" and regular "Fix It" fairs. Metro is another good resource, particularly for landscaping. ODEQ needs to support and reference some of the external resources already in existence, and tap into those specifically available within the Agency.

Residential Wood Combustion

Wood smoke reduction strategies reduce air toxics from woodstoves and fireplaces and can include a combination of voluntary, mandatory, and incentive strategies that focus on things like speeding the turnover to new home heating technologies, energy conservation, using cleaner fuels, education and outreach to improve user practices, and episodic restrictions on burning. Key strategies can include accelerating the replacement of old, high polluting woodstoves with newer, cleaner home heating systems; prohibiting wood burning devices in new home construction; ensure low moisture content of wood by providing guidelines, testing equipment, and education to those who sell and purchase wood, monitoring and restricting the amount of visible smoke allowed from a woodstove, education and weatherization campaigns. These strategies can be applied across the entire PATS study area as well as targeted to specific sub-regions where woodstove pollution poses the greatest risk. These strategies would reduce the suite of air toxics in woodstove smoke as well as fine particulate (PM2.5) which is a federal criteria pollutant that contributes to respiratory and heart problems. Eliminating the wood burning emissions by substituting emissions from oil, coal, or natural gas may eliminate a local impact, but exacerbate a national one in terms of pollution and dependence on external sources of fuel.

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B. Summary of Strategies Evaluated

Table 5: Summary of Strategies

Blueprint level	Strategy
Speed turnover to new cleaner home heating systems	**#1 – Replacement of woodstoves**
	#1a – Replace 19,888 uncertified wood stoves with **certified wood stoves**
	#1b – Replace 19,888 uncertified wood stoves with **pellet stoves**
	#1c – Replace 19,888 uncertified wood stoves with **natural gas furnaces**
	#2 – Ban wood burning devices in new homes
	#2a – Ban **all wood burning devices** in new homes
	#2b – Ban **wood burning fireplaces** in new homes
	#3 – Revive tax credits and other funding assistance
Energy conservation	**#4 – Weatherization – Incentives**
	#5 – Weatherization – Promotion of existing programs
Improve user practices	**#6 – Opacity standard for wood smoke**
	#7 – Education campaign
Improve wood fuel quality	**#8 – Ensure low moisture content of wood**
	#9 – Research emission changes from manufactured firelogs use and develop strategies if appropriate

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This section includes three summary tables:

1. Table 6 describes the emissions of key PATS pollutants reduced for each pollutant as compared with the total emissions from residential wood combustion for that pollutant. These emission reductions in excess of existing strategies listed in Section II on page 12,
2. Table 7 describes other pollutants reduced (or increased) for each of the strategies.

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3. Table 8 describes a rough timeframe to achieve emission reductions, the technical feasibility of the strategy, and summarizes the general magnitude of costs.

Table 6 shows the magnitude of emissions reductions (or increases) associated with each strategy in tons per year. For example under strategy 2(a), replacing 80% of the uncertified woodstoves or fireplace inserts used to burn wood in the entire PATS study area with a certified stove would reduce total 15 PAH emissions from residential wood combustion about 3.3 tons per year and reduce the contribution of residential wood heating emissions to total 15 PAH by 26%. This would mean replacing 19,888 uncertified woodstoves and fireplace inserts. The estimates in Table 6 are for illustration and show the potential effectiveness of each strategy, without regard to feasibility or other considerations to be discussed by the advisory committee. Many strategies in Table 6 can be scaled to address sub-regional areas. For more details on each of the strategies, please refer to Section IV on page 23 and to the Attachments on page 37.

For reference, the 2017 model results estimated:

- 12.59 tons of 15 PAH total are caused by residential wood combustion in 2017, and
- 130.34 tons of benzene: total are caused by residential wood combustion in 2017

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Table 6: PATS Pollutants Emission Reductions from Each Strategy

Strategy	Emissions Reduced from Each Strategy In tons per year and (percent) **Main Risk Driver Pollutants Are Highlighted In Gray** 15-PAH	Acetaldehyde	Acrolein	Benzene	1,3-Butadiene	Cadmium	Formaldehyde	Manganese	Naphthalene	Notes
#1a – Replace 19,888 uncertified wood stoves with certified wood stoves	3.3 (26)	1.9 (2.5)	1.3 (16)	10.4 (8.0)	4.3 (18)		10.2 (6.4)	0.0 (50)	1.8 (7.3)	
#1b – Replace 19,888 uncertified wood stoves with pellet stoves	5.6 (45)	11.4 (15)	1.8 (22)	41.8 (32)	8.5 (36)		24.8 (16)	0.0 (50)	-5.3 (-21)	Naphthalene increases
#1c – Replace 19,888 uncertified wood stoves with natural gas furnaces	5.8 (46)	13.5 (18)	2.0 (24)	42 (33)	8.5 (36)	⇑ -0.0001	31.7 (20)	0.0 (48)	3.9 (16)	Cadmium increases slightly. This is a a 0.05% increase in projected 2017 cadmium emissions from all sources in the PATS study area.
#2a – Ban all wood burning devices in new homes	1.2 (9)	4.8 (6)	0.6 (8)	9.6 (7)	2.0 (8)		10.2 (6)	0.0 (10)	2.2 (9)	
#2b: Ban wood burning fireplaces in new homes	0.0 (0)	1.9 (2.6)	0.2 (2.7)	1.2 (0.9)	0.3 (1.2)		3.2 (2)	0.0 (0)	0.5 (1.9)	
#3 – Revive tax credits & other funding										
#4 – Weatherization – Incentives	⇓	⇓	⇓	⇓	⇓		⇓	⇓	⇓	Weatherization efforts should use non-toxic construction materials where possible.
#5 – Weatherization – Promotion of existing programs										
#6 – Opacity standard for wood smoke	⇓	⇓	⇓	⇓	⇓		⇓	⇓	⇓	In general, emissions will be reduced, because properly burning wood generates less smoke and less air pollution.
#7 – Education campaign	⇓	⇓	⇓	⇓	⇓		⇓	⇓	⇓	It is difficult to quantify emission reductions from an education campaign; however, if people are burning wood properly, they will not generate as much smoke.
#8 – Regulate moisture content of wood	⇓	⇓	⇓	⇓	⇓		⇓	⇓	⇓	It is difficult to quantify emission reductions, however, if people are burning seasoned wood with moisture content 20% or below, they will not generate as much smoke.
#9 – Research emission changes from manufactured firelog use	?	?	?	?	?		?		?	

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Table 7: Other Pollutants Reduced by Each Strategy

Strategy	Other Pollutants Emissions Reduced Tons per year: Volatile Organic Compounds	Fine Particulate ($PM_{2.5}$)	Greenhouse Gases	Nitrogen Oxides	Sulfur Dioxide	Notes
#1a – Replace 19888 uncertified wood stoves with certified wood stoves	831	223	⇓	17.5	0	Reduces toluene, methane and carbon monoxide
#1b – Replace 19888 uncertified wood stoves with pellet stoves	1158	602	⇓	⇑ 22	1.8	Reduces toluene, methane and carbon monoxide
#1c – Replace 19888 uncertified wood stoves with natural gas furnaces	1157	669	⇓	29.2	8.5	Reduces toluene, methane and carbon monoxide
#2a – Ban all wood burning devices in new homes	262	181	⇓	25	3.1	
#2b: Ban wood burning fireplaces in new homes	26	42	⇓	4.7	0.7	Reduces methane and carbon monoxide
#3 – Revive tax credits & other funding	⇓	⇓	⇓	⇓	⇓	
#4 – Weatherization – Incentives	⇑	⇓				Particulate matter could decrease when less wood is burned to heat the home. Initially, weatherization could increase volatile organic compounds or formaldehyde due to insulation, replacing windows, etc.
#5 – Weatherization – Promotion of existing programs	⇓	⇓	⇓	⇓	⇓	
#6 – Opacity standard for wood smoke		⇓				In general, emissions will be reduced, because properly burning wood generates less smoke and less air pollution
#7 – Education campaign		⇓				If the education campaign is successful, PM 2.5 will go down because more people will burn seasoned wood, and burn it properly
#8 – Regulate moisture content of wood		⇓				It is difficult to quantify emission reductions, however, if people are burning seasoned wood with moisture content 20% or below, they will not generate as much smoke.
#9 – Research emission changes from manufactured firelog use and develop strategies if appropriate						VOCs, PM 2.5, and NOx increase when burning manufactured logs compared with burning the same volume of wood. But because manufactured logs are generally used in lower volumes than wood, these pollutants might actually decrease as well.

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Table 8: Summary of Strategies Evaluated: Timeframe, Technical Feasibility, and Cost

Blueprint level	Strategy	Timeframe to Reduce Emissions	Technical Feasibility	Cost Summary
Speed turnover to new cleaner home heating systems	**#1 – Replacement of woodstoves**			
	#1a – Replace 19,888 uncertified wood stoves with **certified wood stoves**	3-10 years	Certified woodstoves are commercially available	$49.7 to $74.5 million. Incentives for switching to high-efficiency furnaces may be available
	#1b – Replace 19,888 uncertified wood stoves with **pellet stoves**	3-10 years	Pellet stoves are commercially available	$74.5 to $111.8 million. Incentives for switching to high-efficiency furnaces may be available
	#1c – Replace 19,888 uncertified wood stoves with **natural gas furnaces**	3-10 years	Natural gas furnaces are commercially available	$111.8 to $149.1 million. Incentives for switching to high-efficiency furnaces may be available
	#2 – Ban wood burning devices in new homes			
	#2a – Ban **all wood burning devices** in new homes	1-5 years	Other areas have programs	Cost of regulation, implementation, enforcement
	#2b: Ban **wood burning fireplaces** in new homes	1-5 years	Other areas have successful programs	Cost of regulation, implementation, enforcement
	#3 – Revive tax credits and other funding assistance	2-4 years	Feasible	Depends on strategy
Energy conservation	#4 – Weatherization – Incentives	1-10 years	Other areas have successful programs	Not calculated
	#5 – Weatherization – Promotion of existing programs	1-3 years	Feasible	Depends on strategy
Improve user practices	#6 – Opacity standard for wood smoke	1-5 years	Other areas have successful programs	Cost of regulation, implementation, enforcement
	#7 – Education campaign	1-3 years	Other areas have successful programs	$4,000 to $20,000 per year
Improve wood fuel quality	#8 – Regulate moisture content of wood	1-5 years	Other areas have successful programs	Cost of regulation, implementation, enforcement
	#9 – Research emission changes from manufactured firelog use and develop strategies if	1-3 years	Unknown	$4,000 to $20,000 per year or cost of regulation, implementation,

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Comment [DB1]: PATSAC feedback: Update cost summaries for switching to high-efficiency furnaces to capture programs that help pay for changes.

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Blueprint level	Strategy	Timeframe to Reduce Emissions	Technical Feasibility	Cost Summary
	appropriate			enforcement

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C. Other Measures Considered

These measures were considered, but are not expected to achieve significant reductions toward meeting DEQ's annual average air toxics benchmarks.

Episodic mandatory curtailment of woodstove burning is a measure worth mentioning. Curtailment is typically used to reduce high levels of fine particulate pollution (PM2.5) during days of wintertime air stagnation to help avoid exceeding federal air quality standards. In an area with a curtailment program, there could be twenty curtailment days in any given year or none, depending on the weather. Since curtailment is only used periodically it would not be a significant air toxics strategy. However, it should be recognized that curtailment days do reduce the public's exposure to PM2.5 and all other associated woodstove air toxics. A mandatory Portland area curtailment program may be needed in the future to address new federal PM2.5 standards.

The use of geothermal heat pumps and passive solar space heating as strategies were not evaluated in this White Paper.

IV. DETAILS FOR EACH POTENTIAL NEW EMISSION REDUCTION MEASURE

A. Strategy #1a, 1b, and 1c: Replacement of Existing Wood Stoves

Narrative Overview

This strategy entails implementing either incentives or a regulation to replace old, uncertified wood stoves and fireplace inserts with new, certified ones, pellet stoves, or gas or electric heating units, without waiting for the home or residence to be transacted. Implementing this strategy would reduce emissions faster than would occur through current requirements for removal of uncertified woodstoves upon home sale.

This strategy could be implemented area-wide or in a targeted area. The magnitude of reductions, timeframe, and costs for woodstove replacement are influenced by several factors:

- Whether the strategy is implemented as a voluntary incentive program or a regulation
- Whether the strategy is implemented area-wide, or just in specific locations
- Total number of uncertified woodstoves replaced
- The availability of funding, if an incentive program.

A regulation could be implemented by any local government for their jurisdiction, or by the state, and would likely require new authority.

Grant programs for woodstove replacement have been implemented successfully in communities throughout Oregon, and do not generally require new authority. Funding sources could include:

- One-time EPA or US Department of Energy grants which pay part or all of the replacement cost.
- Community development block grants for low interest loans, which include a lien on the property to ensure payback. These can involve either a rebate for a portion of the cost, or paying the total cost.
- Tax incentives from local government (there are already federal and state tax incentives).
- Incentives from natural gas or electric utility providers.

This strategy is dependent on interest from wood burning device owners and funding availability. Costs include the cost of the grant/loan/tax incentive program, and the cost of administering the program.

Primary Considerations

a. Magnitude of Reductions.

If you replace an uncertified woodstove or fireplace insert with a certified one, emissions are reduced because the certified woodstove emits fewer pollutants (see Appendix B on page 44). Pellet stoves emit less air toxics than certified woodstoves, with the exception of naphthalene. Natural gas is generally slightly cleaner than pellet stoves and significantly cleaner than woodstoves or fireplace inserts.

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A voluntary program would achieve fewer reductions than a regulatory program. Even with a regulatory program, it is unlikely that all woodstoves will be replaced. Table 6 on page 19 shows emission reductions when 20% to 80% of uncertified stoves or fireplace inserts in the PATS area are replaced with a certified wood stove, a pellet stove, or natural gas. Replacing 20% of used stoves or fireplace inserts in the PATS area would mean replacing 4,972 stoves or fireplace inserts, while replacing 80% of all used stoves or fireplace inserts in the PATS study area would mean replacing 19,888 stoves or fireplace inserts. Replacing 20% of used stoves or fireplace inserts is representative of a large voluntary effort, while 80% is more representative of a regulation, recognizing that compliance will be less than 100%.

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Because not all woodstoves and fireplace inserts are used, a successful program would need to replace ONLY those devices actually used in home heating.

Table 9: Range of Emissions Reduced from Strategy 1

	Range of Emissions Reduced from Strategy 1 In tons per year and (percent)								
Strategy	15-PAH	Acetaldehyde	Acrolein	Benzene	1,3-Butadiene	Cadmium	Formaldehyde	Manganese	Naphthalene
#1a – Replace uncertified wood stoves with certified wood stoves (20% - 80%)	0.8-3.3 (6.6-26)	0.5-1.9 (0.6-2.5)	0.3-1.3 (4.0-16)	2.6-10.4 (2.0-8.0)	1.1-4.3 (4.5-18)		2.6-10 (1.6-6.4)	0.0 (50)	0.5-1.8 (4.5-7.3)
#1b – Replace uncertified wood stoves with pellet stoves (20% - 80%)	1.4-5.6 (11-45)	2.9-11.4 (3.8-15)	0.4-1.8 (5.4-22)	10.4-41.8 (8.0-32)	2.1-8.5 (9.0-36)		6.2-24.8 (3.9-16)	0.0 (50)	-1.3 to 5.3 (-5.3 to 21)
#1c – Replace uncertified wood stoves with natural gas furnaces (20% - 80%)	1.4-5.8 (12-46)	3.4-13.5 (5-18)	0.5-2.0 (6-24)	10.6-42 (8-33)	2.1-8.5 (9.0-36)	0.0-0.0 (-3 to -11)	7.9-31.7 (5-20)	0.0 (12-48)	1.0-3.9 (4-16)

Methodology

***For strategies 1a and 1b**:* To calculate the emission reductions when a non-certified woodstove or fireplace insert is replaced with a certified one or with a pellet stove, the following formula was used:

Non-certified emission factor minus the certified emission factor, multiplied by the average annual tons burned per year in a woodstove, multiplied by the number of devices replaced, converted from lbs to tons.

Example calculation:

- Emission factor for 15 PAH from an uncertified stove is **0.2648** lbs per ton of fuel burned. (See Attachment B on page 44)
- Emission factor for 15 PAH from a certified, catalytic stove is **0.11387** lbs per ton of fuel burned. (See Attachment B on page 44)
- The average annual tons of wood burned per year in woodstoves is **2.2** tons per year.
- There are 2000 lbs in a short ton.
- The number of used wood burning stoves or fireplace inserts replaced is **4972** (20% of used stoves and fireplace inserts)

(0.2648 lbs per ton - 0.11387 lbs per ton) * 2.2 tons per year * 4972 = 1651 lbs per year reduced

1651 lbs /2000 lbs per ton = **0.8 tons of 15 PAH reduced** by replacing 4972 uncertified stoves or fireplace inserts with certified ones.

Estimates of numbers of fireplace inserts and woodstoves used in the PATS area were generated using 2000 census data and results of DEQ's Residential Wood Survey[4]. Volumes of wood burned in each device were also obtained from DEQ's survey as well. The emission factors for woodstoves and fireplace inserts are the same for all pollutants.

Key assumptions are that woodstove and pellet stove owners burn the same number of tons of fuel per year.

***For strategy 1c*:**

The emission factors for residential natural gas is in lbs per million standard cubic feet (scf). Because the emission factors for uncertified wood stoves are in lbs/ton, several assumptions had to be made in order to compare the emissions. First, we assumed that natural gas and wood burners use the same number of BTUs. We converted both the woodstove and natural gas emission factors to pounds of emissions per BTU so that emissions could be compared with each other, and then converted the results back to tons per year so that this strategy could be compared with other strategies.

b. Timeframe to Implement.

New Regulation. 3-5 years. There are three key phases of implementing a woodstove replacement regulation.

- Obtain authority. 6 months - 1 year, depending on legislative body
- Develop regulation. 1-2 years.
- Implementation. Implementation could be phased in over several years.

Grant Program. 5-10 years. There are three key phases of implementing a woodstove replacement grant program, each with its own timeline.

- Find funding, form partnerships. A woodstove replacement grant program is entirely dependent on funding, and could take 1-5 years, although it is possible that no funding or not enough funding could be found.
- Program design and setup. Once funding is found, it takes 6-9 months to develop procedures, recordkeeping, and necessary contracts prior to program implementation.
- Implementation. Once you start awarding funds, it may take 1-5 years to completely change out all stoves.
- Measurement. Measurement of success would involve tracking number of stoves removed, what they were replaced with, and calculation of net emissions reduced.

Historically, funding for woodstove replacement programs has come from EPA or Department of Energy grants, which are becoming increasing scarce and sporadic. Creating a stable and on-going funding source for woodstove replacement grants would speed strategy implementation. A framework for a statewide stove replacement program currently exists in state statute; however no funding mechanism has been identified or authorized by the state legislature.

c. Other pollutants reduced.

In general, all other pollutants (criteria, ozone precursors, and greenhouse gases) decrease, when an uncertified device is replaced with a certified one. Replacing any device with a pellet stove substantially decreases most emissions, with the exception of nitrogen oxides, which increase slightly. See Table 7 on page 20 for details on emission reductions of other pollutants.

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[4] Johnson, et al. Portland State University Survey Research Lab. June, 2009. Department of Environmental Quality Residential Wood Combustion Survey: results report.

d. Technical feasibility.

Certified wood stoves, pellet stoves, and other home heating devices are all readily available and reduce emissions. We know these technologies can significantly reduce emissions. Emissions estimates for different technologies are provided by EPA. Another important part of technical feasibility would be an education component to ensure proper operation of the woodstove.

e. Cost.

- Cost of device and installation.
  - Replacing an uncertified stove with a **certified stove** costs approximately $2,000 to $3,000.
  - Replacing an uncertified stove with a **pellet stove** costs approximately $3,000 to $4,500.
  - Replacing an uncertified stove with a **natural gas or a ductless heat pump** costs approximately $4,500 to $6,000 per stove replacement.

- Cost of regulation. The cost of developing a regulation would vary, depending on the local or state government rulemaking process. The cost is dependent on the rulemaking practices of the city, county, or state conducting the rulemaking, and on whether rulemakings are needed in multiple jurisdictions.

- Cost of program designing and administering grant program. Typically DEQ partners with a local government agency to administer the program. Designing the program would take DEQ resources, and implementation is typically done by the local agency. Designing and implementing the program generally takes 15-25% of available funding.

Table 10: Potential Costs of a Woodstove Replacement Grant Program

	Cost of replacing 4972 devices (20%)		Cost of replacing 19888 devices (80%)	
Type of wood burning device replaced	low cost (including 15% admin)	high cost (including 25% admin)	low cost (including 15% admin)	high cost (including 25% admin)
Uncertified stove or insert with a certified stove or insert	$11.4 million	$17.1 million	$49.7 million	$74.5 million
Uncertified stove or insert with a pellet stove	$17.1 million	$25.7 million	$74.5 million	$111.8 million
Uncertified stove or insert with a natural gas or a ductless heat pump	$25.7 million	$34.3 million	$111.8 million	$149.1 million

Historically, the grant funding available for woodstove replacements has been on the order of a few hundred thousand dollars to 2 million dollars.

The costs cited here are the costs for full woodstove replacement (including installation). A program that paid for a percentage of the cost could replace more stoves with the same amount of money. Program design choices could include full subsidies for low income homes.

B. Strategy #2a and 2b: Ban All Wood Burning Devices or Wood Burning Fireplaces in New Homes

This strategy would entail a change in the local building codes to ban wood burning devices or fireplaces in new homes. Several areas in California have banned fireplaces in new homes[5]. In this California case, options for new home builders include installing natural gas fireplaces or certified woodstoves. There are some areas that have banned all wood burning devices in new homes. Options for home heating in these cases are natural gas, electric, solar, or heating oil. This strategy could be adopted by a local city or county, or within all cities and counties in the PATS area.

Strategy 2a: Ban all Wood Burning Devices (Stoves, Fireplaces, Fireplace Inserts, and Pellet Stoves) in New Homes. DEQ estimates that there will be 3,900 additional woodstoves and fireplace inserts used in the PATS area between 2008 and 2017, and that there will be 2,011 additional pellet stoves used in the PATS area between 2008 and 2017, and that there will be 8,365 additional fireplaces used in the PATS area between 2008 and 2017 (See Table 11). This number takes into account the potential increase in fireplaces available for use because of the Heat Smart program requirement to remove any uncertified fireplace inserts at the time of home sale. If the homeowner chooses not to replace the uncertified device any future homeowner may elect to use the fireplace for heating purposes. If a regulation banning wood burning devices in new homes went into effect, emissions could be diminished if no wood burning devices were installed. However, the emissions reductions would be estimated based on a ban implemented in 2012-2013 (halfway into the timeframe we are evaluating) because stoves, inserts, and pellet stoves have continued to be installed since 2008. If implemented, this strategy would need to consider whether or not EPA certified pellet stoves would be allowable based on their consistent low emission performance. There are currently no EPA certified pellet stoves, but EPA will likely certify pellet stoves in 2013.

Table 11: Estimated New Wood Burning Devices 2008-2017

Type of Device	2008	2017	New devices used in PATS area
Fireplaces	53,816	62,180	8,365
Woodstoves/inserts	23,651	27,564	3,913
Pellet stoves	13,368	15,379	2,011

Strategy 2b: Ban all Wood Burning Fireplaces in New Homes. DEQ estimates that there were 53,816 fireplaces used in the PATS area in 2008, and that there will be 62,180 fireplaces in 2017. This means an estimated additional 8,365 fireplaces from 2008 to 2017. If a regulation banning fireplaces in new homes went into effect, emissions could be diminished if no fireplaces were installed. Some new fireplaces would be available for use when non-certified fireplace inserts are removed. This strategy estimates emission reductions if half of the estimated new wood burning fireplaces are banned, since some have already been installed since 2008.

Primary Considerations

a. Magnitude of Reductions.

In general, all PATS pollutants decrease, when a wood burning device is replaced with natural gas, or a wood burning fireplace is replaced with a gas burning one or a certified wood stove. Small reductions could be achieved with this strategy. This does not include emissions from the replacement source (for example, a natural gas fireplace).

b. Timeframe to Implement.

New Regulation. 1-5 years. There are three key phases of implementing a ban on either wood burning devices in new homes or wood burning fireplaces in new homes:

- Obtain authority. 6 months - 1 year, depending on legislative body. Some jurisdictions might already have the authority, and this step can be skipped.
- Develop regulation. 1-2 years.
- Implementation and enforcement

c. Other pollutants reduced.

In general, all other pollutants (criteria, ozone precursors, and greenhouse gases) decrease, when a wood burning device is replaced with natural gas, or a wood burning fireplace is replaced with a gas burning one. See Table 6 on page 19 for details on emission reductions of other pollutants.

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d. Technical feasibility.

Several communities in California have banned wood burning fireplaces in new homes, and some areas have banned wood burning devices in new homes. The technology exists to replace wood burning devices with natural gas or other home heating methods. This strategy is technically feasible.

e. Cost.

Cost for this strategy includes the cost of new local rules, education and technical assistance to homebuilders, and enforcement. Because natural gas is typically more expensive than a wood stove, new homes might be more costly. This includes the cost of a new natural gas furnace ($2,000 - $4,000), not including installation costs and heating costs for the winter. In contrast, to heat a home with wood heat can cost $1500 for the installation of a new woodstove, plus yearly wood fuel costs as little as $15 for a homeowner to obtain a permit from the Oregon Department of Forestry to chop and haul away forest wood (up to two cords) or to pay someone between $300 - $800 for delivery of two cords of wood. The cost is dependent on the rulemaking practices of the city, county, or state conducting the rulemaking, and on whether rulemakings are needed in multiple jurisdictions.

C. Strategy #3: Revive Tax Credits and Other Funding Assistance

Narrative Overview

ODEQ could be instrumental in helping to revive tax credits and incentives and/or creating new ones. This strategy is focused primarily on pollution prevention by providing the most comprehensive and effective methods of dealing with the pollutants of concern. The measure is cost effective, realizing short pay-back periods and extended savings over the life-time of buildings in the form of lower energy bills and operational costs. Rebates and other incentives could also be implemented by counties, cities or non-profits.

The City is also promoting a "Solarize Portland" program that has proved so successful; it has been repeated not only in every quadrant of the city, but also repeated within quadrants. Basically, residents issue their own RFP and based on the number of participants, are able to take advantage of quantity discounts from their contractors. Information for that program can be found here:

http://www.portlandonline.com/bps/index.cfm?&c=51902

Primary Considerations

a. **Magnitude of Reductions**

One example of reductions is the Ecotrust building in Portland which has a 38.6 kW system that has generated 69,969 kilowatts of energy, saving 84,102 pounds of CO_2 thus far. It also signifies a reduction in criteria and hazardous air pollution.

The State of Oregon installed 60 PV solar panels on the state capital building. The panels will produce 8.4 peak kilowatts, enough to power two energy efficient Oregon homes for one year.

b. **Timeframe to Implement**.

New legislation or rules to implement tax credits or rebates often takes several years, so the timeframe would be 2-4 years.

c. **Other pollutants reduced**.

Any renovations or building project that reduces the use of energy, for heating or even for lighting, will reduce the amount of pollution coming from the coal-fired power plants that generate the electricity. Pollutants include carbon monoxide, ozone precursors, particulate matter, sulfur dioxide, nitrogen oxides, mercury, and lead, as well a many hazardous air pollutants. For non-electrical energy, reduction in use can translate to a reduction in the destructive mining needed to acquire the resource, as well as the HAPs released during use.

d. **Technical feasibility**.

ODEQ has run many grant funded programs and tax rebate/incentive programs in the past, such as the Clean Diesel program. As such, there is in house expertise to write rules, apply for grants, and/or run these programs. Rebates and other incentives can also be implemented by counties, cities or non-profits.

e. **Cost**.

Depends on the program implemented and the particular strategy; except for tax credits, grant funding would likely be needed. In most cases these programs provide a relatively short pay-back period in the form of reduced energy bills.

D. Strategy #4: Weatherization Incentives

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Narrative Overview

Weatherizing homes can be a successful way to reduce wood burning device emissions, particularly when it is combined with replacement of an old device with a new woodstove, pellet stove, or gas or electric heating device. This could involve partnership with entities already doing weatherization, or a grant to do the work. In general, weatherization is done when an uncertified woodstove is changed out. A good example of this is the LRAPA Warm Homes, Clean Air project. http://www.lrapa.org/projects_and_programs/warm_homes_-_clean_air/index.php

Any incentive should ensure that the weatherization of homes takes into account the use of low/no VOC construction to minimize the introduction of materials that increase indoor air pollution.

Primary Considerations

a. Magnitude of Reductions.

When a home is weatherized, the homeowner needs to use less wood to heat the house. The actual emission reductions are unknown, but all PATS pollutants would decrease as a result of using less wood to heat a

house. Some of the weatherization efforts could initially increase volatile organic compounds and formaldehyde due to installing insulation, replacing windows, or other weatherization activities.

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b. Timeframe to Implement.

Grant Program. 5-10 years. There are three key phases of implementing a weatherization grant program, each with its own timeline.

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- Find funding, form partnerships. A weatherization incentive program is entirely dependent on funding, and could take 1-5 years, although it is possible that no funding or not enough funding could be found.
- Program design and setup. Once funding is found, it takes 6-9 months to develop procedures, recordkeeping, and necessary contracts prior to program implementation.
- Implementation. Once you start awarding funds, it may take 1-5 years to weatherize homes.
- Measurement. Measurement of success would involve tracking number of houses weatherized, how much less wood is used, and calculation of net emissions reduced.

c. Other pollutants reduced.

Using less wood to heat a home would generally reduce criteria pollutants, although it is possible that volatile organic compounds might increase temporarily due to construction activities.

d. Technical feasibility.

Weatherization technologies are widely commercially available.

e. Cost.

The cost of this strategy can vary widely, but would depend on the number of homes weatherized and on the needs of the home. A weatherization incentive program is entirely dependent on finding available funding.

E. Strategy #5: Weatherization – Promotion of Existing Programs

Narrative Overview

ODEQ will be in the forefront both internally and externally with respect to The Natural Step and Sustainability—so inasmuch as the Agency will be already making the connections between all our activities and resulting pollution, so should it be able to share and disseminate the information.

Oregon already has many buildings that are certified LEEDs (123 buildings so far) or meet other specifications. Continued support and participation in these programs would have state-wide and even national impacts, although (numerically) Oregon is only a small percent of the national population.

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The strategies described here have far-reaching and long-lasting effects. Many of these strategies are labor intensive and cannot be outsourced—having a positive effect on local employment as well. The City has already piloted projects in environmental justice neighborhoods that offered cost offsets for eco-roofs and other projects. The funding for that program has not been extended, but the pilot was very successful.

Primary Considerations

a. **Magnitude of Reductions**.

The magnitude could be significant, especially for areas of environmental justice communities where many local efforts to date have focused.

b. **Timeframe to Implement**.
1-3 years

c. **Other pollutants reduced**.

Again if electrical generation is part of any process, a reduction in electric use translates to reductions in all criteria pollutants, many HAPs, and greenhouse gases. A switch from wood to natural gas, oil or other fuel would translate to reduced pollution from wood but again, increases the use of non-renewable fuels that are mined, etc. Solar would provide the cleanest switch, but still uses mined resources in its construction. Subsequently, however, there is no need for continued inputs (like coal, or oil) to operate the systems.

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d. **Technical feasibility**.

High-- there is a lot of in house expertise at ODEQ; in addition, ODEQ would simply support other agencies' programs where technical expertise is ample.

e. **Cost.**

Low – education and outreach efforts always take some funding, but it would be minimal compared to the impact the programs can make on preventing pollution.

F. Strategy #6: Enforceable Emission Reduction Program – Mandatory Opacity Standard

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Narrative Overview

Improper burning results in excess smoke. Inspectors can be trained to read smoke and to determine if visible smoke is in violation of an opacity law. For example, under Washington state regulations, smoke from a solid fuel burning device cannot exceed 20 percent opacity for six consecutive minutes. http://www.pscleanair.org/actions/woodstoves/opacity.aspx. This strategy can be implemented throughout the PATS area, or adopted by any city or county within the PATS area.

Primary Considerations

a. Magnitude of Reductions.

Unknown, but would likely decrease, since when wood is burned properly, less smoke and less air toxics as well.

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b. Timeframe to Implement.

New Regulation. 1-5 years. New regulations could take place at the city, county or state level. There are three key phases of implementing an opacity standard:

- Obtain authority. 6 months - 1 year, depending on legislative body. Some jurisdictions might already have the authority, and this step can be skipped.
- Develop regulation. 1-2 years.
- Implementation.

c. Other pollutants reduced.

Burning wood properly results in less smoke and less particulate matter.

d. Technical feasibility.

Other areas have successfully implemented opacity standards.

e. Cost.

Cost for this strategy includes the cost of new rules, education and technical assistance to wood burning device owners, and ongoing complaint response, enforcement, and technical assistance. The cost is dependent on the rulemaking practices of the city, county, or state conducting the rulemaking, and on whether rulemakings are needed in multiple jurisdictions. This strategy is also highly dependent on having adequate staffing resources available for complaint response, enforcement, and technical assistance.

G. Strategy #7: Education Campaign

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Narrative Overview

The pollution from home heating is distributed ubiquitously throughout the PATS study area. All are affected to a greater or lesser extent depending upon type of fuel, type of household, and operations and maintenance. Any reduction in fuel use because of better building operations through insulation, energy

efficient windows and appliances, solar design, etc., translates to a reduction in pollution exposures and therefore risk. The risk is both local and global.

Residential Heating other than Wood: The City of Portland has completed a study called "Grey to Green" (http://www.portlandonline.com/bes/index.cfm?c=47203) that quantified benefits of planting trees (among other issues). Their results indicate that green streets in addition to helping cool the streets and filter the water, also improve health and welfare of the residents. Trees help to block the wind in winter, thus reducing heating loads; and help to cool homes in the summer, thus reducing cooling loads. In either case energy use, and therefore pollution is reduced. There are many other benefits as well. Trees reduce stress, reduce crime, enhance community contact, and provide many other benefits that feed our spirits through beauty, contact with wildlife, and perspective. Livability is always enhanced and resale value is improved.

Residential Wood Combustion: Education campaigns can decrease emissions from existing wood burning devices by educating owners about proper wood seasoning and burning techniques. Education can also inform wood burning device owners about options for woodstove and fireplace insert replacement. Education campaigns can range from minimal, with minimal cost (and possibly minimal effect) to a more in-depth program with hands-on demonstrations and other outreach. Costs could be absorbed by a woodstove installer (if getting a new device). Otherwise, the state or local agencies could hold workshops getting people to do hands-on burning. To be effective, an education program would need several hands-on demonstrations prior to the woodburning season.

Primary Considerations

a. Magnitude of Reductions.

Residential Heating other than Wood: The magnitude could be significant, especially for areas of environmental justice communities where many local efforts to date have focused. For example the City of Portland piloted projects in environmental justice neighborhoods that offered cost offsets for eco-roofs and other projects. The funding for that program has not been extended, but the pilot was very successful

Residential Wood Combustion: The magnitude of reductions for air toxics is unknown. Many air toxics would likely decrease, because PM 2.5 decreases when wood is burned properly as compared to improperly. With proper burning techniques and well-seasoned wood, emissions (even in older stoves) can be significantly reduced. In a study of a woodstove change-out on the Nez Perce Reservation, "Measureable Outcomes of a Woodstove Change-out on the Nez Perce Reservation", (http://www.epa.gov/burnwise/pdfs/NPChangeoutReportUM.pdf)

Following the installation of EPA-certified woodstoves, some of the homes had higher PM2.5 concentrations measured inside the homes after the change-out when compared to pre-change-out levels. After determining the causes of these elevated concentrations, homeowners were given additional education and training. As a result of this education/outreach effort, PM2.5 concentrations were lowered within four homes as demonstrated by follow-up sampling events. Table X presents the pre-change-out results, the initial post-change-out measurements (Post 1), and then those results measured within each of the four homes following the outreach/education provided to the homeowner (Post 2).

Table 12: Woodstove Emission Study Results

		Before outreach/ education	After outreach/ education
	Pre-Changeout Average	**Post 1 Changeout**	**Post 2 Changeout Average**

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To be effective, an education program would need several hands-on demonstrations prior to the woodburning season.¶

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	$PM_{2.5}$ ($\mu g/m^3$)	Average $PM_{2.5}$ ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)
Home 2	20.8	322.7	58.2
Home 6	42.4	63.1	18.4
Home 11	14.0	125.9	12.1
Home 13	47.9	2412.0	12.0

In Home 2, the owner was drying wood on the stove, leaving a layer of pitch on the stove and creating elevated levels of PM2.5. The results from these four homes demonstrate that education and outreach strategies following the change-out can greatly improve the operation (and therefore reduce the levels of PM2.5 within the homes) of the newly installed stoves.

b. Timeframe to Implement.

Residential Heating other than Wood: 1-3 years

Residential Wood Combustion: 1-3 years. Education could be implemented at the city, county, or local level. Many examples of education programs already exist.

c. Other pollutants reduced.

Residential Heating other than Wood: Again if electrical generation is part of any process, a reduction in electric use translates to reductions in all criteria pollutants, many HAPs, and greenhouse gases. A switch from wood to natural gas, oil or other fuel would translate to reduced pollution from wood but again, increases the use of non-renewable fuels that are mined, etc. Solar would provide the cleanest switch, but still uses mined resources in its construction. Subsequently, however, there is no need for continued inputs (like coal, or oil) to operate the systems.

Residential Wood Combustion: PM 2.5 decreases when wood is burned properly, so an effective education program could reduce PM 2.5. The effect on other pollutants is unknown.

e. Cost.

Residential Heating other than Wood: Low – education and outreach efforts always take some funding, but it would be minimal compared to the impact the programs can make on preventing pollution.

Residential Wood Combustion: To increase the chances of having an effective education program, a hands-on demonstration would need to be conducted in various areas throughout Portland and target different demographic/ethnic groups. For example, this could include 5-10 demos prior to the wood heating season.

The cost will vary depending on the number of demonstrations, attendees, location, outreach, etc. but could be in the range of $4,000 to $20,000.

H. Strategy #8: Regulate Moisture Content of Wood

Narrative Overview

Burning wood with a lower moisture content will generate less smoke than burning properly dried wood. In some areas of the country, it is illegal to burn wood that has a moisture content above 20%. Wood retailers can sell wood with a moisture content higher than that, but are required to state on the sales invoice that

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burning wood with a moisture content higher than 20% is illegal. In other areas, sale of wood with a moisture content over 20% has to be accompanied by directions on how to properly dry the wood.

Primary Considerations

a. Magnitude of Reductions.

The magnitude of reductions for air toxics is unknown. Many air toxics would likely decrease, because PM 2.5 is likely to decrease when wood with a moisture content below 20% is burned as compared to wood with a moisture content above 20%. The magnitude of the air toxic reductions is unknown.

b. Timeframe to Implement.

New Regulation. 1-5 years. New regulations could take place at the city, county or state level. There are three key phases of implementing wood moisture regulation:

- Obtain authority. 6 months - 1 year, depending on legislative body. Some jurisdictions might already have the authority, and this step can be skipped.
- Develop regulation. 1-2 years.
- Implementation and enforcement

c. Other pollutants reduced.

PM 2.5 decreases when wood with a moisture content of 20% or below is burned, so an effective regulation could reduce PM 2.5. The effect on other pollutants is unknown.

d. Technical feasibility.

Moisture sensors can detect the moisture content of wood. Other areas have implemented moisture content regulations.

e. Cost.

Cost for this strategy includes the cost of new local rules, education and technical assistance to wood burning device owners, and ongoing complaint response and enforcement. The cost is dependent on the rulemaking practices of the city, county, or state conducting the rulemaking, and on whether rulemakings are needed in multiple jurisdictions. This strategy is also highly dependent on having adequate staffing resources available.

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I. Strategy #9: Research emission changes from manufactured fire log use and develop strategies if appropriate

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Narrative Overview

Some sources of information indicate that using manufactured fire logs in place of wood in a fireplace reduces emissions. http://www.pscleanair.org/actions/woodstoves/documents/duraflame_log_testing.pdf. The emission factors used by DEQ indicate that, for the same mass of fuel burned, fire logs emit more 15 PAH and benzene. However, fewer fire logs may be used than wood, since generally, only one fire log is burned at a time, while generally several pieces of wood are used in a fireplace. Prior to developing the strategy, more research is needed.

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This strategy could be implemented through an education campaign or a regulation, and could be implemented throughout the PATS area, or scaled to a particular location.

Fire logs are not made to be burned in woodstoves or fireplace inserts.

Primary Considerations

a. Magnitude of Reductions.

Unknown.

b. Timeframe to Implement.
Education campaign. 1-3 years
Regulation. 3-5 years.

c. Other pollutants reduced.

Unknown.

d. Technical feasibility.

Manufactured logs are widely commercially available.

e. Cost.

An education campaign could cost $4,000 to $20,000, depending on the education and outreach strategies employed. The cost of a regulation would include the cost of new local rules, education and technical assistance to fireplace owners, and ongoing complaint response and enforcement. The cost is dependent on the rulemaking practices of the city, county, or state conducting the rulemaking, and on whether rulemakings are needed in multiple jurisdictions.

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V. ATTACHMENTS

Attachment A: Considerations

This list of considerations will be used by PATSAC as an informal tool to understand toxics reduction strategies. If the committee chooses, it may also use these considerations to shape its recommended package of strategies or implementation steps. The tables below are cross-walked to the Committee's Considerations reference (DEQ web link below). For example, in

Blueprint level	Strategy
Speed turnover to new cleaner home heating systems	**#1 – Replacement of woodstoves**
	#1a – Replace 19,888 uncertified wood stoves with **certified wood stoves**
	#1b – Replace 19,888 uncertified wood stoves with **pellet stoves**
	#1c – Replace 19,888 uncertified wood stoves with **natural gas furnaces**
	#2 – Ban wood burning devices in new homes
	#2a – Ban **all wood burning devices** in new homes
	#2b – Ban **wood burning fireplaces** in new homes
	#3 – Revive tax credits and other funding assistance
Energy conservation	**#4 – Weatherization – Incentives**
	#5 – Weatherization – Promotion of existing programs
Improve user practices	**#6 – Opacity standard for wood smoke**
	#7 – Education campaign
Improve wood fuel quality	**#8 – Regulate moisture content of wood**
	#9 – Research emission changes from manufactured firelog use and develop strategies if appropriate

Table 14
, consideration 1.c. Effect on Exposure, refers to consideration 1.c in the Committee's full considerations list.

Considerations (reference: http://www.deq.state.or.us/aq/toxics/docs/pats/3_2_11regroupedConsideraton.pdf)

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Table 13: Blueprint and Brainstorm List Strategies

Blueprint level	Strategy
Speed turnover to new cleaner home heating systems	**#1 – Replacement of woodstoves**
	#1a – Replace 19,888 uncertified wood stoves with **certified wood stoves**
	#1b – Replace 19,888 uncertified wood stoves with **pellet stoves**
	#1c – Replace 19,888 uncertified wood stoves with **natural gas furnaces**
	#2 – Ban wood burning devices in new homes
	#2a – Ban **all wood burning devices** in new homes
	#2b – Ban **wood burning fireplaces** in new homes
	#3 – Revive tax credits and other funding assistance
Energy conservation	**#4 – Weatherization – Incentives**
	#5 – Weatherization – Promotion of existing programs
Improve user practices	**#6 – Opacity standard for wood smoke**
	#7 – Education campaign
Improve wood fuel quality	**#8 – Regulate moisture content of wood**
	#9 – Research emission changes from manufactured firelog use and develop strategies if appropriate

Table 14: Strategy Effectiveness

Strategy	1.c. Effect on Exposure[6]	1.d. Pollution Prevention[7]
#1 – Replacement of existing wood stoves	Program could target specific areas, or be area wide.	Modify the process to reduce the quantity and toxicity of air contaminants generated.
#2 – Ban wood burning devices in new homes	Areas of new home construction only	Modify the process to reduce the quantity and toxicity of air contaminants generated.
#3 – Revive tax credits and other	Area-wide	Modify the process to reduce the quantity and toxicity of

[6] Effect on exposure: How well does the measure target spatial extent of the emissions? Some reductions may have more pronounced effects on localized concentrations; others may do more to reduce pollutants area-wide. (OAR 340-246-0170 4(g)). Ability to address short term or acute exposures if relevant.

[7] Pollution prevention: Where does the strategy fit in the pollution prevention hierarchy? 1. Modify the process, raw materials, or product to reduce the quantity and toxicity of air contaminants generated. 2. Capture and reuse air contaminants. 3. Treat to reduce the quantity and toxicity of air contaminants released. (OAR 340-246-0050)

Strategy	1.c. Effect on Exposure[6]	1.d. Pollution Prevention[7]
funding assistance		air contaminants generated.
#4 – Weatherization – Incentives	Area wide, or in a local jurisdiction (for example, one city or county)	Modify the process to reduce the quantity and toxicity of air contaminants generated.
#5 – Weatherization – Promotion of existing programs	Area wide, or in a local jurisdiction (for example, one city or county)	Modify the process to reduce the quantity and toxicity of air contaminants generated.
#6 – Opacity standard for wood smoke	Area wide, or in a local jurisdiction (for example, one city or county)	Modify the process or raw materials to reduce the quantity and toxicity of air contaminants generated.
#7 – Education campaign	Program could target specific areas, or be area wide.	Modify the process, raw materials, or product to reduce the quantity and toxicity of air contaminants generated.
#8 – Regulate moisture content of wood	Area-wide	Modify the raw materials to reduce the quantity and toxicity of air contaminants generated.
#9 – Research emission changes from manufactured firelog use and develop strategies if appropriate	Program could target specific areas, or be area wide.	Modify the product to reduce the quantity and toxicity of air contaminants generated.

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Table 15: Strategy Implementation/Feasibility Barriers

Strategy	2.a. Legal Authority[8]	2.c. Funding[9]	2.d. Implementation[10]	2.e. Acceptance[11]	2.f. Non-regulatory Approaches[12]
#1 – Replacement of existing wood stoves	DEQ does not have the authority to require removal of old stoves, unless it is upon home sale. Either DEQ or a local government would likely have the authority to run an incentive program				Yes. This could be done through a grant or incentive program.
#2 – Ban wood burning devices	New rule and/or local ordinances				No

[8] Legal authority: Does the measure fall under existing regulations or are new laws/ rules required? Does federal pre-emption preclude new laws/rules? Is/will the proposed measure be addressed through other planned Federal, state, or local rulemaking or other processes?

[9] Funding: What is the cost to DEQ or other agency to implement the measure? How could the agency cost be funded? How certain is the funding mechanism?

[10] Implementation: Is there a ready structure for implementation or ability to coordinate with existing programs?

[11] Acceptance: Is there public and stakeholder support for the measure?

[12] Non-regulatory approaches: Could the measure be implemented through incentives or education? Is there an opportunity to implement the measure through a community-based multi-stakeholder collaborative process? Could the measure begin as voluntary and later become mandatory as necessary in a contingency plan?

Strategy	2.a. Legal Authority[8]	2.c. Funding[9]	2.d. Implementation[10]	2.e. Acceptance[11]	2.f. Non-regulatory Approaches[12]
in new homes	required. Authority for DEQ or local government would need to be evaluated.				
#3 – Revive tax credits and other funding assistance	Possible rule change				Yes. Grant or incentives
#4 – Weatherization – Incentives					Yes. This could be done through a grant or incentive program.
#5 – Weatherization – Promotion of existing programs					Advocacy and some technical assistance.
#6 – Opacity standard for wood smoke	New rule required. Authority for DEQ or local government would need to be evaluated.				No
#7 – Education campaign	Local, state authority				Yes. This could be done through a grant or incentive program.
#8 – Regulate moisture content of wood	New rule required. Authority for DEQ or local government would need to be evaluated.				No
#9 – Research emission changes from manufactured firelog use and develop strategies if appropriate	Local, state authority				Yes. This could be done through a grant or incentive program.

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Table 16: Strategy Cost Considerations

Strategy	3.b. Cost Effectiveness[13]	3.c. Other Environmental Impacts[14]	3.d. Energy[15]	3.e. Public Safety[16]	3.f. Indirect Economic Costs[17]
#1 – Replacement of existing wood stoves		Replacement of woodstoves with natural gas could increase cadmium slightly	Reduces energy use	Increases public safety by reducing risk of chimney or house fire from old stove. Potential to improve indoor air quality	It is possible that less wood would be sold.
#2 – Ban wood burning devices in new homes				Potential to improve indoor air quality	Less wood could be sold.
#3 – Revive tax credits and other funding assistance		Could reduce pollution from coal-fired power plants.	Reduces energy use		Could promote employment and provide new skills
#4 – Weatherization – Incentives		Weatherizing might reduce airflow indoors, causing higher indoor air pollutants, particularly if there are things in the home that are off-gassing.	Reduces energy use		Could promote employment and provide new skills
#5 – Weatherization – Promotion of existing programs			Reduces energy use		Could promote employment and provide new skills
#6 – Opacity standard for wood smoke			Reduces energy use	Potential to improve indoor air quality	
#7 – Education campaign		Trees enhance community contact, and provide many other benefits that feed our spirits through beauty, contact with wildlife, and	Could reduce energy use	Potential to improve indoor air quality. Trees and other "green" factors reduce crime.	Could promote employment and provide new skills

[13] Cost effectiveness: What is the cost per unit of air toxics reduced?
[14] Other environmental impacts: Potential for the emission reduction measure to transfer pollutants to soil or water, or cause harm to human health or the ecosystem.
[15] Energy: Effect of measure on energy use.
[16] Public safety: What is the affect of the measure on public safety? For example, would emission reductions restrict activities related to adequate lighting, heat, ventilation, signage or access to emergency services?
[17] Indirect economic costs: What are the potential indirect costs to communities, the local economy or business sectors?

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Strategy	3.b. Cost Effectiveness[13]	3.c. Other Environmental Impacts[14]	3.d. Energy[15]	3.e. Public Safety[16]	3.f. Indirect Economic Costs[17]
		perspective.			
#8 – Regulate moisture content of wood			Reduces energy use	Potential to improve indoor air quality	Cost of wood could increase
#9 – Research emission changes from manufactured firelog use					

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Table 17: Strategy Benefits and Distribution of Benefits and Cost

	Benefits			Distribution of Benefits and Cost	
Strategy	**4.a. Health[18]**	**4.b. Livability[19]**	**4.c. Indirect Economic Benefits[20]**	**5.a. Risk Distribution[21]**	**5.b. Cost Distribution[22]**
#1 – Replacement of existing wood stoves	Potential to improve indoor air quality		More work for contractors, hearth products dealers, manufacturers	Program could specifically address particular areas to address concerns	
#2 – Ban wood burning devices in new homes	Potential to improve indoor air quality				
#3 – Revive tax credits and other funding assistance	Potential to improve indoor air quality		Less energy used = less $ spent on energy costs	Yes – focus may be in EJ areas	No
#4 – Weatherization – Incentives	Potential to improve indoor air quality		More work for contractors, hearth products dealers, manufacturers. Less energy used = less $ spent on energy costs		
#5 – Weatherization – Promotion of existing programs	Potential to improve indoor air quality		Less energy used = less $ spent on energy costs	Yes – focus may be in EJ areas	No
#6 – Opacity standard for wood smoke	Potential to improve indoor air quality				
#7 – Education campaign	Potential to improve indoor air quality		Less energy used = less $ spent on energy costs	Yes – focus may be in EJ areas	No
#8 – Regulate moisture content of wood	Potential to improve indoor air quality				
#9 – Research emission changes from manufactured firelog use and develop strategies if appropriate					

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Deleted: #7 – Promote manufactured firelog use

[18] Health: What are the health benefits of meeting the benchmarks? This could be measured as the number of cancer cases avoided and/or value of statistical life and medical costs avoided.

[19] Livability: Improved quality of life associated with improved nuisance conditions such as odor or noise.

[20] Indirect economic benefits: What are the potential benefits to communities, the local economy or business sectors?

[21] Risk distribution: Could the measure change the social distribution of risk in the PATS area, i.e. sensitive populations and environmental justice communities?

[22] Cost distribution: Could the measure impose disproportionate costs or economic impacts to environmental justice communities in the PATS study area?

Attachment B: Emissions from each type of wood burning device.

Pollutant	Fireplace	Fireplace inserts			Woodstoves				Firelog
		Non-EPA certified	EPA certified		Non-EPA certified	EPA certified		Pellet-fired	
Pounds of emissions per ton of fuel burned	General		Non-catalytic	Catalytic		Non-catalytic	Catalytic	General	All device Types
PATS pollutants									
1,3-butadiene	0.157	0.39	0.175	0.195	0.39	0.175	0.195	0.00095	
Naphthalene	0.265	0.179	0.0582	0.0954	0.179	0.0582	0.0954	0.423	0.09756
Benzene	0.686	1.938	0.959	1.464	1.938	0.959	1.464	0.0289	1.068
Formaldehyde	1.79	1.45	2.22	0.982	1.45	2.22	0.982	0.316	
Acrolein	0.123	0.091	0.0404	0.0314	0.091	0.0404	0.0314	0.0101	
Acetaldehyde	1.07	0.616	0.632	0.531	0.616	0.632	0.531	0.094	
Manganese		0.00017	0.00014		0.00017	0.00014			
15 PAH	0.001	0.2648	0.10948	0.11387	0.2648	0.10948	0.11387	0.0069116	0.05
Number PAH emission factors available	1	12	13	15	12	13	15	5	14
Other pollutants									
Volatile organic compounds	18.9	53	12	15	53	12	15	0.041	39.56
Methane	14.4	64	28.4	26	64	28.4	26	0.248	
Carbon monoxide	149	230.8	140.8	104.4	230.8	140.8	104.4	15.9	125.08
Nitrogen oxides	2.6	2.8	2.28	2	2.8	2.28	2	3.8	7.684
Primary PM 10	23.6	30.6	19.6	20.4	30.6	19.6	20.4	3.06	29.32
Primary PM 2.5	23.6	30.6	19.6	20.4	30.6	19.6	20.4	3.06	28.4
Sulfur dioxide	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.32	
Toluene		0.73		0.52	0.73		0.52		

Table data sources: 2002 NEI, EPA report to Congress, MARAMA, Firelogs. Content and emission characteristics of Artificial Wax Firelogs, Environment Canada

Attachment C: Alternative Heating Resources

http://www.naturalstep.org/en/using-natural-step-a-framework-toward-construction-and-operation-fully-sustainable-buildings
Paper on applying The Natural Step to the construction industry

http://ilbi.org/lbc
Living Building Challenge

http://www.usgbc.org/
US Green Building Council, including LEEDs for Homes info

http://www.architecture2030.org/

http://www.earthadvantage.org/
Earth Advantage Institute – Home Certification Program

http://www.energystar.gov/index.cfm?c=new_homes.hm_index
Energy Star Homes

http://www.energystar.gov/index.cfm?c=mortgages.energy_efficient_mortgages
Energy Efficient Mortgages

http://www.oregon.gov/ENERGY/CONS/BUS/docs/HPH_handout.pdf?ga=t
Specs on the Oregon High Performance Home

http://www.nahbgreen.org/
National Green Building Program

http://solaroregon.org/residential-solar
Solar Oregon nonprofit

http://www.oregon.gov/ENERGY/RENEW/Solar/Support-RETC.shtml
Oregon's tax credits for solar energy: electric, water heating, passive space heating

http://www.passivehouse.us/passiveHouse/PHIUSHome.html
Passive House building standard