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The firewood dilemma: Human health in a broader context of well-being in Chile

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ABSTRACT

The mitigation of climate change requires developing alternatives to fossil fuels, while simultaneously looking for ways to increase the resilience of our socioecological systems especially those reliant on ecosystem goods and services. Forest biomass is receiving increased attention as a source of renewable fuel; yet at the same time, increased use of wood fuels raises health concerns about the adverse effects of pollution and as a possible contributor to deforestation and forest degradation. For these reasons, where people use wood fuel, policies are designed to shift people away from wood fuel and using forest biomass and up the energy ladder, typically toward fossil fuels. Using a case study from Chile, where air pollution from residential firewood combustion has become a serious issue, we show that while such policies might reduce pollution in the short term, they are unlikely to improve either human well-being or the sustainability of resource use in the long term. Instead of policies designed to reduce or eliminate wood fuel use, by examining the interlinked energy and resource subsystems and socioeconomic context within which wood fuel is used, we argue that a combination of policy interventions targeting the adoption of energy-saving technologies, while still maintaining wood fuel as a primary energy source, would yield higher economic, social, and environmental benefits.

Introduction

Wood fuels[2] are an important source of energy in the world: approximately 2.8 billion people rely them, especially in developing countries (Food and Agriculture Organization of the United Nations, FAO, 2010; Bonjour et al., 2013), and it makes up 9% of the world primary energy matrix (International Energy Agency, IEA, 2014). Over half of global timber harvests (52%) are used for fuel (FAO, 2015). Asia, Africa, and Latin America are the main wood fuel consumers, with 42%, 32%, and 17% of the total volume, respectively (FAO, 2010). The associated impacts of wood fuel use depend on what kind of biomass is used, who uses it and how, and the impact of the level and kind of extraction activities on the forest ecosystem.

In Africa and Asia, where wood fuels have been mainly studied, woody biomass is used in low efficiency cook stoves or as open fires, which can be also observed in some areas of Latin America. However, in the most developed countries of South America (Uruguay, Argentina, and Chile), wood fuels are used for cooking and heating in rural areas and for heating in urban ones, using higher efficiency equipment (Costa and Delgado, 2001; Reyes, 2013), and there is extensive use of natural gas or liquefied petroleum gas (LPG) for cooking, especially in urban areas.[3] In North America and Europe, the use of forest biomass is growing, where the wood fuel comes in the form of pellets, mainly produced from forest wastes (Goh et al., 2013), and used for both residential heating and power generation.

There is a divergence in wood fuel policies, with those promoting its use as potentially more sustainable energy sources than fossil fuels, as in Europe and North America (Lundmark and Mansikkasalo, 2009; Sikkema et al., 2011). In other regions, wood fuel consumption is producing significant health issues due to indoor air pollution[4] and ambient particulate matter pollution (Lim et al., 2012). Health problems related to indoor air pollution from solid fuels in sub-Saharan Africa and South

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[2] All types of biofuels derived directly or indirectly from woody biomass (FAO, 2004).

[3] In contrast to Africa and Asia, wood fuels in Latin America are also widely used by industry as well (steel factories, ceramic factories, food and beverage manufacturing plants, dairies, sawmills, forest industries, etc.), commercial and retail firms (restaurants, bakeries, hotels, etc.), and public institutions (hospitals, schools, municipalities, etc.) (Baker et al., 2014; Ministerio de Minas y Energía de Brasil, 2009; Reyes, 2013).
[4] The smoke produced by burning forest biomass and other materials in unventilated places is an important driver of respiratory diseases, cataracts, and cardiovascular problems, among others (Srogi, 2007; Fullerton et al., 2008; Pénard-Morand et al., 2010). Indoor air pollution accounted for 3.5 million deaths and 108 million disability-adjusted life years in 2010 (Lim et al., 2012). This has given rise to many research and development initiatives oriented to promote new cooking stoves, the use of cleaner fuels, etc. (Kanagawa and Nakata, 2007; Ruiz-Mercado et al., 2011).

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Asia account for between 4% and 6% of the total DALYs,[5] while in Chile they only represent 0.75% (30,000 DALYs).[6] Yet, in Southern Chile, wood fuel consumption is the main driver of ambient particulate matter pollution, being the responsible for the emission of more than 80% of the total PM2.5 (Ministerio de Medio Ambiente, 2013) with a significant impact in public health (Secretaría de Medio Ambiente Región de Los Ríos, 2014).

Moreover, there has been a long debate on the role that wood fuels play in deforestation and forest degradation, starting in the 1970s with the publication of "the other energy crisis" (Eckholm, 1977). Although the incidence of wood fuel production on deforestation remains a controversial topic (Bensel, 2008; Bhatt and Sachan, 2004), it is accepted that overharvesting of wood for fuel contributes to forest degradation (Ahrends et al., 2010; FAO, 2010). Nevertheless, the balance between supply and demand, and the potential overharvesting, significantly varies among countries and regions (Bailis et al., 2015), where some Asian and African countries have the highest rates of non-renewable biomass consumption (Bailis et al., 2015).

Much of the analysis and concerns around the social and environmental impacts of wood fuel consumption has drawn on the experiences of places like India, China, and sub-Saharan Africa, where poverty, high population density, and other factors create a complex scenario for the consumption of wood fuels. Chile (and other regions in Latin America), by contrast, present a different socioeconomic setting, where (a) there are higher levels of income and development, (b) extraction of forest biomass takes place with different forms of forest governance and for personal and commercial use, and (c) wood fuel is used mainly for heating rather than cooking.

This different context offers the opportunity to examine the "wood fuel issue" from a novel perspective, where wood fuel use is quite high (28%) being the second most important primary energy source after petroleum (CNE, 2014). At the same time, Chile is one of the Latin American countries with a negative rate of deforestation (FAO, 2012), and while wood fuel production has been raised as a cause of forest degradation in some areas, there is evidence that cattle grazing is the main driver behind this process (Zamorano et al., 2014). In this setting then, the wood fuel issue in Chile may not necessarily be to shift users "up" the energy ladder; instead, it is to evaluate wood fuel policies against a broader set of measures reflecting the environmental and social impacts of these policies not only human health, but also on human well-being and resource sustainability.

The Chilean context

In the last four decades, Chile has experienced rapid development resulting in a significant improvement of the socioeconomic condition of its population. According to the World Bank (2014), Chile now has comparable levels of per capita income (US$21,000/year) and life expectancy (80 years) to developed countries, and it has seen reductions in poverty and corruption, indicators that have characterized it as a successful development case (Ramirez and Silva, 2008; Rehner et al., 2014). Yet at the same time Chile is one of the countries with the highest per capita wood fuel consumption worldwide (Bailis et al., 2015), although there is strong regional variation, influenced by differences in resource availability and climate. Industrial wood fuel consumption is more concentrated in central Chile (between Valparaiso and Biobío regions), where the economic activity is more intense, while the residential consumption is concentrated in southern Chile, due to colder climatic conditions (Fig. 1). The average wood fuel consumption in the urban residential sector of central Chile is 1 m^3/hh/year, as opposed to 18 m^3/hh/year in Patagonia[7] (Reyes, 2013).

Wood fuel consumption is strongly rooted in the Chilean tradition and culture due to the abundance of forest biomass, the relative scarcity and high cost of fossil fuels, and the cold and rainy winters (Burschel et al., 2003). The wood fuel market is also very important from a socioeconomic standpoint, employing 60,000 people in the supply chain and related services (maintenance of heaters, exhaust systems and chimneys, input supply, and others) (Burschel et al., 2003). The firewood market represents an important income source for thousands of small and medium landowners, especially during winter or periods of economic recession, when agricultural activity is lower.

In this document, we analyze the case of Valdivia City in Southern Chile to show the social and environmental impacts of policies designed to limit or eliminate the use of wood fuel and alternative policies. Valdivia is the largest city in the region and is representative of other southern cities in terms of both demographics and the socioenvironmental characteristics related to the firewood consumption. In addition, several studies have been carried out in Valdivia in the last two decades, providing the data necessary to perform a more comprehensive analysis of this topic.

The firewood issue in Valdivia

In Valdivia City, the wood fuel consumption (mainly firewood) averages 211,000 m^3/year (Reyes and Frene, 2006). It is consumed in 84% of households, basically for heating, with an average of 8.3 m^3/hh/year (Reyes and Frene, 2006), and even at the highest socioeconomic decile (average income larger than US$70,000/hh/year), 62% of households consume firewood for heating. Wood fuel consumption is not necessarily driven by poverty but also by traditions, availability, comfort, and other factors (Reyes and Frene, 2006) as has been reported in other countries (Hiemstravan der Horst and Hovorka, 2008). One consequence has been ambient particulate matter pollution. From 2008, when the Air Monitoring Program started to be implemented in Valdivia, PM10 and PM2.5 concentrations have frequently overcame the Chilean air quality standards for both particles[8] (Ministerio de Medio Ambiente, 2015). In 2014, Valdivia was declared a PM10 Saturated Zone, requiring the development of an Environmental Decontamination Plan that includes several measures to reduce air pollution. One of the measures that has been proposed is the replacement of wood fuel by LPG or other oil derivatives. However, international experience shows that the replacement of traditional fuels by oil derivatives, normally through prohibitions or/and subsidies, has not been very effective (Gangopadhyay et al., 2005; Hosier and Kipondya, 1993; Pitt, 1985). The fuel switching process is not linear, but instead much more complex, where other factors influence behavior and use, especially where different energy sources are simultaneously used to satisfy the family needs (Hiemstravan der Horst and Hovorka, 2008). It is this question we address in the remainder of this study: what are the costs and benefits of wood fuel-based systems versus the proposed alternatives, and which offers the most long-term sustainable environmental and social benefits, with a focus on the well-being of Valdivian residents?

Methods

We answer these questions by carrying out a comprehensive analysis of the residential heating system (RHS) of Valdivia, including both environmental and social dimensions (Fig. 2), to assess the implications of switching fuel sources along with the alternative of continuing wood

[5] Disability-adjusted years of life—this factor reflects the quantity of years lost due to ill-health, disability, or early death (Murray, 1994) and is a common metric used in public health to better capture the broader health impacts beyond just mortality.

[6] It includes 1,500 deaths and 28,500 disability-adjusted life years (Institute for Health Metric and Evaluation, 2013).

[7] Solid cubic meter. 1 m^3 solid = 1.5625 m^3 bulk (stacked firewood with air between spaces).

[8] That is, 150 and 50 μg /m^3, 24-h average, for PM10 and PM2.5, respectively (Ministerio de Medio Ambiente, 2013). Data show that PM2.5 is dominant in the total PM10 (Ministerio de Medio Ambiente, 2015).