



Review

Coal use for residential heating: Patterns, health implications and lessons learned



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ABSTRACT

Residential coal consumption has decreased significantly since 1990 in most developed and developing countries, due to fuel switching. However, there are still countries with a high proportion of households using coal for heating purposes, in some cases with increasing coal consumption trends. This review discusses the patterns of the coal use, associated emissions, the negative impacts on health, and the policies and interventions used to limit the negative effects of high residential coal use. The patterns of residential coal use in those selected countries that account for 86% of global residential coal consumption are reviewed. Interventions in these selected countries have been accessed. It appears that the World Health Organization (WHO) may substantially underestimate the health impacts in these countries, particularly with respect to the burden of disease from household air pollution from using solid fuel for cooking as the indicator of exposure. The alternative to the WHO approach uses International Energy Agency (IEA) data because it provides the energy consumption for each country by fuel type and all household end-uses in a consistent framework. National survey data on energy and emissions also provides better metrics of exposure. Most of the assessed studies in developed countries focused on ambient air pollution, while in developing countries indoor air pollution was given primary attention (except for Mongolia). The PM concentrations within households using coal in Ireland, Mongolia, and China were compared and substantial differences were found as a result of differences in ventilation, stove design, fuel quality and stove maintenance and operation. Policy measures such as the large stove switching programs in China and Mongolia were mostly successful, but did not fully reach desired targets because of several factors. One of these key factors was the variability of human behavior and its response to the policy stimuli. Important barriers to the transition to cleaner energy alternatives are relatively low coal prices coupled with its level of supply security. Health benefits, however, are generally higher than the abatement costs in the most polluted areas, and support from governments for cleaner energy, that includes a focus on health, can be feasible and effective if carefully designed and targeted.

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Introduction

Coal has been used for residential heating for centuries. In the middle of the last century, coal use for residential heating was widespread. Today, coal burning for heat in most developed countries has diminished substantially because of the recognition of the resulting air pollution producing significant local air quality degradation. For example, the Great Smog of London in December 1952 was caused largely by smoke from household heating with coal. It caused thousands of premature deaths within a short period (Brimblecombe, 1987). Coal combustion releases toxic species including particulate matter (PM), NO_x, SO₂, CO, and Hg. Solid fuel generated PM is associated with an increased risk of adverse health outcomes, such as acute lower respiratory infections in children, chronic obstructive pulmonary disease, chronic bronchitis and lung cancer (WHO, 2014).

Residential emissions from space heating and cooking with solid fuels remains to be an important and generally unrecognized source of ambient air pollution in China and other developing countries (Liu et al., 2016; Zhi et al., 2017). The residential sector emissions are attributed to greater uncertainty than industrial emissions due to lack of activity data and lack of understanding of end-use (Archer-Nicholls et al., 2016; Zhi et al., 2017; Winijkul and Bond, 2016).

The World Health Organization (WHO) uses estimates of the populations employing solid fuels for cooking as a proxy for household air pollution in its Global Burden of Disease program since it is difficult to obtain “nationally representative samples of indoor concentrations of criteria pollutants, such as PM and carbon monoxide” (WHO, 2015a). Solid fuel combustion for space heating was not included by WHO because of the lack of routinely conducted surveys on space heating (Bonjour et al., 2013). Given this limitation, the WHO assessment of the burden of disease from household air pollution in countries with high use of solid fuels for heating may be underestimated. It is important to supplement the WHO estimates with studies investigating solid fuel use patterns for cooking and heating at national and regional scales in order to fully quantify the domestic burden of diseases. This study addresses this knowledge gap.

There remain countries with many households that burn coal for heating purposes. In cold climates, long heating seasons as well as poor ventilation are likely to produce negative adverse effects from heating with coal. However, there are few studies reviewing patterns of coal use, the associated exposure to the emissions from coal burning, their negative impact on health, and on policies and interventions to reduce these negative effects.

In this study, we investigated the patterns of global residential coal use in selected countries that represent 86% of global residential coal consumption in 2014, and reviewed the likely exposure to indoor air pollution, and the related health effects. The study also

reviews policy interventions that seek to address the effects of household coal use.

Global coal use and countries selection

The International Energy Agency (IEA) data on energy balances (IEA, 2016a) were used for the analysis of global residential coal combustion trends and the selection of affected countries. In the IEA Energy Balance tables for each region/country, data in the row “Residential” and the column “coal” (IEA, 2016a) were selected. The IEA Energy Balance tables are the only source that reports energy consumption for each country in the world by fuel type and for all household end-uses, including cooking, heating, and water heating within a consistent framework. Coal consumption is derived mainly from the amounts of coal sold by companies to the population. Hence, supply and consumption are assumed to be balanced and include all of the coal use in the country. The limitation of this data source is that energy consumption is not further disaggregated to its end-uses (e.g. cooking, heating, water heating).

Fig. 1 compares (on the left axis) solid fuel use per capita with coal use per capita by regions of the world in 2014. Solid fuel use (primary solid biofuels and coal) and coal use data for each region were obtained from the IEA Energy Balance tables (IEA, 2016a). Populations by region/country were obtained from IEA indicator tables (IEA, 2016b). To obtain per capita consumption of fuels, the solid fuel or coal consumption by region/country was divided by the population of the corresponding country/region.

Fig. 2 shows the WHO assessment on percentage of population using solid fuels for cooking applied in the Global Burden of Disease as indicator of household air pollution.

Fig. 1 shows that the highest per capita solid fuel use occurred in Africa, China, Asia (excluding China) and OECD Europe. However, coal consumption in Africa, non-OECD Americas, OECD Americas, Middle East is very low since their solid fuel of choice is wood or other biomass. The highest coal share in total residential solid fuels use was reported in OECD Asia Oceania, followed by non-OECD-Europe and Eurasia, OECD Europe and China. Both WHO and IEA indicators report high solid fuel use in Africa and Asia. The WHO (2015a, b) assessment of household air pollution for OECD Europe may be underestimated because it does not consider solid fuel use for heating purposes. In addition, countries classified as high-income with a Gross National Income (GNI) of more than US\$ 12,746 per capita according to the World Bank (2015) were assumed by WHO to have completed the transition to cleaner fuels since solid fuel consumption for those countries were reported to be less than 5% (WHO, 2015a).

Global residential coal consumption declined by 51% between 1990 and 2014 and there are decreasing trends in most developed

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