Energy and Air Pollution Benefits of Household Fuel Policies in Northern China

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Introduction

North China has the highest regional levels of air pollution in the country due to intensive industrialization, dense population, and its long heating season. The rapid transition from traditional fuels to LPG (liquefied petroleum gas), biogas, and electricity for cooking, is resulting in much lower emissions. Still, solid fuels remain a dominant energy source for heating. To address the issue, a campaign (Clean Heating Plan for Northern China in Winter for 2017-2021) was launched to substitute electricity or pipeline-based natural gas (PNG) for heating in northern China, focusing on the so called 2+26 (Beijing, Tianjin, and 26 other municipalities in the surrounding area) region. This study evaluates the impacts of the campaign on rural residential energy use, emissions, ambient and indoor air quality, and population exposure to $PM_{2.5}$ in the 2+26 region (termed the study region hereafter).

Methods

➢ **Scenarios :**

- S1 (business as usual): no intervention involved except those driven by changes in population distribution and economic growth;
- S2 (limited effort): limited and non-specific effort on residential emission reduction as planned in the 13th Five-year Plan for Air Pollution Control (APCP13), which mainly focused on industry, transportation, and energy production;
- S3 (partial substitution): 60% substitution are projected to achieved as planned by the Clean Heating Plan for Northern China in Winter for 2017-2021;
- S4 (full substitution).

➢ **Quantification of $PM_{2.5}$ concentrations in outdoor and indoor environment:**

- A novel reduced-form model was used to quantitatively distinguish influences of emissions and meteorology on $PM_{2.5}$ in air (Zhong et al., 2018).
- A simple statistical method following Chen et al. was applied to quantify average $PM_{2.5}$ concentrations in living/bed room, and kitchen of rural households given energy for cooking and heating (coal, crop residue, fuelwood, and clean energy including LPG and electricity) based on data in Chen et al. (Chen et al., 2018).

➢ **Exposure assessment:**

- The population were divided into two genders (male and female) and four age groups (<5, 5-15, 16-65, >65). Population-weighted $PM_{2.5}$ concentrations (PWE) were calculated to assess population exposure based on $PM_{2.5}$ concentrations in indoor and outdoor environment and behavior time model.

References:

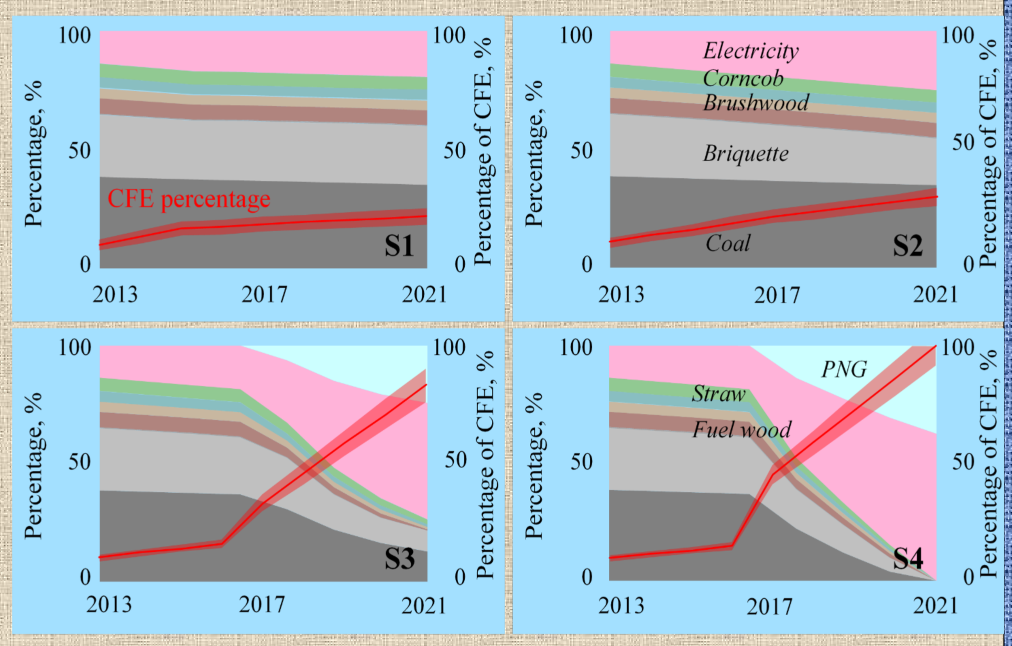
Zhong Q, et al. (2018) Distinguishing Emission-Associated Ambient Air PM2.5 Concentrations and Meteorological Factor-Induced Fluctuations. *Environmental Science & Technology* 52(18):10416-10425.

Chen Y, et al. (2018) Estimating household air pollution exposures and health impacts from space heating in rural China. *Environment International* 119:117-124.

Results and Discussion

➢ **Impact of the campaign on rural residential energy transition :**

Percentage of clean fuels or electricity (CFE) for cooking and heating increased from 8% to 68% and from 0.7% to 11% from 1992 to 2012, respectively, similar to those for the entire country. Without any intervention, CFE percentages would rise to 86% and 19% for the study region in 2021.

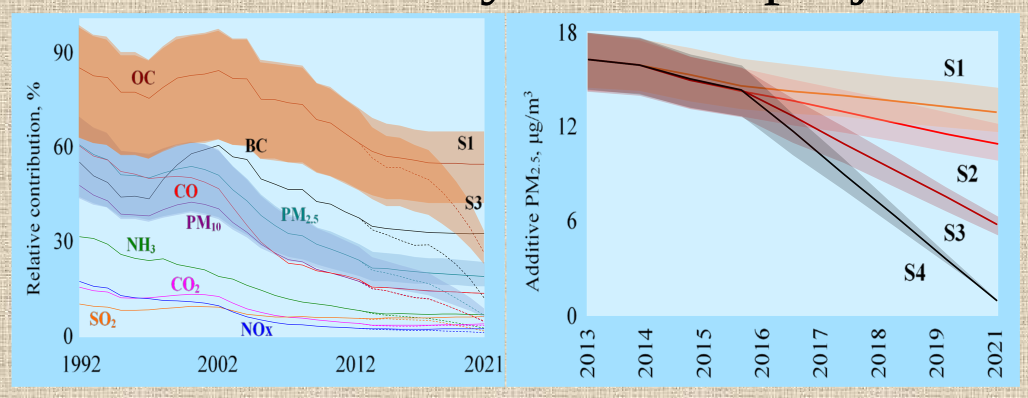


➢ **Emissions reduction due to the substitution:**

In 1992, the relative contribution of this sector was as high as 61% and is expected to drop to 19% in 2021 without any intentional intervention. But in S3, the percentage is going to be as low as 7%.

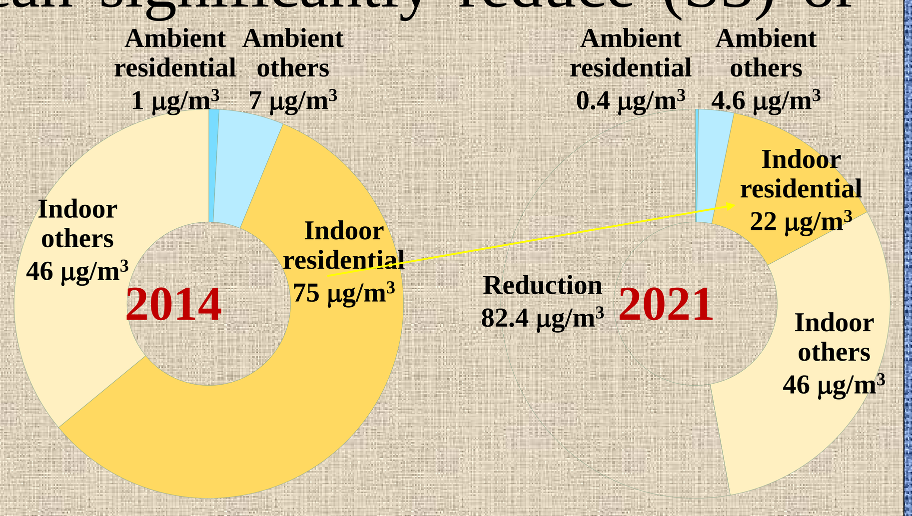
In S1, the annual average concentrations from the residential sectors would decrease at a slow pace from 15 to 12 μg/m^3. In S3, the contribution is projected to decrease to less than 5 μg/m^3, suggesting that the campaign will be highly effective.

Although the aim of the campaign was to improve ambient air quality, the results will directly benefit indoor air quality as well, since the solid fuels are burned directly indoor. The indoor air $PM_{2.5}$ levels in winter in the study area are projected to be 40% lower than S1.



➢ **The campaign is projected to improve air quality and reduce exposure substantially:**

With men, women and children considered, the weighted concentration in the study region was 135 μg/m^3 in 2014 and would decrease to 109 μg/m^3 in the case of S1 and 78 μg/m^3 in the case of S4 by 2021, equivalent to 19% and 42% reductions in the two cases, respectively. In the case of S3, the remaining exposure would be dominated by non-residential sources (72%), suggesting that the campaign can significantly reduce (S3) or even eliminate (S4) the exposure originally from the residential source.



- W. Meng et al., Energy and air pollution benefits of household fuel policies in northern China. *Proceedings of the National Academy of Sciences* 116, 16773-16780 (2019).

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