Fueling Kyrgyzstan's Transition to Clean Household Heating Solutions

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Abbreviations and Acronyms

ARIS	Community Development and Investment Agency
CAEWDP	Central Asia Energy-Water Development Program (now CAWEP)
CASA-1000	Central Asia-South Asia Electricity Transmission and Trade Project
CO	Carbon Monoxide
DIY	Do-it-Yourself
EE	Energy Efficiency
ESMAP	Energy Sector Management Assistance Program
EU	European Union
GHG	Greenhouse Gas
GJ	Giga Joules
HELE	High Efficiency, Low Emissions
HOB	Heat Only Boiler
KGS	Kyrgyz Soms
kWh	Kilowatt Hours
LPB	Low Pressure Boiler
NGO	Non-Governmental Organization
NSC	National Statistical Committee of the Kyrgyz Republic
PM	Particulate Matter
TA	Technical Assistance
WHO	World Health Organization

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For the reader more interested in design details and technical features of the stoves deployed during the pilot trial described in this report, the earlier 2019 World Bank publication "*Advancing Heating Services Beyond the Last Mile: Central Asia Pilot Experience with High-Efficiency, Low-Emissions Heating Technologies*" is recommended. The Kyrgyz stove pilot described in the present report contributed to the regional experience and learning on the high efficiency, low emissions (HELE) heating technologies highlighted in the 2019 publication.

Multi-year financial support of the stove activity in the Kyrgyz Republic from the Energy Sector Management Assistance Program (ESMAP, www.ESMAP.org), the Central Asia Energy-Water Development Program (CAWEP, www.cawep.org), and a Multi-Donor Trust Fund related to the Community Support Program under the CASA-1000 Project is gratefully acknowledged.

Photo credits: *Crispin Pemberton-Pigott, Murat Zhumashev, Ruslan Ismailov.*

Executive Summary

In the Kyrgyz Republic, access to reliable and affordable heating is critical given the cold and long winters in its mountainous regions. With central heating solutions such as district heating limited to the capital city Bishkek and other urban areas, over 80% of households resort to individual heating solutions. Every second household uses a traditional coal-fired stove, dung is frequently used as primary heating fuel in regions where animal husbandry is prevalent, and other solid fuels from wood to rubber are burnt to meet heating needs. Traditional stoves are characterized by low efficiency (below 40 percent) and are the source of high ambient and indoor air pollution. Low income households are particularly susceptible to the consequences of inadequate heating and respiratory illness is frequent; lower respiratory infections and chronic obstructive pulmonary disease figure among the five most frequent causes of death in the country.[1] According to the World Health Organization, Kyrgyzstan ranks first in the world in mortality from lung diseases. Regions and remote areas located in the highlands are especially affected with the main cause being identified as indoor air pollution.[2]

Alternatives to traditional solid-fuel based stoves are limited in the Kyrgyz Republic, especially for low income households: electricity supply is increasingly constrained during winter months as insufficient new generating capacity is being added to keep up with the growing needs of the population and government decrees cap winter consumption on a regional level. Where it is available, natural gas is relatively more expensive than district heating and therefore limited to wealthier households in urban areas. Throughout the country, biomass resources are localized and scarce.

In this context, high efficiency, low emissions (HELE)[3] heating stoves offer significant benefits for household comfort, public health and air pollution which is an increasing problem in urban areas in the winter. The World Bank supported a comprehensive technical assistance (TA) program on HELE stoves over a three-year period 2016-19, examining demand features and supply characteristics of the Kyrgyz stoves market and piloting the use of HELE stoves in 76 low income households in four regions, with a focus on high altitude locations. The findings from the market studies and the lessons from the pilot trial are summarized in this report. The HELE stove program has been made possible through grant financing received from three Global Trustfunds and their support is gratefully acknowledged: the Energy Sector Management Assistance Program (ESMAP, www.ESMAP.org), the Central Asia Energy-Water Development Program (CAWEP, www.cawep.org), and a Multi-Donor Trust Fund related to the Community Support Program under the CASA-1000 Project.

[1] Source: GBD Compare, 2010.

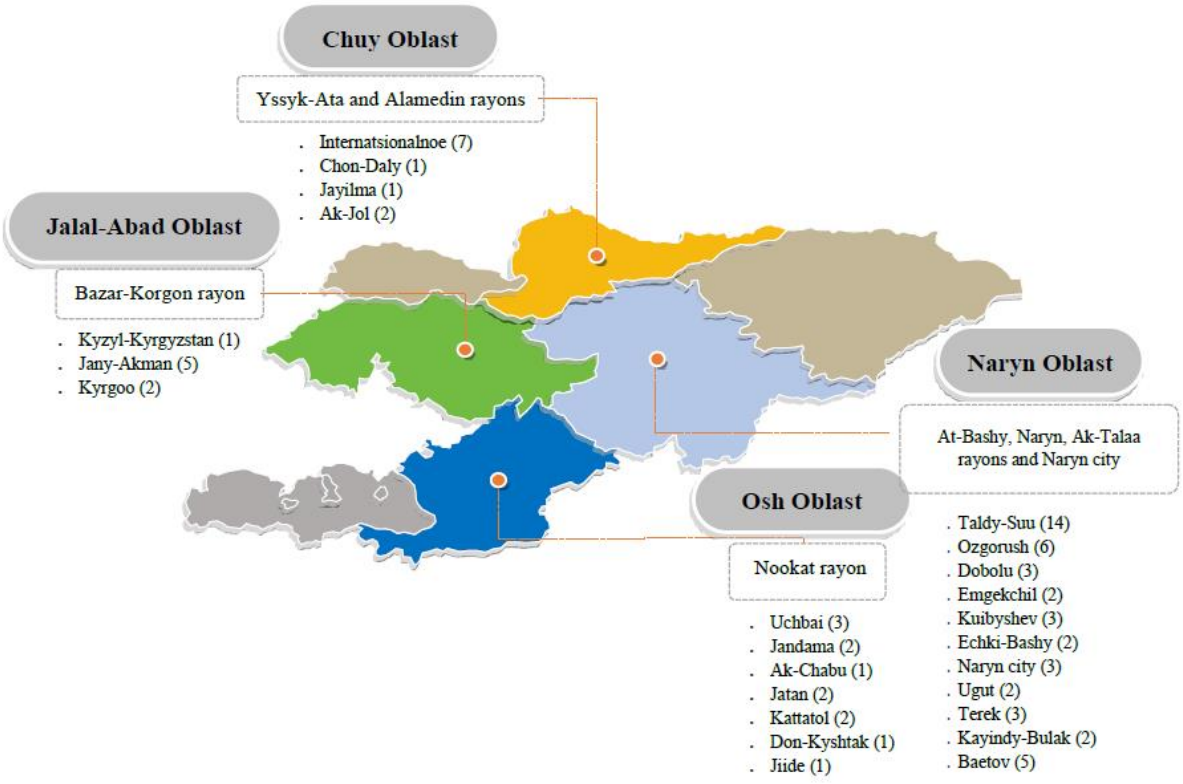
[2] KABAR. Talantbek Sooronbaev: “Kyrgyzstan is the first in the world by mortality from lung diseases”. The breath of life of Kyrgyzstan, 2015, http://dem.kg/index.php/ru/article/18422/talantbek-sooronbaev-kyrgyzstan-stoit-na-pervom-meste-v-mire-po-smertnosti-ot-bolezney-legkih.

[3] The term High Efficiency, Low Emissions is adopted from the definition by the IEA Clean Coal Centre in the UK, https://www.iea-coal.org/.

The extensive TA provided input into the design of a World Bank lending operation, the Heat Supply Improvement Project, approved by the Bank's board in October 2017 and signed by Government in January 2018. The project integrated a US$ 5 million grant component aimed at incentivizing the switch to HELE stoves and creating the enabling conditions for the local production and distribution of around 14,000 HELE stoves to low income households. During the ratification process of the Heat Supply Improvement Project, the stove component was challenged by members of parliament in terms of its priority and in July 2019 the Government sent the request to the World Bank to cancel the component and reallocate the grant funds to other development priorities. The report summarizes the TA work undertaken to prepare the stove component and documents the research findings and pilot results.

Three areas from the TA are summarized in what follows: (i) the characteristics of household heating demand, (ii) features of the supply market; and (iii) results from the field experiment piloting HELE technologies over three heating seasons 2016-19.

Map: Location and number of installed stoves and low-pressure boilers in the Kyrgyz Republic (oblast, rayon, village levels)



Source: Map is designed by the Word Bank, based on CAMP Alatoo data, using template from the website https://yourfreetemplates.com/

A. Household heating demand

The key findings concerning **heating demand** set out in this report include:

Close to 90 percent of households without access to district heating rely on solid fuel (mostly coal, which is used by 88 percent of rural and urban households outside Bishkek) as their primary heating fuel to keep their homes warm. The lower the income, the higher the reliance on solid fuels (coal, dung, wood): 97 percent in the lowest income tertile (as opposed to 88 percent in the top tertile) rely on solid fuels for home heating. Poorer households in rural areas tend to supplement their coal use mainly with traditional fuels (animal dung and wood), while electricity is the prevalent secondary fuel in urban areas.

Chronic under-heating is the rule in households that use solid fuels and home comfort levels in winter are low, with only some of the available rooms being heated. Considering the average house size of 88m^2 with about five rooms, households that burn coal and wood as their primary fuel typically heat only three of them, while those using dung heat only about half the house. (By contrast, wealthier, gas heating households heat 86 percent of their rooms.) Under-heating affects more particularly women, children and the elderly as they spend more time at home. At times when women are home alone, they report not heating it to full comfort levels in order to save energy (costs). Finally, about three-quarters of households outside of Bishkek also use their space heating stove for cooking, with a high seasonal effect: in summer, only 1 percent of households continue to use their heating device for cooking.

With regard to **heating equipment in use**, the household survey yields the following key results:

The majority of Kyrgyz households, especially among lower income segments, rely on traditional solid fuel-fired stoves as their primary heating equipment. Among households without access to district heating, close to two thirds in urban and rural areas and one fifth of households in Bishkek use a traditional coal-fired stove as their primary heating source (totaling about 532,000 households). These stoves are either home-made or produced by artisans, most of whom are based in Bishkek. The second most common heating systems are simple coal-fired low-pressure boilers (LPBs), installed in 37 percent of households in Bishkek and around 10 percent in urban and rural areas, respectively (see Figure 2.7 in Section 2). A variety of solid fuel fired stoves and LPBs are available, but predominantly the stove models in use are of limited capacity (sufficient to heat one room) and fuel efficiency is generally low (25-40 percent, as measured on site during the study). Emissions are a function of the stove's combustion characteristics and fuel burnt: users are found to often burn a combination of fuels, from coal to wood, to garbage and tires. LPBs range from do-it-yourself types (built by the user with/without the support of an engineer/welder), over simple commercial LPBs without automation, to fully automated systems mainly imported from China and other countries. The household survey revealed that both stoves and LPBs are in use many years beyond their expected useful lifetime. For stoves, the equipment costs range from US$ 35 for the simplest, low capacity and low efficiency model, to US$ 280 for better designed models with higher fuel and combustion efficiency (up to 60 percent). For solid-fuel LPBs, the price range for the most common models is US$ 170 for the low-end models (25-50 percent efficiency) to US$ 860 for high-end semi-automatic models (up to 80 percent efficiency).

On average, **households using stoves consume about 2.6 tons of coal per heating season**. The range of consumption volume is wide, reaching up to 4.1 tons, indicating that a range of factors determine coal consumption. Apart from the efficiency of the equipment, household income, size and condition of the dwelling, household composition and behavior, and the price of coal all affect fuel consumption. Monthly costs for heating in rural and urban areas are similar and range between KGS 1,000 and 2,000 (US$ 14-28), with Bishkek presenting an exception with significantly higher and wider ranging monthly heating costs (KGS 1,500 – 6,000). In particular the use of natural gas for heating drives up the costs in the capital city (see Figure 2.9, Section 2). In relative terms, **households without access to district heating spend between 7 and 15 percent of their monthly expenditures on heating**. As a share of total monthly expenditure per capita, poor households spend 12 percent for heating energy (mostly coal), compared to 9 percent spent by households in the middle-income tertial and 7 percent by the wealthiest households.

Regardless of low efficiency, frequent refueling and emissions, the large majority of households (70 percent) surveyed for the study were satisfied with their heating stoves and an even higher percentage applied to LPBs. As a result of this, the share of households interested in changing their heating system is relatively low: only 29 percent of households using traditional stoves express an interest in switching. Reasons for this finding are thought to be lack of awareness regarding better performing heating options, combined with affordability concerns and behavioral inertia. When asked about perceived areas for improvement for their existing heating systems, households highlighted the limited heating capacity of their existing systems.

Much higher degrees of dissatisfaction were expressed regarding indoor air quality. Around 70 percent of households living in urban and rural areas agree that indoor air pollution is an issue. Households across all locations (rural, urban and Bishkek) recognize solid fuel-fired heating stoves as a contributor to local air pollution, behind municipal solid waste and motor vehicles. But only one fourth of all respondents consider it to be an issue (see Figure 2.15). When asked what heating solutions they would prefer to adopt that would contribute to reducing air pollution, clean stoves were the main response. Reduced fuel consumption was raised as the main area of interest for improvement of currently used heating solutions, followed by longer heat retention, quality and cost-effectiveness and provision of fast heat. **Households expressed willingness to pay for such improved stoves**, between US$185 for rural households and US$280 for the average urban household outside Bishkek. While this is close to the range of common HELE stoves, HELE LPBs would cost significantly more; one of the findings of the pilot was however that once advanced HELE LPB were demonstrated to households, interest and willingness to pay increased. A subsidy available through the proposed Heat Supply Improvement Project was to cover the cost difference between traditional and HELE technologies up to US$100.

B. Stove Supply Market

The **stove supply market** survey findings complement the picture, based on 24 companies and workshops surveyed. A key objective of this part of the TA work was the assessment of the potential to introduce locally produced HELE stoves and boilers into the Kyrgyz market and examine the readiness of local producers to support a switch to HELE technologies using the

current supply chain. At present, stoves and boilers are sold in bazaars and markets, with more expensive, imported models also available in select shops. Local stove and LPB producers fall into three main categories:

- small artisan producers which employ 1-4 persons and sell from a couple to up to 400 stoves and boilers per year;
- specialized companies focusing on the production of stoves and LPBs with larger production capacity and specialized equipment, able to sell between 200 and 1,000 stoves and boilers per year; and
- construction companies which can make stoves or boilers at the request of customers in large production facilities (usually producing less than 100 boiler per year).

Locally-produced stoves and boilers are usually based on the manufacturers' own designs with a few exceptions (e.g. designs by client or other manufacturers from Poland or Kazakhstan). The potential for capacity expansion is limited for the majority of surveyed producers, with lack of resources to finance an expansion of production facilities, investment in materials and hiring of additional employees. **More than 70 percent of the surveyed manufacturers stressed that they may not have access to affordable financing for the purpose of expansion to produce HELE stoves.** The largest potential for local producers to enter the market of HELE stoves and markets is found among specialized companies. In most cases, they are developers of their own stoves, skilled in stove design and possess relevant knowledge and experience. In addition, they have the necessary equipment for the production at scale of high-quality stoves and boilers. Regardless, interest in offering HELE stoves and boilers was found to be limited without scalable program supported by grant finance. Reasons for the reluctance cited included: (i) focusing on meeting the needs of the existing clientele; (ii) more complicated and costly production of HELE technologies; (iii) lack of appropriate equipment and material for producing HELE technologies; and (iv) insufficient demand/ awareness by households for HELE stoves and boilers. During the development process of the stove and LPB models over two heating seasons, it was found that the acceptance of stove producers increased as the designs adapted to local resources and skills.

C. Results of the pilot trial

In addition to the examination of the demand and supply features of the Kyrgyz stove and boiler market, the potential for the introduction of HELE stoves and boilers was further tested by a **pilot trial of HELE technologies in households** over the period of three heating seasons 2016 - 2019. The objective of the pilot was to: (i) support the development and testing of HELE heating stoves in select locations; (ii) build local awareness about the benefits of switching to better heating technologies; (iii) develop local market capacity to design and install HELE stoves; and (iv) inform the design of a scaled-up pilot program.

The pilot was implemented with the support of CAMP Alatoo, a non-governmental organization (NGO) based in Bishkek, and in part supplemented by the EU-funded Fresh Air Program led by the Ministry of Health. The Kyrgyz Community Development and Investment Agency (ARIS) was also involved in the pilot as designated implementing entity for the scaled-up program that was to

be financed under the World Bank Heat Supply Improvement Project (the component was subsequently cancelled at the request of the Kyrgyz Government). The pilot was executed in two phases:

- *Phase I (2016-2017)* involved the participation of 51 low income households selected from 10 villages located in four oblasts (Naryn, Chui, Jalal-Abad and Osh) and the installation of three first generation HELE heating models; and
- *Phase II (2017-2018)* involved 25 low income households from 10 villages in Naryn where two second generation HELE heating models were installed.

During the heating season 2018-19, follow up visits were conducted to households who had been provided with HELE stoves in Phase I to gain an understanding of the medium-term operation of the stoves.

Households for participation in Phase I were selected on the basis of a baseline assessment of 93 households in the **regions Naryn, Chui, Jalal-Abad and Osh**. The regions were selected based on considerations related to climate, heating patterns and culture as well as their alignment with programs of implementing partners, notably the EU funded Fresh Air program and the CASA 1000 multi-donor trustfund. Echoing the findings of the nation-wide demand survey, the majority of households in the four pilot regions rely on coal as their primary heating fuel, complemented mainly by dung. The stoves and LPBs in use were found to have been in operation long beyond their useful life (over half were installed more than 11 years ago) and frequent refueling throughout the days underlines the low efficiency of the stoves, affecting more particularly women. The majority of households in the pilot regions recognized the link between smoke emitted from their heating stoves in poorly ventilated rooms and respiratory symptoms. The high baseline concentration of particulate matter (PM) in the air has also been confirmed through baseline measurements conducted by the Fresh Air program in 20 selected households: $PM_{2.5}$ values are 3 to 5 times higher than WHO maximum $PM_{2.5}$ levels (see Figure 4.6).

Despite households expressing concerns about the current performance of stoves in terms of smoke emittance, low heat retention and high fuel consumption, **only about one third of the surveyed households considered the overall performance of the existing stove as non-satisfactory**.

During Phase I of the pilot (2016-2017), 51 out of 93 low-income households surveyed were selected for participation using a cluster sampling method along with socioeconomic and technical eligibility criteria which included confirmation of the low-income status according to local regulations. During Phase II of the pilot (2017-2018), the **selection of 25 low-income households** followed the same criteria and a similar cluster sampling method, but household eligibility verification and the selection process were closely coordinated with ARIS, with the intent to test operational arrangements and related templates designed for a larger scale replication of HELE stove distribution under the Heat Supply Improvement Project. For all selected households, results were monitored in terms of household satisfaction, fuel consumption, and refueling frequency. Exposure to indoor air pollution was monitored for part of the households selected in Phase I and

measurements administered by the Fresh Air Program implemented by the International Primary Care Respiratory Group.[4]

Given the absence of locally produced HELE stoves and LPBs to be distributed in the trials, the **TA was used to develop prototypes and initiate the local manufacture of models that met eligibility criteria and heating needs of low-income households**. Eligibility criteria for HELE stoves included the use of solid fuels (i.e., coal, dung and/or wood), overall thermal efficiency of at least 70 percent, a peak heating capacity of 6-30 kW, and satisfactory safety performance and emissions reduction. The Kyrgyz prototypes were based on experience from Mongolia and Tajikistan, and adapted to the Kyrgyz context to take into account local availability of materials, tools, skills and heating practices. [5] Feedback from users and producers directed the evolution of both the heating stoves and LPBs with the design being adjusted and final models reaching market readiness in 2019.

Extensive capacity building for local stove producers and installers took place throughout the trial period 2016-19 to demonstrate the design and manufacture of HELE stoves in hands-on workshops and repeated training sessions were organized. Detailed production and installation manuals were produced to accompany the training activities. All technical designs were made available under open-source standards and can be found under www.camp.kg.

As a result of the technical assistance and focused capacity building, the design for the prototype stoves installed during the trials was improved via an active feedback loop and challenges encountered at production and installation stages were taken on board between Phase I and II. Among the **key challenges encountered at the production stage** were the lack of local capacity to implement the HELE designs and ensuing mistakes and imprecisions which affected stove performance and operations; the fragmentation of the market also for raw materials such as bricks and cast iron, and the need for custom-made stove components which took time to procure and required adjustments. As a result, production costs were high, impacted by the small quantities produced and need for repeated corrections to achieve the desired quality of product, eventually achieved in 2019. The range of production costs found during the trial was KGS 14,500 (US$ 207 at an exchange rate of 69.9) for the two best adapted HELE stove models (KG2.5 and KG4.4), increasing to KGS 24,500 (US$ 350 at an exchange rate of 69.9) for the HELE LPB model (KG5.2) piloted; additional costs for new chimneys are in range of KGS 2,000 (US$ 29) and installation KGS 2,400-3,500 (US$ 34-50).

During the **installation process**, local specificities of dwellings proved important and the lack of standard construction was a challenge. To ensure adequate performance and safe operation of the

[4] For a detailed description of the results of the Kyrgyz pilot, please also refer to World Bank (2019) "Advancing Heating Services Beyond the Last Mile: Central Asia Pilot Experience with High-Efficiency, Low-Emissions Heating Technologies." World Bank, Washington, DC.

[5] See above reference to World Bank (2019) for a detailed description of the technical aspects of the HELE technologies deployed.

new stoves, installation works were done by professional teams that had received expert training. Installation works in some households had to include reconstruction of heating walls, replacement of leaking chimneys, dismantling of old stoves, and installation of additional connectors for water pipes. The development of detailed installation manuals that could be used of scaled distribution had to take a multitude to different installation scenarios into account. Key challenges for installation of the stoves included ex-post modifications directly connecting stoves to chimneys rather than heating walls and associated cases of households backing away from the new stoves due to the needed modifications. Early results from the trial also revealed that chimneys were a weak point which affected the performance of the stoves and the installation of new chimneys became the rule to mitigate safety concerns and ensure full performance.

Finally, the proper **operation of stoves by users** was uneven despite training provided to all households during installation and monitoring. The performance of stoves was impacted by the improper kindling of the fire and the burning of fuels other than coal or dung due to supply shortages, affordability concerns and established habits. Monitoring over several heating seasons also revealed modification of the stoves after installation due to households undertaking DIY repairs, moving or selling their stove. During the final monitoring conducted in spring 2019, households had temporarily or permanently discontinued the use of 42 out of 76 installed stoves, with lack of appropriate fuel being one of the main explanations.

Regardless of the implementation challenges along the supply chain, the monitoring of stove performance and measurement of household satisfaction was consistently positive: when operated as designed, all users recognized and appreciated the benefits brought by HELE stoves. In terms of efficiency improvements, laboratory tests of the prototypes confirmed the efficiency of HELE stoves between 70-87 percent compared to an average of around 25 percent of traditional models. Fuel consumption recorded for the trial households confirmed that **households on average used roughly 40 percent less coal to keep a larger area of their homes warm**. Significant improvement in the frequency of refueling was shown by the monitoring data (refueling once every 6-15 hours rather than every 1-3 hours) and more than half of the surveyed households noticed a decrease in the time spent to operate the new stove. **Around 80 percent of households participating in the trial reported an increase of indoor comfort levels after installation of HELE stoves, even though they often increased the number of rooms heated.**

Outstanding results were also produced at the level of reduced indoor pollution and positive health impact. Indoor exposure measurements were conducted during two consecutive winters (2016/17 and 2017/18) for 41 pilot households with heating stoves from the first and second generation of locally produced products and 20 control group households. The results showed that the mean $PM_{2.5}$ exposures of pilot households decreased from 92.3 $\mu g/m^3$ to 32.4 $\mu g/m^3$, a total decrease of 65 percent. A decrease was also observed for CO exposure levels, which dropped below the air quality guidelines (both for minimum and maximum values) issued by the World

Health Organization (WHO).[6] Monitoring of respiratory symptoms conducted by the Fresh Air team found a significant decrease in all symptoms reported among adults and children and the number of missed days at school for surveyed children was reduced by 72 percent.[7]

D. Lessons Learnt

The findings of the TA summarized in this report confirm that clean heating solutions have the potential to generate multiple benefits at all levels of Kyrgyz society, cutting across diverse dimensions including poverty alleviation, gender, health, education, environment, and private-sector development. An independent evaluation by the European Union–funded Fresh Air Program showed that indoor air quality improved significantly, with a decrease in personal exposure of up to 60 percent in $PM_{2.5}$ concentrations and a dramatic reduction in respiratory symptoms for all family members.[8]

Regardless of the potential of HELE stoves, the cancellation of the clean stove component by the Government in July 2019 shows that in a context of competing demands for grant resources, support for household-level items such as heating stoves are considered a lesser development priority than collective assets (e.g. public transport or support of water supply). However, without commitment at public policy level and extensive technical and start-up support, the development of a market for HELE technologies will likely be a lengthy process. The TA program summarized in this report describes the multitude of individual features that need to be taken into account in an iterative development process at production, installation and operational stage to achieve a self-sustaining local HELE market. Until a market of sufficient scale is reached and a sufficient number of local producers have the capacity to adapt and successfully market the new models, local production will result in higher cost models with off-take mostly by higher income customers interested in higher quality models. The 2016-19 pilot program implemented by the World Bank in the Kyrgyz Republic has demonstrated to the Government, producers and users that better heating solutions exist and planted the seed for an emerging market: a small number of requests for the production of HELE stoves has been received in 2019 by producers participating in the capacity building program and provide a number of demonstration cases with potential for future growth.

[6] Gemert et al, Effects and acceptability of implementing improved cookstoves and heaters to reduce household air pollution: a FRESH AIR study, 2019

[7] Gemert et al, 2019.

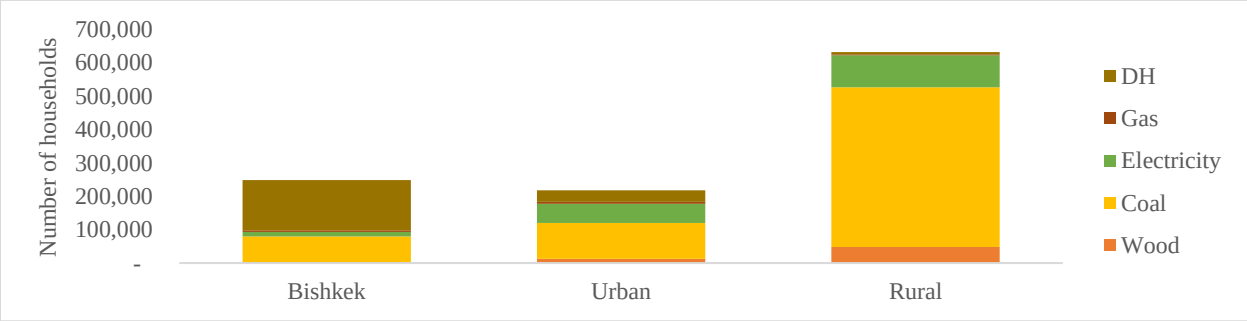
[8] For the stove installations in Chui District, incidence of chest infections among children in the 11 participant households fell from 86 percent to 13 percent, and incidence of children with more than two chest infections fell to just 1 percent, 31 percentage points below the baseline incidence. Coughing or breathing difficulties decreased to near zero among adults. See World Bank 2019 for detail.

Chapter 1. Introduction

Kyrgyzstan is a land-locked, mountainous country of 6.5 million people, with an income per capita of US$1,323 (2020). Inflation rate was 5 percent in 2019,[9] unemployment rate in the country amounted to 3.0 percent,[10] GDP grew by 3.8 percent in 2019,[11] The country has considerable economic potential based on its rich endowments, including arable land (7 percent of the country) and pastures (48 percent) along with substantial forests and minerals. There is also significant potential for the expansion of its agriculture sector, hydropower production and exports as well as its tourism industry. Despite this potential for growth, headcount poverty remains high and modest economic growth has left the country with a poverty rate at 22.4 percent in 2018. A large share of Kyrgyz households is clustered just above the poverty line, making them extremely vulnerable to poverty in the face of macroeconomic shocks such as food price increases and of households shocks such as loose of employment, illness, death of the head of a household.[12] According to NSC, 68 percent of poor people lived in rural areas in 2017, and 8 percent of the population was classified as being in the poverty risk zone (around 5% of the poverty line) in 2018.

Given Kyrgyzstan's continental climate with cold and long winters, access to reliable and affordable heating is critical for the wellbeing of its population. Out of the 1.1 million Kyrgyz households, only about 17 percent benefit from access to modern district heating services, mainly in Bishkek and other urban centers. The remaining 907,000 households have to resort to individual heating solutions, primarily fueled by coal (60 percent of all households), electricity (15 percent), wood and dung (6 percent) or gas (1 percent).[13]

Figure 1.1: Primary fuels used for heating purposes by location



Source: Authors based on World Bank, Technical Household Survey: Understanding Kyrgyz Heating Patterns, April 2016; and World Bank, Project Appraisal Document for a Heat Supply Improvement Project, October 2017.

[9] National Statistical Committee of the Kyrgyz Republic (NSC). Main macroeconomic indicators in January-April 2020. http://www.stat.kg/en/

[10] Ministry of Labor and Social Development of the Kyrgyz Republic, March 1, 2020.

[11] NSC (2020).

[12] World Bank Group, Country Partnership Framework for the Kyrgyz Republic for the Period FY19-FY22, October 2018; and Kyrgyz Republic Country Economic Memorandum 2020, March 2020.

[13] 2016. World Bank and Soc Econic, Technical report: Household survey on use of individual heating systems in 2015. Recourse: https://catalog.ihsn.org/index.php/catalog/6934/related-materials

Every second household in Kyrgyzstan uses a traditional coal-fired, inefficient stove with significant costs to households and the broader economy. These traditional stoves, usually burning raw coal and/or various forms of dung and wood, are characterized by a low thermal efficiency (20-40 percent) and high ambient and indoor air pollution (see Chapter 4).[14] They require frequent tending of the fire (~2-3 hrs) and chimney cleaning (~10 days). Poor combustion and low heat transfer efficiency directly contribute to energy poverty and have significant health impacts: around 80 percent of low income households in Kyrgyzstan use these inefficient stoves which leads directly to chronic under-heating, and fugitive indoor emissions aggravate a range of health impacts (e.g. chronic respiratory illness, see Chapter 4). This results in significant costs to households and the national economy. At aggregate level, air pollution in the Kyrgyz Republic is on the rise, in particular in urban areas.[15] According to a 2016 Report on the State of the Environment in the Kyrgyz Republic, emissions of harmful substances have doubled since 2010. The share of households heating with coal, using inefficient stoves, has contributed to the problem although the contributed fraction has not been quantified in the research.[16]

Viable alternatives to traditional solid fuel-based stoves are limited in the short- to medium-term, especially for low income households. Many Kyrgyz households cannot afford and/or do not have access to modern fuels and technologies needed to keep their homes consistently warm while avoiding negative environmental and health impacts. Alternative heating options based on electricity, gas or central heating are constrained not only because of affordability issues but also infrastructure limitations:[17]

- *Electricity*: the capacity of the power network in Kyrgyzstan is already strained, causing recurrent winter power shortages and necessitating the rationing of electricity by means of yearly government plans with consumption limits for each region.[18] Modernization investments in the network are ongoing, but a large-scale switch to electric heating solutions is not a viable alternative until significantly more generation capacity is added. Rough estimates indicate that a switch to electricity by households currently using solid fuel would increase winter peak load by up to 50 percent.
- *District heating:* an expansion of the district heating network is not an economically viable option in peri-urban and rural areas characterized by low heat load density and limited

[14] World Bank, Advancing Heating Services Beyond the Last Mile: Central Asia Pilot Experience with High-Efficiency, Low-Emissions Heating Technologies, 2019.

[15] See for example https://center.kg/article/295 or the recent report from UNIDO https://www.unido.org/sites/default/files/files/2019-10/Kyrgyzstan%20HPAP.English.pdf

[16] National Statistical Committee, Report on the State of the Environment in the Kyrgyz Republic, 2016. http://stat.kg/media/publicationarchive/8c0e9d22-6bb6-4145-b1d6-8311da33521d.pdf

[17] World Bank, Keeping Warm: Urban Heating Options in the Kyrgyz Republic, 2015. World Bank, Project Appraisal Document for a Heat Supply Improvement Project, October 2017.

[18] The Government of the Kyrgyz Republic, Decree on the progress of preparing the sectors of the economy and population of the Kyrgyz Republic for the autumn-winter period 2019/2020, No. 544, October 14, 2019.

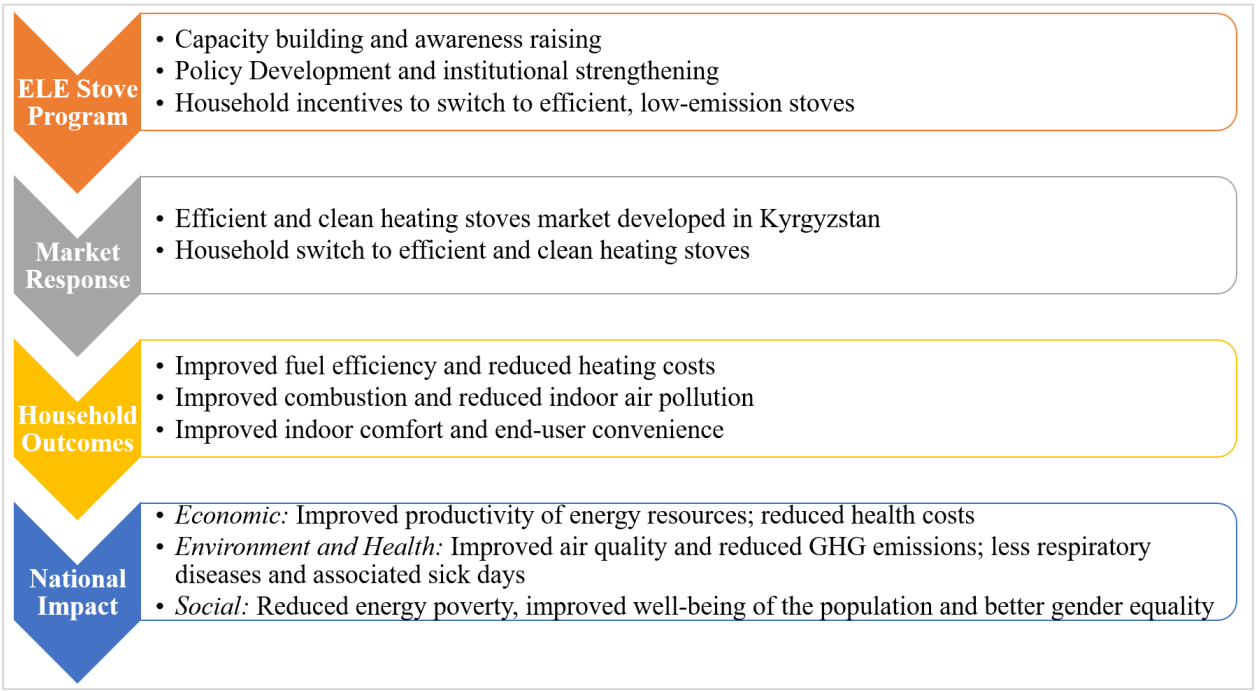
affordability. Access to district heating will likely remain limited to households located in Bishkek and other major urban centers.

- *Gas and other alternatives:* the gasification of the country is constrained by geography and income considerations, and access to gas remains limited to wealthier households in Bishkek and select cities. At the household level, renewable energy resources (e.g., solar or geothermal) are not yet financially viable for space heating applications, and woody biomass resources are limited in Kyrgyzstan.

Under these circumstances, incentivizing households to switch to high-efficient, low-emission (HELE) heating stoves can bring a multitude of benefits to Kyrgyzstan. International experience[19] demonstrates that HELE stoves can bring significant benefits at the household level, for public health, climate, economy and society. For households, the reduction in stove emissions and indoor air pollution would mean cleaner homes and better health (e.g., a reduction in respiratory illnesses), particularly among women, children, and the elderly, who tend to spend more hours inside the home. Households could also enjoy more disposable income resulting from the fuel savings offered by HELE stoves, as well as increased comfort levels and time savings resulting from the use of more efficient and easier to operate technologies. For local suppliers of fuel-efficient, clean-burning stoves and boilers, significant market potential is identified, estimated at roughly US$6–17 million per year in Kyrgyzstan based on heating demand. At the country level, if HELE technologies are implemented at scale, benefits include improved ambient air quality, contributing to lesser particulate matter pollution and a reduction in global greenhouse gas (GHG) emissions; a healthier population and workforce, lessening the country's burden of respiratory disease; and savings in natural resources (see Figure 1.2).

[19] World Bank, Advancing Heating Services Beyond the Last Mile, *op.cit.*, 2019. World Bank, Feature Story: Better Air Quality in Ulaanbaatar Begins in Ger Areas, June 2018. International Energy Agency (IEA), Capturing the Multiple Benefits of Energy Efficiency, 2014.

Figure 1.2: Potential benefits and impacts associated with an HELE stove program in Kyrgyzstan



Source: Authors based on Zhang et al, Toward Universal Access to Clean Cooking and Heating: Early Lessons from the East Asia and Pacific Clean Stove Initiative, Live Wire 2016/62, World Bank, 2016; and Zhang et al, Results-Based Financing To Promote Clean Stoves: Initial Lessons from Pilots in China and Indonesia, Live Wire 2015/46, World Bank, 2015.

HELE technologies are also the economically most viable intermediate solution for households without access to modern fuels for space heating. An urban heating assessment conducted in 2015 identified the switch to HELE heating stoves and low-pressure boilers (LPB) as the economically most viable alternatives for households currently using traditional stoves or LPBs and living in individual houses (see Figure 1.3 and Figure 1.4).[20]

[20] World Bank, Keeping Warm: Urban Heating Options in the Kyrgyz Republic, 2015.

Figure 1.3: Levelized Cost of Urban Heating Options

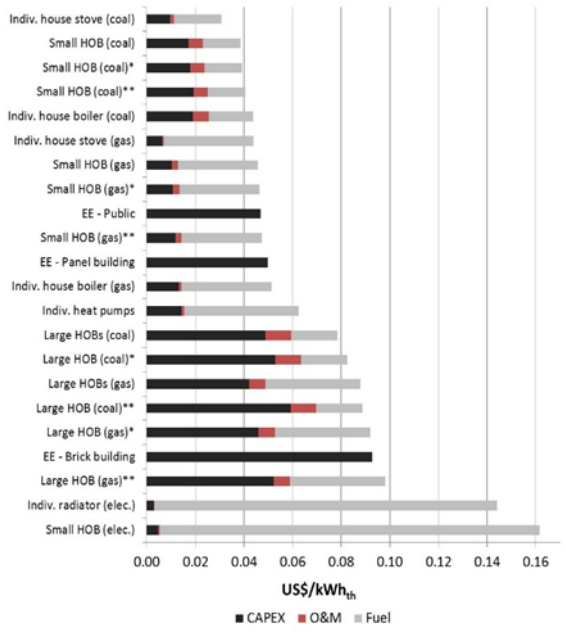
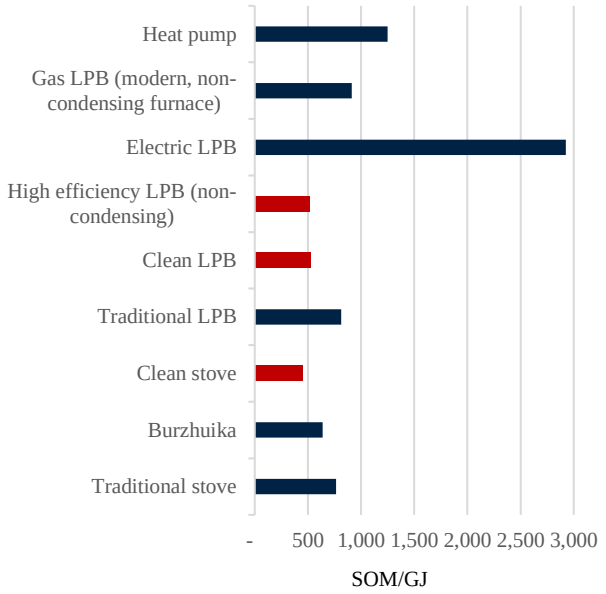


Figure 1.4: Levelized Cost of Individual Heating Solutions



Abbreviations: HOB= Heat-Only-Boiler; LPB= Low Pressure Boiler; EE= Energy Efficiency; Indiv. = Individual

* Indicates the levelized cost of a centralized heating option assuming that the existing building internal heating systems are upgraded.

** Indicates the levelized cost of a centralized heating option assuming that new building internal heating systems are constructed

Source: World Bank, Keeping Warm: Urban Heating Options in the Kyrgyz Republic, 2015; World Bank, Project Appraisal Document, op. cit., 2017.

Against this background, the World Bank supported a comprehensive technical assistance program on HELE stoves in Kyrgyzstan in 2016-2019. With the support of three multi-donor Trust Funds,[21] the World Bank initiated a technical assistance program on HELE stoves in 2016. The objective of the program was to provide technical assistance to help improve access to more efficient heating technologies for households without access to district heating. The multi-year program involved the following key activities:

- *Demand- and supply-side assessment*: this included a representative household survey (urban, rural and Bishkek) to better understand the baseline heating conditions and patterns in Kyrgyzstan. The household survey was complemented by a technical market assessment to investigate the stove supply market, related capacities and heating products offered on the Kyrgyz market. A summary of the key findings of the demand- and supply-side assessment is provided in Chapters 2 and 3.

[21] These included: Energy Sector Management Assistance Program (ESMAP); Central Asia Energy-Water Development Program (CAEWDP); and a Multi-Donor Trust Fund related to the Community Support Program under the CASA-1000 Project.

- *Capacity building and awareness raising:* as part of the technical assistance program, the following capacity building activities were conducted: (i) development and repeated delivery of a 2-day training courses for stove suppliers (manufacturers, welders, installers, designers, etc.) to help build their capacity in designing, producing and installing HELE stove technologies; (ii) organization of executive training and demonstration events targeting Government representatives and other key stakeholders; and (iii) implementation of information/ awareness raising activities to help increase awareness on the benefits of HELE technologies targeting Government representatives, local communities, households, development partners and other stakeholders. Additional details on the activities conducted and lessons learned are presented in Chapters 4 and 5.
- *Pilot program:* a pilot trial on HELE technologies was developed and implemented in 2016-2019, including 76 low-income households located in four Oblasts (Naryn, Chui, Jalal-Abad and Osh). The trial involved: (i) developing the first generation HELE heating stoves locally and testing them in a laboratory and in the field; (ii) providing training to stove suppliers regarding producing HELE stoves and to households regarding their operation; (iii) conducting community outreach activities in select villages; (iv) developing and implementing operational guidelines for manufacturers, installers and households; and (v) conducting monitoring and evaluation of results achieved in terms of fuel consumption, home comfort levels, user convenience, household satisfaction, health impact and stove performance. With continued improvements in designs, three generations of stove products were developed by the end of the engagement. A summary of the activities conducted, and results achieved is provided in Chapter 4.

In parallel to the technical assistance program, the Government and the World Bank prepared the Heat Supply Improvement Project, which was approved by the World Bank Board in October 2017. Based on the Government's request and the findings of the 2015 urban heating assessment, the preparation of the Heat Supply Improvement Project was initiated in 2015. The project was supported by US$46 million in IDA grant and credit and aimed to improve the efficiency and quality of heating in select project areas. To this end, the project involved three components: (i) improving supply efficiency and quality of the district heating system in Bishkek: (ii) piloting HELE heating stoves; and (iii) demonstrating the benefits of energy efficiency improvements in public buildings. The second component on HELE stoves was supported by US$5 million in IDA grants, informed by the above referenced multi-year technical assistance program and designed to incentivize the switch to HELE technologies for around 14,000 low income households in rural/ peri-urban areas. Eventually however, this second component on HELE stoves was dropped responding to a request of the Government made in July 2019, reflecting a shift in Government priorities and the desire to reallocate scarce grant resources.

This report provides a summary of the multi-year technical assistance program on HELE stove technologies in Kyrgyzstan. The report is organized in five chapters. *Chapter 2* assesses the heating demand situation for individual households without access to district heating. *Chapter*

3 describes supply-side features of the local stove market. *Chapter 4* provides a summary of the HELE stove pilot conducted in 2016-2019 with focus on its challenges and results. Finally, *Chapter 5* closes the report with a summary of lessons learned.

Chapter 2. Household Heating Demand

This chapter presents the key findings of a representative household survey conducted in 2015/2016, which involved 1,500 households (located in Bishkek, rural and urban areas) without access to district heating. Based on the survey findings, this chapter maps household fuel use and heating patterns, followed by a description of solid fuel-fired heating equipment currently in use. Subsequent sections discuss household heating expenditures, perceptions about current heating systems and willingness to change to HELE heating solutions.

2.1 Household Fuel Use and Heating Patterns[22]

Close to 90 percent of households without access to district heating rely on solid fuel (mostly coal) as their primary heating fuel to keep their homes warm. While the share of household using primarily coal is similar in urban and rural areas (88 percent) and slightly lower in Bishkek (75 percent), the total number of households relying on coal in rural areas is more than double the number in Bishkek and urban areas (Figure 2.1). The second primary heating fuel is electricity (8 percent of households), followed by gas (6 percent) and wood/dung (3 percent).

The lower the income, the higher the reliance on solid fuels (dung, wood, coal). Reliance on solid fuels for home heating is highest among households in the lowest income group – at 97 percent compared with 88 percent for the wealthiest households, who supplement more of their coal use with electricity and gas (Figure 2.2). For households that can afford neither coal nor firewood, the use of animal dung is prevalent, particularly in rural areas, where people can process this fuel themselves.

Figure 2.1: Primary heating fuels by location

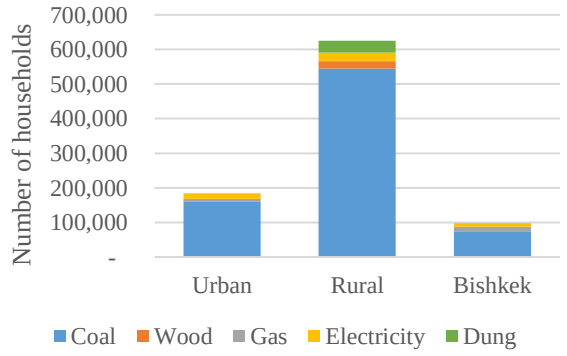
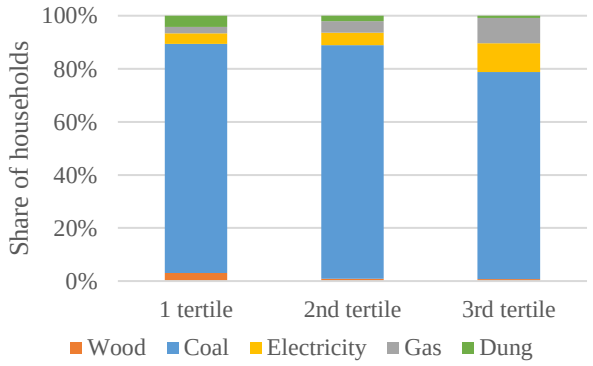


Figure 2.2: Primary heating fuels by income level



Source: Authors based on World Bank, Technical Household Survey: Understanding Kyrgyz Heating Patterns, April 2016.

[22] All results and data presented in this chapter are based on the technical household survey, unless otherwise stated. Relative results (share of household) presented refers to those **without access to district heating** unless otherwise stated.

For space heating, households tend to supplement their coal use with other fuels. For households in Bishkek and other urban areas, 52 percent and 42 percent, respectively, use more than one fuel, compared to 65 percent of rural households (Table 2.1). In urban areas, electricity is the most prevalent secondary fuel, while poorer households in rural areas tend to supplement their coal use with traditional biomass fuels (animal dung and wood), as well as electricity. The lowest income households tend to use coal in combination with wood or dung, while higher income household supplement coal with wood or electricity. Wood is primarily used for starting the fire.

Table 2.1: Space heating fuel combinations by location

	Bishkek	**Urban**	**Rural**	**Total**
Coal only	45%	58%	37%	47%
Coal + wood	32%	29%	36%	32%
Coal + electricity	20%	9%	7%	12%
Coal + dung	0%	3%	19%	8%
Coal + gas	2%	1%	2%	2%
Total coal users	**73,433**	**159,908**	**546,098**	**779,438**
Electricity only	36%	53%	75%	45%
Gas only	28%	22%	0%	24%
Gas + electricity	18%	14%	5%	15%
Electricity + coal	7%	12%	20%	10%
Gas + coal	11%	0%	0%	7%
Total electricity/gas users	**24,543**	**22,043**	**24,879**	**71,466**
dung + wood	0%	25%	24%	23%
dung + coal	0%	0%	24%	21%
wood only	100%	50%	13%	17%
wood + dung	0%	0%	20%	17%
dung only	0%	25%	13%	13%
wood + coal	0%	0%	4%	4%
Total traditional fuel users	**196**	**1,494**	**55,978**	**57,669**

Source: Authors based on World Bank, Technical Household Survey: Understanding Kyrgyz Heating Patterns, April 2016.

The usual heating season lasts from November through February. In late autumn (October) and early spring (March–April), fewer households (13 percent in October, 32 percent in March and 3 percent in April, respectively) heat their homes despite relatively low average temperatures during these months. Based on space heating patterns reported by surveyed households, peak hours for space heating during the day are the mornings and the evenings (Figure 2.3).

However, chronic under-heating is prevalent, in particular for households that use solid fuels.[23] Typically, houses are one-story, made of brick or rammed earth (*pisé de terre*). The average house size is 88 m^2, with about five rooms.[24] Insulation is poor, with considerable scope

[23] As recognized by the WHO, chronic underheating leads to negative health impacts different from one-off cold spells.

[24] The average number of household members is 4.5.

for improving home comfort levels. Households that burn coal and wood as their primary fuel usually heat only about three out of five rooms, while those using dung heat only about half of the house. By contrast, wealthier, gas-using households heat 86 percent of their rooms. Wealthier coal-using households and those in Bishkek are also able to heat more of their rooms (Figure 2.4).

Figure 2.3: Space heating patterns

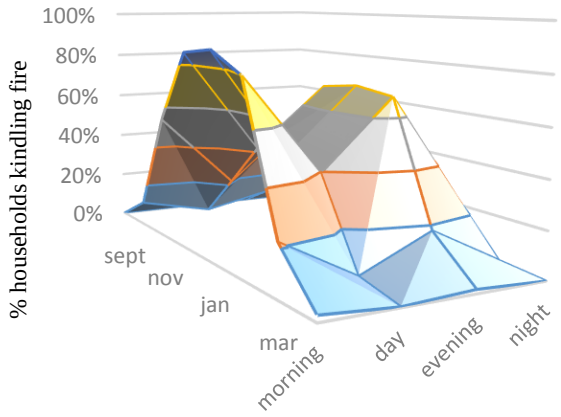
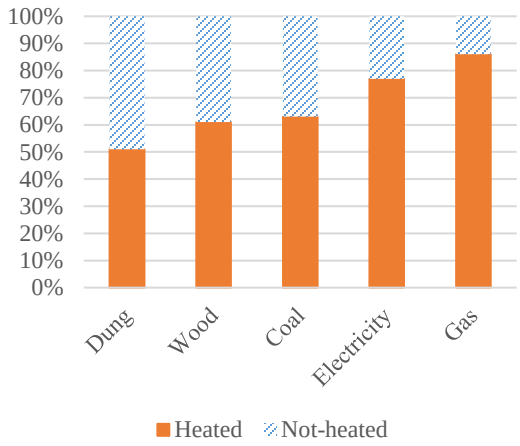


Figure 2.4: Share of rooms heated



Source: Authors based on World Bank, Technical Household Survey: Understanding Kyrgyz Heating Patterns, April 2016.

Chronic under-heating impacts women, children and elderly the most as they spend more time at home. In households without district heating, at times when women are home alone, they report not heating it to full comfort levels in order to save energy (costs). Some households indicate they limit the heating requirement by occupying only one room and closing down the rest of the house for the winter in order to reduce heating expenses. Women are also usually responsible for cooking and refueling the stoves, which makes them more exposed to indoor air pollution emanating from the stove – pollution caused by the low combustion efficiency of solid fuel. [25] To complete cooking tasks, women in Kyrgyzstan spend in total 2.3 hours a day, of which 1.7 h indoors and 0.6 h outdoors. [26]

About three-quarters of households outside of Bishkek also use their space heating stove for cooking. This enables households to accommodate at least some of their cooking needs during the winter months. In Bishkek, however, only 19 percent use their single home heating system for cooking purposes (Figure 2.5). This is *inter alia* due to the fact that the share of households using LPBs or electric/ gas heaters is much higher in Bishkek than in other urban or in rural areas. The choice of primary fuel for cooking varies quite a bit by location and season (Figure 2.6); in summer, only 1 percent of households continue to use their space heating device for cooking. About one third of households in urban areas and 16 percent in rural areas use separate coal/wood stoves for cooking during summer. Households that do not combined space and water heating use a dedicated water heating stove (27 percent) or an electric water heater (19 percent); however, this

[25] World Bank, Poverty and Social Impacts of Energy Reforms in the Kyrgyz Republic: Summary of Qualitative Assessment, 2014.
[26] Gemert et al, Effects and acceptability of implementing improved cookstoves and heaters to reduce household air pollution: a FRESH AIR study, 2019

share is much higher in Bishkek where 70 percent of the households use electricity for water heating.

Figure 2.5: Combined heating, cooking and/or water heating

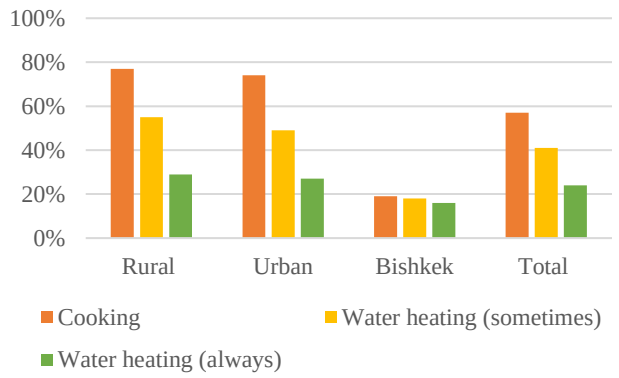
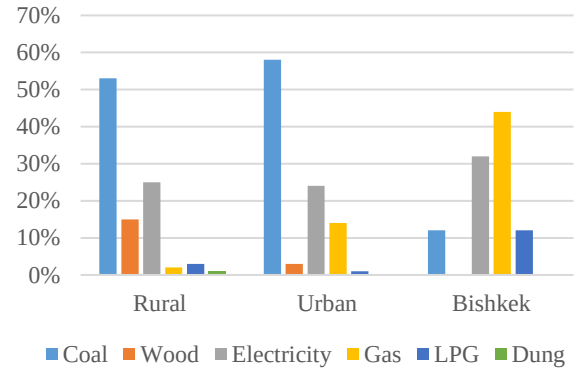


Figure 2.6: Primary fuel for cooking in winter

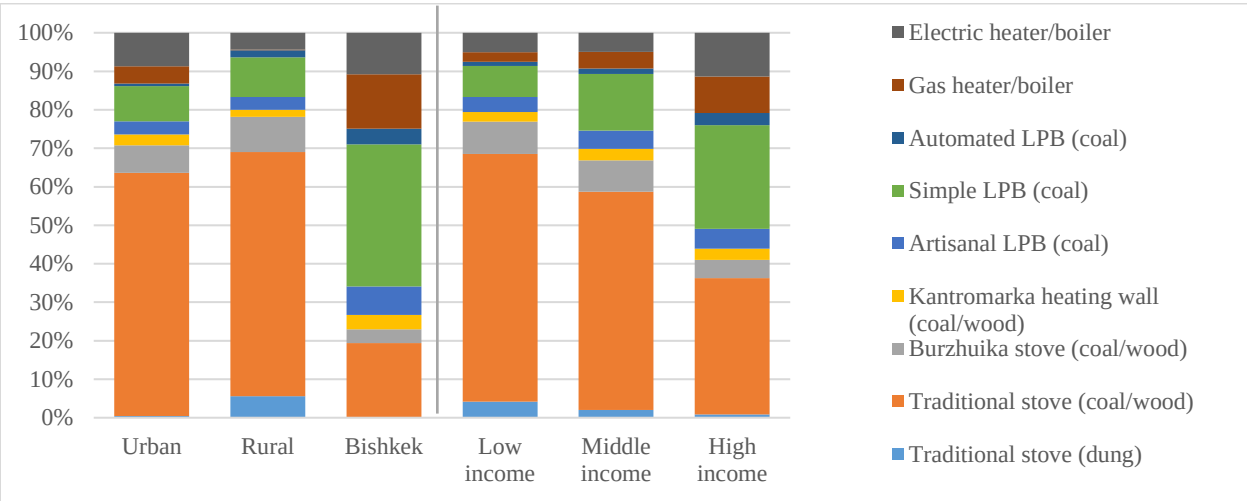


Source: Authors based on World Bank, Technical Household Survey: Understanding Kyrgyz Heating Patterns, April 2016.

2.2 Heating Equipment in Use

The majority of Kyrgyz households, especially among lower income segments, rely on traditional solid fuel-fired stoves as their primary heating equipment. Among households without access to district heating, close to two thirds in urban and rural areas and one fifth of households in Bishkek use a traditional coal-fired stove as their primary heating source (totaling about 532,000 households). The second most common heating systems are simple coal-fired LPBs, installed in 37 percent of households in Bishkek and around 10 percent in urban and rural areas, respectively (Figure 2.7).

Figure 2.7: Heating system by location and income level



Source: Authors based on World Bank, Technical Household Survey: Understanding Kyrgyz Heating Patterns, April 2016.

There is a variety of traditional solid fuel-fired stoves types in use. The simplest technologies are traditional coal, dung or wood stoves. The heating capacity of these stoves is usually large

enough for only one room. The heat is delivered by radiation and convection. The fuel is burned in a combustion chamber inside the stove, while hot gases escape through a chimney. In some cases, traditional stoves are connected to so-called heating walls which function both as a chimney and a heat exchanger that can radiate heat into two rooms. Thermal efficiency and emissions depend on the stove's combustion characteristics, but efficiency is generally low (25-40 percent efficiency measured on site). One function that users appreciate with traditional models is the stove's ability to cook and warm water at the same time. In addition, users often burn a combination of fuels, ranging from coal, to wood, garbage and tires. The 'Burzhuika' and 'Kontramarka' stove models are slightly different in their design from typical stoves but are also part of the traditional stove group with similar characteristics in terms of low efficiency and high emissions. The household survey showed that most traditional heating stoves have been in use for 11-14 years, therefore exceeding their expected useful lifetime of around 9 years.

Table 2.2: Examples of Traditional Solid-Fuel Heating Stoves

	Square iron traditional stove	**Round iron traditional stove**	**Burzhuika**	**Kontramarka**	**Built-in brick stove with heating wall**
					
Price range (US$)	35–70	35–140	70–280	No longer sold	60–200
Thermal efficiency (%)	Low: 25 High: 40	Low: 25 High: 40	Low: 45 High: 60	Low	Low: 25 High: 40
Other key features	Low quality and capacity (3–7 kW); frequent refueling required; heavy air pollution during starting and fueling; heats only 1 room		Better design and slightly higher fuel and combustion efficiencies compared to other models	Remnant of the past; some stoves have been converted to gas	Custom built at home by craftsmen

Source: CAMP Alatoo, Market Assessment on Suppliers of Heating Technologies in Kyrgyzstan, April 2016.

A wide range of LPBs is currently in use, especially among the middle- and higher- income households. About a quarter of households uses some type of LPB to heat their home, ranging from do-it-yourself type of LPBs (built by the user with/without the support of an engineer/welder), to simple commercial LPB (without automation) and fully automated systems, mainly imported from China and other countries. The household survey showed that, on average, the simplest LPBs have been in use for about 11 years, whereas the average age of all LPBs is about 6 years.

Table 2.3: Examples of Solid-Fuel LPBs

	Low-end	High-end	Heating/cooking models using coal and wood		
					
Price range (US$)	170–360	430–860	170–285	285–570	360
Thermal efficiency (%)	Low: 25 High: 50	70–80	Low: 25 High: 50	Low: 25 High: 50	Low: 25 High: 50
Other key features	Low capacity; frequent fuel loading; issues with compliance with standards	Semi-automated operation; large fuel reservoir; high cost; lack of spare parts	Low capacity; frequent fuel loading; issues with compliance with standards	Low capacity, frequent fuel loading; issues with compliance with standards	Poor-quality steel

Source: CAMP Alatoo, Market Assessment on Suppliers of Heating Technologies in Kyrgyzstan, April 2016.

2.3 Household Fuel Consumption and Heating Expenditures

On average, households using stoves consume about 2.6 tons of coal per heating season. Annual coal consumption for domestic cooking and heating needs in Kyrgyzstan ranges from 2.3 – 4.1 tons of coal (Figure 2.8). Although automated LPBs are more efficient than traditional stoves, their coal consumption (according to surveyed households) is reported to be higher. This supports the conclusion that aside from the efficiency of a heating system, a range of other factors determine how much coal is consumed, e.g. household income, heated area and condition of apartments/ houses, household composition and behavior, desired comfort level, the price of coal, etc. Average coal consumption per household in Kyrgyzstan is high compared with other countries using similar heating technologies, such as Mongolia, but located in climatic zones with a higher number of degree days.[27]

While monthly costs for heating in rural and urban areas are similar for all fuel-use patterns, costs escalate significantly in Bishkek depending on the fuel used. Specifically, monthly heating costs in urban and rural areas range between KGS 1,000-2,000 per month irrespective of the fuel-use pattern and income level. In Bishkek, costs vary from KGS 1,500-6,000 depending on the fuel used (Figure 2.9).

[27] Degree days are a measure used to determine the heating requirements of buildings, representing a fall of one degree below a specified average outdoor temperature (usually 18°C or 65°F) for one day. A higher number of degree days implies higher need for heating.

Figure 2.8: Annual coal consumption by type of heating technology

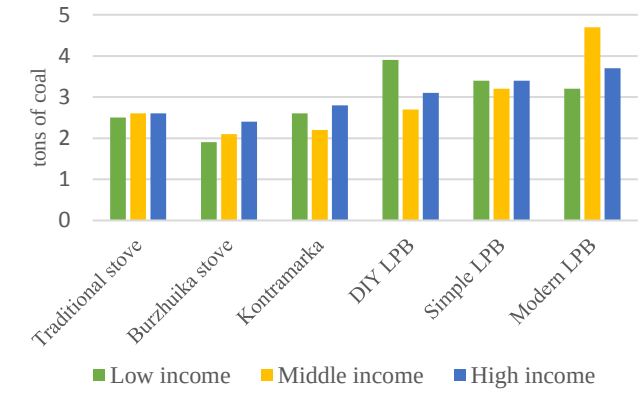
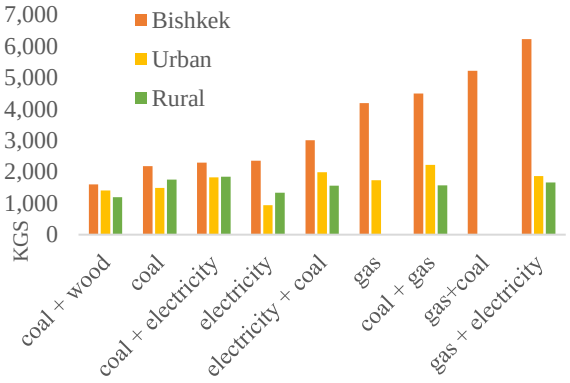


Figure 2.9: Monthly expenditures for heating by type of fuel used



Note: Exchange rate at the time of the survey (2016) is 70 KGS = 1 U.S. Dollar; DIY= do-it-yourself
Source: Authors based on World Bank, Technical Household Survey: Understanding Kyrgyz Heating Patterns, April 2016.

Households without access to district heating spend between 7 and 15 percent of their monthly expenditures on heating. For Bishkek residents, heating energy comprises 15 percent of total monthly expenditures, compared to 12 percent for other urban areas, and 8 percent for rural areas. As a share of total monthly expenditure per capita, poor households spend 12 percent for heating energy (mostly coal), compared with 9 percent spent by households in the middle-income tertial and 7 percent by the wealthiest (Figure 2.10). On average, 9 percent of household expenditures are spent on coal for heating (US$21 per month; 2016). Asked about this expenditure, 20-25 percent of households strongly agree and 50-70 percent agree that it is expensive to keep the house warm (Figure 2.11).

Figure 2.10: Heating expenditures

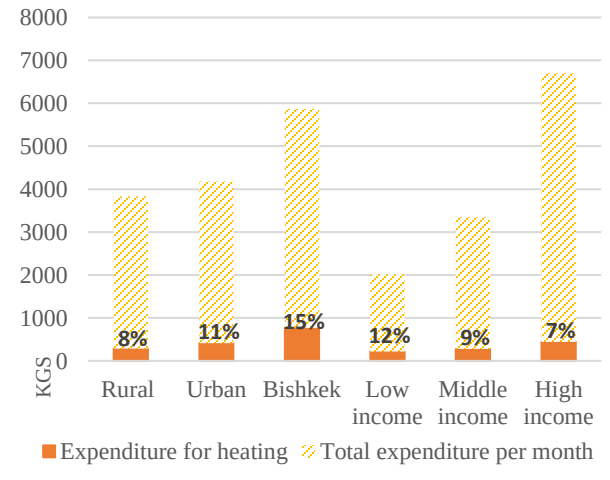
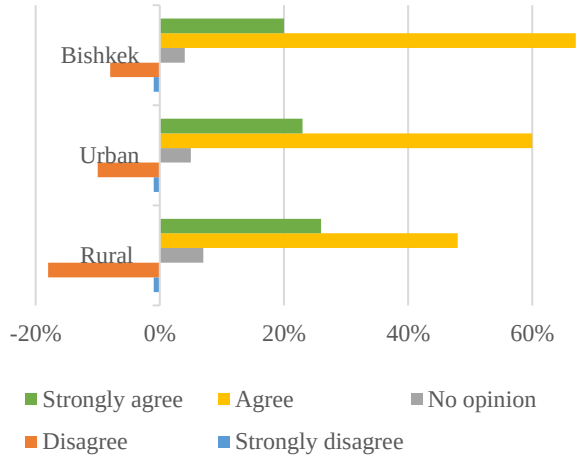


Figure 2.11: Household perception whether heating is expensive



Source: Authors based on World Bank, Technical Household Survey: Understanding Kyrgyz Heating Patterns, April 2016.

2.4 Household Perceptions and Willingness to Change

The large majority of households are satisfied with their heating stoves and LPBs in the 2016 baseline study. Around 70 percent of households across all locations are satisfied with their traditional stove for heating. This share is even higher for households using LPBs. By contrast, around 18 percent of households in Bishkek and 14-15 percent in rural and other urban areas are not satisfied with their stoves, with the highest being those living in Bishkek and using Burzhuika stoves (67 percent) or Kontramarka (35 percent). Because of the general satisfaction with current heating stoves or LPBs, the share of households interested in changing their heating system is relatively low: 29 percent of households using traditional stoves, 20 percent using Kontramarka's and 16 percent using Burzhuikas. One of the reasons for the unwillingness to change heating systems may be the lack of awareness of better performing heating options combined with affordability concerns and households' inertia when it comes to adopting new technologies.

Figure 2.12: 'I am satisfied with stove for heating' – household responses

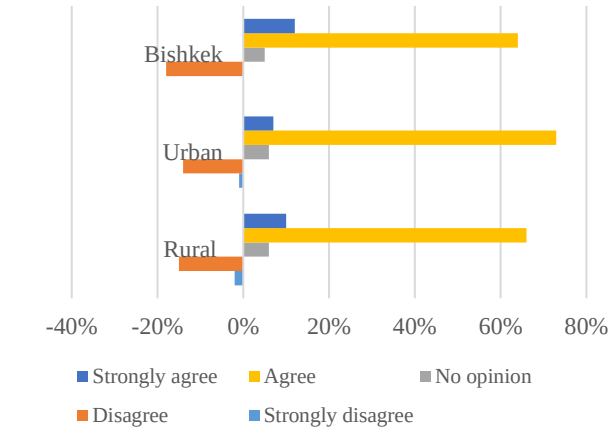
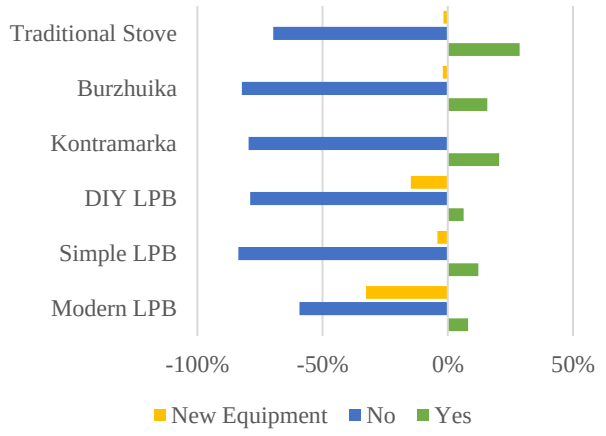


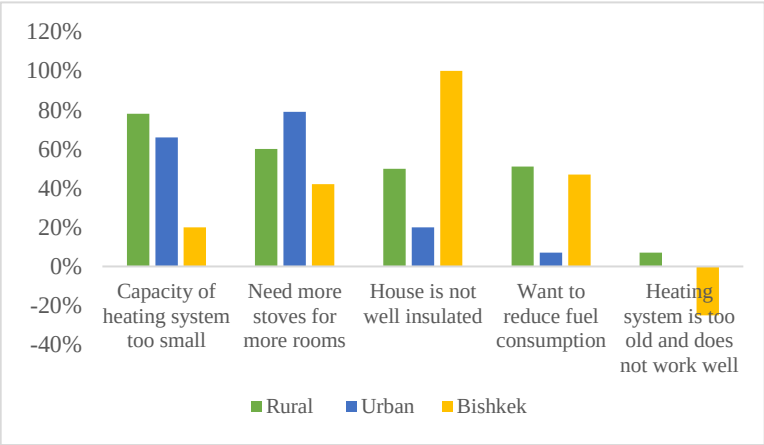
Figure 2.13: Willingness/ interest to change the current heating system



Source: Authors based on World Bank, Technical Household Survey: Understanding Kyrgyz Heating Patterns, April 2016.

A priority area for improvement is the stoves' capacity/ ability to adequately heat the entire home, particularly in urban and rural areas. In terms of responses to pre-identified issues for improvement, urban and rural households highlighted that the capacity of their heating system is too small and believed that additional stoves would be needed to heat their other rooms. Households in Bishkek identified the lack of adequate home insulation as a key issue, which is yet another challenge for ensuring a comfortable indoor environment. More than half the rural households and 47 percent of households in Bishkek agree that their current heating system uses a lot of fuel. On the contrary, only around 7 percent of other urban households agree with this statement. Regarding the age of the heating system in use, less than 7 percent of rural households consider their heating system to be old. Taking a more disaggregated perspective by heating system, two third of the households with a Kontramarka, 57 percent with a traditional stove and 43 percent with a Burzhuika agreed that their heating system is old. Households also reported that their traditional stoves, except for the Kontramarka and excluding LPBs, require frequent refueling.

Figure 2.14: Household perception on select issues



Around 70 percent of households living in urban and rural areas agree that indoor air pollution is a problem. In Bishkek, where more gas and electricity are used, 58 percent of households do not consider indoor air pollution a problem (Figure 2.15). Households in all three areas consider solid fuel–fired heating stoves to be a contributor to local air pollution, after municipal solid waste and motor vehicles, but only around one fourth of them consider that pollution to be a problem. When asked what heating solutions they would prefer to use and which would reduce air pollution, "clean stoves" was the primary response.

Figure 2.15: 'Is indoor air pollution a problem?' – household responses

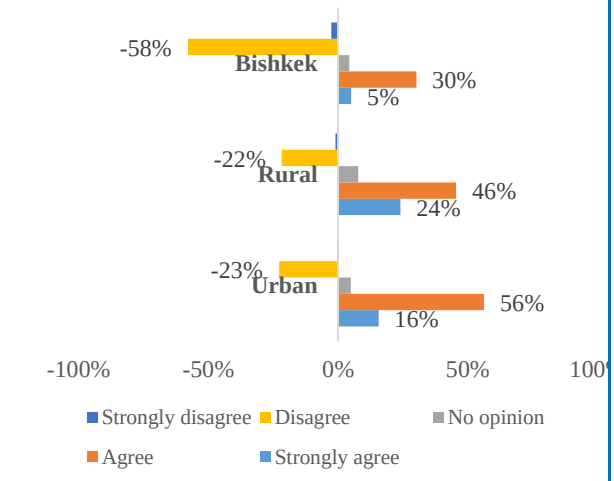


Figure 2.16: Smoke emittance from a traditional stove

Source: Authors based on World Bank, Technical Household Survey: Understanding Kyrgyz Heating Patterns, April 2016.

The priority for improvement is reduced fuel consumption. As shown in Figure 2.13 above, only a minority of households (12 percent in Bishkek and 25 percent in other urban and rural areas) might consider replacing their heating system. When asked which key features for improvement would interest them, the top priorities included lower fuel consumption, longer heat retention,

better quality and cost-effectiveness, and provision of high power heat soon after ignition (Figure 2.17). Other desired features highlighted included: a lower price, lower pollution, easy fire starting, and ability to both heat and cook.

Households interested in changing their heating system are willing to invest in low-cost, clean-burning, higher-efficiency stoves if they were made available. The stove features households are willing to pay the most for are reduced fuel consumption and having a longer-lasting fire. On average urban households outside Bishkek are willing to pay US$280 for a new heating system, while rural households would invest US$185. This means that households are willing to pay 10–12 months of their current fuel expenditures on a better heating system.[28] On average, HELE stoves cost around $200, which is close to the price range that households indicated they are willing to pay. By contrast, HELE LPBs cost significantly more than households are willing to pay for a space heater.

Figure 2.17: Priority Features Preferred by Households for New Heating Systems

Source: Authors based on World Bank, Technical Household Survey: Understanding Kyrgyz Heating Patterns, April 2016.

[28] Generally, respondents prefer to use cash to pay for their stoves, and only 5 percent have used a microfinance institution in the past. Among the respondents that reported having a bank account, more than 40 percent would be interested in using their phones to make mobile banking transactions, but only 7–23 percent are aware of this option.

Chapter 3. Stove Supply Market

This chapter examines key supply-side features of the solid-fuel heating stove market in Kyrgyzstan to map the current supply chain and examine the readiness of local producers to support a switch to HELE technologies. It begins with a market overview, including features of major supplier groups, market points, expansion potential and typical transportation/ installation arrangements. The chapter concludes with a short description on certification and performance issues.[29]

3.1 Supplier Features

Categories of local stove and LPB producers. Local producers of solid fuel-fired stoves and LPBs in Kyrgyzstan can be divided into three main categories:[30]

- *Artisans:* most stove producing metal welding/ artisan workshops are small and use simple tools for various welding works, e.g. hammers, grinders and welding machines. Few artisans specialize in stove production alone, typically selling other metal products as part of their trade (e.g., gates and doors), sold either along the streets, in shops or at market places (Figure 3.1).[31] On average, a workshop typically includes a master/owner, supported by 2-3 apprentices. The number of stoves and boilers sold per heating season varies from only a couple to up to 400 stoves and boilers per year. Based on the supply market survey, most artisan workshops have been in operation for about 12 years and are informal (i.e. without being a registered business entity with a trading license).
- *Specialized companies:* these are registered companies focusing on LPBs with a larger production capacity and specialized equipment not owned by a typical artisan's workshop. On average, specialized companies have been in operation for 14 years and employ 6 workers with 11 additional contractors on-call during peak times. They sell between 200 and 1,000 stoves/ boilers per heating season. All companies surveyed are registered and possess necessary licenses. Some of the specialized producers also export their products to neighboring countries (e.g. Kazakhstan, Tajikistan) and a few have had their products certified according to the Russian standard.

[29] Unless otherwise indicated, this chapter is based on World Bank–supported market research conducted by the nongovernmental organization CAMP Alatoo in 2016 and 2017 to assess the current stove supply market and related capacities (CAMP Alatoo, Market Assessment on Suppliers of Heating Technologies in Kyrgyzstan, 2016; and CAMP Alatoo, Summary report on the market research of stove suppliers, 2017), along with relevant market findings of the 2016 technical household survey.

[30] CAMP Alatoo, Summary report on the market research of stove suppliers, May 2017. The market report included a survey of 24 manufacturers located in Bishkek, Osh and Naryn, producing 42 different stove and boiler models.

[31] It should be noted that as a rule, socially vulnerable segments of the population purchase their stoves from such artisan producers.

- *Construction companies:* construction companies do not specialize in the production of stoves or boilers but make them at the request of customers (usually less than 100 boilers per year). However, they do have large production facilities, relatively large staff (on average 21 staff and 20 contractors on-call), adequate equipment and warehouses. Further, they are frequently not busy with construction activities during the stove-making season.

Figure 3.1 Illustration of Welders' Workshop in Stariy Tolschok Bazaar, Bishkek

Source: CAMP Alatoo, Market Assessment on Suppliers of Heating Technologies in Kyrgyzstan, 2016.

Local vending markets. Kyrgyzstan's primary market for selling solid fuel–fired stoves and LPBs is the Stariy Tolschok Bazaar in Bishkek. Some 40 manufacturers and workshops produce a wide range of products (Table 3.1), and most have retail shops at the bazaar. Each year, some 4,000–6,000 products are sold at the market, with the largest shops selling 300–400 units each. More expensive are imported models from Russia, China, Turkey and other countries are also available in select shops. Although stoves can be purchased year-round, autumn (September–November) is the peak buying period for households. There are numerous other markets where stoves are sold throughout Kyrgyzstan (e.g. Murok in Tokmok, Taatan Trade Center and market in Osh, markets in Naryn and Jalalabad), many selling both imported heaters/ boilers operating on a variety of fuels alongside locally manufactured products.

Table 3.1: Selected Solid-Fuel Heating Systems Available in the Marketplace

Picture	*Name*	*Key functions and features*
	**Cast iron stove**	Heat radiating from stove surface and other parts. Cast iron plates above the burning chamber used for winter cooking. Durable and can easily be transported and disassembled. Available only in Stariy Tolschok Bazaar in Bishkek. Can heat one 35m^3 room.
	**Round iron stove**	Handmade out of re-used metal pipe with a thickness of 5mm. A welded-in grid inside the stove separates the burning and ash chambers, each of which has a door. Volume depends on the size of the metal pipe. Can heat one 30 m^3 room.
	**Square iron stove**	Made of metal plates welded together. Price depends on the size and quality of the stove and thickness of the metal. Some have a cast iron top. No

		firebricks to absorb the heat generated. Doors do not close properly. Affordable, but has limited capacity (30m^3). Can be used for cooking.
	**Square LPB**	Similar in appearance to square iron stove, but has a more complex interior design. The outer shell consists of metal plates with a cavity within which the water circulates. Thermal convection, feeding 8–10 hot water radiators. Fragile radiator system, with doors that do not close properly. Can heat more than one room (500m^3).
	**Sapog**	Best-selling boiler. Rectangular iron cooking stove with integrated water heating system. Some have a cast iron cooking surface used for both cooking and when closed, heating via convection. No sealing on doors. Usually located in a separate room or kitchen with water pipes passing through radiators for heating adjacent rooms.
	**Chinese stove**	Solid fuel burns in the combustion chamber and the flame heats the upper iron rings on which meals can be prepared. Found only in Taatan Trade Center in Osh (four points of sale). Compared with local products, has more precise control of the air supply to the combustion chamber. Doors close tightly and are fitted with a pressure relief valve and temperature indicators.
	**Prometey**	Heat only LPB. One model is designed like the square iron stove with an integrated water heating system; the other without water. Above the burning chamber are a set of water pipes. Compared with other designs with one solid iron plate above the burn chamber, pipe system has a larger surface, allowing more effective heat absorption. Proper sealing of doors for controlled burning.
	**Tansu stove**	High-quality, square iron LPB with an integrated water heating system. Heat only boiler (HOB). Functions on same principle as the Prometey. A variety of smaller household models available. Also requires a circulation pump and pressure tank. Customers mainly in Bishkek.
	**Brick stove**	Regular and fireproof bricks, available in Bishkek and Osh, are used for stove construction. Locally made metal parts include doors and grates. Small quantities are not sold by brick factories; craftsmen mainly re-use old bricks for construction. Households purchase materials and invite stove masters to do in-home installation.

Source: CAMP Alatoo, Maret Assessment on Suppliers of Heating Technologies in Kyrgyzstan, April 2016.

Potential to expand capacity. Locally-produced stoves and boilers are usually designed by the manufacturers, with a few exceptions (e.g. designs by client or other manufacturers from Russia or Kazakhstan). There are a number of typical stove/ boiler designs (see chapter 2, Figure 2.7 and Table 2.2) with additional designs being variations of the same type. Based on the manufacturer survey of 24 companies/ workshops, the majority indicated a production capacity of stoves/boilers based on completely new (third party) designs of between 20 and 1,000 units per season with an

expected production duration of 5-12 months. An order for new designs would require for most workshops/ companies a down-payment of at least 50 percent, accompanied by an expansion of the production facilities through investments in a stock of material and additional skilled employees. More than 70 percent of the surveyed manufacturers stressed that they may not have access to affordable financing for that purpose. They expressed concerns about finding customers.

Based on the disaggregated findings of the 2016 and 2017 market assessments, specialized companies are likely to have the largest potential for producing HELE stoves and LPBs. In most cases, they are developers of own stove designs and possess the relevant knowledge. They use various marketing technologies to promote their products, produce stoves and boilers in advance, and have storage facilities. Most importantly, they have the equipment needed for rapid production of high-quality stoves and boilers. Artisanal producers lack such equipment, as well as access to skilled labor, scale of production and financing. While construction companies have their own basic equipment, large production facilities, and access to financing (often from deposits), they are unfamiliar with some of the skills needed to produce HELE stoves and boilers intended for sale to the general public.

Limited interest has been found in offering HELE technologies without a scalable program of support. At the time of the supply market surveys (2016 and 2017), local manufacturers expressed limited interest in offering HELE stoves and LPBs although after seeing some demonstrated, acknowledged their benefits in terms of fuel efficiency and pollution reduction. Reasons cited for this reluctance included: (i) focusing on meeting the immediate needs of the existing clientele; (ii) HELE models were perceived to be more complicated and costly to produce; (iii) some lacked appropriate equipment and materials for producing HELE technologies; and (iv) insufficient demand/ awareness by households about HELE stoves and LPBs. In case of an HELE stove/ boiler incentive program, close to 90 percent of the surveyed manufacturers were in principle interested in participating (i.e. but only willing to produce HELE stoves against confirmed orders). The situation has slightly changed as a result of the pilot trial program implemented in 2016-2019 (see Chapter 4), with stove producers gaining familiarity with HELE designs and a limited number of orders having been received by producers from private individuals on the basis of the demonstration stoves installed under the TA.

Stove transportation and installation. According to anecdotal evidence, most households transport purchased stoves themselves (given the relatively high transportation costs in case of third-party involvement). Specialized companies usually include delivery as part of the stove/ boiler costs in their operational district; beyond their regular destinations, they can deliver products for a fee. With respect to installation, stove/ boiler producers usually have partnerships with trusted local installers

living in their communities. However, it is up to the households to organize and pay for installation. Based on data from the pilot trial (see Chapter 4), transportation and proper installation can add up to 30 percent of total stove costs. This fragmentation of the stove supply chain with its cost structure represents an important challenge for designing/ implementing scalable results-based financing and delivery mechanisms. The range of production costs found during the trial was KGS 14,500 (US$ 207 at an exchange rate of 69.9) for the two best adapted ELE stove models (KG2.5 and KG4.4), increasing to KGS 24,500 (US$ 350 at an exchange rate of 69.9) for the ELE LPB model (KG5.2) piloted; additional costs for new chimneys are in range of KGS 2,000 (US$ 29) and installation KGS 2,400-3,500 (US$ 34-50).

Coal and dung supply. As shown in Figure 1.1, more than 60 percent of all households in Kyrgyzstan use coal as primary heating fuel. On average, households use 2-4 tons of raw coal annually. Coal is available at specialized wholesale locations/ deposit areas, and is sold to households at markets and local fuel sale points, either in bulk or by the bag. Home delivery is offered for an additional charge. The representative household survey show that more than half the households use coal sourced from three local mines: Sary-Mogol, Kara-Keche and Kokyangak, Tash Kumur. The price of coal varies quite a bit throughout the country, depending on the quality, size, season and location.[32] Coal is usually provided in large random-sized lumps which must be split into smaller pieces for use in stoves. However, in some locations, coal is also sold as dust, which is difficult to burn properly in domestic stoves. Dung is a common heating fuel especially in rural area, as shown in Chapter 2. The most popular format for dung is the so-called dung cake; these are stocked by individual households and sold only infrequently.

3.2 Certification and Performance

While some regulations pertaining to the performance and related inspection of LPBs and buildings exist, enforcement is *inter alia* hampered by a lack of testing methodologies, laboratory testing facilities,[33] and absence of a certification system and rulebooks guiding approved performance of technical equipment. As a result, the market for small capacity individual heating stoves remains largely unregulated and houses smaller than 150 square meters are rarely inspected. Some products on the market are certified to the Russian, Kazakhstan or Czech Republic National Standards. Out of 24 surveyed manufacturers producing 42 different stove and boiler models, only two producers indicated to possess certificates for seven different boilers,[34] with all such certifications having been obtained outside the country.

[32] Transport cost contribute a significant share of the coal retail price in some locations.

[33] For instance, with respect to LPBs, testing usually only involves checking for construction quality under elevated water pressure due to lack of adequate testing facilities and methodologies. The only relevant National Standard is for "boilers under 100 kW" and is not suited to domestic appliances.

[34] CAMP Alatoo, Summary report on the market research of stove suppliers, May 2017.

Chapter 4. Summary of key findings and challenges from a 3-year pilot on high-efficient, low-emission stoves

In 2016-2019, the World Bank with the assistance of three multi-donor Trust Funds[35] supported the development and implementation of a pilot trial of improved heating technologies in the Kyrgyz Republic. The objective of the pilot was to: (i) support the development and testing of improved heating stoves in select locations; (ii) build local awareness about the benefits of switching to better heating technologies; (iii) develop local market capacity to design and install such improved stoves; and (iv) inform the design of a scaled-up pilot program. Some of the newly developed heating technologies were highly improved (benefitting also from advanced product development programs in other countries)[36] and are referred to as High Efficiency, Low Emissions (HELE) coal-burning appliances.[37]

The pilot was implemented with the support of CAMP Alatoo, a non-governmental organization (NGO) based in Bishkek, and in part supplemented by the EU-funded Fresh Air Program led by the Ministry of Health. The Kyrgyz Community Development and Investment Agency (ARIS) was also involved in the pilot as designated implementing entity for the scale-up program that was to be financed under the World Bank Heat Supply Improvement Project. The pilot was executed in two phases:

- *Phase I (2016-2017)* involved the participation of 51 low income households selected from about 10 villages located in four oblasts (Naryn, Chui, Jalal-Abad and Osh) and the installation of three heating models; and
- *Phase II (2017-2018)* involved 25 low income households from 10 villages in Naryn where two heating models were installed.

This chapter provides a summary of the baseline heating situation in the four pilot regions and the pilot household selection process, followed by a description of the stove selection, manufacturing and installation process. The chapter concludes with a summary of results achieved.

4.1 Baseline heating situation and pilot selection approach

Prior to the pilot trial, a baseline assessment of the current heating situation and related household strategies was conducted in the four selected oblasts (Naryn, Chui, Jalal-Abad and Osh), complementing the nation-wide household survey (see chapter 2). The focus regions were selected based on considerations related to climate, heating patterns and culture, as well as geographic focus

[35] The pilot trial was supported by trust fund resources from the Energy Sector Management Assistance Program (ESMAP), the Central Asia Energy-Water Development Program (CAEWDP), and a Multi-Donor Trust Fund related to the Community Support Program under the CASA-1000 Project.

[36] Most importantly, the Ulaanbaatar Clean Air Project (UB-CAP) which worked in close cooperation with this Pilot.

[37] For wood and dung fueled models, significant efficiency improvements were also achieved but not to the same degree as for the coal fired models.

of key implementing partners, notably the EU-funded Fresh Air program and the CASA-1000 multi-donor Trust Fund. A total of 93 households were surveyed using semi-structured questionnaires to collect information on their fuel consumption, heating and cooking practices, housing conditions, satisfaction with and condition of existing heating stoves and willingness to participate in the pilot trial.

Overview of Current Heating Situation[38]

The majority of households in the four pilot regions rely on coal as their primary heating fuel, complemented mainly by dung. The most intensive use of coal is found in Chui (100 percent), Osh and Jalalabad (93 percent),[39] *inter alia* owing to those regions' proximity to urban areas. In Naryn, Kyrgyzstan's poorest region, dung is a primary heating fuel (45 percent) as a result of livestock breeding in upland rural areas, along with coal (55 percent). In terms of secondary heating fuels, Naryn has the most diversified sources, including dung (52 percent), wood (24 percent),[40] and electricity (7 percent). For Chui, secondary heating fuels include dung (23 percent), electricity (14 percent), and wood (9 percent), while households in Osh and Jalalabad rely mainly on dung (40 percent) as secondary heating fuel. These heating fuel patterns are similar to the findings of the nation-wide survey.

Figure 4.1: Primary heating fuel

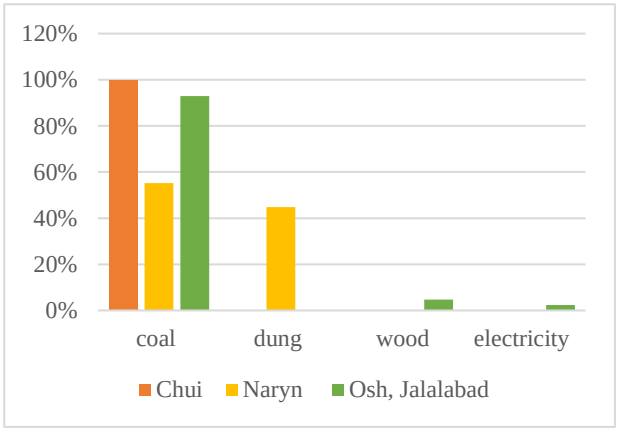
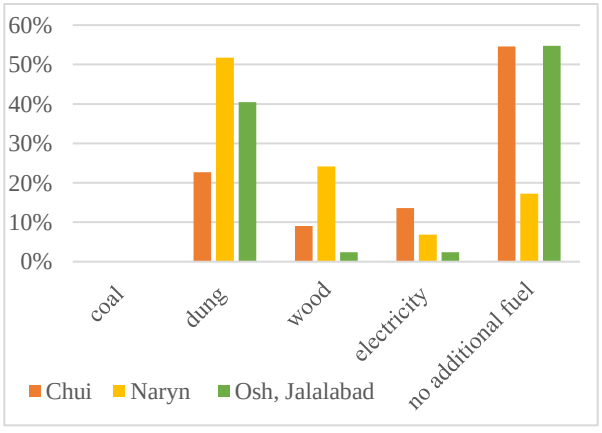


Figure 4.2: Secondary heating fuel



Source: CAMP Alatoo, Baseline Report: Assessment of households' stoves and heating strategies in Osh, Jalalabad, Naryn and Chui Oblast, October 2016.

The large majority of stoves and LPBs in use at the time of the pilots have been in operation for 15-30 years. Those in very long service were usually Russian stoves made from cast iron and presented as a wedding gift from the groom's family to the bride – a popular local tradition. More

[38] All findings and data presented in this section are based on: CAMP Alatoo, Baseline Report: Assessment of households' stoves and heating strategies in Osh, Jalalabad, Naryn and Chui Oblast, October 2016, unless otherwise indicated.

[39] The transport costs from coal-mining fields determine, in large part, the price of coal. For Osh and Jalalabad, coal prices are comparatively higher than in Chui and Naryn because of the harsh transport conditions through mountainous terrain in the neighboring Batken oblast.

[40] In Naryn, 13 percent of wood consumers collect it freely from the surrounding environment.

than 90 percent of households in Naryn, Osh and Jalalabad use traditional brick or steel stoves, most of which have exceeded their useful lifetime a long time ago. Around 55 percent are connected to a heating wall while the remainder are directly connected to the chimney. In Chui, around 82 percent of surveyed household use LPBs, while the remainder use ordinary brick stoves. Over half these LPBs and stoves were installed more than 11 years ago. The region-specific results indicate a higher share of heating walls in use and much older age of equipment compared with the nation-wide survey averages.

The old and traditional stoves require frequent refueling throughout the day, affecting comfort levels in homes and users' – especially women's – time allocation. The number of heating hours per day is influenced by weather conditions, fuel burn time and economic decisions, among other factors. Frequent refueling of stoves is an issue mentioned in all four oblasts. The causal factors include fuel type and quality, along with stove construction, operation and maintenance. In Naryn, where winters are especially harsh, virtually all families heat their homes for 16 hours or more, requiring the large majority to refuel their stoves up to 16 times per day. In Osh, Jalalabad and Chui, where reliance on coal is higher and daily heating hours shorter, 71 percent and 64 percent of households, respectively, report a 2–3 hour burn period for the stove and therefore less need for refueling activity.

Figure 4.3: Heating hours/day

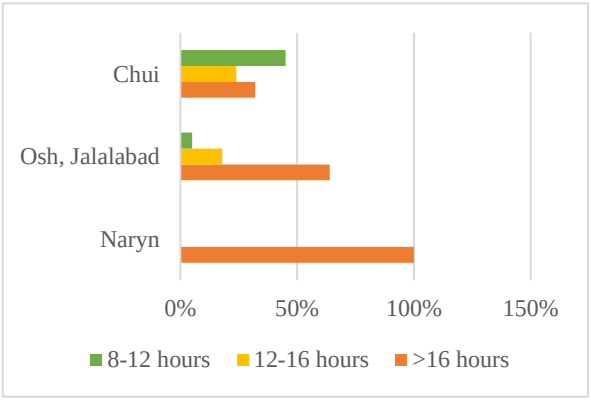


Figure 4.4: Perceived fuel burning period

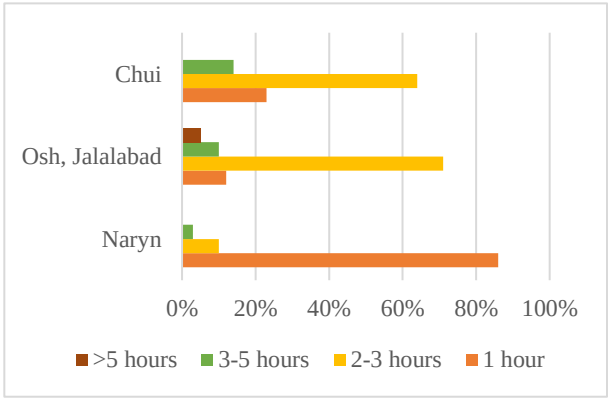
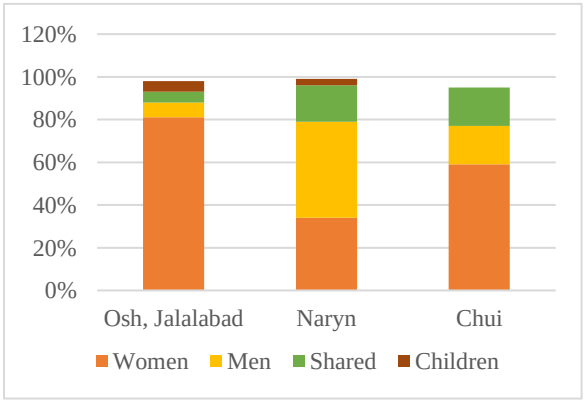


Figure 4.5: Heating responsibilities

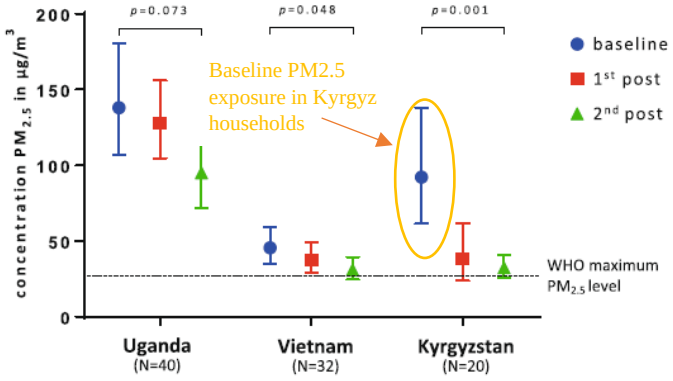


Source: Authors based on CAMP Alatoo, Baseline Report: Assessment of households' stoves and heating strategies in Osh, Jalalabad, Naryn and Chui Oblast, October 2016

In many households, women are responsible for keeping the house warm. In the majority of households in Osh, Jalalabad and Chui, women are responsible for heating, i.e. kindling the fire and keeping the house warm throughout the day. In Naryn, men are mainly responsible for heating. Virtually all of the stoves in Naryn and 95 percent of the stoves in Osh and Jalalabad are also used for cooking and water heating. In Chui, around two third are also used for cooking and close to 75 percent for water heating.

The majority of households in the pilot regions recognize the link between smoke emitted from their heating stoves in poorly ventilated rooms and symptoms of respiratory illness. The great majority of households (82-95 percent) notices smoke entering the home especially when kindling the stoves in the morning and recognize that the smoke affects indoor air quality and causes respiratory problems (e.g. coughing) along with irritated eyes. The high baseline concentration of particulate matter (notably $PM_{2.5}$) in the air has also been confirmed through measurements conducted by the Fresh Air program in 20 selected households (Figure 4.6).

Figure 4.6: Exposure comparison mean values $PM_{2.5}$

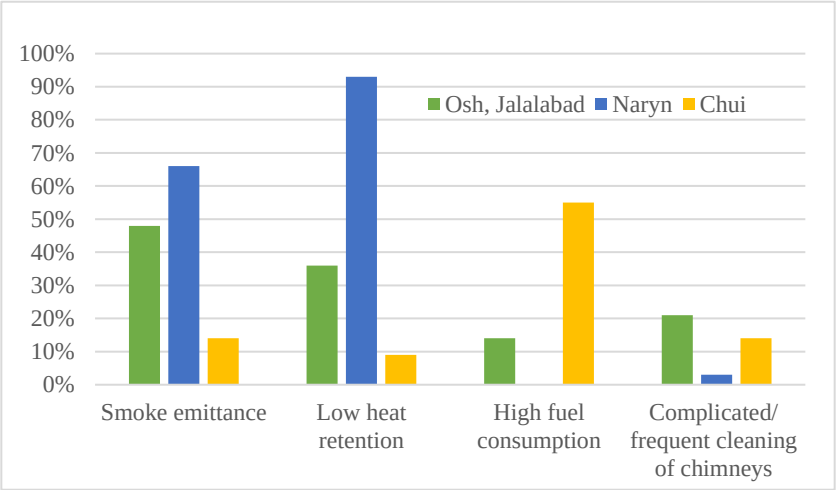


Source: Gemert et al, Effects and acceptability of implementing improved cookstoves and heaters to reduce household air pollution: a FRESH AIR study, 2019

Figure 4.7: Emissions from a traditional Burzhuika stove

In the pilot regions, householders' priority concerns with the current performance of traditional stoves include fugitive smoke, low heat retention and high fuel consumption. Priority concerns in terms of current stove performance differ quite a bit by oblast: high fuel consumption is a main concern for households in Chui that are highly dependent on coal and spend the largest average amount per heating season; households in Naryn, exposed to harsh climatic conditions during winter, cite the low heat retaining capacity of their stoves as their main concern; in Osh and Jalalabad, leaking smoke dominates the list of issues noted, followed by low heat retention. It is interesting that, in spite of these complaints, only about one third of the surveyed households considered the overall performance of the stove "unsatisfactory". When it comes to the prioritized characteristics of new/ improved stoves, desired top features included: cooking function, fuel type (i.e. coal or dung, respectively) and a high heating efficiency.

Figure 4.8: Priority issues impacting stove performance



Selection of Pilot Households and Test Stoves

Selection of households. During Phase I of the pilot (2016-2017), 51 out of 93 low-income households surveyed were selected for participation using a cluster sampling method together with socioeconomic and technical eligibility criteria. These included: availability of a social passport granted by local authorities confirming low-income status according to local regulations; no major source of thermal losses of the building envelope (e.g., resulting from roof damage, broken windows or faulty doors); use of solid fuel-fired heating stoves or small LPBs as the primary heating appliance; and a strong willingness to participate in the pilot trial and provide feedback during the monitoring period. During Phase II of the pilot (2017-2018), the selection of 25 low-income households applied the same selection criteria using a similar cluster sampling method. The main difference was that the household eligibility verification and selection process was closely coordinated with ARIS, testing the proposed operational arrangements and related templates designed for larger scale replication under the Heat Supply Improvement Project. Accordingly, community information campaigns were organized, designated focal points from ARIS and local authorities were involved and household eligibility was verified using standardized checklists. For all selected households, results were monitored in terms of household satisfaction, fuel consumption, and refueling frequency. Exposure to indoor air pollution was monitored for some of the households selected in Phase I. Measurements administered by the Fresh Air Program were implemented by the International Primary Care Respiratory Group.

Approach and eligibility criteria for HELE stove technologies. In August 2016, a call for proposals was issued to stove producers and suppliers in Kyrgyzstan to submit models for the pilot trial that met required criteria: to qualify, the improved heating technologies had to use solid fuels (i.e., coal, dung and/or wood) and were required to have an overall thermal efficiency of at least 70 percent, a peak heating capacity of 6–30 kW, and satisfactory safety performance and emissions reduction, as qualitatively assessed relative to the baseline products. None of the models submitted

met these criteria, owing to the lack of locally produced, clean-burning and fuel-efficient stoves and simple LPBs.

Development of locally produced prototypes. As a result, comprehensive technical assistance and capacity building was provided to help develop prototypes for the local manufacture of models that met both the eligibility criteria of the pilot and the heating needs of the selected low-income households. Five prototypes were developed based on experiences in Mongolia and Tajikistan, and adapted to the Kyrgyz social context to take into consideration the local availability of fuels, materials, tools, skills as well as heating and cooking practices. The latter involved findings from the national and local baseline surveys conducted in 2016, taking into account cooking and water heating functionalities, fuel availability, average heated area of low-income houses, etc. From the five prototypes developed, three were selected for the pilot trial in Phase I and two in Phase II. All of the prototypes went through several rounds of technical modifications to reflect early household feedback, lessons learned, and various challenges encountered during implementation. A more detailed description of technical aspects of the HELE technologies deployed is provided in the 2019 World Bank Report "Advancing Heating Services Beyond the Last Mile: Central Asia Pilot Experience with High-Efficiency, Low-Emissions Heating Technologies".[41]

Testing of prototypes and selected stoves. The performance of selected prototypes was tested in the BEST Laboratory of the Agricultural University of China following a contextual test protocol developed in accordance with Kyrgyz heating patterns and with concurrent pre- and post-installation measurements and visual inspections. The three main prototypes, a short description and deployment timing/ locations are provided in Table 4.1 Key results are presented in the next section 4.2.

Table 4.1: ELE heating prototypes developed and installed as part of the pilot trail

Prototype	**Description**	**Phase**	**# of stoves installed per location**		
			Naryn	**Osh, Jalal-Abad**	**Chui**
	**Model KG2.5**, burning primarily dung/ wood with cooking function and average thermal efficiency of 80%.	Phase I	10	-	-
		Phase II	10	--	--
		Total	**20**	-	-
	**Model KG4.4**, crossdraft coal-gasifier heating stove with cooking function and average thermal efficiency of around 80%.	Phase I	10	19	1
		Phase II	10	-	-
		Total	**20**	**19**	**1**
		Phase I	-	1	10

[41] There is also a Live Wire publication about the technologies available here.

	**Model KG5**, LPB, burning coal without cooking function with average thermal efficiency of around 70%.	Phase II	-	-	-
		Total	**-**	**1**	**10**

4.2 Implementation of the pilot trial: Challenges and Benefits

Manufacturing, installation and operation of stoves

Manufacturing of selected HELE stoves. Considering international experience from other clean cooking and heating stoves programs, the pilot trial had a strong focus on the objective of maximizing local capacity building and cultural inputs when developing HELE technologies to enable a transformational impact on the market. To this end, extensive technical assistance was provided to local producers of stoves throughout the pilot involving:

- Regular outreach to and consultations with numerous stove producers and suppliers, large and small including demonstrations of HELE stoves and their related benefits to build enthusiasm for the project;
- Free 2-day training courses for producers and installers of stoves, including the theory of HELE technologies, operation and hands-on assembly of stoves (see Box 4.1 for more detail);

- Provision of open-source designs for three HELE models (KG2.5, KG4.4, and KG5.2 and KG5.3) and step-by-step stove production manual for selected prototypes; [42]
- Interactions with local cast iron foundries, refractory brick vendors and metal cutting and shaping businesses; provision of drawings, 3-D models and assistance in the automation of plasma cutting the parts.
- Hands-on support by local consultants to more than 25 producers in the manufacturing of HELE stoves.

[42] CAMP Alatoo: Energy efficiency publications. Source: http://camp.kg/publikacii-i-otchety/publikacii-camp-alatoo.html

Box 4.1: Training program for HELE stoves and LPBs

Starting in 2016, the CAMP Alatoo team organized series of trainings on the manufacture and installation of HELE stoves and LPBs, in locations spanning Bishkek and Osh cities, Talas and Naryn oblasts, and Ak-Talaa, Alay, and Nookat rayons. During 2017-19, 11 trainings were held, attracting around 200 participants. In addition to professional stove producers, the sessions also drew students of the bioengineering course at the Kyrgyz National University. Announcements for trainings were made public on the CAMP Alatoo website (http://camp.kg/news/7/365.html), social networks, and Facebook, and via direct solicitation of known stove professionals.

The goal of the training program was to introduce the concept of HELE stoves to producers and installers and support the development of a local supply market for energy-efficient and clean heating stoves. The technical designs for various types of heating stoves and LPBs developed under the pilot were distributed at the training sessions under open access principles. The designs remain available on the CAMP Alatoo website and any interested person can download the drawings and make their own energy-efficient stoves (http://camp.kg/publikacii-i-otchety/publikacii-camp-alatoo.html)

In a process of continued improvement and refinement based on feedback received from producers, installers and users, two models of heating stoves (KG2.5 v1.5 and KG4.4) and two LPB models (KG5.2 and KG 5.3) emerged as best adapted to the local market. Technical guides on how to manufacture these stoves and LPBs, test for compliance with the technical specifications, install and operate them were developed and finalized with feedback received.

The two-day trainings were based on a combination of theory and practice and included step-by-step hands-on assembly and welding of stoves and LPBs using 3-dimensional visualization software tools (Solid Works and AutoCAD). The advantages and complexities of HELE stoves and boilers were presented and the procedure and sequence of positioning of bricks inside the stoves and methods of cutting bricks explained to generate understanding of the energy-efficient combustion process. Further, the steps for stoves ignition using photographs and practical tips were discussed. At the end of the assembly process, participants of the trainings were shown how to take measurements of the proper functioning of the stove (high efficiency). After the trainings, all drawings, technical specifications, production and installation procedures were distributed among participants.

Production challenges. Despite the early market surveys (see Chapter 3) and capacity building activities, supply-side challenges persisted and were underestimated during the early stages of the pilot. On the production side, key challenges encountered included: (i) lack of local capacity in developing and adopting HELE technologies and awareness about related benefits; (ii) relatively fragmented stove market with many small, artisanal welding workshops, separate installers and a limited number of cast iron and brick suppliers required for the production of prototypes to provide the required dimensions and quantities of stove components; (iii) a separation between producers and installers located in the countryside; (iv) as a result, the need for a 'market facilitator' organizing assembling and installation of stoves; (v) higher production costs due to relatively small quantities of components needed for pilot trail and novelty of dimensions/ designs; (vi) ongoing need for adjustment of a design evolving to accommodate customer preferences, local materials and production know-how; and (vii) initial production mistakes and imprecisions during stove manufacturing impacting stove performance and operations. This experience led to the creation of

a well-documented, four-stage training, production, installation and inspection protocol.[43] Specific measures undertaken to help address these challenges are summarized in Table 4.2 below.

Installation of stoves. Installation of the selected HELE stoves was done by professional teams that had received training on these products. To ensure adequate performance and safe operation of the new stoves, installation in some households also included the reconstruction of a new heating wall if the existing one was damaged or inadequate in some manner, the replacement of leaking chimneys, the dismantling of the old stove and the installation of required water pipe connections for LPBs. As part of the technical assistance package, detailed manuals were developed dividing the work into four separate stages: (Document 1) approval of a manufacturer based on their demonstrated capacity to manufacture to specification; (Document 2) inspection of all products leaving the workshop; (Document 3) installation manual for the different stove and LPB models, incorporating the technical and safety requirements for chimneys in line with national or international requirements; (Document 4) independent inspection of the installation by a professional, confirming its proper function and the adequate transfer of necessary operating skills to the new owner. The key challenges for installation of the stoves included the following: (i) during monitoring, it was discovered that HELE models are not well suited for connection to a heating wall. This required ex-post modifications to directly connect stoves to chimneys; (ii) the condition of many stove connections and chimneys in the houses of low income families was found to be poor. Excessive extraction of heat results in condensation and increases the leakage of smoke into the home; this was resolved by the installation of completely new chimneys; (iii) many households refused to have existing chimneys or heating walls replaced even though the installation and material would have been provided for free; and (iv) in several cases, especially early on, the quality of installation works was found to be sub-optimal and requiring subsequent remediation.[44] Not only was the suite of stoves being developed, the pilot revealed the need for the development of installation requirements and guidance that would permit expansion at a national scale. An illustration of installation results is provided in Figure 4.9.

[43] CAMP Alatoo, various production and installation reports, 2017-2019; CAMP Alatoo, Final Monitoring and Evaluation Report, Assessment of the efficient stoves performance in the pilot households for the period 2016-2019, 2019.

[44] CAMP Alatoo, various production and installation reports, 2017-2019; CAMP Alatoo, Final Monitoring and Evaluation Report, Assessment of the efficient stoves performance in the pilot households for the period 2016-2019, 2019.

Figure 4.9: Before and after comparison of stoves installed in Naryn Oblast

Before

After: Model 2.5 installed in Naryn

Before

After: Model 4.4 installed in Ak-Talaa

Source: CAMP Alatoo, A summary report on manufacturing and installation of stoves, 2018.

Operation and maintenance of stoves. During installation and monitoring, households received training on the proper operation of the stoves and the appropriate quantity, quality, and sizing of the fuel to be used. For each of the three stove models, household operational manuals were developed and distributed to the participating households, complemented by easy to read, illustrated 'summary posters'. Despite these efforts, proper operation of the stove by users remained one of the key challenges during the pilot program. Specific examples of challenges encountered on the end-user side included:

- Many households did not properly kindle the fire, especially early on, impacting the durability of some parts of the stove and its performance during ignition (slow lighting).
- A few households changed the structure of the stoves or LPBs without understanding how it functioned, with a negative impact on safety and/or performance.

- A reliable supply of coal was a recurrent issue, aggravated by price fluctuations on the market which impacted households' ability to find affordable fuel supply. In Naryn, for instance, during the winter 2018, coal was only sold starting from the middle of December while the heating season started in mid-October. As a result, households had to resort to alternative fuel sources, such as dung, tires or other fuels (including burning garbage), to keep their homes warm. As the HELE stoves were designed for specific fuels, this impacted their performance and resulted in the temporary or permanent discontinuation of some KG4.4 models and re-installation of the traditional stove, which was perceived to operate better on any non-coal fuel. The single-fuel feature of the stove was subsequently highlighted as one of the key challenges by households along with the need to use good quality and correctly sized coal.
- Some households had moved after receiving the HELE stoves, passed it on to family members (dismantling and re-installing their original device), while others sold it for a variety of reasons.
- Due to frequent and time-consuming need for cleaning the LPB KG5, almost all households discontinued its use; out of 11 installed boilers, only 1 remains in use.[45] This issue was addressed comprehensively in the later versions of the LPB model, culminating in the model KG5.3.3.[46]

Discontinued use of HELE stoves for various reasons. Specific measures undertaken to help address above indicated manufacturing, installation and users challenges are summarized in Table 4.2 below. Despite these measures, during the last monitoring round (conducted in spring 2019) households had discontinued (either temporarily or permanently) the use of 42 out of 76 stoves installed. The most important reason cited for the discontinuation was not a functional issue but the lack of a reliable coal supply in some areas in Naryn oblast and/or its cost. Unlike traditional stoves, the performance of HELE models is sensitive to the use of proper fuel, as indicated above. The second reason was the discontinued use of 10 LPBs which were installed during the first phase of the program and discontinued due to design flaws relating to the clogging of the upper part of the boiler with fly ash, resulting in the need for frequent cleaning and related emittance of smoke.[47] Improper operation may also have been a significant factor when the unit was installed in a home above 80m^2.

[45] *Ibid.*

[46] This evolution is described in detail in World Bank (2019) referenced above.

[47] CAMP Alatoo, Final Monitoring and Evaluation Reports: Assessment of the efficient stoves performance in the pilot households for 2017, 2018 and 2016-2019.

Figure 4.10: Reasons for discontinued use of ELE stoves

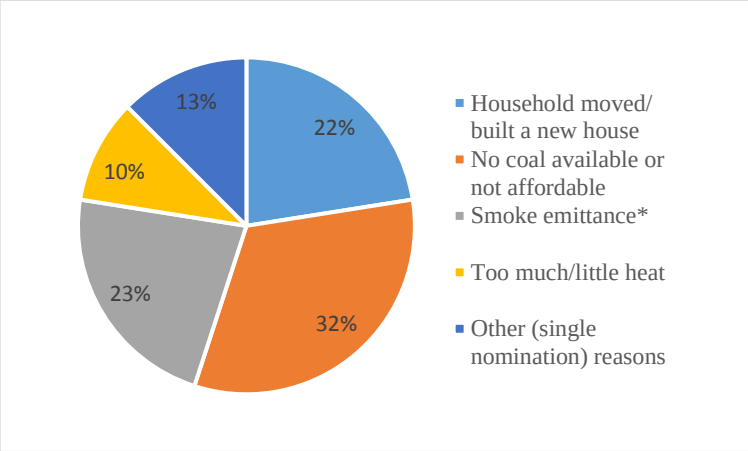


Table 4.2: Summary of challenges and measures undertaken during implementation

Challenge	Measure undertaken
Lack of awareness from suppliers, installers and users about ELE stove benefits	• Outreach and information campaigns on benefits of HELE technologies, including stove information and demonstration 'events' involving local authorities, Government representatives, stove suppliers/installers/users and local communities
Lack of capacity to develop, produce and install ELE technologies	• 2-day training courses to producers and installers of stoves • Site visits to individual producers to match the stove specifications to their capacities and equipment • Open source designs • Step-by-step production manual, including technical specifications, photos and video material (Document 1) • Step-by-step installation manual, including technical specifications, photos and video material (Document 3)
Fragmented supply market	• Facilitated assembly/ installation of stoves through local partner and pre-set arrangements rather than results-based scheme
Various imprecisions and mistakes during production and installation of stoves	• Detailed production checklist (interim and final) to be used before acceptance of the product (Document 2) • Detailed installation checklist/ commissioning protocol to be used before commissioning of the works (Document 4) • Repair and replacement of stoves with defaults during pilot (part or in full)
Design flaws	• Repairs/ replacement of stoves and updating of designs, integrating improved design features and taking into account user feedback and lessons learned

Inferior quality of material	• Replacement of stove parts made of inferior material with improved/ stronger parts during repairs where possible
Poor condition of chimneys	• Installation/ repair of chimneys in almost all households where owners agreed to it • Additional instructions on chimney installations and related technical specifications including incorporation of requirements according to current National Building Standards in other countries
Lack of household understanding how to properly operate the stoves	• Detailed user manuals and summary steps • Hands-on demonstration training • Continued phone support and repeater training during monitoring

Source: Authors based on CAMP Alatoo, Final Monitoring and Evaluation Reports: Assessment of the efficient stoves performance in the pilot households for 2017, 2018 and 2016-2019. CAMP Alatoo, various production and installation reports, 2017-2019.

Monitoring and evaluation of results and benefits

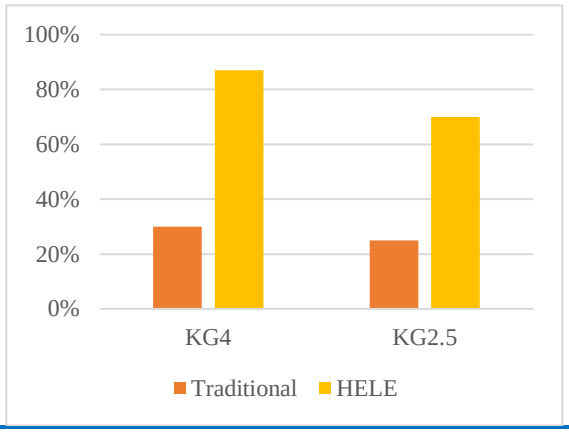
Monitoring. Using a select group of indicators, monitoring was conducted during three heating seasons 2016/17, 2017/18 and 2018/19 for pilot trial households in the four oblasts. In Naryn, measurements were taken before and after stove installation. In Osh, Jalalabad and Chui, measurements were compared for trial and control groups. Health-related monitoring was conducted using household questionnaires and personal exposure measurements (for control group and select households included in Phase I) two months after stove installation and again one year later (thereby covering two heating seasons). For monitoring of other aspects, household questionnaires and log-books for recording fuel consumption were developed. Households were trained on the recording of consumption (e.g., by mass or the use of measuring buckets) and regular field visits (2-3 times per heating season) were conducted to monitor satisfaction levels, observe stove performance (visual and with measuring equipment), fuel consumption, home comfort levels, user convenience, and householder's willingness to pay.

Efficiency improvements. Measurements conducted as part of the initial market assessment (see Chapter 2 and 3) and baseline research in the selected oblasts (see Section 4.1) showed that traditional stoves have a thermal efficiency of around 25 percent. Tests conducted in the laboratory of the China Agricultural University in Beijing and on-site measurements made during the pilot using portable instrumentation confirmed that the efficiency of HELE stoves ranges between 70-87 percent, thus enabling households to save up to 45-50 percent in terms of fuel consumption and money. In some placed, the fuel saving for coal was greater because the "right size" coal is smaller than the most popular sizes and is sold at a discount.[48] This estimate was later on confirmed by

[48] In villages above the town of Osh, savings due to greater fuel efficiency and lower cost per kg resulted in a saving of 75% compared with the traditional stove burning the larger pieces, even though the new stove was operated 24 hours per day. Together these had a strong, positive social and monetary impact. See this presentation for details.

records from pilot households on their fuel consumptions and related calculations, showing that households on average used roughly 40 percent less coal to keep their homes warm during winter.[49]

Figure 4.11: Efficiency Improvements



Indoor comfort improvements. Traditional stoves and boilers require refueling every 1-3 hours (see Figure 4.4) during winter. Monitoring data showed that HELE stoves needed on average only refueling once in 6-15 hours for coal stoves and 4-5 hours for dung and wood burning models. This can bring significant improvements in terms of convenience, comfort and time spent. More than half of the surveyed households reported a noticeable decrease in the time spent to operate the new stove and around 80 percent reported an increase of indoor comfort levels after installation, despite an increase in the heated area in many households.[50]

Positive health impact due to reduced indoor pollution.[51] Indoor exposure measurements were conducted during two consecutive winters (2016/17 and 2017/18) for 41 pilot households from the first phase and a control group of 20 similar households. The results showed that the mean $PM_{2.5}$ exposures of pilot households decreased 65% from 92.3 $\mu g/m^3$ to 32.4 $\mu g/m^3$ (see Figure 4.6). A decrease was also observed for CO exposure which dropped below the air quality guidelines issued by the World Health Organization (WHO).[52] A reduction of more than 90 percent in $PM_{2.5}$ and CO emissions was measured for the KG4 model at the CAU-BEST testing laboratory in China, using a traditional Mongolian stove (with characteristics as similar to the traditional Kyrgyz

[49] World Bank, Advancing Heating Services Beyond the Last Mile: Central Asia Pilot Experience with High-Efficiency, Low-Emissions Heating Technologies, 2019. CAMP Alatoo, Final Monitoring and Evaluation Reports: Assessment of the efficient stoves performance in the pilot households for 2017, 2018 and 2016-2019.

[50] CAMP Alatoo, Final Monitoring and Evaluation Reports: Assessment of the efficient stoves performance in the pilot households for 2017, 2018 and 2016-2019.

[51] For a detailed description of the results of the Kyrgyz pilot, please also refer to World Bank (2019) "Advancing Heating Services Beyond the Last Mile: Central Asia Pilot Experience with High-Efficiency, Low-Emissions Heating Technologies." World Bank, Washington, DC.

[52] Gemert et al, Effects and acceptability of implementing improved cookstoves and heaters to reduce household air pollution: a FRESH AIR study, 2019

stoves) as a baseline reference.[53] In addition, monitoring of respiratory symptoms conducted by the Fresh Air team found a significant decrease in all symptoms reported among adults and children (Figure 4.12). Furthermore, the number of missed days at school for surveyed children was reduced by 72 percent. All changes between the baseline and second post-intervention measurement were found to be statistically significant for all stove models.[54]

Figure 4.12: Daily respiratory symptoms of monitored children

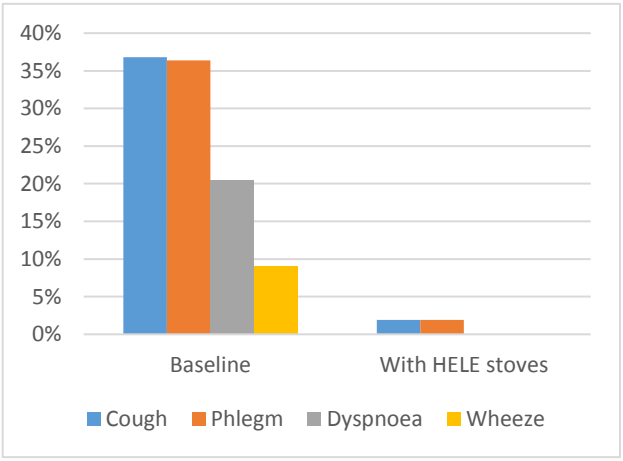


Figure 4.13: Measurements of respiratory symptoms by Fresh Air

Source: Authors based on Gemert et al, Effects and acceptability of implementing improved cookstoves and heaters to reduce household air pollution: a FRESH AIR study, 2019.

Strong overall stove performance. Despite above mentioned challenges, when asked to rate select performance features of the HELE stove models KG2.5 and KG4 scale 1-5 with 1 being very bad and 5 excellent), the majority of households in all three rounds of monitoring (2017, 2018 and 2019) rated all of the key features as good or excellent.[55]

Increasing interest by stove manufacturers to offer HELE stoves as part of their regular product portfolio. As an outcome of the trials and the extensive capacity building activities over several years, private stove producers have reported orders for the news HELE stoves to CAMP Alatoo, albeit for limited numbers. After the cancellation of the grant-supported World Bank project to support the scale-up of HELE stove distribution, the independent development of the clean stove market in the Kyrgyz Republic is anticipated. The early indication is that the emerging demand is coming from higher-income households, reflecting the fact that the innovative stoves are more expensive than traditional models and that the need for proper installation and operation, including the consistent use of the appropriate fuel (consistent supply of coal of specified quality,

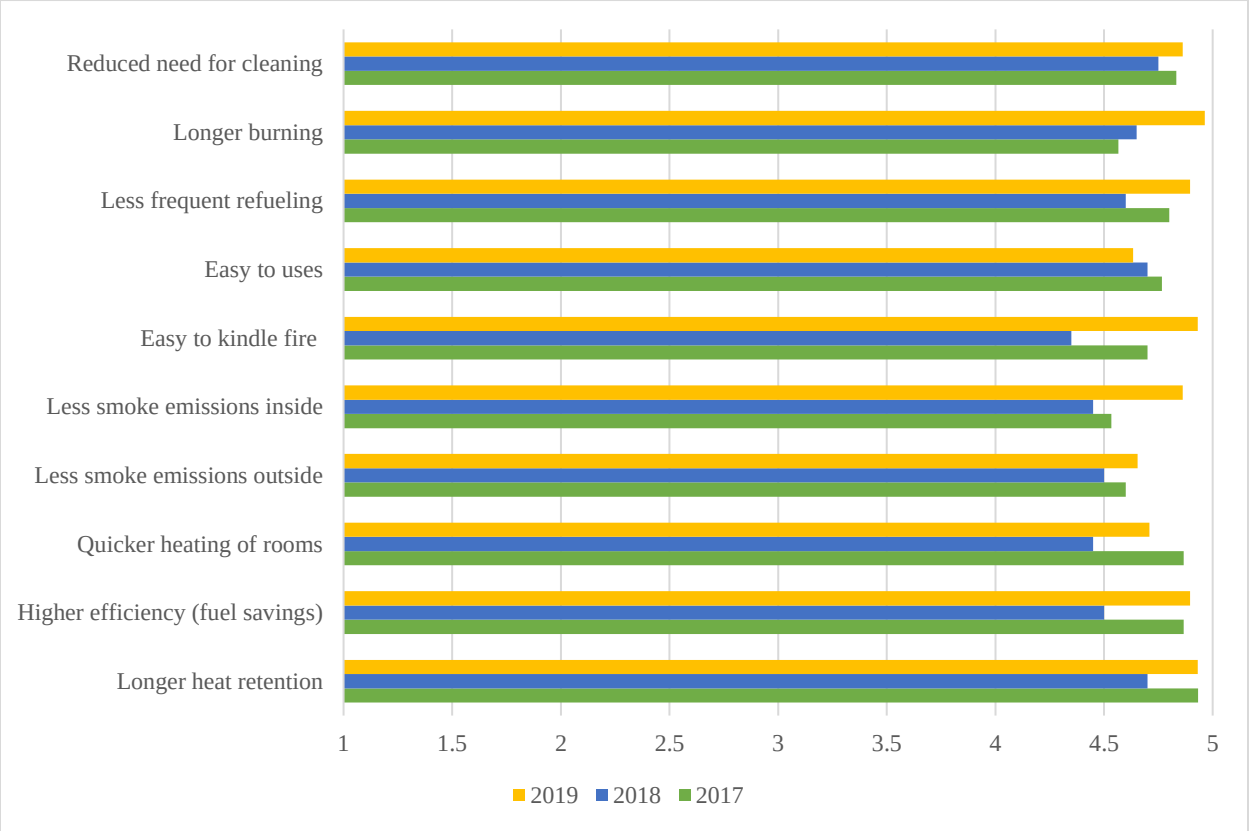
[53] World Bank, Advancing Heating Services Beyond the Last Mile: Central Asia Pilot Experience with High-Efficiency, Low-Emissions Heating Technologies, 2019.

[54] Gemert et al, Effects and acceptability of implementing improved cookstoves and heaters to reduce household air pollution: a FRESH AIR study, 2019

[55] CAMP Alatoo, Final Monitoring and Evaluation Reports: Assessment of the efficient stoves performance in the pilot households for 2017, 2018 and 2016-2019.

no burning of trash or tires). These requirements are more easily followed by higher income households.

Figure 4.14: Performance rating of KG2.5 and KG4.4 in 2017-2019



Source: CAMP Alatoo, Final Monitoring and Evaluation Reports: Assessment of the efficient stoves performance in the pilot households for 2017, 2018 and 2016-2019. Note on scale: 5=excellent and 1= very bad.

Chapter 5. Lessons Learned

5.1 Why Clean Heating Technologies Matter in Kyrgyzstan

Clean heating solutions have the potential to generate multiple benefits at all levels of Kyrgyz society, cutting across diverse social and economic dimensions including poverty alleviation, gender, health, education, environment, and private-sector development. For low-income households, the dramatically higher thermal efficiency of clean models (at least 70 percent) could mean a 45–50 percent reduction in expenditures on solid-fuel consumption.[56] This saving would free up limited resources to meet other essential family needs, including home repairs and upgrading, bringing additional energy savings. Extending the duration of the burn time eliminates the need for frequent refueling, reducing the demand on women's time and leading to improved home comfort levels, creating a better study environment for children.

Making the switch to these clean heating solutions would also yield significant health benefits, particularly for women and children, as well as the elderly. The long winter heating season currently means an extended period of exposure to indoor air pollution, which is a risk factor for serious respiratory disease and related illnesses. Women are the most affected group since they usually have a greater responsibility for cooking and stove refueling; young children are also affected since they tend to spend more hours indoors while elders spend long hours in close proximity to the source of heat. Using clean heating solutions would also reduce ambient air pollution considerably, benefiting both the local environment and global climate. Figure 5.1 provides some testimonials of households participating in the pilot implemented in the Kyrgyz Republic.

[56] The estimated payback period for the clean stoves and LPBs would be 2–5 years.

Figure 5.1: User testimonials from households in the villages of Naryn

Source: CAMP Alatoo

Switching to clean solid fuel–fired heating stoves and LPBs would significantly reduce Kyrgyzstan's burden of disease, particularly in rural homes. In 2010, respiratory infections figured

among the country's top three causes of disability-adjusted life years (DALYs). Using clean heating stoves and LPBs would reduce the number of adult working days lost each year due to illness; children's lost school days due to illness, which could affect educational outcomes and future earnings; and the country's overall costs of health and hospitalization.

5.2 What have we learned based on regional and local experience?

The 2019 World Bank publication "*Advancing Heating Services Beyond the Last Mile: Central Asia Pilot Experience with High-Efficiency, Low-Emissions Heating Technologies*" documents existing evidence that HELE technologies are available that meet customer heating demand and substantially improve the heating experience of households in terms of operational benefits (lesser refueling, lower fuel consumption) while leading to considerable health benefits. This conclusion is mirrored in this report. The Kyrgyz experience however also illustrates the challenges the roll-out of HELE technologies at larger scale and on a stand-alone commercial basis face.

In the Kyrgyz context, to prepare the grant-supported distribution of locally produced HELE stoves to approximately 14,000 households under the World Bank Heat Supply Improvement Project, extensive technical assistance and capacity building was put in place to enable the local production and installation of the stoves as well as adoption by households. The need for iterative development of tailored solutions is a main finding of the experience, as is the necessity of commitment from policy makers to support solutions for a household-level issue that has externalities far beyond individual families.

The design and adaptation of HELE technologies to the Kyrgyz market requires intensive engagement with producers and users to understand the local context: their needs, preferences, living conditions, operating capabilities, and access to competing fuels and equipment. The stove activity has achieved the development of stove and LPBs models adapted to the resources and capacities of local stakeholders (producers and consumers). At the same time, a lack of familiarity with the more advanced technological requirements of HELE stoves and LPBs leads to deviations in the operation of the devices (e.g. use of old chimneys, or inappropriate fuels) which in turn lower performance. Deviations from standard operation are more particularly a phenomenon observed in low income households which do not have the means to ensure consistent fuel supply. Adjustments of the design to producer capacities and household needs (in the latter case for example in case of moving house), present another challenge. A multi-year engagement with continued communication and capacity building activities is required to build sufficient understanding of the technologies represented by the new stoves. The process is complex, involving a wide range of stakeholders linked to diverse issues, including household behavior, institutional capacity, and private-sector development. Although the linkages to poverty alleviation are quite clear, the process of establishing and nurturing a sustainable clean stoves market will take dedicated institutional time and effort.

The government can play an important supportive role in raising awareness of HELE technologies, through demonstration projects and communication campaigns, for example involving local politicians and community leaders. Clean cooking and heating programs should involve stakeholders across many sectors (public, private, and civil society) at all levels (local, provincial, national, and international). But there is no substitute for high-level political, technical, and financial support from national leaders and agencies. Such support is a key success factor and requires time and engagement to build and maintain until the entire sector is transformed.

5.3 Next Steps - the Challenge of Market Transformation

While clean stoves have great potential in delivering significant multi-benefits for households relying on traditional, solid fuel–fired heating stoves without alternatives, the scaled-up implementations have been challenging. Future market transformation requires continued efforts on both supply and demand side, as well as an enabling environment. HELE technologies are available on a commercial basis through imports (e.g. from China and Russia), but if Kyrgyz stove makers want to participate in the development of the market, public policy support assisting with initial demand generation and aggregation will be essential, as will outreach to local communities and instruments to bridge the initial additional efforts and costs associated with promulgating the new technologies.

References

CAMP Alatoo. 2016. “Baseline Report: Assessment of households’ stoves and heating strategies in Osh, Jalalabad, Naryn and Chui oblasts.” Bishkek: CAMP Alatoo. Recourse to all CAMP Alatoo reports listed below: http://camp.kg/publikacii-i-otchety/otchety-po-proektam.html

———. 2017. “Monitoring and Evaluation Report: Assessment of the efficient stoves in the pilot households in Osh, Jalalabad, Naryn and Chui oblasts..” Bishkek: CAMP Alatoo.

———. 2017. “Summary Report on the Market Research of Stove Suppliers.” Bishkek: CAMP Alatoo.

———. 2018. “Final Monitoring and Evaluation Report: Assessment of the efficient stoves in the pilot households in Naryn oblast.” Bishkek: CAMP Alatoo.

———. 2019. “Final Monitoring and Evaluation Report: Assessment of the efficient stoves performance in the pilot households for the period 2016-2019.” Bishkek: CAMP Alatoo.

Gemert et al. 2019. “Effects and acceptability of implementing improved cookstoves and heaters to reduce household air pollution: a FRESH AIR study.” Npj, Primare Care Respiratory Medicine. Recourse: https://www.nature.com/articles/s41533-019-0144-8

IEA (International Energy Agency). 2014. “Capturing the Multiple Benefits of Energy Efficiency”. Recourse: https://webstore.iea.org/capturing-the-multiple-benefits-of-energy-efficiency

KABAR. 2015. Talantbek Sooronbaev: “Kyrgyzstan is the first in the world by mortality from lung diseases”. The breath of life of Kyrgyzstan. Recourse: http://dem.kg/index.php/ru/article/18422/talantbek-sooronbaev-kyrgyzstan-stoit-na-pervom-meste-v-mire-po-smertnosti-ot-bolezney-legkih.

T. Sooronbaev, B. Ghezai, S. Williams, M. Akmatalieva, M. Mademilov, and N. Chavannes. 2015. “Indoor Pollutions and the Prevalence of Respiratory Symptoms among Highlanders in Kyrgyzstan.” European Respiratory Journal 46: Suppl. 59. Recourse: https://erj.ersjournals.com/content/48/suppl_60/PA1276

World Bank. 2015. “Keeping Warm: Urban Heating Options in the Kyrgyz Republic.” Washington, DC: World Bank. Recourse: http://documents.worldbank.org/curated/en/555021468011161504/Keeping-warm-urban-heating-options-in-the-Kyrgyz-Republic-summary-report

———. 2015. “Results-Based Financing To Promote Clean Stoves: Initial Lessons from Pilots in China and Indonesia.” Live Wire 2015/46. Washington, DC: World Bank. Recourse: http://documents.worldbank.org/curated/en/838501468189549922/Results-based-financing-to-promote-clean-stoves-initial-lessons-from-pilots-in-China-and-Indonesia

———. 2016. “Toward Universal Access to Clean Cooking and Heating: Early Lessons from the East Asia and Pacific Clean Stove Initiative.” Live Wire 2016/62. Washington, DC: World Bank. Recourse: http://documents.worldbank.org/curated/en/530991467991919783/Toward-universal-access-to-clean-cooking-and-heating-early-lessons-from-the-East-Asia-and-Pacific-clean-stove-initiative

———. 2016. “Technical report: Household survey on use of individual heating systems in 2015.” World Bank and Center for Social and Economic Research (SocEonic). Recourse: https://catalog.ihsn.org/index.php/catalog/6934/related-materials

———. 2017. “Project Appraisal Document (PAD) on a Proposed Grant and Credit to the Kyrgyz Republic for a Heat Supply Improvement Project.” Report No. PAD2164. World Bank, Washington, DC. Recourse: http://documents.worldbank.org/curated/en/292401509328823311/Kyrgyz-Republic-Heat-Supply-Improvement-Project

_____. 2017b. Clean Individual Heating Solutions in the Kyrgyz Republic and Tajikistan. Washington, DC: World Bank. Recourse: http://www.worldbank.org/en/news/video/2017/06/20/clean-individual-heating-solutions-in-the-kyrgyz-republic-and-tajikistan.

———. 2017c. Magic Stoves- For Cleaner Air, Better Health and More Effective Heating in the Kyrgyz Republic. Washington, DC: World Bank. Recourse: http://www.worldbank.org/en/news/video/2017/05/04/magic-stoves-for-cleaner-air-better-health-and-more-effective-heating-in-the-kyrgyz-republic.

_____.2017 The Social Impact of Highly Improved Stoves, C Pemberton-Pigott, Domestic Use of Energy Conference paper, Cape Town, South Africa. http://www.newdawnengineering.com/website/library/Papers+Articles/DUE/DUE%202017/20170405%20Pemberton-Pigott%20Social%20impact%20of%20improved%20stoves%20DUE%202017.pdf

———. 2018. “Country Partnership Framework for the Kyrgyz Republic for the Period FY19-FY22.” World Bank, Washington, DC. Recourse: http://documents.worldbank.org/curated/en/358791542423680772/Kyrgyz-Republic-Country-Partnership-Framework-for-the-Period-FY19-FY22

———. 2018. “Feature Story: Better Air Quality in Ulaanbaatar Begins in Ger Areas.” World Bank, Washington, DC. Recourse: https://www.worldbank.org/en/news/feature/2018/06/26/better-air-quality-in-ulaanbaatar-begins-in-ger-areas

———. 2019. “Advancing Heating Services Beyond the Last Mile: Central Asia Pilot Experience with High-Efficiency, Low-Emissions Heating Technologies.” World Bank, Washington, DC. Recourse: http://documents.worldbank.org/curated/en/120331550068872377/Advancing-Heating-Services-Beyond-the-Last-Mile-Central-Asia-Pilot-Experience-with-High-Efficiency-Low-Emissions-Heating-Technologies

_____. The Efficient, Clean Cooking and Heating Community of Practice. World Bank. Recourse: https://collaboration.worldbank.org/groups/clean-cooking-and-heating-solutions