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Green Rural

万科公益基金会
VANKE FOUNDATION

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GLOBAL ENVIRONMENT FACILITY

SGP The GEF Small Grants Programme

UNDP

TEAM

BCAA
中关村创蓝清洁空气产业联盟
BLUETECH CLEAN AIR ALLIANCE

婦源滙
GDS

Inception

In rural areas of China’s northern Shaanxi province, villagers typically resort to tradition when it comes to heating their homes in winter. Such traditions rely on solid fuels (coal, fuel wood, etc.), resulting in a high level of indoor soot emissions and potential health hazards. Winter is a season with typically poor air circulation and little capacity for accommodating pollutants; compound this with the heating needs of northern China and part of the central-eastern territories, the efforts preventing and controlling air pollution are faced with stern challenges.

As the Chinese board member of the Global Alliance for Clean Cookstoves launched by the United Nations Foundation in 2010, Wang Shi is committed to promoting the implementation of clean cookstove projects across China. In 2017, with the backing of Vanke Foundation and Vanke Honorary Chairman's Office, C Team rolled out clean stoves to 500 households across 8 natural villages in Shaanxi, in an effort to address the health and environment challenges brought about by less-than-clean cooking stoves and fuel. In 2018, on concluding the lessons learnt from the Clean Cookstove scheme and in response to the more pronounced heating needs and community environmental challenges, C Team launched the "Green Rural" project, which focuses on rural clean energy and community development to make China's villages greener and more resident-friendly.

Multi-party Collaboration

The “Green Rural” project and the prior Clean Cookstove scheme enjoyed ongoing sponsorship from the Vanke Foundation (2017-2020). In 2019, the UNDP Global Environmental Facility’s Small Grants Programme supported the Green Rural project in launching the "Northern Shaanxi Rural Clean Energy Demonstration and Community Development Project".

To guarantee the level of expertise and adopt a locally-tailored approach in implementation, C Team, together with its technology providers Zhongguancun Bluetech Clean Air Industry Alliance and the field taskforce Shaanxi Gender Development Solutions, chose the Nangoumen village in Shimen town of Ganquan county, in the city of Yan'an in Shaanxi province as a pilot site to explore locally-tailored clean heating solutions, support the establishment of grassroots community organizations, conduct eco-friendly livelihoods-boosting and environmental awareness raising activities, serving as a reference rulebook for other types of communities in China to develop clean heating and environmental improvements.


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Project Site

Vanke Foundation, initiated by China Vanke CO., LTD. and founded in 2008, is a national private foundation approved by the State Council and the Ministry of Civil Affairs of China and supervised by the Ministry of Civil Affairs. Being future-oriented pioneers, Vanke Foundation addresses issues with a profound impact on the future, aims for sustainable communities, and promotes environmental protection and community development.

The Global Environmental Facility (GEF) was established in 1991 with a mandate to provide financial and technical support to developing countries to help implement international environmental conventions. The Small Grants Programme (SGP) was launched in 1992 and is implemented by the United Nations Development Programme (UNDP) on behalf of GEF partners and executed by the United Nations Office for Project Services (UNOPS).

Zhongguancun Bluetech Clean Air Industry Alliance is a not-for-profit organization committed to promoting the technology and industry development of clean air and accelerating global air quality improvement by conducting technology transfer, technology assessment and demonstration, investment services, patent protection, and policy research.

Shaanxi Gender Development Solutions is a social service organization registered with Shaanxi Civil Affairs Department in August 2008, by Shaanxi Research Association for Women and Family, an established women's development organization in China; it is a Class 4A social organization and the one of the first charitable organizations in Shaanxi.

Nangoumen Village is located in Ganquan Town, Yan'an City, Northern Shaanxi. The town has a population of 89,000, which is a typical agricultural county with serious aging and hollowing of the rural population, low income levels of residents, and tight financial funds. The residential houses here are mostly cave like (called Yaodong). It is common for a household with three people. Using indoor stoves to burn corncobs and coal for heating and cooking emits a lot of air pollutants and greenhouse gases.

Clean Heating

In the rollout of the clean heating pilot in Yan'an, clean heating-related technological pathways suitable for the city’s rural areas are prioritized, and the environmental benefits generated by the relevant technological measures are validated and evaluated to facilitate the wider application of such pathways in Yan'an and elsewhere across Shaanxi. The environmental benefits evaluated for the purposes of this project are the dual benefits of air pollution control and greenhouse gas emission reduction, in support of the improvement of ambient air quality and countering global climate change.

Big Environment and Small Ecosystem

The project site is located in rural Yan'an of China’s northern Shaanxi province, where villagers typically adopt conventional heating practices in winter, and the smoke emissions from heating can cause severe damages to human health.

Yan'an is situated in the northern part of Shaanxi province, along the middle section of the Yellow river and covers the mid-southern part of the Huangtu plateau. As of the end of 2016, the province had some 920 million square meters of heating-available buildings across its urban and rural territories, with a clean heating rate of about 50%. The dominant energy sources for heating are coal (59%) and natural gas (37.3%).

Household burning of bulk coal emits a large amount of air pollutant called black carbon.

Statistics show that the emission of black carbon from household burning of loose coal in China accounts for more than half of the nation-wide black carbon emissions. Black carbon heats the atmosphere by absorbing solar radiation and producing a greenhouse effect; when black carbon settles on snow and ice, it alters the albedo of its surface, thus accelerating the melting of snow and ice. The global warming potential of black carbon is 900 times greater than that of carbon dioxide. It is for this reason that reducing the emission of black carbon has become a pivotal measure to counter climate change.

As a resource-rich province, Shaanxi is the first province in China to put forward the concept of province-wide gasification, and has set out its strategic goal of "gasification of Shaanxi" and embarked on the "gasification of Shaanxi" journey as far back as 2009. In June 2018, Shaanxi province released its "Implementation Program for Clean Heating (2017-2021)".

It can be observed from the above that the pertinent policies are in place on the provincial level, but the implementation level is not presenting a rosy picture due to various constraints.

At the project site, the Nangoumen village, cave-like housing structures are adopted by the vast majority of households, and farmers still rely on indoor stoves (burning a combination of corn cobs and fuel wood with anthracite/soft coal) for heating and cooking in winter, which fails to meet clean heating standards.

Power grid upgrading has been ongoing for ten consecutive years, and the rural power grid has been renovated to accommodate larger-power equipment and be better prepared for renovation. However, peak/trough tariff subsidy for residential electricity has not yet been introduced to Ganquan county, and air source heat pumps and other electric heating practices consume a high level of electricity, thus rarely used by farmers. All residents have not procured electric heaters, indicating premature timing for the full rollout of "electricity replacing coal" in the village of Nangoumen.

C Team is nonprofit organization launched by leading business figures and environmentalists represented by Wang Shi in 2017, dedicated to promoting green innovation and change, exploring green and low-carbon development models, and fostering sustainable development and eco-friendly civilization.

The goal of the Green Rural project’s clean heating segment is to explore rural clean heating practices suitable for the Yan'an territory, improve the indoor air quality for farmers and mitigate climate change; promote the extensive rollout of government-backed solutions in Shimen town of Ganquan county; and optimize the establishment of locally tailored clean heating solutions that can be rolled out elsewhere.

The tasks included the research and evaluation of the local heating practices and resource access in Yan'an, the devising of tailored clean heating technological pathways, and the selection of pilot households for technology application and evaluation.

The project was piloted in the Nanguomen village, governed by the Ganquan county in the city of Yan'an, a typical agriculture-focused county with an aging and hollowed-out demographic. The residents have moderate means. County-wide fiscal income sits at over CNY100 million, with an expenditure reaching 300 million yuan, showing a significant fiscal gap. Most of the residential housing in Nangoumen village adopt a cave-like structure and traditional heating and cooking practices.

Technological Path

For the purposes of the project, 17 pilot households were selected for the demonstration and evaluation of three technologies. Among them, five households piloted photovoltaic power generation + water-heated bed structures, two households piloted solar thermal + passive housing retrofitting, and 10 households carried out biomass pellet fuel-adapted stove pilots.

PV Power Generation + Water-heated Bed Structure

The water-heated bed structure is a heating device that uses solar photovoltaic panels to generate electricity, with water-heated coils retrofitted on top of the bed structure. The water in the bed structure is heated with electricity. The electricity generated by the solar photovoltaic panels offsets part of the electricity bill.

PV solar panel installation and finished look

Solar Thermal + Passive Housing

Solar water heaters are installed on the roofing and water circulation radiators are installed on the interior wall of the bedroom.

Doors, windows and exterior walls of the rooms connected to the bedrooms are retrofitted to strengthen the airtightness, reduce the heat load indicators, improve heat insulation, avoid heat dissipation to achieve the passive housing effect.

Solar water heater

Passive Housing Retrofit: retrofitting strengthens the airtightness of doors, windows and exterior walls, and improves insulation performance.

Biomass Pellet Fuel-adapted Stoves

Pairing biomass stoves with shaped biomass fuel for combustion-based heating. The biomass fuel is made from local corn stalks and discarded branches, and the processing work is now done by local villagers.

Biomass pellet production site

Biomass stoves paired with biomass fuel provide a suitable heating solution to be rolled out in Yan'an. Biomass fuel is a renewable energy source that reduces greenhouse gas emissions; and the 10 pilot households of the project together reduced greenhouse gas emissions by 46.4 tons. In addition, the use of biomass stoves is similar to that of traditional coal-fired or wood-fired heating alternatives, easily accessible to local villagers. And the running cost of biomass cookstoves and biomass fuel is more affordable, compared with the photovoltaic and solar-thermal technologies adopted under the project, making it easier to roll out.

Biomass refers to various organisms produced by photosynthesis, including, primarily, agricultural and forestry residues, fuelwood, straw, human and animal excrements, urban household waste, etc. Shaped biomass fuel is made into fuel blocks by mechanical compression of biomass, which can be directly burned and utilized in boilers or cooking stoves, making it a clean and renewable energy form with zero greenhouse gas emission. Shaped pellets can replace bulk coal as a quality eco-friendly fuel.

The Nangoumen Village has trialed local production and supply of shaped biomass fuel. The villagers would provide equal measures of corn stalks and waste firewood to be processed in the processing workshop. For every 250kg of finished product so produced, the supplying villagers are eligible to collect one biomass cookstove for free by signing a confirmation form, promising to keep supplying the raw materials in exchange for biomass fuel, which will be used in lieu of coal. In the 2020–2021 heating season, a total of 30 people signed up for the straw processing scheme.

Local production and supply of shaped biomass fuel yields positive results on multiple fronts: it addresses the problem of unregulated disposal (through burning) of straw by local villagers, and helps to promote the philosophy of low-carbon and eco-friendly living in the countryside, thereby driving up local employment.

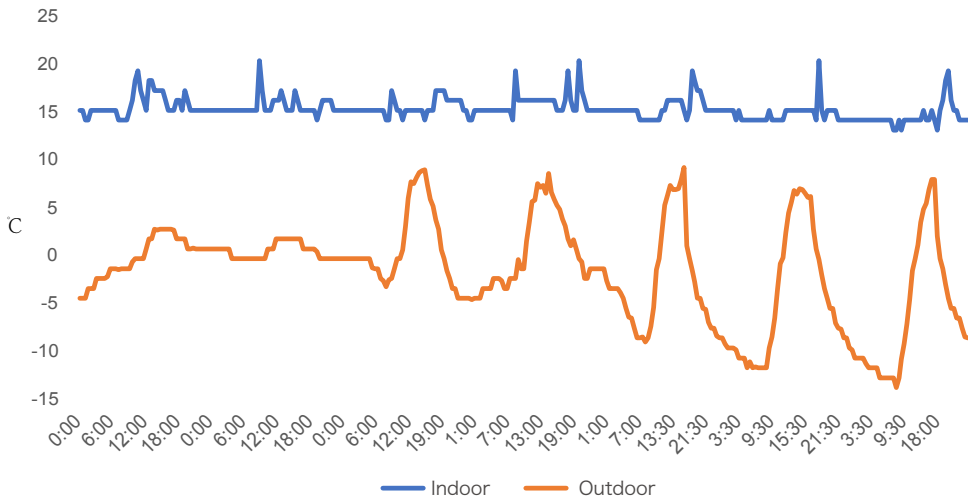
Analysis of Implementation Effectiveness

The taskforce has monitored and measured the heating effectiveness, environmental benefits and greenhouse gas emission reductions via monitoring instruments.

How effective is the heating?

1 PV power generation + water-heated bed structure pilot households

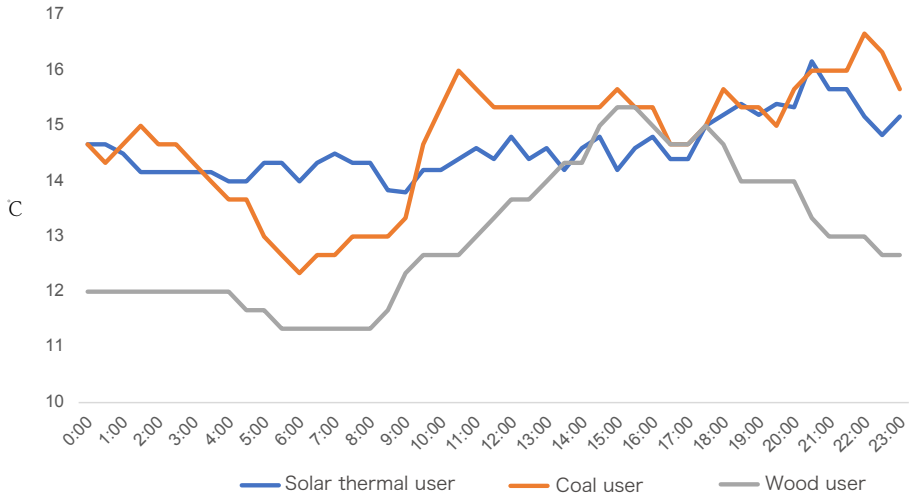
The graph below shows the indoor vs outdoor temperatures of the PV + water-heated bed structure pilot household.



Heating effectiveness by hours of PV power generation + water-heated bed structures

The main appliance employed for indoor heating purposes in the PV pilot households is the water-heated bed structure, which is well received among the pilot households for having the perceived ability of better improving sleeping comfort at night. The conventional fire-heated bed structures can only maintain desired temperatures for 5-6 hours before dropping to room temperature in the early morning. The water-heated beds, however, can maintain a constant, adjustable, temperature throughout the night, providing a higher level of sleep comfort.

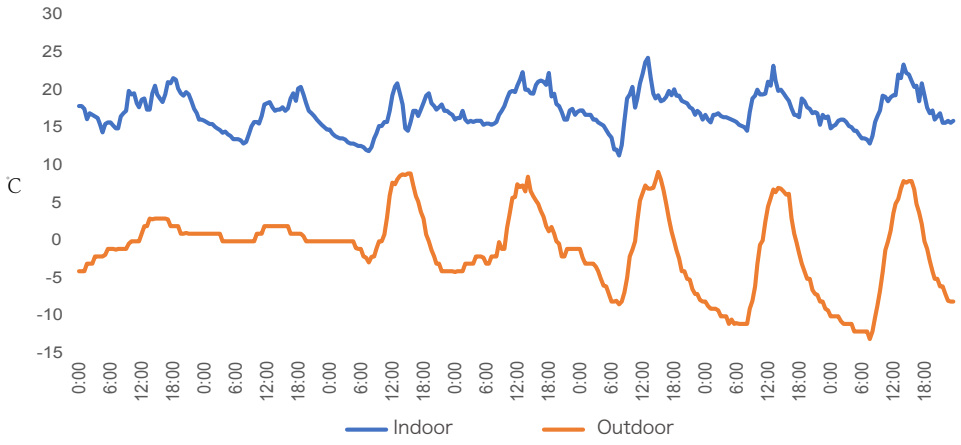
2 Solar thermal + passive housing retrofit pilot households



Room temperature during heating season, solar thermal + passive housing retrofit users vs coal-fired and wood-fired [stove] users

Similar to the case of PV pilot households, there are fewer indoor heat sources in solar thermal pilot households, which, compounded with factors including thermal value of the heat sources, resulted in slightly lower indoor temperatures compared with the coal-fired pilot households, but marginally improved over the levels seen among the wood-fired stove users. The solar thermal pilot households also reside in cave-like structures, and the better insulation of their houses maintains the indoor temperature at about 15℃ .

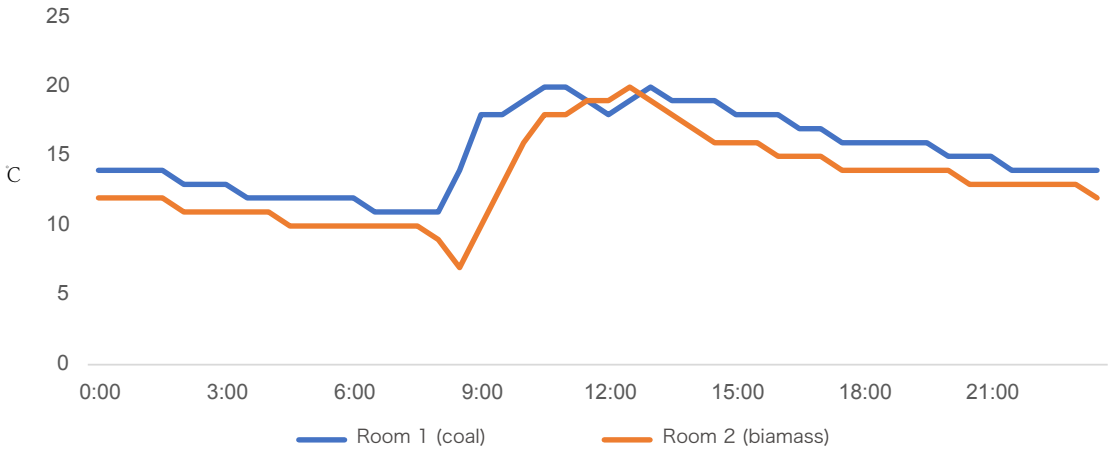
3 Biomass pellet fuel-adapted stove pilot households



Heating effectiveness of biomass pellet fuel-adapted stove by hours in pilot households

Biomass vs coal-fired:

A biomass stove is installed in the Clerk's Room 2 of Nangoumen Village Committee, while the Clerk's Room 1 has a traditional coal-fired stove. The two rooms are of the same architectural structure, and have similar usage of the stoves. The following is a 24-hour data comparison between the two clerks' rooms. The graph indicates comparable heating effectiveness levels of the two heating methods.

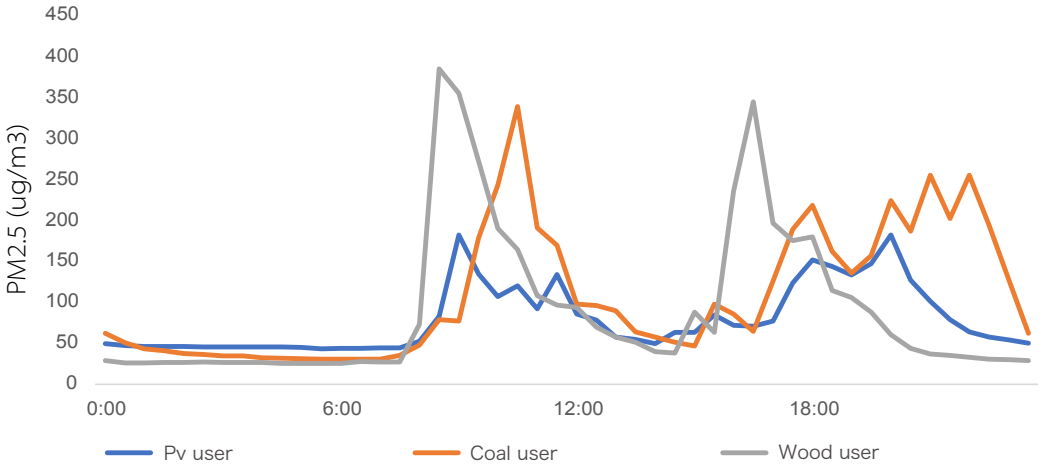


Typical household temperature by time of day

What is the environmental benefit?

An analysis is conducted of the air quality monitoring data collected by indoor and outdoor online monitoring instruments to compare the impacts of different heating methods on air quality, and calculate the level of greenhouse gas emission reduction.

1 power generation + water-heated bed structure pilot household



Weekly average of PM2.5 concentration by time slots, PV users vs coal-fired and wood-fired [stove] users

The PV pilot households have no other combustion-based forms of heating equipment and have reasonably decent indoor PM2.5 levels. The levels tend to increase in early mornings and evenings, due to both the outdoor ambient air quality increasing in these two windows, and these two windows being the typical times of cooking, generating a certain level of PM2.5 emissions.

Greenhouse gas emissions

The PV power generation + water-heated bed structure approach does not emit any greenhouse gas in itself. In terms of the implementation practice, the power generated from PV panels at the pilot household is connected to the national grid and the farmers use power from the grid. Therefore the final calculation of reduced emission needs to be conducted based on the difference between the electricity produced and the electricity used. Grid connection of the project has been finalized on February 28, 2020, and the statistics are as follows.

Pilot household	Daily avg. power generated (Mar 16-Jul 12)	Power generated (as at Jul 12)	Projected power generation p.a.	Projected winter power use by water-heated bed structures
Mr. Cao	8.8kWh	1195	Avg. 4500kWh	Avg. 175kWh
Mr. He	15.1kWh	2013		
Mr. Wen	14.9kWh	1988		
Mr. Mr. Li	15.0kWh	1982		
Mr. Gao	9.5kWh	1238		

Table 4-8 PV power generation statistics

Each household can generate 3,000-5,000kWh of electricity per annum, which works out to 22,500kWh of clean electricity p.a. on average generated by the 5 pilot households, together with a reduction of 10 tons of coal for winter heating each year.

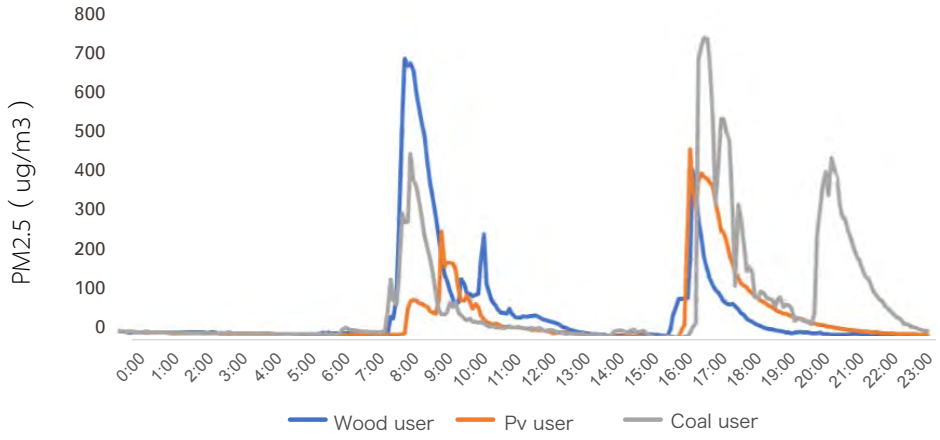
Calculations of reduced pollutant and greenhouse gas emissions

Photovoltaic power generation can run all year round, engendering additional clean power emission reductions from the grid and enabling further greenhouse gas emission reduction.

	Emission reduction p.a.			
Reduced pollutants	5 households from coal substitution	5 households from power generation	5 households total	400 households total
Reduced greenhouse gas (ton)	26.2	23.6	49.8	3984.0
Reduced NO_x (kg) emissions	16.0	65.7	81.7	6536.0
Reduced SO_2 (kg) emissions	74.0	71.1	145.1	11608.0
Reduced $PM_{2.5}$ (kg) emissions	243.0	7.2	250.2	20016.0
Total reduced emissions (kg)	333.0	144.0	477.0	38160.0

Calculation of emission reduction, replacing coal-fired heating with PV power generation + water-heated bed structures

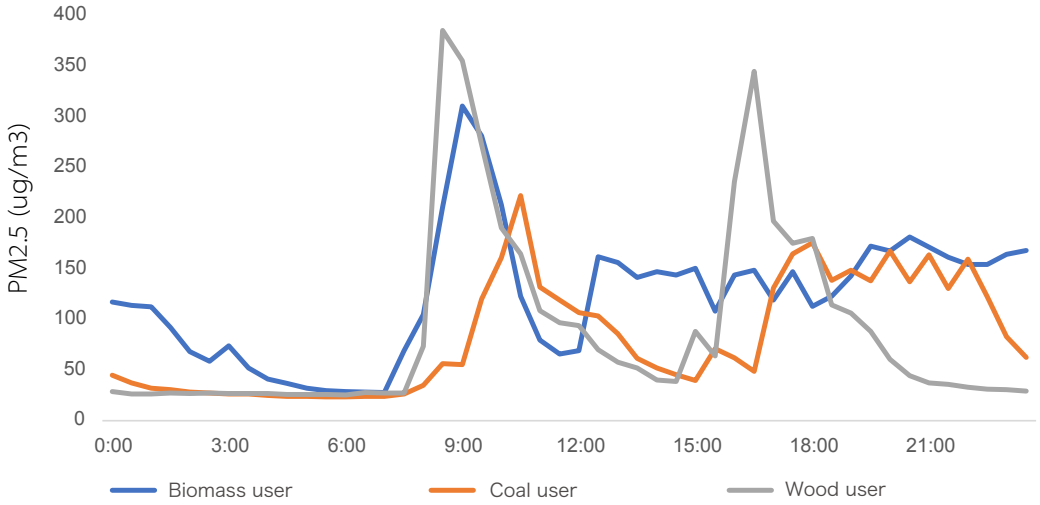
2 Solar thermal + passive housing retrofit pilot households



Comparison of PM2.5 concentrations, solar thermal users vs coal-fired and wood-fired users

The graph above shows a lower level of particulate matter emissions from solar thermal heating compared with coal–fired and wood–fired stoves, with indoor air quality the best across the hours compared to the latter two types of usages in terms of indoor PM2.5. The levels show some tendency to rise in mornings and just before dusk, given that cooking activities are generally carried out during these two windows, hence certain levels of PM2.5 emission.

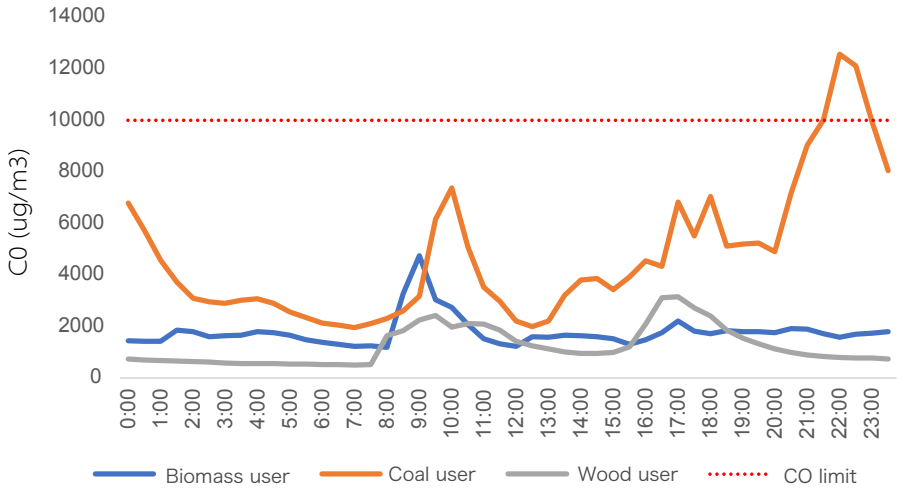
3 Biomass fuel adapted stoves for household heating



Weekly average of PM2.5 (ug/m3) concentration, biomass users vs coal-fired and wood-fired [stove] users

The indoor PM2.5 levels are generally the same for all three heating methods, with pollution peaks observed during ignition of the stove every morning and afternoon. It is therefore advisable for the villagers to increase ventilation during ignition and extinguishing, and avoid using traditional methods involving newspaper, twigs and dry weeds to ignite the stove.

- **Carbon monoxide:**



Graph 4-8 Weekly average of CO concentration by time slots, biomass users vs coal-fired and wood-fired [stove] usersFor CO limits, refer to the Indoor Air Quality Standard (GB/T 18883-2002)

The indoor CO concentration of biomass stove pilot households is significantly lower than that of coal-fired [stove] users, which is on a par with that of wood-fired heating stove users.

• Pollutant and greenhouse gas emission reduction:

The taskforce conducted calculations of the annual emission reduction for the 10 pilot households of biomass stoves and all 400 households in the village. As biomass stoves typically have a service life of more than 10 years, the taskforce also extrapolated the emission reduction over the next decade. 10 pilot households can reduce emissions by 2350.5 kg of pollutants and 46.4 tons of greenhouse gas per year; if rolled out to all 400 households in the village, a reduction of 959.9 tons of pollutants and 18,560 tons of greenhouse gases can be achieved in the next 10 years.

	Emission reduction per heating season		10-year emission reduction		
	Item	10 pilot households	Rollout to all 400 households in village	10 pilot households	Rollout to all 400 households in village
Greenhouse gas	CO_2 (t)	46.4	1856	464	18560
	BC(black carbon) (kg)	2.8	112	28	1120
Pollutants	NOx(kg)	56.6	2264	566	22640
	SO_2(kg)	103.9	4156	1039	41560
	CO (kg)	1911.0	76440	19110	764400
	PM (particles (kg)	279.0	11160	2790	111600
	Total reduction of pollutants (kg)	2350.5	95988	23997	959880

Heating emissions, replacing ordinary anthracite coal with biomass

Community Development

The Green Rural project also invited the Shaanxi Gender Development Solution (GDS) to educate villagers on how to cultivate folk community organizations and raise environmental awareness in the community of Nangoumen village.

The taskforce engaged in research and mobilization efforts in Nangoumen village, and convened a meeting with village representatives, where three were elected member of the Nangoumen Village Community Fund Management Committee (the “key lady officers”), and a tailored "Community Development Fund Operating Bylaw" was drafted in a group effort, setting forth a line of credit in the amount of 20,000 to 40,000 per household for agricultural development only.

GDS provided training and counseling to the three lady officers, and organized a trip for active members of the community to tour a neighboring village in Weinan, Shaanxi province, and receive financial training, and a trip to Zundao, Sichuan province, to be educated on the rollout practices and lessons learnt in community waste classification. Under the UNDP Global Environmental Facility’s Small Grants Programme, the community leaders went to Lijiang, Yunnan, to attend an endogenous community development workshop for an informative discussion about the potential ways to access community resources for sustainable development.

The three lady officers now manage a total of CNY160,000 in accordance with the protocol laid down by the Community Development Fund Management Committee, and have issued a total of 7 loans for growing greenhouse vegetables and animal farming. Currently CNY160,000 has been fully loaned, and interest income is 4100 yuan. One case is that a village resident engaging in animal farming has successfully reared to maturity some ten piglets they purchased, which leaves them with more than 30,000 yuan in profit after repayment of principal and interests.

A total of eight events centered on environmental awareness raising and field activities (e.g., themed cultural event, summer camps, and village-wide waste cleanups), which were attended by an aggregate of 500+ villagers, enhanced villagers' awareness of environmental protection, fostered a change towards a more eco-friendly lifestyle for the villager residents and elevated the environmental hygiene and welfare of the entire community.

In terms of waste classification and recycling, the community environmental protection taskforce—in partnership with the two village committees—devised the exchange criteria for recyclables at the village's charitable supermarket. Beverage container (plastic bottles) is the most commonly traded-in recyclable among the village residents at the moment, with one beverage bottle worth 1 cumulative credit, which can be used to redeem daily household supplies as needed, including laundry detergent, soap, cooking oil, flour, toothpaste and toothbrush. The main participants of the scheme are village seniors over 60 years old.

Words From Stakeholders

Xie Hongxing, Director of Zhongguancun Bluetech Clean Air Industry Alliance:

Cleaner energy in rural areas is one of the key tasks to achieve the goal of "carbon neutrality by 2060" in China, and clean heating is one of the top priorities. The clean heating project in Yan'an has not only successfully demonstrated a clean heating technology solution tailored to local circumstances, but also identified, over the course of the project, a commercially sustainable solution that benefit farmers, which generate new income streams for farmers while achieving the dual environmental benefits of reducing both air pollution and greenhouse gas emission, which in turn will serve to inspire and inform future rural energy efforts.

Li Kai, a resident of Nangoumen village and a pilot household of biomass fuel:

Previously we all used coal-burning stoves for winter heating, which was costly and caused a lot of air pollution. Ever since we switched to the free biomass stoves provided as part of the project, our heating costs came down, and we have been able to get rid of the straw piles after the autumn harvest, so I'd say it's very suitable for rural use.

Gao Liang,
a resident of Nangoumen village, overseeing biomass fuel processing:

The biomass stove fuel processing project has served to both reduce the air pollution caused by farmers burning corn stalks for disposal and burning coal for winter heating, and relieve the strain on the finances of the village’s residents. I think that neighboring villages should be encouraged to get involved and contribute in whatever way they could to environmental protection in the countryside.

Luo Yun,
accountant of the Nangoumen Village Community Development Fund:

Our village community development fund has addressed the lack of funding for some farmers with proven results and efficiency, and fostered the village's agricultural endeavors. The interest collected [from the borrowers] has been reinvested in welfare-boosting causes for the entire village and very well received in the resident community. We would like to see more residents of our village go on to lead a prosperous life with the help of the Community Development Fund.

Yang Yang,
Coordinator of Community Development Department, Shaanxi Gender Development Solution:

The Green Rural project promotes community development of eco-friendly livelihood-boosting projects through improving community environmental infrastructure, environmental remediation and awareness-raising and educational activities, as well as support for community organizations such as the Community Development Fund and community environmental associations to promote villagers' environmental awareness and behavioral change, and assist them with enhancing their production skills and income.

C Team thanks the following organizations for their support:

Vanke Foundation

UNDP Global Environmental Facility’s Small Grants Programme

Zhongguancun Bluetech Clean Air Industry Alliance

China Agricultural University, Ministry of Agriculture and Rural Areas, Renewable Energy Clean Utilization Technology Research Center

National Biomass Energy Science and Technology International Joint Research Center of China Agricultural University

Longi Green Energy Technology Co., Ltd.

Yantai Shangmeijia New Energy Co., Ltd.

Huaneng Ecological Technology Co., Ltd.

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