



Managing the social consequences of the transition away from coal: the case of clean heating in Shanxi Province, China

1. Introduction

Many countries, including in Asia Pacific, have announced pledges to variously peak greenhouse gas emissions or achieve net zero emissions in the coming decades. In many countries, the low-carbon energy transition will require a radical change in systems for space heating and cooking. This is especially important in regions with long, cold winters. Whilst many of these regions today rely on electricity or natural gas, China is an exception where coal accounted for 12% of final energy consumption in buildings in 2019. Traditional biomass accounted for 13%. This compares to a global average of 4% and 19% respectively.¹ Within China, the use of coal for winter heating and cooking is particularly prominent in the northern regions. Not only are the winters long and cold, but the production and use of coal have formed the core of the economy for decades. For this reason, the government has embarked on a programme to introduce clean heating and cooking systems across northern China to reduce the use of coal and traditional biomass.

This paper addresses challenges in the introduction of clean heating. The focus is on Shanxi Province in northern China, being the country's heartland for coal production and consumption. It is argued that although achieving significant success, China's programmes for introducing clean heating encountered significant obstacles to implementation. These challenges arose from a combination of the top-down campaign style of the programmes that led to poor policy coordination and the inadequate scale of available financial resources.

2. Managing the clean heating strategy

2.1 Background to the clean heating strategy

As well as being the country's main source of primary energy, coal has also been the principal cause of air pollution in northern China and of the continuing high level carbon dioxide emissions. Over the last 20 years, the government has taken strong measures to reduce the share of coal in the primary energy mix, from around 75% in the 1990s to 56% in 2020. This has been achieved through a combination of fuel switching, promoting the use of non-fossil fuels in power generation, and enhancing industrial energy efficiency. Nevertheless, the annual consumption of coal has continued to rise, despite a slight decline in 2015 and 2016. As part of the aim of peaking carbon emissions by 2030, President Xi Jinping has pledged that annual coal consumption will peak by 2025 and then start to decline.²

¹ International Energy Agency, World Energy Outlook 2020, Paris, IEA, 2020.

² Xie, E., 2021. China 'Well Placed' to Beat its Carbon Emission Targets, Experts Say. South China Morning Post, 4 May. <https://www.scmp.com/print/news/china/science/article/3132080/china-well-placed-beat-its-carbon-emission-targets-experts-say>

Despite the success of government policies to reduce the use of coal for space-heating in the major cities of northern China, coal continued to provide a source of energy for household heating and for small-scale boilers and kilns in rural and other less developed areas. This coal is usually of low quality with high ash and sulphur contents and is known as “loose coal”. Households using such coal for heating and cooking also suffer from severe health consequences.³ In 2017, the annual consumption of loose coal was estimated to be about 750 million tonnes or 20% of national consumption. Of this, 200 million tonnes, or 27%, was for household heating.⁴ Not only is the use of coal for space heating very inefficient, it is also highly polluting.

For these reasons, the central government launched a major programme in 2017 to convert household heating systems in northern China from loose coal to cleaner fuels.

2.2 Policies and achievements in deploying clean heating

As is often the case in China’s energy sector, the overarching strategy for deploying clean heating were developed by the central government. Provincial governments were then responsible for developing strategies suited to their circumstances and delegated on-the-ground implementation to selected cities and municipalities. The Ministry of Finance provided some funding to the provincial governments, but these funds needed supplementing by provincial and lower level governments.

Central government’s strategies and achievements

Central government made the decision to address the problem of clean heating at a meeting of the Central leading Group for Finance and Economics chaired by Xi Jinping in December 2016.⁵ The following May, the Ministry of Finance issued a notice laying out the plan to support to deployment of clean heating across northern China in a pilot programme spanning the period 2017 to 2019. The pilot programme was also to include energy efficiency. The coverage spanned Beijing, Tianjin and 26 other cities in Hebei, Shanxi, Shandong and Henan Provinces (“2+26” cities). In addition, the Ministry allocated substantial funding: one billion RMB per year to direct-administered municipalities (Beijing, Tianjin, Shanghai and Chongqing), 700 million per year to provincial capitals, and 500 million per year to prefecture level cities.⁶ The National Energy Administration (NEA) followed this up by clarifying that clean heating includes natural gas, electricity, geothermal, biomass, solar energy, industrial waste heat, and “clean” coal (ultra-low emission).⁷ Further, the source of energy should be chosen on the basis of suitability to the specific location.⁸ A wide variety of technologies are available for electrical heating (Table 1).

³ J. Zhang and K.R. Smith, Household air pollution from coal and biomass fuels in China: measurements, health impacts, and interventions, *Environmental Health Perspectives*, 2007, 115(6), 848-855.

⁴ People’s Daily, 2017. We need more ideas to control loose-coal pollution. *Xinhua News*, 9 December. http://www.xinhuanet.com/politics/2017-12/09/c_1122083019.htm (in Chinese)

⁵ Hong, T., 2021. Promote clean heating needs to strike a balance on the blue sky and warmth. Development Research Centre of the State Council. 15 November. <https://www.drc.gov.cn/DocView.aspx?chnid=379&leafid=1338&docid=2904392> (in Chinese).

⁶ Ministry of Finance, 2017. Notice on carrying out the Winter Clean Heating Plan for Northern Region supported by Central Financial Funds. Chinese Central Government Website, 20 May. http://www.gov.cn/xinwen/2017-05/20/content_5195490.htm (in Chinese)

⁷ Here ‘clean coal’ refers to coal with emission concentrations of soot, sulphur dioxide and nitrogen oxides less than 10 mg/m³, 35 mg/m³ and 50 mg/m³ respectively to under the condition of benchmark oxygen content of 6%, NDRC, Winter Clean Heating Plan for Northern Region (2017-2021); http://www.gov.cn/xinwen/2017-12/20/content_5248855.htm (in Chinese); National Energy Administration, 2018. Press Conference on Winter Clean Heating Plan for Northern Region (2017-2021). National Energy Administration Official Website, 24 January. http://www.nea.gov.cn/2018-01/24/c_136921343.htm (in Chinese).

⁸ State Action Plan to Win the Blue Sky Defence War. Chinese Central Government Website, 3 July. http://www.gov.cn/zhengce/content/2018-07/03/content_5303158.htm (in Chinese)

The clean heating programme was extended to span the period 2017-2021 and broadened in scope to include cities in Inner Mongolia, Liaoning, Heilongjiang, Shaanxi, Gansu, Ningxia, Qinghai and Xinjiang. In March 2021, the central government renewed its support for clean heating in the northern regions.⁹

Table 1: Main types of electric heating appliances available in northern China (see Appendix for details of each technology).

Type of heater	Varieties
Air source heat pump fan heater	
Direct electric heater	Micathermic heater Convection and panel heater Electric baseboard heater Fan heater (e.g. 'Little Sun')
Storage heater	
Oil-filled electric radiator	
Electric boiler	
Cooling Air-conditioner with an additional electric heating device (PTC)	

The clean heating programme seems to have achieved a relatively high degree of success in term of overall statistics, though a consistent set of statistics is hard to find. One area of particular concern has been the “2+26” cities. Between 2017 and 2019, the number of households in this region using loose coal fell from about 24 million to about 10 million and the quantity of loose coal consumed annually declined from about 56 million tonnes to 23 million tonnes.¹⁰ According to inconsistent statistics from different sources, by the end of 2020 some 19 million rural households in northern China had undergone conversion from coal to gas¹¹ and 12.1 million from coal to electricity. Overall, the clean heating rate in rural areas had increased from 9% to about 28% with more than 25 million households having been converted, saving 100 million tonnes per year of loose coal. One year later, the government claimed that the overall clean heating rate in northern China had reached nearly 70%.¹²

Shanxi Provincial government strategies and achievements

Shanxi received 10.2 billion RMB from the Ministry of Finance over the five-year plan period 2016-2020 to implement clean heating conversions in eight cities and their rural communities across the province.¹³

⁹ Ministry of Finance, 2021. Notice on Applying for Clean Heating Projects in Winter Areas in the Northern Region. Department of Finance, Inner Mongolia Official website. 10.May.

<http://czt.nmg.gov.cn/zwgk/zfxqk/fdzdgknr/tzgg/202105/P020210510426047599814.pdf> (in Chinese)

¹⁰ Ministry of Ecology and Environment, 2020. The control of loose coal is still the key in Beijing-Tianjin-Hebei and surrounding areas. The official website of Ministry of Ecology and Environment, 10 March

https://www.mee.gov.cn/ywqz/dqhjbh/dqhjzql/202003/t20200310_768238.shtml (in Chinese).

¹¹Ministry of Natural Resources, 2021. China Natural Gas Development Report (2021)-Executive summary. Hubei Provincial Development and Reform Commission official website. 09 September.

http://fgw.hubei.gov.cn/fbjd/xxqkml/jqzn/wgdw/nj/mthsytrqlycsyqb/gzdt/202110/t20211015_3810208.shtml (in Chinese)

Ministry of Natural Resources, 2021. China Natural Gas Development Report (2021)-Full Report. National Energy Administration Official Website, 21 August. http://www.nea.gov.cn/2021-08/21/c_1310139334.htm (in Chinese).

¹² State Grid Corporation of China, 2020.State Grid Corporation of China has fully completed the construction of this year's "coal-to-electricity" supporting power grid. The official website of State-owned Assets Supervision and Administration Commission. 13 November. <https://www.sasac.gov.cn/n2588025/n2588124/c15944124/content.html> (in Chinese)

Hong, T., 2021. Promote clean heating needs to strike a balance on the blue sky and warmth. Development Research Centre of the State Council. 15 November. <https://www.drc.gov.cn/DocView.aspx?chnid=379&leafid=1338&docid=2904392> (in Chinese)

¹³ Ministry of Finance, 2021. Reply of the Ministry of Finance to Recommendation No. 5629 of the Fourth Session of the Thirteenth National People's Congress. Ministry of Finance Official Website. 05 August.

http://zyhj.mof.gov.cn/lh/2021jytafwgk_1/rddbifyfwgk/202108/t20210805_3743099.htm (in Chinese)

The provincial government developed four discrete programmes: combined heat and power, coal-to-gas, coal-to-electricity, and clean coal and environmentally friendly stoves. To a great extent, the type of clean heating chosen would depend on its relative availability and cost at each location. Industrial waste heat relies on there being suitable nearby industrial plants, whilst gas heating requires proximity to a gas pipeline. In the absence of these two, the choice would likely be electricity. Only if all three of these options were unavailable or too expensive would the option of clean coal be chosen.

In 2015, the central government drew up a plan to make use of industrial waste heat for heating buildings and selected 150 cities and counties for demonstration. Target industries included power, steel, cement and chemicals.¹⁴ As these industries are abundant in Shanxi, the provincial government included industrial waste heat in its plans.¹⁵

Launching the coal-to-gas programme in October 2017, the provincial government instructed local authorities to first secure the supply of natural gas before carrying out the appliance conversions.¹⁶ Subsidies for gas consumption lay in the range 1.00-1.36 RMB per cubic metre (cbm). Heating a 60 square metre space would require an estimated 1,200 cbm gas for a heating season, which would bring the cost to the household for a heating season to about 2,000 RMB.¹⁷

To address the relatively high cost of using electricity for heating, the provincial government introduced two mechanisms during the heating season: a lower price per kilowatt hour and a higher ceiling on the first tier in the tiered pricing system (Table 2).

Table 2: comparison of electricity prices during and outside the heating season for household with electrical heating system

	Outside heating season ¹⁸		During heating season ¹⁹	
	Consumption	Price	Consumption	Price
Tier 1	< 170 kWh/month	0.477 RMB/kWh	< 260 kWh/month	0.2862 RMB/kWh
Tier 2	171-260 kWh/month	0.527 RMB/kWh	>260 kWh/month	0.507 RMB/kWh
Tier 3	>260 kWh/month	0.777 RMB/kWh		

The estimated electricity consumption for 60 square metres of space at 16 hours per day for 150 days is 7,200 kWh, giving a cost of 2,060 RMB per heating season.²⁰

As coal resources are still abundant in Shanxi, the use of coal has remained within the provincial plan for clean heating but with a focus on district heating systems using low-emissions coal to reduce air

¹⁴National Development and Reform Commission and Ministry of Housing and Urban-Rural Development, 2015. Notice on Excess Heat Warming Project Implementation Plan. The official website of Inner Mongolia Autonomous Region Development and Reform Commission. 26 January. http://fgw.nmg.gov.cn/ywqz/jndt/202101/t20210126_773219.html (in Chinese)

¹⁵Shanxi Provincial Government, 2018. Implementation plan of clean heating in winter in Shanxi Province. In-en.com. 17.August. <https://coal.in-en.com/html/coal-2552247.shtml> (in Chinese)

¹⁶ Economic Information Daily, 2017. Cities of Shanxi must not blindly issue the task of "coal to gas. The Official Website of National Energy Administration. 31 October. http://www.nea.gov.cn/2017-10/31/c_136717543.htm (in Chinese)

¹⁷ Shanxi Energy Bureau, 2021. Reply to Recommendation No. 1348 of the Fourth Session of the Thirteenth Provincial People's Congress. Shanxi Energy Bureau official website. 23 June. https://nyj.shanxi.gov.cn/zfxgk/fdzdgknr/jyta/rdjd/202106/t20210623_1424937.html (in Chinese)

¹⁸ Shanxi Daily, 2012. the stepped electricity price for residential electricity consumption in Shanxi Province will be implemented from July 1st, The Official Website of China Central Government. 2 July. http://www.gov.cn/gzdt/2012-07/02/content_2174937.htm (in Chinese)

¹⁹ Shanxi Energy Bureau, 2021. Reply to Recommendation No. 1324 of the Fourth Session of the Thirteenth Provincial People's Congress Shanxi Energy Bureau official website. Shanxi Energy Bureau official website. 23 June. https://nyj.shanxi.gov.cn/zfxgk/fdzdgknr/jyta/rdjd/202106/t20210623_1424937.html (in Chinese)

²⁰ Shanxi Energy Bureau, 2021. Reply to Recommendation No. 1324 of the Fourth Session of the Thirteenth Provincial People's Congress Shanxi Energy Bureau official website. Shanxi Energy Bureau official website. 23 June. https://nyj.shanxi.gov.cn/zfxgk/fdzdgknr/jyta/rdjd/202106/t20210623_1424937.html (in Chinese)

pollution in the form of soot, sulphur dioxide and nitrous oxides.²¹ Ultra-low-emissions coal, along with biomass, is also used to fire heating stoves in remote areas that lack access to these other forms of heating.²²

City governments undertook the final design and implementation of the clean heating programmes. The subsidies for gas and electrical heating addressed the cost of the appliances and their installation as well as the cost of energy use during the heating season. Each city government took a different approach to the structuring and size of subsidies, as well as to the choices of technology for electrical heating (Table 3).

Table 3: Illustrative summary of subsidies offered by different city governments for gas and electrical heating systems (note that data is incomplete)

Location	Urban/ Rural	Appliance	Appliance + installation			Energy use	
			Subsidy RMB	Subsidy max RMB	Cost to household RMB	Subsidy RMB	Subsidy max
<i>Energy source</i>							
Taiyuan (2018) ²³							
<i>Coal to gas</i>	Rural		10,000		1,900	1.1-1.36 /cbm	2,865 RMB 2,250 cbm ^a
<i>Coal to electricity</i>	Rural	Heat pump	94%,	27,400		0.2/kWh,	
		Boiler, heater, storage	89%	14,400			
Yangquan (2020/2021) ²⁴							
<i>Coal to electricity</i>		1 heat pump, 2 heaters, 1 cooker		6,000			
		2 heat pump, 1 cooker		6,800			200 RMB
		1 heat pump, 1 heater, 1 cooker		5,800			1,200 RMB

²¹Shanxi Provincial Government, 2018. Implementation plan of clean heating in winter in Shanxi Province. In-en.com. 17.August. <https://coal.in-en.com/html/coal-2552247.shtml> (in Chinese)

²²Fangshan County Government, 2020. Notice of the Implementation Plan for Clean Heating in Winter 2020 in Fangshan County, Lvliang City, Shanxi Province. The Official Website of Fangshan County Government. 28 April. http://www.fangshan.gov.cn/xxqk/zwbwj/202004/t20200428_1394442.html (in Chinese).

²³ Taiyuan News, 2018. Taiyuan's "coal-to-electricity" and "coal-to-gas" subsidy policy was introduced. The official website of Department of Industry and Information Technology of Shanxi Province. 27 September. http://qxt.shanxi.gov.cn/gxqz/sxqz/202109/t20210927_2520135.shtml (in Chinese)

²⁴ Shanxi News, 2020. Subsidy standards for "coal-to-electricity" in many places in Shanxi have been released. The Paper. 09 October. https://www.thepaper.cn/newsDetail_forward_9503496 (in Chinese)

Yuncheng (2018-2020) ²⁵							
<i>Coal to gas</i>	Urban		5,500				
	Rural		6,300				
<i>Coal to electricity</i>	Urban		4,000				
	Rural		4,600				
Datong, Shuozhou, Xinzhou (2021) ²⁶							
<i>Coal to gas</i>			4,400		3,000	1.00/cbm	1,200
<i>Coal to electricity</i>		1 heat pump, 2 heaters, 1 cooker	4,700	5,500			
		As above+ solar PV	8,300	9,100			

Note: ^a subsidy of 1.36 RMB/cbm for the first 1,500 cbm; then 1.1 RMB/cbm for the next 750 cbm.

By the end of 2020, Shanxi had converted more than five million households to clean heating. Of these, 70% used either industrial waste heat or natural gas (Table 6). By the end of 2021, the total number of households had risen to six million,²⁷ thus meeting the planned target for the year.²⁸

Table 4: Achievements of Shanxi Province in clean heating conversion, 2017-2020.²⁹

Energy source	Number of households (million)	Percentage of total households
Industrial waste heat	2.074	40.7%
Coal to gas	1.534	30.1%
Coal to electricity	0.822	16.1%
Clean coal and environmentally friendly stoves	0.663	13.0%
Total	5,095	100%

Critical to the success of the coal-to-gas and coal-to-electricity programmes has been the construction of the necessary energy transmission infrastructure. By 2020, total length of long-distance pipelines in Shanxi was 8,610 km, about 600 km more than at the end of 2015. These comprise 1,867 km of national transit pipelines and 6,742 km of intra-provincial lines. These pipelines reach 111 county-level built up areas with an annual capacity of 30 bcm. By 2025, the total length is planned to exceed

²⁵ Shanxi News, 2020. Subsidy standards for "coal-to-electricity" in many places in Shanxi have been released. The Paper. 09 October. https://www.thepaper.cn/newsDetail_forward_9503496 (in Chinese)

²⁶ China News, 2021. Shanxi completed clean heating renovation of more than 860,000 households. China News. 02 November. <http://www.sx.chinanews.com.cn/news/2021/1102/198306.html> (in Chinese)

²⁷ Lishi District Government, 2021. 2.3 billion! Shanxi issues funds for clean heating in winter of 2022. The Official Website of Lishi District, Lvliang City. 13 December. http://www.lishi.gov.cn/hdjl/qghy/202112/t20211213_1599788.shtml (in Chinese)

²⁸ Shanxi Provincial People's Government. 2016. "Thirteenth Five-Year" Comprehensive Energy Development Plan of Shanxi Province. 27 December. <https://news.bjx.com.cn/html/20161227/799959.shtml> (in Chinese) Or http://shanxi.gov.cn/sxszfxxgk/sxsrnzfczm/sxszfzfbgt/flfg_7203/szfgfwj_7205/201612/t20161226_272758.shtml (in Chinese); Shanxi Energy Bureau, 2021. Reply to Recommendation No. 1348 of the Fourth Session of the Thirteenth Provincial People's Congress. Shanxi Energy Bureau official website. 23 June. https://nyj.shanxi.gov.cn/zfxgk/fdzdgknr/jyta/rdjd/202106/t20210623_1424937.html (in Chinese)

²⁹ Shanxi Energy Bureau, 2021. Reply to Recommendation No. 1348 of the Fourth Session of the Thirteenth Provincial People's Congress. Shanxi Energy Bureau official website. 23 June. https://nyj.shanxi.gov.cn/zfxgk/fdzdgknr/jyta/rdjd/202106/t20210623_1424937.html (in Chinese)

11,000 km with a capacity exceeding 40 bcm/yr. 30 To support the electrification of heating, in January 2021 the State Grid Shanxi Electrical Power Company claimed to have spent 2.31 billion RMB on constructing power grids and substations to support coal to electricity projects, thus helping to reduce the use of loose coal consumption by about one million tonnes per year.³¹

2.3 Challenges faced by the clean heating programme

Problems started to appear in the first winter of the programme, the winter of 2017/2018. Local governments pushed ahead to meet the ambitious targets that had been set for clean heating conversions across northern China. Most authorities chose natural gas over electricity. A lack of planning, poor coordination and hasty implementation resulted in an inability to effectively manage what is a complex supply chain involving additional supplies of natural gas, new pipelines to carry the gas, and new heating appliance in households and communities. The outcome was an unsatisfied surge in demand for gas. In addition, many existing heating systems were removed before the new ones had been installed and gas supplies secured, thus leaving households without any form of heating. The higher price of gas compared to coal also deterred many households from using the new heating systems fully.³²

Whilst the conversion from coal to gas in northern China lowered levels of air pollution in this region, the resultant shortage of gas supply elsewhere caused pollution levels to rise in central provinces that also needed winter heating.³³ The shortage also forced some industrial plants to suspend production.³⁴ In many respects, the events of 2017/2018 were a repeat of more localised problems encountered in Shaanxi during the winter of 2013/2014 during conversion of heating boilers from coal to natural gas in that province.³⁵

In December 2021, the Development Research Center of the State Council drew attention to several similar challenges facing the clean heating programme. These included the high cost to households and consequent unwillingness to adopt the new heating systems, the financial burden on local governments, and supply risks for both natural gas and electricity.³⁶ All these issues and others were experienced in Shanxi Province.

The main challenges faced by many Shanxi households were the high capital cost of effective heating systems and the ineffectiveness of affordable heating systems. The costs faced by households include those for the appliance, for installation and for winter operation. In one example of coal-to-gas conversion, households had to pay 2,800 RMB for the appliance and 3,000 RMB for installation. As this was a coal-free area, those who could not afford this cost could only use portable electric resistance heaters (known as 'Little Sun' heaters) which do not provide adequate heating.³⁷ In another coal-free

³⁰Shanxi Energy Bureau, 2021. Regarding the reply to the proposal No. 0188 of the 4th meeting of the 12th Provincial Political Consultative Conference. Shanxi Energy Bureau official website. 23 June.

https://nyj.shanxi.gov.cn/zfxqgk/fdzdqknr/jyta/zxtadf/202106/t20210623_1424938.html (in Chinese)

³¹ Energy Bureau of Xinzhou City, 2021. Shanxi's "Coal-to-Electricity" effect is obvious, pollution control and energy saving warm people's hearts. The official website of Energy Bureau of Xinzhou City. 05 January.

https://nyj.sxxz.gov.cn/mqwh/202101/t20210105_3591555.html (in Chinese)

³² Li, J., 2017. What caused China's squeeze on natural gas?. The China Dialogue. 22 December.

<https://chinadialogue.net/en/energy/10322-what-caused-china-s-squeeze-on-natural-gas/>

³³ Wang, S., & et al . 2020. Natural gas shortages during the "coal-to-gas" transition in China have caused a large redistribution of air pollution in winter 2017. *Proceedings of the National Academy of Sciences*, 117(49), 31018-31025.

<https://www.pnas.org/content/117/49/31018>

³⁴ Reuters, 2017. As China gas crisis deepens, factories, homes lose supply, Reuters. 13 December.

<https://www.reuters.com/article/us-china-pollution-gas-idUSKBN1E714C>

³⁵ Economic Information Daily, 2014. "Coal-to-gas" rush to expose the hidden danger of "shortness of breath" Xinhua News. 28 February. http://ijckb.xinhuanet.com/2014-02/28/content_493441.htm (in Chinese)

³⁶ Hong, T., 2021. Promote clean heating needs to strike a balance on the blue sky and warmth. Development Research Centre of the State Council. 15 November. <https://www.drc.gov.cn/DocView.aspx?chnid=379&leafid=1338&docid=2904392> (in Chinese)

³⁷ Clean Heating Industry Committee, 2021. Rural clean heating needs to balance environmental and economic costs. The official Website of Clean Heating Industry Committee. 26 September. <http://www.chic.org.cn/Home/index/detail?id=1225> (in Chinese)

village, residents declined to install gas heating due to the up-front costs and chose wall-mounted electric air conditioning (resistance heating) which is more expensive than gas to operate.³⁸ Heat pumps can be effective but cost 20,000 Yuan and require a local government subsidy of more than 4,600 Yuan.³⁹

In 2021, the Clean Heating Industry Committee estimated that the operating cost of clean heating (gas or electricity) per rural household to keep the same temperature as before was 3,000-6,000 RMB per heating season after subsidies. This compares to 1,600-2,000 RMB using coal. Assuming three-member households, winter heating costs account for 5.7%-7.1% of disposable income for rural households, compared to 2.6% for urban households.⁴⁰ Operating costs vary with technology. For example, an electric boiler which provides effective heating might cost 700 RMB per month, but the cheaper hot air blower at 89 RMB or so per month is much less effective.⁴¹ As a result, an estimated 20% of households with gas appliances consume zero gas.⁴² Similarly, many households which have installed electrical heating appliances still use wood, corn cobs and coal for cooking and heating rather than electricity. Other reasons for not using electrical appliances include a lack of electricity supply and non-operability of the heating appliances.⁴³ These operating cost constraints arise in part from the poor thermal characteristics of most rural homes.⁴⁴

The clean heating programme also places a large, long-term financial burden on the Shanxi Provincial government as well as on the relevant cities. The burden includes not only subsidies to households but also the construction to electricity and gas supply infrastructure in rural areas. The annual subsidies to households are long-term fixed costs and are set to increase as the clean heating programme expands.⁴⁵ The cost to the provincial government of the annual subsidies for "coal-to-gas" and "coal-to-electricity" after 2021 was estimated to be as high as two to four billion RMB. This assumed an annual subsidy of 1,000-2,000 RMB per household.⁴⁶ The problem is exacerbated because only the eight pilot cities have received central government subsidies for three years, whereas the costs of conversion for the three other cities have depended entirely on provincial and city funds.⁴⁷ From the winter of 2021/2022 onwards, only three cities in Shanxi will receive funding from central government – Datong,

Note: The Clean Heating Industry Committee (CHIC), established in 2018, is a cross-regional and cross-sectoral organization composed of clean heating companies, product and equipment manufacturers, energy-saving and environmental protection companies, and financial investment institutions

³⁸ China News, 2019. "Cement blocked stove" in Hongdong County, Shanxi Province. Not allowed to use coal for heating? China News. 23 December. <https://www.chinanews.com.cn/sh/2019/12-23/9040449.shtml> (in Chinese)

³⁹ Xinhua News, 2021. How to make rural clean heating equipment affordable for the masses? 18 December. Xinhua News. http://www.news.cn/2021-12/18/c_1128176790.htm(in Chinese)

⁴⁰ Clean Heating Industry Committee, 2021. Rural clean heating needs to balance environmental and economic costs. The official Website of Clean Heating Industry Committee. 26 September. <http://www.chic.org.cn/Home/index/detail?id=1225> (in Chinese)

⁴¹ Xinhua News, 2021. How to make rural clean heating equipment affordable for the masses? 18 December. Xinhua News. http://www.news.cn/2021-12/18/c_1128176790.htm(in Chinese)

⁴² Shanxi Energy Bureau, 2021. Reply to Recommendation No. 1348 of the Fourth Session of the Thirteenth Provincial People's Congress. Shanxi Energy Bureau official website. 23 June. https://nyj.shanxi.gov.cn/zfxgk/fdzdgnr/jyta/rjydf/202106/t20210623_1424937.html (in Chinese)

⁴³ China Youth Daily, 2021. The urgency of burning "coal": A Shanxi coal ration ticket. China Youth Daily. http://zqb.cyol.com/html/2021-11/24/nw.D110000zqgnb_20211124_3-05.htm(in Chinese)

⁴⁴ For example: B. li, L. You, M. Zheng, Y. Wang and Z. Wang, Energy consumption pattern and indoor thermal environment of residential building in rural China, Energy and Built Environment, 2020, 1(3), 327-336.

⁴⁵ Shanxi Energy Bureau, 2021. Reply to Recommendation No. 1425 of the Fourth Session of the Thirteenth Provincial People's Congress. Shanxi Energy Bureau official website. 23 June. https://nyj.shanxi.gov.cn/zfxgk/fdzdgnr/jyta/rjydf/202106/t20210623_1424937.html (in Chinese)

⁴⁶ Clean Heating Industry Committee, 2021. Rural clean heating needs to balance environmental and economic costs. The official Website of Clean Heating Industry Committee. 26 September. <http://www.chic.org.cn/Home/index/detail?id=1225> (in Chinese)

⁴⁷ Financial Support from central government (ministry of finance) lasts from 3 years. Cities in Shanxi received the funding in various periods. Taiyuan(2017/18-19/20 Heating Seasons); Lvliang, Yangquan, Changzhi, Jincheng, Jinzhong, Yuncheng, Linfen(2018/19-2020/21 Heating Seasons) ; Xinzhou, Shuozhou, Datong(2021/22-23/24 Heating Seasons). Clean Heating Industry Committee, 2021. Policy Recommendations: Facing the problem and continuing to promote the clean heating project. The official Website of Clean Heating Industry Committee. 27 September. <http://www.chic.org.cn/Home/Index/detail?id=1230> (in Chinese).

Shuozhou and Xinzhou.⁴⁸ Because of this large financial burden on local governments, the provincial government in 2021 proposed to limit the subsidy for each household to a maximum of 1,000 per cubic meter of gas per heating season⁴⁹ or up to 6000 kWh for electricity.⁵⁰ In addition, many rural areas lack gas and electricity supply infrastructure and the construction costs put a large burden on local governments at all levels.⁵¹

The final significant challenge arises from poor planning by local governments resulting in higher costs. In one township street, households were switched from coal to gas in one year then to district heating two years later.⁵² In another case, local government chose to electrify the heating in an agricultural school although it was close to a district heating pipeline.⁵³

3. Conclusions

China's leadership recognised clearly that the shift away from coal as part of the nation's low-carbon energy transition would have costs that would be borne by enterprises, local governments, households and individuals. The central government, therefore, put in place various policies including targets and financial support mechanisms which were complemented by local government measures and finance. Despite the seemingly generous nature of financial support provided by the central government and the multiplicity of local government policies, the experience in Shanxi Province over the period 2016-2020 suggests that they encountered a range of challenges – financial, social, logistical, administrative and planning.

The clean heating programme achieved some success across China and in Shanxi Province. The central government supplied funding for the conversion of heating appliance and construction of energy infrastructure (gas pipelines and transmission wires) that local governments were to supplement. Some of this funding went to subsidise the cost to households of the new appliances. The type of appliance installed varied between location depending on local conditions. The major challenges arose from the cost of this exercise. First, the programme placed a large financial burden on local governments, some of which were already financially stretched. Second, many households were unable to afford either the capital cost of the more effective new appliances offered or the running costs. As a result, they experienced lower room temperatures or chose to revert to biomass or coal for cooking and heating. In addition to these financial challenges, the programme encountered logistical and planning difficulties given the scale and required speed of implementation.

⁴⁸Dazhong Daily,2021. The fourth batch of clean heating list announced. Dazhong Daily. 26 April http://dzrb.dzng.com/articleContent/3271_864780.html (in Chinese).

⁴⁹ Shanxi Energy Bureau,2021. Reply to Recommendation No. 1348 of the Fourth Session of the Thirteenth Provincial People's Congress. Shanxi Energy Bureau official website. 23 June. https://nyj.shanxi.gov.cn/zfxgk/fdzdgknr/jyta/rjydf/202106/t20210623_1424937.html (in Chinese)

⁵⁰ Shanxi Energy Bureau,2021. Reply to Recommendation No. 1324 of the Fourth Session of the Thirteenth Provincial People's Congress Shanxi Energy Bureau official website. Shanxi Energy Bureau official website. 23 June. https://nyj.shanxi.gov.cn/zfxgk/fdzdgknr/jyta/rjydf/202106/t20210623_1424937.html (in Chinese)

⁵¹ Clean Heating Industry Committee, 2021. Policy Recommendations: Facing the problem and continuing to promote the clean heating project. The official Website of Clean Heating Industry Committee. 27 September. <http://www.chic.org.cn/Home/Index/detail?id=1230> (in Chinese)

⁵² Clean Heating Industry Committee, 2021. Rural clean heating needs to balance environmental and economic costs. The official Website of Clean Heating Industry Committee. 26 September. <http://www.chic.org.cn/Home/index/detail?id=1225> (in Chinese)

⁵³ Clean Heating Industry Committee, 2021. Rural clean heating needs to balance environmental and economic costs. The official Website of Clean Heating Industry Committee. 26 September. <http://www.chic.org.cn/Home/index/detail?id=1225> (in Chinese)