Published in : Biomass and Bioenergy (2023), vol. 170, n°03
DOI: 10.1016/j.biombioe.2023.106725
Status : Postprint (Author's version)

Barter mode: The institutional innovation for affordable and clean energy (SDG7) in rural China

Shu Wang [a,b], Changbin Yin [a,c], Xiaomei Yang [a], Aurore Richel [b]

[a] *Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing, 100081, China*
[b] *Laboratory of Biomass and Green Technologies, Gembloux Agro-Bio Tech, University of Liege, Gembloux, B-5030, Belgium*
[c] *Research Center for Agricultural Green Development in China, Beijing, 100081, China*

Abstract

As the world's largest agricultural production country, China has abundant straw resource for bioenergy utilization. Plenty of studies have explored that straw pellet is relatively clean, with lower greenhouse gas as well as air pollutant emissions than coal, whereas how to make it more affordable for low-income rural families is eager for a plausible and practical solution. Therefore, barter mode is proposed as an institutional innovation, and it is working successfully in Meihekou city, Northeast China. Under this mode, rural families can supply 3-ton straw feedstock in return for 1-ton straw pellet. The results from the life cycle assessment illustrate that greenhouse gas emissions from barter mode are remarkably lower than straw pellet in commercial mode and coal heating mode. The economic evaluation indicates that the benefits for the consumer and the producer could be promoted dramatically. In addition, the experiences that how barter mode can work in Meihekou city are summarized systematically. Barter mode gives a unique angle on how to achieve SDG7 (affordable and clean energy) in China, and the experiences and lessons learned are particularly useful for policymakers to alleviate rural energy poverty in developing countries.

Keywords:

Barter mode

Straw pellet

SDG7

China

Published in : Biomass and Bioenergy (2023), vol. 170, n°03
DOI: 10.1016/j.biombioe.2023.106725
Status : Postprint (Author's version)

1. Introduction

Many environmental issues are resulted from or related to the production, conversion as well as consumption of energy. Conventional fossil fuel is a finite resource and its continued consumption leads to a remarkable environmental burden. The most globally significant environmental issues, in which energy plays a crucial role, are global climate change, stratospheric ozone depletion and acid precipitation [1]. The hazard caused by these environmental issues threatens the life of human-being and property. Therefore, mitigating the reliability and dependency on fossil fuels is crucial. McGlade and Ekins (2015) [2] estimated and suggested that more than 80% of coal, 50% of gas, and 33% of oil reserves should not be consumed from 2010 to 2050, in order to restrict average global warming to 2°C. In front of the global crisis, the power and force of every nation should be united together, and the United Nations (UN) have made the most prominent effort in proposing sustainable development goals (SDGs), which require all UN members to adopt. In total, 17 Sustainable Development Goals (SDGs) were proposed to protect the planet, end poverty and ensure prosperity [3–5]. In particular, energy is crucial for achieving almost all of the SDGs, from its role in the eradication of poverty through advancements in health, education, water supply and industrialization, to combating climate change [6,7]. Hence, to phase out fossil fuels and achieve SDG7: Affordable and clean energy, sourcing alternative energy, such as bioenergy, is of paramount importance.

Among renewable energy sources, bioenergy is the largest, and it accounted for 70% of renewable energy consumption in 2017 [8]. The contribution of bioenergy to final energy demand across all sectors is five times higher than wind and solar PV combined, even when the conventional utilization of biomass in developing countries, such as direct combustion of firewood and straw for cooking and heating, is excluded [9]. The feedstock of bioenergy is biomass, which includes all molecular and macromolecular compounds arising from agricultural products (foods), forestry products as well as residues, etc. [10], and the selection of the different types of biomass feedstock for bioenergy is distinct, which is based on the national food and energy strategy. Major food export countries (US, Brazil, etc.) utilize food (e.g., corn, sugarcane) as feedstock to produce bioethanol, which is also an important means to reduce the surplus, thereby maintaining the sale price of food and protecting the interest of farmers. In developing countries with vast amount of populations, national food security is the top priority for food production, and projects that use food for bioenergy are not encouraged. So, the advantage of straw-based cellulosic bioethanol is that it uses agricultural waste as the primary feedstock, which does not threaten national food security as compared with bioethanol production [11]. In addition, planting energy crops, such as miscanthus and switchgrass, is another popular way of bioenergy production [12,13]. But planting energy crops also brings about the debate on land use impacts. In general, land-use change has usually been regarded as negative, referring to environmental impacts of deforestation and expansion of energy crops plantations on uncultivated land, including habitat destruction, greenhouse gas (GHG) emissions, soil erosion and degradation, as well as non-point source pollution [14–17]. For developing countries where agriculture has profound development (e.g., China, India), the marginal land is limited [18], which is uneconomical for supporting energy

Published in : Biomass and Bioenergy (2023), vol. 170, n°03
DOI: 10.1016/j.biombioe.2023.106725
Status : Postprint (Author's version)

crops. Therefore, the use of straw, the by-product and waste from agricultural production, is more attractive, from the perspective of little negative impact on the environment.

There is huge potential to use straw for bioenergy. The worldwide estimation from Ref. [19] indicates that theoretical energy potential for utilizing straw could represent 15% of global primary energy consumption. The enhancement of agriculture by modern technology lays a good foundation for straw-based bioenergy. With the continuous increase of global crop yield, the quantity of straw is rising correspondingly [20], and there is little worry about the shortage of feedstock provision. China is the world's largest agricultural production as well as straw production country, and abundant straw resource has great potential for bioenergy utilization. Apart from biodiesel, electricity and biogas, straw briquetting pellet is also a considerable form of bioenergy utilization. National Energy Administration in China has promulgated two "five-year plans" to support the development of straw pellet production [21,22]. Until the end of 2020, the annual consumption of pellet fuel can reach 20 million tons [22], which could substitute 10 million tons of standard coal.

The utilization of straw pellet for bioenergy is one of the major contributors to fossil fuel substitution and achieving SDG7. There have been plenty of studies to explore that straw pellet is relatively clean, because their GHG as well as air pollutant emissions are lower than coal [23–28]. However, although there has been some financial assessment (by calculating net present value) to elucidate that biomass pellet production is lucrative [29–31], from the perspective of return on investment, there is little research trying to explore how to make it more affordable, especially standing for the consumer's point of view. The corresponding concept of affordable is energy poverty. An estimation of 1.25–3 billion people in the world lack access to beneficial energy for their living, demonstrating that energy poverty is a persistent problem [32,33]. The high and rising fuel price exacerbates poverty, and worse still, some families are labelled with "fuel-cost-induced poverty" because fuel cost accounts for a significant proportion of family income [34,35]. This phenomenon can be observed and measured with Engel's Coefficient, where fuel expenditure is estimated instead. In developed countries, energy poverty can be defined as fuel expenditure representing above 10% of family income [36]. In developing countries like China, the situation of energy poverty is also very serious. In particular, rural families (smallholder farmers) are more vulnerable because of the huge urban-rural income gap and disparities [37]. Urban residents have more options for consuming clean and stable energy sources, such as electricity, LGP and so on. But for poor rural families, in order to reduce fuel expenditure, they have no alternative except to use straw directly for energy proposes or coal.

However, there are several remarkable disadvantages of straw direct utilization. Due to low combustion efficiency, straw direct use has significantly higher pollutants emission than straw pellet [38,39]. Straw is scatter-distributed with low energy density, which is very inconvenient for transportation [24]. In addition, the high volume of straw occupied a large space for storage [40]. Due to cold weather in winter, carrying straw from warehouse to stove is both labor-consuming and feeling uncomfortable for rural residents. Especially the dominant population in rural China are elderly people and adolescent (adult labor force migrate to urban for more employment opportunities), and they are more vulnerable to loading straw. Besides, the traditional use of biomass is not only appeared in China,

Published in : Biomass and Bioenergy (2023), vol. 170, n°03
DOI: 10.1016/j.biombioe.2023.106725
Status : Postprint (Author's version)

but also popular primary energy consumption in developing countries. Globally, Sub-Sahara Africa (SSA) and India have the greatest percentage of population relying on the traditional use of biomass [41]. Over 80% of the population in SSA is dependent on traditional biomass use, and in India, about 32% of primary energy use depends upon biomass [42], but it is still derived from traditional biomass use to a large extent. Furthermore, the prediction from Fig. 1 indicates that the number of people using traditional biomass is still increasing in India and SSA. So, more actions should be taken to alter such a trend. With the development of modern energy utilization of biomass, the technique is no longer the bottleneck. In front of the low-income rural families in developing countries, how to reduce the accessible obstacle of modern biomass utilization is more challenging but meaningful. Such an issue is not only crucial in China, but it has a wider interest with a worldwide common concern.

Using straw pellet, which is a high-density and high-value solid fuel [24], has the advantages of being easier for transportation, storage and utilization. However, the instant energy transition from straw to straw pellet may put financial burden on poor rural families, because straw pellet procurement and replacement of coal stove with biomass stove are both required higher and extra expenditure. Therefore, the institutional innovation, barter mode, is proposed by Meihekou city, which is located in Jilin province, Northeast China (see Fig. 2). Currently, three demonstration towns are conducted, and the experience and running mode will soon expand to every town of Meihekou city. In barter mode, participating rural families can supply 3-ton straw feedstock in return for 1-ton straw pellet, and the Meihekou city government provides and installs biomass stove for free. This mode has been working in Meihekou city for several years, which significantly alleviates financial burden for participating rural families while everything is free. However, this mode has not been studied and assessed before, and its innovation and contribution to SDG7 require a scientific and quantitative explanation. So, by using the life cycle assessment (LCA) and economic evaluation, the performance of barter mode, from the perspective of GHG emission reduction (which is 'clean') and benefit for participating rural families (who can be 'affordable'), is going to be revealed. The findings from barter mode can be referenced by other developing countries to provide affordable and clean energy for the rural population, and reduce energy poverty as well.

Fig. 1. *Number of populations using traditional biomass (in millions) [43–45].*

Published in : Biomass and Bioenergy (2023), vol. 170, n°03
DOI: 10.1016/j.biombioe.2023.106725
Status : Postprint (Author's version)

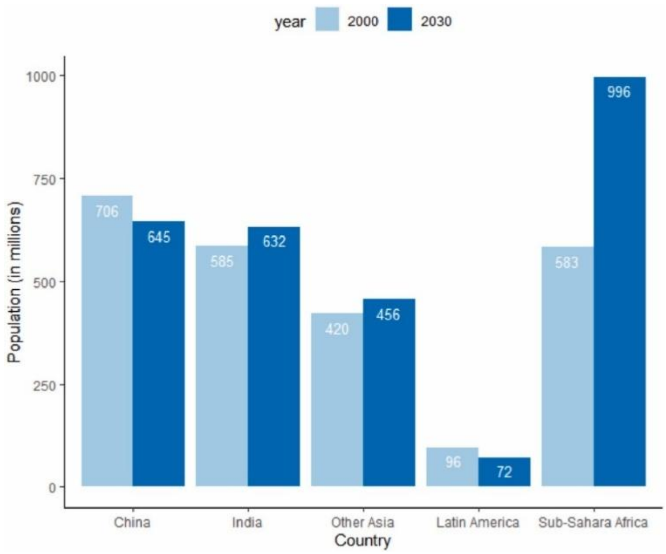
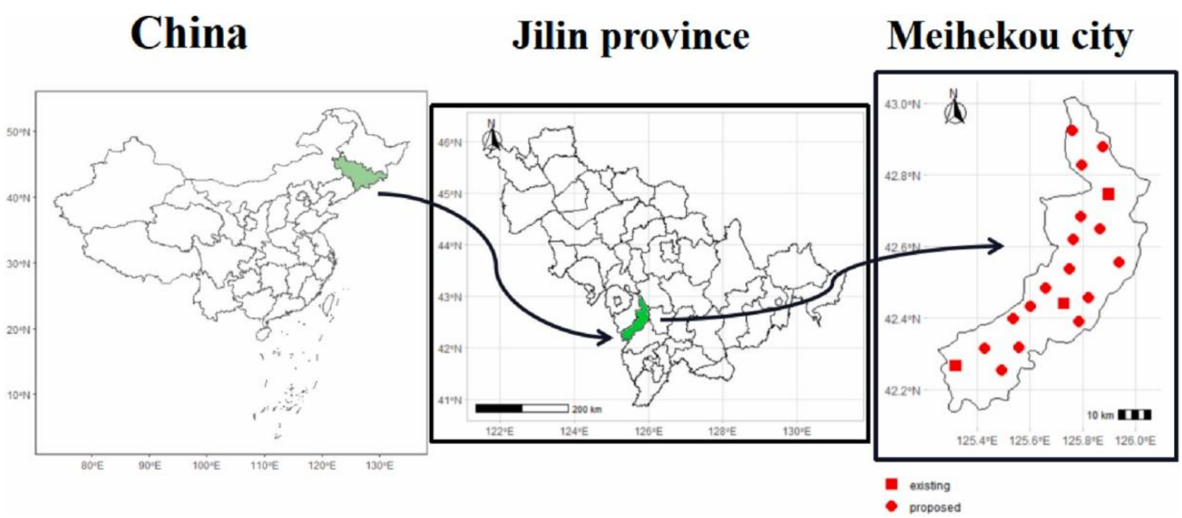


Fig. 2. *The geographical location of Jilin province in China and the deployment of straw pellet briquetting factories in Meihekou city (squares represent the locations of briquetting factories and circles represent the hypothetical locations in the future).*



The aim of this paper is to establish a LCA model and an economic model which are suitable for the evaluation of straw utilization for heating in barter mode. They can be applied to investigate the achievement pathway of SDG7 in barter mode through a case study of a straw pellet project in Meihekou city, Jilin province in Northeast China. And also, they can improve the understanding of energy poverty mitigation as well as a benefit-sharing mechanism among stakeholders of the consumer, the producer and the government. The rest of this paper is structured as follows. Section 2 describes system boundary and inventory of LCA in barter mode, and clarifies the scenario design for economic evaluation. Section 3 describes the results from LCA and economic evaluation, especially

Published in : Biomass and Bioenergy (2023), vol. 170, n°03
DOI: 10.1016/j.biombioe.2023.106725
Status : Postprint (Author's version)

emphasising how participating rural farmers could be beneficial from barter mode. Section 4 discusses and elaborates on the secrets of the successful operation of barter mode in Meihekou city. The important notions should be noticed when other areas want to reproduce barter mode. Section 5 gives the conclusion of this paper.

2. MATERIAL AND METHOD

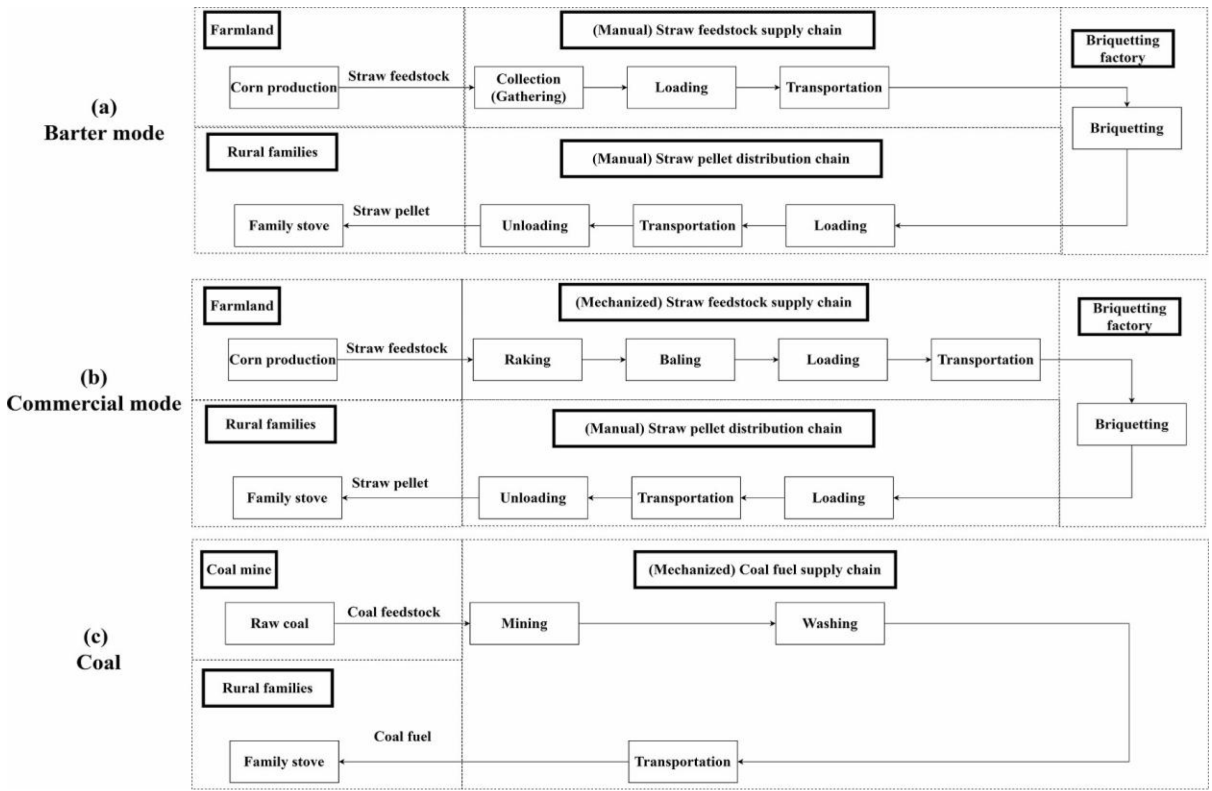
2.1. SYSTEM BOUNDARY AND LIFE CYCLE INVENTORY

LCA and economic evaluation are conducted for barter mode in Meihekou city with an aim to identify its optimality and advantages from economic, environmental and social perspectives. The system boundary of barter mode is illustrated in Fig. 3 (a). Prior to modeling and assessing, all adjustments and improvements while calculating GHG emissions and cost for producing 1-ton straw pellet and a comprehensive inventory of emission factors of GHG emissions have been shown in Table S4.

Meihekou city is consist of 24 towns. Barter mode is in operation in three towns at present, and soon will expand to every town (see Fig. 2 (b)). Herein, the running project of barter mode in Niuxinding town is chosen as the case study. The average yield of corn in Meihekou city is 5.80 tons/ha. Based on straw to grain ratio (1.86), theoretical collectable corn straw yield on average is 10.44 tons/ha. During harvesting, corn and straw are cut by a combined harvester, and straw is cut 15 cm from the ground (low stubble). So, collectable coefficient of straw feedstock is about 85% (15% of straw has remained as stubble), and the ultimate collectable corn straw yield on average is 8.87 tons/ha, without considering utilization competition for fodder, fertilizer etc. The required data for LCA is collected and summarized from a series of administrative documents, industry reports, environmental impact assessment (EIA), academic literature and field survey. In this analysis, Niuxinding town is first selected as a case study area, and then expand the knowledge into Meihekou city.

Fig. 3. *The diagram of system boundary and major activities of barter mode and commercial mode for straw pellet and coal mode for heating.*

Published in : Biomass and Bioenergy (2023), vol. 170, n°03
DOI: 10.1016/j.biombioe.2023.106725
Status : Postprint (Author's version)



2.1.1. Straw feedstock in the farmland

In barter mode, the scale of corn straw briquetting plant is 24,000 tons of straw pellet per year in Niuxingding town, Meihekou city. Considering loss during the briquetting process, the ultimate demand for straw feedstock is 26,000 tons per year. In Niuxinding town, the corn sown area is 7278 ha, which could annually produce 64,585 tons of straw feedstock in total. However, such quantity excessively exceeds the production capacity of the straw briquetting plant in Niuxinding town. In regards to characteristics of non-profit and social welfare in barter mode, the amount of rural families that could participate in this mode is restricted. The government is the leader in this institutional innovation, and it could determine the priority of rural families that could first be selected and benefited from barter mode. The selection criteria include family income, family size, the distance between farmland and straw briquetting plant etc. It is reported that, each rural family in Meihekou city would require 3.5-ton straw pellet on average for heating demand during winter. Hence, it could be further estimated that, 2286 rural families (25% of the total rural families) in Niuxinding town have an opportunity to participate in barter mode.

2.1.2. Straw feedstock supply chain

Currently, the major straw feedstock supply chain in China has been fulfilled with mechanization. In other words, almost all activities in straw feedstock supply chain, including collection with baler, and loading & unloading with forklift or loader are operated with machines. On the contrary, in barter mode, manpower from participating rural families is the major input in straw feedstock supply chain. Collection, loading and unloading activities are no longer relied on machines, where participating farmers carry and drop (unload) straw feedstock manually. In such a situation, energy consumption and GHG emissions in collection, loading and unloading activities are neglected in this analysis.

Transportation activity is the only source of energy consumption and GHG emissions in straw feedstock supply chain. According to a field survey and personal communication with local farmers in Meihekou city, nearly all the farmers have chosen to use tricycle (brand: Shifeng, e.g.) in barter mode. The tricycle is affordable for 20,000 RMB on average, and very convenient for transportation and it is owned by every rural family in Northeast China. Moreover, straw feedstock supply chain in barter mode only occupies a short period during farmers' free time, so accounting-related issues, such as depreciation, and maintenance, are not included in estimation. In straw feedstock supply chain, it all boils down that fuel consumption by tricycle is the only factor that is considered with energy consumption and GHG emissions. Based on the field survey and Fu et al. (2007) [46], the carrying capacity, and fuel consumption is 0.7 ton, 0.07 L/(t*km) in full loading mode as well as 0.04 L/km in empty mode. According to the geographical conditions and village distribution in Niuxingding town, it can be assumed that the transportation distance between each rural family to the briquetting plant is 15 km.

2.1.3. Straw pellet distribution chain

Compared to straw feedstock that is scattered in the farmland, and farmers need to spend much higher manpower in gathering and collection, straw pellet is concentrated and manual force input in collection and loading is much lower. For the same reason in straw feedstock supply chain, only fuel consumption in straw pellet transportation is the unique factor in energy consumption and GHG emissions.

2.1.4. Briquetting process

The briquetting process, which converts straw feedstock into straw pellet, is the most energy consumption and GHG emissions contributor among others. In accordance with similar study in China [24], it could account for over 93% of overall energy consumption. The power source of the briquetting process is electricity. Here in this analysis, the energy consumption and GHG emissions in the briquetting process are 68 kWh/ton [24] and 89.93 kg CO_2 eq./ton respectively.

2.1.5. Carbon neutrality in straw feedstock production and straw pellet combustion

Straw feedstock is a renewable and sustainable resource. In theory, the CO_2 released from straw pellet combustion is absorbed previously from atmosphere during corn growth by photosynthesis. Hence the CO_2 emission from straw pellet combustion in stove is equivalent to CO_2 captured during corn growth in the farmland, and direct CO_2 emissions are neutralized to zero in two stages. In this

Published in : Biomass and Bioenergy (2023), vol. 170, n°03
DOI: 10.1016/j.biombioe.2023.106725
Status : Postprint (Author's version)

analysis, corn straw feedstock is regarded as a by-product from corn production. Therefore, the energy consumption and GHG emissions have belonged to corn production process, which is not considered. However, GHG emissions with other GHG criteria variables including CH_4, N_2O etc. in straw pellet combustion should be taken into account, where they are 5.2 kg CH_4/ ton and 0.13 kg N_2O/ton respectively [47], and they are equivalent to 248 kg CO_2 eq./ton in total.

2.2. SCENARIO DESIGN AND ECONOMIC EVALUATION

For a better interpretation of the results obtained, horizontal and vertical comparisons are conducted. In horizontal comparison, like similar studies for biomass pellet for heating, the outcomes of GHG performance of straw pellet utilization are collected and summarized from literature. The feedstocks of pellet are mainly straw as agricultural waste, wood as forestry waste and other biomass. In vertical comparison, the results from barter mode will be compared with two popular and practical modes for heating provision: commercial mode and coal- for-heating mode, and the system boundary of these modes are illustrated in Fig. 3 (b,c) separately. The distinctions between commercial mode with barter mode are in straw feedstock supply chain and straw pellet distribution, whereas the rest of the activities for briquetting as well as straw pellet combustion are identical. The commercial mode is the application of StrawFeed mode [48]: the straw feedstock supply chain is completely mechanized and the briquetting factory needs to purchase straw feedstock from local brokers. The calculation procedure of GHG emissions in the mechanized straw feedstock supply chain is shown in the supplementary, and the economic indicators are from Hu et al. (2014) [24]. In coal-for-heating mode, rural families use coal for heating, and the outcome of GHG emissions is from Wang et al. (2017a) [49]. The functional unit in economic evaluation is fuel demand of rural families for heating during winter, which could be 3.5-ton straw pellet in barter and commercial modes, and 2-ton coal fuel in coal-for-heating mode. In barter mode, biomass stove is paid for and installed by the government, and the entire cost is around 4000 CNY for each rural family. Assuming that the lifespan of the biomass stove is 10 years, then it could be further estimated that the government should spend 400 CNY for each rural family during each winter. The cost of straw feedstock procurement, briquetting as well as the selling price of straw pellet is from a field survey.

3. RESULT

3.1. THE WHOLE AND COMPONENTS OF GHG EMISSIONS IN BARTER MODE

As illustrated in Fig. 4 (a), GHG emissions of straw pellet in barter mode are estimated at 10.15 g CO_2 eq./MJ. The energy conversion in briquetting process contributes the most GHG emissions (57.24%) in straw pellet production because electricity is indispensable in briquetting. Emissions of straw feedstock supply, as well as straw pellet distribution, are only 0.43 and 0.09 g CO_2 eq./MJ respectively, which occupy a small amount of GHG emissions (5.13%). On the contrary, straw pellet combustion (fuel consumption stage) occupies a significant proportion of GHG emissions, which is in line with Song et al. (2017) [26] but is different from Wang et al. (2017a) [49]. The benefits of the use of straw for bioenergy production in terms of GHG mitigation should not be overestimated [10]. There is no doubt that straw-based bioenergy can be regarded as carbon neutrality: direct CO_2 released in the pellet combustion stage can be absorbed during the straw planting stage [50]. However, other short-lived climate pollutants, particularly CH_4 and N_2O, have a stronger impact on global warming potential (GWP) and are neglected in the calculation of GHG emissions. According to the latest coefficients published by IPCC, the GWP-100 of CH_4 and N_2O are 29.8 and 273 respectively [51]. Hence, the results of this analysis echo the opinion from the 26th UN Climate Change Conference of Parties (COP26) that the mitigation of CH_4 and N_2O should pay higher attention [52,53], especially in bioenergy that GHG emissions may be underestimated.

3.2. HORIZONTAL COMPARISON

Fig. 5 compares the results in barter mode with other similar studies from China and other countries, and feedstock (raw material) is all from biomass, such as straw, wood residue etc. It should be emphasized that, the results from LCA cannot be compared directly. On one hand, differences come from many aspects, including geographic circumstance, the technique used as well as management level. On the other hand, diversity from LCA methods, such as inconsistent system boundaries, coefficient selection as well as the quality of data, can have a notable influence on the outcome [54]. But the comparison is still useful and necessary because it can check the reliability and robustness of the results, if the results fall into the same order of magnitude as other similar studies. The results in barter mode appear reasonable, and outperform the outcomes from most of the studies. The results are in line with the outcomes and argument from Wang et al. (2017b) [27] that straw pellet is much more environmental-friendly than other types of biomass pellet (GHG emissions are 11 g CO_2 eq./MJ). The results in barter mode are different with Hu et al. (2014) [24], where it has a lower estimation of GHG emissions (7 g CO_2 eq./MJ) by incorporating straw planting stages in LCA. In fact, unlike biomass feedstock such as corn or popular energy crops (switchgrass, miscanthus) that are planted intentionally, straw is the by-product of agricultural production, and its GHG emissions are out of scope in bioenergy utilization [55]. Therefore, it should be further emphasized that the selection and determination of system boundary should be done with caution and comprehensive understanding.

3.3. VERTICAL COMPARISON

The results in barter mode further compare with the commercial mode of straw pellet production as well as coal mode for heating (see Fig. 4 (b)). The results indicate that, the GHG emissions of manual straw feedstock supply in barter mode are slightly lower than mechanized straw feedstock supply in commercial mode. That is because barter mode takes advantage of physical activity from participating farmers, which does not count for GHG emissions. If the GHG emissions of physical activity are taken into account (2.83 kg CO_2 eq./(person × day), [72]), the GHG emissions in barter mode would rise dramatically to 97 g CO2 eq./MJ. In fact, the GHG emissions of physical activities in conventional manual labor are not analogies with a participating rural family, because the labor marginal cost is close to zero. After crop harvesting, rural families are in slack season. Apart from being recruited

Published in : Biomass and Bioenergy (2023), vol. 170, n°03
DOI: 10.1016/j.biombioe.2023.106725
Status : Postprint (Author's version)

temporarily for some simple physical work, most farmers are free. With the help of the use of agricultural machines [73–75], farmers can have more spare time. They can be available for participating in barter mode and earning free straw pellet for heating. So, when taking into account the labor marginal cost from GHG emissions, manual straw feedstock supply is neither economic [76] nor environmental-friendly. But as for social welfare project, barter mode can mobilize rural families' enthusiasm to participate in energy provision for heating, and it alleviates the government's financial burden and administrative resource if the government undertakes every responsibility of providing affordable and clean energy. The components of GHG emissions between barter and commercial modes are shown in Table S5. GHG emissions of briquetting and combustion activities in barter mode are equal to commercial mode, because they are identical in system boundary. The differences are in straw feedstock supply and straw pellet distribution activities. GHG emissions of straw feedstock supply in barter mode are remarkably lower than in commercial mode, because only transportation stage has fuel consumption with GHG emissions. On the contrary, in commercial mode, raking, baling, loading and transportation require a series of machines, including raker, baler, forklift and truck. Hence, the GHG emissions in mechanized straw feedstock supply are nearly 6 times greater than in manual straw feedstock supply. As for straw pellet distribution stage, the GHG emissions in barter mode are also lower than in commercial mode. That is because transportation frequency has been increased in straw feedstock supply with low carting capacity of tricycle, and GHG emissions of empty transportation have been allocated to straw feedstock supply activity.

Fig. 4. *(a) The components of GHG emissions in barter mode; (b)The comparison of GHG emissions between barter mode, commercial mode and coal mode for heating.*

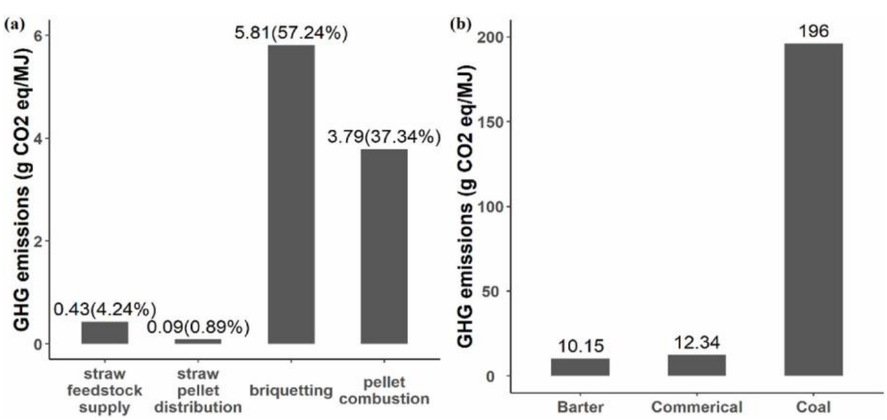


Fig. 5. *The comparison of GHG emission between barter mode with other biomass pellet, including straw [2–9]: Ref. [24,26,27,56–60], wood [10–19]: Ref. [49,58, 61–67], others biomass (switchgrass, sawdust and charcoal dust) [20–23]: Ref. [68–71].*

Published in : Biomass and Bioenergy (2023), vol. 170, n°03
DOI: 10.1016/j.biombioe.2023.106725
Status : Postprint (Author's version)

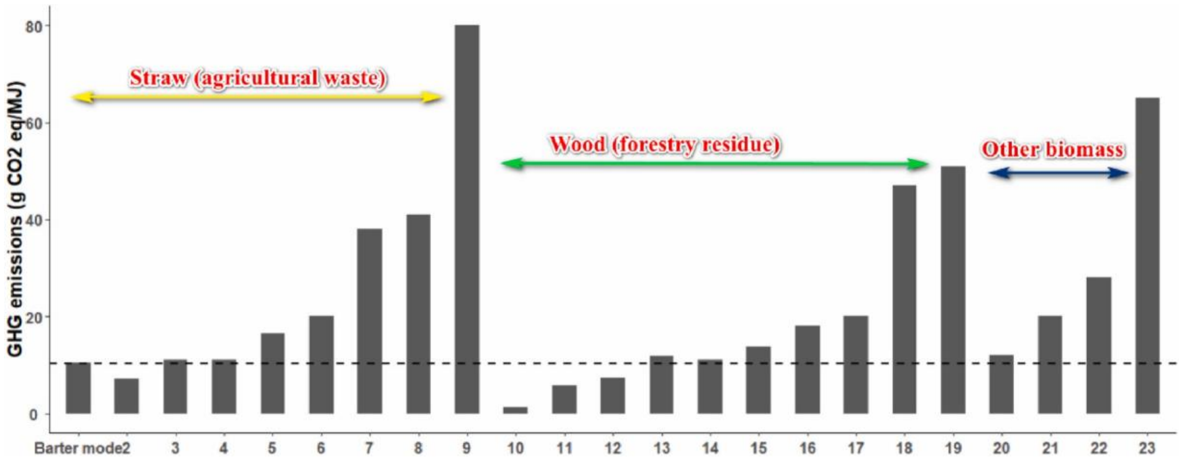


Fig. 6. *The results of economic evaluation in different modes (CNY).*

Entity	Item	Barter	Commercial	Coal
Rural family	Acquisition cost	135	40	25
	Product cost	0	2,450	1,400
	Total cost	135	2,490	1,425
Briquetting factory	Feedstock cost	0	1,083	-
	Other production cost	1,039	1,039	-
	Total production cost	1,039	2,122	-
	Revenue	2,450	2,450	-
	Profit	1,411	328	-
The government	Cost	400	-	-

The results in barter mode are consistent with all studies exploring GHG emissions of biomass pellet production and utilization when they took coal as an object reference. GHG emissions of barter mode are around 5% of coal mode for heating. Even including leftover straw pellet outside boundary of participating rural families (utilized by other consumers), GHG emissions of barter mode are still significantly lower than coal mode for heating. Furthermore, when the substitution effect of avoided straw burning in the farmland as well as avoided GHG emissions from displaced coal is concerned, GHG emissions abatement potential could be larger. The net GHG emissions can be estimated from straw pellet consumption including provision and production minus avoided GHG emissions from burning straw in the farmland and minus avoided GHG emissions from coal consumption for heating [77,78]. On one hand, if farmers decide to burn the corn straw in the farmland, it will emit GHG criteria variables including CO_2 and CH_4, and the emission factor of corn straw burning is 1489 g CO_2 eq./kg [79]. Barter mode can be helpful for farmers who have a low capacity to dispose of straw effectively. On the other hand, straw pellet instead of another type of fossil fuel can achieve emission reduction. Hence, the overall GHG emissions reduction can be 282 g CO_2 eq./MJ. Therefore, if rural families utilize straw pellet that substitutes coal for winter heating, it can make a remarkable contribution to GHG emissions reduction as well as non-renewable resources saving. Coal can be used for more important

Published in : Biomass and Bioenergy (2023), vol. 170, n°03
DOI: 10.1016/j.biombioe.2023.106725
Status : Postprint (Author's version)

applications (e.g., chemicals, materials), and straw pellet utilization for heating can build up a positive beneficent cycle in agriculture, rural as well as energy sectors.

3.4. THE COMPARISON OF AIR POLLUTANT EMISSIONS IN THREE UTILIZATION MODES

Furthermore, the emissions of air pollutants in barter, commercial and coal modes are also assessed, and details on calculations and inventory of emission factors of air pollutants are provided in Table S2. Based on the comprehensive inventory of emission factors of air pollutants, air pollutant emissions on straw pellet utilization with barter and commercial mode as well as coal utilization are estimated, and the results are shown in Table 1.

Table 1. *The air pollutant emissions on three energy utilization modes (g/kg).*

Mode\ Indicator	PM2.5	CO	NOx	SO2
Barter mode	0.049	0.121	0.426	0.008
Commercial mode	0.050	0.127	0.446	0.008
Coal mode	0.498	5.627	0.136	0.474

The results demonstrate that, the air pollutant emissions in straw pellet utilization are remarkably lower than in coal utilization mode, except for NOx. Even including leftover straw pellet outside boundary of participating rural families, air pollutant emissions of barter mode are still significantly lower than coal mode for heating. Based on the environmental impact assessment report of the surveyed briquetting factory in Meihekou city, the major pollution is noise and dust. The briquetting factory is far away from residents, so the noise has little impact on people's life. As for dust, the briquetting factory has installed bag dust collector, and the dust emission is at a very low level. Hence, in comparison with the high pollution activities of coal mining and washing, straw feedstock supply and briquetting are relatively clean, because only diesel and electricity are consumed in operation. As for SO_2, the gap between straw pellet and coal is significant. That is because the emission factor of coal combustion is 5.5 g/kg, whereas SO_2 from straw pellet combustion is below the equipment detection limit [80]. However, NOx emission in straw pellet utilization is greater than in coal mode. With the construction of railway system in China, coal transportation is mainly relied on train and truck transportation between station and terminal is neglected [49]. Compared with other types of renewable energy, straw pellet has higher air pollutant emissions, because renewable energy like hydropower [81], solar [82] and wind energy [83] does not directly emit air pollutant into atmosphere. Hence, straw-based bioenergy is a relatively clean source, and also has great potential for exploring air pollutant emissions reduction (e.g., NOx) in the future.

3.5. UNCERTAINTY ANALYSIS

In order to assess the uncertainty of barter mode, uncertainty analysis with Monte Carlo simulation is employed [84–86]. The parameters of RASF (required amount of straw feedstock), FCR (fuel consumption rate of tricycle), distance as well as ECB (energy consumption for briquetting) are selected for uncertainty analysis. Assuming that these uncertain parameters follow triangular distribution [87], and their lower and upper limits are set to be ±25% of predefined values. Monte Carlo simulation runs 10,000 times, and coefficient of variance [88,89] of GHG emissions as well as air pollutant indicators are estimated (shown in Table S3). The results generally indicate that the coefficient of variance is of very low value. It further indicates that, barter mode is robust and reliable in supplying straw pellet for a rural family from the perspective of environment and sustainability.

3.6. ECONOMIC EVALUATION

In economic evaluation, the function unit is the annual energy demand for heating in a rural family, it could be 3.5-ton straw pellet in barter and commercial modes, or 2-ton coal fuel in coal mode. For barter mode, there is no feedstock charge as straw is by-product of farmers' crop production. For straw collection cost in barter mode, the participating farmers are using their free time after crop has been harvested. So, the straw collection cost with manual labor is zero in barter mode. As for the transportation vehicle, according to field survey and personal communication with local farmers in Meihekou city, nearly all the rural families have tricycle because it is cheap and convenient. Hence, farmers do not need to buy a new and specific vehicle for delivering straw feedstock and returning straw pellet. Besides, biomass stove is paid for and installed by the government. To sum up, the only monetary expenditure for the farmers is diesel for transportation by tricycle. Assuming that the diesel price is 6 CNY per litre and the distance between market and rural families is 15 km on average, it can be estimated that the monetary expenditure for each rural family in transportation is 135 CNY, 40 CNY and 25 CNY annually (the transportation frequencies are 30, 10 and 6 trips), in barter mode, commercial mode and coal mode respectively.

As for rural families, according to the aforementioned discussion of cost components, the acquisition cost is transportation expenditure. The product cost is rural families paid for buying straw pellet or coal, which are 2450 CNY and 1400 CNY in commercial mode or coal mode respectively. The total cost is the sum of acquisition cost and product cost, which are 135 CNY, 2490 CNY and 1425 CNY respectively. The results demonstrate that barter mode has a great economic advantage with free straw pellet in return.

As for cost-benefit analysis in briquetting factory, the parameters of business operation are from Hu et al. (2014) [24] by concerning inflation. They also conducted an economic evaluation of a fully-operating 20,000-ton corn straw briquetting factory in China. These parameters can be useful for supporting economic evaluation because conditions and circumstances are similar. The only difference between barter mode and commercial mode is the exclusion and inclusion of straw feedstock purchase cost. Feedstock (purchase) costs are 0 and 1083 CNY, whereas other production cost is equivalent (1039 CNY) between barter mode and commercial mode. The total production cost is the sum of feedstock and other production, which are 1039 CNY and 2122 CNY respectively. The revenue for selling straw pellet to the market is 2450 CNY from each rural family. Hence, by taking the advantage of free straw feedstock provided by farmers, the briquetting factory can make a great saving cost on feedstock, and thereby profit can be raised from 328 CNY in commercial mode to 1411 CNY in barter mode.

Besides, the economic evaluation also illustrates that, using coal for heating is much cheaper than using straw pellet in commercial mode (1425 versus 2490 CNY/year), and this cost does not incorporate the cost of replacing coal stove with biomass stove. As for the government, the expenditure is supporting rural families with new biomass stove. Assuming that each biomass stove is 4000 CNY and the lifespan is 10 years, then the government should spend 400 CNY for each participating rural family annually. These results reflect the dilemma of the campaign to "phase out coal for heating" in China. Even under the administrative force, the consumer still prefers to use coal because of the cost. On the contrary, rural families can receive free straw pellet from briquetting factory in barter mode, and the government helps to clear up the worry by providing free biomass stove. In barter mode, rural families can make great saving from heating expenditure, and the utilization of clean bioenergy can reduce the air pollutants from coal burning that could impair their health. In general, their sense of happiness raises significantly.

4. DISCUSSION: THE SECRETS OF THE SUCCESSFUL OPERATION OF BARTER MODE IN MEIHEKOU CITY

4.1. NORTH CHINA HAS STRONGER HEATING DEMAND THAN SOUTH CHINA

The heat generated from straw pellet can satisfy pluralistic energy demands, mainly for cooking, heating as well as boiling water. The energy consumption by rural families has the character of selectivity. Apart from the expenditure, availability, convenience and cleanliness should also take into account [90,91]. From the perspective of convenience, the consumer is more prefers to use electricity, natural gas for cooking or boiling water, because they can provide heat energy within a very short period, whereas straw pellet should wait for a longer time. On the other hand, the territory of China covers a broad span of latitudes, and thus the regions in the north are colder than in the south. Correspondingly, regions in the north have stronger winter's heating demand than in the south. And the drawbacks of straw pellet for cooking and boiling water is no longer significant in heating, because straw pellet combustion can provide long and sustainable heat energy in the winter, whereas the cost of using electricity for heating is much more expensive and uneconomical. Therefore, straw pellet has better market potential and acceptance in north China. Meihekou city is located in Northeast China, and barter mode is attractive to rural families.

4.2. THE WORLD-FAMOUS CORN BELT CAN SUPPLY PROFOUND STRAW FEEDSTOCK IN CHINA

There is no strict threshold for determining which type of straw is more suitable for straw briquetting. Considering the quantity of straw feedstock, crop straw has a wide application prospect in bioenergy utilization. In straw feedstock supply chain, transportation is one of the major obstacles to impacting the profitability of bioenergy production [92–94]. Therefore, these bioenergy projects and investments are usually successful in major crop-sown areas. Among these areas, the corn belt in

China [95] has great potential for bioenergy production. The corn belt in Northeast China is one of the two largest corn belts in the world (the other one is the corn belt in the Midwest, U.S., [96]). This corn belt is made up of over 40% of total corn production in China [97]. Meihekou city is located in the corn belt in Northeast China, and barter mode can be beneficial from its abundant feedstock and sustainable supply.

4.3. THE GOOD ENVIRONMENT AND ECONOMIC FOUNDATION IN MEIHEKOU CITY CAN SUPPORT INSTITUTIONAL INNOVATION

Northeast China is one of three famous industrial recession areas in the world (the other two are the Ruhr Industrial Base and the Rust Belt in the Great Lakes). According to the latest national population census data, population decline in Northeast China is the most serious area in China [98]. Negative population growth may accelerate ageing and population migration [98]. And these negative impacts further result in the decline of financial revenue and a rise in the government debt. Extraordinary, Meihekou is a minority of city where it can attract population inflow in Northeast China [99]. And it also receives the honour of being one of the most beautiful cities (counties) in China [100]. Barter mode can reduce the straw burning in farmland as much as possible, thereby reducing air pollution and promoting the living environment. In barter mode, both free straw pellet and free biomass stove are necessary. The absence of either component would make rural families unaffordable for clean bioenergy. In addition, a good economic foundation in Meihekou city also can alleviate rural families' burden and make straw pellet genuinely affordable. Considering straw pellet production capacity and straw yield, 20% of rural families can be beneficial from barter mode. The government's expense for providing free biomass stove will occupy a portion of the government annual revenue. Such expense is valuable, the Meihekou city government and residents, participating rural families as well as straw pellet briquetting factory all can be beneficial from barter mode.

4.4. THE CONSTRUCTION OF A BENEFIT-SHARING MECHANISM AMONG THE CONSUMER, THE PRODUCER AND THE GOVERNMENT

The construction of a benefit-sharing mechanism among the consumer (rural families), the producer (briquetting factory) and the government is the determinant that can make barter mode successful and efficient. In the benefit-sharing mechanism, the responsibility of each object is clarified, and they are not only the beneficiary, but also the benefactor of the cooperation. The interaction relationships between each pair of objects are shown in Fig. 7, and they are further elaborated in the following paragraphs.

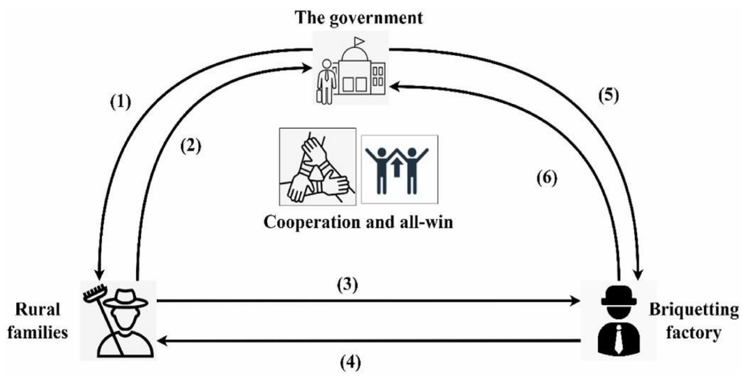
(1) What the government can gain from rural families: eliminate straw burning in farmland and make a contribution to the carbon neutrality goal

What the government can gain from rural families can be split into two aspects: official promotion of eliminating straw burning in the farmland and contribution to carbon neutrality goal. The initiative of barter mode is not for providing affordable and clean energy for rural families, but for eliminating a

Published in : Biomass and Bioenergy (2023), vol. 170, n°03
DOI: 10.1016/j.biombioe.2023.106725
Status : Postprint (Author's version)

problem that harasses China for decades: straw burning behavior. Even though China has implemented strict straw burning ban, the execution level has great spatial variety. Fire accidents still can be observed in Northeast China [102,103].

Fig. 7. *The diagram of a benefit-sharing mechanism among stakeholders (the consumer, the producer and the government) in barter mode.*



The estimation from Zhang et al. (2019) [101] indicates that fire accidents are clustered in Northeast China, which could represent 56.37% of overall fire accidents in China. Worse still, some fire accidents are close to airports and highways, which are threatening transportation safety [104]. Therefore, local government in Northeast China has strong pressure from the central government [105]. Some officials are dismissed because they are too feeble to prevent straw burning [106,107]. Meihekou city is located in Northeast China, and in order to entirely control straw burning, Meihekou city government has very strong motivation and willingness to design and implement institutional innovation. So, if the government can gain assurance for rural families that are used to burning straw in the farmland because of low disposal capacity, they can make better performance in straw burning control than other adjacent areas. The externality of straw burning can be annihilated, and the air quality, as well as the environment, can be improved, which can promote a sense of happiness for both rural families and urban citizens. Such achievement in environmental protection can provide an advantage for official promotion.

Rural families utilizing straw pellet for heating can reduce GHG emissions from straw burning as well as substitution of coal consumption, which can contribute to the carbon neutrality goal. In order to realize the goal of the Paris Agreement, President Xi announced the goal of GHG emission mitigation of "China will achieve a peak in carbon emissions by 2030 and carbon neutrality by 2060" [108], and this is important progress that China contributes to combating global warming as well as the transition of energy structure. The achievement of this "macro strategic goal" requires top-down allocation of emission reduction tasks [109].

(2) What rural families can gain from the government: environmental & health benefits

Apart from direct monetary expenditure savings, rural families can gain indirect environmental and health benefits from participation in this government-driven project. To begin with, the smoke from straw could threaten people's health, harmful air pollutant is emitted from straw burning [110–112].

Published in : Biomass and Bioenergy (2023), vol. 170, n°03
DOI: 10.1016/j.biombioe.2023.106725
Status : Postprint (Author's version)

Specifically, it could damage health by impairing the function of the lung [113,114], and raising the illness of bronchial asthma [111,115,116]. PAHs from straw burning are potential carcinogens [111,117–120], and result in lung cancer [121]. Singh [122] summarized the illness of cough, pulmonary symptoms, irritation and dryness of the eyes that could be attributed to smoke during straw burning season. The empirical study from He et al. (2021) [123] demonstrated a relationship with the increase in cardiorespiratory disease in China. The smoke-related illness would end up raising the medical cost and putting a burden on rural families [113]. Hence, the participating rural families can prevent straw burning in the farmland voluntarily by exchanging this straw feedstock for energy production, thereby protecting them from harmful air pollutants.

Besides, the substitution of coal consumption can reduce indoor air pollutant, which is also an important threat to people's health. Apart from air pollutants [124,125], coal burning can also generate poisonous substances including arsenic [126] and fluoride [127,128]. Diseases related to household coal consumption incorporate respiratory illnesses, pneumonia, chronic obstructive pulmonary disease, coronary syndromes, weakening of the immune system and chronic arsenic poisoning [126,129–131]. Evidence from medical experiments demonstrated that long-term consumption of fossil fuel may increase the health risk to families' members, and children and women are more relatively vulnerable [130,131]. In addition, higher mortality in women and infant groups could be identified, compared with non-coal users or non-winter months [132,133]. Therefore, the government has vigorously promoted the policies of energy transition from the "coal-to-gas" [134–136] and "coal-to-electricity" [137,138] policies in North China. Barter mode can be regarded as supplementary to the "coal-to-biomass" [139] policy that serves energy transition in China with health benefits [140–142]. In addition, unlike using gas or electricity which raises the consumer's expenditure for energy because gas and electricity are usually more expensive than coal, barter mode can be genuinely beneficial for low-income rural families with free straw pellet supply, which can be helpful for achieving energy transition.

(3) What briquetting factory can gain from rural families: free straw feedstock supply and production cost reduction.

Compared to the commercial mode, the producer should pay for local brokers to supply straw feedstock (300 CNY/ton), whereas a briquetting factory can be beneficial for reducing production cost from free raw feedstock (see Fig. 6). In addition, under the 3:1 exchange rate of straw feedstock to straw pellet, the remaining straw feedstock is free for briquetting factory to produce more straw pellet that can be for sale. Hence, with the advantages of these two aspects, briquetting factory can earn a larger profit than in commercial mode, and this is interesting for financial assessment in the future, from the perspective of the producer.

(4) What rural families can gain from briquetting factory: free straw pellet

Rural families are the major beneficiary in barter mode, and free straw pellet provided by straw briquetting factory can reduce expenditure for heating and mitigate energy poverty. Rural families can

Published in : Biomass and Bioenergy (2023), vol. 170, n°03
DOI: 10.1016/j.biombioe.2023.106725
Status : Postprint (Author's version)

save money and add other necessary expenses, such as education, food procurement, leisure and so on, which their welfare level can be promoted substantially.

(5) What the government can gain from briquetting factory: increase employment opportunity

As for utilizing the feedstock from the local community, the social benefit of bioenergy utilization is also an important concern by the government [143], because it can reflect the social contribution that bioenergy investment can make to local welfare improvement. The employment opportunity creation is the direct and substantial social benefit that straw briquetting brings [144–146]. For developing countries, with the help of relatively cheap labor cost, briquetting work is still labor-intensive [147], and straw briquetting factory can recruit a lot of labor and increase their income [148]. In particular, Pradhan et al. (2019) [149] assessed and concluded that, straw pellet project has significantly better performance of employment creation than biomass co-firing power stations, by increasing a maximum of 10 times more job opportunities with the same amount of investment. Hu et al. (2014) [24] estimated that over 30 jobs were created with the 20,000-ton scale straw briquetting factory in China. Therefore, the promotion of barter mode can help Meihekou city by creating more employment opportunities and increasing income, especially being beneficial for rural areas.

(6) What briquetting factory can gain from the government: expansion of the consumer group and supportive policy

Energy poverty is the bilateral characteristic of "difficulty of accessing and using energy" [151]. Without intervention from the government, the demand for straw pellet is facing great challenges and obstacles in substituting biomass stove (it requires extra expense from the low-income rural families, which is unaffordable). Free straw pellet provision solves the obstacle of "energy access", and the Meihekou city government provides free biomass stove, which can solve the obstacle of "energy use" for combating energy poverty. From the perspective of the producer (briquetting factory), barter mode is helpful for the expansion of market size, and this motivation can alter the consumer's habits to prefer bio-products.

As for the bioenergy production project, straw briquetting factory is strongly supported by the government including direct monetary subsidy. The government subsidizes investors according to their scale of yield and investment (see Table 2), and the other areas of Northeast China refer to this subsidy standard. Such direct monetary subsidy can significantly alleviate the financial burden of investors, and can also encourage and mobilize their enthusiasm for incremental investment and stable operation. In addition, in front of thousands of smallholder farmers, straw briquetting factory demands administrative support, including liaison and mediation of conflicts and disputes, by the government involvement.

5. CONCLUSION

Achieving SDG7: Affordable and clean energy is very challenging for developing countries, they not only lack access to a reliable and efficient energy source, but also cannot afford it. Therefore, the solution for reducing energy poverty and consuming clean energy will be extremely attractive and meaningful. This paper describes the institutional innovation for providing affordable and clean bioenergy to rural families in Meihekou city, Northeast China: barter mode. In this mode, the participating rural families can supply 3-ton straw feedstock in return for 1-ton free straw pellet, and the Meihekou city government provides and installs free biomass stove. The results of LCA indicate that straw pellet utilization for heating in barter mode is relatively clean, and the estimation is consistent with the previous LCA results. The results of economic evaluation illustrate that the benefits of the participating rural families (the consumer) as well as straw briquetting factory (the producer) are promoted significantly. The secrets of how this mode is working successfully in Meihekou city are discussed and systematically summarized, especially a benefit-sharing mechanism among stakeholders is proposed. Also, the research framework of this paper can enlighten other researchers on how to assess the institutional innovation of energy utilization, from the perspective of methodology.

In conclusion, apart from SDG7, barter mode can also serve for other related SDGs simultaneously [152]. Using straw pellet instead of coal can reduce indoor air pollution and improve health circumstances (SDG3: good health and well-being). The consumption of straw pellet (clean bioenergy) can be helpful for GHG emissions reduction thereby assisting with SDG13: climate action.

Table 2. *The subsidy standard for straw briquetting investment in Heilongjiang province, Northeast China [150].*

Yield (ton)	Subsidized proportion of investment (%)	Maximum subsidy scale (10 thousand CNY)
2500	70%	70
10,000	50%	150
20,000	30%	177
>30,000	30%	88.5 per 10,000 tons

And finally, the recycling of straw feedstock for bioenergy utilization can alleviate the dependency on firewood or energy crops, thereby reducing deforestation, land degradation as well as desertification (SDG15: life on land). Barter mode gives a unique angle on how to achieve SDG7 in China, and the experiences and lessons learned are particularly useful for policymakers to alleviate energy poverty of rural families in developing countries.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DATA AVAILABILITY

Data will be made available on request.

ACKNOWLEDGEMENTS

This research was funded by Major Program of National Social Science Foundation of China (No.18ZDA048), the earmarked fund for Modern Agro-industry Technology Research System-Green Manure (CARS-22-25), Fundamental Research Funds for Central Non-profit Scientific Institution (No.1610132021002). The China Scholarship Council (CSC) is gratefully acknowledged for financial support for the PhD study of Mr. Shu Wang. Also, the authors would like to appreciate the valuable comments from the editors and anonymous reviewers to improve the quality of this paper.

APPENDIX A. SUPPLEMENTARY DATA

Supplementary data to this article can be found online at https://doi.org/10.1016/j.biombioe.2023.106725.

REFERENCES

[1] I. Dincer, M.A. Rosen, Chapter 4-Exergy, environment, and sustainable development, Exergy, in: Energy, Environment and Sustainable Development, third ed., 2021, pp. 61–89.

[2] C. McGlade, P. Ekins, The geographical distribution of fossil fuels unused when limiting global warming to 2 ◦C,, Nature 517 (2015) 187–190.

[3] J.C.S. Toro, C.A.C. Alzate, Biorefineries as the base for accomplishing the sustainable development goals (SDGs) and the transition to bioeconomy: technical aspects, challenges and perspectives, Bioresour. Technol. 340 (2021) 125626.

[4] A.S. Matharu, E.M. de Melo, J.A. Houghton, Opportunity for high value-added chemicals from food supply chain wastes, Bioresour. Technol. 215 (2016) 123–130.

[5] A. Asadikia, A. Rajabifard, M. Kalantari, Systematic prioritisation of SDGs: machine learning approach, World Dev. 140 (2021) 105269.

[6] E. Fingleton-Smith, Blinded by the light: the need to nuance our expectations of how modern energy will increase productivity for the poor in Kenya,, Energy Res. Social Sci. 70 (2020) 101731.

[7] UNESC, Report of the secretary-general, "progress towards the sustainable development goals. https://www.un.org/ga/search/view_doc.asp?symbol=E/ 2016/75andLang=E, 2016.

[8] World Bioenergy Association, Global bioenergy statistics 2019. http://www. worldbioenergy.org/uploads/191129%20WBA%20GBS%202019_HQ.pdf, 2019.

[9] IEA, Bioenergy accounts for roughly one-tenth of world total primary energy supply today. https://www.iea.org/fuels-and-technologies/bioenergy, 2020.

[10] Y. Queneau, B. Han, Biomass: renewable carbon resource for chemical and energy industry, Innovation 3 (2021) 100184.

[11] T. Lin, L.F. Rodríguez, Y.N. Shastri, K. T. Alan C Hansen, Gis-enabled biomass- ethanol supply chain optimization: model development and miscanthus application, Biofuels, Bioprod, Bio 7 (2013) 314–333.

[12] A. Bauen, A. Dunnett, G. Richter, A. Dailey, M. Aylott, E. Casella, G. Taylor, Modelling supply and demand of bioenergy from short rotation coppice and Miscanthus in the UK, Bioresour. Technol. 101 (2010) 8132–8143.

[13] L. Das, E. Liu, A. Saeed, D.W. Williams, H. Hu, C. Li, J. S. Allison E. Ray and, Industrial hemp as a potential bioenergy crop in comparison with kenaf, switchgrass and biomass sorghum, Bioresour. Technol. 244 (2017) 641–649.

[14] R.P. Powers, W. Jetz, Global habitat loss and extinction risk of terrestrial vertebrates under future land-use-change scenarios, Nat. Clim. Change 9 (2019) 323–329.

[15] J.B. Dunn, S. Mueller, H. young Kwon, M.Q. Wang, Land-use change and greenhouse gas emissions from corn and cellulosic ethanol, Biotechnol. Biofuels 6 (2013) 51.

[16] Y. Khaledian, F. Kiani, S. Ebrahimi, E.C. Brevik, J. Aitkenhead-Peterson, Assessment and monitoring of soil degradation during land use change using multivariate analysis, Land Degrad. Dev. 28 (2017) 128–141.

[17] M. Liu, C. Li, Y. Hu, F. Sun, Y. Xu, T. Chen, Combining CLUE-S and SWAT models to forecast land use change and non-point source pollution impact at a watershed scale in Liaoning Province, China, Chin. Geogr. Sci. 24 (2014) 540–550.

[18] Y, e. a. Chen, Assessment of marginal land potential for energy plants in China, Land Dev. Eng. Res. 2 (2017) 1–7.

[19] N.S. Bentsen, C. Felby, B.J. Thorsen, Agricultural residue production and potentials for energy and materials services, Prog. Energy Combust. Sci. 40 (2014) 59–73.

[20] S. Wang, X. Huang, C. Yin, A. Richel, A critical review on the key issues and optimization of agricultural residue transportation,, Biomass Bioenergy 146 (2021) 105979.

[21] National Energy Administration, 13th five-year-plan of biomass energy development. http://www.gov.cn/xinwen/2016-12/06/content_5143612.htm, 2016.

[22] Xinhua Finance, National Energy Administration: the "14th Five-Year Plan" will continue to steadily promote the diversified developmentof biomass energy. https://www.cnfin.com/hg-lb/detail/20211207/3476033_1.html, 2021.

[23] L. Jiang, B. Xue, Z. Ma, L. Yu, B. Huang, X. Chen, A life-cycle based co-benefits analysis of biomass pellet production in China,, Renew. Energy 154 (2020) 445–452.

[24] J. Hu, T. Lei, Z. Wang, X. Yan, X. Shi, Z. Li, X. He, Q. Zhang, Economic, environmental and social assessment of briquette fuel from agricultural residues in China e A study on flat die briquetting using corn stalk, Energy 64 (2014) 557–566.

[25] C. Ji, K. Cheng, D. Nayak, G. Pan, Environmental and economic assessment of crop residue competitive utilization for biochar, briquette fuel and combined heat and power generation, J. Clean. Prod. 192 (2018) 916–923.

[26] S. Song, P. Liu, J. Xu, C. Chong, X. Huang, L. Ma, Z. Li, W. Ni, Life cycle assessment and economic evaluation of pellet fuel from corn straw in China: a case study in Jilin Province,, Energy 130 (2017) 373–381.

[27] Z. Wang, T. Lei, M. Yang, Z. Li, T. Qi, X. Xin, X. He, A. Ajayebi, X. Yan, Life cycle environmental impacts of cornstalk briquette fuel in China, Appl. Energy 192 (2017) 83–94.

[28] J. Liu, W. Yang, Straw densification briquette fuel: a contribution to fuel supply in rural China,, Energy Environ. 22 (2011) 925–928.

[29] A. Pirraglia, R. Gonzalez, D. Saloni, Techno-economical analysis of wood pellets production for U.S. manufacturers, Bioresources 5 (2010) 2374–2390.

[30] A. Pa, X. Bi, S. Sokhansanj, Evaluation of wood pellet application for residential heating in British Columbia based on a streamlined life cycle analysis, Biomass Bioenergy 49 (2013) 109–122.

[31] V. Nabavi, M. Azizi, A. Tarmian, C.D. Ray, Feasibility study on the production and consumption of wood pellets in Iran to meet return-on-investment and greenhouse gas emissions targets, Renew. Energy 151 (2020) 1–20.

[32] One Earth Editorial, Tackling Energy Poverty, One Earth 1, 2019, pp. 385–387.

[33] L. Guruswamy, Energy poverty, Annu. Rev. Environ. Resour. 36 (2011) 139–161. [34] A. Burlinson, M. Giulietti, G. Battisti, The elephant in the energy room: establishing the nexus between housing poverty and fuel poverty,, Energy Econ. 72 (2018) 135–144.

[35] R. Marchand, A. Genovesea, S.L. Koh, A. Brennan, Examining the relationship between energy poverty and measures of deprivation, Energy Pol. 130 (2019) 206–217.

[36] S. Feeny, T.-A. Trinh, A. Zhu, Temperature shocks and energy poverty: findings from Vietnam, Energy Econ. 99 (2021) 105310.

[37] The 19th national congress of CPC, in: Report on the 19th National Congress of the Communist Party of China, 2017. http://cpc.people.com.cn/n1/2017/1028/c 64094-29613660.html.

[38] J. Sun, Z. Shen, Y. Zhang, Q. Zhang, F. Wang, T. Wang, X. Chang, Y. Lei, H. Xu, J. Cao, N. Zhang, S. Liu, X. Li, Effects of biomass briquetting and carbonization on PM2.5 emission from residential burning in Guanzhong Plain, China, Fuel 244
(2019) 379–387.

[39] J. Sun, Z. Shen, Y. Zeng, X. Niu, J. Wang, J. Cao, X. Gong, H. Xu, T. Wang, H. Liu, L. Yang, Characterization and cytotoxicity of PAHs in PM2.5 emitted from residential solid fuel burning in the Guanzhong Plain, China, Environ. Pollut. 241
(2018) 359–368.

[40] M. Tajmirriahi, F. Momayez, K. Karimi, The critical impact of rice straw extractives on biogas and bioethanol production,, Bioresour. Technol. 319 (2021) 124167.

[41] International Renewable Energy Agency, Biomass potential in Africa. https://www.irena.org/publications/2013/Aug/Biomass-Potential-in-Africa, 2013.

[42] Ministry of New and Renewable Energy, India, bioenergy overview in India. https://mnre.gov.in/bio-energy/current-status, 2021.

[43] IEA, World Energy Outlook, 2002, https://iea.blob.core.windows.net/assets
/11bc7b29-db2a-46fb-a515-1f5e7d2c7dfd/WorldEnergyOutlook2002.pdf, 2002.

[44] S. Karekezi, K. Lata, S.T. Coelho, Traditional biomass energy. https://www.ren21.net/Portals/0/documents/irecs/renew2004/Traditional%20Biomass%20Energy. pdf, 2004.

[45] VENRO, Rethinking biomass energy in sub-sahara Africa. https://www.ic eednigeria.org/resources/venro-2009.pdf, 2009.

[46] Y. Fu, F. Fan, Y. Fu, Influence factors and resolution about the straw power generation in China, J. Shenyang Inst. Eng. (Nat. Sci). 3 (2007) 206–210.

[47] CBCSD, Guidelines for provincial-level greenhouse gas inventory. http://www.cbcsd.org.cn/sjk/nengyuan/standard/home/20140113/download/shengjiwensh iqiti.pdf, 2014.

[48] S. Wang, C. Yin, J. Jiao, X. Yang, B. Shi, A. Richel, StrawFeed model: an integrated model of straw feedstock supply chain for bioenergy in China, Resources, Conserv. Recycl. 185 (2022) 106439.

[49] C. Wang, Y. Chang, L. Zhang, M. Pang, Y. Hao, A life-cycle comparison of the energy, environmental and economic impacts of coal versus wood pellets for generating heat in China,, Energy 120 (2017) 374–384.

[50] U.S.EIA, Biomass explained, Biomass and the environment. https://www.eia.gov/ energyexplained/biomass/biomass-and-the-environment.php, 2021.

[51] IPCC2021, Climate Change, The physical science basis. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report_smaller.pdf, 2021, 2021.

[52] BBC, COP26: US and EU announce global pledge to slash methane. https://www. bbc.co.uk/news/world-59137828, 2021.

[53] UK Centre for Ecology and Hydrology, Nitrogen's key role for future climate action will be highlighted at COP26. https://www.ceh.ac.uk/news-and-me dia/news/nitrogens-key-role-future-climate-action-will-be-highlighted-cop26, 2021.

[54] S. Soimakallio, J. Kiviluom, L. Saikku, The complexity and challenges of determining GHG (greenhouse gas) emissions from grid electricity consumption and conservation in LCA (life cycle assessment) – a methodological review,, Energy 36 (2011) 6705–6713.

[55] S. Soam, P. Borjesson, P.K. Sharma, R.P. Gupta, D.K. Tuli, R. Kumar, Life cycle assessment of rice straw utilization practices in India, Bioresour. Technol. 228
(2017) 89–98.

[56] L. Huo, Y. Tian, H. Meng, L. Zhao, Z. Yao, Life cycle assessment analysis for densified biofuel, Acta Energiae Solaris Sin. 32 (2011) 1875–1880.

[57] A. Sultana, A. Kumar, Development of energy and emission parameters for densified form of lignocellulosic biomass, Energy 36 (2011) 2716–2732.

[58] M.R. Kabir, A. Kumar, Comparison of the energy and environmental performances of nine biomass/coal co-firing pathways, Bioresour. Technol. 124
(2012) 394–405.

[59] L. Nguyen, K.G. Cafferty, E.M. Searcy, S. Spatari, Uncertainties in life cycle greenhouse gas emissions from advanced biomass feedstock logistics supply chains in Kansas, Energies 7 (2014) 7125–7146.

[60] J. Waewsak, P. Nutongkaew, C. Kongruang, S. Tirawanichakul, Environmental life cycle assessment of small scale mixed rice husk-glycerol briquettes gasification power plant, International Conference on Alternative Energy in Developing Countries and Emerging Economies, Energy Proc. 79 (2013).
[61] T. Tabataa, H. Torikai, M. Tsurumaki, Y. Genchi, K. Ukegawa, Life cycle assessment for co-firing semi-carbonized fuel manufactured using woody biomass with coal: a case study in the central area of Wakayama, Japan,, Renew. Sustain. Energy Rev. 15 (2011) 2772–2778.
[62] F. Fantozzi, C. Buratti, Life cycle assessment of biomass chains: wood pellet from short rotation coppice using data measured on a real plant, Biomass Bioenergy 34
(2010) 1796–1804.
[63] Y.L. Chiew, S. Shimada, Current state and environmental impact assessment for utilizing oil palm empty fruit bunches for fuel, fiber and fertilizer : a case study of Malaysia,, Biomass Bioenergy 51 (2013) 109–124.
[64] A. Kylili, E. Christoforou, P.A. Fokaides, Environmental evaluation of biomass pelleting using life cycle assessment, Biomass Bioenergy 84 (2016) 107–117.
[65] H. Liu, X. Yin, C. Wu, W. Liang, J. Xu, Life cycle analysis of energy consumption and greenhouse gas emissions for wood pellet, Acta Energiae Solaris Sin. 34
(2013) 709–713.
[66] P. Adams, J. Shirley, M. McManus, Comparative cradle-to-gate life cycle assessment of wood pellet production with torrefaction, Appl. Energy 138 (2015) 367–380.
[67] D. Reed, R. Bergman, J.-W. Kim, A. Taylor, D. Harper, D. Jones, C. Knowles, M. E. Puettmann, Cradle-to-gate life-cycle inventory and impact assessment of wood fuel pellet manufacturing from hardwood flooring residues in the southeastern United States, For. Prod. J. 62 (2012) 280–288.
[68] R.D. Bergman, D.L. Reed, A.M. Taylor, D.P. Harper, D.G. Hodges, Cradle-to-gate life cycle assessment of switchgrass fuel pellets manufactured in the Southeastern United States, Wood Fiber Sci. 47 (2015) 147–159.
[69] S. Mani, S. Sokhansanj, X. Bi, A Streamlined Life Cycle Analysis of Biomass Densification Process, AIChE Annual Meeting, Cincinnati, 2005.
[70] F. Magelli, K. Boucher, H.T. Bi, S. Melin, A. Bonoli, An environmental impact assessment of exported wood pellets from Canada to Europe, Biomass Bioenergy
33 (2009) 434–441.
[71] M. Njenga, N. Karanja, H. Karlsson, R. Jamnadass, M. Iiyama, J. Kithinji, C. Sundberg, Additional cooking fuel supply and reduced global warming potential from recycling charcoal dust into charcoal briquette in Kenya, J. Clean.
Prod. 81 (2014) 81–88.
[72] S. Jiao, A method for measuring carbon emissions in the whole Life Cycle of highways and its application, cN 102567619 A, https://patents.google.com/pat ent/CN102567619A/zh, 2011.
[73] Y. Wang, R. Wei, H. Tang, J. Zhao, C. Lin, An integrated scheduling framework for synchronizing harvesting and straw returning, Comput. Electron. Agric. 189 (2021) 106360.
[74] Y. Wang, G. Huang, A two-step framework for dispatching shared agricultural machinery with time windows, Comput. Electron. Agric. 192 (2022) 106607.
[75] Y. Wang, G. Huang, Harvester scheduling joint with operator assignment, Comput. Electron. Agric. 202 (2022) 107354.
[76] Y. Sun, W. Cai, B. Chen, X. Guo, J. Hu, Y. Jiao, Economic analysis of fuel collection, storage, and transportation in straw power generation in China, Energy 132 (2017) 194–203.
[77] T. Suramaythangkoor, S.H. Gheewala, Potential of practical implementation of rice straw-based power generation in Thailand, Energy Pol. 36 (2008)
3193–3197.
[78] S. Shafie, H. Masjuki, T. Mahlia, Life cycle assessment of rice straw-based power generation in Malaysia, Energy 70 (2014) 401–410.
[79] L. Li, K. Wang, J. Jiang, F. Liu, Y. Pu, W. Liu, H. Qi, H. Yu, Emission inventory and the temporal and spatial distribution of pollutant for open field straw burning in Heilongjiang Province, China Environ. Sci. 38 (2018) 3280–3287.
[80] Y. Liu, Z. Li, E. Floess, Y. Zhang, N. Lam, S.K. Mawusi, P. Shrestha, X. Li, C. Xue, G. Liu, Field assessment of straw pellet combustion in improved heating stoves in rural Northeast China, J. Environ. Sci. 127 (2023) 295–307.
[81] U.S. EIA, Hydropower explained, Hydropower. Environ. (2021). https://www.ei
a.gov/energyexplained/hydropower/hydropower-and-the-environment.php.
[82] U.S. EIA, Solar explained, Solar energy. Environ. (2022). https://www.eia.gov /energyexplained/solar/solar-energy-and-the-environment.php.

[83] U.S. EIA, Wind explained, Wind Energy. Environ. (2021). https://www.eia.gov/e nergyexplained/wind/wind-energy-and-the-environment.php.
[84] N. Bamber, I. Turner, V. Arulnathan, Y. Li, S.Z. Ershadi, A. Smart, N. Pelletier, Comparing sources and analysis of uncertainty in consequential and attributional life cycle assessment: review of current practice and recommendations, Int. J. Life Cycle Assess. 25 (2020) 168–180.
[85] M. Guo, R. Murphy, LCA data quality: sensitivity and uncertainty analysis, Sci. Total Environ. 435–436 (2012) 230–243.
[86] H. Hu, T. Lin, S. Wang, L.F. Rodriguez, A cyberGIS approach to uncertainty and sensitivity analysis in biomass supply chain optimization,, Appl. Energy 203
(2017) 26–40.
[87] P. Trivedi, R. Malina, S.R.H. Barrett, Environmental and economic tradeoffs of using corn stover for liquid fuels and power production, Energy Environ. Sci. 8 (2015) 1428.
[88] K. Cacua, A. Amell, F. Cadavid, Effects of oxygen enriched air on the operation and performance of a diesel-biogas dual fuel engine, Biomass Bioenergy 45
(2012) 159–167.
[89] Q. Jing, H. Bai, W. Luo, B. Cai, H. Xu, A top-bottom method for city-scale energy- related CO2 emissions estimation: a case study of 41 Chinese cities,, J. Clean.
Prod. 202 (2018) 444–455.
[90] G. Li, G. Yu, W. Lu, S. Niu, Differences in rural household energy consumption across the loess hilly region of Gansu, Resour. Sci. 34 (2012) 1839–1844.
[91] Y. Xiao, L. Gu, H. Zhang, Poverty, energy and environment: analysis on factors affecting rural cooking energy utilization in poverty-stricken counties, J. Huazhong Agri. Univ.(Soc. Sci. Ed.) 12 (2010) 36–42.
[92] Q. Zhang, Z. Shi, P. Zhang, Z. Li, M. Jaberi-Douraki, Predictive temperature modeling and experimental investigation of ultrasonic vibration-assisted pelleting of wheat straw, Appl. Energy 205 (2017) 511–528.
[93] N.Q. Diep, S. Fujimoto, T. Minowa, K. Sakanishi, N. Nakagoshi, Estimation of the potential of rice straw for ethanol production and the optimum facility size for different regions in Vietnam, Appl. Energy 93 (2012) 205–211.
[94] J. Cao, B. Pang, X. Mo, F. Xu, A new model that using transfer stations for straw collection and transportation in the rural areas of China: a case of Jinghai, Tianjin,, Renew. Energy 99 (2016) 911–918.
[95] X. Lu, Z. Li, Q. Bu, D. Cheng, W. Duan, Z. Sun, Effects of rainfall harvesting and mulching on corn yield and water use in the corn belt of Northeast China, Agron. J. 106 (2014) 2175–2184.
[96] T.R. Green, H. Kipka, O. David, G.S. McMaster, Where is the USA Corn Belt, and how is it changing? Sci. Total Environ. 618 (2018) 1613–1618.
[97] S. Wang, X. Huang, Y. Zhang, C. Yin, A. Richel, The effect of corn straw return on corn production in Northeast China: an integrated regional evaluation with meta- analysis and system dynamics, Resources,, Conserv. Recycl. 167 (2021) 105402.
[98] R. Liu, S. Liu, Q. Liu, Research on the impact of population change on Northeast economic growth, Chin. J. Popul. Sci. 35 (2021) 63–76.
[99] C.N.R. News, Jilin Meihekou: how it achieve the population inflow. http://www. mhk.gov.cn/mhsq/, 2021.
[100] Meihekou government, The introduction of Meihekou city. http://www.mhk.gov. cn/mhsq/, 2021.
[101] J. Zhang, X. Yang, X. Tu, K. Ning, X. Luan, Spatio-temporal change of straw burning fire points in field of China from 2014 to 2018, Trans. Chin. Soc. Agric.
Eng. 35 (2019) 191–199.
[102] S. Cui, Z. Song, L. Zhang, Z. Shen, R. Hough, Z. Zhang, L. An, Q. Fu, Y. Zhao, Z. Jia, Spatial and temporal variations of open straw burning based on fire spots in northeast China from 2013 to 2017, Atmos. Environ. 244 (2021) 117962.
[103] H. Ke, S. Gong, J. He, C. Zhou, L. Zhang, Y. Zhou, Spatial and temporal distribution of open bio-mass burning in China from 2013 to 2017 Atmospheric Environment, Atmos. Environ. 210 (2019) 156–165.
[104] X. Tu, X. Yang, J. Zhang, X. Luan, K. Ning, Analyzing geographical characteristics of straw burning in China during 2014-2019, Geogr. Res. 39 (2020) 2379–2390.
[105] Legal Daily, Ministry of Ecology and Environment: dispatch an expert team to Northeast China to carry out supervision on the prohibition of straw burning. https://m.gmw.cn/baijia/2021-02/25/1302133486.html, 2021.
[106] The People's Daily, Ineffective air pollution control, in: 65 responsible persons in 4 cities in Heilongjiang are held accountable, 2018. http://politics.people.com. cn/n1/2018/0530/c1001-30021772.html.

[107] Southern Metropolis Daily, Ministry of Ecology and Environment: the heavy pollution caused by the straw open burning in the Northeast has caused many officials to be held accountable and will be strictly controlled. http://m.mp.oeeee. com/a/BAAFRD000020210225443876.html, 2021.

[108] Xinhua News, Xi jinping's speech at the general debate of the 75th united nations general assembly (full text). https://baijiahao.baidu.com/s?id=1678595656 103445127&wfr=spider&for=pc, 2020.

[109] J. Wu, Q. Guo, J. Yuan, J. Lin, L. Xiao, D. Yang, An integrated approach for allocating carbon emission quotas in China's emissions trading system, Resources, Conserv. Recycl. 143 (2019) 982–992.

[110] W. Jiang, T. Yan, B. Chen, Impact of media channels and social interactions on the adoption of straw return by Chinese farmers, Sci. Total Environ. 756 (2021) 144078.

[111] S. Wang, C. Yin, F. Li, A. Richel, Innovative incentives can sustainably enhance the achievement of straw burning control in China, Sci. Total Environ. 857 (2023) 159498.

[112] H. Chen, S. Yin, X. Li, J. Wang, R. Zhang, Analyses of biomass burning contribution to aerosol in Zhengzhou during wheat harvest season in 2015, Atmos. Res. 207 (2018) 62–73.

[113] P.A. Seglah, Y. Wang, H. Wang, Y. Bi, K. Zhou, Y. Wang, H. Wang, X. Feng, Crop straw utilization and field burning in Northern region of Ghana, J. Clean. Prod. 261 (2020) 121191.

[114] G.S. Saggu, S.K. Mittal, R. Agarwal, G. Beig, Epidemiological study on respiratory health of school children of rural sites of malwa region (India) during post-harvest stubble burning events, MAPAN 33 (2018) 281–295.

[115] J. Jacobs, R. Kreutzer, D. Smith, Rice burning and asthma hospitalizations, butte county, California, 1983-1992, Environ. Health Perspect. 105 (1997) 980–985.

[116] K. Torigoe, S. Hasegawa, O. Numata, S. Yazaki, M. Matsunaga, N. Boku, M. Hiura, H. Ino, Pediatrics International Influence of emission from rice straw burning on bronchial asthma in children, Pediatr. Int. 42 (2000) 143–150.

[117] B. Jenkins, S. Turn, R. Williams, Atmospheric emissions from agricultural burning in California: determination of burn fractions, distribution factors, and crop- specific contributions, Agriculture, Ecosys. Environ. 38 (1992) 313–330.

[118] N.Y.M. Omar, M.B. Abas, K.A. Ketuly, N.M. Tahir, Concentrations of PAHs in atmospheric particles (PM-10) and roadside soil particles collected in Kuala Lumpur, Malaysia, Atmos. Environ. 36 (2002) 247–254.

[119] J. Ding, J. Cong, J. Zhou, S. Gao, Polycyclic aromatic hydrocarbon biodegradation and extracellular enzyme secretion in agitated and stationary cultures of Phanerochaete chrysosporium, J. Environ. Sci. 20 (2008) 88–93.

[120] Y. Yu, H. Guo, Y. Liu, K. Huang, Z. Wang, X. Zhan, Mixed uncertainty analysis of polycyclic aromatic hydrocarbon inhalation and risk assessment in ambient air of Beijing, J. Environ. Sci. 20 (2008) 505–512.

[121] C. Batra, Stubble burning in North-west India and its impact on health, journal of chemistry, Environ.Sci. Appl. 4 (2017) 13–18.

[122] J. Singh, Paddy and wheat stubble blazing in Haryana and Punjab states of India: a menace for environmental health,, Environ. Qual. Manag. 28 (2018) 47–53.

[123] G. He, T. Liu, M. Zhou, Straw burning, PM2.5, and death: evidence from China, J. Dev. Econ. 145 (2020) 102468.

[124] J.E. Bunnell, L.V. Garcia, J.M. Furst, H. Lerch, R.A. Olea, S.E. Suitt, A. Kolker, Navajo coal combustion and respiratory health near shiprock, New Mexico, J. Environ. Public Health. 260525 (2010) 1–14.

[125] N. Zhao, B. Li, H. Li, G. Li, R. Wu, Q. Hong, P. Mperejekumana, S. Liu, Y. Zhou, R. Ahmad, A.M.I. Zayan, C. Pemberton-Pigott, R. Dong, The potential co-benefits for health, economy and climate by substituting raw coal with waste cooking oil as a winter heating fuel in rural households of northern China,, Environ. Res. 194 (2021) 110683.

[126] H.E. Belkin, B. Zheng, D. Zhou, R.B. Finkelman, Chronic arsenic poisoning from domestic combustion of coal in rural China: a case study of the relationship between earth materials and human health, Environ. Geochem. (2008) 401–420. [127] M. Ando, M. Tadano, S. Yamamoto, K. Tamura, S. Asanuma, T. Watanabe, T. Kondo, S. Sakurai, R. Ji, C. Liang, X. Chen, Z. Hong, S. Cao, Health effects of fluoride pollution caused by coal burning, Sci. Total Environ. 271 (2001) 107–116.

[128] M. Ando, M. Tadano, S. Asanuma, K. Tamura, S. Matsushima, T. Watanabe, T. Kondo, S. Sakurai, R. Ji, C. Liang, S. Cao, Health effects of indoor fluoride pollution from coal burning in China, Environ. Health Perspect. 106 (1998) 239–244.

[129] J.J. Zhang, K.R. Smith, Household air pollution from coal and biomass fuels in China: measurements, health impacts, and interventions, Environ. Health Perspect. 115 (2007) 848–855.

[130] D. Mahalanabis, S. Gupta, D. Paul, A. Gupta, M. Lahiri, M.A. Khaled, Risk factors for pneumonia in infants and young children and the role of solid fuel for cooking: a case-control study,, Epidemiol. Infect. 129 (2002) 65–71.

[131] Z. Fatmi, D. Coggon, A. Kazi, I. Naeem, M. Kadir, N. Sathiakumar, Solid fuel use is a major risk factor for acute coronary syndromes among rural women: a matched case control study, Publ. Health 128 (2014) 77–82.
[132] C. Kim, W.J. Seow, X.-O. Shu, B.A. Bassig, N. Rothman, B.E. Chen, Y.-B. Xiang, H. D.H III, B.-T. Ji, W. Hu, C. Wen, W.-H. Chow, Q. Cai, G. Yang, Y.-T. Gao, W. Zheng, Q. Lan, Cooking coal use and all-cause and cause-specific mortality in a prospective cohort study of women in Shanghai, China, Environ. Health Perspect. 124 (2016) 1384–1389.
[133] A. Barreca, K. Clay, J. Tarr, Coal, smoke, and death: bituminous coal and American home heating. https://ssrn.com/abstract=2393594, 2014.
[134] R. Cesur, E. Tekin, A. Ulker, Can natural gas save lives? Evidence from the deployment of a fuel delivery system in a developing country, J. Health Econ. 59 (2018) 91–108.
[135] R. Cesur, E. Tekin, A. Ulker, Air pollution and infant mortality: evidence from the expansion of natural gas infrastructure, Econ. J. 127 (2017) 330–362.
[136] S. Xu, J. Ge, Sustainable shifting from coal to gas in North China: an analysis of resident satisfaction, Energy Pol. 138 (2020) 111296.
[137] K.R. Bilsback, J. Baumgartner, M. Cheeseman, B. Ford, J.K. Kodros, X. Li, E. Ramnarine, S. Tao, Y. Zhang, E. Carter, J.R. Pierce, Estimated aerosol health and radiative effects of the residential coal ban in the Beijing-Tianjin-Hebei region of China, Aerosol Air Qual. Res. 20 (2020) 2332–2346.
[138] X. Shuxue, W. Yueyue, N. Jianhui, M. Guoyuan, 'Coal-to-electricity' project is ongoing in north China, Energy 191 (2020) 116525.
[139] Q. Wang, T. Dogot, Y. Yang, J. Jiao, B. Shi, C. Yin, From "coal to gas" to "coal to biomass": the strategic choice of social capital in China,, Energies 13 (2020) 4171.
[140] J. Liu, J. Zhang, F. Wang, R. Liu, The importance of compressed straw fuel in rural China: taking Henan province as an example,, Energy Environ. 24 (2013) 1043–1049.
[141] G. Shen, S. Tao, S. Wei, Y. Zhang, R. Wang, B. Wang, W. Li, H. Shen, Y. Huang, Y. Chen, H. Chen, Y. Yang, W. Wang, W. Wei, X. Wang, W. Liu, X. Wang, S.L. M. Simonich, Reductions in emissions of carbonaceous particulate matter and polycyclic aromatic hydrocarbons from combustion of biomass pellets in comparison with raw fuel burning, Environ. Sci. Technol. 46 (2012) 6409–6416.
[142] W. Wei, W. Zhang, D. Hu, L. Ou, Y. Tong, G. Shen, H. Shen, X. Wang, Emissions of carbon monoxide and carbon dioxide from uncompressed and pelletized biomass fuel burning in typical household stoves in China, Atmos. Environ. 56 (2012) 136–142.
[143] S.M. Zahraee, N. Shiwakoti, P. Stasinopoulos, Biomass supply chain environmental and socio-economic analysis: 40-Years comprehensive review of methods, decision issues, sustainability challenges, and the way forward, Biomass Bioenergy 142 (2020) 105777.
[144] K.W. Corscadden, J. Biggs, A. Thomson, An integrated on-farm production system: agricultural briquettes for residential heating in Nova Scotia, Canada, Renew. Sustain. Energy Rev. 39 (2014) 394–402.
[145] L. Liu, D. Wang, L. Gao, R. Duan, Distributed heating/centralized monitoring mode of biomass briquette fuel in Chinese northern rural areas, Renew. Energy 147 (2020) 1221–1230.
[146] V. Karkania, E. Fanara, A. Zabaniotou, Review of sustainable biomass pellets production - a study for agricultural residues pellets' market in Greece, Renew. Sustain. Energy Rev. 16 (2012) 1426–1436.
[147] G.K. Ngusale, Y. Luo, J.K. Kiplagat, Briquette making in Kenya: nairobi and peri- urban areas, Renew. Sustain. Energy Rev. 40 (2014) 749–759.
[148] M.E. Mostafa, S. Hu, Y. Wang, S. Su, X. Hu, S.A. Elsayed, J. Xiang, The significance of pelletization operating conditions: an analysis of physical and mechanical characteristics as well as energy consumption of biomass pellets,, Renew. Sustain. Energy Rev. 105 (2019) 332–348.
[149] P. Pradhan, P. Gadkari, S.M. Mahajani, A. Arora, A conceptual framework and techno-economic analysis of a pelletization gasification based bioenergy system,, Appl. Energy 249 (2019) 1–13.
[150] D.R.C. Heilongjiang, Implementation plan of straw comprehensive utilization in Heilongjiang Province in 2020. http://drc.hlj.gov.cn/art/2020/10/10/art_293 _31110.html, 2020.
[151] Z. Liu, D. Wu, B.-J. He, Q. Wang, H. Yu, W. Ma, G. Jin, Evaluating potentials of passive solar heating renovation for the energy poverty alleviation of plateau areas in developing countries: a case study in rural Qinghai-Tibet Plateau, China,, Sol. Energy 187 (2019) 95–107.

Published in : Biomass and Bioenergy (2023), vol. 170, n°03
DOI: 10.1016/j.biombioe.2023.106725
Status : Postprint (Author's version)

[152] J. Rosenthal, A. Quinn, A.P. Grieshop, A. Pillarisetti, R.I. Glass, Clean cooking and the SDGs: integrated analytical approaches to guide energy interventions for health and environment goals, Energy. Sustain. Dev. 42 (2018) 152–159.