Briefing

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China's domestic biogas sector must adjust to changing conditions

Policy pointers

The domestic biogas sector needs a comprehensive review to accurately measure the costs and benefits of biodigesters, and to establish actual not just potential usage.

Public and/or private sector biogas service networks need improvement, as maintaining biodigesters poses challenges to many rural households.

Alternative government subsidies should be explored to find the most cost-effective options, whether cash rewards for households using biogas or performance-based subsidies for biogas providers.

Biogas should be made more pro-poor, because those who could gain the most from the technology are usually least able to afford it. More grants to help low-income households install digesters, or to provide them with more effective technical support services, could help.

China's biogas programme is renowned for its rapid expansion in rural areas and community-level uptake. A decade of heavy government investment means that around 100 million rural people now benefit from biogas digesters, turning livestock manure into clean cooking fuel and organic fertiliser and cutting carbon dioxide emissions by up to 61 million tonnes a year. But China is changing. Rapid urbanisation has reduced rural labour, and household livestock are declining. A shortage of technical services poses another challenge. China's new socioeconomic landscape could threaten biogas as a sustainable energy solution for millions of rural households. Reviewing the biogas sector and taking objective action to secure its future would benefit China and provide lessons to other countries facing challenges in rural energy supply.

Biogas development in rural China is at a crossroads. Following a decade of expansion, emerging problems are calling into question whether domestic biogas can meet rural households' increasing energy needs, and how government subsidies can be made more cost-effective. The potential benefits of overcoming these obstacles are huge.

Clear benefits for rural households

Biogas technology can address several rural problems, such as a lack of clean cooking fuels (and associated indoor air pollution), water pollution from waste, human and animal waste as an infection source, soil degradation from overuse of inorganic fertilisers, and over-collection of firewood.

These benefits have motivated China's huge biogas expansion programme, which had a cumulative government investment of 31.5 billion Chinese yuan (US$4.5 billion) by 2012, reaching a quarter of all rural households with biogas technology (Figure 1).

Problems and opportunities

In the midst of this massive expansion programme, challenges have emerged. Problems include a shortage of manure as traditional animal husbandry at individual households gives way to centralised livestock farms, the increasing cost of rural labour and migration away from villages, and the competing availability of liquefied petroleum gas and electricity. The proportion of biogas digesters reported to be in regular use varies widely across villages, from less than 30 per cent to over 90 per cent.

On the other hand, new opportunities are emerging. People are more aware of the advantages of using decentralised renewable

China needs to review its biogas sector to ensure it remains appropriate for rural areas

energy sources; rural biogas service networks are springing up, initiated by the government and implemented in partnership with public and private players; mass production is offering cheaper, prefabricated biogas digesters; there are ongoing efforts towards technical innovations; and the government remains committed to pro-poor development. These positive changes may lead to increased government investment and greater willingness and ability to pay for, operate and maintain digesters among rural households. Together, these factors could maintain a robust and sustainable biogas sector in China.

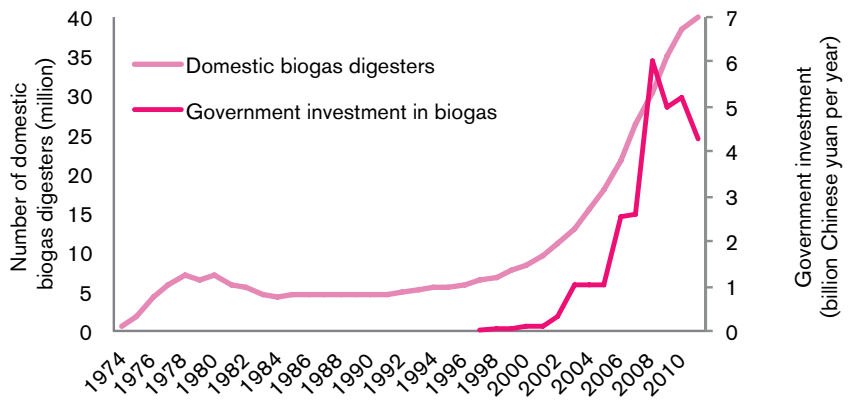
Costs and benefits

Data from the Ministry of Agriculture show that biogas digesters produce 410 million tonnes of organic fertilisers in China each year, reduce carbon dioxide emissions by 61 million tonnes, and generate benefits worth US$7.7 billion from cost savings and income growth.[1] But are they a sound investment for individual households?

It is easy to overestimate biogas benefits. A 2008 World Bank financial analysis put the net present value of a normal biogas digester at about US$203,[2] based on reduced use of traditional fuels such as firewood or coal, saved time that could be used to generate income, and chemical fertiliser costs being offset by switching to bio-slurry. However, most households would not reap all of these benefits. If the saved time does not generate alternate income and the bio-slurry is replacing animal manure rather than chemical fertilisers, then the net present value becomes minus US$48, making biogas digesters financially unattractive.

A more realistic assessment would include the time spent on digester operation and the cost of labour, a comparison of biogas against the cost of alternative cooking fuels (such as liquefied petroleum gas), the amount of biogas produced and used in a year, the price difference between biogas feedstock (usually manure and other waste) and the discharged bio-slurry, and the proportion of the year when biogas digesters are in normal use. These parameters fluctuate significantly according to location so it may not be possible to generalise about the financial viability of domestic biogas digesters, but for some households the direct economic benefits of a domestic biogas digester may not exceed its costs over the expected lifecycle.

Figure 1. Number of domestic biogas digesters and government investment in biogas in China, 1974-2011



Note: biogas digester figures are cumulative, while investment figures are annual.
Sources: see notes 3,4,5.

Funding domestic biogas development

Funding for biogas development comes from central government, provincial government, government agencies, the private sector and international players such as the World Bank and the Asian Development Bank. Two-thirds of the US$4.5 billion invested by China's government from 2003 to 2012 was used to directly subsidise rural households for biogas construction.[5]

Beneficiary households usually contribute a significant portion of the installation costs of biogas digesters, varying from labour inputs alone to 50–70 per cent of the total installation cost,[6] and all of the operational costs. Investment in domestic biogas is mainly via subsidies, such as cash grants to households, construction materials, biogas appliances, and technician services. But some of the funding criteria make households ineligible for subsidies. For instance, the Treasury Bonds For Rural Biogas Construction Programme stipulates that for a village to qualify, 70 per cent of households must own enough livestock, which can lead to the exculsion of whole villages.

Biogas systems

Domestic biogas digesters in rural areas usually have 'upstream' and 'downstream' connections to ease routine management and to capture the multiple benefits of biogas. 'Upstream' connections carry feedstock into the biogas digester, such as from a toilet, livestock pen or water storage (in arid areas). 'Downstream' connections carry biogas and bio-slurry to where

they can be used, such as a kitchen or vegetable plot. This has led to a variety of biogas systems:

- **The 'three-combined' model**. Traditionally in rural China a domestic biogas digester is integrated with the toilet and livestock pen, allowing animal and human waste to be fed in easily.
- **The 'one-plus-three renovation'.** This system is also known as a 'rural biogas digester and three renovations', because a rural household renovates the livestock pen, toilet and kitchen when constructing the biogas digester.
- **The 'three-in-one' model in southern China.** This system prioritises using bio-slurry efficiently. Originally, the three-in-one name referred to 'pig-biogas-fruit', using pig manure for biogas production and then bio-slurry as fertiliser for orange trees. This system has improved both the quality and quantity of fruit production.
- **The 'four-in-one' model in northern China.** A biogas digester, a cattle pen and a toilet are all installed inside a greenhouse, which is also used for vegetable or fruit production. In these colder regions, the higher temperature in a greenhouse enhances biogas production, animal growth and vegetable production.
- **The 'five-in-one' model in northwest China.** Designed for arid areas with water shortages and long, cold winters, this is similar to the 'four-in-one' model, except that the greenhouse is used as a warm enclosure for livestock, and a rainwater collection cellar is included to meet the water needs of the household and to support biogas production.

These more comprehensive systems help to improve the economic benefits of using biogas, such as increased fruit production, but their higher capital costs constrain those on lower incomes.

Services

Inadequate biogas service systems and insufficient post-installation services have emerged as a major challenge. The government's emphasis has therefore shifted from extending the provision of biogas digesters across the country to ensuring normal functioning of the existing installations. In 2007, the government launched the National Rural Biogas Service System Development Initiative, aimed at nurturing sustainable and market-driven services to rural biogas users. By the end of 2011, the government had invested US$400 million. But there is still a long way to go before these services reach maturity, and their overall performance is yet to be fully evaluated.

Attitudes to investing

Despite all the benefits of domestic biogas, its adoption varies widely across regions. Whether or not a household is willing to invest in biogas construction very much depends on people's understanding of its cost-effectiveness and advantages, whether financial, technical or socioeconomic. A field survey in Hebei Province reported that 45.5 per cent of sampled households did not consider domestic biogas to be satisfactory, citing the lack of technical support and services (55.8 per cent), a lack of financial capital (21.2 per cent), a lack of feedstock (19.2 per cent), or the unpleasantness of working with bio-slurry discharge (3.8 per cent).[7]

Even where there is interest, the ability to pay for biogas installation is another major challenge in many cases. Constructing a domestic biogas digester at a cost of US$368–792 would be a significant investment for rural households below the middle-income level, taking into account the wide disparities in income across the country. Even with the government subsidies (at US$261 for the central region and US$327 for the western region), biogas may still not be affordable for those living near or below the poverty line.

Recommendations

After a decade of rapid development, it is time to adjust strategies in response to changing circumstances. A 'business as usual' approach is not the best way to minimise the risks associated with the government's massive investment in the biogas sector.

Tackle the current problems

- **Analyse the biogas sector objectively.** Significant data gaps must be filled, particularly on the quantified economic costs and benefits of biogas digesters, to confirm whether government subsidies are justified. Political will is needed to encourage an objective, unbiased analysis of the sector. If possible, independent third parties should carry out this work in close cooperation with stakeholders.
- **Accurately measure what proportion of rural biogas digesters are in use.** Field studies must have a clear definition of normal use to ensure compatible results from different sources. Studies should include factors such as the *actual* daily biogas production versus the *potential* daily production, and what proportion of a household's daily and annual cooking fuel needs are met by the biogas produced.
- **Improve servicing and maintenance.** The lack here is a major stumbling block to rural households' ability and willingness to use biogas. One possible solution is for public and/

or private 'social biogas services' to carry out all or part of the operation, maintenance and trouble-shooting of digesters. Some post-installation service delivery models have been developed, but longer-term trials of such models are required to evaluate their effectiveness and sustainability.

Make subsidies more cost-effective

There are concerns about the cost-effectiveness of the current subsidy scheme. For instance, biogas digesters are still eligible for government subsidies if they run far below their full potential, or are abandoned shortly after installation.

- **Review the assumptions used for the economic assessment of domestic biogas digesters** under today's changed circumstances in rural areas, in order to confirm the justification for continuing government subsidies.
- **Explore alternative forms of subsidy,** including:
  - Performance-based subsidies linking payment to the performance of the installed biogas digesters. Service delivery could be contracted to biogas companies, which would be reimbursed by the government only after the service has been verified.
  - Cash rewards for biogas use. Households would receive rewards if the actual amount of biogas used in a year reached certain levels. Pilot studies of this show a 10 per cent improvement in digester use rates.
  - Smart subsidies, such as those used in the agriculture and rural telecommunications sectors, which could accelerate the adoption of technology without distorting the behaviour of the beneficiaries. One example is a voucher-based subsidy that is flexible (can be issued to target households and can be used with many qualified providers) but also restricted (only for biogas development, non-transferable, time-bound, etc.).

Make biogas investment more pro-poor

- **Explore alternative methods of subsidy** so that public resources can best provide timely assistance and maximise benefits for those who need them most. The current subsidy schemes do not address income disparities within a region or community, leaving lower-income households unable to afford a biogas digester even though these households may be best-placed to supply the necessary labour and feedstock to maintain one.
- **Consider a pro-poor component** in the form of more government grants for low-income households, more effective social biogas services, or improved technical support.

China needs to review its biogas sector to ensure it remains an appropriate technology for rural areas. China's experience can also help other countries understand some of the challenges and opportunities offered by biogas. If rural populations around the world shift their primary energy supply away from local renewable energy sources like biogas to commercial fossil fuels, there will be huge economic and environmental impacts affecting energy security at national, or even global, levels. For this reason, it is essential — in China as elsewhere — to overcome the various barriers to robust and sustainable development of the biogas sector.

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This briefing is based on the full report ***Domestic biogas in a changing** China: Can biogas still meet the energy needs of China's rural households?* by Xia Zuzhang, published under the IIED Access to Energy series. For more information on this and other Access to Energy publications, see www.iied.org/improving-people-s-access-sustainable-energy.

Notes

[1] MoA. 2012. *Promote Crop Straw for Household-Scale Biogas Production to Tackle Feedstock Shortage.* Ministry of Agriculture, Beijing. / [2] World Bank 2008. Project Appraisal Document for China Eco-Farming Project. Rural Development, Natural Resources and Environmental Sector Unit, Sustainable Development Department, East Asia and Pacific Region, The World Bank, Washington DC. / [3] Li, J. Domestic biogas programme in China. Presentation to the International Workshop on Domestic Biogas, Chengdu, China, 20 November 2012. / [4] Hao, X. Development of post-installation services within the National Biogas Programme of China. Presentation to the International Workshop on Domestic Biogas Programmes in Asia, Bandung, Indonesia, 22 November 2011. / [5] Wang, X., Tu, Y., Chen, X. 2012. Status quo and suggestions on domestic biogas development in China. *Agricultural Engineering and Technology (New Energy Industry)* 11, 13–16. / [6] MoA. 2007. *National Rural Biogas Programme Development Plan 2006–2010*, Ministry of Agriculture, Beijing / [7] Wang, S. *et al.* 2011. Analysis of farmers' willingness to adopt small scale household biogas facilities. *Chinese Journal of Eco-Agriculture* 19(3), 718–722.

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