

Economic Analysis of Anaerobic Digester Systems (ADS) on Vermont Dairy Farms

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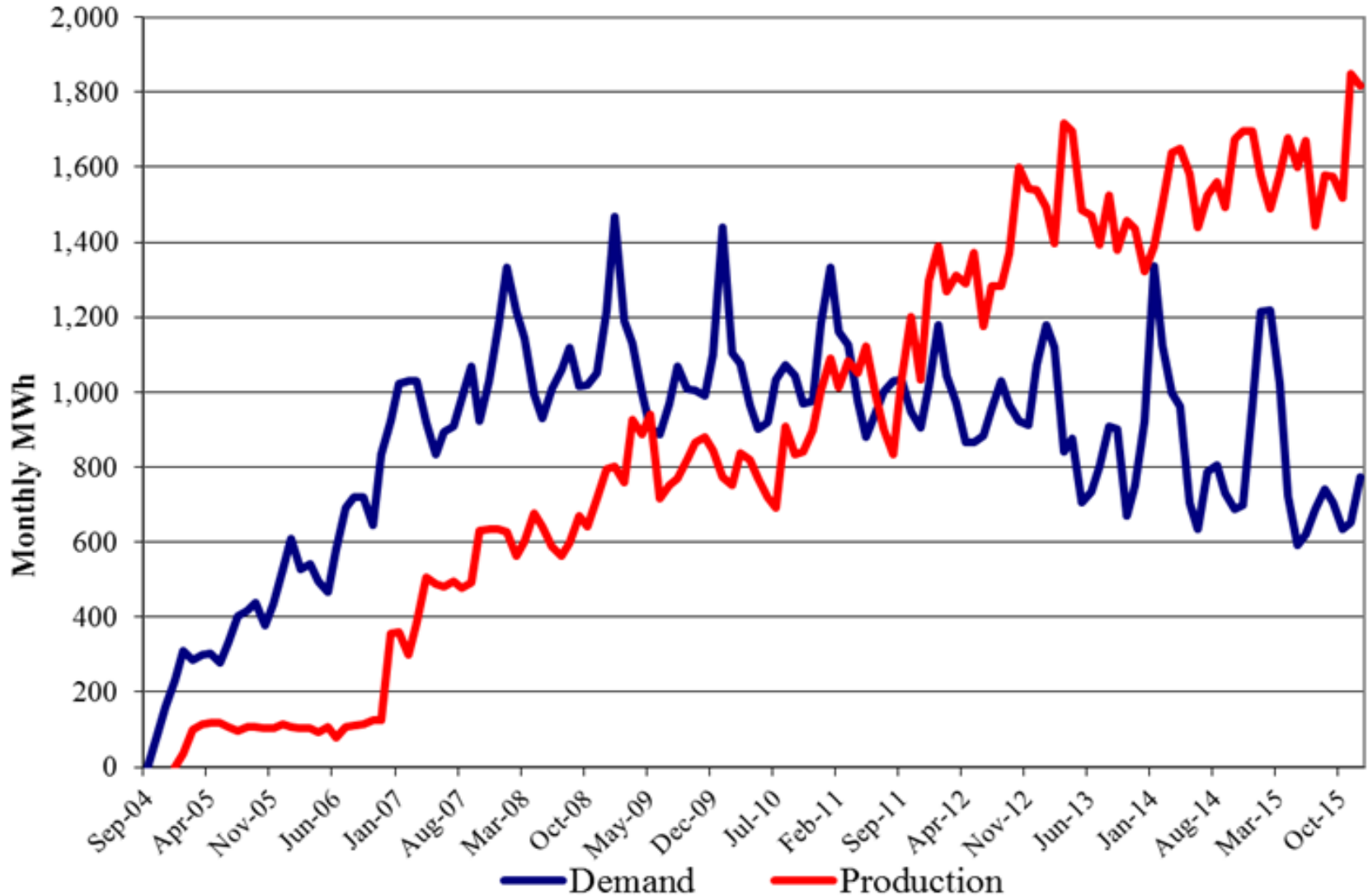
Agenda

- RESULTS OF ECONOMIC ASSESSMENT OF ADS IN VERMONT
- ASSESSING LOCAL SUPPORT FOR THE VTC COMMUNITY ANAEROBIC BIODIGESTER
- VERY SMALL SCALE ADS IN CHINA

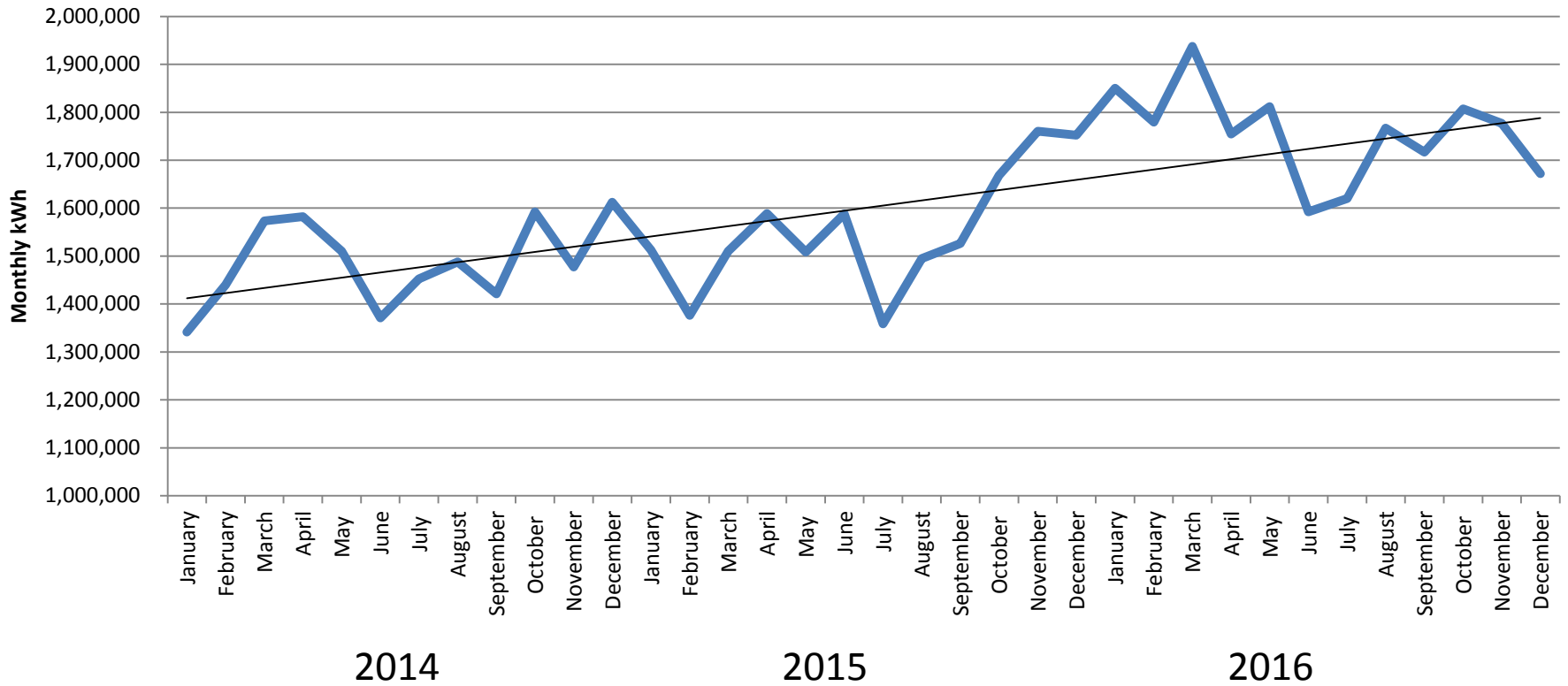
How are ADS performing for dairy farms in Vermont?

- Investments in large digester systems (over 500 head) appear to benefit dairy farms economically and yield the most beneficial returns (ROE & ROA of >12%).
- Small and medium farms (<500head) are struggling with the economics of ADS, realizing approximately 1% ROE and ROA
- Financial returns do not account for non-monetary benefits of ADS such as:
 - **reduced farm odors and pathogens,**
 - **improved manure management,**
 - **reduced GHG emissions, reduced farm runoff, and**
 - **diversification of farm operations that engage next generation**

Monthly Supply & Demand GMP CowPower Program

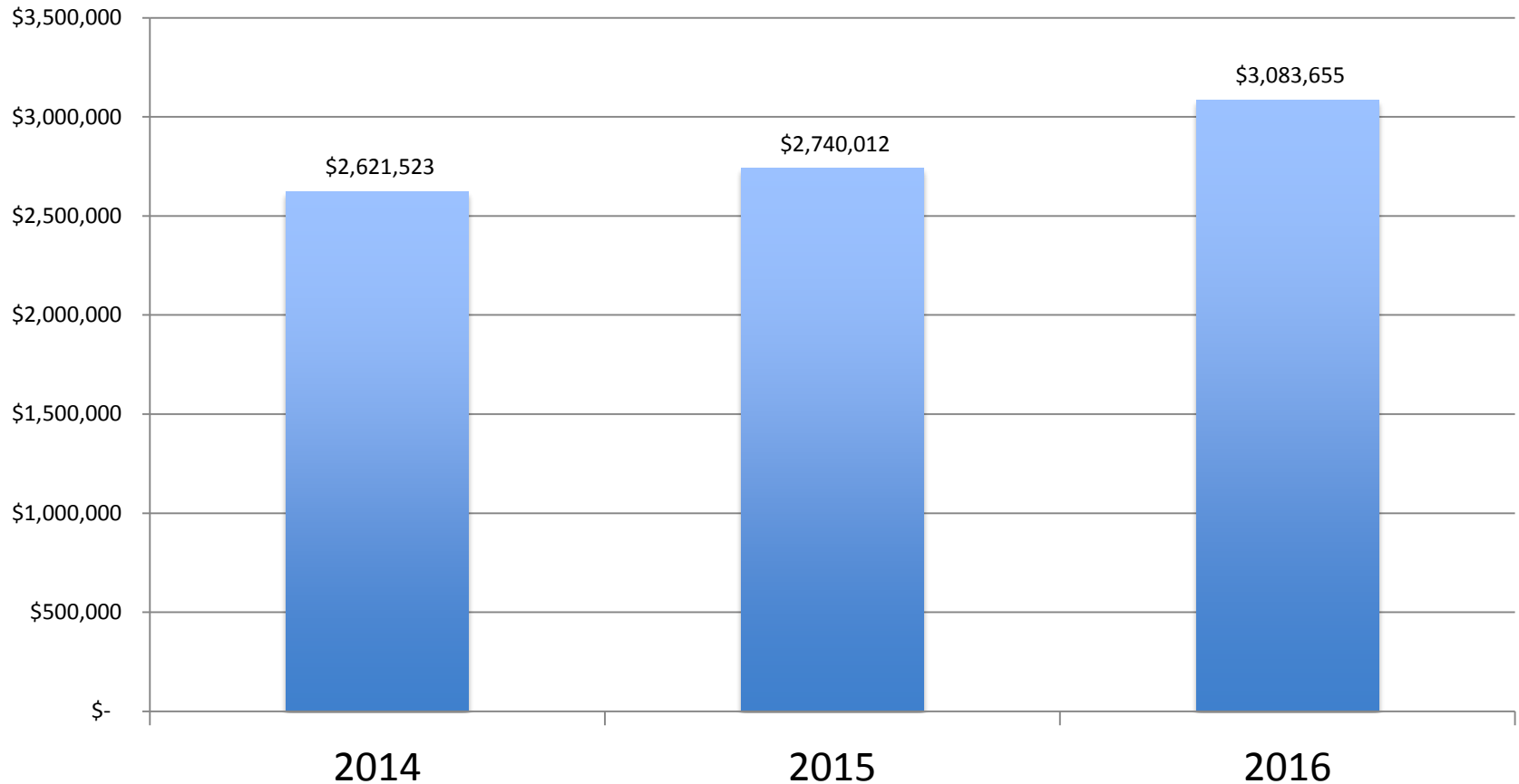


ADS Production 2014-2016



Data from VEPPI: <http://www.vermontstandardoffer.com/sop-production/>

Annual Electricity Sales for Vermont ADS



Data from VEPPI: <http://www.vermontstandardoffer.com/sop-production/>

Characteristics of the ADS analyzed

	Farm	Cows	Installed capacity ¹ (kW)	Installed kW per cow	Digester type ²	Operational period ³ (months)
Large	A	1,050	450	0.43	Plug Flow	125
	B	2,100	300	0.14	Complete Mix	83
	C	1,200	450	0.38	Plug Flow	81
	D	1,450	450	0.31	Plug Flow	57
Small & Medium	E	500	155	0.31	Plug Flow	74
	F	375	150	0.40	Plug Flow	57
	G	200	40	0.20	Covered Lagoon	36
	H	75	20	0.27	Mod Plug Flow	50

¹ This can be different from the operational capacity as some ADS installed more capacity than the herd size due to grant eligibility or anticipated growth in herd size.

² See Wilkie [21] for design specifications.

³ Number of months since the digester first became operational, as of September, 2017.

Average initial investment and funding sources by farm size

	Herd size (cows)	
	75-500 (n=4)	501-2,100 (n=4)
Average of Initial Investments		
Engineering and design	\$66,077	\$441,033
Construction labor	\$164,592	\$68,771
Grid interconnection	\$57,347	\$255,159
Other (permits, installation)	\$213,652	\$308,470
Co-generation unit, solids separator, buildings & other equipment	\$851,154	\$1,370,782
Total initial investment	\$1,352,820	\$2,444,213
Average Funding Sources		
Grants	\$1,040,008	\$1,403,540
Loans	\$238,412	\$965,673
Owner's cash & labor	\$74,400	\$75,000
Total funding	\$1,352,820	\$2,444,213

Does not include systems that were not operational at the time this data was collected

Income and Expenses of ADS by farm size

		Herd size (cows)	
		75–500 (n=4)	501– 2,100 (n=4)
Income			
	Electricity sales	\$55,524	\$374,651
	Bedding on-farm & sales	\$16,220	\$78,125
	Other income	\$7,093	\$28,225
	Total annual income	\$78,837	\$481,001
Expenses			
	Maintenance and repairs	\$8,185	\$55,866
	Labor	\$7,571	\$17,215
	Interest payments	\$7,266	\$38,277
	Insurance	\$792	\$5,736
	Oil and fuel	\$11,681	\$11,939
	Other expenses	\$6,371	\$4,705
	Total annual expenses	\$41,866	\$133,737
Net Earnings			
	Net annual income	\$36,971	\$347,263
	Annual depreciation costs	\$27,988	\$67,599
	Net annual earnings¹	\$8,983	\$279,664

¹Net Annual Earnings = Net Annual Income – Annual Depreciation cost

Financial returns of ADS by farm size

	Herd size (cows)	
	75–500 (n=4)	501–2,100 (n=4)
Total initial cost	\$1,352,820	\$2,444,213
Initial Farm Cost (Initial Investment – Grants)	\$312,812	\$1,040,673
Net annual earnings	\$8,983	\$279,665
ROA	1.07%	13.50%
NPV based on total cost	(\$1,351,155)	(\$487,973)
NPV based on farm cost	(\$300,912)	\$817,646
IRR based on total cost	(39.0%)	2.73%
IRR based on farm cost	(17.8%)	27.15%

ROA is calculated as net earnings plus annual interest expenses divided by average assets. NPV is an indicator of the value of an investment expressed in a future expected value of money and is calculated using the following equation and a 7.5% discount rate:

$$NPV = \sum_{t=1}^n \frac{values_t}{(1 + rate)^t}$$

IRR is a budgeting tool used to evaluate the projected capital growth rate a project generates. IRR is equal to the discount rate required to make the NPV over the projected lifespan of the investment exactly equal to zero. A higher IRR indicates a more desirable rate of return on the investment.

Economic Assessment Take-aways

- Large ADS are performing better on average - as system size increases, the marginal increase in initial investment is significantly smaller than the marginal increase in electricity revenue
- Small & medium ADS (75–500 cows) achieve positive net annual earnings; however, under the current cost and pricing situations, these earnings are not sufficient to yield positive NPV and IRR, indicating that competing investment opportunities could provide better alternatives
- Given the average energy-generation capacity of small and medium ADS (approximately 122,000 kWh per year), these systems do not produce the volume of electricity needed to keep up with debt service and maintenance costs. Likewise, bedding production is insufficient to generate a financial offset large enough to justify the investment on economic benefits alone.

Research in progress

While the ADS developed in the U.S. are financially feasible for only large farms, community based ADS (CADS) developed in Europe and the mini digesters developed in China may offer potential opportunities for small dairy farms

Community ADS (CADS):

- Developed in Europe (e.g., more than 4,000 in Germany)
- Small progress in the U.S.
- CADS at Vermont Technical College – A case study

ASSESSING LOCAL SUPPORT FOR THE VTC COMMUNITY ANAEROBIC BIODIGESTER

Findings from MS Thesis

Samantha Lewandowski

December, 2017

Nearly two-thirds of respondents reported support for increasing public investment in ADS technology.

Support for increasing public investment in...

- Solar (71.0%)
- ADS (63.4%)
- Wind (59.9%)

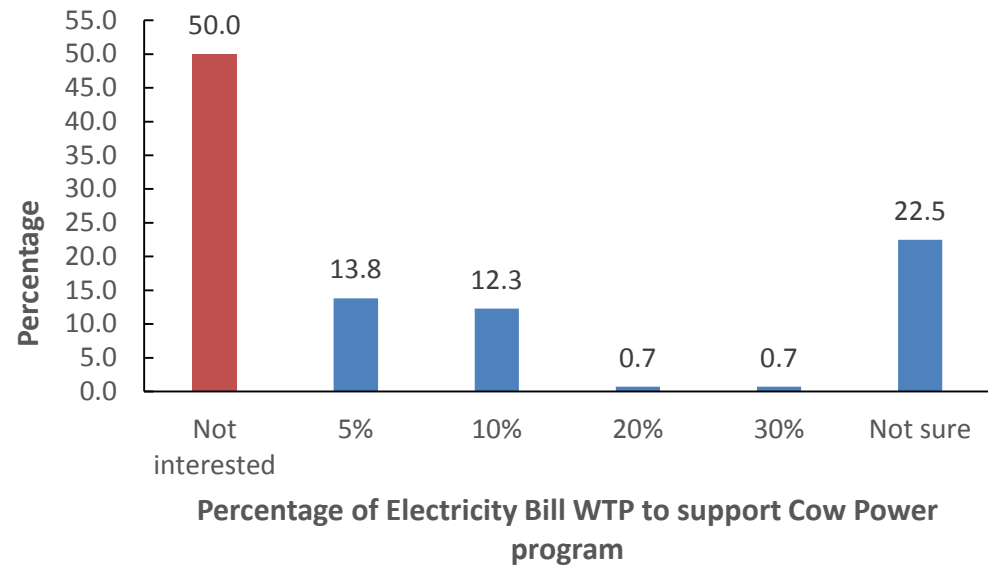
Similar to Borchers et al. (2007)

Respondents showed limited interest in participating in the Cow Power program.

Familiarity with Cow Power program

- Heard of (68.1%)
- Participated in (10.6%)
- Never heard of (21.3%)

Follow-up question: *“If you are interested in participating in the Cow Power program, what is the maximum premium you would like to pay as a percent of your electricity bill to support Cow Power farms (e.g., 10% means you pay 10% more of your electricity bill each month to support the program)?”*



Attitudes towards the CADS

Extent of Agreement with Statements About Potential Outcomes of the CADS

	Disagree (D + SD)	Not sure	Agree (A + SA)
+ Produces renewable energy from wastes	2.2%	17.8%	80.0%
Reduces food wastes going into landfills	2.2%	21.3%	76.5%
Serves as teaching tool on sustainable agriculture	2.2%	25.4%	72.4%
Helps with manure management	1.4%	28.2%	70.4%
Decreases dependence on fossil fuels	6.0%	25.9%	68.1%
Reduces nutrient runoff into waterways	3.0%	36.6%	60.4%
Reduces methane emissions from agriculture	4.6%	45.8%	49.6%
Reduces odors produced by manure	9.6%	58.5%	31.9%
- Reduces community aesthetics	28.8%	54.2%	17.0%
Lowers air quality	33.8%	52.3%	13.9%
Lowers property values	29.9%	58.2%	11.9%
Raises noise levels	29.8%	63.5%	6.7%
Lowers water quality	36.7%	59.4%	3.9%

Note. The n-value varied for each statement, but ranged from n = 131 to n = 136.

Significant differences were found between those who reported CADS support and those who did not (demographic and otherwise).

Diffusion of Innovation Theory

- “Early adopters” more likely to be more highly educated, wealthier, have greater exposure to mass media and interpersonal forms of communication, and be more positive towards science and change

Those who supported the CADS more likely to...

- Have higher incomes
- Have received more types of communication, in both mass media and interpersonal forms
- Support VT environmental policy
- Be familiar with the CADS
- Believe it brought about positive outcomes
- Be politically liberal
- Live 2 – 5 miles away (as compared to over 5 miles away)

Research in progress

Mini digesters developed in China:

- About 50 million in China
- About 10 cubic meters in size
- Cost about 3000-4000 yuan (\$450 - \$615) and the government pays about 30-50%
- There are also large ADS in China, similar to the ADS developed in the U.S.

Household digesters in China

(million)

