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针对大中型沼气工程设计人员和政策决策者第四次培训
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Modelling of a Performance Oriented Subsidy System in China
中国绩效补贴体系的模型计算

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中德生物质能优化利用项目

China‘s need for energy 中国的能源需求

China’s energy consumption is continuously rising:
中国的能源消耗持续增长:

- primary energy demand is expected to increase up to 3,975 Mtce in 2015 and up to 5,467 Mtce in 2030
一次能源需求预计将在2015年增长到3,975吨标准煤，在2030年增长到5,467吨标准煤
- electricity consumption is expected to increase up to 4,723 TkWh in 2015 and further up to 7,513 TkWh in 2030.
耗电量预计在2015年增长到4,723 TkWh，2030年增长到7,513 TkWh
(Source: IEA) （来源：国际能源署）

- Coal covers almost 70% of the primary energy supply.
煤炭占据了几乎70%的一次能源供应。
- Facing limited domestic recources China is expected to become a coal net importer of 90 Mtce 2030.
面对有限的国内资源，中国的煤炭净进口量将在2030年达到90 吨标煤。

→China needs to utilize every energy ressource possible.
中国需要利用每一个可能的能量资源。

China‘s Biomass Resources 中国的生物质资源

- **Studies estimated that the currently the theoretical total biomass resource in China accounts for 2,620 to 3,510 Mtce.**
  研究估计,目前中国理论总生物质资源有**2,620**到**3,510** 吨标煤。
- **Of this amount 440 to 640 Mtce can be seen as the available feedstock per year for further energy production.**
  其中**440**到**640** 吨标煤的生物质资源可用作原料进行每年的能源生产。

- **NDRC estimations of the available feedstock resulted in an amount of 500 million tce in 2007.**
  由国家发改委开展的可用原料估算结果为**2007**年为**5**亿吨标煤，支持了上述发现。

- **This energetic potential is equal to 17.7% of the total primary energy demand of the People’s Republic of China (PRC) during the same year.**
  同年，该能源潜力等于中国一次能源总量需求的**17.7%**。

- **Currently, only 1.5 to 2.5% of the potential available feedstock is transferred into energy leaving a tremendous amount of energy resources unused.**
  目前，仅有**1.5%-2.5%**的可利用原料转化为能源，大量的能量资源未被利用。

(Sources: Li, 2010; NDRC, 2007; own calculation)
（来源：Li，2010；国家发改委，2007；计算）

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Governmental efforts towards Biomass Utilization
关于生物质利用的国家政策

- **High political motivation to support this sector based on environmental and energy politcal challenges faced at present**
  当今社会，环境与能源面临着严重的挑战，中国应大力支持生物质利用行业。

- **Political goal:**：
  3 GW from MLSBPs in 2020
  目标：到**2020**年大中型沼气工程产能达**3 GW**

- **In monetary terms:**
  经济上：
  - **Total investment by the MOA into the biogas sector until 2010: more than 24 billion CNY.**
    到**2010**年，农业部在沼气行业的投资超过**240**亿人民币。

  - **Average annual investment support of the MOA over the last 3 years alone 5 to 6 billion CNY per year.**
    在过去三年内，农业部每年平均投资**50-60**亿元。

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Current Subsidy System for Biogas production in China
中国当今沼气生产的补贴体系

1) Subsidisation of the construction investment (S_{CONST}) 建设投资的补贴

For MLBGPs, the government will subsidize in the western areas 45% (max. 2.5 million CNY), in central areas 35% (max. 2 million CNY) and eastern regions 25% (max. 1.5 million CNY) of the total investment. The local governments will give additional support according to the standard not less than 5%, 10% and 20% of total investment.

对西、中、东部地区大中型沼气工程，中央分别补助项目总投资的45%、35%和25%，总量分别不超过250万元、200万元和150万元，地方分别按照不低于项目总投资的5%、10%和20%的标准予以配套投入。

2) Subsidisation of biogas based electricity fed into the national grid (S_{OUT}) 沼气并网发电的补贴

0.25 CNY/kWh (projects before 2010) Duration: 15 years

（2010年前的项目） 持续时间：15年

1st year: 0.25 CNY/kWh, decrease 2% each year. (projects after 2010)

第一年： : 0.25 CNY/kWh，每年减少2% （2010年后的项目）

Effects of the policy support until now 当前政策支持的成效

The Construction Subsidy and several support policies have had a positive impact on the Chinese biogas sector:
建设补贴和几项国家政策对中国沼气行业产生了积极的影响：

- **Rising number of biogas plants 沼气工程数量的增加**
  Until 2010: 4.641 large scale BGP, 22.800 Middle scale, 45.300 Small scale
  到2010年，4,641座大型沼气工程，22,800座中型沼气工程，25,300座小型沼气工程
- **Increasing size of biogas plants 沼气工程规模扩大**
  Introduction of super-large-scale BP (> 5000 m^3 fermenter volumen)
  超大型沼气工程（发酵罐体积> 5000 m^3 ）的引进
- **Rising numbers of biogas companies 沼气公司的增加**
- **Increasing operational knowledge 操作知识的补充**

→ Pointing towards a positive development of the sector
均表明了沼气行业的积极发展

Challenges faced today: 现今面临的挑战：

1) **Grid connection is only obligatory for BG-plants > 0.5 MW installed capacity**
   沼气并网发电只适用于装机容量> 0.5 MW 的沼气工程

2) **Low motivation of the grid companies to connect**
   电网企业不支持沼气并网发电

3) **Missing grid connection leaves the current output subsidy without effect**
   并网发电不成功导致投入的补贴未能发挥作用

4) **Overall low specific biogas productivity (nm^3 BG / m^3 fermenter volume / day)**
   沼气生产力总体上较低

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Research Introduction 研究背景

The reasearch analyses the economic feasability of 4 case studies (Beijing and Sichuan) under different subsidy scenarios

本研究分析了**4**个案例（北京和四川）在不同补贴体系的经济可行性。

The research follows the approach of: 本研究采用的方法：

Abandoning the construction subsidy to reallocate the construction subsidy funds into the output subsidy, creating an exclusive subsidy system

放弃建设补贴，重新分配输出补贴中的建设补贴，新创一个补贴体系。

→ By doing so the policy makers would create a strong economic incentive for the biogas producers to increase their specific biogas productivity

这样做使决策者创建一个经济需求环境，以使沼气生产者提高沼气产量

Further 8 theoretical cases have been developed under the same scenarios to verify the former results

另有**8**个相同情况下的理论案例已经验证了之前的结果。

Research Assumptions and Objective假设和目标

1) Grid connection is only obligatory for BG-plants > 0.5 MW installed capacity
沼气并网发电只适用于装机容量> 0.5 MW 的沼气工程

2) Low motivation of the grid companies to connect 电网企业不支持沼气并网发电

3) Missing grid connection leaves the current output subsidy without effect
并网发电不成功导致投入的补贴未能发挥作用

→ **Grid Connections are guaranteed for every BG-plant**
每个沼气工程都并网发电

→ **Current Output Subsidy system is fully working**
当前的补贴体系完全运行

(this situation reflects the successfull implementation of the current Chinese legal situation)（这种是当今中国立法成功实施的情况）

4) Low specific biogas productivity (nm^3 BG/m^3 fermenter volumen/day)
沼气生产力总体上较低

→ **Can a fully output oriented subsidy system create incentives contributing to overcome this challenge?**
补贴体系的充分产出是否能产生激励作用以克服挑战?

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Assessed case studies 评估案例研究

	Unit **单位**	**Data Set 1** **数据1**	**Data Set 2** **数据2**	**Data Set 3 –** Design 数据3-设计	**Data Set 4 –** Design 数据4-设计
Name **名称**		Shulong Breeding Company 蜀龙养殖有限公司	Sanyuan Lvhe Cattle Farm 三元种业绿荷牛场	Lanyan Animal Husbandry Technology Development Company 四川蓝雁畜牧科技发展有限公司	Beijing Deqingyuan Agriculture Technology Company 北京德青源农业科技股份有限公司
Location **地点**		Sichuan, Deyang City 四川，德阳市	Beijing, Yongledian Municipality 北京，永乐店	Sichuan, Leshan City 四川，乐山市	Beijing, Yanqing County 北京，延庆县
Fementer size **发酵罐体积**	nm^3	700	1,200	1,600	3,000
Animal type **畜禽类型**	-	Pig	Cattle	Pig	Chicken
Animal number **畜禽数量**	c	2,000	2,000	5,000	3,000,000
Biogas produced **产气量**	nm^3/day	180	800	1,600	20,000

Data assessed through interviews with the owners/operaters of the respective biogas plants in 2011
数据来源于2011年对各沼气工程的业主/运营者的采访评估。

Feasibility of case studies – under current subsidy system
在当前补贴体系下案例研究的可行性

		Unit 单位	Data Set 1 数据1	Data Set 2 数据2	Data Set 3 – Design 数据3-设计	Data Set 4 – Design 数据4-设计
1	**Fementer size** 发酵罐体积	nm^3	700	1,200	1,600	3,000
2	**Biogas produced** 产气量	nm^3/day	180	800	1,600	20,000
3	Biogas usage	nm^3/day	90 for electricity/ 90 direct use	400 for electricity/ 400 direct use	1,600 for electricity	20,000 for electricity
4	I_0 Total investment costs	CNY	1,400,000	3,291,900	4,060,000	60,000,000
5	S_{CONST} 建设投资的补贴	CNY	1,400,000	1,900,000	2,050,000	2,000,000
6	S_{OUT} 沼气并电发网的补贴	CNY	184,781	821250	3,285,000	54,750,000
7	S (incl. S_{CONST} and S_{OUT})	CNY	1,584,781	2,721,250	5,335,000	56,750,000
8	**NPV** 净现值	CNY	-345,054	-1,329,022	3,758,337	47,156,055

Feasibility of case studies – under current subsidy system
在当前补贴体系下案例研究的可行性

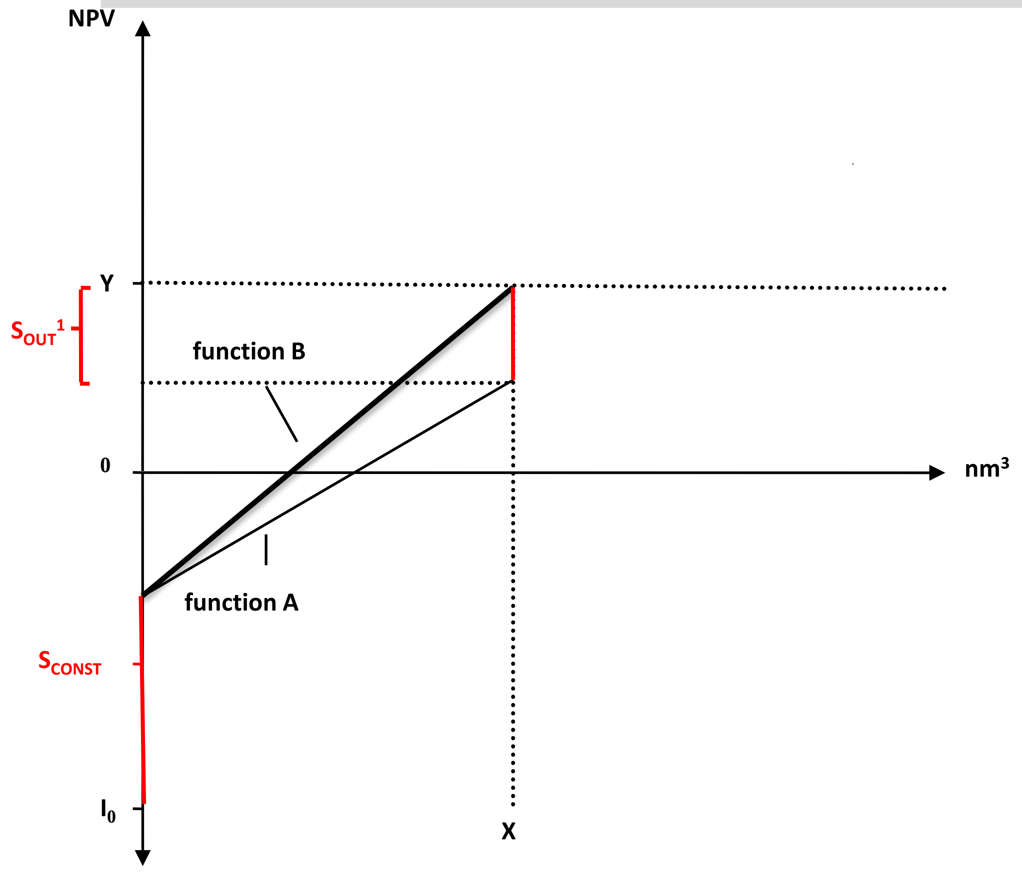
1) **The two smaller cases do not reach a positive NPV**
   蜀龙养殖有限公司、三元种业绿荷牛场这两个案例净现值为负。

2) **Even though the net connection is hypothetical ,the biogas plants did not maximise their production to make use of the biogas to substitute their own gas consumption, which would even create a higher income**
   即使假设并网发电，沼气工程并没有最大化地利用产气以代替自身的沼气消耗，导致了更多的投入

→**The reason for this behaviour could lie in a missing economic incentive.**
出现该现象的原因是缺少经济激励

Therefore we will now abandon the construction subsidy and increase the feed-in tariff in order to create a strong incentive for the biogas producer to optimize his production behaviour!
所以我们将放弃建设补贴，增加上网电价，
以期更能激励沼气生产者优化生产！

NPV and BG-Output under the current subsidy system
在当前补贴体系下净现值和沼气工程输出



Theoretical total production of a BGP and it's generated income over the whole lifetime (15 yr) under the current subsidy system
当今补贴体系下沼气工程运行寿命周期中（15年）的理论产量与收益

Current subsidy system relies on two aspects:
当前补贴体系有两个方面：

1) **Construction subsidy (S_{CONST}) 建设补贴**
2) **Output subsidy (S_{OUT}^1) 输出补贴**
   (feed in tarif of 0,25 CNY/kWh fed into the electricity grid)
   (上网电价 补贴**0,25 CNY/kWh)**

→ **Leads to:** 得到：

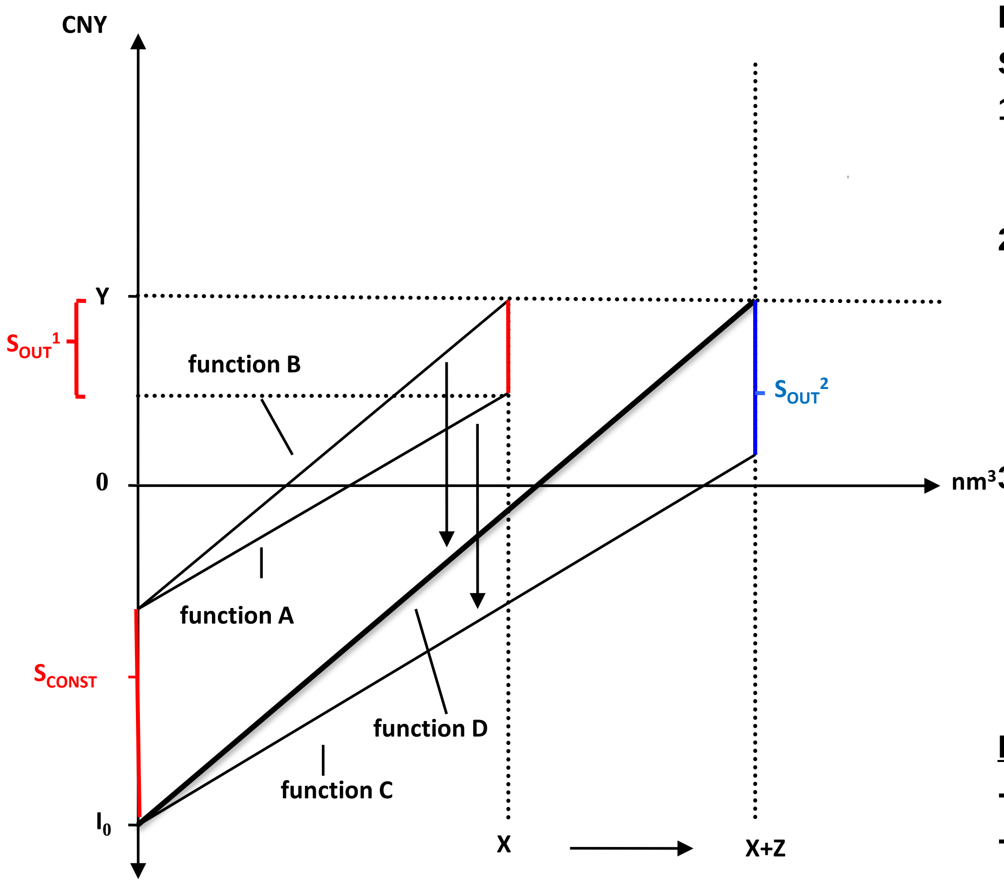
a) **Production of X nm³ biogas over the whole lifetime of the BGP (15 years)**
沼气工程运行寿命周期中（**15**年）的产气量**-X nm³**

b) **NPV of Y for the biogas producer**
沼气生产者的净现值**-Y**

c) **total Subsidy payments of**
总补贴为建设补贴**+**输出补贴

Construction subsidy + Output subsidy
建设补贴 **+** 输出补贴
S_{CONST} + S_{OUT}^1

Abandonment of the Construction Subsidy 放弃建设补贴



Theoretical total production of a BGP and it's generated income over the whole lifetime (15 yr) without contrauction subsidy and under the same feed-in tariff than under the current syste
放弃建设补贴，在现在的上网电价补贴下，沼气工程整个运行寿命周期（15年）中的理论产量与收益

Effects of an abandonment of the Construction Subsidy: 放弃建设补贴的效果：

1) Producer has to cover the whole investment costs I_0
生产者要负担全部投资

2) Producer has to increase his production up to X+Z nm³ biogas over the whole lifetime of the BGP (15 years) to reach the <u>same NPV (Y)</u> than under current cirumstances
在当前情况下，生产者要将沼气工程整个运行寿命周期中（**15**年）的产气量提高到**X+Z nm³** 才能达到相同的净现值

3) Total Subsidy payment of the government decreases:
政府付出的总补贴将减少：

Output subsidy < (Construction subsidy + Output subsidy)

$S_{OUT}^2 < S_{CONST} + S_{OUT}^1$

<u>Key Result:</u> <u>主要结果：</u>

- Lower subsidy payments 降低补贴投入

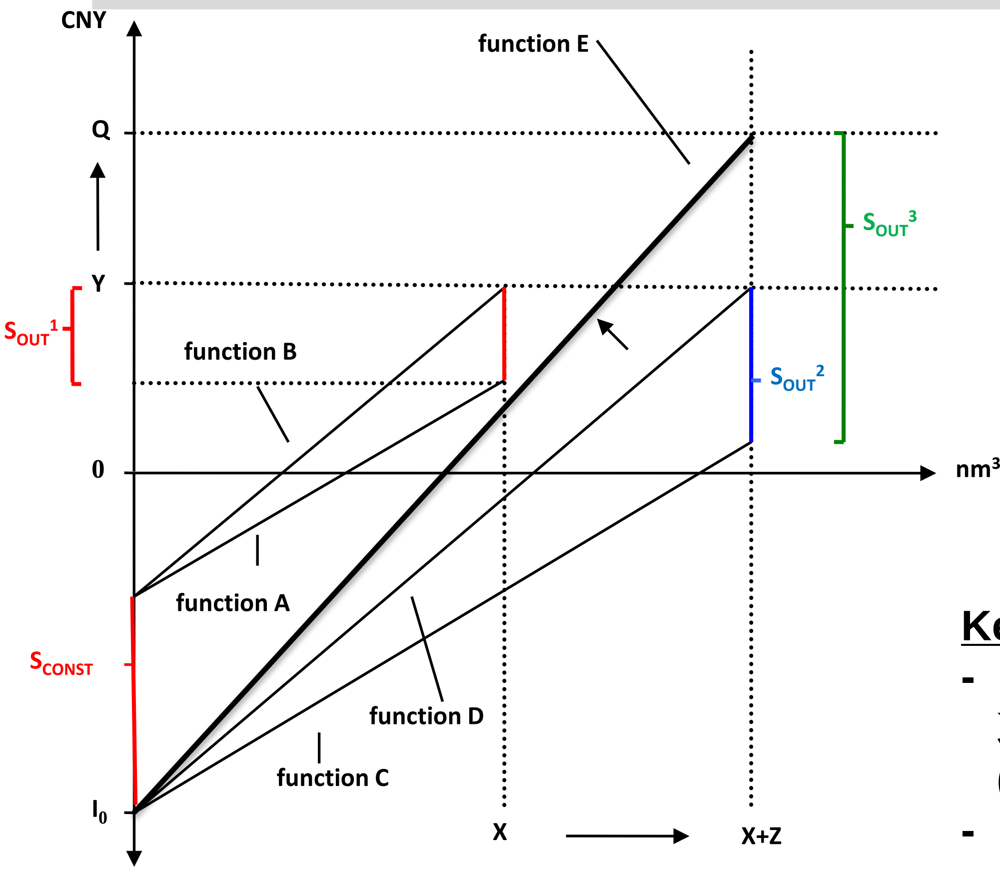
- Higher Biogas production 提高沼气产量

→Favourble scenario for the government 对政府有利

BUT: 但是：

Might discourage the producers (more effort for the same NPV (Y) than before the abandonment)
可能会使生产者气馁

Reallocation of funds into an exclusive output subsidy system
新补贴政策下的资金再分配



Effects of a change in the subsidy distribution modalities (by constant total amount) on the income of a biogas producer over the whole lifetime of the BGP (15 years)
在沼气厂整个运行寿命周期（15年）中，补贴体系的改变对生产商的产品和收入增长（Z）的影响

Effects of an increased feed-in tarif:
上网 电价补贴增加的影响：

1) **The feed-in tarif or end-product revenue can be increased** 上网电价或最终产品的收益增加
2) **A strong incentive for the biogas producers to increase their output up to X+Z will be created.** 激励沼气生产商增加产量，增加比例将可达到X+Z。
3) **The NPV will increase** 收益将会增加
4) **The total amount of subsidy invested maintains constant** 补贴总额保持不变
   (Construction subsidy + Output subsidy)
   = Output subsidy (with increased feed in tariff)

Key Results: 主要结果

- **NO additional costs for the government**
  政府没有额外支出
  (S_{OUT}^1 + S_{Const} = S_{OUT}^3)
- **HIGHER Biogas production (X+Z)**
  沼气产量增加 (X+Z)
- **HIGHER NPV for the producer (Q)**
  生产者净现值增加 (Q)

Feasibility of case studies – under current subsidy system
在当前补贴体系下案例研究的可行性

		Unit 单位	Data Set 1 数据1	Data Set 2 数据2	Data Set 3 – Design 数据3-设计	Data Set 4 – Design 数据4-设计
1	**Fementer size** 发酵罐体积	nm^3	700	1,200	1,600	3,000
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6	S_{OUT} 沼气并电发网的补贴	CNY	184,781	821250	3,285,000	54,750,000
7	S (incl. S_{CONST} and S_{OUT})	CNY	1,584,781	2,721,250	5,335,000	56,750,000
8	**NPV** 净现值	CNY	-345,054	-1,329,022	3,758,337	47,156,055

Feasibility of case studies – under NEW subsidy system
在新的补贴体系下，案例的可行性

	Unit 单位	Data Set 1 数据1	Data Set 2 数据2	Data Set 3 – Design 数据3-设计	Data Set 4 – Design 数据4-设计
Fementer size 发酵罐体积	nm^3	700	1,200	1,600	3,000
Co fermentation 联合发酵		yes	yes	yes	NO
Biogas produced 沼气产量	nm^3/day	349	1,179	2,227	20,000
Production Increase 增加产量	**%**	**94**	**47**	**42**	**0**
S_{OUT} NEW feed in tarif 新上网电价补贴	CNY/kWh	0.55	0.42	0.29	0.19
I_0	CNY	1,540,000	3,291,900	4,060,000	60,000,000
S_{CONST}	CNY	0	0	0	0
S_{OUT}	CNY	1,584,781	2,721,250	5,335,000	56,750,000
NPV	CNY	**254,671**	**-820,946**	**3,968,753**	**39,177,522**
NPV Increase	CNY	**599,725**	**508,076**	**-210,416**	**-7,978,533**

Higher need to maximise the income → higher need for optimized production (co-fermentation) → total higher output

利益最大化的需求 → 优化生产 → 更高的产出

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Verification 验证

Development of theoretical cases 理论型案例的发展

	Installed Capacity	Type of animal	Number of animals needed	Total feedstock needed per year	Average Specific Investment Costs per ton of feedstock	Average Total Investment Costs (I_0)	Average Yearly Production Costs (C)
Unit	kW		c	t/yr	CNY/t	CNY	CNY
Case 1	75	Pig	12,000	52,560	189.249138	9,946,935	810,765
		Cattle	2,400	35,040	236.308364	8,280,245	674,840
Case 2	150	Pig	24,000	105,120	129.467208	13,609,593	1,109,182
		Cattle	4,800	70,080	161.66089	11,329,195	923,329
Case 3	750	Pig	120,000	525,600	53.6208768	28,183,133	2,296,925
		Cattle	24,000	350,400	66.9543955	23,460,820	1,912,057
Case 4	5,000	Pig	800,000	3,504,000	18.9705138	66,472,680	5,417,523
		Cattle	160,000	2,336,000	23.6877754	55,334,643	4,509,773

1) Connection between the Total feedstock needed per year (x) and Average Specific Investment Costs per ton of feedstock (y): $y = 72{,}868 * x^{-0.5477}$
(based on: *ADB report Preparing the Integrated Renewable Biomass Energy Development Project)*

2) UNFCCC research from 2008 leads to a ratio of 8.15% between the investment costs and the yearly production cost.

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Feasibility under current subsidy system
当前补贴体系的可行性

	Unit 单位	Case 1 案例1	Case 2 案例2	Case 3 案例3	Case 4 案例4
Installed Capacity 安装容量	kW	75	150	750	5,000
Pig 猪					
X	m^3/day	1,200	2,400	12,000	80,000
s_{out}	CNY/kWh	0.24	0.24	0.24	0.24
NPV	CNY	-10,050,604	-11,052,981	6,293,538	241,192,667
S (S_{CONST} + S_{OUT})	CNY	4,365,200	6,730,400	25,652,000	159,680,000
Beef Cattle 牛					
X	m^3/day	1,200	2,400	12,000	80,000
s_{out}	CNY/kWh	0.24	0.24	0.24	0,24
NPV	CNY	-7,124,459	-7,046,931	14,595,835	260,796,597
S(S_{CONST} + S_{OUT})	CNY	4,365,200	6,730,400	25,652,000	159,680,000

Feasibility under NEW subsidy system 新补贴体系下的可行性

		Unit 单位	Case 1 案例1	Case 2 案例2	Case 3 案例3	Case 4 案例4
1	**Installed Capacity** 安装容量	kW	75	150	750	5,000
2	**Pig** 猪					
3	**NPV** (before)	CNY	-10,050,604	-11,052,981	6,293,538	241,192,667
4	**S** (before)	CNY	4,365,200	6,730,400	25,652,000	159,680,000
5	**X** (before)	m^3/day	1,200	2,400	12,000	80,000
6	**Z**	m^3/day	662	750	1,091	1,974
7	s_{out}^2	CNY/kWh	**0.29**	**0.26**	**0.24**	**0.24**
8	NPV_2	CNY	-9,621,823	-10,733,349	6,202,256	240,045,031
9	S_{OUT}^2	CNY	4,365,200	6,730,400	25,652,000	159,680,000
10	**Beef Cattle** 牛					
11	**NPV** (before)	CNY	-7,124,459	-7,046,931	14,595,835	260,796,597
12	**S** (before)	CNY	4,365,200	6,730,400	25,652,000	159,680,000
13	**X** (before)	m^3/day	1,200	2,400	12,000	80,000
14	**Z**	m^3/day	624	700	987	1,730
15	s_{out}^2	CNY/kWh	**0.29**	**0.26**	**0.24**	**0.24**
16	NPV_2	CNY	-6,647,875	-6,665,247	14,628,674	259,941,074
17	S_{OUT}^2	CNY	4,365,200	6,730,400	25,652,000	159,680,000

Increased NPV: **Pig:** **Case 1, 2**
Beef Cattle: **Case 1, 2, 3**
Slightly Decreased NPV: **Pig:** **Case 3, 4**
Beef Cattle: **Case 4**

Key Findings and Recommendation 主要结果和建议

- By rellocating the funds of the construction subsidy into the Output susbdiy the feed in tariff can be increased (no additional costs)
  建设补贴重新分配到产出补贴中，上网电价将提高（无额外费用）
- Output oriented subsidy system would create strong incentives for the biogas producers to increase their production, through optimized production behaviour and the adoption of co-fermentation
  产出补贴体系将有力地激励沼气生产者通过优化生产方式和引进联合发酵来提高产气量
- Increased production would increase the NPV of the BGP and the total amount of biogas produced in China
  产气量的提高会增加沼气工程的收益，也增加了中国沼气的总产气量
- Larger BGP can operate profitable under the current subsidy tarif, giving an increased production through the adoption of co-fermentation
  考虑到联合发酵增加了产气量，大型沼气工程在当前的补贴下更有利地运行

→ A more diversfied subsidy system is needed, taking the size and feedstock of the respective BGP into account
我们需要一种更多样化的补贴体系，将沼气工程的规模和发酵原料考虑在内。

Future Possibilites 未来的可能性

Output subsidies can be further specified in accordance to the end product produced by the respective BGP

产出补贴可以更细化，与相应的沼气工程的最终产物保持一致

By doing so, the government can support and steer the production of certain end products like

这样做，政府可以支持和调控某些最终产物的生产，比如：

- **biogas** 沼气
- **electricity** 发电
- **biomethane** 生物甲烷
- **fertilizer** 肥料

Thank you for your time!
谢谢！

Dipl. reg. wiss. Michael Oos

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Optimization of Biomass Utilization Project
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