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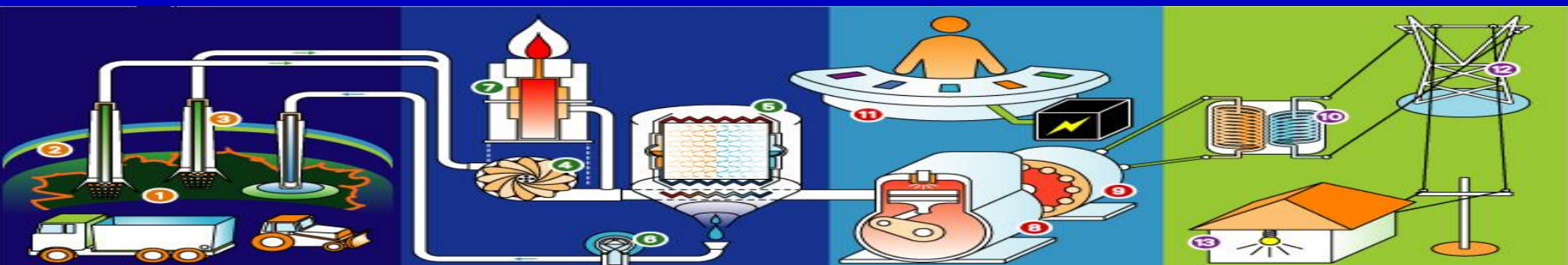
Landfill Gas Exploitation for Electricity Production in China

在中国利用垃圾填埋气发电

郭雯

D'Appolonia S.p.A.



Main issues of the presentation
报告的主要内容

- Landfill gas recovery and reutilization Rationale.
  垃圾填埋气回收及再利用的缘由
- Landfill gas generation and corresponding GHG emission
  垃圾填埋气的产生以及相应的温室气排放
- Main Components of LFG Recovery and Power Generation Plant
  垃圾填埋气回收和发电所需的主要设备
- Electricity generation technologies for Landfill gas
  垃圾填埋气发电的技术
- CDM Perspective of Landfill Gas Projects
  垃圾填埋气项目的CDM前景
- Registered CDM Landfill gas projects in China
  已注册的中国垃圾填埋气CDM 项目
- Sino-Italian cooperation projects in Landfill gas utilisation
  中意合作就垃圾填埋气利用方面开发的项目
- Lessons learnt 经验与教训

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Biogas Recovery and Reuse Rationale (I)
垃圾填埋气回收及再利用的缘由(I)

- Refuse disposal is one of the most common ways currently used for solid urban waste management. Currently, China produces more than 150 Mtons of garbage annually, of which 90% is dumped, untreated, into dedicated landfills.

  垃圾填埋是现今城市固体废物管理中最常用的方法之一。目前中国每年的城市垃圾量达1.5亿吨，其中90%未经任何处理、直接填埋。

- In most landfill facilities (often managed “open sky”) the biogas produced by urban waste decomposition is not collected, thus representing an important green house gas (GHG) emission.

  大部分垃圾填埋场均未对废物分解所产生的生物气进行回收,就此造成了每年大量的温室气排放 。

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Biogas Recovery and Reuse Rationale (II)
垃圾填埋气回收及再利用的缘由(II)

Moreover 此外,

- the recovery and utilisation of LFG may reduce odors and other hazards associated with LFG emissions and give a significant contribution to GHG emission reduction, as CH_4 causes 21 times more damaging to climate changes than CO_2).
  垃圾填埋气的回收和利用可以减少垃圾场及周边的气味，以及由垃圾填埋气排放所带来的其它危害；为温室气减排做出重要的贡献，因为甲烷（CH4）排放所产生的温室效应是二氧化碳的21倍。
- instead of allowing LFG to escape into the air, it can be captured, converted, and used as an energy source.
  与其让填埋气排放于大气，将填埋气回收、处理可用作能源。
- therefore, to control GHGs emissions, LFG recovery and utilization need to be considered when establishing the municipal solid waste disposal system.
  为了控制温室气的排放，在建造城市固体废物处理系统时应就垃圾填埋气的回收与利用给予考虑。

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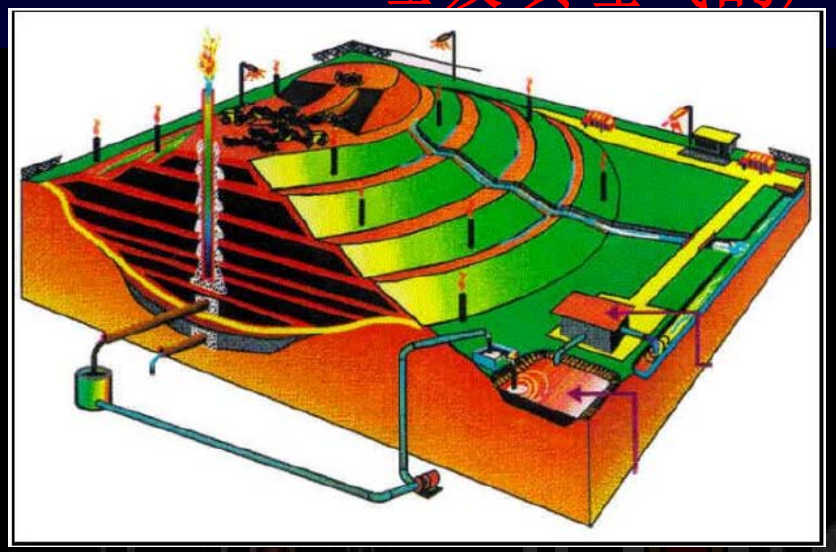
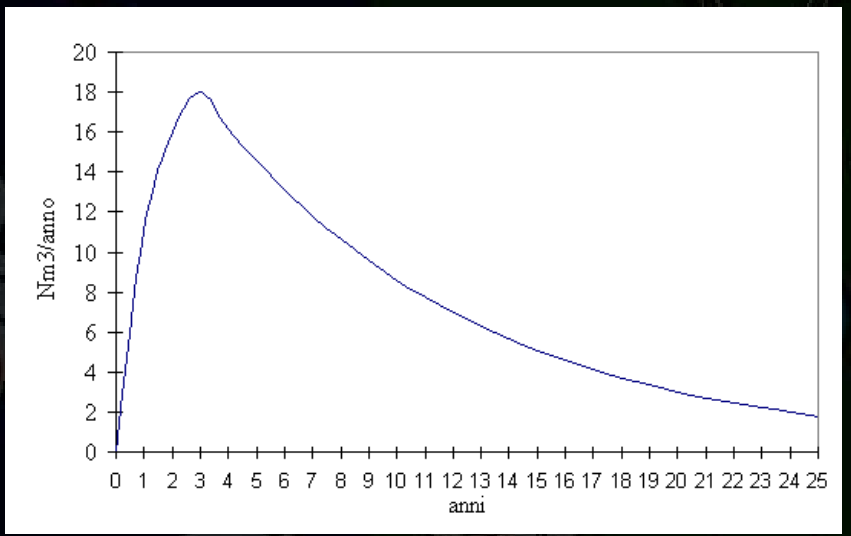
Landfill gas generation and corresponding GHG emission (I)
垃圾填埋气的产生以及相应的温室气排放(I)



Schematic Landfill
垃圾填埋示意图

Theoretical CH4 Generation from 1 ton of Waste
理论上每吨垃圾每年所产生的甲烷量



- Municipal solid waste (MSW) contains significant portions of organic materials; MSW is dumped, compacted, and covered in landfills。
  城市固体废物中包括大量的有机物； 垃圾被填埋、压实和覆盖；
- Anaerobic bacteria thrives in the oxygen-free environment, the decomposition of the organic materials and the production of primarily CO_2 and CH_4.
  厌氧菌在缺氧的环境中大量繁殖生长，促成有机物的分解及CO2和CH4的形成。
- Each tons of organic waste generates 60 to 120 cubic meters of LFG over its lifetime (25-30 years).
  理论上讲，每吨有机废料在它不断分解的25-30年中可产生60-120立方的垃圾填埋气。

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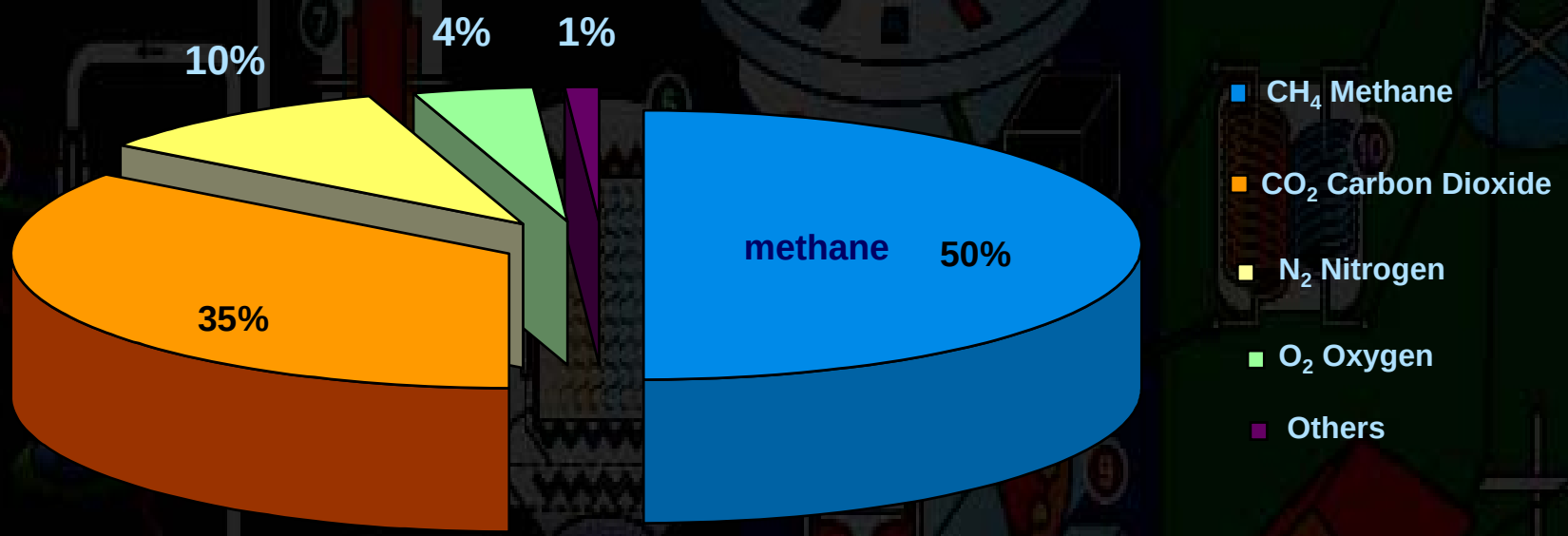
Landfill gas generation and corresponding GHG emission (II)
垃圾填埋气的产生以及相应的温室气排放(II)

- It is well known that the landfill biogas represents a valuable source of renewable energy:
  众所周知垃圾填埋生物气是一个颇有价值的可再生能源：
  - the percentage of methane in the landfill gas: 50%, having a calorific value of 37 GJ/t, compared to 50 GJ/t for natural gas
    垃圾填埋气含有近50%甲烷, 热值达37GJ/t (天然气的热值达50GJ/t)



- Methane can be recovered and used in gas fired electrical power plants and the technology for biogas reuse is available on the market.
  生物气甲烷可被回收用来发电，目前市场上就生物气的利用提供不同的技术。

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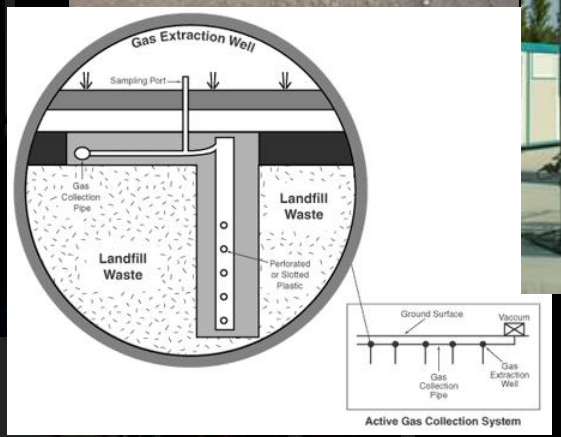
Main Components of LFG Recovery and Power Generation Plant

垃圾填埋气回收和发电所需的主要设备



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Electricity generation technologies for Landfill gas (I)
垃圾填埋气发电的技术（I）

The general options for generating electricity with landfill gas (once collected) are:
一旦垃圾填埋气收集后可选择用来发电的技术有：

- Reciprocating internal combustion engines (IC engines), more than two thirds of the operational landfills use this type of equipment.
  往复式内燃机，目前运作的垃圾填埋场中多于三分之二采用这种设备
- Stirling Cycle - external combustion engine
  斯特林循环外燃式发动机.
- Gas turbines, steam turbines
  燃气轮机， 蒸汽轮机
- Alternative solutions: fuel cell, which are technologies that are available in small incremental capacities, have short lead times from planning to construction, and have lower air emissions than other, larger-scale, generation technologies.
  替代方案：燃料电池，目前该技术装机容量小，从设计到施工周转期短，与其他大容量发电技术相比排放量低。

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Electricity generation technologies for Landfill gas (II)
垃圾填埋气发电的技术（II）

- Fuel cells generate electricity through an electrochemical process in which the energy stored in a fuel is converted directly into electricity, avoiding the need for combustion.
  燃料电池通过电化学反应发电，在反应过程中储存在燃料内的能量被直接转化成电，就此避免了燃料的燃烧。
- The microturbine is a derivative of the much larger combustion turbines employed in the electric power industries. Microturbines spin at much faster speeds than traditional combustion turbines.
  微型涡轮机是电力工业所用大型燃气涡轮机的派生品，但微型涡轮机的旋转速度要比传统燃气涡轮机的快得多。

Currently, however, no steam turbines and commercially available Stirling engines have been applied in LFG application. Most used technologies are internal combustion engine and gas turbine.
然而，目前在垃圾填埋场项目中尚未看到蒸汽轮机和斯特林循环外燃式发动机的应用，应用最广的仍是内燃发动机和燃气涡轮机。

Electricity generation technologies for Landfill gas (III)
垃圾填埋气发电的技术（III）

	Advantage 优势	Disadvantage 劣势
Internal combustion engine 内燃机	– High efficiency 效率高 – Utilize low pressure fuel gas compressor 燃料压力低 – Adaptable to variable LFG supplies 可用于各种不同的垃圾填埋气 – Suitable for moderate size landfills 装机容量可根据垃圾填埋场的规模进行调整 – Lower capital cost 投资费用低	– Higher emissions 排放较高 – More complex cooling system 冷却系统较复杂 – More moving parts 移动部件较多 – Higher maintenance cost 维修、保养费用较高
Gas turbine 燃气轮机	– Low emission 低排放 – No cooling water required 无需冷却水 – Simple lubrication system 润滑系统简单 – Few moving parts and wear points 移动部件和磨损点少 – Vibration free operation – Exhaust can be utilized in cogeneration 烟气可用于热电联产	– Lower efficiency 效率偏低 – High pressure fuel gas compressor required 高压燃气 – High capital cost 投资高 – Not suitable for moderate size landfills 装机容量不宜调整 – Sensitive to varied LFG supply loads 对供气量的改变敏感 – Sensitive to ambiente air temperature 对机组周边空气的温度敏感

Electricity generation technologies for Landfill gas (IV)
垃圾填埋气发电的技术（IV）

In short, 简短来讲

- the IC engines has the lowest capital cost, whereas the capital cost of gas turbines is about 25% higher than reciprocating engines.
  内燃机投资成本最低，燃气轮机的投资费用大约要比内燃机高25%。
- the IC engines has the highest O&M cost, about 25 to 30 % higher than gas turbines.
  内燃机运行和维修费用高，大约比燃气轮机高25-30%。
- gas turbines are only suitable for larger sites (3,000 kW and larger power plants) and require more careful control of the methane content in the LFG supply.
  燃气轮机仅适用于大型垃圾填埋场（装机容量最好在3000kW以上），且对垃圾填埋气的甲烷含量的控制要求较严。

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CDM Perspective of Landfill Gas Projects (I)
垃圾填埋气项目的CDM 前景（I）

- LFG to power is not free, base on the common business scenario in China or other developing countries no investor will be interested in this kind of project.
  垃圾填埋气的电力转化不是免费的，基于目前象中国这样的发展国家的商业状况，没有投资商对这样的项目感兴趣。

- CDM gives a very good opportunity to reduce GHG emissions while developing LFG to energy projects using revenue generated by the sale of emission reductions.
  CDM为温室气的减排提供了良机，同时为发展垃圾填埋气项目带来了机会，利用出售减排量所所得的收益可补偿该类项目的经济回报。

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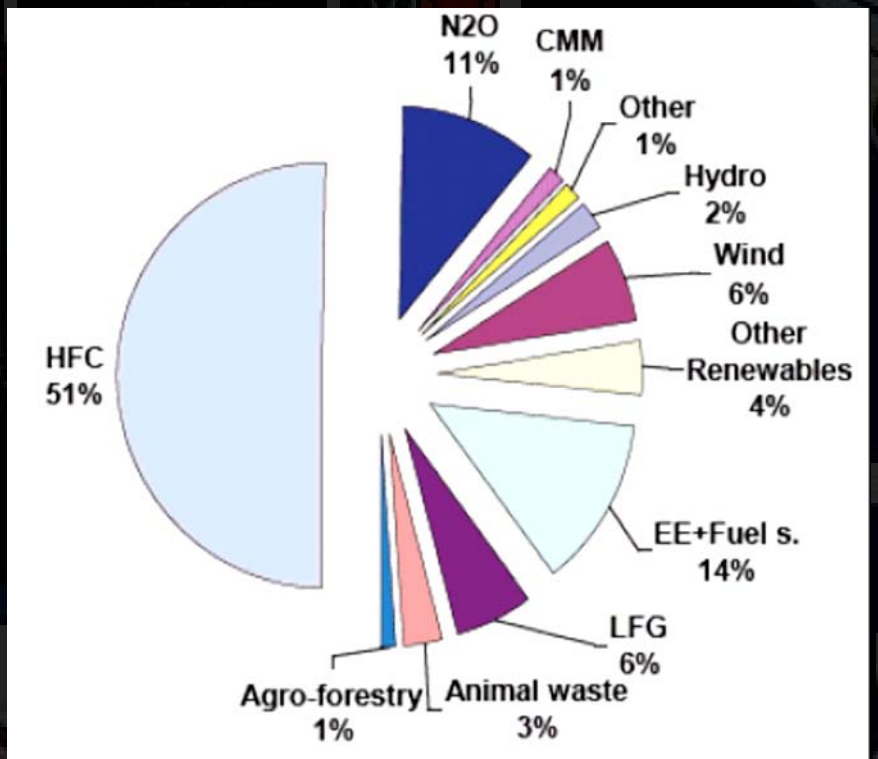
CDM Perspective of Landfill Gas Projects (II)
垃圾填埋气项目的CDM 前景（II）

- However, at the end of 2006 of all of the types of CDM projects allowed under the Kyoto Protocol rules, LFG CDM project were only 6%.
  截止到2006年年底，在所有开发的CDM项目中仅有6%为垃圾填埋气项目。



CDM project types: share of volumes of CERs through 2006.
2006年注册的CDM项目种类。

(*source: "LANDFILL GAS CDM PROJECTS: CURRENT TRENDS AND FUTURE OPPORTUNITIES FOR DEVELOPING COUNTRIES", C. LEE*, J. BOGNER**, AND A. TOEFY°*)

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CDM Perspective of Landfill Gas Projects (III)
垃圾填埋气项目的CDM 前景（III）

Country 国家	N. Of projects 项目数量
Argentina 阿根廷	5
Armenia 亚美尼亚	2
Bangladesh 孟加拉	2
Bolivia 玻利维亚	1
Brazil 巴西	40
Cambodia 柬埔寨	1
Chile 智利	11
China 中国	4
Costa Rica 哥斯达黎加	1
Ecuador 厄瓜多尔	4
Egypt, El Salvador, Georgia, Honduras 埃及、萨尔瓦多、乔治亚、洪都拉斯	1 each
India 印度	10
Indonesia 印度尼西亚	2
Israel 以色列	2
Malaysia 马来西亚	9
Mexico 墨西哥	71
Nicaragua, Peru 尼加拉瓜、秘鲁	1 each
Philippines 菲律宾	6
South Africa 南非	1
Tunisia 突尼斯	2

- Up to April 2007, there were 180 registered landfill gas CDM projects out of a total of 632. They are located in the countries indicated in the table.
  截止到2007年四月，已注册的632个CDM项目中180个为垃圾填埋气项目。
- Opportunities for LFG projects under the Kyoto Protocol still exist, and these opportunities are expected to continue beyond 2012, the end of the first Kyoto commitment period.
  即便到2012年第一京都许诺期结束后,仍有在京都协议下继续发展垃圾填埋气项目的机会。

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Registered CDM Landfill gas projects in China

已注册的中国垃圾填埋气CDM 项目

Registered	Title	Other Parties	Methodology	Estimated reductions (tCO_2e/year)
18 Dec 05	Nanjing Tianjingwa Landfill Gas to Electricity Project	UK Northern Ireland	ACM0001 ver. 1 AMS-I.D. ver. 6	246,107
03 Mar 06	Meizhou Landfills Gas Recovery and Utilization as Energy	Austria	ACM0001 ver. 2	286,525
21 May 06	Anding Landfill Gas Recovery and Utilisation Project	Netherlands	ACM0001 ver. 2	75,557
09 Apr 07	Wuxi Taohuashan Landfill Gas to Electricity	Japan	ACM0001 ver. 4 AMS-I.D. ver. 9	75,343
04 May 07	Shenzhen Xiaping Landfill Gas Collection and Utilization Project	UK and Northern Ireland	ACM0001 ver. 4	471,619
13 May 07	Jinan Landfill Gas to Energy Project	UK and Northern Ireland	ACM0001 ver. 4 AMS-I.D. ver. 9	112,908
21 Jul 07	Composting of organic waste in Wuzhou	Germany	AM0025 ver. 5	41,880

Of which 6 projects (written in yellow) produce electricity. 其中六个为发电项目。

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Sino-Italian cooperation projects in Landfill gas utilisation
中意合作就垃圾填埋气利用方面开发的项目

The Italian Ministry for the Environment, Territory and Sea launched LFG CDM activities in the second half of year 2003 in China. In cooperation with partners (both Chinese and Italian), D'Appolonia has worked on several biogas reuse for energy production in China. The objectives of this initiative are:

意大利环境领土海洋部于2003年下半年启动了在中国的垃圾填埋气CDM项目。D'Appolnia 公司与其它中意项目合作伙伴一起参加了不同生物气利用、能源转换项目工作。 项目的主要目的为：

- selection of the landfill sites 垃圾填埋场的选择;
- preliminary assessment of the Technical and Economic Feasibility 技术、经济可行性的初步研究;
- set up of a Memorandum of Understanding (MoU) with the site owner 与垃圾填埋场签订谅解协议;
- development of the relevant CDM documentation: PIN, PDD 准备CDM有关的项目文件：PIN、 PDD;
- development of the final design and technical specifications 项目的最终设计和技术规范的制定.

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International Partnership for Project Development
项目开发的国际伙伴关系

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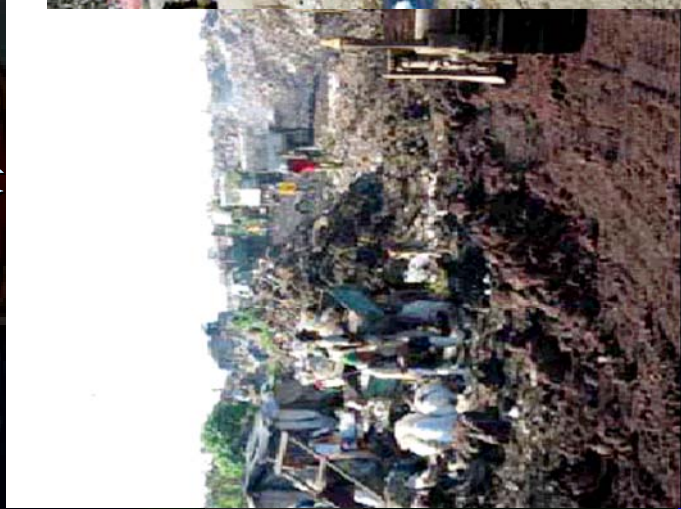
Lessons learnt 应吸取的教训

Based on the recent Sino-Italian experience, LFG projects development in China must overcome several obstructions.
基于近年来意中合作项目的经验，中国垃圾填埋气项目的发展还有待克服不同的障碍。

Technical 技术方面

- Poor system design of landfill sites 垃圾填埋场的设计不够完善;
- Poor system operations & management (cover, site practices: impact, leachate, etc.)
  运作和管理不够健全 (如垃圾的堆压、填埋方式、覆盖等）;
- Vandalism/informal recycling (paper recycling, etc.)
  一些破坏活动或不正规的再循环（如纸张的回收利用等）



Over estimating recoverable LFG 可回收垃圾填埋气量的估算过高

- Scarce data on waste characterization 有关垃圾特性的数据欠缺
- Less information on waste disposal history
  有关垃圾填埋历史的信息欠缺;
- Difficult to be sure for projected future waste
  对垃圾长远的填埋量没把握.

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Thanks for your attention!

谢谢大家的关注！

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