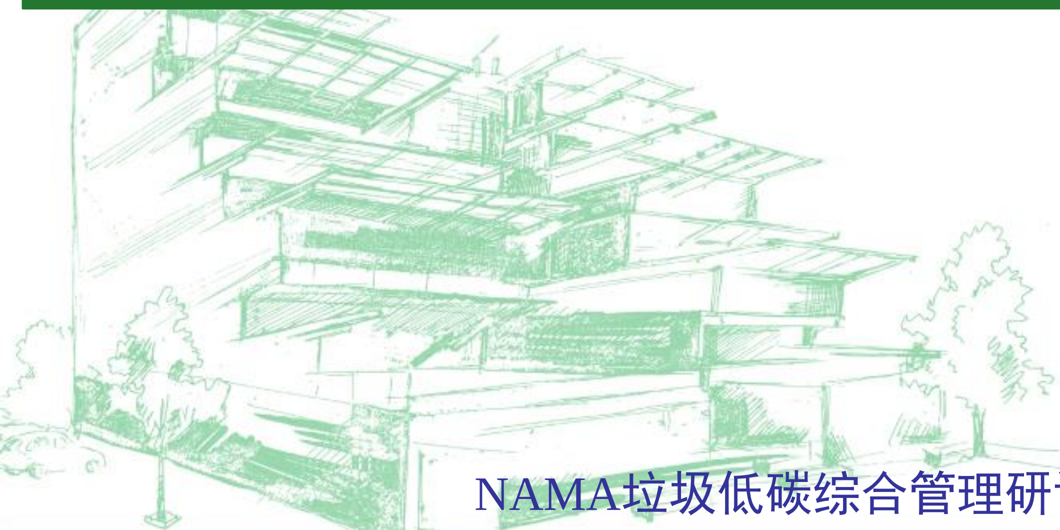
高厨余含量生活垃圾处理过程温室气体排放：基于碳流、能流分析

Greenhouse gas emissions from different municipal solid waste management scenarios in China: based on carbon and energy flow analysis



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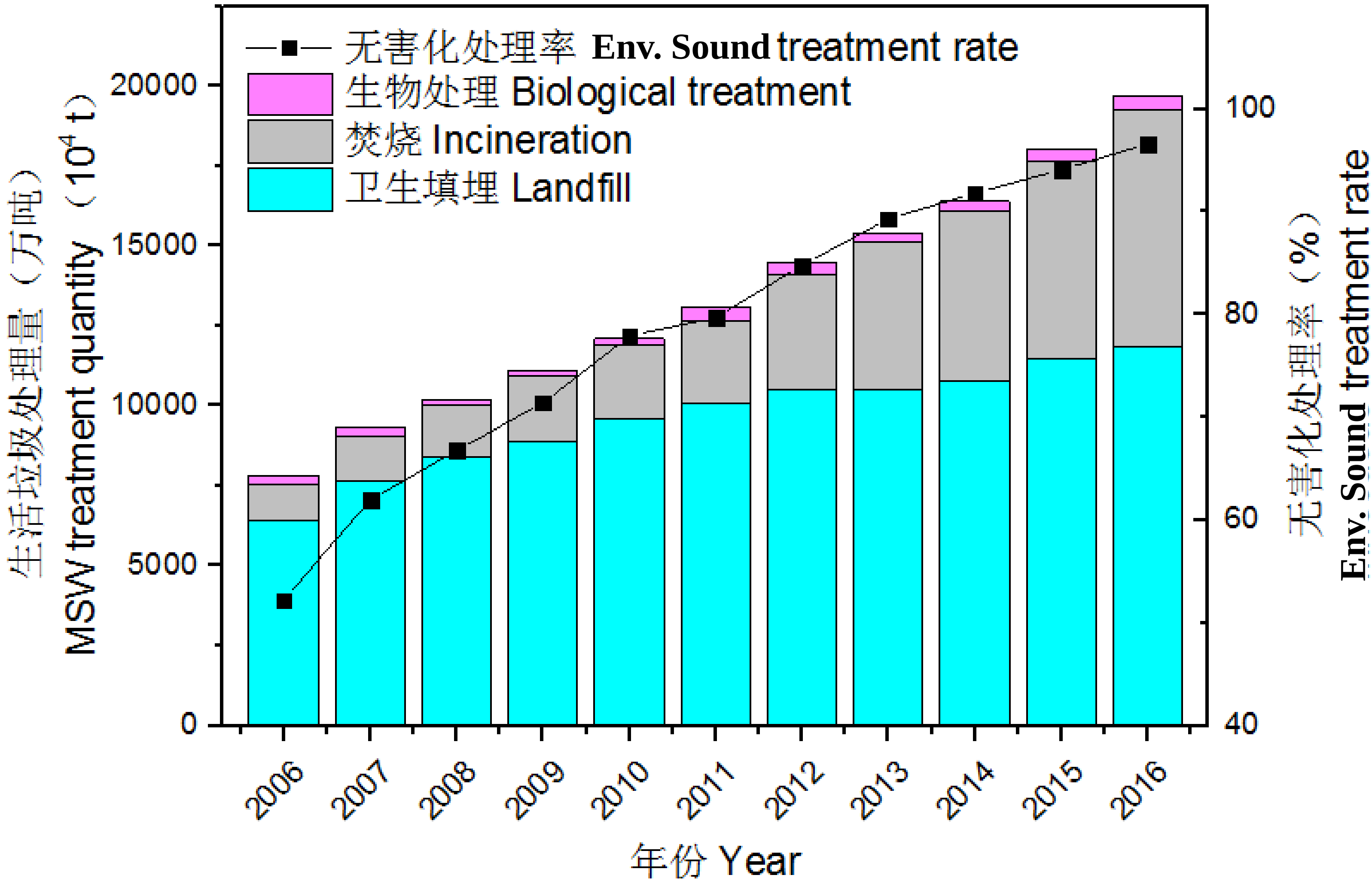
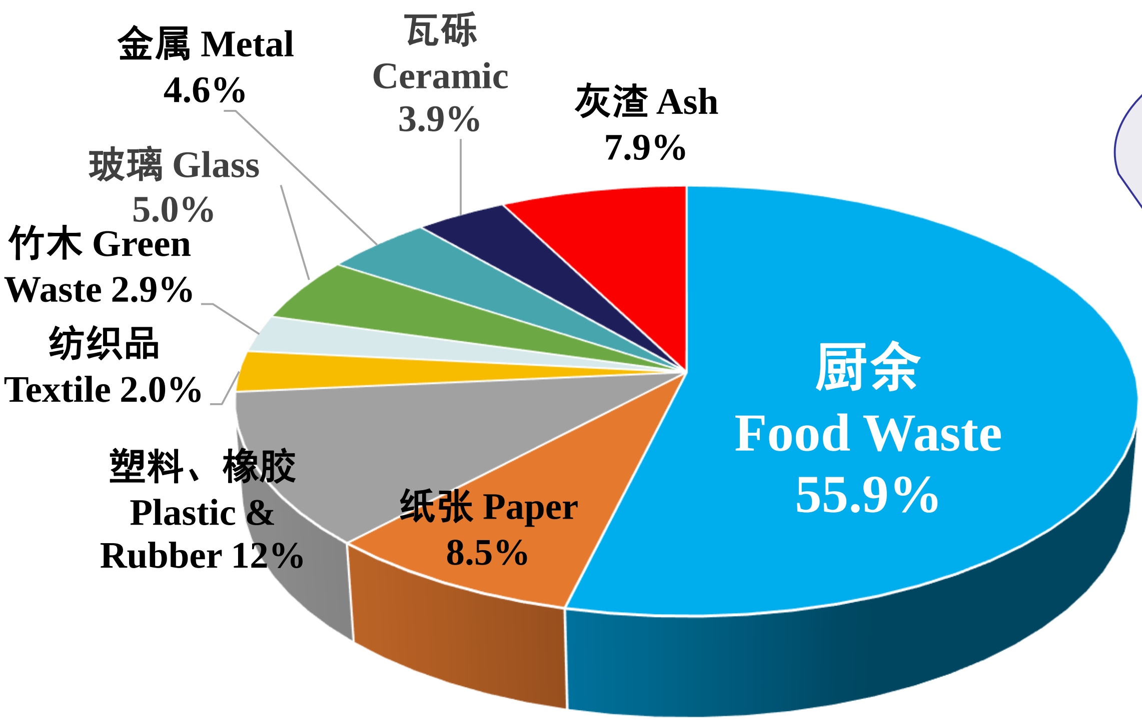
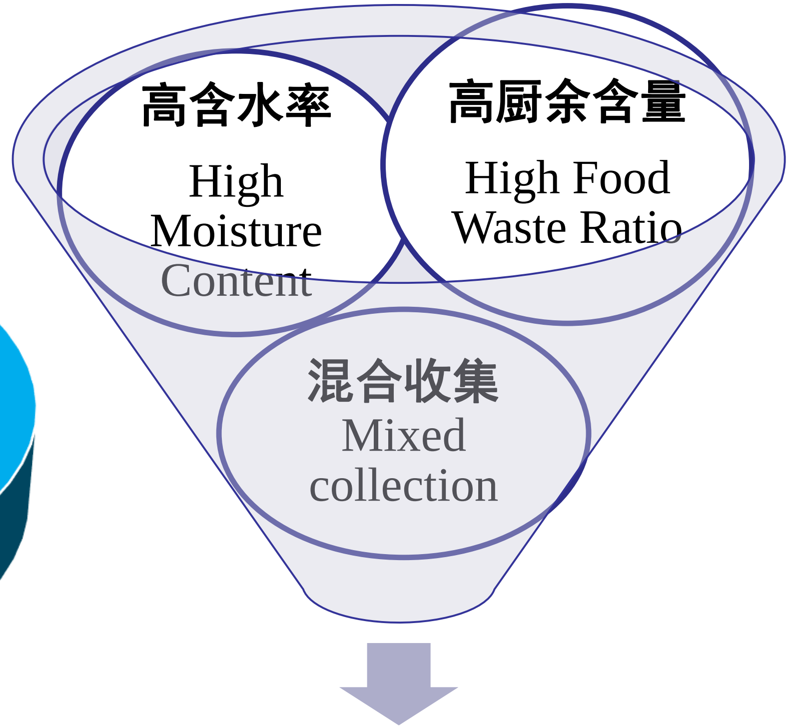
NAMA垃圾低碳综合管理研讨会，苏州，**2018.8.28-29**

研究背景 Research Background



研究背景 Research Background





垃圾特性与处理方式差异

Composition and management different from developed countries

从混合收集向分类收集过渡

From mixed collection to separate collection

含水率 moisture：54.8%

低位热值 LHV：4875 MJ/t

生物源碳 BSC：82.68kg/t

化石源碳 FSC：49.08kg/t

研究背景 Research Background

各国温室气体排放量
Greenhouse gas emissions from various countries

中国温室气体减排目标
Chinese emission reduction targets

固体废物处理领域减排潜力大
Considerable reduction potential in solid waste treatment

International Solid Waste Association White Paper

	1990	2007	2012-2020 (projected)
European municipal waste sector annual net GHG emissions	69 million tonnes CO_2	32 million tonnes CO_2	Net reducer

研究背景 Research Background

温室气体排放评估
GHG Emission Evaluation

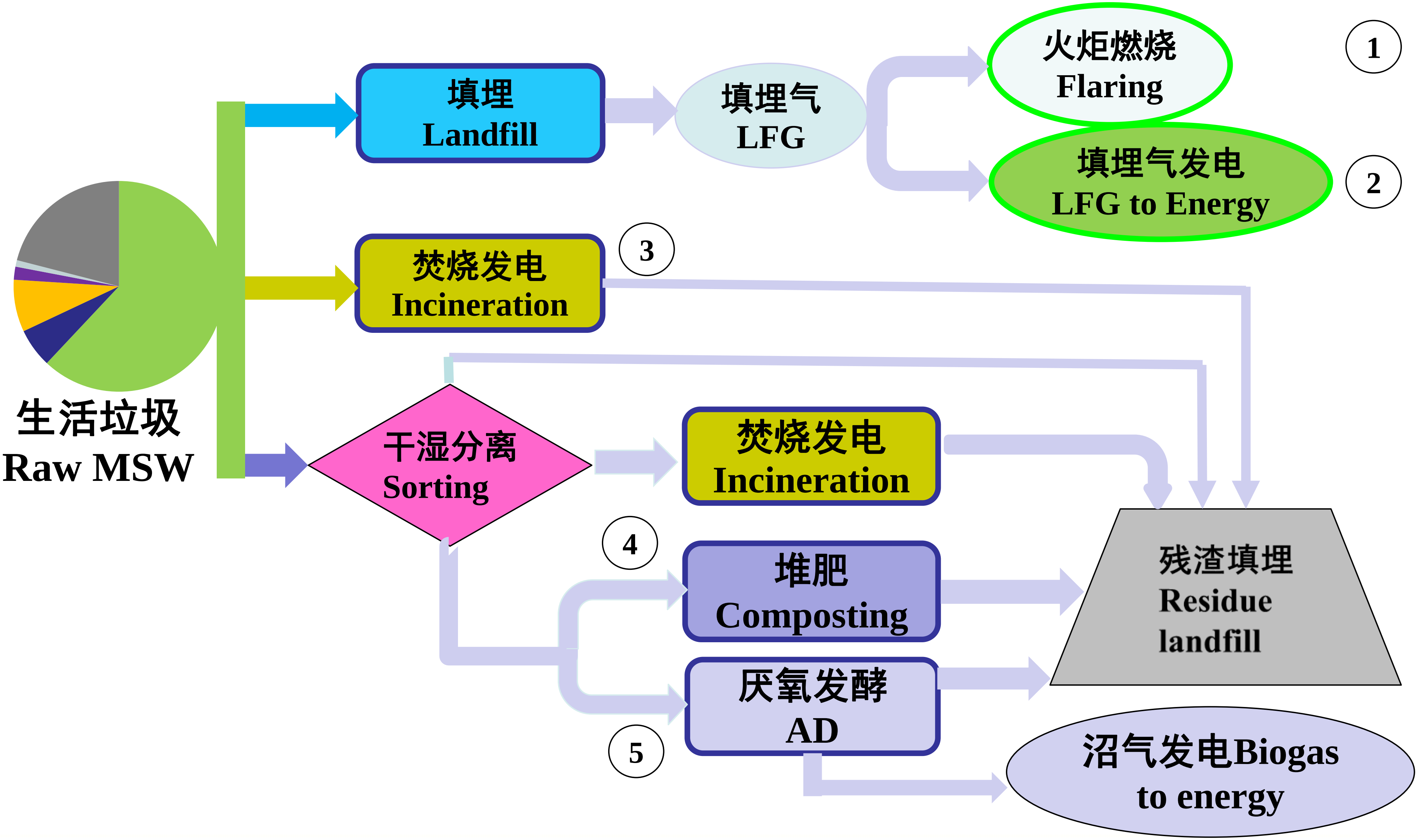
生命周期分析 Life Cycle Analysis

碳流、能流分析
Carbon and energy flow analysis
ISO 14040s & Easetech software

不同处理场景构建 Different Disposal Scenarios

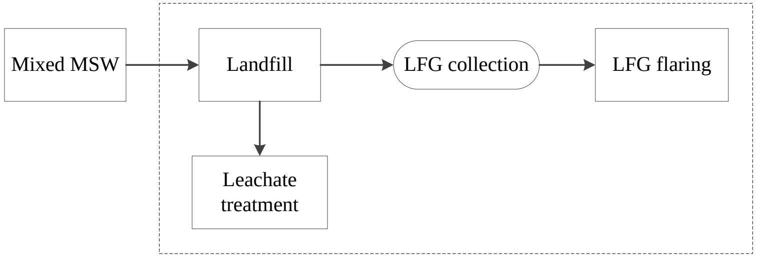
各处置场景中长期留存在土壤部分的生物源碳记为碳减排，以CO_2形式重新返回大气部分记为碳中性；而长期留存的化石源碳记为碳中性，经焚烧释放到大气中部分记为碳排放（ISO/TS 14067）

研究方法 Research Method

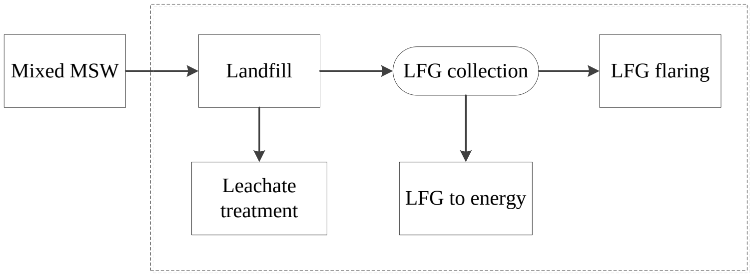


研究方法 Research Method

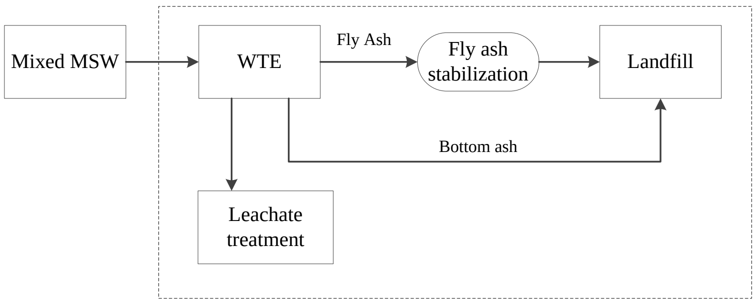
Scenario 1:



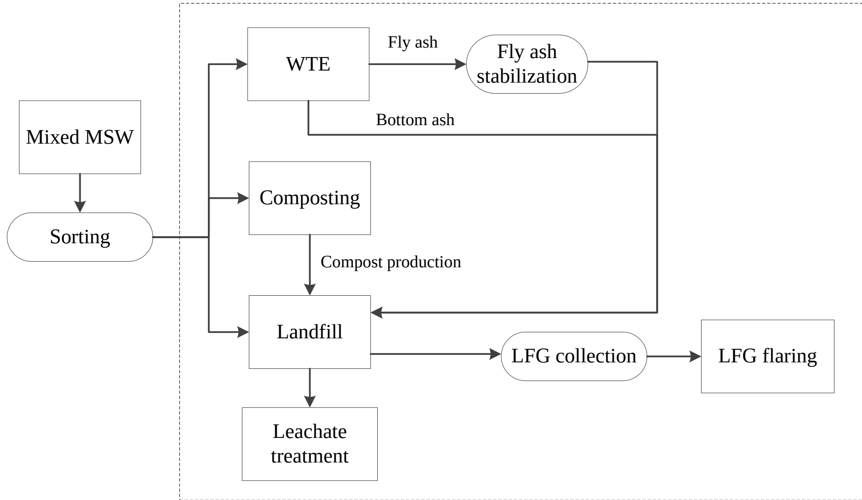
Scenario 2:



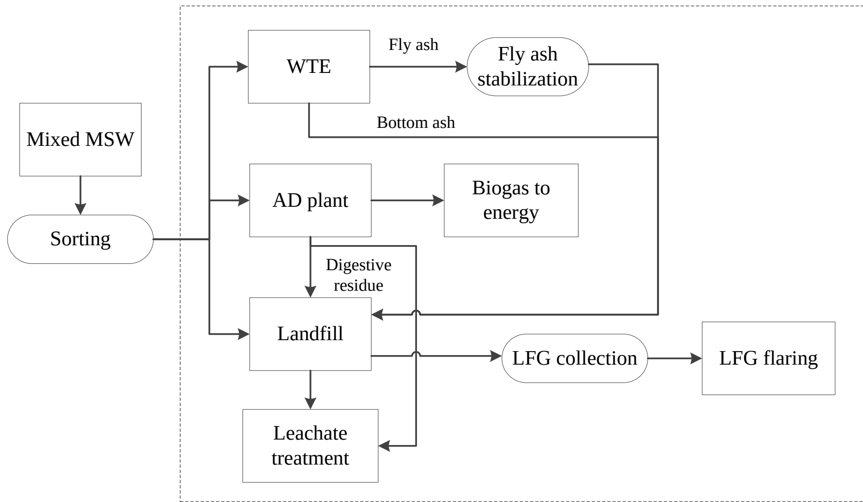
Scenario 3:



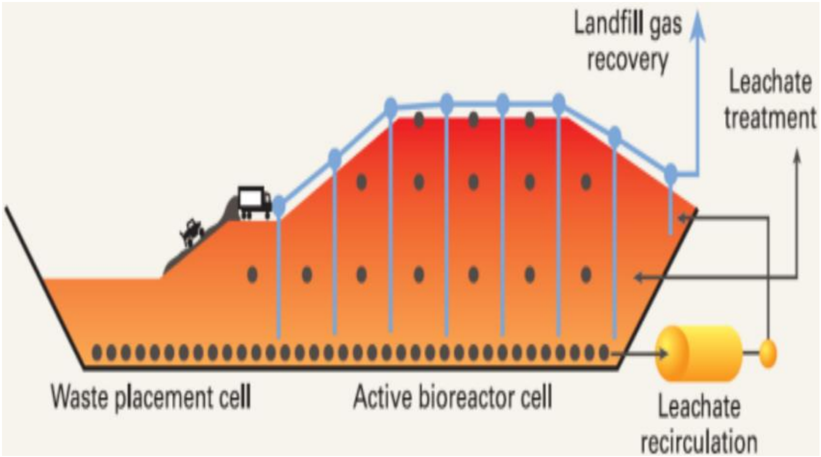
Scenario 4:



Scenario 5:



研究方法 Research Method



场景1、2：填埋（无/有填埋气回收发电）
Scenario 1 & 2: Landfill
(without or with LFG to power)

填埋气 LFG：

各组分一阶降解模型
First order degradation model
填埋气收集效率 40-80% （+ 4.5%）
Collection efficiency 40-80% +（ 4.5%）

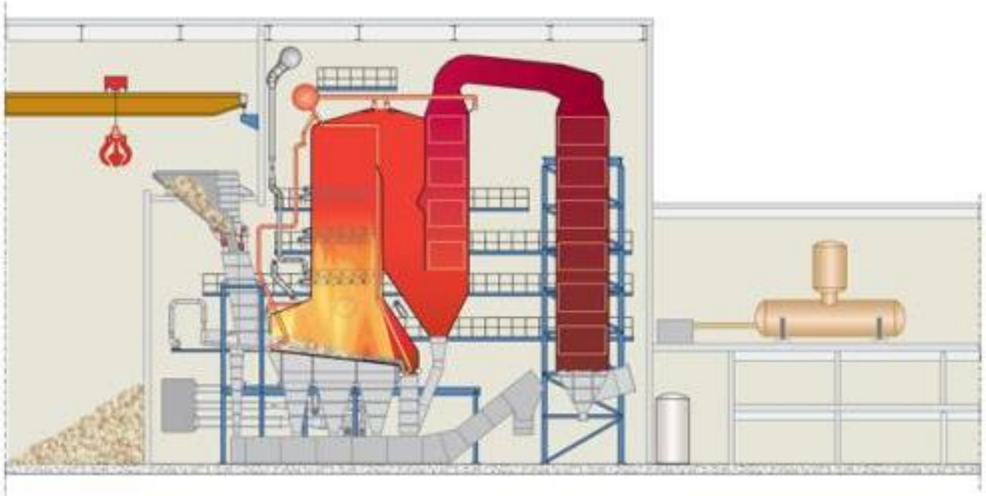
渗滤液 Leachate：

产生量 500 L/ton MSW
generation quantity 500 L/ton MSW
处理耗电30 Kw·h/ton
30 Kw·h/ton for treatment

碳存储 Carbon storage：

基于各组分完全分解比例
Max decomposition ratio of each component

研究方法 Research Method



场景3：焚烧发电（炉排炉）
Scenario 3: Incineration with electricity recovery（ Grate furnace ）

储坑沥水： 33% water drained in the storage bunker (15% of MSW)

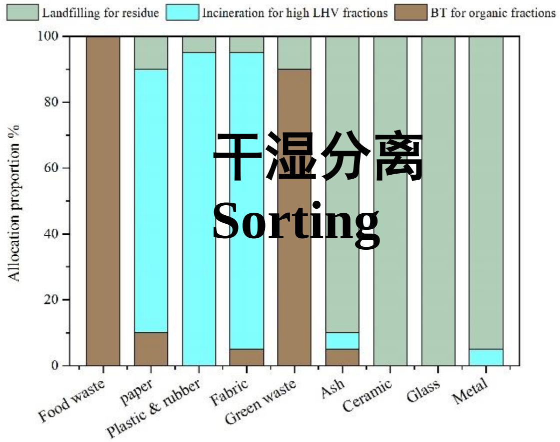
能量转化效率 Energy conversion efficiency：

锅炉 boiler 81.2%

汽轮机 turbine 31.6%

炉渣填埋，飞灰水泥固化后填埋 Bottom ash to landfill, Fly ash stabilized by cement

研究方法 Research Method



电耗 Electricity consuming

分选 Sorting 20 Kw·h/t

堆肥 Composting 15.6 Kw·h/t

LFG：一阶降解模型

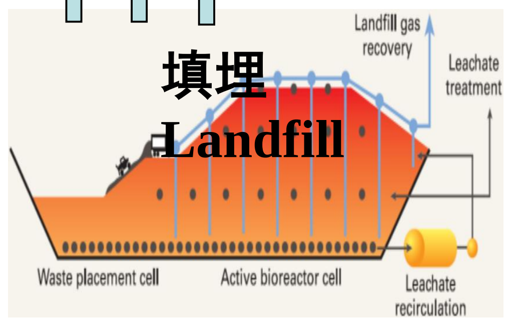
First order degradation model

生物质垃圾

Organic fraction

CH_4 10 g/ton

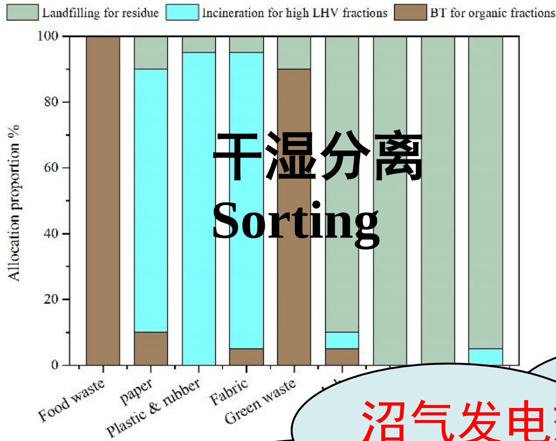
N_2O 90 g/ton



场景4：干湿分离+生物质堆肥+高热值组分焚烧+残渣填埋

Scenario 4 : Dry-Wet separation + Composting + Incineration + Landfill

研究方法 Research Method



电耗 Electricity consuming

分选 Sorting 20 Kw·h/t

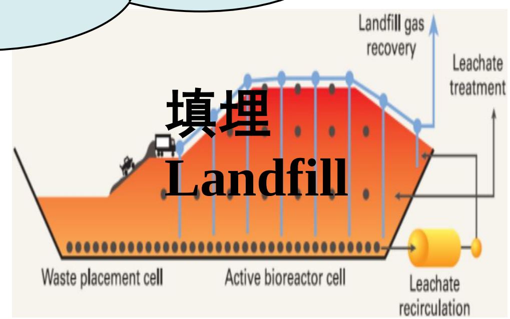
厌氧消化 AD 50 Kw·h/t

沼气发电效率 Energy conversion efficiency：35%

沼气泄漏 Biogas leakage：5%

生物质垃圾

Organic fraction

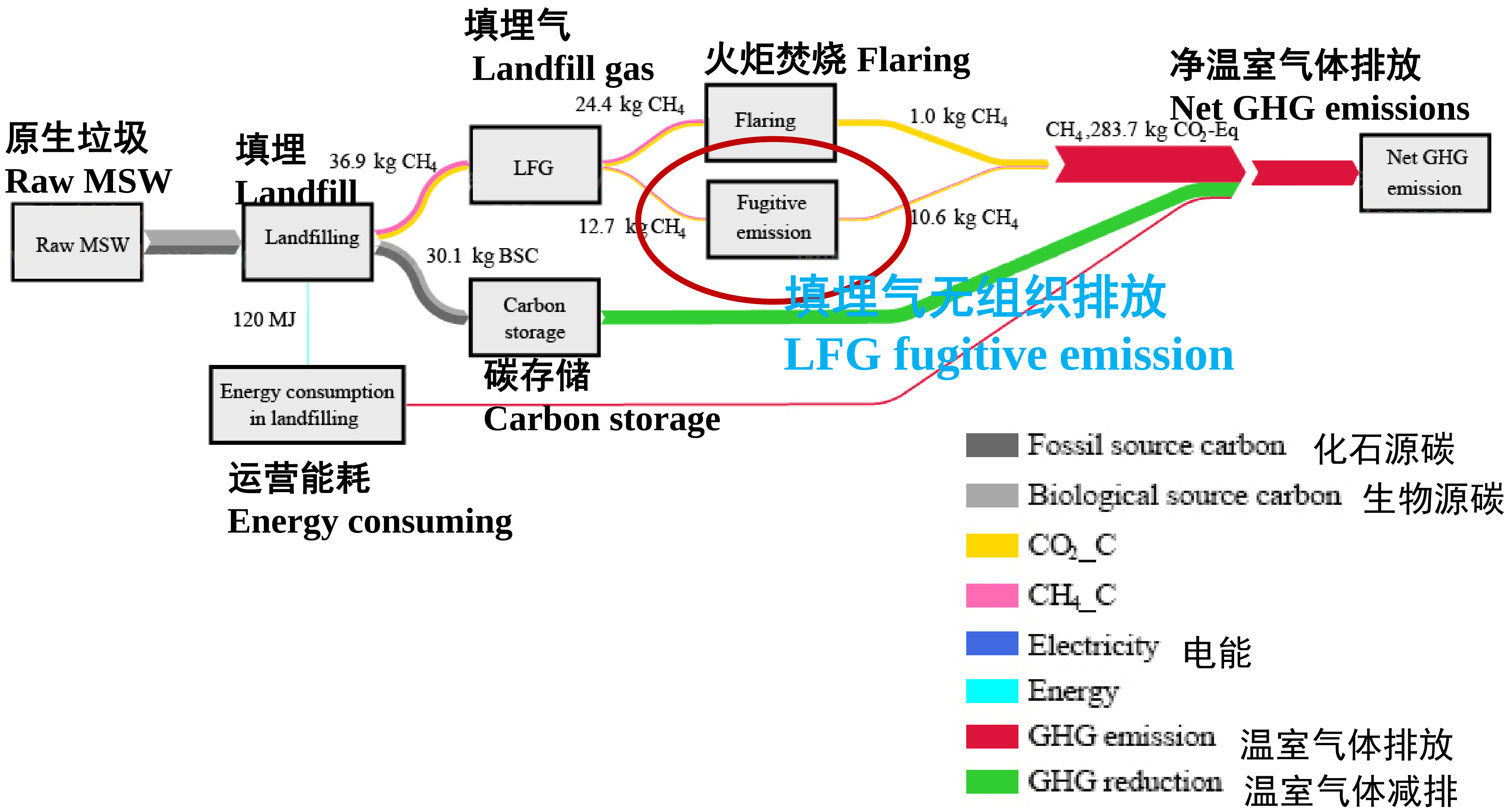


场景5：干湿分离+生物质厌氧消化+高热值组分焚烧+残渣填埋

Scenario 5 : Dry-Wet separation + Anaerobic digestion + Incineration + Landfill

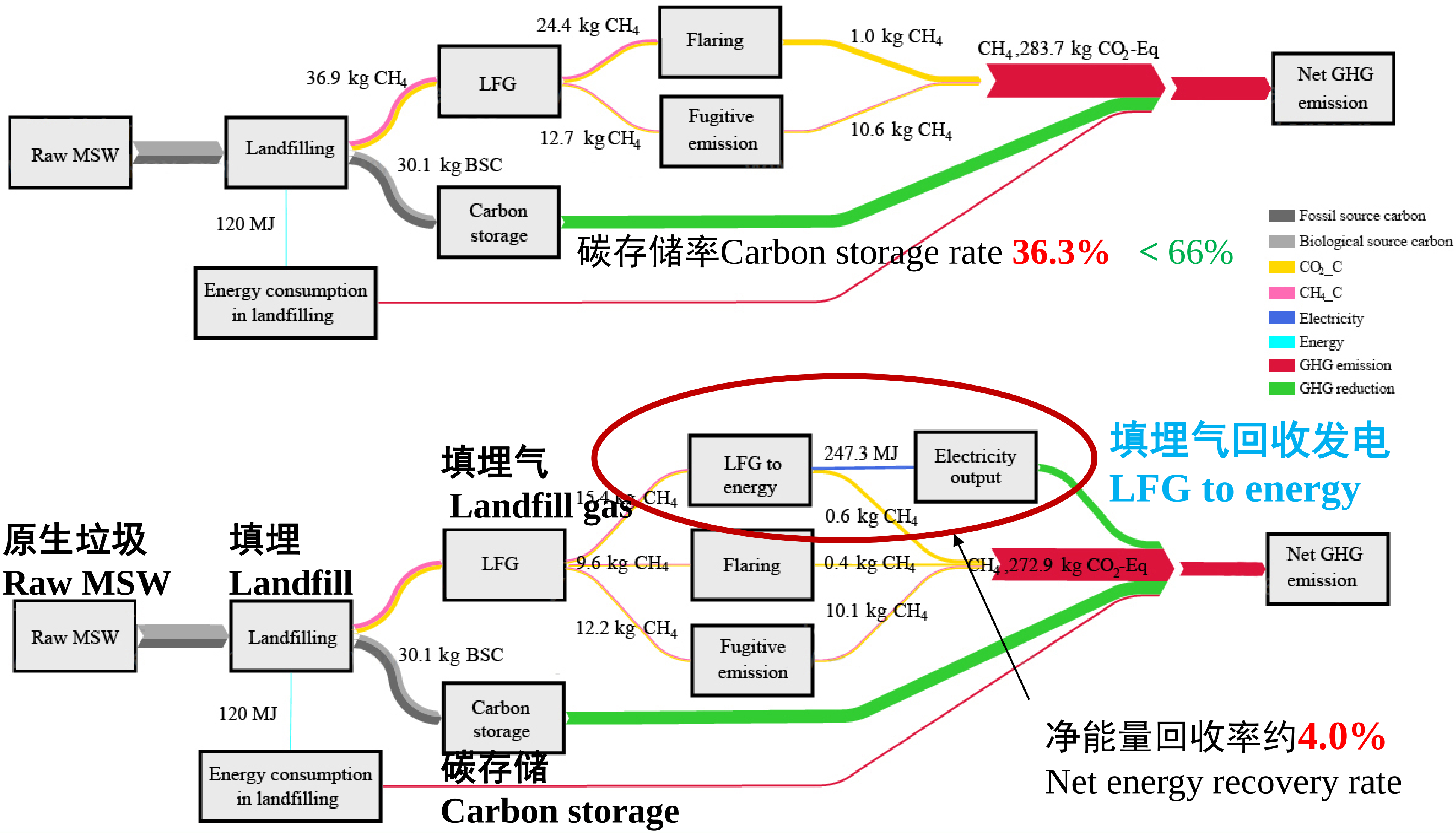
研究结果 Results

场景1、2：填埋 Scenario 1&2：Landfill (without or with LFG to power)



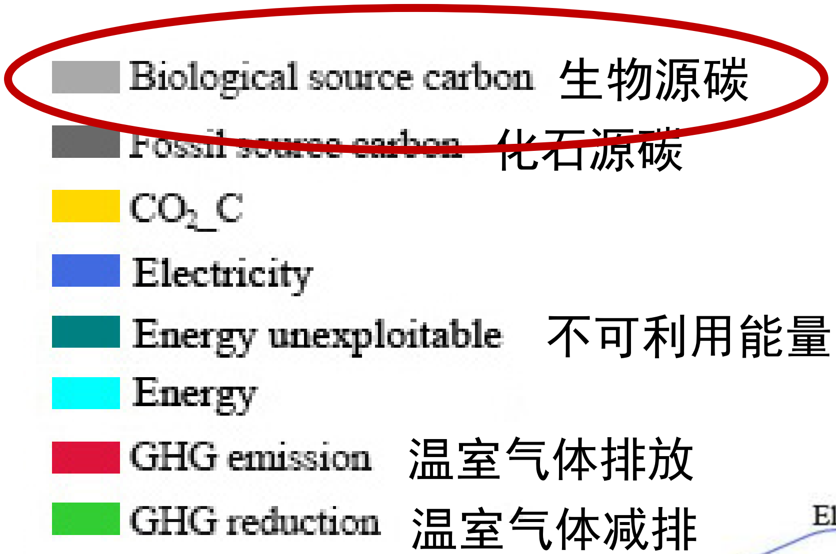
研究结果 Results

场景1、2：填埋 Scenario 1&2：Landfill (without or with LFG to power)



研究结果 Results

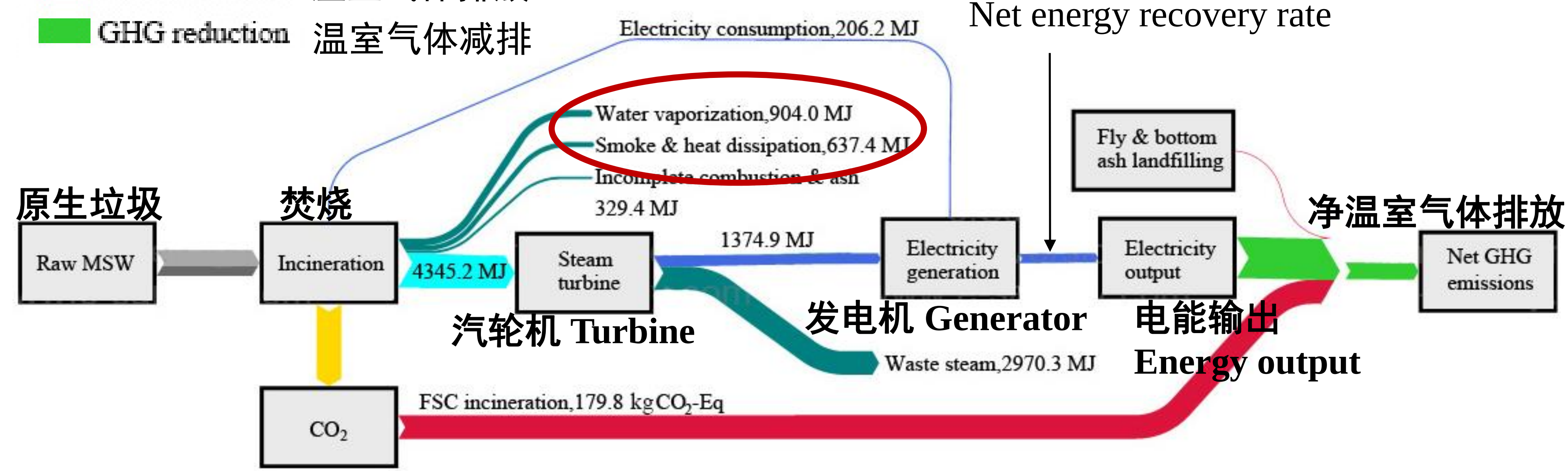
场景3：焚烧发电 Scenario 3：Incineration



更高的减排潜力 higher GHG reduction potential

高含水率削弱了减排潜力
higher moisture lowers GHG reduction potential

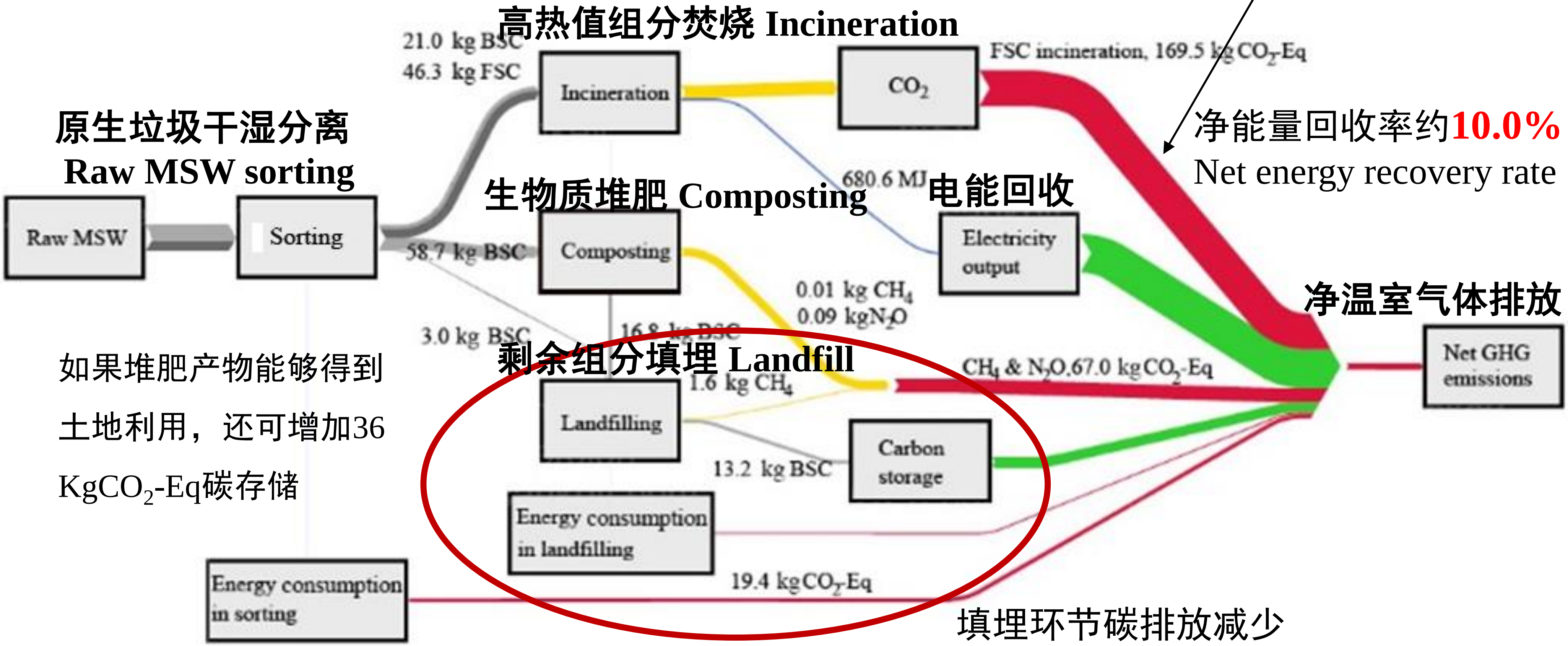
净能量回收率约**18.7%** **< 30%**
Net energy recovery rate



研究结果 Results

场景4：干湿分离+堆肥 Scenario 4: Separation + Composting + Incineration + Landfill

焚烧过程化石源碳排放：169.5 kgCO_2-eq
GHG emissions from fossil source carbon incineration



净能量回收率约**10.0%**
Net energy recovery rate

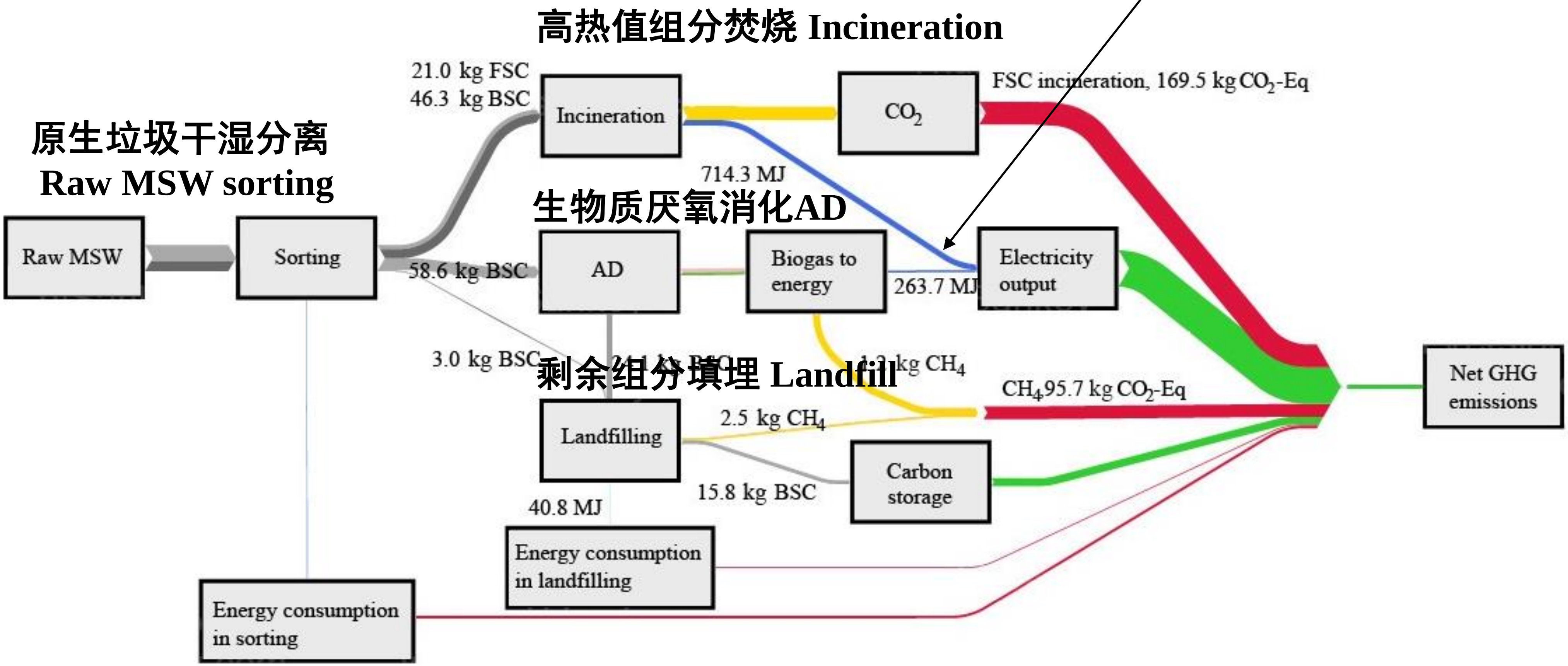
如果堆肥产物能够得到土地利用，还可增加36 KgCO_2-Eq碳存储

填埋环节碳排放减少
GHG emissions from landfill reduced

研究结果 Results

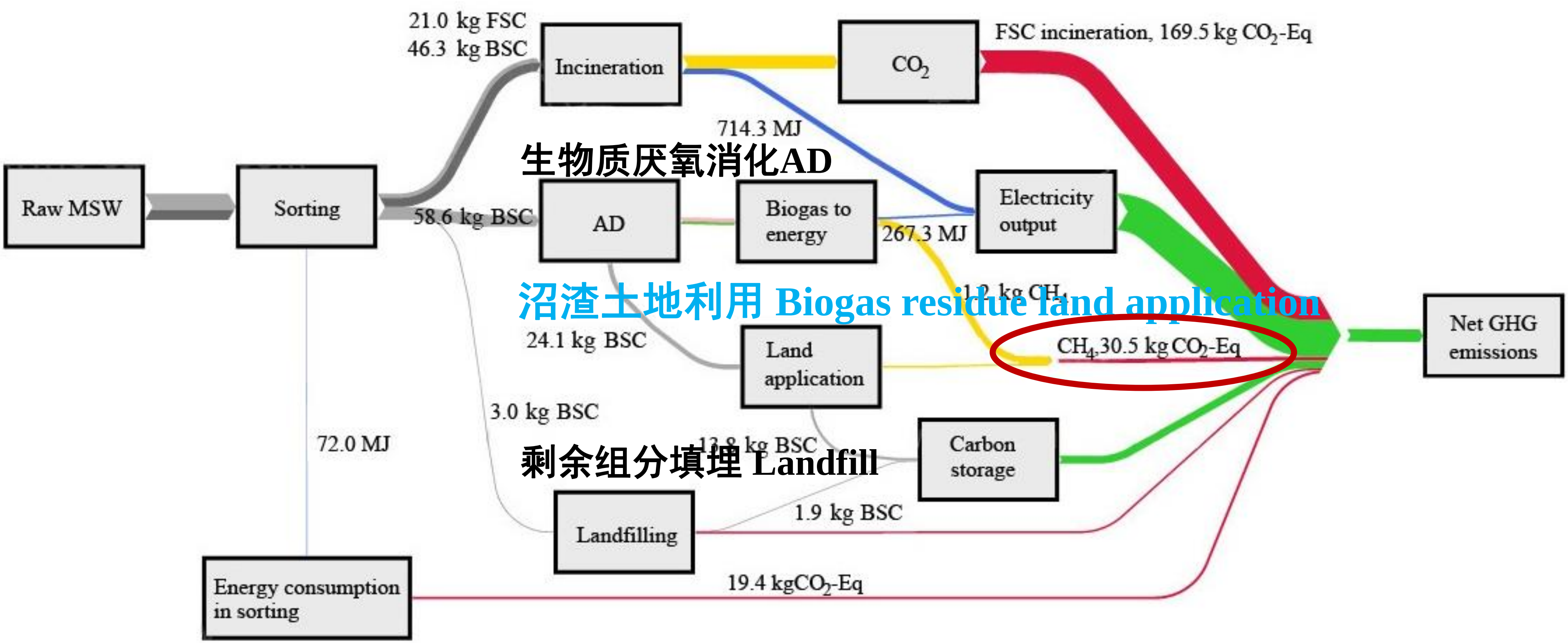
场景5：干湿分离+厌氧消化 Scenario 5: Separation + AD + Incineration + Landfill

总能量回收Total energy recovery： 978 MJ
焚烧Incineration 714.3 MJ ; 沼气回收Biogas recovery 263.7 MJ）
净能量回收率 Net energy recovery rate: **14.0%**



研究结果 Results

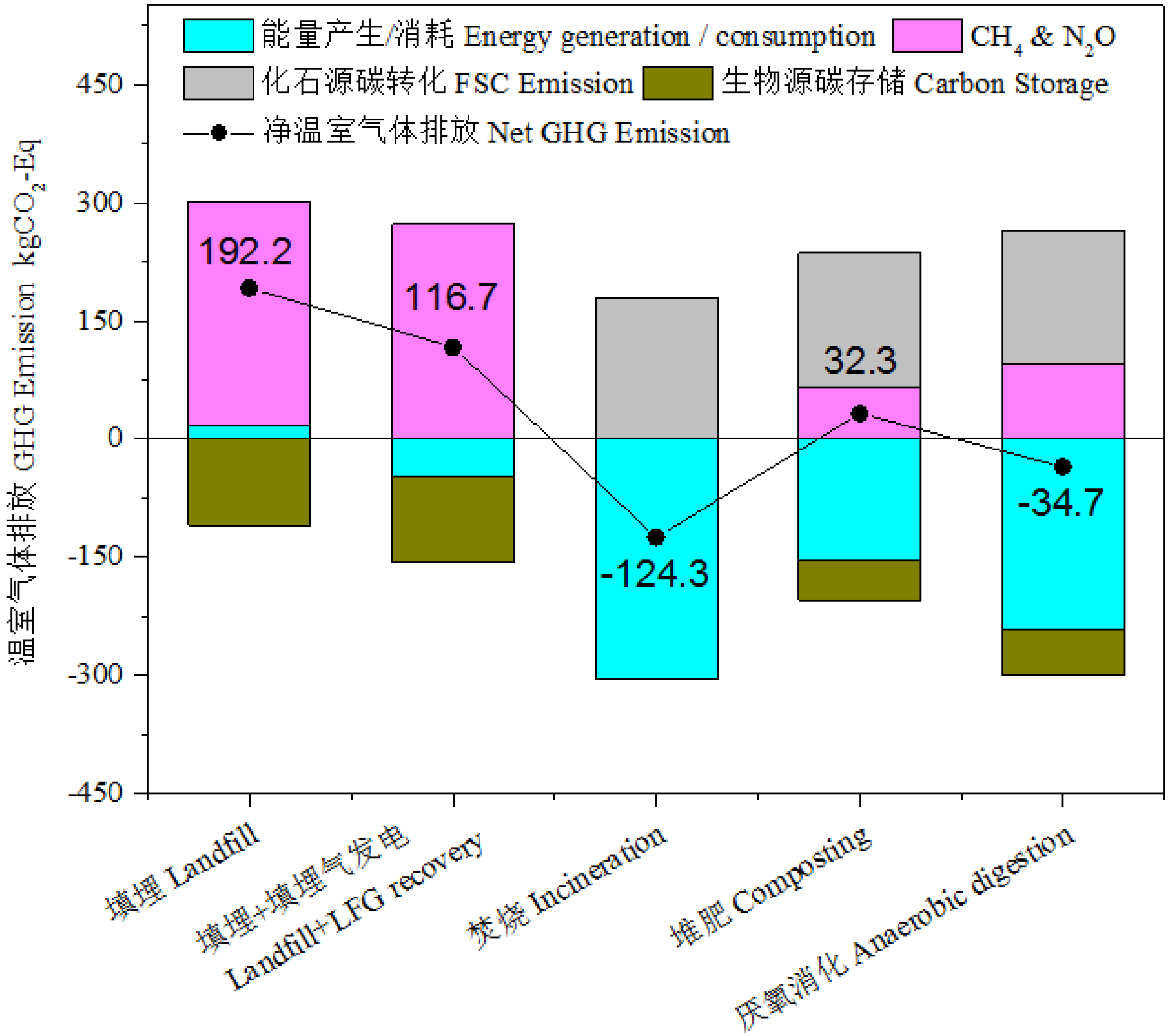
场景5：干湿分离+厌氧消化 Scenario 5: Separation + AD + Incineration + Landfill



当沼渣能够得到土地利用时，可通过避免沼渣填埋过程中57.5 KgCO_2-Eq的甲烷释放获得95.8 KgCO_2-Eq的温室气体减排收益。同时，随着垃圾分类的推广，前端分选能耗造成的温室气体排放也将逐步降低。

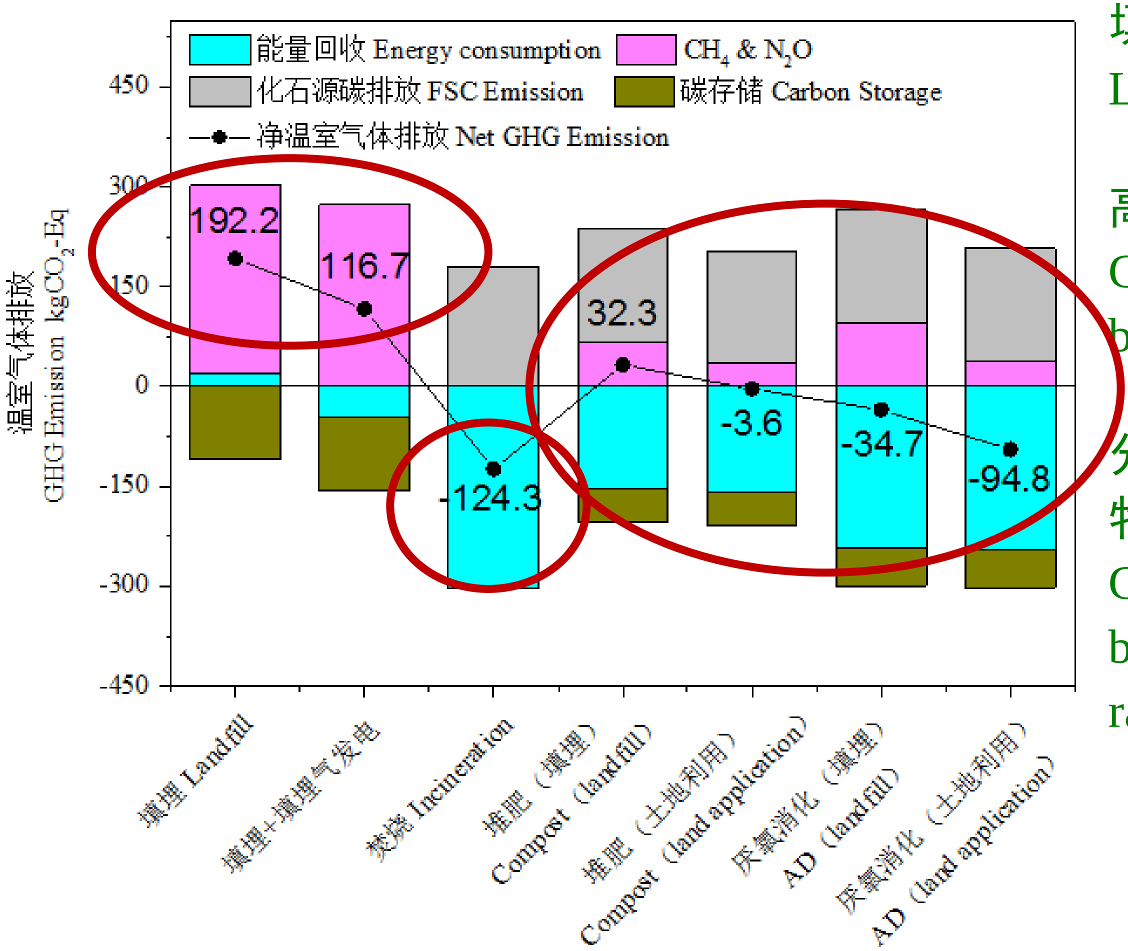
研究结果 Results

各场景对比 Comparison of different scenarios



研究结果 Results

各场景对比 Comparison of different scenarios



填埋温室气体排放量高

Landfill generates the most GHG emissions

高生物质比例突出了焚烧的减排潜力

GHG reduction is promoted by higher bio-source carbon in incineration

分类处理时温室气体减排效果受生物处理产物能否实现土地利用影响较大

GHG reduction potential is effected by biological treatment products land application ratio

研究结果 Results

对垃圾分类的启示 Implications for MSW source separation

垃圾分类的重点在于分类、回收**有价值的物质**

MSW separate collection is to recover

most valuable materials

避免被厨余组分污染

Avoid contamination by food waste

高质量的厨余垃圾分类是后续生物处理及土地利用的基础

High quality food waste classification is the foundation of subsequent biological treatment and land application

厨余垃圾分类求**精**不求全

Quality is more important than quantity in food waste source separation.

研究结果 Results

更多信息请参阅本课题组相关论文 Please refer to following literatures for more information

Yili Liu, Zhe Ni, Xin Kong, **Jianguo Liu***. Greenhouse gas emissions from municipal solid waste with a high organic fraction under different management scenarios, Journal of Cleaner Production, 147: 451-457, 2017

Yili Liu, Peixuan Xing, **Jianguo Liu***. Environmental Performance Evaluation of Different Municipal Solid Waste Management Scenarios in China. Resources, Conservation & Recycling, 125, 98–106, 2017

Yili Liu, Weixin Sun, **Jianguo Liu***. Greenhouse gas emissions from municipal solid waste with a high organic fraction under different management scenarios based on carbon and energy flow analysis. Waste Management, 68: 653-661, 2017.

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谢谢! Thanks !

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