LOCAL GoGREEN

Waste-to-Energy

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ABOUT THE LOCAL GOGREEN PROJECT

Clean Energy Transition process in 6 small European municipalities

8 partners from 7 European countries leading the capacity building, participatory decision-making and collaborative actions for the design and implementation of integrated climate and energy plans.

Aims:
- Provide **technical assistance** to local pilots in a comparable transnational framework
- Improve **synergies among public & private stakeholders** in implementing ICEPs
- **Facilitate the deployment of targeted investments** provided by the European Funds for improved ICEP planning
- Replicate & upscale the integrated measures for CET through **transnational municipal cooperation**
- Enable green & circular climate & inclusive decarbonisation **plans that support sustainable development**

300 stakeholders with increased skills in the area of Clean Energy Transition

90 local and regional authorities committed to accelerate the implementation of ICEPs

5GWh/year of renewable energy generation

1,600tCO2/year CO2 reduction in the 3-year period & 4,500 tCO2/year in the period 5 years after the project

2.94GWh/year of energy savings in the 3-year period & 8.4 GWh/year in the period 5 years after the project

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AGENDA

Part 2: **waste-to-energy**

- Importance of WTE in the clean energy transition
  - Policy and Regulatory Frameworks
  - Overview of Waste-to-Energy Technologies
  - WTE systems: benefits and challenges
  - Environmental Impacts of WTE
  - Uses for organic waste from municipal areas

- Landfill Remediation and Methane Capture
  - Techniques for landfill remediation
  - Methane capture process and its application for electricity generation

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LEARNING OBJECTIVES OF THE TRAINING

After this training you will be able to:

- ➔ Understand main ways how energy can be produced from municipal and organic waste
- ➔ Have an overview of main legislation regulating waste to energy sector
- ➔ Understand environmental impacts connected to producing energy from waste
- ➔ Have an overview of methane capture technologies from landfills

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IMPORTANCE OF WASTE-TO-ENERGY IN THE CLEAN ENERGY TRANSITION

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WASTE-TO-ENERGY & CLEAN ENERGY TRANSITION

Integration into energy systems

- WTE provides energy from non-recyclable waste, helping reduce fossil fuel reliance.

Reduction of greenhouse gas emissions

- WTE lowers methane emissions from landfills and offsets fossil fuel use.

Resource efficiency

- WTE supports a circular economy by recovering energy from waste materials.

Complementary role

- WTE acts as a bridge technology, providing stable energy while renewables develop.

Support to waste management

- WTE aids in managing non-recyclable waste, aligning with sustainability and circularity objectives of the transition.

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RELEVANT POLICIES AND REGULATIONS SUPPORTING WTE

Policy	Connection
European Waste Framework Directive	Establishes the legal framework for waste management within the EU, emphasizing waste reduction, recycling, and the sustainable management of resources. In support of these goals, the directive also plays a crucial role in promoting WTE initiatives.
EU Landfill Directive	Aims to reduce the environmental impact of waste disposal. In parallel with waste reduction efforts, the directive supports WTE initiatives as a key strategy to divert waste from landfills.
Circular Economy Action Plan	Focuses on reducing waste and fostering resource efficiency. In parallel with promoting recycling and reuse, the plan supports WTE as a complementary approach to managing non-recyclable waste.

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RELEVANT POLICIES AND REGULATIONS SUPPORTING WTE

Policy	Connection
Renewable Energy Directive (RED II)	Sets ambitious targets for renewable energy use across member states. In parallel with expanding wind, solar, and other renewable sources, the directive supports WTE as a key component of the renewable energy mix. Also enhances the role of WTE in achieving the EU’s climate and energy goals while reducing dependence on fossil fuels.
EU Green Deal	Sets a comprehensive agenda for climate action and environmental protection. In parallel with initiatives to reduce emissions and enhance energy efficiency, the Green Deal supports WTE as a vital strategy for managing residual waste. Also, contributes to resource recovery, reduces landfill dependency, and helps achieve the EU's ambitious climate and energy
EU Emission Trading System (ETS)	Sets a cap-and-trade framework to incentivize emission reductions. In parallel with limiting carbon emissions, the ETS supports WTE by recognizing it as a means to reduce landfill-related methane emissions and recover energy from waste.

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OVERVIEW OF WASTE-TO-ENERGY TECHNOLOGIES

Technology	Description
Incineration	Burning waste at high temperatures to generate energy.
Gasification	Converts waste into syngas through high-temperature processing.
Pyrolysis	Decomposes organic waste in the absence of oxygen.
Anaerobic Digestion	Breaks down organic waste in an oxygen-free environment.
Landfill Gas Recovery	Captures methane from decomposing waste in landfills.
Plasma Arc Gasification	Uses high-energy plasma to convert waste into syngas.
Refuse-Derived Fuel (RDF)	Converts waste into fuel pellets for combustion.
Hydrothermal Carbonization	Converts wet waste into carbon-rich hydrochar.

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BENEFITS VS CHALLENGES

Technology	Benefits	Challenges
Incineration	Reduces waste volume, generates electricity.	Emissions control, ash disposal.
Gasification	Produces syngas for energy, reduces landfill use.	Complex technology, high capital cost.
Pyrolysis	Produces bio-oil, bio-char, and syngas.	Requires pre-treatment, energy-intensive.
Anaerobic Digestion	Produces biogas, reduces organic waste.	Limited to organic waste, requires management of digestate.
Landfill Gas Recovery	Utilizes methane for energy, reduces greenhouse gases.	Dependent on landfill conditions, potential gas leakage.
Plasma Arc Gasification	High energy output, reduces hazardous waste.	Extremely high operational costs.
Refuse-Derived Fuel (RDF)	Efficient use of non-recyclable waste.	Requires sorting, potential emissions during burning.
Hydrothermal Carbonization	Produces biochar, reduces water content in waste.	Emerging technology, still under development.

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Environmental Impacts of WTE

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ENVIRONMENTAL IMPACTS OF WTE CONVERSION 1

WtE can contribute to a more sustainable energy sector, but careful consideration of the specific technologies and their environmental trade-offs is crucial.

Reduction in Greenhouse Gas Emissions:	WtE technologies generally result in lower greenhouse gas emissions compared to fossil fuels, making them a cleaner alternative for energy production
Pollutant Emissions:	WtE systems can emit various pollutants, including particulate matter, sulfur oxides, nitrogen oxides, hydrogen chloride, hydrocarbons, carbon monoxide, and trace elements like beryllium, cadmium, copper, and lead. These emissions can be higher than those from traditional fossil fuel combustion. Results depend on the composition of waste being used.
Life Cycle Assessment (LCA) Findings:	LCA studies indicate that WtE systems can have both positive and negative environmental impacts. While they often reduce greenhouse gas emissions, they can also contribute to acidification and eutrophication due to the use of chemicals in the waste feedstock

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ENVIRONMENTAL IMPACTS OF WTE CONVERSION 2

Technological Variability:	Different WtE technologies have varying environmental impacts. For instance, anaerobic digestion is considered more environmentally friendly compared to incineration or pyrolysis, which can produce more pollutants and is more energy intensive
Energy Efficiency and Environmental Trade-offs:	High-efficiency WtE plants, such as those integrating torrefaction and plasma gasification, can improve energy output but may also have higher energy demands and associated environmental impacts
Food Waste Conversion:	Converting food waste to energy can avoid the environmental impacts of traditional waste disposal methods like landfilling. However, the high moisture content and variable composition of food waste pose challenges for efficient energy recovery, therefore good planning and pretreatment may be needed.
Municipal Solid Waste (MSW) Management:	Proper management of MSW through WtE technologies can mitigate environmental pollution and public health risks. Gasification is highlighted as an efficient and environmentally friendly method for converting MSW to energy

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USES FOR ORGANIC WASTE FROM MUNICIPAL AREAS

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USING ORGANIC WASTE FROM MUNICIPAL AREAS 1

Municipal organic waste from public areas can be effectively managed and utilized through various methods. Composting and anaerobic digestion are primary methods for recycling and energy production, respectively. Machine learning is enhancing the efficiency of these processes, while bioreactor landfills offer a sustainable alternative for waste stabilization and resource recovery. Valorization of organic waste into useful products further supports a circular economy approach.

Examples of organic waste management options:

Composting as a Primary Method:	Composting is widely recognized as an effective method for treating municipal organic waste, diverting it from landfills and producing valuable compost for agricultural use
Valorization of Organic Waste:	Organic waste, rich in proteins, minerals, and sugars, can be valorized as substrates or raw materials for other processes, such as animal feed or bio-based products

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USING ORGANIC WASTE FROM MUNICIPAL AREAS 2

Anaerobic Digestion for Biogas Production:	Anaerobic digestion (AD) is another common method, converting organic waste into biogas, which can be used as a renewable energy source. This method is particularly relevant in the context of a circular economy and decarbonized energy systems
Machine Learning in Waste Management:	Machine learning models, especially artificial neural networks, are increasingly being applied to optimize the treatment and recycling processes of organic solid waste, improving efficiency and accuracy
Landfilling and Bioreactor Landfills:	While traditional landfilling is still prevalent, bioreactor landfills are emerging as a more sustainable option. These landfills enhance waste stabilization through controlled recirculation of leachate and gases, facilitating resource recovery and environmental protection

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LANDFILL REMEDIATION AND METHANE CAPTURE

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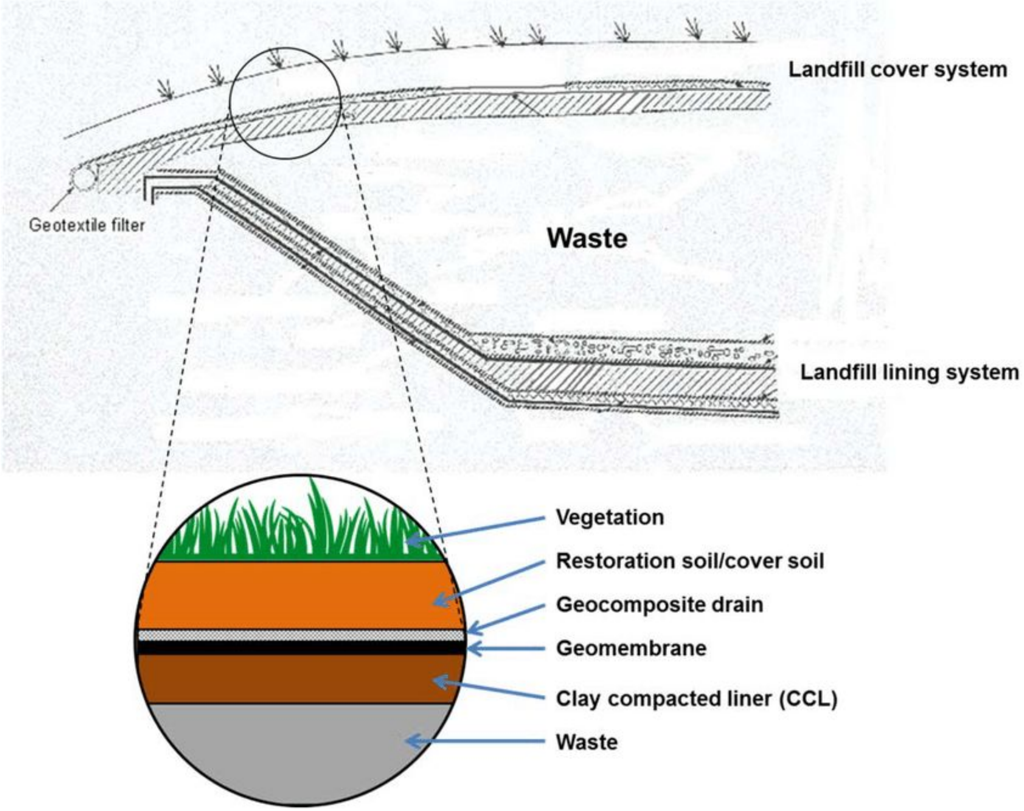
TECHNIQUE: COVER SYSTEMS

Description:
Applying a cover to reduce water infiltration and gas emissions.

Advantages:
Reduces leachate and gas; prevents erosion.

Disadvantages:
Requires maintenance; doesn't remove existing contamination.



https://www.researchgate.net/figure/Landfill-cover-system-after-Zornberg-and-Christopher-2007_fig1_319101837

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TECHNIQUE: LEACHATE COLLECTION AND TREATMENT

Description:

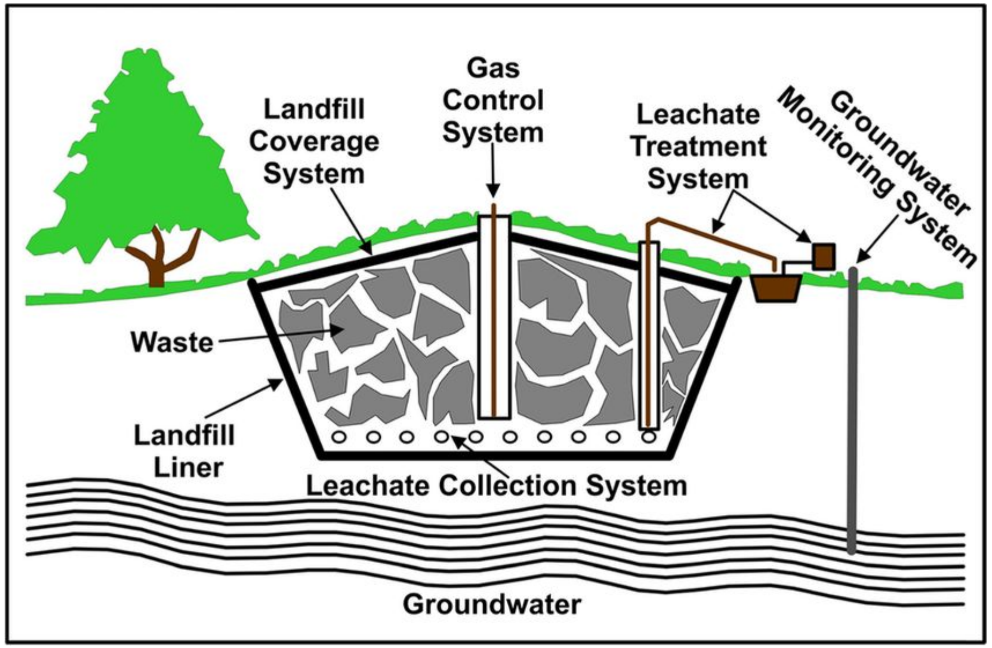
Collecting and treating leachate to prevent groundwater pollution.

Advantages:

Reduces groundwater contamination; can meet discharge standards.

Disadvantages:

Expensive; requires ongoing maintenance.



https://www.researchgate.net/figure/Sanitary-landfill-with-leachate-collection-and-treatment-systems-and-systems-for-gas_fig2_372748670

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TECHNIQUE: GAS COLLECTION AND UTILIZATION

Description:

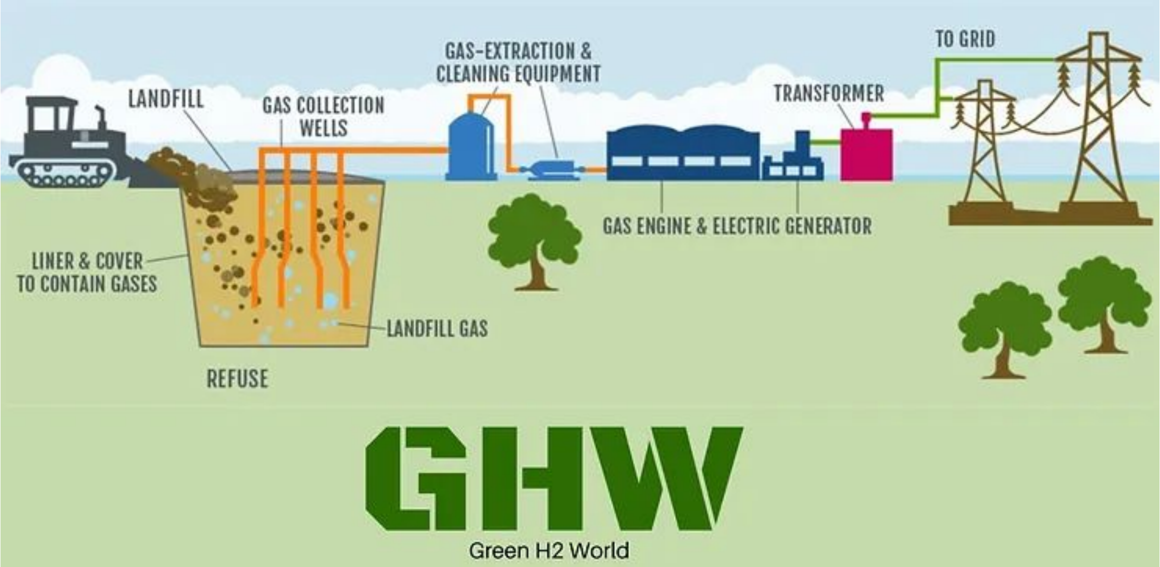
Capturing and using or flaring methane and other gases.

Advantages:

Reduces greenhouse gases; generates energy.

Disadvantages:

Requires infrastructure; efficiency varies.



https://www.greenh2world.com/post/methane-capture-technology

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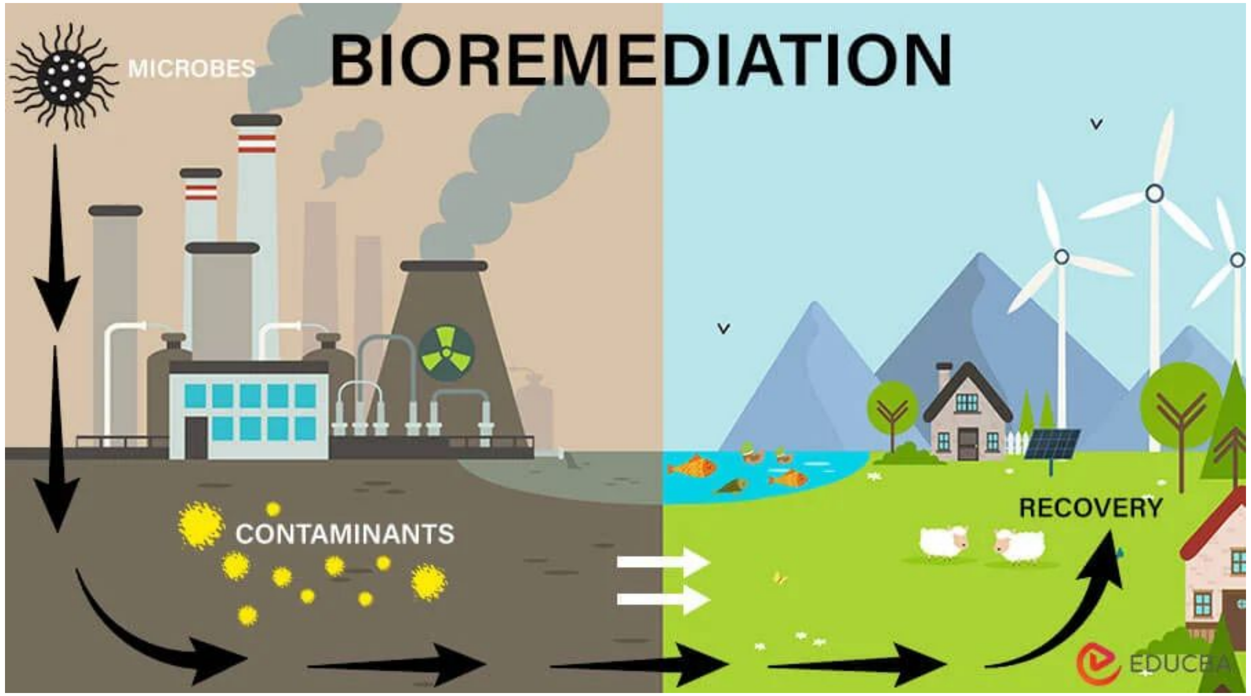
TECHNIQUE: BIOREMEDIATION

Description:
Using microorganisms to degrade organic contaminants.

Advantages:
Cost-effective; reduces contaminants.

Disadvantages:
May be slow; effectiveness varies.



https://www.educba.com/what-is-bioremediation/

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TECHNIQUE: EXCAVATION AND OFF-SITE DISPOSAL

Description:
Removing and transporting landfill contents for treatment or disposal.

Advantages:
Completely removes contaminants; controlled treatment.

Disadvantages:
Very costly; disruptive; needs disposal sites.

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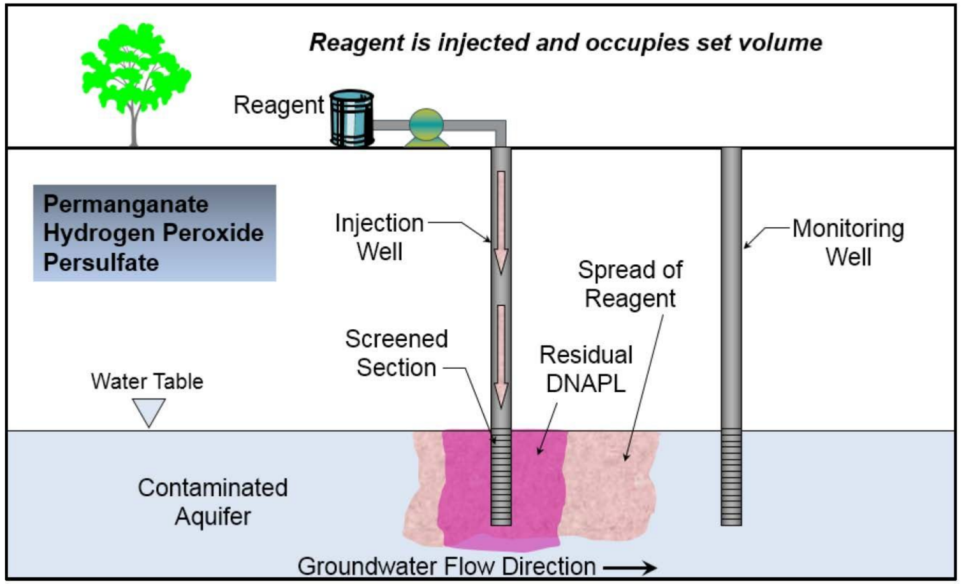
TECHNIQUE: CHEMICAL OXIDATION/REDUCTION

Description:
Injecting chemicals to treat contaminants in the landfill.

Advantages:
Effective for certain contaminants; relatively fast.

Disadvantages:
High cost; incomplete treatment possible.



https://www.frtr.gov/matrix/In-Situ-Chemical-Oxidation/

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METHANE CAPTURE PROCESS

Methane Capture Process - a method to harness methane emissions from landfills and other waste sites for energy production.

These processes focus on capturing methane, a potent greenhouse gas, and converting it into a usable energy source, thereby reducing emissions and providing a renewable energy option.

Aim: to mitigate climate change by reducing methane emissions and generating clean electricity.

Background: methane is produced during the decomposition of organic waste in landfills. Capturing and utilizing this methane can prevent its release into the atmosphere and provide a renewable energy source.

Measures:

- installing gas collection systems
- processing and treating methane
- generating electricity

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METHANE CAPTURE PROCESS AND ITS APPLICATION FOR ELECTRICITY GENERATION

Application for electricity generation:

Environmental benefits: reduces greenhouse gas emissions and displaces fossil fuel use.

Economic benefits: provides a cost-effective energy source and supports local economies through job creation in the installation and maintenance of methane capture systems.

Social benefits: improved air quality, enhanced safety by reducing landfill fire risks, increased community engagement in sustainability efforts, and better respiratory health for nearby residents.

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