Landfill Gas Capture and Utilisation Projects

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Gary CRAWFORD
Vice President
Greenhouse Gas Department

Presentation Topics

- Introduction to Veolia Environmental Services
- Landfill gas capture and utilisation technologies
- Current status of project implementation
  - Developed Countries / Developing Countries (CDM)
- Future development potential
- Measuring CDM project performance
- CDM Project Examples
  - Alexandria, Egypt
  - Tremembe, Brazil
- Conclusions
Veolia Environnement

Veolia Environmental Services

From collection to waste recovery...
Veolia Environmental Services

From collection to waste recovery...
...also industrial outsourcing, cleaning & remediation services

Veolia Environmental Services
Key Figures - 2006

- Annual Revenue: € 7.5 Billion
- Operating in 33 Countries
- 82,700 employees worldwide
- Collected 35 million tonnes of waste
- Treated 58 million tonnes of waste in 698 treatment facilities
- Recovered 7 million tonnes of waste
- 4.2 Million MWh of electricity and 2.5 Million MWh of thermal energy sold
- 4 registered CDM projects (2007); others in the « pipeline »
Veolia Environmental Services, second largest waste management service provider in the world

Veolia Environmental Services manages a total of 698 treatment installations

- 146 non-hazardous waste landfills and 13 hazardous waste landfills
- 102 composting facilities
- 72 non-hazardous waste incinerators and 22 hazardous waste incinerators
- 243 non-hazardous waste sorting/recycling facilities and 32 hazardous waste recycling/recovery facilities
- 11 facilities for soil decontamination
- 57 facilities for physical-chemical treatment of hazardous waste

Greenhouse Gas (GHG) emissions from Veolia Environmental Services’ activities

Veolia Environmental Services’ GHG emissions in lorry CO2eq

- Direct emissions
- Indirect emissions
- Avoided emissions

Share of the different activities in Veolia environmental footprint:

- 54%
- 39%
- 16%
In 2006, Veolia Environmental Services’ avoided emissions represented 23% in volume of its direct emissions (2.55 million tonnes CO₂ eq, the equivalent of the average yearly emissions of 1,050,000 european private cars).

Actions to reduce GhG emissions

- **Collection**
  - Rationalise the collection operations
  - Alternative transportation
  - Alternative fuels

- **Incineration**
  - Increase energy recovery
  - Recovery of ash / slag

- **Landfill**
  - Maximise landfill gas collection
  - Promote landfill gas to energy

- **Recycling**
  - Develop new recycling opportunities
  - Increase recycling rates

- **Composting**
  - Optimisation of aerobic conditions
  - Increase compost production

- **Hazardous Waste**
  - Increase the production of substitute fuels
  - Increase recycling rates
Recovery and Flaring of Methane

Veolia Environmental Services' landfills

Veolia Environmental Services manages 146 non-hazardous waste landfills world-wide

Thermal energy and electricity generated from landfills

- Thermal energy production
- Electricity production
- Number of landfills equipped with landfill gas energy recovery systems (operating and post-closure landfills)
Landfill Methane Emissions

\[ CH_4 \text{ fugitive} = CH_4 \text{ produced} - CH_4 \text{ collected and treated} - CH_4 \text{ oxidised} \]

Components of Landfill Gas Collection System

- Vertical Wells
- Horizontal trenches
- Above-ground header
- Blower / Flare Station
Landfill Gas Utilisation Technologies

The figure presents the various applications for the three grades of fuel that can be produced from raw LFG. It also illustrates the increasing degree of processing that is required to transform the LFG from a low-grade fuel into a more refined fuel source.

**Increasing degree of processing:**
- Moisture removal
- Particulate removal
- CO₂ Separation
- Removal of impurities

**Landfill Gas Utilisation projects**

**VES Examples:**
- **US**: Cranberry Creek Landfill
- **US**: Greentree Landfill
- **France**: REP Energie
- **China**: Xingfeng Landfill
- **Brazil**: SASA Landfill
Landfill Gas Utilisation projects

Site: SASA LANDFILL, Brazil

Technology: Leachate Evaporator

- Treats up to 19m³/day of leachate using LFG as fuel for evaporator

Benefits:

- Developed as a Clean Development Mechanism (CDM) project
- VES’ first registered project and carbon transaction!
- GhG emission reductions estimated at 700,000 tCO2e over 10 years

Reference: Tremembe Landfill, Brazil

Landfill Gas Utilisation projects

Site: CRANBERRY CREEK LANDFILL, USA

Technology: Direct Use

- Partnership between Veolia ES Cranberry Creek Landfill and a nearby Ocean Spray plant
- LFG is compressed, filtered and dried at an onsite compressor station and conveyed from the landfill to the plant through a 2.4 km pipeline.
- Methane gas from this pipeline powers the Ocean Spray’s steam boilers, that energise the cranberry concentrator.

Benefits:

- Greenhouse gas emissions reductions: 6,300 tonnes a year (comparable to the elimination of the CO2 emissions produced from 12,000 automobiles)
- Ocean Spray cut fuel costs by 25%.

Æ In 2006, the site received the « GOLD STAR AWARD » from SWANA (Solid Waste Association of North America)

Reference: Cranberry Creek Landfill, Wisconsin, USA
Landfill Gas Utilisation projects

Site: XINGFENG LANDFILL, China

- Ownership: Guangzhou Government
- Contracts to VES: Landfill design, design coordination and 8 years operation; Separate LFG design, build and operate contract

Technology: Reciprocating Engines

- Two 970 kW reciprocating engines / gensets for electricity production
- Additional modular units to be added as recovered landfill gas increases
- Reciprocating engines use medium grade LFG as fuel. It is necessary to condensate and remove particulates of the landfill gas.

Benefits:

- CDM project being developed for this site
- Reduced greenhouse gas emissions – expected 5 million tCO2e to the end of 2012
- Alleviate electricity shortages

Reference

Xingfeng Landfill, Guangzhou, China

Landfill Gas Utilization projects

Site: REP ENERGIE, France

Technology: Combined Cycle

11 MW
9300 Nm3 LFG / hr recovered

→ In 2005, selected under French Government tender for renewable energy project from Biomass / Biogas to meet EU 2010 target

Since 2006

Total: 25 MW
17 000 Nm3 LFG / hr recovered

Benefits:

- Reduced GHG emissions: 74,000 tonnes CO2e avoided emissions
- Reduced fuel consumption: 16,400 toe saved
- The installed capacity of 25 MW is equivalent to the consumption of 80,000 inhabitants.

Reference

REP Landfill, Claye Souilly, France
**Landfill Gas Utilisation projects**

**Site : Greentree Landfill, USA**

**Technology : Pipeline Quality**
- Conversion of landfill gas (17,000 m³/hr), which is otherwise burned in a flare, into pipeline quality methane gas.
- At the landfill, a processing facility processes and separates the natural gas from the remainder of the landfill gas. This natural gas is then transported by the project’s pipeline to an interstate natural gas pipeline located near the landfill site.

**Benefits :**
- Reduced greenhouse gas emissions
- "Green Energy" to be purchased by electricity producer
- The produced energy (the equivalent of 40 MW of electricity) is enough to satisfy the needs of 45,000 homes.

**Reference**
Greentree Landfill, Pennsylvania, USA

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**Utilisation Selection Factors**

Various technologies exist for the utilisation of LFG. Selection of the best alternative for a specific site is dependent upon a number of factors including:
- projected recoverable LFG;
- presence and location of suitable markets;
- market price for end products;
- environmental and regulatory factors; and
- capital and operating costs of utilisation system options, including processing and transporting issues/costs.

There has been increased development of landfill gas utilisation projects in a number of developed countries thanks to national incentive systems (Feed-in tariffs, green certificates, subsidies...)

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11
Incentives for electricity production from landfill gas in various European Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Price</th>
<th>Incentive system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>73.5 € / MWh (&lt;1.5 MW), 80.5 € / MWh (&gt;3.5 MW)</td>
<td>Feed-in tariff</td>
</tr>
<tr>
<td>Denmark</td>
<td>93 € / MWh</td>
<td>Feed-in tariff</td>
</tr>
<tr>
<td>Finland</td>
<td>31 € / MWh</td>
<td>Feed-in tariff</td>
</tr>
<tr>
<td>Sweden</td>
<td>24 € / MWh (market price) + 10% of the regulated price</td>
<td>Premium + subsidy on investment</td>
</tr>
<tr>
<td>France</td>
<td>Base tariff: 75 to 94 €/MWh, Efficiency premium: 0 to 20 €/MWh</td>
<td>Feed-in tariff for installations &lt; 12 MW</td>
</tr>
<tr>
<td>UK</td>
<td>29 € / MWh (market price) + 56 € / MWh (green certificate) (as of July 2006)</td>
<td>Green certificates</td>
</tr>
<tr>
<td>Italy</td>
<td>46 € / MWh (market price) + 8% to 14 € / MWh (green certificate)</td>
<td>Green certificates</td>
</tr>
<tr>
<td>Czech Republic</td>
<td>Choice between:</td>
<td>Feed-in tariff</td>
</tr>
<tr>
<td></td>
<td>A regulated price of 79.35 € / MWh in the years following the put in operation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Market price + premium: 34.92 € / MWh</td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>495 €/MWh: decentralised, installed capacity &gt; 50 MW</td>
<td>Feed-in tariff</td>
</tr>
<tr>
<td></td>
<td>495 €/MWh: others</td>
<td>Feed-in tariff</td>
</tr>
<tr>
<td>Belgium</td>
<td>Wallonia: market price + bonus + green certificate (until 90 €/MWh)</td>
<td>Feed-in tariff</td>
</tr>
<tr>
<td></td>
<td>Flanders: market price + bonus + green certificate (until 90 €/MWh)</td>
<td>Feed-in tariff</td>
</tr>
<tr>
<td></td>
<td>Green certificates</td>
<td></td>
</tr>
<tr>
<td>Austria</td>
<td>24 € / MWh for installed capacity &lt; 1 MW</td>
<td>Feed-in tariff</td>
</tr>
<tr>
<td></td>
<td>30 € / MWh for installed capacity &gt; 1 MW</td>
<td></td>
</tr>
<tr>
<td>Spain</td>
<td>Choice between:</td>
<td>Feed-in tariff</td>
</tr>
<tr>
<td></td>
<td>40 to 90% of the regulated price or market price</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A premium to be defined (forthcoming decree)</td>
<td></td>
</tr>
</tbody>
</table>

Primary energy production of biogas of the European Union in 2006 (in ktoe)

Europe:
- Energy Production from Landfill Gas:
  - Estimated 6% increase from 2005 to 2006
  - 58% of the Primary Energy from Biogas

- Landfill gas
- Sewage sludge gas
- Other biogases (agricultural waste, etc.)

Red figures show total production

Source: EurObserv'ER 2007
Landfill Gas Energy Projects and Candidate landfills in the US

The Clean Development Mechanism (CDM)

These types of national incentives are not yet available in most developing countries.

However, a different form of incentive that helps the transfer of landfill gas recovery technology into developing countries is the Clean Development Mechanism (CDM).
Status of the Clean Development Mechanism

Sectorial repartition of registered CDM projects

- Energy industries (renewable vs non-renewable sources): 53.0%
- Fugitive emissions from fuels (solid, oil, and gas): 8.2%
- Waste handling and disposal: 20.9%
- Agriculture: 6.6%
- Manufacturing industries: 5.5%
- Chemical industries: 2.3%
- Others: 1.4%

Waste management projects are well represented amongst the registered projects

Status as of 1st April 2008

Status of the CDM in the waste management sector

- Waste related projects in the pipeline by region
  - Asia & Pacific: 61%
  - Latin America: 30%
  - Sub-Saharan Africa: 7%
  - Europe and Central Asia: 1%
  - North Africa & Middle-East: 1%

The « waste related » category includes landfill, composting, gasification and incineration projects (wastewater treatment, manure management projects excluded)

Status as of 1st April 2008
Status of the CDM in the waste management sector

Registered waste related projects - Distribution by type

- Landfill flaring: 42%
- Landfill power: 31%
- Composting: 9%
- Gasification of MSW: 1%

83 (978)

Status as of 1st April 2008

Waste related projects in the pipeline - Distribution by type

- Landfill flaring: 33%
- Composting: 32%
- Landfill power: 31%
- Combustion of MSW: 3%
- Gasification of MSW: 1%

251 (3188)

Status as of 1st April 2008
Global Landfill Methane Emissions

Worldwide methane emissions from landfills are expected to decrease in industrialised countries and increase in developing countries.

- Industrialised countries’ landfill methane emissions are expected to continue to decline because of:
  - expanding recycling-and-reuse programs
  - increased LFG regulation
  - improved LFG recovery technologies

- Developing countries’ landfill methane emissions are expected to increase because of:
  - their rapidly expanding populations
  - Increasing waste production
  - a lack of formal recycling programs
  - a shift away from open dumps to sanitary landfills to improve health conditions.

Evolution of landfilled waste

What is projected for 2020?

<table>
<thead>
<tr>
<th>Year</th>
<th>Landfilled</th>
<th>Incinerated</th>
<th>Recycled</th>
<th>Composted</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2020</td>
<td></td>
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</tr>
</tbody>
</table>

**Global potential for LFG CDM projects**

**Strong case for « additionality »**

**Mexico**
"To date there has been very limited development of LFG projects in Mexico."
"The reason for the lack of widespread LFG collection and combustion systems is that there currently is no economic incentive for capturing and utilising the LFG. In summary, the passive venting method is still a common practice in landfills throughout Mexico."

**Brazil**
"Presently, methane recovery is not mandatory for landfills in Brazil and the cost of capturing the methane and investing in electricity generation is not economically feasible as a baseline scenario. The fact of the majority of the waste in Brazil (83%) is disposal at sites which are not at the level of sanitary landfill."
"Currently, there are no national or sector policies or regulations governing the release of LFG into the atmosphere."

**China**
"Venting LFG directly to the atmosphere is the common practice for landfill management in China. Apart from simple control systems installed for safety reasons to prevent explosions, the overwhelming majority of landfills vent their LFG directly into the atmosphere."
"Currently in China there are regulations in place dealing with the management of landfills and landfill gas. However, due to financial and technology difficulties these activities have not been widely practiced in China."

**Extracts from recently registered projects PDDs**

**From uncontrolled dump sites to environmentally sound landfills**

**Uncontrolled Dumpsites**

**Modern Sanitary Landfills**
Estimating Landfill Methane Emissions

**CDM EB Methodologies and « tool » require that first order decay (FOD) models are used to estimate future methane generation.**

- Assumes optimised microbial kinetics.
- Required input data:
  - Historical and projected waste quantities
  - Waste composition
  - Moisture content
  - ...
- Determine:
  - Methane generation potential (Lo)
  - Kinetic constant (k)
- Assign:
  - Landfill gas capture rate
    - Open and controlled dumpsites (~30-60%)
    - Engineered Sanitary Landfill (~60-90%)

![Landfill gas theoretical production potential](image)

Monitoring CDM Project Emissions

**Issued CERs are based on actual methane destroyed or energy produced.**

- **Monitoring requirements** specified in CDM methodologies for LFG projects have become more and more complex
  - Continuous monitoring of LFG flow, quality, T,P,…
  - Flaring unit – combustion efficiency in addition to the temperature of combustion, hours of operation…

→ Need to ensure proper instrumentation (flowmeters, gauges, emission monitoring) installed and calibrated according to manufacturer’s specifications
→ Install secure data storage system and conduct routine QA / QC
Measuring Performance

One measure of performance for CDM projects is the “CER issuance success rate”:

\[
\text{CER issuance success rate} = \frac{\text{CERs Issued}}{\text{CERs estimated in PDD for the same period}}
\]

As of 1st February, 2008, registered landfill gas projects having reached the issuance step had a “CER issuance success rate” of 37%.

This under-delivery can be attributed to several possible reasons:

• an over-estimation of emission reductions by the FOD model because of:
  – lack of available site specific data (waste quantity and composition, moisture content…)
  – Operational constraints not considered
• technical issues, especially when projects are based on old sites (leachate levels, poor containment systems, inadequate compaction / cover…)
• delays in the installation of required equipment
• Insufficient monitoring equipment / data

→ Still in the early phases of project implementation
→ Need to take into account the level of uncertainty of future CER estimation when entering into negotiation for sales

Alexandria, Egypt -
a Global Waste Management Contract
Example : Alexandria, Egypt

Global waste management and street cleaning

- Contract signed in September 2000 (15 years)
- Service started 1st October 2001
- Collection and treatment of 2600 tonnes (avg.) of waste per day
- Onyx Alexandria serves a population of 4.5 million people

The contract includes the following services:

STREET CLEANING

- Manual and mechanical street sweeping
- Washing of roadways
- Manual and mechanical beach cleaning
- Sanitation /cleaning (monuments, fountains, parks…)
Example: Alexandria, Egypt

The contract includes the following services:

**WASTE MANAGEMENT**

- Collection of household and commercial waste
- Waste transfer

Example: Alexandria, Egypt

The contract includes the following services:

**WASTE MANAGEMENT**

- Waste treatment at 2 new landfills
Example: Alexandria, Egypt

The contract includes the following services:

WASTE MANAGEMENT

- Composting at 3 compost plants

Example: Alexandria, Egypt

Before

After
Example: Alexandria, Egypt

Before

After
Example: Alexandria, Egypt

Global Waste Management Contract

Alexandria has been recognised on an international level for its transformation and cleanliness:

- In 2003, voted the cleanest city of the Arab world
- In 2005, Winner in the « Environment » category of the Metropolis prize (awarded by the UN, WHO and the World Bank)
- In 2006, the Habitat Scroll of Honour of the United Nations was jointly awarded to the Governate of Alexandria and VES

Onyx Alexandria – CDM Project Example
CDM Project - Alexandria, Egypt

Onyx Alexandria
Landfills operated as part of global waste management contract

CDM Project – consists of :
- Upgrade of the landfill gas collection system
- Commissioning of a leachate evaporator (Borg El Arab)
- Potential GhG emission reductions of approx. 3,700,000 t CO₂eq.

Sale of CERs
2005 : Signed ERPA with World Bank for first tranche of CERs (30%)

Site Information
- Start of Operations: 2001
- Expected Closure Date: 2016
- Site Capacity: 13.2 million tonnes
- Quantity of waste received: 4.9 million tonnes
- Annual precipitation: 197 mm
- Waste composition: >70% organic waste, high moisture content
**CDM Project - Alexandria, Egypt**

**CDM Project Cycle**

### Completed Steps

- **2005** - Prepared Project Design Documents; EIA completed by Consultant
- **2005-2006** - Conducted Stakeholder meetings
- **January 2006** - Letter of No Objection received from the Egyptian DNA
- **April 2006** - Validation Completed
- **June / July 2006** - Received Egyptian / Spanish / French DNA LOA
- **August 2006** - Submitted PDD for Registration to the CDM Executive Board
- **15 December 2006** - project registered!

**CDM Project Cycle**

### Implementation

- Leachate evaporator installed at the Borg El Arab landfill; flares and initial phase of collection system have been installed on both sites
- Landfill gas monitoring is on-going
- November-December, 2007 - Upgraded monitoring equipment was installed.
- September, 2007 - Verification process by external Verifier was launched.
- 2nd Quarter, 2008 - Issue first CERs.
Emission Reductions 2006 - 2007

- Project registered on 15 December, 2006.
- Pre-registration ERs
  - 15,396 ERs (of which 5,653 ERs in first 5 months)
- Post-registration CERs
  - 17,824 CERs from 15 Dec. 2006 to 30 Sept. 2007
  - 9,500 CERs estimated for 1 Oct. To 31 Dec. 2008
- Shortfall
  - There will be a shortfall of approximately 102,968 ERs for the first 2 years
- Shortfall of ERs can be attributed to the following:
  - Delay in registration
  - Delay in equipment installation

Planned Upgrades

- Borg El Arab
  - Thirty eight (38) vertical LFG extraction wells to be added to the system (Cells 2, 3A and 3B). The extension includes the necessary piping systems and wellheads to connect to the existing system.
  - Leachate extraction pumps will be installed in a number of wells to remove leachate from the waste mass
Planned Upgrades

- **El Hammam**
  - Forty seven (47) new vertical wells and the corresponding network will be installed (Cells 3 and 4).
  - Leachate extraction pumps will be installed in a number of wells to remove leachate from the waste mass.

CDM Project - Alexandria, Egypt Instrumentation

- Implemented an Automated Extraction Monitoring System (from LANDTEC)
  - Field Server Unit; Field Analytical Unit with Auto-Calibration
  - Continuous monitoring of required parameters
  - All Calibration Records stored within system and available for reporting
  - All incoming data rigorously reviewed for validity
  - Comprehensive reporting for validating CER production.
SASA, Tremembe, Brazil – CDM Project Example

SASA CDM Project

SASA
Landfill owned / operated
North of Sao Paolo, Brazil

CDM Project - Installation of:
- Landfill gas collection system
- Landfill gas-fueled leachate evaporator
- Landfill gas flare equipment

VES’s first carbon transaction!
2001: Responded to Dutch Government tender (CERUPT)
2003: Signed contract for sale of future emission reductions to the Netherlands – 490,000 tonnes of CO₂eq over 10 years

Total estimated Emission Reductions for the project - 700,000 tonnes of CO₂eq over 10 years
SASA CDM Project

Site Information
- Start of Operations: 1996
- Expected Closure Date: 2012
- Site Capacity: 2.6 million tonnes
- Quantity of waste received: 1.5 million tonnes
- Annual precipitation: 1317 mm
- Waste composition:
  - MSW: 22%
  - Ind & Commercial: 61.6%
  - Biological sludge: 1.2%
  - Foundry sand / inert: 15.2%

CDM Project Cycle

2002 - Prepared Project Design Documents
July 2004 - Methodology prepared and submitted in 2003 was approved (AM0011)
November 2004 - Obtained the validation of the DOE
January 2005 - Submission of the project to the Brazilian Designated National Authority (DNA)
July 2005 - Letter of Approval (LOA) received from the Brazilian DNA
September 2005 – Received French LOA
September 2005 - Submitted project to the CDM Executive Board for registration
Project registered on 27 November, 2005!
SASA CDM Project

CDM Project Cycle

- Implementation
- Monitoring
- Verification
- Issue CERs

- Leachate evaporator / flare have been installed; landfill gas collection equipment installed as landfilling progresses
- Monitoring on-going
- March, 2007 – Issued first CERs!
- Working on 2006 & 2007 Verifications

- Enabled us to participate in the development of « the rules of the game »
- Created in-house expertise in emission reduction project development

SASA CER Production

SASA - CER PRODUCTION 2003-2005

- ERPA signed with Dutch Government; Annual amounts at 70% of estimation in PDD
- 10% reduction was required for 2003-2005 CERs for insufficient number of flare emission analysis
- Monitoring report for 2006 – estimated 46,300 CERs (not yet issued)
**Benefits of CDM projects**

The benefits of CDM projects in terms of Sustainable Development:

- Reduced GHG emissions
- Continuous improvement - environmental controls
- Transfer of technology
- Beneficial use of renewable energy source
- Reinforced local participation
- Technical training of on-site staff

Veolia Environmental Services has developed four registered projects. The group has other on-going projects, under preparation or being evaluated:

- Projects in South America, in partnership with VE subsidiary Proactiva.
- In Asia and in Africa / Middle East for the CDM.
- In Eastern Europe for the Joint Implementation.

**Conclusion**

- Landfill gas recovery and utilisation technologies are proven and reliable.
- There will be continued development of landfill gas to energy projects in developed countries as a result of renewable energy incentives.
- There is a significant potential to transfer these technologies into developing countries under the CDM.
- Continued efforts are needed to adapt the landfill gas modelling, system design and operations to developing country conditions.
- The supplemental revenue generated by the sale of emission credits can contribute to the development of environmentally sound waste treatment facilities in developing countries and other sustainable development benefits.
Thank you for your attention!