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X-150 RNG

Renewable Natural Gas from Waste

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Executive Summary

The X-150 RNG configuration produces renewable natural gas (biomethane) from organic waste through gasification and methanation. This system creates pipeline-quality gas compatible with existing natural gas infrastructure, providing a drop-in renewable fuel for heating, transportation, and industrial applications.

Key Benefits:

- **30-40 Nm^3/h biomethane production** per 150 kg/h unit
- **60-70% methane conversion efficiency**
- **240,000 Nm^3 annual RNG** (8,000 operating hours)
- **€0.30-0.45/Nm^3 production cost**
- **Negative carbon intensity** with waste diversion credits

Technology Overview

Process Flow

The X-150 RNG system produces renewable natural gas through four integrated stages:

Stage 1: Syngas Production
Organic waste undergoes gasification at 800-1000°C, producing synthesis gas (syngas) composed of hydrogen (H_2), carbon monoxide (CO), and carbon dioxide (CO_2). The gasification process is optimized for maximum gas yield while minimizing tar formation.

Stage 2: Catalytic Methanation
Syngas reacts over nickel-based catalysts at 300-400°C to form methane through the Sabatier reaction: $CO + 3H_2 \rightarrow CH_4 + H_2O$ and $CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$. The exothermic methanation process converts syngas into methane-rich gas with 60-75% CH_4 content.

Stage 3: Gas Upgrading
The methane-rich gas undergoes CO_2 removal through pressure swing adsorption (PSA), membrane separation, or amine scrubbing to achieve pipeline-quality biomethane (>95% CH_4). Trace contaminants including H_2S, siloxanes, and moisture are removed to meet natural gas grid injection standards.

Stage 4: Compression & Injection
Upgraded biomethane is compressed to pipeline pressure (4-70 bar depending on grid requirements) and odorized with mercaptans for safety. The gas can be injected into natural gas grids, compressed for vehicle fuel (CNG), or liquefied for transportation (LNG).

Technical Specifications

Performance Parameters

Parameter	Specification
Biomethane Production (per 150 kg/h unit)	30-40 Nm^3/h
Methane Content	> 95% CH_4 (pipeline quality)
Production Efficiency	60-70% (LHV basis)
Annual RNG Production (8,000h)	240,000 Nm^3/year
Heating Value	9.5-10.5 kWh/Nm^3
Delivery Pressure	4-70 bar (grid-dependent)
Start-up Time	< 3 hours
Availability	> 90%
Carbon Intensity	-50 to -100 gCO_2e/MJ

Gas Quality Compliance

Meets international biomethane standards:

- **EN 16723**: European biomethane quality standard
- **ISO 23500**: Biomethane for transport and injection
- **Methane content**: > 95%
- **Oxygen**: < 0.5%
- **CO_2**: < 2%
- **H_2S**: < 5 mg/Nm^3
- **Total sulfur**: < 30 mg/Nm^3
- **Water dew point**: < -8°C at 70 bar

Target Applications

Natural Gas Grid Injection

Problem Solved: Natural gas grids need renewable gas sources to decarbonize heating and industrial sectors. Conventional biogas from anaerobic digestion is limited by feedstock availability and requires expensive upgrading.

Solution: Waste-to-RNG systems produce pipeline-quality biomethane from diverse organic waste streams. Grid injection creates immediate value by displacing fossil natural gas while managing waste disposal challenges.

Economic Impact: A facility producing 240,000 Nm^3/year of RNG generates €120,000-180,000 in gas sales revenue (€0.50-0.75/Nm^3 grid price) plus €24,000-72,000 in waste tipping fees, while avoiding 480 tonnes CO_2 annually.

Compressed Natural Gas (CNG) Vehicle Fuel

Problem Solved: Fleet operators (buses, trucks, waste collection vehicles) seeking to reduce emissions and fuel costs face limited renewable fuel options. Conventional CNG from fossil sources offers lower emissions than diesel but is not renewable.

Solution: Waste-to-RNG provides renewable CNG for vehicle fleets, achieving 80-90% CO_2 reduction compared to diesel. On-site production from municipal or commercial waste creates fuel self-sufficiency and price stability.

Economic Impact: A waste collection fleet consuming 100,000 Nm^3 CNG annually can save €30,000-60,000 in fuel costs (vs. diesel equivalent) while eliminating €50,000-150,000 in waste disposal fees by fueling vehicles with collected organic waste.

Industrial Natural Gas Replacement

Problem Solved: Industries using natural gas for process heat, steam generation, or chemical feedstock face volatile fossil fuel prices and increasing carbon costs.

Solution: On-site waste-to-RNG systems convert industrial organic waste into renewable natural gas for immediate use in existing boilers, furnaces, and processes. This eliminates natural gas purchases while managing waste streams.

Economic Impact: A food processor using 500,000 Nm^3 natural gas annually can save €250,000-375,000 in fuel costs while eliminating €60,000-180,000 in waste disposal fees, achieving 2-4 year payback periods.

Economic Analysis

Cost Structure

Levelized Cost of RNG (LCOR): €0.30-0.45/Nm^3

Cost Component	Value
Capital Expenditure (CAPEX)	€1,400,000 - 2,100,000 per unit
Installation & Commissioning	15-20% of equipment cost
Annual Operating Costs (OPEX)	€60,000 - 90,000 per unit
Maintenance	€25,000 - 35,000 per year
Consumables (catalysts, adsorbents)	€18,000 - 28,000 per year
Labor (0.5 FTE per unit)	€25,000 - 35,000 per year
Compression Energy	€12,000 - 20,000 per year

Revenue Streams

Primary Revenue:

- **RNG Sales**: €120,000-180,000/year per unit (240,000 Nm^3 at €0.50-0.75/Nm^3)
- **Tipping Fees**: €24,000-72,000/year (1,200 tonnes at €20-60/tonne)
- **Renewable Gas Certificates**: €24,000-48,000/year (varies by market)

Secondary Revenue:

- **Carbon Credits** (negative emissions): €12,000-24,000/year
- **Biochar Sales**: €24,000-48,000/year (120 tonnes at €200-400/tonne)
- **Waste Heat Utilization**: €5,000-10,000/year

Total Annual Revenue: €209,000 - 382,000 per unit

Simple Payback Period: 4-6 years (depending on local gas prices and incentives)

Environmental Impact

Carbon Intensity

The X-150 RNG system achieves **negative carbon intensity** of -50 to -100 gCO_2e/MJ when accounting for:

- **Biogenic carbon neutrality**: Organic waste feedstock is carbon-neutral
- **Waste diversion credit**: Avoiding landfill methane emissions (100 tonnes CO_2e/year)
- **Fossil fuel displacement**: Replacing fossil natural gas (56 gCO_2e/MJ)

This makes waste-derived RNG one of the lowest-carbon fuel pathways available, superior to conventional biogas from anaerobic digestion.

Comparison with Natural Gas Sources

Gas Source	Carbon Intensity	Cost
Fossil Natural Gas	56 gCO_2e/MJ	€0.40-0.60/Nm^3
Biogas (anaerobic digestion)	20-40 gCO_2e/MJ	€0.50-0.80/Nm^3
Synthetic Natural Gas (power-to-gas)	0-20 gCO_2e/MJ	€0.80-1.20/Nm^3
X-150 RNG (waste gasification)	**-50 to -100 gCO_2e/MJ**	**€0.30-0.45/Nm^3**

Fossil Fuel Displacement

Annual fossil natural gas displacement of **240,000 Nm^3** per unit, equivalent to:

- Heating for 120-150 residential households
- Fuel for 40-50 CNG vehicles
- 480 tonnes CO_2 emissions avoided

- €96,000-144,000 in fossil fuel imports avoided

Case Studies

Municipal Waste-to-Grid - Zittau, Germany

Project: Municipal organic waste to natural gas grid injection
Capacity: 2x X-150 RNG units (80 Nm^3/h total)
Feedstock: Source-separated municipal organic waste
Results:

- 480,000 Nm^3 annual biomethane production
- €300,000 annual gas sales revenue (€0.625/Nm^3)
- €60,000 annual waste tipping fee revenue
- €48,000 annual renewable gas certificate revenue
- 960 tonnes CO_2 avoided annually
- 4.2-year payback period

Fleet Fueling - Togo Waste Management

Project: Waste collection fleet fueling with waste-derived CNG
Capacity: 3x X-150 RNG units (120 Nm^3/h total)
Feedstock: Municipal organic waste collected by fleet
Results:

- 720,000 Nm^3 annual biomethane production
- €216,000 annual fuel cost savings (vs. diesel equivalent)
- €120,000 annual waste tipping fee revenue
- 30-vehicle waste collection fleet powered by collected waste
- Closed-loop waste management system
- 3.8-year payback period

Installation & Commissioning

Site Requirements

Footprint: 220-300 m^2 per unit (including feedstock storage, methanation reactor, upgrading, compression)

Utilities:

- Electrical connection: 400V 3-phase, 30 kW (compression, auxiliary systems)
- Water supply: 2-3 m^3/day (cooling, steam generation)
- Gas grid connection: Pipeline access for injection (if applicable)

Safety:

- Gas detection and ventilation systems
- Emergency shutdown systems
- Explosion-proof electrical equipment in classified zones
- Odorization system for safety compliance

Environmental:

- Emissions compliance: EU IED 2010/75/EU
- Noise: < 65 dB(A) at 10m distance (compressor)
- Gas quality monitoring and reporting

Timeline

Phase	Duration
Site Preparation	4-6 weeks
Equipment Delivery	14-18 weeks (from order)
Installation	7-9 weeks
Commissioning	3-4 weeks
Gas Quality Certification	2-3 weeks
Total Project Duration	8-10 months

Grid Injection & Distribution

Grid Connection Requirements

Technical Requirements:

- Gas quality per EN 16723 or local grid codes
- Pressure regulation to match grid pressure
- Odorization with mercaptans (typically 10-30 mg/Nm^3)
- Flow metering and data reporting
- Safety shut-off valves and overpressure protection

Regulatory Requirements:

- Grid connection agreement with gas network operator
- Gas quality certification and ongoing monitoring
- Renewable gas certificate registration
- Compliance with national gas regulations

Alternative Distribution

For locations without grid access:

Compressed Gas (CNG):

- Compression to 200-250 bar
- Storage in high-pressure cylinders
- Distribution via tube trailers or on-site vehicle fueling

Liquefied Gas (LNG):

- Cryogenic liquefaction to -162°C
- Storage in insulated tanks
- Distribution via LNG tankers for long-distance transport

Regulatory & Certification

Compliance Standards

- **Gas Quality**: EN 16723, ISO 23500
- **Pressure Equipment**: EN 13445 (pressure vessels), PED 2014/68/EU
- **Gas Safety**: EN 1918 (gas supply systems)
- **Emissions**: EU Industrial Emissions Directive (IED) 2010/75/EU

Renewable Gas Qualification

The X-150 RNG system qualifies for renewable gas incentives:

- **EU Renewable Energy Directive (RED II)**: Renewable gas from waste
- **Guarantees of Origin (GO)**: Tradeable certificates for renewable gas
- **Renewable Gas Obligations**: Compliance with national renewable gas mandates
- **Carbon Credits**: Negative emissions eligible for premium carbon credits

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Service & Support

Maintenance Program

Preventive Maintenance Schedule:

- **Daily**: Automated monitoring, gas quality testing
- **Weekly**: Visual inspections, ash removal, condensate drainage
- **Monthly**: Methanation catalyst activity monitoring
- **Every 3,000 hours**: Catalyst regeneration, upgrading system maintenance
- **Annual**: Comprehensive system overhaul, pressure vessel inspection, gas quality recertification

Service Packages:

- **Basic**: Remote monitoring, spare parts supply, technical support
- **Standard**: Basic + annual on-site maintenance visit + gas quality testing
- **Premium**: Standard + guaranteed uptime (>90%), emergency response (<48h), catalyst management, grid compliance support

Performance Monitoring

Real-time dashboard tracks:

- Biomethane production rate and quality
- Methane yield and conversion efficiency
- Grid injection flow and pressure
- Energy cost savings vs. fossil natural gas baseline
- CO_2 avoidance and renewable gas certificate generation

Next Steps

Project Development Process

1. **Feasibility Assessment** (2-4 weeks)
    - Gas demand analysis and offtake agreements
    - Waste characterization and availability
    - Grid connection assessment (if applicable)
    - Preliminary economic modeling
2. **Proposal & Engineering** (4-6 weeks)
    - Detailed system design and grid integration
    - Financial modeling and project economics
    - Permitting strategy (gas production, emissions, grid connection)
    - Formal proposal and contract negotiation
3. **Project Execution** (8-10 months)
    - Equipment manufacturing and testing
    - Site preparation and grid connection
    - Installation and commissioning
    - Gas quality certification and grid approval
    - Performance testing and handover

Contact Information

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Regional Partners:

- **Asia Pacific**: Life PTMA (Indonesia), Akira Asai Corporation (Japan)

- **South Asia**: Tata Power (India)
- **Europe**: Equation Labs (Spain)
- **Africa**: GIZ partnerships across 6 countries

Appendix: Technical Diagrams

System Schematic

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[Waste Feedstock] → [Gasifier] → [Methanation] → [CO₂ Removal] →
[Compression] → [Grid Injection/CNG]
                          ↓              ↓               ↓
                    [Biochar]    [Waste Heat]    [CO₂ Capture]
```

Energy Balance

Input: 150 kg/h organic waste (4.5 MWh/day LHV)

Output:

- Biomethane: 720 Nm^3/day (7.2 MWh LHV, 160% efficiency on gas basis)
- Biochar: 15 kg/h (carbon sequestration)
- Waste heat: 1.5 MWh/day (available for utilization)

Note: Efficiency >100% on gas basis due to hydrogen addition in methanation process

Losses: 25-30% (stack losses, compression energy, heat rejection)

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