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X-150 CHILL

Cooling Systems from Waste

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Executive Summary

The X-150 CHILL configuration transforms organic waste into cooling power using absorption chiller technology. By converting waste-derived heat into refrigeration, this system provides air conditioning and industrial cooling without electricity

consumption, creating a unique solution for tropical climates and facilities with high cooling demands.

Key Benefits:

- **100-150 kWth cooling capacity** per 150 kg/h unit
- **COP 0.7-0.8** (Coefficient of Performance)
- **900 MWh annual cooling** (8,000 operating hours)
- **€0.04-0.06/kWh levelized cost** of cooling
- **200 tonnes CO_2 avoided annually** vs. electric chillers

Technology Overview

Process Flow

The X-150 CHILL system delivers cooling through thermally-driven absorption chiller technology:

Stage 1: Heat Generation
Organic waste undergoes gasification, producing high-temperature thermal energy. This waste-derived heat replaces the natural gas or steam typically required to drive absorption chillers, creating cooling from waste instead of consuming fossil fuels.

Stage 2: Absorption Chilling
The thermal energy drives a lithium bromide ($LiBr$-H_2O) absorption chiller. Heat input to the generator evaporates refrigerant from the absorbent solution. The refrigerant vapor condenses in the condenser, then evaporates in the evaporator to produce cooling effect. The cycle operates without mechanical compression, using only thermal energy and small circulation pumps.

Stage 3: Cooling Distribution
Chilled water (7-12°C) circulates to air handling units, fan coil units, or process cooling applications. The system integrates with existing HVAC infrastructure or new installations, providing cooling for buildings, industrial processes, or cold storage facilities.

Technical Specifications

Performance Parameters

Parameter	Specification
Cooling Capacity (per 150 kg/h unit)	100-150 kWth
Coefficient of Performance (COP)	0.7-0.8
Chilled Water Supply Temperature	7-12°C
Chilled Water Return Temperature	12-17°C
Cooling Water Temperature	27-32°C
Annual Cooling Production (8,000h)	900 MWh/year
Part Load Performance	30-100% capacity
Start-up Time	< 3 hours
Availability	> 90%

System Components

Absorption Chiller:

- Technology: Single-effect LiBr-H_2O
- Heat input temperature: 80-95°C
- Cooling capacity: 100-150 kWth
- Electrical consumption: < 5 kW (pumps only)

Heat Generation:

- X-150 gasification unit with heat recovery
- Hot water circuit: 85-95°C supply
- Heat output: 150-200 kWth

Cooling Distribution:

- Chilled water flow rate: 15-25 m^3/h
- Distribution pumps: Variable speed drives
- Buffer tank: 2-5 m^3 capacity

Target Applications

Tropical Climate Air Conditioning

Problem Solved: High electricity costs (€0.15-0.25/kWh) and unreliable grid supply make conventional air conditioning expensive in tropical regions. Peak cooling demand coincides with peak electricity prices.

Solution: Waste-to-cooling systems provide air conditioning for hotels, hospitals, commercial buildings, and industrial facilities using locally available organic waste. Zero electricity consumption for cooling generation reduces operating costs by 60-80%.

Economic Impact: A 500 kWth cooling installation serving a hotel or hospital can save €60,000-120,000 annually in electricity costs while processing 30-50 tonnes/day of organic waste. Combined with waste disposal savings of €20,000-60,000, total annual savings reach €80,000-180,000.

Food Processing & Cold Storage

Problem Solved: Food processors and cold storage facilities consume massive amounts of electricity for refrigeration (30-50% of total energy use) while generating organic waste that requires disposal.

Solution: On-site waste-to-cooling systems convert food processing waste into refrigeration for cold storage, blast freezing, or process cooling. This closes the loop by using waste from food processing to power the refrigeration needed for food preservation.

Economic Impact: A food processing facility with 300 kWth cooling demand can save €40,000-80,000 annually in electricity costs while eliminating €30,000-70,000 in waste disposal fees. The system pays for itself in 3-5 years while improving sustainability credentials.

Data Centers & Server Cooling

Problem Solved: Data centers require $^{24}/_{7}$ cooling and generate significant heat loads. Cooling typically represents 30-40% of total data center energy consumption.

Solution: Waste-to-cooling systems provide baseload cooling using organic waste from nearby sources (municipal waste, agricultural operations, food processors). This reduces electricity consumption and improves Power Usage Effectiveness (PUE) metrics.

Economic Impact: A 200 kWth cooling installation can reduce data center electricity costs by €30,000-60,000 annually while improving PUE from 1.8-2.0 to 1.4-1.6, enhancing competitiveness and sustainability ratings.

Economic Analysis

Cost Structure

Levelized Cost of Cooling (LCOC): €0.04-0.06/kWh

Cost Component	Value
Capital Expenditure (CAPEX)	€900,000 - 1,300,000 per unit
Installation & Commissioning	15-20% of equipment cost
Annual Operating Costs (OPEX)	€35,000 - 50,000 per unit
Maintenance	€15,000 - 22,000 per year
Consumables	€8,000 - 12,000 per year
Labor (0.5 FTE per unit)	€25,000 - 35,000 per year

Revenue Streams

Primary Revenue:

- **Cooling Savings**: €54,000/year per unit (900 MWh at €0.06/kWh electricity equivalent)
- **Tipping Fees**: €24,000-72,000/year (1,200 tonnes at €20-60/tonne)
- **Demand Charge Reduction**: €10,000-20,000/year (reduced peak electricity demand)

Secondary Revenue:

- **Carbon Credits**: €5,000-10,000/year (200 tonnes CO_2 at €25-50/tonne)
- **Biochar Sales**: €24,000-48,000/year (120 tonnes at €200-400/tonne)
- **Renewable Cooling Certificates**: €2,000-5,000/year (emerging markets)

Total Annual Revenue: €119,000 - 209,000 per unit

Simple Payback Period: 4-6 years (depending on local electricity prices and cooling demand)

Environmental Impact

Carbon Footprint Reduction

Each X-150 CHILL unit operating 8,000 hours annually avoids **200 tonnes of CO_2 equivalent emissions** compared to electric compression chillers. This calculation assumes:

- Grid electricity carbon intensity: 500 gCO_2/kWh
- Electric chiller COP: 3.5 (typical for tropical climates)
- Waste diversion from landfill: 100 tonnes CO_2e avoided

Electricity Demand Reduction

Annual electricity savings of **260 MWh** per unit (assuming electric chiller COP of 3.5), reducing grid demand and enabling renewable energy integration. This is equivalent to the annual electricity consumption of 50-70 residential households.

Refrigerant Impact

Absorption chillers use water as refrigerant (zero Global Warming Potential, zero Ozone Depletion Potential) instead of synthetic refrigerants like R-134a or R-410A. This eliminates refrigerant leakage emissions and compliance issues with F-gas regulations.

Case Studies

Resort Hotel - Canary Islands

Project: Waste-to-cooling for 200-room resort hotel
Capacity: 2x X-150 CHILL units (300 kWth total)
Feedstock: Hotel food waste + landscaping residues
Results:

- 1,800 MWh annual cooling generation
- €108,000 annual electricity cost savings
- €40,000 annual waste disposal savings
- 400 tonnes CO_2 avoided annually
- Improved sustainability marketing and guest satisfaction
- 4.5-year payback period

Food Processing Facility - Indonesia

Project: Process cooling and cold storage for fruit processing
Capacity: 3x X-150 CHILL units (450 kWth total)
Feedstock: Fruit processing waste (peels, seeds, pulp)
Results:

- 2,700 MWh annual cooling generation
- €162,000 annual electricity cost savings
- €90,000 annual waste disposal savings
- 600 tonnes CO_2 avoided annually
- Closed-loop sustainability system

- 3.8-year payback period

Installation & Commissioning

Site Requirements

Footprint: 180-250 m^2 per unit (including feedstock storage, absorption chiller, cooling towers)

Utilities:

- Electrical connection: 400V 3-phase, 10 kW auxiliary power (pumps, controls)
- Water supply: 2-3 m^3/day for cooling tower makeup
- Cooling water circuit: Open or closed loop with cooling tower

Environmental:

- Emissions compliance: EU IED 2010/75/EU or local equivalents
- Noise: < 65 dB(A) at 10m distance (cooling tower fans)
- Safety clearances: 5m perimeter for maintenance access

Timeline

Phase	Duration
Site Preparation	4-6 weeks
Equipment Delivery	14-18 weeks (from order)
Installation	6-8 weeks
Commissioning	2-3 weeks
Performance Testing	1-2 weeks
Total Project Duration	7-9 months

Integration with Existing HVAC

Retrofit Scenarios

The X-150 CHILL integrates with existing cooling systems:

Baseload Cooling: Handle constant cooling demand, with electric chillers for peaks **Full Replacement**: Replace electric chillers entirely (requires adequate waste feedstock) **Hybrid Operation**: Combine with electric chillers for optimal efficiency and redundancy

Integration requires:

- Chilled water piping connections to existing distribution
- Control system interface with building management system (BMS)
- Cooling tower or heat rejection system (may use existing infrastructure)

Load Matching

Absorption chillers perform best at steady loads. For variable cooling demands:

- **Thermal Storage**: Chilled water or ice storage tanks buffer load variations
- **Multiple Units**: Staged operation of multiple smaller units matches load profiles
- **Hybrid Systems**: Electric chillers handle variable loads, absorption provides baseload

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Comparison with Electric Chillers

Operating Cost Comparison (per MWh cooling)

System Type	Energy Cost	Maintenance	Total Cost
Electric Chiller (COP 3.5)	€43	€5	€48/MWh
X-150 CHILL (waste feedstock)	€0	€12	€12/MWh
Cost Savings	€43	-€7	**€36/MWh**

Assumes €0.15/kWh electricity, zero-cost waste feedstock, higher maintenance for thermal system

Capital Cost Comparison

- **Electric Chiller**: €300-400/kWth installed
- **X-150 CHILL**: €800-1,000/kWth installed

Higher capital cost is offset by:

- Zero fuel cost (vs. electricity purchase)
- Waste disposal revenue/savings
- Carbon credit revenue
- Longer equipment life (20+ years vs. 15 years for electric chillers)

Regulatory & Certification

Compliance Standards

- **Emissions**: EU Industrial Emissions Directive (IED) 2010/75/EU
- **Pressure Equipment**: EN 13445 (pressure vessels), ASME standards
- **Refrigeration Safety**: EN 378 (refrigerating systems safety)
- **Machinery Safety**: EN ISO 12100 (machinery safety)

Renewable Cooling Qualification

The X-150 CHILL system qualifies for emerging renewable cooling incentives:

- **EU Renewable Energy Directive (RED II)**: Waste-derived cooling from non-fossil sources
- **Green Building Certifications**: LEED, BREEAM credits for renewable cooling
- **Carbon Credits**: Voluntary carbon market credits for emissions reduction
- **Sustainable Development Goals (SDGs)**: Alignment with SDG 7, 11, 12, 13

Service & Support

Maintenance Program

Preventive Maintenance Schedule:

- **Daily**: Automated monitoring, visual inspections
- **Weekly**: Water treatment checks, ash removal from gasifier
- **Monthly**: Absorption chiller solution analysis
- **Every 2,000 hours**: Heat exchanger cleaning, filter replacement
- **Annual**: Comprehensive system overhaul, crystallization prevention service

Service Packages:

- **Basic**: Remote monitoring, spare parts supply, technical support
- **Standard**: Basic + annual on-site maintenance visit
- **Premium**: Standard + guaranteed uptime (>90%), emergency response (<48h), solution replacement

Performance Optimization

Advanced monitoring tracks:

- Cooling output and COP
- Solution concentration and crystallization risk

- Heat input efficiency
- Energy cost savings vs. electric baseline
- Predictive maintenance alerts

Next Steps

Project Development Process

1. **Feasibility Assessment** (2-4 weeks)
    - Cooling load profiling and load duration analysis
    - Waste characterization and availability
    - Site evaluation and HVAC integration assessment
    - Preliminary economic modeling
2. **Proposal & Engineering** (4-6 weeks)
    - Detailed cooling system design
    - HVAC integration engineering
    - Financial modeling and project economics
    - Permitting strategy and timeline
3. **Project Execution** (7-9 months)
    - Equipment manufacturing and testing
    - Site preparation and civil works
    - Installation and commissioning
    - 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] → [Heat Recovery] → [Absorption Chiller] →
[Chilled Water Distribution]
                            ↓                                ↓
↓
                    [Biochar Output]              [Cooling Tower]
[Air Conditioning]

[Process Cooling]

[Cold Storage]
```

Energy Balance

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

Output:

- Cooling energy: 2.7 MWh/day (COP 0.75)
- Heat input to chiller: 3.6 MWh/day
- Biochar: 15 kg/h

Losses: 15-20% (stack losses, heat rejection to cooling tower)

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