BREAKBULK NEXTWAVE EDUCATION DAY

TEXAS A&M UNIVERSITY GALVESTON CAMPUS®

HOUSTON MARITIME Center & Museum

SAN JACINTO COLLEGE

BACHELOR OF APPLIED TECHNOLOGY - LOGISTICS & SUPPLY CHAIN MANAGEMENT

From Wastewater to Resource:
AI-Enabled Mechanical Vapor Recompression and Nitrogen Recovery for Affordable Clean Energy

CHALLENGE & RESEARCH

Industrial Wastewater Challenges

- High energy consumption
- Continuous greenhouse gas emissions
- Rising wastewater treatment costs
- Loss of valuable nitrogen resources
- Equipment transportation and logistics challenges

Research Challenges

- Energy-intensive ammonia removal
- Volatile utility and chemical costs
- Integration of MVR, membrane, AI, and hydrogen technologies
- High capital and scaling costs
- Resource variability
- Renewable energy intermittency
- Pilot-to-industrial scale implementation
- Environmental and lifecycle assessment requirements

Key Problem

Valuable nitrogen is lost when treatment stops at removal instead of resource recovery.

Proposed Research Statement

Develop an integrated circular eco system that converts nitrogen-rich industrial wastewater into:

- **Clean Energy**
- **Green Fertilizer**
- **Reusable Water**

The system combines AI, MVR technology, membrane systems, renewable energy, and hydrogen production to create a scalable and sustainable industrial solution.

SOLUTION & PROCESS

MVR + Ammonia Distillation Process

Reject Water	MVR	Distillation	Product
High-Nitrogen Side Streame	Evaporate & Reuse Heat	Separate Ammonia	Ammonia Water

Key Performance Metrics

5-30%
Reject water remaining after evaporation

~80°C
Operating temperature reported in case studies

16% N
Ammonia-water product concentration

Recovery Outcome

Recovered nitrogen becomes a usable ammonia product instead of only a treatment liability

Conclusion:

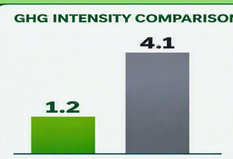
Mechanical Vapor Recompression (MVR) and nitrogen recovery technologies turn industrial wastewater into clean energy, reusable water, and valuable fertilizer products. By minimizing energy consumption, greenhouse gas emissions, costs, and waste, this innovative approach moves industries closer to a near-zero carbon footprint, strengthens the circular economy, and helps secure a cleaner, more sustainable and affordable future for generations to come.

IMPACT, AI & FUTURE APPLICATIONS

Future Research Areas

- **AI-Driven Energy Optimization**
- **Ammonia-to-Hydrogen Conversion**
- **Modular Transportable MVR Systems**
- **Renewable Energy Integration**
- **Lifecycle Carbon Analysis**
- **Port and Industrial Applications**

SUSTAINABLE IMPACT



ENVIRONMENTAL BENEFIT

1,135
Metric Tons CO_2e / year reduction estimated at **Bryan WWTP**

Expected Benefits

- **20-50% Lower Energy Consumption**
- **Reduced Treatment Costs**
- **Valuable Resource Recovery**
- **Reduced CO_2 Emissions**
- **Hydrogen & Ammonia Production**

Key Takeaway

Using AI to optimize MVR and nitrogen recovery can transform industrial wastewater into affordable clean energy, green fertilizer, and reusable water while supporting sustainable port operations and the global energy transition.

Our Research

Transforming Industrial Wastewater into Clean Energy, Green Fertilizer, and Reusable Water

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