END™ Field Testing

In partnership with BGNDRF and UTEP
The Water Crisis

• Over 800 million people struggle daily without safe, clean drinking water.

• The United Nations (UN) General Assembly instituted seventeen Sustainable Development Goals (SDGs), the sixth of which calls for universal access to clean water for all people.

• Part of solving this challenge is reducing *industrial water consumption* to conserve water resources.
MI Systems’ Vision

We are dedicated to enabling solutions to the world’s water crisis through technology innovation

- Passionate Team
- Solving the Toughest Problems
- Focused on the Mission
MI Systems’ Near-Term Mission

Maximum Recovery. Minimum Energy™

• Removal of dissolved contaminants from water is energy intensive

• High water recovery is necessary to conserve water and drive economics
Introducing END™ electro-desalination

- Transformation of legacy electrodialysis reversal (EDR)
- Contemporary Ion-Selective Membranes
- Innovative Membrane Spacers
- Advanced Electrode Materials
- Modern Real-Time Digital Controls
- Low-Pressure Operation: 15-50 psig
- High Recovery: up to 98%
- Low Energy: as low as 0.1 kWh/m3/mS
- Up to 50% Lower OPEX
- Up to 30% Higher Water Recovery
Brine Recovery

- Recycle Brine from existing RO/NF systems
- Increase recovery >90%
- Reduce Waste Volume & Disposal Cost
- Improve Sustainability

- **Key Drivers:** Water Scarcity, Water Cost, Energy Cost, Waste Disposal Limits / Cost, Sustainability
- **Market / Application:** Food & Beverage, Industrial, Municipal, Potable Water
- **Geography:** Any, Water Scarcity / Cost,
## Treatment Performance

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONVENTIONAL NF/RO</th>
<th>END™ TREATMENT</th>
<th>END™ BENEFITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean Water</td>
<td>50-70%</td>
<td>85-97%</td>
<td><strong>30-70%</strong></td>
</tr>
<tr>
<td>Brine Waste</td>
<td>30-50%</td>
<td>5-15%</td>
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### TARGET NF/RO MARKETS
- Industrial Process and Wastewater
- Desalting
- Food & Beverage Makeup / CIP Water
Hi Silica Brackish Water:
- Hi Silica waters foul RO/NF systems
- Improve production, lower fouling, lower OPEX, Less chemicals
- **Market / Application**: Potable & Process Water
- **Geography**: CA, TX, FL, NM, AZ, CO, HI

Brackish Water Treatment:
- Treatment of low salinity water (typ. Groundwater)
- Increased recovery and energy savings vs NF/RO
- Focus on Multiple Issue Sites (Arsenic + Fluoride + Ammonium + Nitrates, etc.)
- **Market / Application**: Food & Beverage, Industrial, Potable Water
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## Treatment Performance

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<tr>
<td>Clean Water</td>
<td>70-90%</td>
<td>85-98%</td>
<td>10—25%</td>
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<tr>
<td>Brine Waste</td>
<td>10-30%</td>
<td>2-15%</td>
<td></td>
</tr>
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</table>

### Diagram

- **Conventional NF/RO**
  - Clean Water: 100% R = 70-90%
  - Brine Waste: 10-30%
  - Waste: 100%

- **END™**
  - Clean Water: 100% R = 85-98%
  - Brine Waste: 2-15%
  - Waste: 100%
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How END™ Works

Operating Principles

Water Introduction
- Low pressure
- Fills voids between sheets

Charge Applied
- Attracts / repels ions thru membrane
- Salts concentrated between layers

Charge Reversal
- “Cleans” electrodes and membranes
- Reduces scale buildup

Concentrated Brine
- Extracted from brine channel
- High concentration

Clean Water
- Extracted from stack
- Ready for conditioning or use

Periodic Cleaning
- Per application requirements
1. Demonstrate ENDM™ performance on real water
2. Develop reliability around process under real-world conditions
3. Benchmark performance against existing technologies
4. Develop strategies around desalinating for high hydraulic recovery
BGNDRF Pilot-Background

- Installed and commissioned 5/7/18
- 1 GPM installed capacity
- Operated for >2300 hrs on Well-1
- Pilot Features:
  - Continuous/Batch operation
  - High degree of autonomous control
    - Automated CIP
  - Remote connectivity
  - Accepts multiple cell sizes
  - Small Footprint
  - Mobility
  - Quiet operation
BGNDRF Pilot-UTEP Collaboration

- Collaborated with Dr. Shane Walker, Dr. Malynda Cappelle and Shahrouz Ghadimi
- Benchmark Study
  - 1 week study on BGNDRF Well-1
  - 90% Hydraulic Recovery
  - 60-70% conductivity removal
    - Inlet: 1700-1800 µS/cm
    - Outlet: <800 µS/cm
- Results
  - Normalized SEC: 0.2-0.23 kWh/m³/mS/cm
“The END system was able to achieve a higher recovery and greater average conductivity reduction than the GE system. The Total SEC values are in a similar range for both systems, including when the conductivity removal is used to normalize the SEC values.”

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<tr>
<th></th>
<th>END™</th>
<th>Kirimi et al.¹</th>
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<tbody>
<tr>
<td>Conductivity Reduction</td>
<td>68-70%</td>
<td>55-60%</td>
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<tr>
<td>Hydraulic Recovery</td>
<td>91-95%</td>
<td>87-92%</td>
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<tr>
<td>Total Normalized SEC (Pump+Desal)</td>
<td>0.20-0.23 kWh/m³/mS/cm</td>
<td>0.30-0.43 kWh/m³/mS/cm</td>
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<tr>
<td></td>
<td>0.14-0.16 kWh/m³/mS/cm</td>
<td>0.13-0.20 kWh/m³/mS/cm</td>
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• High recovery testing
  • Demonstrated continuous operation >90% hydraulic recovery

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<thead>
<tr>
<th></th>
<th>Hydraulic Recovery</th>
<th>SEC (kWh/m³/mS/cm)</th>
<th>Time (hrs)</th>
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<tbody>
<tr>
<td>Set point 1 (6/5)</td>
<td>90%</td>
<td>.24</td>
<td>24</td>
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<tr>
<td>Set point 2 (7/16)</td>
<td>93%</td>
<td>.26</td>
<td>109</td>
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<tr>
<td>Set point 3 (8/15)</td>
<td>94%</td>
<td>.28</td>
<td>107</td>
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<tr>
<td>Pilot Composite</td>
<td>91%</td>
<td></td>
<td>2350</td>
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BGNDRF Pilot-Scale Control

- Anti-scalant Strategies
  - Primary scalants: CaSO₄ and CaCO₃
  - Off-the-shelf vs. Commercial Anti-scalant
  - pH control
  - Reversal Time
  - Brine Batch Size

![Image of solid white substance with a pink lid]
BGNDRF Pilot-Future Work

- Deploy next generation of END™ core technology
- Demonstrate high recovery on different source water (Well 3 and 4)
- Demonstrate RO concentrate recovery