



The 23rd International Asset
Facility and Maintenance
Management Conference

Systematic Innovation for Sustainable Water Systems

Turning Contradictions into Opportunities

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Why Water Systems Need Innovation

- 14 countries in MENA face "extreme water stress" *
- High dependence on desalination ($\approx 40\%$ global capacity produced in MENA) *
- Intensifying stress on water systems driven by:
 - Aging infrastructure
 - Climate change
 - Growing freshwater demand
- Incremental and fragmented innovation is no longer sufficient



* World Economic Forum. "From scarcity to solutions: How Asia and the Middle East are advancing food-water innovation" (Jun 2025).

Technology ≠ Innovation

Why brainstorming is not enough

Deploying technology alone does not solve systemic problems

Tools without a method tend to optimize local solutions while worsening the overall system

Engineering has defined processes - innovation does not

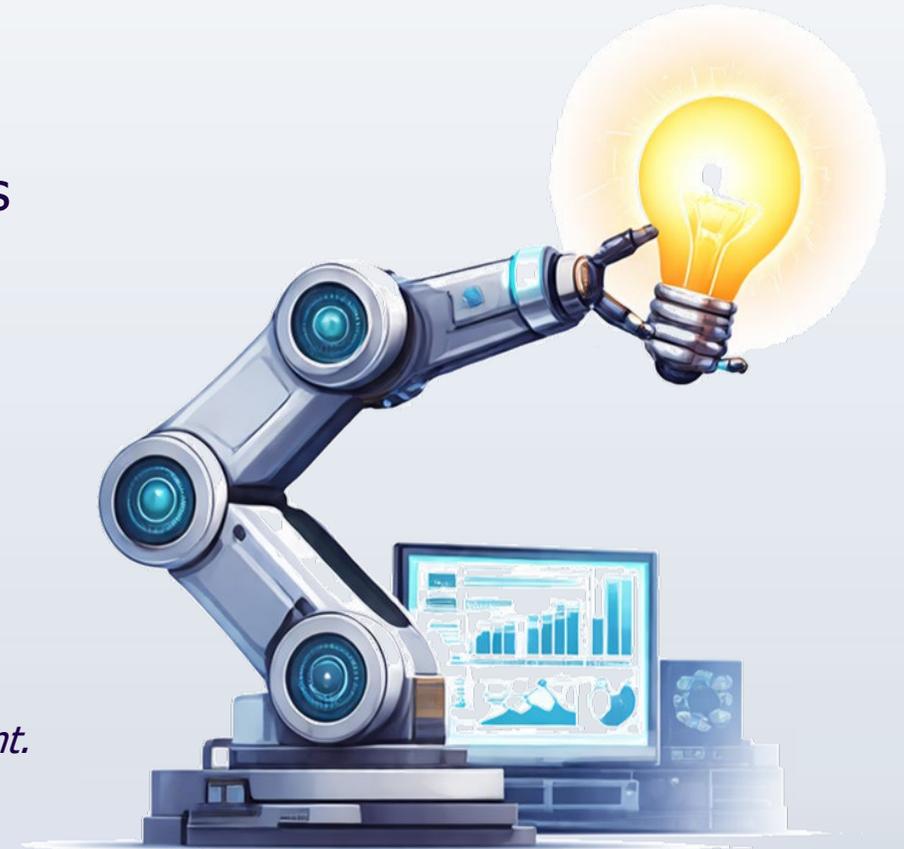
Brainstorming generates ideas, but lacks direction, prioritization, and validation

Unstructured ideation wastes time, money, and resources

Many ideas, low impact, high implementation risk.

Innovation must be deliberate, repeatable, and structured

Without a framework, innovation becomes episodic and dependent on individual talent.



What Systematic Innovation Means

Systematic Innovation

- Organized, guided process → avoids random idea generation
- Addresses contradictions and trade-offs
- Integrates domain expertise with methodological rigor



TRIZ

- Founded by Genrich Altshuller (1926-1998)
- Based on patterns from 200k+ patents
- Key idea: Innovations resolve contradictions
- Tools: Inventive Principles, Contradiction Matrix, IFR, Resources

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b) Ideal Final Result (IFR)

IFR defines the best possible solution: the function is achieved with no cost, no harm, and no added complexity.

c) Resources

Resources are existing elements of the system and its environment that can be reused to achieve the desired function with minimal cost and added complexity.

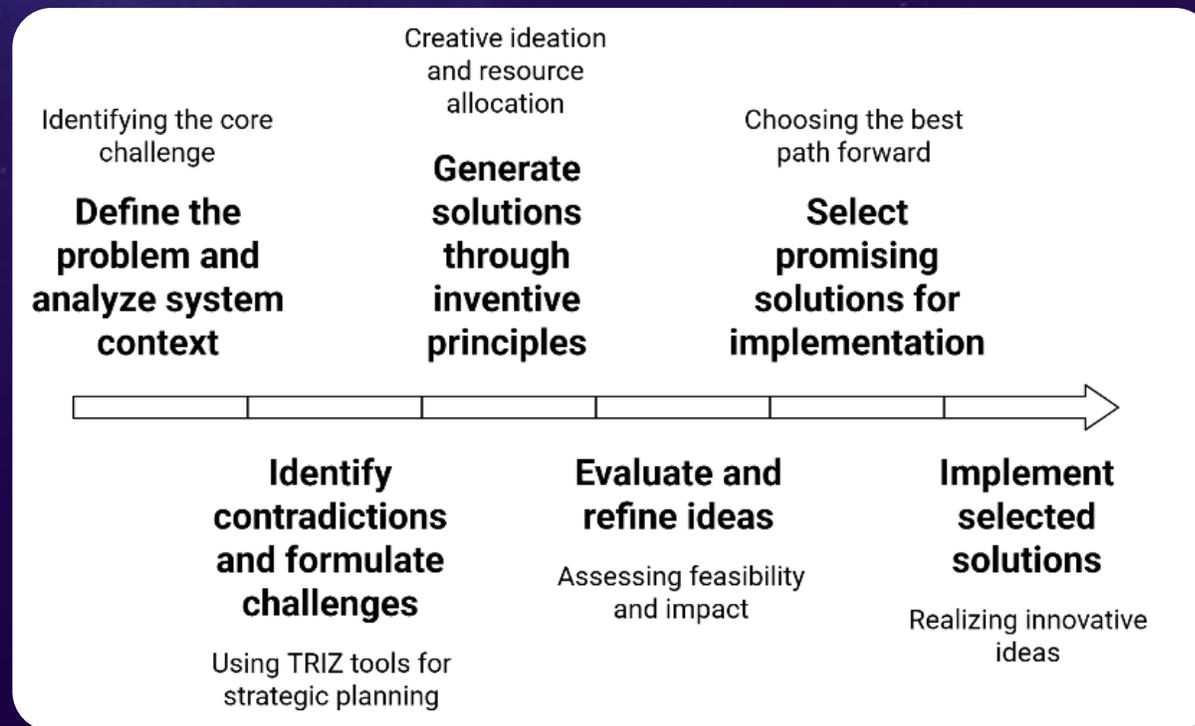
a) Contradiction Matrix and 40 Inventive Principles

- A contradiction arises when improving one parameter of a system causes another parameter to worsen.
- Traditional engineering accepts trade-offs; TRIZ aims to eliminate them.
- The Contradiction Matrix maps conflicting parameters to the most effective inventive principles.
- The 40 Principles provide proven solution patterns to resolve contradictions.

PROPOSED METHODOLOGY

The Systematic Innovation Process

1. Problem Definition
2. System & Functional Analysis
3. Identify Contradictions
4. TRIZ-driven Solution Generation
5. Evaluation & Selection
6. Implementation
7. Planning (Digital Twin)



PROPOSED METHODOLOGY

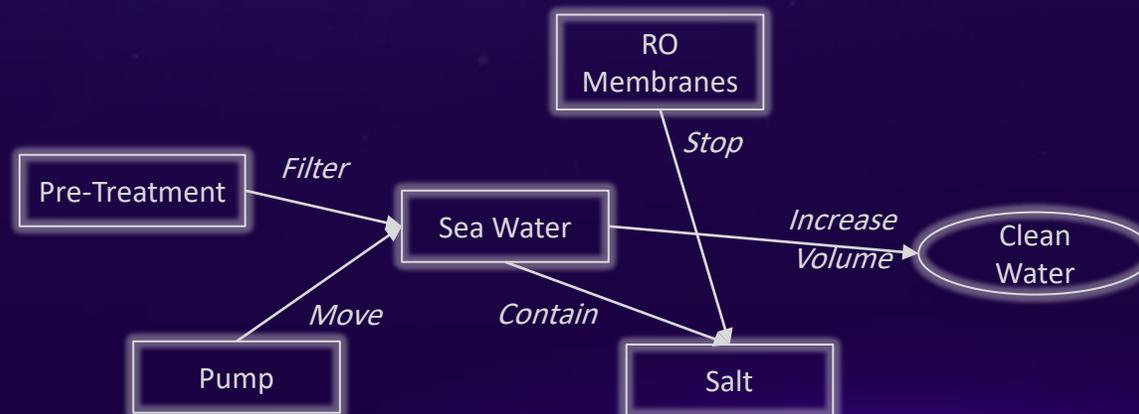
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System and Functional Analysis

- Map components and interactions
- Identify harmful effects
- Avoid pre-selecting solutions
- *Example issues: fouling, leaks, energy losses, overdosing*



PROPOSED METHODOLOGY

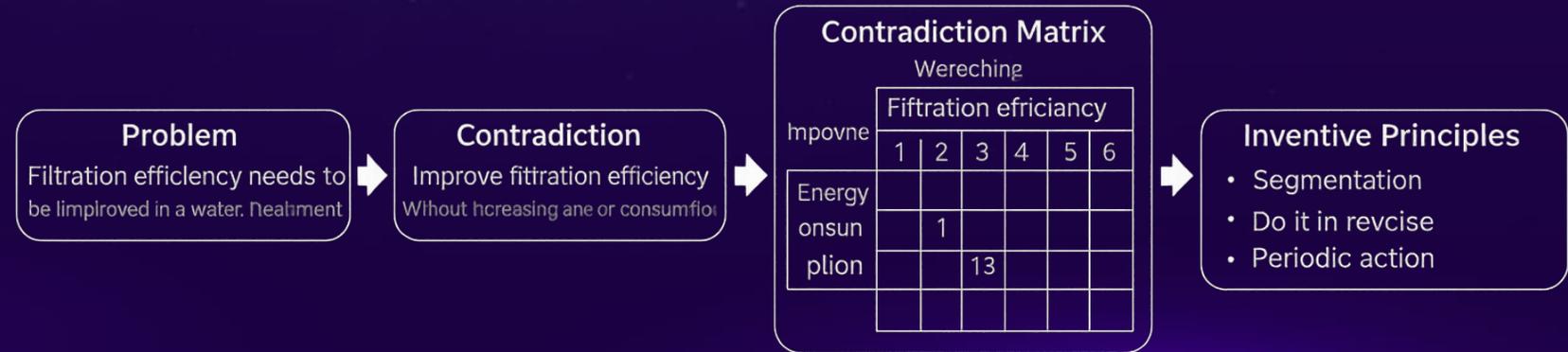
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Identify Contradictions and Solution Generation

- Key Contradictions classification
- Explore IFR direction
- Use Matrix + 40 Inventive Principles
- Target resource-based solutions
- Shift from "optimize" to "overcome conflict"



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Evaluation & Selection + Implementation

- Feasibility
- Energy & cost impact
- Complexity
- Regulatory alignment
- Implementation time
- ...

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Implementation planning through Digital Twin / TRIZ Feedback Cycle

- Digital Twin as an active innovation lab
- Reveals operational trade-offs and contradictions
- TRIZ transforms contradictions into solutions
- Reality is safely mirrored to test change before deployment
- Continuous validation and organizational learning

Simulate
Validation

Develop
Inventive
Strategies

Apply
TRIZ Tools

Identify
Contradictions

Generate
New
Knowledge

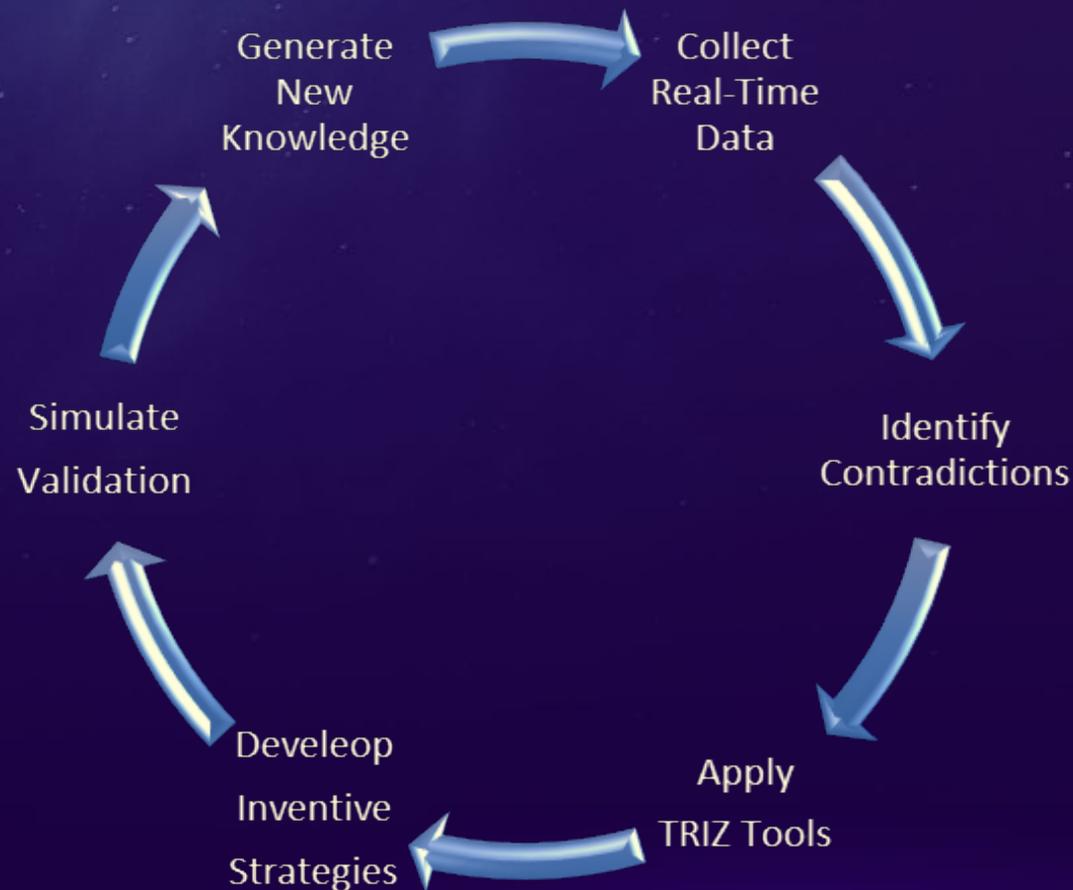
Collect
Real-Time
Data



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CASE STUDY

Improving Desalination through TRIZ and Digital Twin



Context

Water scarcity
(reliance on desalination)

Industrial-scale
Reverse Osmosis (RO)

Need to increase
capacity and efficiency



Operational reality

High energy consumption

Membrane fouling

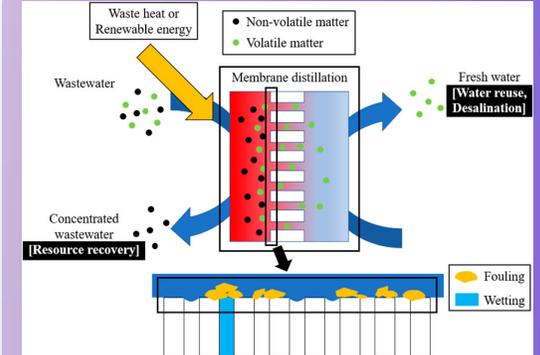
Chemical usage

OPEX escalation



Business constraints

- ✗ No increase in cost
- ✗ No increase in complexity
- ✓ Maintain reliability and robustness



TRIZ CONTRADICTION

Increase
water output and quality

↕

Reducing
energy consumption and
membrane fouling

CASE STUDY

Improving Desalination through TRIZ and Digital Twin

TRIZ CONTRADICTION

Enabling non-incremental performance leaps



no increasing of complexity, costs and risks

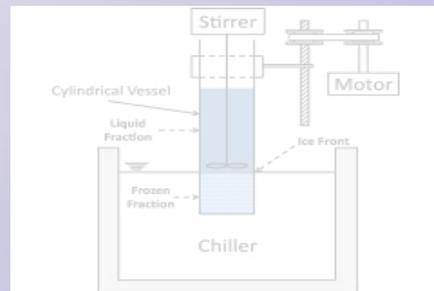


- #36 Phase Transition
- #5 Merging (Combine)
- #26 Copy (Twin)

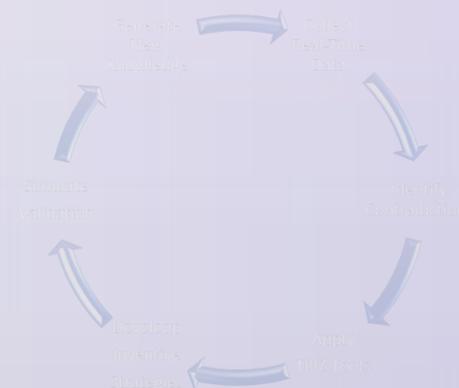
INVENTIVE CONCEPTS

Add freezing step

- Salt exclusion during ice formation
- Reduced fouling load on RO membranes
- Lower chemical dosing
- Lower energy demand (~25%)



Digital Twin as a Continuous TRIZ Innovation Loop



- 1. Collect Real-Time Data**
Pressure, flow, salinity, consumption,...
- 2. Identify Contradictions**
*Output ↑ vs Energy saving ↑
Fouling reduction vs Robustness
Pressure ↑ vs Membrane lifetime*
- 3. Apply TRIZ Tools**
Contradiction Matrix, Inventive Principles,...
- 4. Develop Inventive Strategies**
Hybrid configurations (Freezing + RO), Phase transition,...
- 5. Simulate & Validate**
What-if scenario, Seasonal Variability,...
- 6. Generate New Knowledge**
Refined models, New operational Rules,...



The Digital Twin transforms TRIZ from a one-time problem-solving tool into a continuous, data-driven innovation engine.

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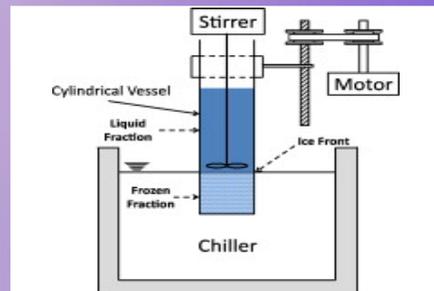


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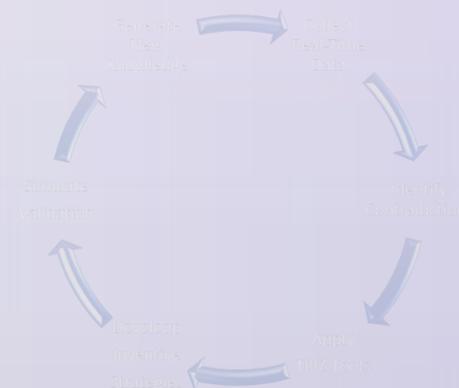
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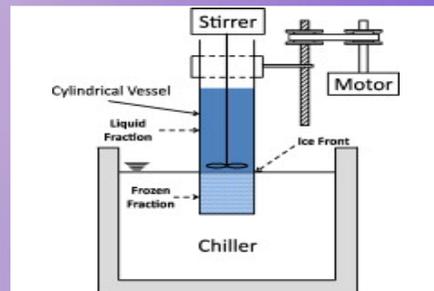


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CONCLUSIONS

- Innovation in critical infrastructure **cannot be left to chance**
- TRIZ enables the **systematic elimination of trade-offs**, not their optimization
- Digital Twins transform innovation into a **continuous, data-driven learning loop**
- The same methodology applies across sectors:
 - water & energy
 - manufacturing
 - healthcare
 - software and automated systems
- Systematic Innovation turns creativity into a **strategic, repeatable capability**



Taweelah Reverse Osmosis Desalination Plant, Abu Dhabi, 2024



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THANK YOU!

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