

Concentrate Solution Soluti Solution Solution Solution Solution Solution Solution So

Saied Delagah MSSC - 2/28/19



Toolbox

Why is it important?

Evaluate existing technologies

- Catalog of available technologies
- Open platform
- Identify technologies and research gaps







Toolbox

What is it?

Subjective assessment

- Many choices in CM Technologies
 - No existing comparison
- Existing technologies
 - Not sustainable
 - Expensive
 - Difficult to implement
- Planning level tool



"Apples to Apples" Comparison of Concentrate Treating Technologies





Toolbox Overview

O Assessment Sheets

- Constraints
- O Criteria
- Peer reviewed

- Compilation of assessment sheets
- Guidance or planning level
 - Excel based



Toolbox Overview

Technology Description and Comparison

- Subjective
- Literature Based
- Open Platform

Not an assessment of proprietary technology

- Literature not available
- Limited data, expertise and knowledge
- Proprietary technology will be added to technology assessment



RECLAMATION Managing Water in the West

Assessment

RECLAMATION

U.S. Department of the is Bureau of Reclamation

Direct Contact Membrane Distillation (DCMD)

Membrane distillation utilizes membranes and a vapor pressure driving force to produce distillate. Membrane distillation provides improved distillate production (more water production with a lower energy impt) compared to tradinosal thermal distillation. Membrane distillation can be used as a promary desalination method, however, because distillate production is less dependent on feed water salinaty that conventional membrane desalination, it may be best salind to ascendary desalination specifically tailored to encontrate desalination.

1.0 Technology Description

Condensation of water varies on the permeate side of the membrane is required for membrane distillation. There are various configurations that condense this vapor and in the DCMD configuration, a cooler liquid is in direct contact with the membrane on the permeate side of the membrane. This exuits in water vapor going through the membrane and configuration in the cooler liquid.



DCMD Configuration - A. Alkhudhiri et al. / Desalisation 287 (2012) 2-18

2.0 Technology Constraints

The following table describes some of the wage constraints that may limit the applicability of the technology to optimize applications. The answers to these questions are used to eliminate technologies from future consideration.

Ð				
	Category	Description	Score/Value (if applicable)	References
	Creenfield or bolt- on Integrated into primary desal facility?	When used as a concentrate treatment process, MD does not need to be integrate during initial design.	Bolt-On	
	Technology maturity	DCMD is the most mature configuration of MD currently.	7	Alkhudhiri et al 2012 Thomas, N et al 2017 Mickley 2018





Assessment Sheets

Describes the technology

- Literature
- Experience
- Interpretation of available information

Sections

- Description
- Constraints
- Capability
- Research Needs
- References



Technology Constraints

Reduce potential viable technologies

Use input

Constraints

Greenfield or bolt-on?

Technology maturity

Flexibility

Scalability

Environmental constraints

Process residuals

Land Area Availability



Technology Constraints

Technology Maturity

Eliminate based on user need

TRL Status Groupings

- 1-4, Concept development, bench scale
- 5-7, Pilot and demonstration
 - 8-9, Full scale

Constraints

Greenfield or bolt-on?

Technology maturity

Flexibility

Scalability

Environmental constraints

TRL 1 Basic principles observed and reported (idea d systems and architectures. Descriptive tools are mat

application area to define the concept. Characteristi

cteristics and behaviors of

analysis of the application.

 TRL 3 Analytical and experimental critical function and/or characteristic proof-of concept (bench scale): Proof of concept validation. Active Research and Development (R&D) is initiated with analytical and laboratory studies.

 TRL 4 Component/subsystem validation in laboratory environment (bench scale): Standalone prototyping implementation and test. Integration of technology elements. Experiments with full-scale problems or data sets.

 TRL 5 System/subsystem/component validation in relevant environment (pilot testing): Thorough testing of prototyping in representative environment; pilot testing.

 Basic technology elements integrated with reasonably realistic supporting elements. Prototyping implementations conform to target environment and interfaces.

TRL 6 System/subsystem model or prototyping demonstration in a relevant end-to-end environment (pilot testing): Prototyping implementations on full-scale realistic problems. Partially integrated with existing systems. Limited documentation available. Engineering feasibility fully demonstrated in actual system application.

TRL 7 System prototyping demonstration in an operational environment (demonstration testing): System prototyping demonstration in operational environment. System is at or near scale of the operational system, with most functions available for demonstration and test. Well integrated with collateral and ancillary systems. Limited documentation available.

TRL 8 Actual system evaluated through test and demonstration in an operational environment: End of system development. Fully integrated with operational hardware and software systems. Most user documentation, training documentation, and maintenance documentation completed. All functionality tested in simulated and operational scenarios. Verification and Validation (V&V) completed.

TRL 9 Technology has been used successfully at full-scale use: Fully integrated with operational hardware/software systems. Actual system has been thoroughly demonstrated and tested in its operational environment. All documentation completed. Successful operational experience.

TRL Status Groupings:

Concept development Bench Scale Testing: 1-4 Pilot and Demonstration Testing: 5-7 Full Scale: 8-9



Technology Constraints

Scalability

Process redesign/modification based on change in flowrate

Constraints

Greenfield or bolt-on?

Technology maturity

Flexibility

Scalability

Environmental constraints

Process residuals

Land Area Availability





Scores used for ranking

Evaluated by reviewer -/+/++/+++

Weighted by user

Technology Readiness	
Level	Heavy metals removal
	Organic contaminant
Cost (LCC)	removal
Produces additional	
"usable" water	Radionuclide removal
If water is produced, anticipated water quality (salinity)	Low chemical demand
Overall process	
recovery (concentrate	
volume minimization)	Energy demand
Residual Waste	
Disposal	Labor requirements
Limitations to large	
scale utilization	Reliability
Hardness removal	Value added



Produces Additional "usable" water

- +++ Additional water produced
- Concentrate volume reduced; no water produced

Technology Readiness	Heavy metals removal
Cost (LCC)	Organic contaminant
Produces additional "usable" water	Radionuclide removal
If water is produced, anticipated water quality (salinity)	Low chemical demand
Overall process recovery (concentrate volume minimization)	Energy demand
Residual Waste	Labor requirements
Limitations to large scale utilization	Reliability
Hardness removal	Value added



If water is produced, anticipated water quality (salinity)

Anticipated product water salinity

- +++ Less than 500 mg/L
- ++ 500 to 1000 mg/L
- + 1000 to 2000 mg/L
- more than 2000 mg/L

Technology Readiness Level	Heavy metals removal
Cost (LCC)	Organic contaminant removal
Produces additional "usable" water	Radionuclide removal
If water is produced, anticipated water quality (salinity)	Low chemical demand
Overall process recovery (concentrate volume minimization)	Energy demand
Residual Waste	Labor requirements
Limitations to large scale utilization	Reliability
Hardness removal	Value added



Labor requirements Operator oversight needed

- +++ Little or no operator oversight
- ++ Trained operator onsite at all times
- + Level (A) operator to be onsite at all times
 - System complexity is considered prohibitive, 24x7x365 top level (A) dedicated operator

Technology Readiness	
Level	Heavy metals removal
	Organic contaminant
Cost (LCC)	removal
Produces additional	
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RECLAMATION Managing Water in the West

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RECLAMATION Managing Water in the West

6	Technology Constraints											
7	Technology	Greenfield or bolt- on? Integrated into primary desal facility?	Technology maturity	Flexibility	Scalabilit V	Environmenta I constraints	Process residuals	Land Area Requirements	Feed water quality limitations	Technology filtered out	Constraint Fail	
	NTMWD Requirement (as described											
8	in 'User input - NTMWD' worksheet)	Primary or Bolt on	6 or above	No	Yes	Yes	Yes	No	No			
9	AquaSel	Bolt-on	5	Yes	Yes	Yes	Yes	Yes	No	Yes	Technology Maturity	
10	Brine Crystallizer	Bolt-On	9	Yes	Yes	Yes	Yes	Yes	Yes			
11	CDI	Bolt-on	7	Yes	Yes	Yes	Yes	Yes	Yes			
2	Direct Solar Vapor	Bolt-On	3	Yes	No	No	Yes	No	Yes	Yes	Technology Maturity	, La
13	Dual RO with IX for Silica Removal	Bolt-On	7	Yes	Yes	Yes	Yes	Yes	Yes			
4	Dual RO with Pellet Reactor	Bolt-On	7	Yes	Yes	Yes	Yes	Yes	Yes			
15	Dual RO with SPARRO	Bolt-On	7	Yes	Yes	Yes	Yes	Yes	Yes			
6	Dual RO with precipitation	Bolt-On Bolt-On	8	Yes	Yes	Yes	Yes	Yes	Yes			
12	ED	Botton	0	Vee	Vae	Vee	Vee	Vee	Vee			
0	ED with SPAPPO	Bolt-On	7	Vee	Vee	Vee	Vee	Vee	Vee			
20	EDM	Bolt-on	5	Yes	Yes	Yes	Yes	No	Yes	Yes	Technology Maturity	,
21	ED with gypsum precipitation	Bolt-On	8	Yes	Yes	Yes	Yes	Yes	Yes			
22	FO	Bolt-On	8	Yes	Yes	No	Yes	Yes	No	Yes	Environmental Contr	aints
23	HDH	Bolt-On	5	Yes	Yes	Yes	Yes	Yes	Yes			
24	HEED	Bolt-on	7	Yes	Yes	Yes	Yes	Yes	Yes			
25	MD	Bolt-On	7	Yes	Yes	Yes	Yes	Yes	Yes			
26	MD - Crystallization	Bolt-On		Yes	Yes	Yes	Yes	Yes	Yes			
7	MD Vacuum	Bolt On		Vaa	Vac	Vaa	Vac	Vac	Vac			



Тес								
Technology	Technology Readiness Level	Cost (LCC)	Produces additional "usable" water	If water is produced, anticipate d water quality (salinity)		Techn ology Score	Technology Score (normalize d to 100)	Technology Rank for being a solution for NTMWD
Weight (as described and changed in	10	1	7	5		210	100	Pank
'User Input' worksheet)	10 -		•	J 🗸		21	- 100	
Vapor Compression	7	1	3	3		185	88	1
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Brine Crystallizer	9	0	3	3		184	88	3
ED with gypsum precipitation	8	1	3	3		183	87	4
RO - CCD	7	2	3	3	······	182	87	5
MD	7	2	3	3		177	84	6
MD-Direct Contact	7	2	3	3	₽ [™]	177	84	6
ED with SPARRO	7	1	3	3		176	84	8
MSF	9	1	3	3		176	84	9
Dual RO with precipitation	8	1	3	3		171	81	10
HEED	7	2	3	3		169	81	11
ED	9	1	3	2		168	80	12
MD - Vacuum	6	1	3	3		166	79	13
MD-Air Gap	6	1	3	3		166	79	13
MD-Sweep Gas	6	1	3	3		166	79	13
Pervaporation	4	2	3	3		162	77	16





Technology assessment sheets

Recommended list of technologies based on enduser input

Verification of end-user selection(s)







Desktop study on toolbox recommended technology

Piloting of recommended technologies

- Performance testing
- Cost estimation



Beyond

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