



Role of integrated membrane systems in enhancing desalination capacity of Saudi Arabia and the need for a desalination roadmap development

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ORGANIZING PARTNERS



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OUTLINE

1	Overview of the Grand Challenge Project	<ul style="list-style-type: none">• Project Framework• Project Concept• Project Objectives and Structure
2	Desalination Technology Pathway (Integrated Membrane Systems)	<ul style="list-style-type: none">• The future of Membrane-based Desalination Technology in Saudi Arabia• Overview of Project Components on Desalination Technology Development
3	National Planning Pathway (KSA Desalination Roadmap)	<ul style="list-style-type: none">• Water Sector in KSA Vision 2030• Fundamental Principles of KSA Desalination Roadmap• KSA Desalination Roadmap: Methodology• KSA Desalination Roadmap: Components

Overview of the Grand Challenge Project: Project Framework

Project title

Integrated membrane systems for enhancing efficiency and productivity of desalination and water reuse capacity of the Kingdom of Saudi Arabia

Program

Kingdom of Saudi Arabia International Collaboration Grant (Grand Challenge Grant)

Grand Challenge title

Increase the total available capacity of desalinated water by 50%

KSA Vision 2030 strategic objective

“total available capacity (designed) of desalinated water to be increased from 5.1 MCM to 7.3 MCM/day”.



Research & Development Office

KSA International Collaboration Grant

Application guidelines

Funding Agency

Research and Innovation Deputyship,
Ministry of Education

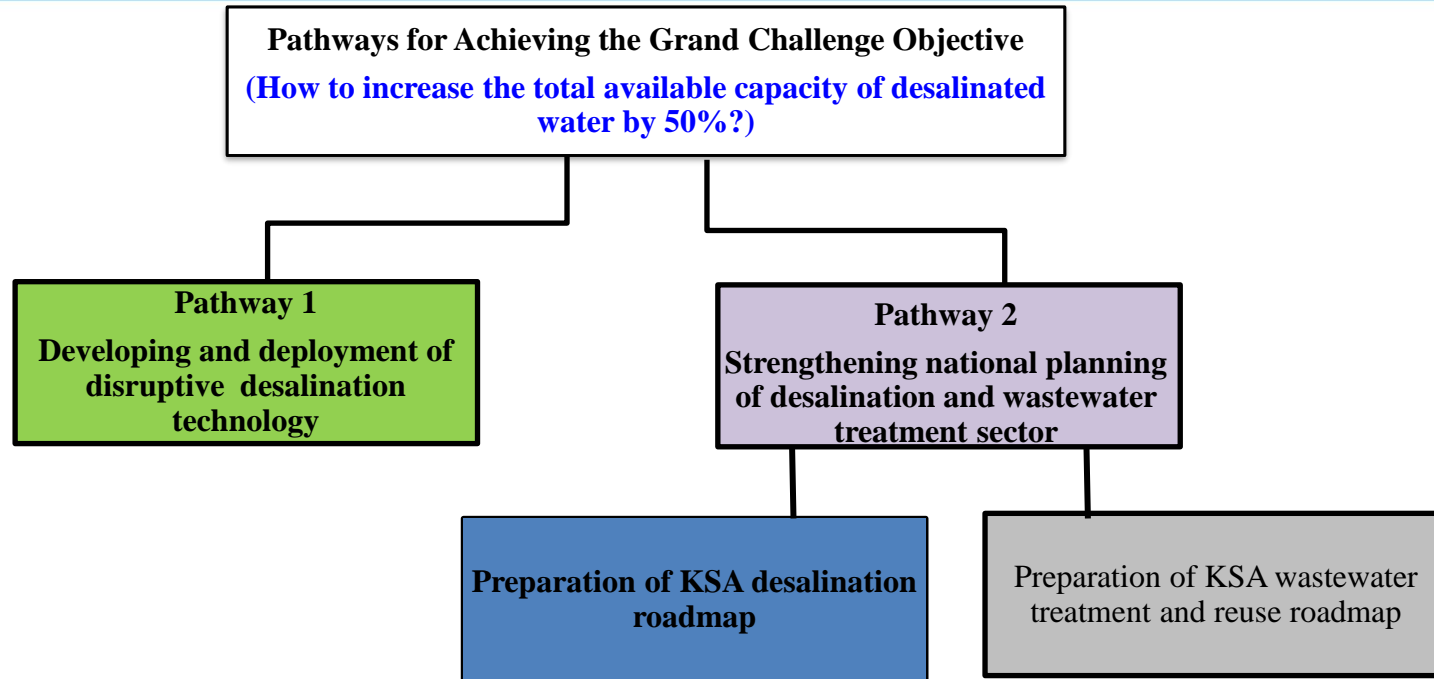
Grand challenge

1. Increase the total available capacity of desalinated water by 50%

Potential fields for investigation¹

Desalination & Water Reuse

Overview of the Grand Challenge Project : Project Concept



Overview of the Grand Challenge Project : Project Objectives

To develop a roadmap for increasing desalination and water reuse capacity of Saudi Arabia

Work Package 1
KSA
Desalination
Roadmap

Work Package 3
Hybrid MBR
systems

To develop and optimize MBR based hybrid membrane systems for wastewater treatment and seawater pretreatment

To develop and optimize MD systems for brine desalination and produced water treatment

Work Package 2
Hybrid MD
systems

Work Package 4
Membrane
development

To develop PVDF membranes and membrane modules for MD and MBR Processes

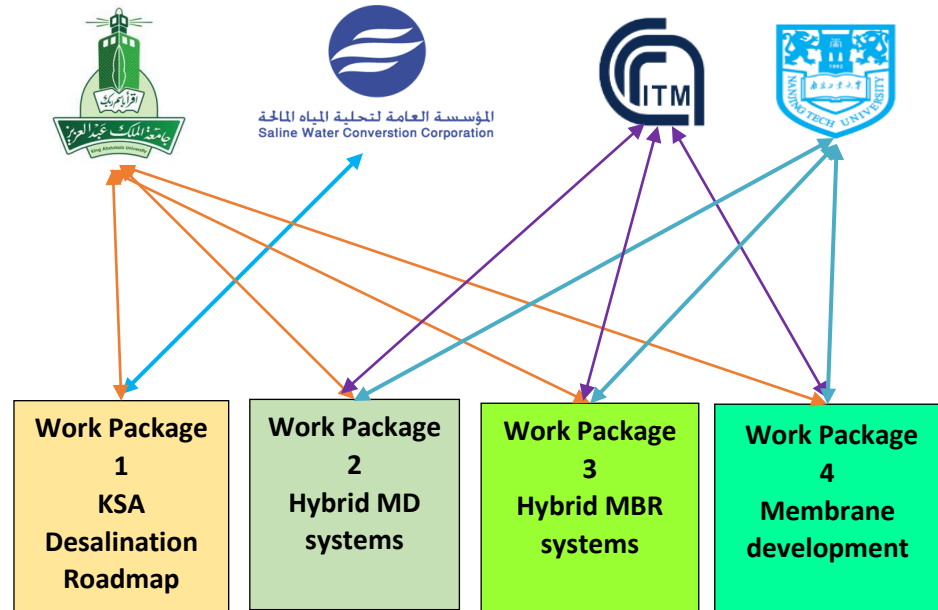
Overview of the Grand Challenge Project : Research Partners

Lead University

*Center of Excellence in Desalination Technology,
King Abdulaziz University*

Local and international partners

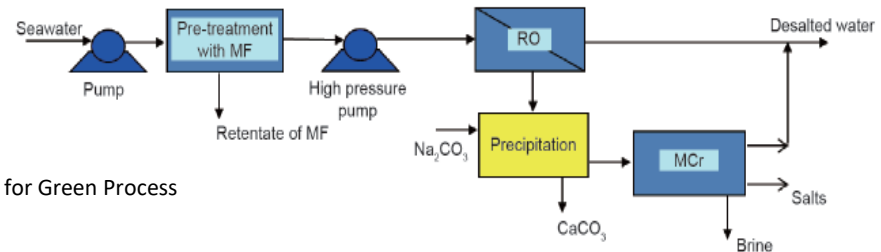
1. *Desalination Technologies Research Institute (DTRI), Saline water Conversion Corporation(SWCC)*
2. *ITM-CNR c/o University of Calabria, Italy*
3. *Nanjing Tech University, State Key Laboratory of Materials Oriented Chemical Engineering, China*



Desalination Technology Pathway: Integrated membrane systems

- ❑ Integrated membrane systems (IMS) refer to combining or coupling more than one membrane process in a single water desalination or treatment line of production
- ❑ IMS are based on process intensification principles which aim to maximizing returns and reducing cost of desalination process.
- ❑ IMS offer many advantages: Increase the overall recovery ratio, improved quality of product water, reducing fouling, and providing additional economic benefits to water treatment systems.
- ❑ IMS can utilize different forms of energy (i.e. waste heat, solar thermal energy)

An example of integrated SWRO desalination system consisting of MF/RO/MCr membrane processes

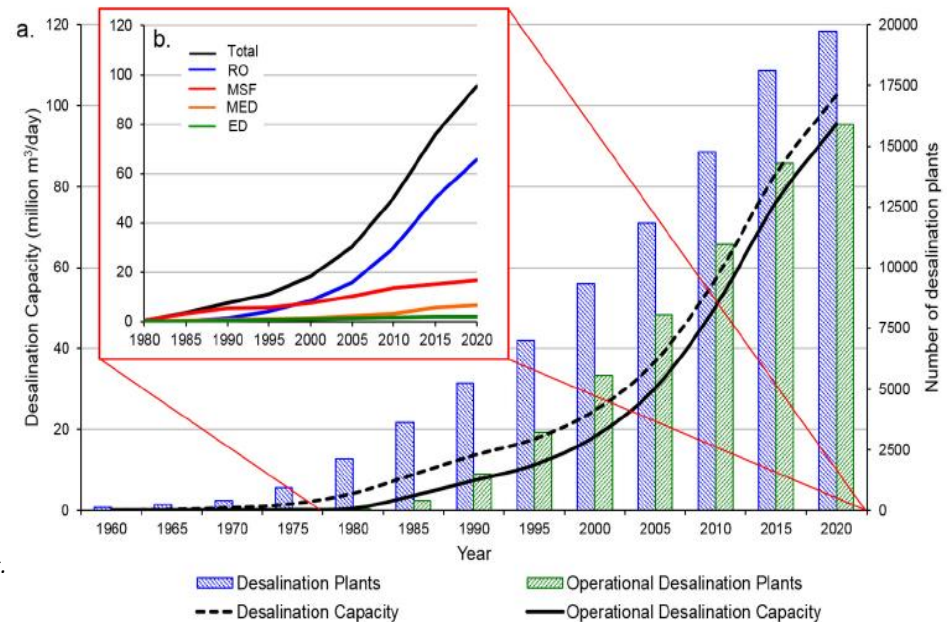


Source: Francesca Macedonio, Enrico Drioli.2017. Membrane Engineering for Green Process Engineering, Engineering 3 (2017) 290–298

Integrated membrane systems for desalination

Trends in global desalination by:

- (a) Number and capacity of total and operational desalination facilities
- (b) Operational capacity by desalination technology

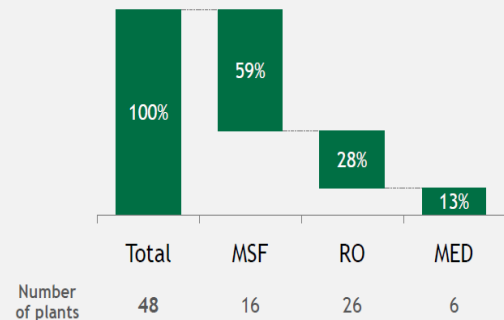


Jones, E., Qadir, M., van Vliet, M. T. H., Smakhtin, V., & Kang, S. (2019). *The state of desalination and brine production: A global outlook. Science of The Total Environment, 657, 1343–1356.* doi:10.1016/j.scitotenv.2018.12.076

Integrated membrane systems for desalination

Currently, desalination plants in KSA rely mainly on MSF technology

Installed capacity breakdown by technology 2016



In the future, added plants will rely mainly on RO technology

Number of new planned projects by 2030 2016-2030

Technology	Number of new projects
MSF	2
RO	28
MED	TBD

Source: Invest Saudi, Water & Water Treatment Sectors in the Kingdom of Saudi Arabia
<https://investsaudi.sa/media//1341-ni-rotces-tnemtaert-retaw-retaw-fdp.ask>

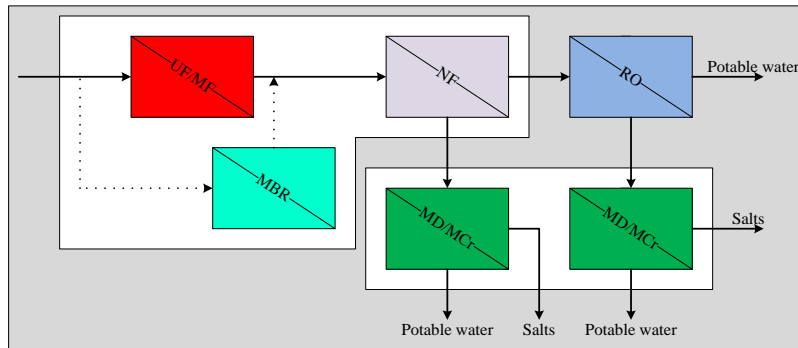
Integrated membrane systems for desalination: Project components

Work Package 2: Advancement of MD based hybrid systems for brine minimization

Increase water recovery ratio of desalination plants for maximizing production of desalinated water and extract income generating minerals from concentrated brines

Task 1 : Develop a hybrid RO-MD system for SWRO brine desalination

Task 2: Develop a hybrid membrane distillation (MD)/ membrane crystallizer (MCr) for Minerals recovery from produced water and RO brine



Integrated membrane system in desalination for pretreatment (UF/MF or MBR, NF) and post-treatment (MD, MCr)

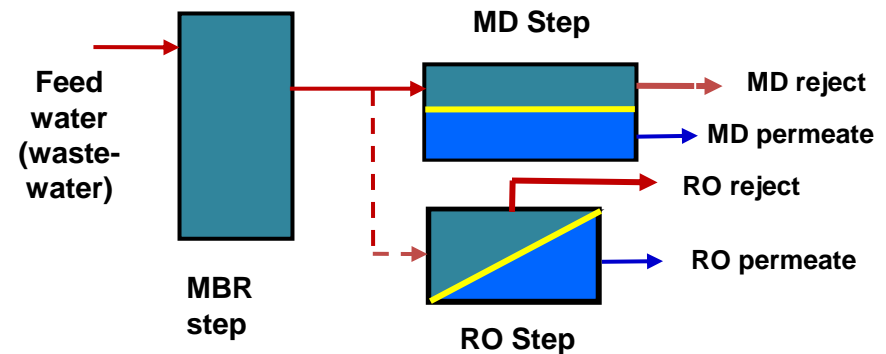


Integrated membrane systems for desalination: Project components

Work Package 3: Advancement of MBR based hybrid systems for wastewater treatment and seawater pre-treatment

Assessing the feasibility of MBR based hybrid MD and RO process for purification of potential wastewater sources in urban area for onsite reuse and investigate the application of MBR for pre-treatment of seawater for RO fouling minimization

- Task 1: Develop a hybrid MBR/MD for wastewater treatment and reuse
- Task 2: Develop a hybrid MBR/UF/low pressure RO for urban wastewater treatment and reuse
- Task 3: Develop MBR system for pre-treatment of seawater prior to RO desalination



A schematic drawing of an Integrated MBR/MD or MBR/RO membrane system for wastewater purification

Integrated membrane systems for desalination: Project components

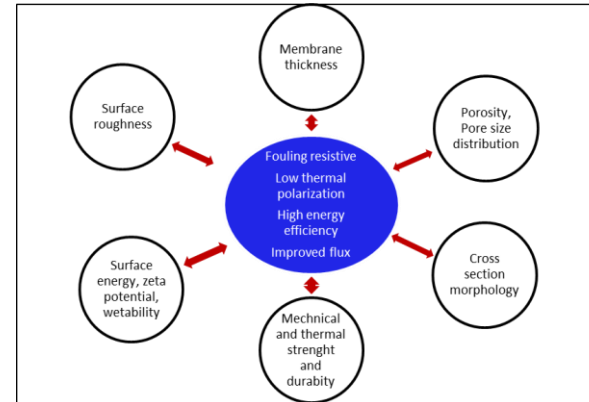
Work Package 4: Optimization of PVDF membrane preparation and membrane modules for MD and MBR processes

Optimize the preparation process of PVDF hollow fiber membrane for improved performance and better mechanical stability and develop efficient membrane modules suitable for MD and MBR processes

Task 1: Prepare hydrophobic PVDF membranes for MD and MCr.

Task 2: Develop and optimize suitable membrane modules for MD/MCr and MBR processes.

Task 3: Analyze and optimize MD and MBR based hybrid membrane process configurations.



Relationships between membrane performance indices and membrane features

KSA Desalination Roadmap: Strategic Objectives for Water Sector in KSA Vision 2030

- Promoting sustainable water supply sources and improving service coverage.
- Reducing excessive water consumption.
- Achieving customer satisfaction by providing high quality service and reducing waste.
- Reduce the sector dependence on state funding by taking steps toward privatization.
- Improving financial and operational efficiency.



KSA Desalination Roadmap: Strategic Objectives and Key Performance Indicators

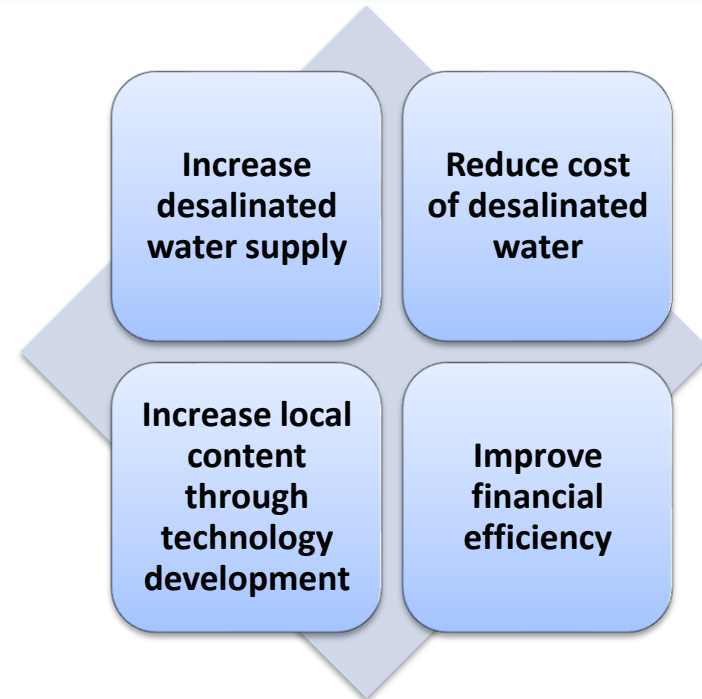
Strategic Objective	Key Performance Indicator
Boost water storage resources and security	Total available capacity (designed) of desalinated water to be increased from 5.1 MCM to 7.3 MCM/Day
Expand service coverage	Percentage of reused sewage water to be increased from 17 % to 35%
Establish emerging technology companies with added value to contribute to the increase of local content	Number of tech-companies emerging from universities through the Innovative Companies Program to achieve a target of 800 companies
Optimize the use of renewable water resources for agricultural purposes	Percentage of water used in the agricultural sector relative to total available renewable water resources to be decreased from 416% to 191% by 2030
Organizational Development and Privatization	Percentage of treated water production through strategic partners to be increased from 0 % to 20%
Increase local content	Percentage of local content in capital and operational projects to be increased from 30 % to 40%
Improve financial efficiency	Percentage of tariff to actual water cost to be increased from 30 % to 100%

Source: Kingdom of Saudi Arabia Vision 2030 and the National Transformation Program 2020, www.vision2030.gov.sa

KSA Desalination Roadmap: Goal and objectives of KSA Desalination Roadmap

Roadmap goal

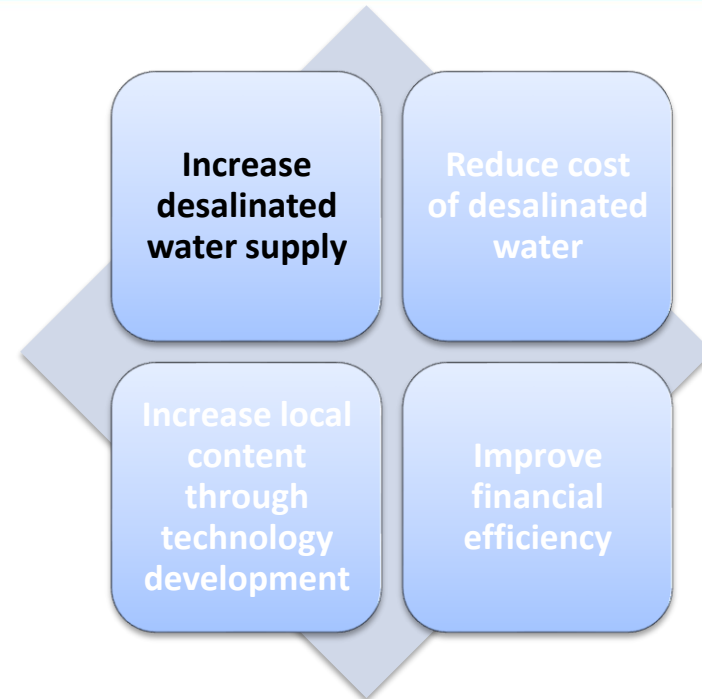
The primary purpose of the roadmap is to present a detailed description and analysis of the water desalination sector in Saudi Arabia and to identify and prioritize the needs of research and development projects in this sector. The roadmap will also serve as a policy guide and reference to help decision-makers, scientific research institutions, industry, and businesses in planning and developing the sector to achieve better performance and maximum benefits of input resources.



KSA Desalination Roadmap: Goal and objectives of KSA Desalination Roadmap

Approaches to achieving the objective

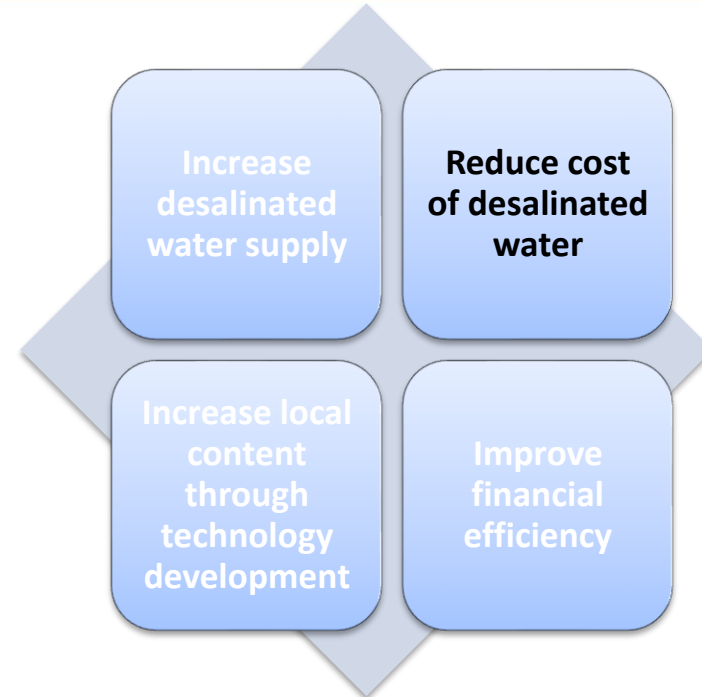
- Improve utilization of installed desalinated water capacity
- Increase freshwater recovery of existing desalination plants
- Increase share of alternative purified water supplies (wastewater reuse)
- Promote desalinated water production by water users (autonomous small scale desalination plants)



KSA Desalination Roadmap: Goal and objectives of KSA Desalination Roadmap

Approaches to achieving the objective

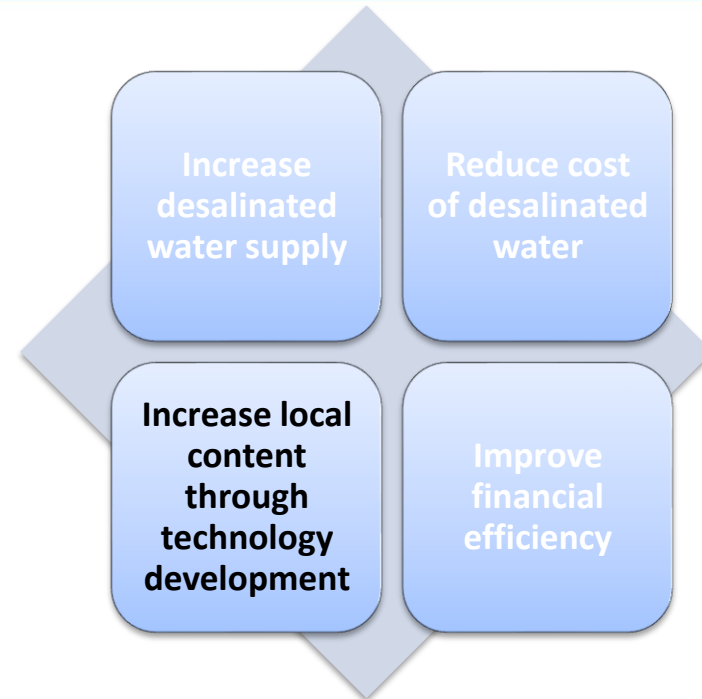
- ❑ Minimize the cost of the water supply chain (minimize desalinated water losses)
- ❑ Use the best cost-efficient and energy-efficient technology (full transformation to RO desalination)
- ❑ Generate alternative revenue from brine (deployment of brine mining technology)
- ❑ Increase share of renewable energy desalination
- ❑ Provide cost-effective, alternative water supply options for remote communities



KSA Desalination Roadmap: Goal and objectives of KSA Desalination Roadmap

Approaches to achieving the objective

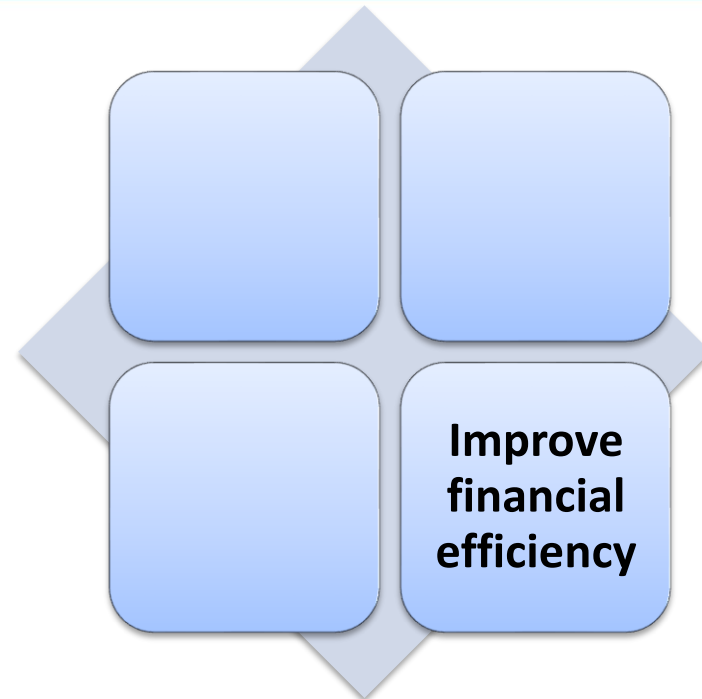
- ❑ Identify and promote the technology and equipment categories that offer the greatest potential for localization.
- ❑ Establish new market models and mechanisms for the desalination technology supply chain which are favorable for Saudi desalination technology.



KSA Desalination Roadmap: Goal and objectives of KSA Desalination Roadmap

Approaches to achieving the objective

- ❑ Identify shortcomings and deficiencies in the policies and regulations governing the desalination sector.
- ❑ Identify drivers that stimulate private sector participation – licensing, regulation, financing, operation, and marketing.



KSA Desalination Roadmap: Fundamental Principles

Participation

Relevant stakeholders at the national level across related specializations, geographical distribution, water sectors, water industries and technologies and business will be included in the roadmap development process

Building national consensus and support

Good public relations are required to create awareness and visibility of the roadmap at national level to insure the support of relevant institutions for roadmap implementation

Feedback and update

The roadmap should be a dynamic document which undergoes frequent update based on systematic feedback and backstopping process

KSA Desalination Roadmap: Roadmap Methodology



Roadmap Teams

Small groups of diverse experts of Core Team members (6 people) and Broader Team members (25 people) that meet regularly and cultivate interest in roadmapping across sectors, provide key insights, and help identify new diverse roadmap participants who can contribute



Interviews

One-on-one conversations to elicit nuanced information about major challenges and promising technologies



Surveys

Opportunities to get more detailed/technical data while also allowing for potentially more thoughtful and deeper responses.

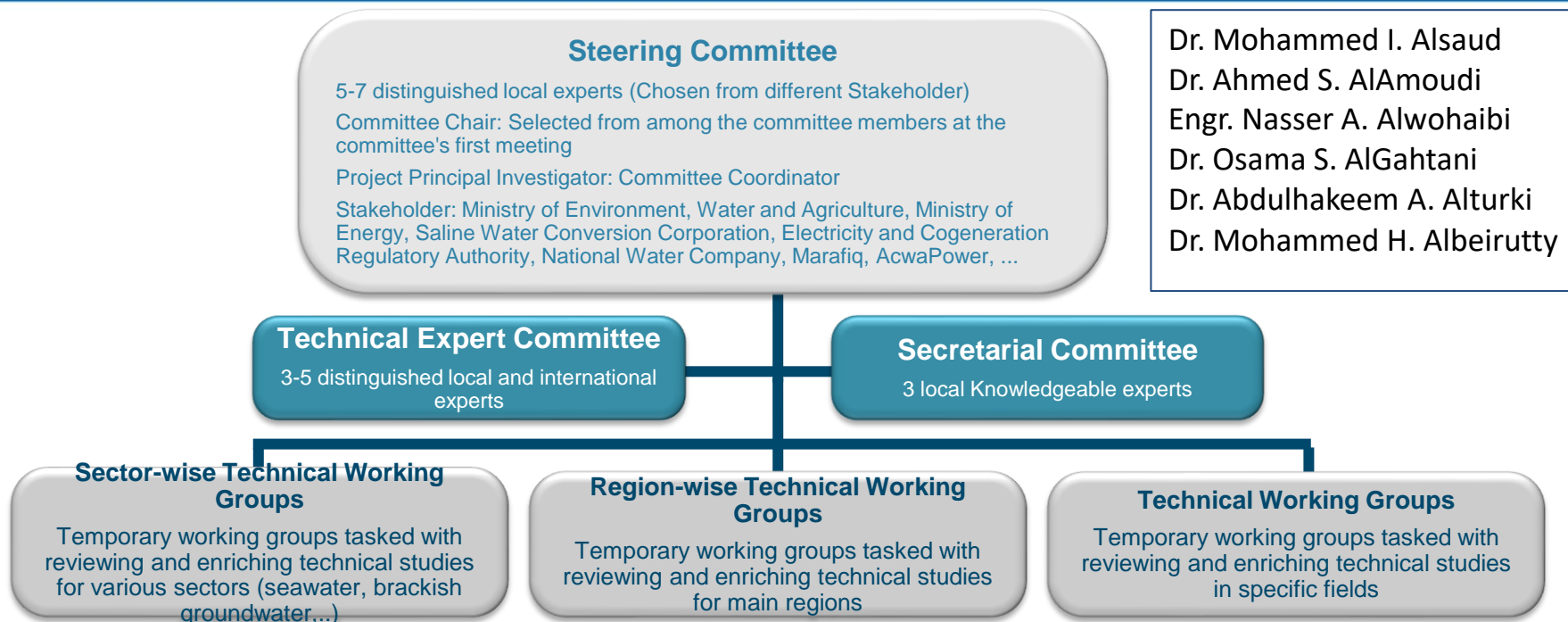


Workshops

Interactive sessions (virtual and in-person) allow multiple stakeholders to discuss and build off others

Ref: Nikolay Voutchkov, Overview of Ongoing Desalination Roadmap Scoping Activities in the US, Scoping Workshop for Defining the Procedure for Preparing a Desalination Development Roadmap for the Kingdom of Saudi Arabia, 29 October 2020, Jeddah

KSA Desalination Roadmap: Proposed Structure



KSA Desalination Roadmap: Tasks of Roadmap Committees

Steering Committee	<ul style="list-style-type: none">▪ Review and approve methodology of roadmap development▪ Review and approve RFPs for roadmap development and select the Consultant and technical experts.▪ Review and approve the deliverables prepared by the Consultant▪ Prioritize key topics and research projects▪ Lead workshop discussions▪ Mobilize support for the roadmap project from concerned authorities and stakeholders
Technical Advisor	<ul style="list-style-type: none">▪ Advise steering committee on the technical issues on roadmap development▪ Identify the main issues and research needs of KSA desalination sector▪ Review of the deliverables prepared by the Consultant
Roadmap Secretariat	<ul style="list-style-type: none">▪ Undertake office commutation tasks and assist the Principal Investigator in preparing draft reports and organization of meetings and workshops.
Roadmap Consultant Global Water Intelligence, UK	<ul style="list-style-type: none">▪ Prepare Literature Review▪ Undertake and analyse surveys▪ Prepare <i>State of the Desalination Report</i>▪ Assist in facilitating workshops▪ Prepare <i>Roadmap Report</i>

KSA Desalination Roadmap: Development Process

Step 1 - Establish Steering Committee and Technical Experts Committee



Step 2 – Procure Consultant to Facilitate Roadmap Development



Step 3 – Complete Research Needs Survey



Step 4 – Create State of Desalination Report



Step 8 – Complete Desalination Roadmap Workshops



Step 7 – Prepare Desalination Roadmap First Draft



Step 6 – Complete Desalination Roadmap Workshops



Step 5- Contract prominent experts to prepare selected background papers



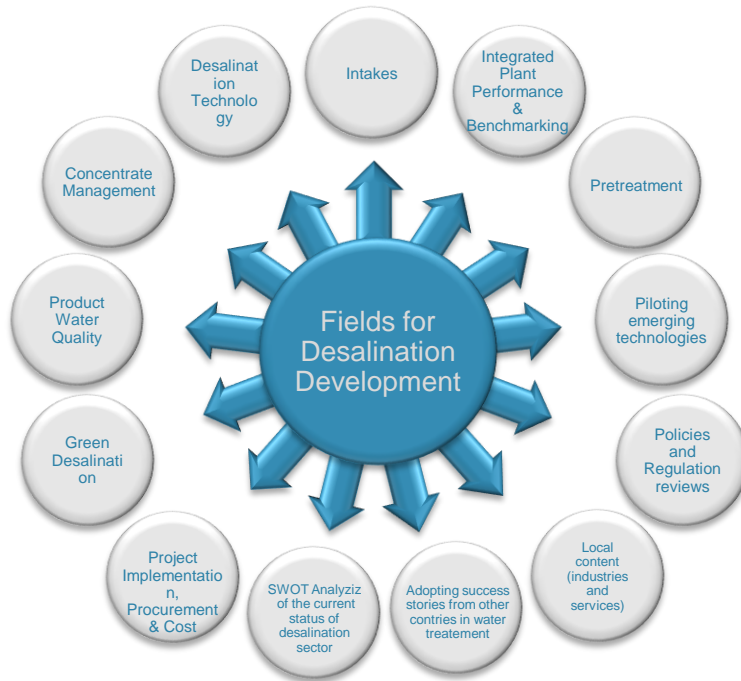
Step 9 – Prepare Desalination Roadmap final draft



Step 10 – Organise end-of-project Desalination Roadmap workshop

Ref: Nikolay Voutchkov, Overview of Ongoing Desalination Roadmap Scoping Activities in the US, Scoping Workshop for Defining the Procedure for Preparing a Desalination Development Roadmap for the Kingdom of Saudi Arabia, 29 October 2020, Jeddah (updated)

KSA Desalination Roadmap: Primary Fields of Interest

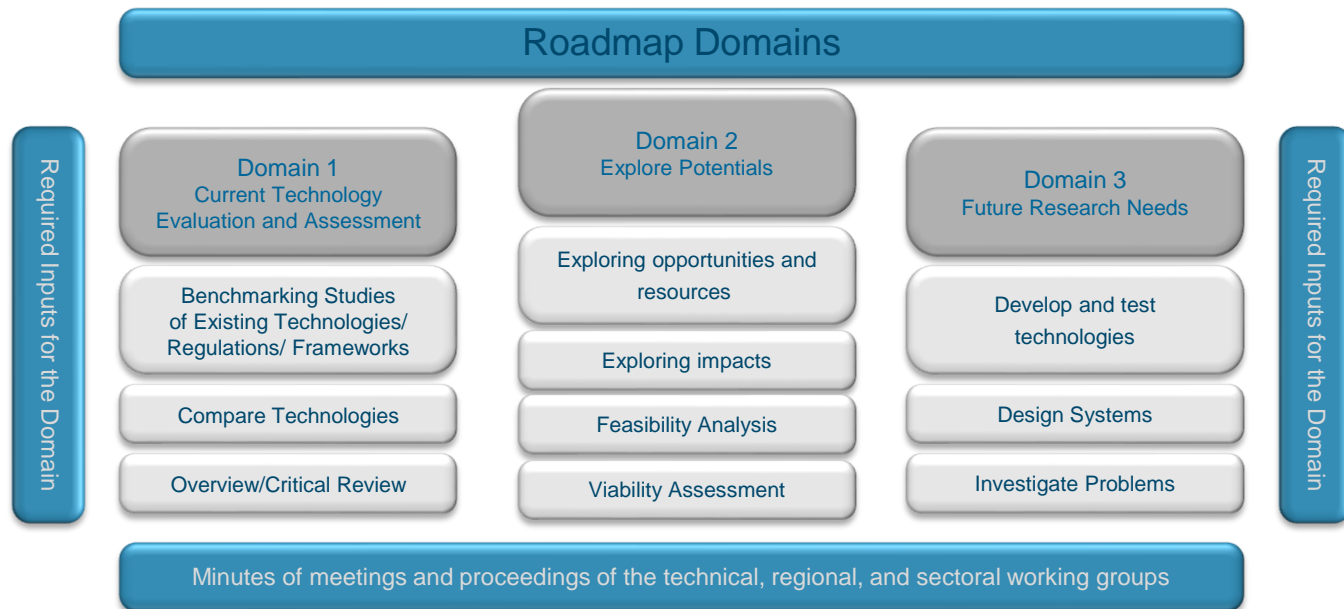


Main issues in desalination and wastewater treatment sector in KSA

The corner stone in the roadmap process is to identify the main priority fields for desalination development in KSA and the key issues in each field.

KSA Desalination Roadmap: Taxonomy

The final roadmap document will be a compendium of a concise and highly authentic knowledge of the desalination and water treatment sector of KSA covering its main fields and key issues which aims to help planners and policy makers in future development of the sector and maximize its efficiency



Conclusions and Recommendations

- **The national efforts for increasing the desalination capacity of Saudi Arabia should focus not only on expanding the capacity of the existing large central seawater desalination plants and the construction of large new plants based on traditional desalination technologies but should also focus on the next generation desalination technologies which are based on brine mining, renewable energy, and exergy concepts. Also, diversification of desalination technologies should be encouraged especially for distributed desalination solutions.**
- **Saudi Arabia has a great potential for different applications of integrated membrane systems in desalination and water reuse. The integrated membrane systems will not only enhance desalination capacity but also will improve the local content.**

Conclusions and Recommendations

- **In 2018 Saudi Arabia has already developed The National Water Strategy 2030. However, a detailed national roadmap for the development of the desalination sector till 2030 is required. The desalination sector in Saudi Arabia is the largest desalination industry in the World, but still lacks a roadmap that clearly visualizes its vision and targets.**
- **For sustainability and economic consideration, desalinated water in Saudi Arabia must be accompanied by water reuse at the same capacity levels. Therefore, a detailed national roadmap for the development of the water reuse sector till 2030 is required.**

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Governor of Riyadh Region

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