

Feasibility of Integrating Nuclear Reactors with Seawater Desalination in Tripoli, Libya

An Assessment within the IAEA INPRO Framework

Khaled.A

Libyan Atomic Energy Establishment



The Problem

Tripoli's freshwater security is eroding



97%

of Libya's water supply
comes from groundwater



~28%

average capacity utilisation
of existing desalination plants



6×

higher cost of desalinated water
vs. Great Man-Made River water

Population growth, climate change, and declining groundwater recharge are converging on a single coastal city — while Libya's Great Man-Made River, once the backbone of national supply, continues to degrade.

Why This Matters: the Water–Energy Nexus

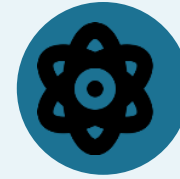


Desalination is energy-hungry

Energy is typically the single largest cost component of desalinated water.

Fossil-fuelled plants tie water production to volatile fuel prices and an already strained national grid.

A stable, low-carbon energy source can decouple water security from fuel markets.



Why nuclear, why now

Reactors deliver continuous baseload heat and power over 40–60 year lifetimes.

Small modular and research reactors match the scale of a municipal desalination plant — not a gigawatt grid.

This is the technical premise this study evaluates for Tripoli.

Study Objective & Methodology

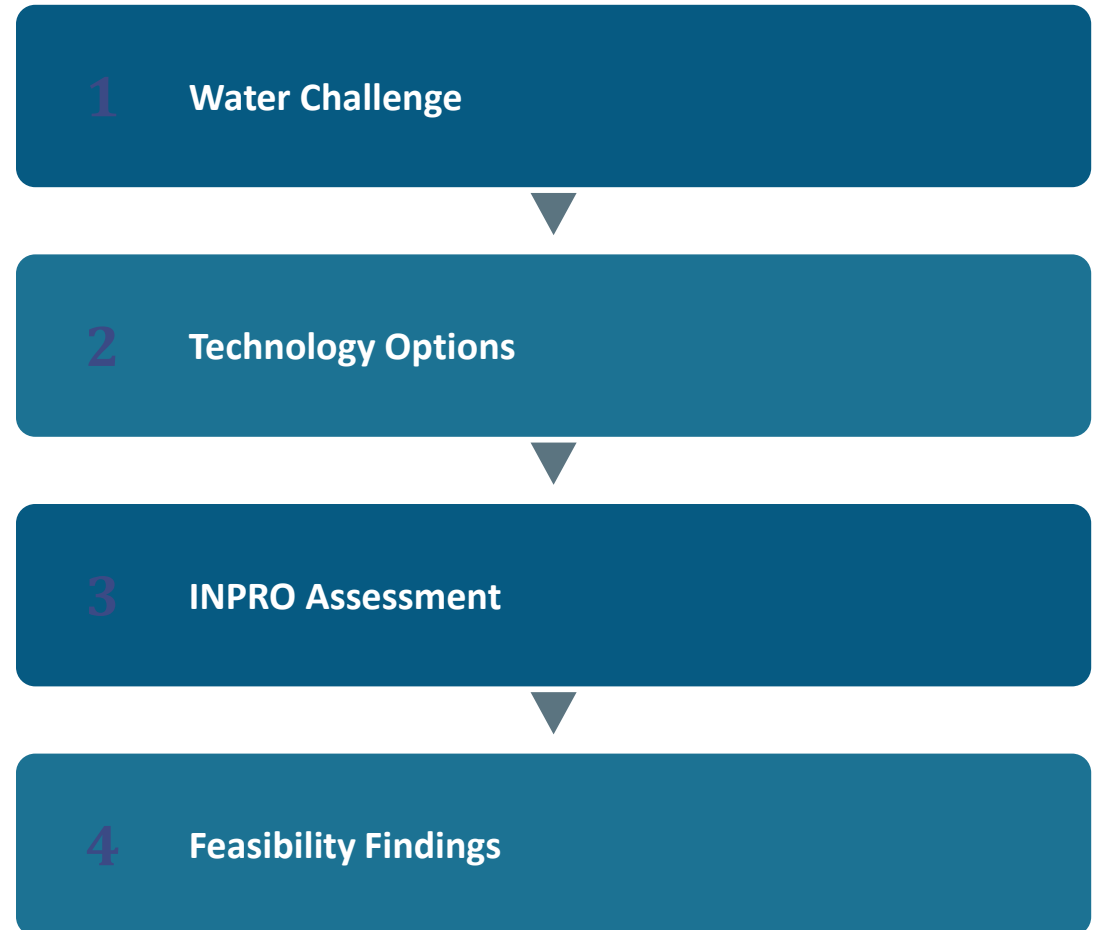
Objective

Assess the technical, economic, and institutional feasibility of coupling a small or research nuclear reactor with seawater desalination for Tripoli.

Framework: IAEA INPRO

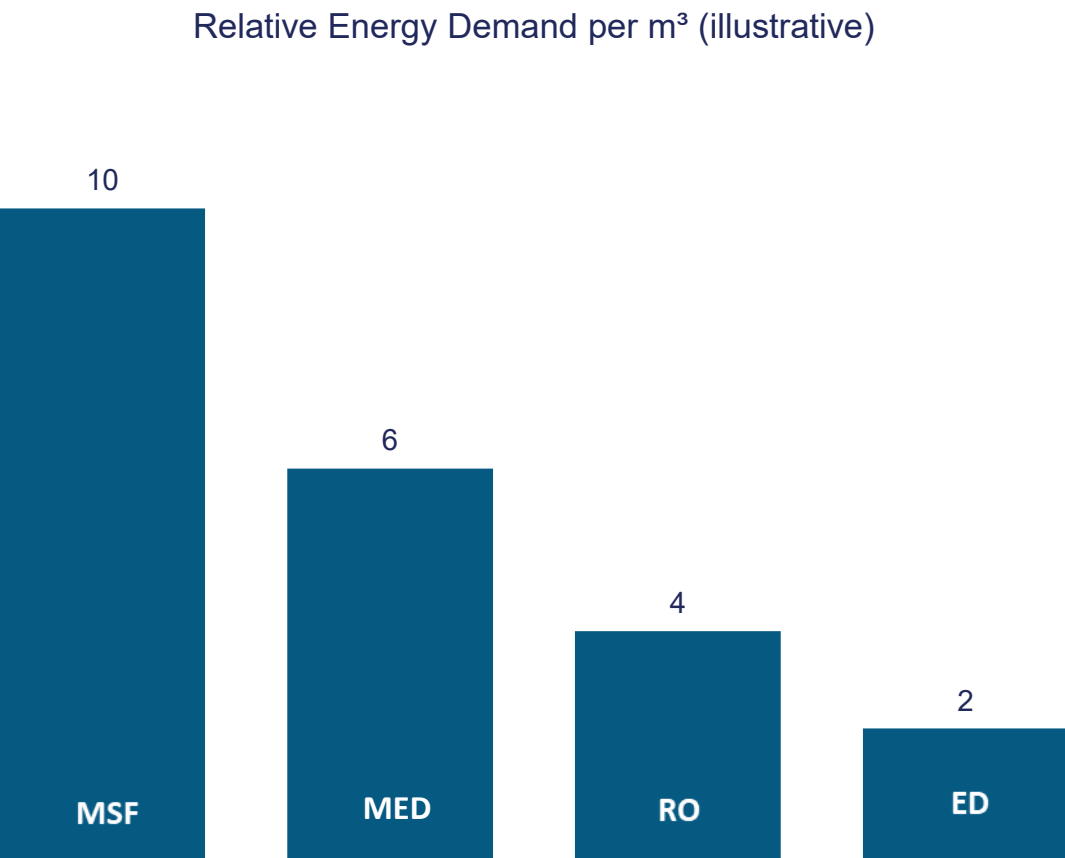
Launched 2000 · endorsed by GC(44)/RES/21 · 48 Member States + EC

An integrated methodology spanning economics, infrastructure, safety, waste, safeguards, and environment.



Desalination Technology Options

Matching energy profile to reactor output

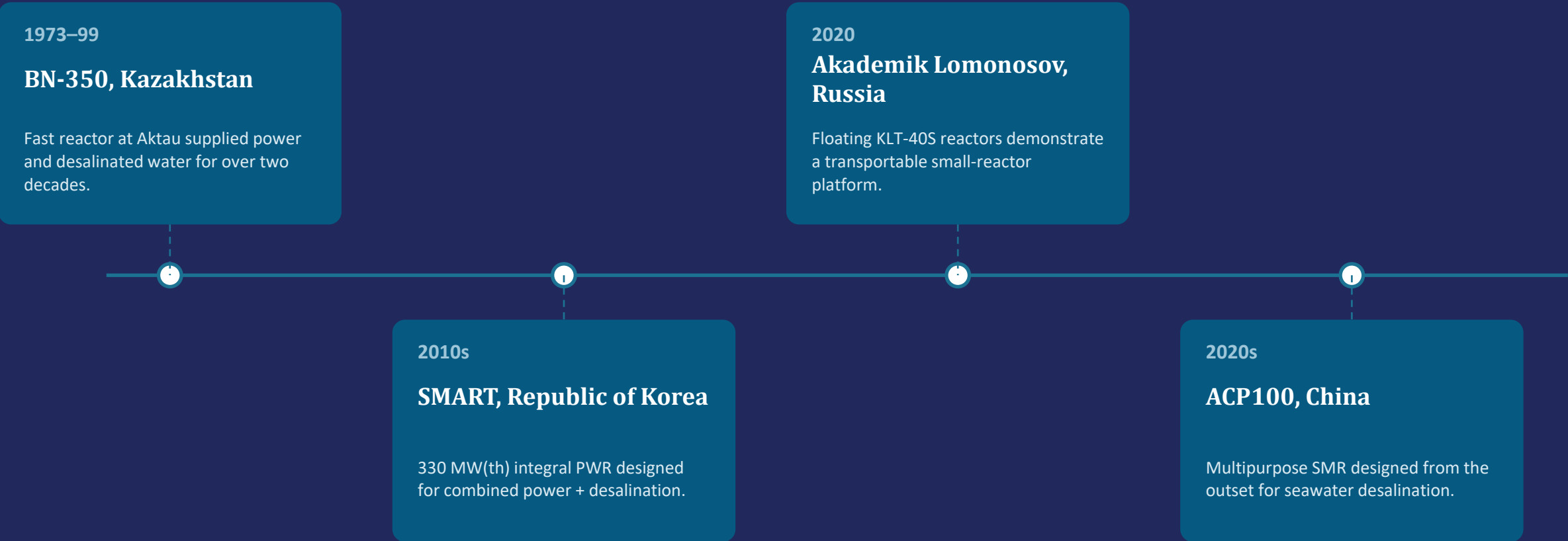


- MSF** Mature, robust; well matched to reactor process steam
- MED** Lower thermal demand; efficient with medium-temperature heat
- RO** Lowest energy demand; simple electrical interface
- ED** Suited to brackish water; limited relevance to seawater feed

A hybrid MED–RO configuration, drawing both heat and electricity from one reactor, is the most promising design point for Tripoli.

International Experience with Nuclear Desalination

The technology is demonstrated — deployment for desalination remains limited



Precedent for the region: Jordan is assessing SMRs for its own desalination needs following direct engagement with IAEA specialists.

Applying the INPRO Assessment Dimensions



Economics

Levelised cost of water and electricity vs. alternatives



Infrastructure

Grid capacity, siting, and desalination network integration



Safety

Coastal siting, seismic risk, assured cooling and feed water



Waste Management

Spent fuel and radioactive waste, scaled to reactor size



Safeguards

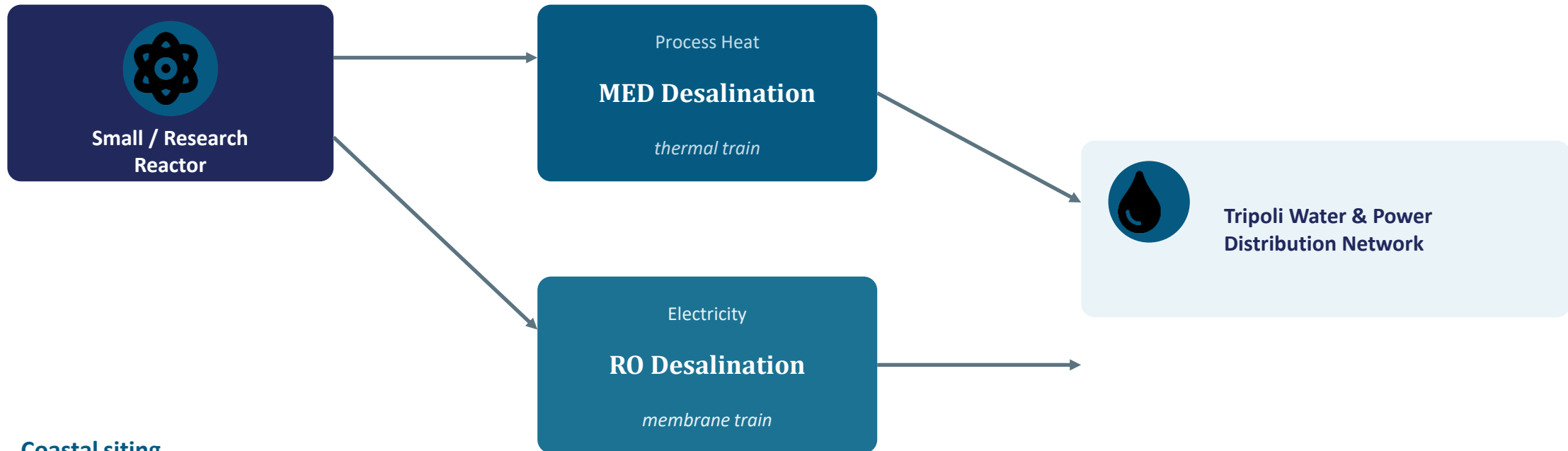
Proliferation resistance and IAEA non-proliferation obligations



Environment

Brine management in the semi-enclosed Mediterranean basin

A Proposed System Concept for Tripoli



Coastal siting

provides direct seawater access for both cooling and desalination feed.

Modular, staged capacity

allows the system to expand as demand and operational confidence grow.

Dedicated intake / brine outfall engineering

is required given the semi-enclosed Mediterranean basin.

Economic Feasibility

Trading upfront capital cost for long-term price stability

Today

Desalinated water costs

~6×

more than GMMRP-sourced water

Driven mainly by fossil-fuel input costs

Exposed to global fuel price volatility

Plants run at only ~28% of capacity due to maintenance and spare-parts shortages

With Nuclear Coupling

Higher upfront capital cost

Decades of stable operating cost, largely insulated from fuel markets

SMR modular construction targets lower capital cost than large-scale nuclear

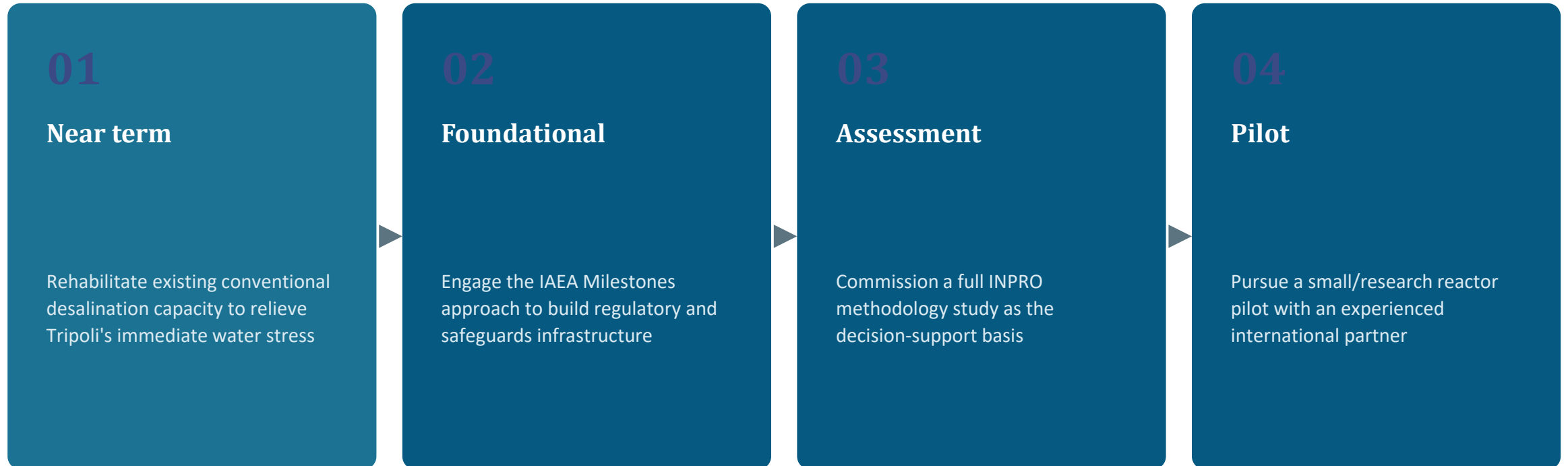
Likely requires blended financing: IAEA technical cooperation, bilateral partnerships, phased milestones

Key Challenges

The barriers are institutional as much as technical

- 1 Political and institutional instability since 2011 complicates long-term planning and financing
- 2 No established national nuclear regulator or safeguards infrastructure yet in place
- 3 Limited domestic nuclear engineering and operations workforce
- 4 Physical security considerations for critical infrastructure
- 5 Long lead times — a decade or more under the IAEA Milestones approach

Recommendations & Roadmap



Institutional readiness — not reactor technology — is the longer critical path.

Conclusion



The technology is demonstrated.

Nuclear-desalination cogeneration has an established, if limited, international track record.

The barriers are institutional, not technical.

Regulatory infrastructure, financing capacity, and political stability — not reactor design — will determine feasibility for Tripoli.

The path forward is phased.

Near-term rehabilitation of conventional desalination, paired with long-term institutional groundwork under the INPRO and Milestones frameworks.



Thank You

Questions & Discussion

Khaled Alashtar
Libyan Atomic Energy Establishment