What if sustainable desalination could provide drinking water for everyone?

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Aqua Tech

GenAI

Within Reach | **Transitional** | Visionary

Smart, renewable desalination systems combine renewable energy and novel materials to turn seawater or groundwater into freshwater in water-scarce regions.

UNCERTAINTIES

Systems, Technology

MEGATREND (Most significant)

Evolving Ecosystems

TRENDS

Biomimicry
Cross-Sectoral Partnerships
Food–Water–Energy Nexus
International Collaboration
New Materials

TECHNOLOGIES

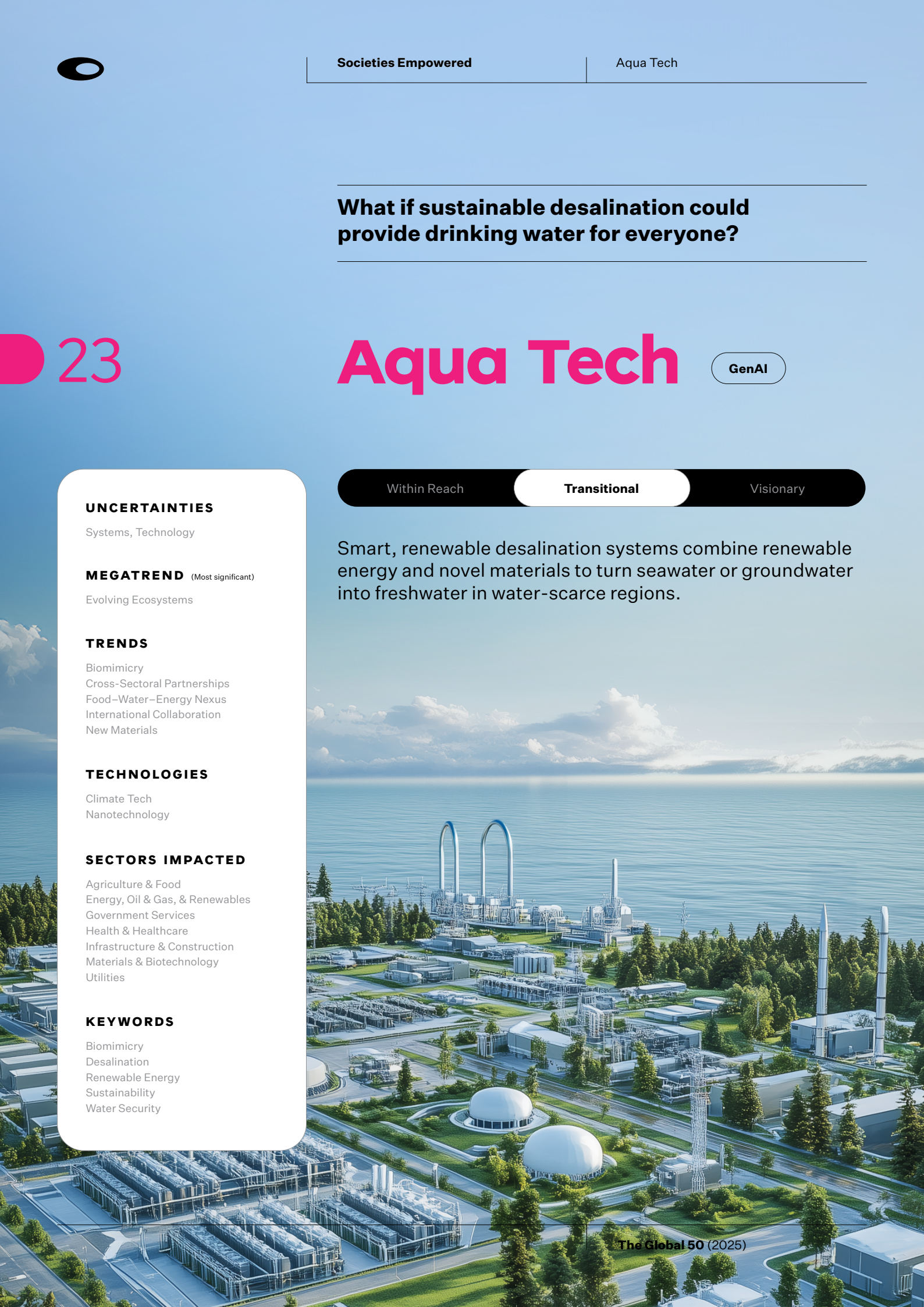
Climate Tech
Nanotechnology

SECTORS IMPACTED

Agriculture & Food
Energy, Oil & Gas, & Renewables
Government Services
Health & Healthcare
Infrastructure & Construction
Materials & Biotechnology
Utilities

KEYWORDS

Biomimicry
Desalination
Renewable Energy
Sustainability
Water Security



WHY IT MATTERS TODAY

2 billion

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Freshwater is a critical resource globally. Nearly 70% of the Earth's surface is water, of which roughly 97.5% is salty.[856] Of the Earth's freshwater, approximately 69% is in the ice caps and glaciers and 30% is in the ground, leaving only 1% readily accessible for human use – for example, in ice, snow, lakes and rivers.[857] It is estimated that 2 billion people currently lack access to a managed source of safe drinking water,[858] and global water stress is projected to impact 4 billion people by 2030.[859] In addition to the effect of a growing global population,[860] global water stress will be exacerbated by climate change, as rising sea levels increase the salinity of groundwater, and floods and droughts increase water pollution.[861]

A lack of clean water has significant impacts on human health and hygiene. Each year, around a million people are estimated to die from diarrhoea because of unsafe drinking water and sanitation, and in 2021 over 251 million people required treatment for schistosomiasis, caused by parasites in infested water.[862] Increasing water salinity is limiting crop production[863] and contributing to soil erosion,[864] reducing global agricultural production by 124 trillion kilocalories annually, equivalent to feeding 170 million people per year.[865]

The global capacity for desalination has grown by 7% annually since 2010, reaching 99 million m^3/day in 2022, with the Middle East and North Africa (MENA) contributing 70%.[866] Reverse osmosis dominates in the European Union, accounting for 88.5% of capacity, while the MENA region favours thermal processes.[867] Besides the carbon emissions of desalination technologies,[868] desalination also produces over 150 million m^3/day of brine globally, harming marine ecosystems, reducing oxygen, and killing aquatic life.[869]

THE OPPORTUNITY

BENEFITS

Water security; reduced emissions; reduced brine output; improved health through increased access to clean and safe water; improved agriculture and more robust agricultural economy.

RISKS

Durability of the materials; cost and complexity of maintaining and managing multiple clean energy technologies.

Advanced machine intelligence, the Internet of Things (IoT), edge computing, and real-time analytics are combined with hybrid solar[870] and wind power[871] systems in single or multiple units designed[872] to autonomously produce clean, cost-effective and safe[873] freshwater from seawater or groundwater[874] at scale. This integration is significant for water-scarce regions,[875] as solar desalination has been limited by lower yields and higher costs and intermittency compared with traditional desalination.[876]

Innovative materials[877] enhance desalination. For example, 2D nanomaterials, including graphene and other highly permeable materials, enable efficient filtering membranes,[878] while 3D-printed porous structures with tree-like topologies[879] improve water transport through capillaries that significantly reduce, or even eliminate, brine as a by-product.[880]

Minimum and zero liquid discharge desalination methods[881] present further opportunities for innovation, with biomimicry possibly enhancing efficiency and reducing costs. For example, researchers at Khalifa University recently explored an all-encompassing solar desalination solution that mimics mangrove processes, using brine crystallisation to eliminate the production of brine as waste.[882]

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