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Sustainability

Changing Tides: Investing for Future Water Access

Water inequality is stark: a quarter of the planet lacks access to safe drinking water, nearly half to safe sanitation. Yet demand is set to rise by ~30% by 2050, at a time when climate change and the energy transition will alter patterns of supply and demand in ways that are hard to predict. We explore solutions in markets, regulation and technologies, identifying companies exposed.

Sustainability

Authors

MORGAN STANLEY & CO. INTERNATIONAL PLC+
Jessica Alsford, CFA
Equity Strategist
+44 20 7425-8985
Jessica.Alsford@morganstanley.com

MORGAN STANLEY & CO. LLC
Connor Lynagh
Equity Analyst
+1 212 296-8145
Connor.Lynagh@morganstanley.com

MORGAN STANLEY & CO. INTERNATIONAL PLC+
Lucy Beauvallet
Equity Strategist
+44 20 7677-2470
Lucy.Beauvallet@morganstanley.com

MORGAN STANLEY & CO. INTERNATIONAL PLC+
Dominika Stylinska
Research Associate
+44 20 7677-5201
Dominika.Stylinska@morganstanley.com

MORGAN STANLEY MÉXICO, CASA DE BOLSA, S.A. DE C.V.+
Nikolaj Lippmann
Equity Analyst
+52 55 5282-6778
Nikolaj.Lippmann@morganstanley.com

MORGAN STANLEY C.T.V.M. S.A.+
Miguel F Rodrigues
Equity Analyst
+55 11 3048-6016
Miguel.Rodrigues@morganstanley.com

MORGAN STANLEY & CO. LLC
Vincent Andrews
Equity Analyst
+1 212 761-3293
Vincent.Andrews@morganstanley.com

MORGAN STANLEY & CO. LLC
Thomas Claes Johnson
Research Associate
+1 212 761-4628
Thomas.Johnson@morganstanley.com

Contributors

MORGAN STANLEY & CO. LLC
Mark Carlucci, CFA
Equity Strategist
+1 212 761-6586
Mark.Carlucci@morganstanley.com

MORGAN STANLEY & CO. LLC
Carolyn L Campbell
Equity Strategist
+1 212 761-3748
Carolyn.Campbell@morganstanley.com

MORGAN STANLEY TAIWAN LIMITED+
Charlie Chan
Equity Analyst
+886 2 2730-1725
Charlie.Chan@morganstanley.com

MORGAN STANLEY ASIA LIMITED+
Tim Chan, CFA
Equity Strategist
+852 3963-4568
Tim.Chan@morganstanley.com

MORGAN STANLEY & CO. INTERNATIONAL PLC+
Cedar Ekblom, CFA
Equity Analyst
+44 20 7425-4623
Cedar.Ekblom@morganstanley.com

MORGAN STANLEY & CO. INTERNATIONAL PLC+
Tilly Eno
Research Associate
+44 20 7677-3662
Tilly.Eno@morganstanley.com

MORGAN STANLEY & CO. INTERNATIONAL PLC+
Pinar Ergun, CFA
Equity Analyst
+44 20 7425-6181
Pinar.Ergun@morganstanley.com

MORGAN STANLEY & CO. LLC
Simon Flannery
Equity Analyst
+1 212 761-6432
Simon.Flannery@morganstanley.com

MORGAN STANLEY ASIA LIMITED+
Ehsernta Fu
Equity Strategist
+852 3963-3711
Ehsernta.Fu@morganstanley.com

MORGAN STANLEY & CO. LLC
Kimberly C Greenberger
Equity Analyst
+1 212 761-6284
Kimberly.Greenberger@morganstanley.com

MORGAN STANLEY & CO. INTERNATIONAL PLC+
Victoria Irving
Equity Strategist
+44 20 7425-6651
Victoria.Irving@morganstanley.com

MORGAN STANLEY & CO. LLC
Quinn Jacobs
Research Associate
+1 212 761-2271
Quinn.Jacobs@morganstanley.com

MORGAN STANLEY & CO. INTERNATIONAL PLC+
Ioannis Masvoulas, CFA
Equity Analyst
+44 20 7425-0427
Ioannis.Masvoulas@morganstanley.com

MORGAN STANLEY & CO. INTERNATIONAL PLC+
Meredith M Pickett
Equity Strategist
+44 20 7677-3646
Meredith.Pickett@morganstanley.com

MORGAN STANLEY & CO. INTERNATIONAL PLC+
Robert Pulleyn
Equity Analyst and Commodity Strategist
+44 20 7425-4388
Robert.Pulleyn@morganstanley.com

MORGAN STANLEY & CO. INTERNATIONAL PLC+
Mark D Purcell
Equity Analyst
+44 20 7677-8557
Mark.Purcell@morganstanley.com

MORGAN STANLEY & CO. INTERNATIONAL PLC+
Amy Sergeant, CFA
Equity Analyst and Commodities Strategist
+44 20 7677-6937
Amy.Sergeant@morganstanley.com

MORGAN STANLEY & CO. INTERNATIONAL PLC+
Arthur Sitbon, CFA
Equity Analyst
+44 20 7425-5371
Arthur.Sitbon@morganstanley.com

MORGAN STANLEY MÉXICO, CASA DE BOLSA, S.A. DE C.V.+
Alejandra Obregon
Research Associate
+52 55 5282-6732
Alejandra.Obregon@morganstanley.com

MORGAN STANLEY C.T.V.M. S.A.+
Alexandre Zimmermann
Research Associate
+55 11 3048-6044
Alexandre.Zimmermann@morganstanley.com

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Inequality, rising demand and increasingly unpredictable supply

Water is essential to life, finite and unevenly distributed. Water usage has risen six-fold in the last century, yet 2 billion people still lack access to safely managed drinking water and 3.6 billion to safely managed sanitation. Demand is set to rise another ~30% by 2050 with agricultural withdrawals (70% of total demand) needing to increase to feed a growing population along with incremental needs from industry and mining. At the same time climate change and the energy transition alter the patterns of supply and demand in ways that are hard to predict.

Water pricing is complex: price rarely covers costs, and this hinders investment. We look at the potential for market-based solutions, the role of governments and regulation (could carbon provide a blueprint for water pricing?). Industrial consumers will increasingly need to focus on water efficiency. We explore the most water-intensive sectors, and look at which companies are leading the way in reducing water usage.

Innovations in technology will help: desalination, crop science, micro-irrigation, metering & digital solutions and vertical farming. For each of these, we list 'solution stocks' – companies with revenue exposure to these technologies. For water-intensive companies, we focus on direction of travel to identify 'transition stocks' – companies with high water usage today but clear action plans to reduce consumption.

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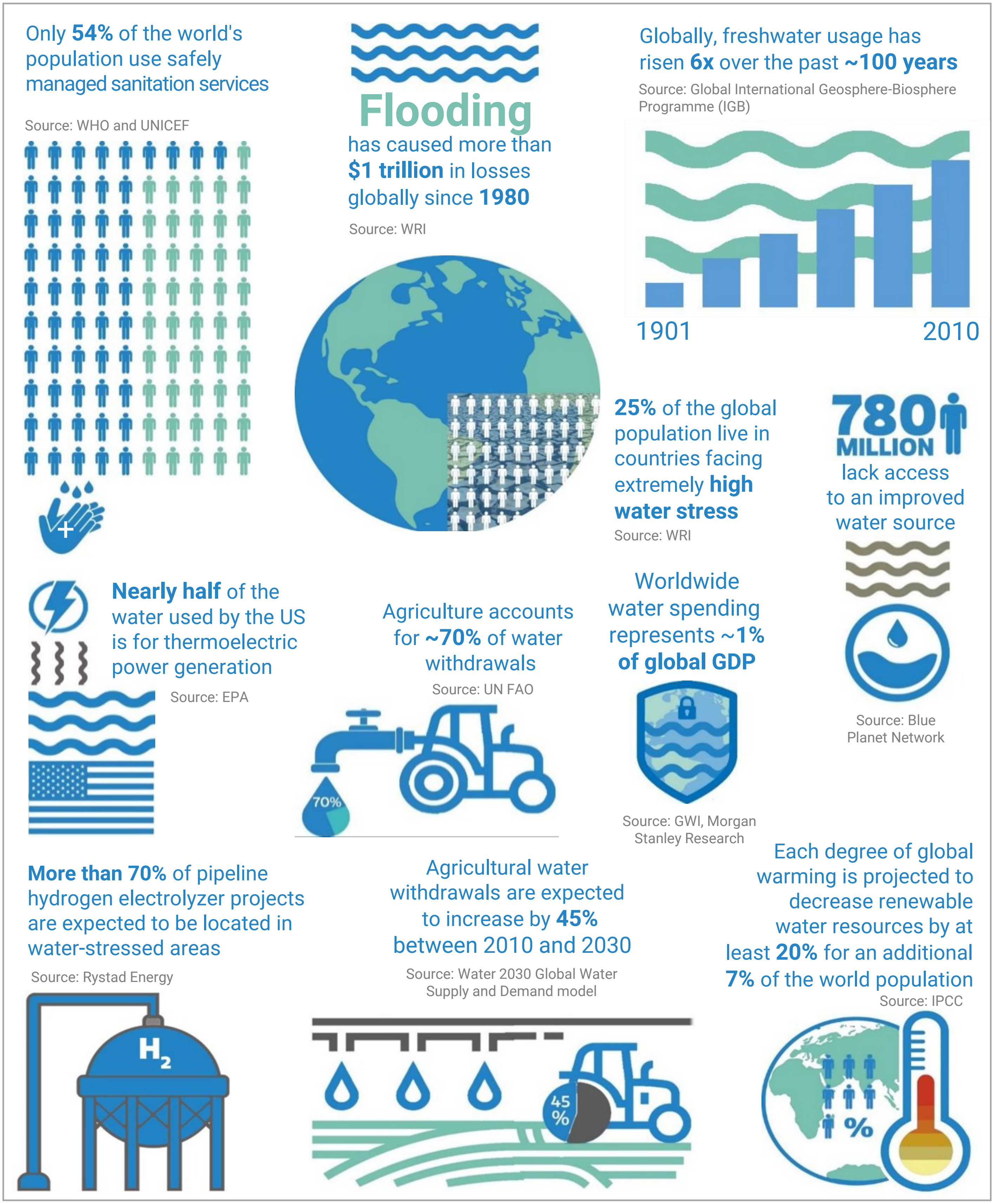
Exhibit 1:



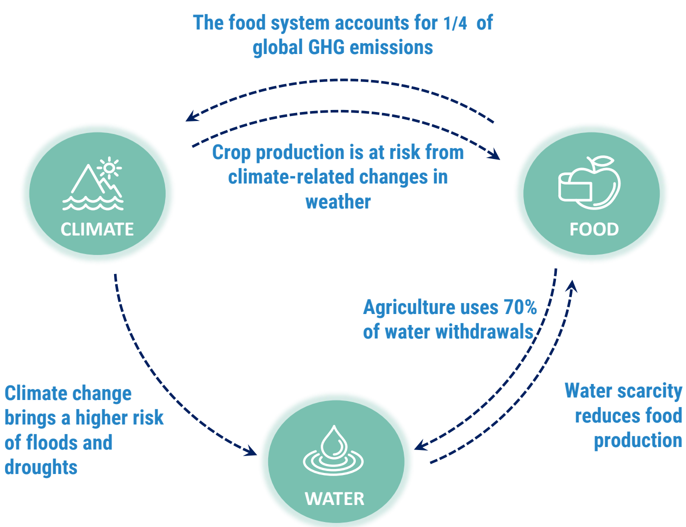
Source: Morgan Stanley Research

Changing Tides: Summary

Water demand is set to increase by ~30% over the next 30 years,[1] *at a time when climate change will put incremental pressure on already stretched water sources. Tension over access to sufficient water by industry, agriculture and municipalities could lead to increased scrutiny, greater regulation, and ultimately higher costs.*

Water, Climate and Food: A trilogy of sustainability challenges. In our previous Blue Papers Decarbonisation: The Race to Net Zero and The Future of Food: Complexities and Compromises we explored the investment implications of halting climate change and providing sufficient nutritious food for 10 billion people. We now turn to the third sustainability challenge: Water. The three are intrinsically linked: agriculture uses ~70% of global water withdrawals, whilst climate change will alter the hydrological cycle, resulting in greater risk of floods in some areas and drought in others. This in turn will present new pressures for crop production.

Exhibit 2: Climate, Food and Water – Interrelated Sustainability Challenges

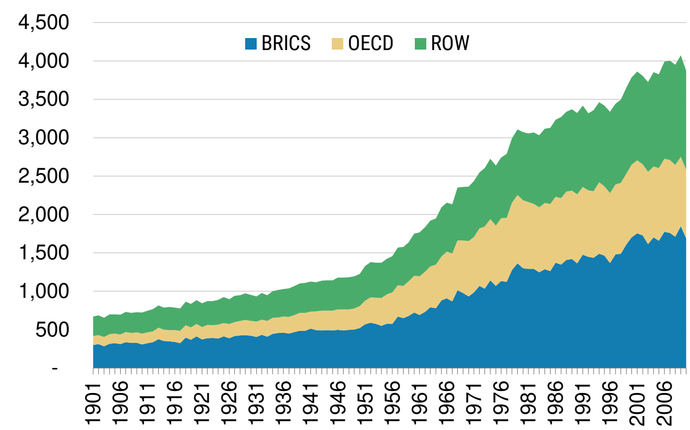


Source: Morgan Stanley Research

Water is potentially the most complex and costly to solve for. None of these topics is simple, but water's unique characteristics make the problems here particularly challenging. First, it is finite. Whereas we can produce more food, we cannot make more water. Second, it is difficult and costly to transport. Energy and food can be transferred over large distances, but water is a regionally specific commodity. Third, water is underpriced compared to the cost of provision, with an absence of free markets to set prices according to supply and demand dynamics. Clearly, water is essential to life, so issues of pricing are not straightforward. It can thus be difficult for providers of capital to make attractive returns on investment.

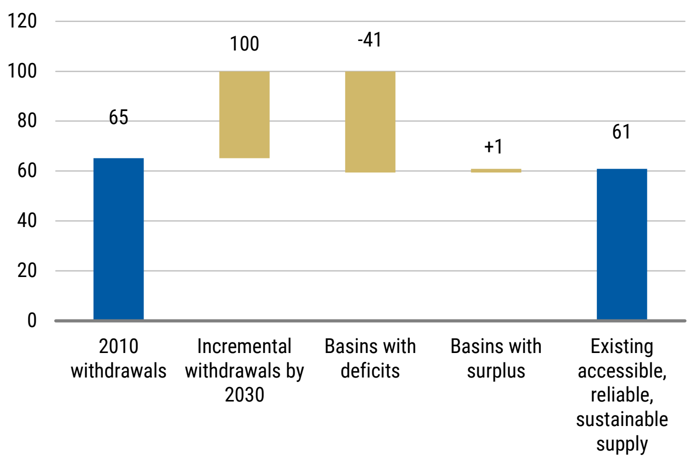
Exhibit 3: Water withdrawals have increased six-fold in the last 100 years

Global freshwater usage (bn cubic metres)



Source: Global International Geosphere-Biosphere Programme (IGB) via Our World in Data, Morgan Stanley Research

Exhibit 4: A 40% gap between demand and renewable supply of water is already expected by 2030 (bn m3)



Source: Water 2030 Global Water Supply and Demand model; agricultural production based on IFPRI IMPACT-WATER base case via 2030 water resource group; Numbers rebased with 2030 demand = 100

1 Burek et al 2016

The Challenge: Inequality, Rising Demand, Increasingly Unpredictable Supply

There is still a long way to go to address water inequality ... 2 billion people still lack safely managed drinking water, and 3.6 billion have no access to safely managed sanitation.[2] The UN's 6th Sustainable Development Goal aims to ensure availability and sustainable management of water and sanitation for all, and yet 129 countries are still not on track to have sustainably managed water resources by 2030. See Sustainability: SDG#6: Clean Water and Sanitation - Impact Ideas (31 May 2018). Achieving SDG 6.1 and 6.2 could cost in the range of $1.1 trillion and $2.5 trillion, according to World Bank estimates.[3]

. . . while the energy transition and feeding a growing global population will drive incremental water demand. Nearly 70% of water withdrawals are used for agriculture. With food demand set to increase by 50% over the next 30 years[4] the pressure on water supply for the agricultural sector will intensify. As the power sector decarbonises, direct water withdrawals could be largely unchanged out to 2050 in a net zero scenario, as higher water usage for nuclear and biogas offset the declines in thermal power generation. However, we estimate that hydrogen and copper (needed for renewables, EVs and the power grid) will require incremental water use of ~12 billion m3 a year. This is a drop in the ocean compared to global water withdrawals of ~4100 billion m3 a year, but more than 70% of possible 2040 hydrogen capacity is likely to be located in water-scarce regions.[5] Copper too is largely produced in regions of medium to high aridity.

2 https://sdgs.un.org

3 https://openknowledge.worldbank.org

4 World Resources Institute, OECD, Morgan Stanley Research estimates

5 Rystad

At the same time, climate change will affect water patterns in ways that are hard to predict. The earth's lower atmosphere is becoming warmer and moister due to the rise in greenhouse gas emissions. This, in turn, is increasing the frequency and intensity of storms and extreme weather events, leading to more droughts in some regions – such as the US Southwest, which could potentially trend towards mega-drought periods on some predictions,[6] and higher flood risk, especially in East Asia and South Asia.[7] Some areas are subject to both types of water risk: for example, Brazil experienced the worst drought in a century in 2021,[8] but is now seeing unprecedented levels of rainfall, which are flooding crop fields and disrupting mining operations.[9] By 2040, the World Resources Institute expects an additional 9 countries to be exposed to high and extremely high water risk, taking the total to 57.

By 2050, water scarcity in some regions could impact GDP growth by up to 11.5%, the World Bank estimates. Analysis from the World Bank suggests that constrained water supply could impact global GDP by -0.49% to 0.09% in 2050, depending on the policies adopted – Exhibit 8 . However, this masks significant differences at a regional level: for Central Asia and the Middle East, for example, the impact is estimated to be double-digit percentages of GDP.[10]

6 EDF

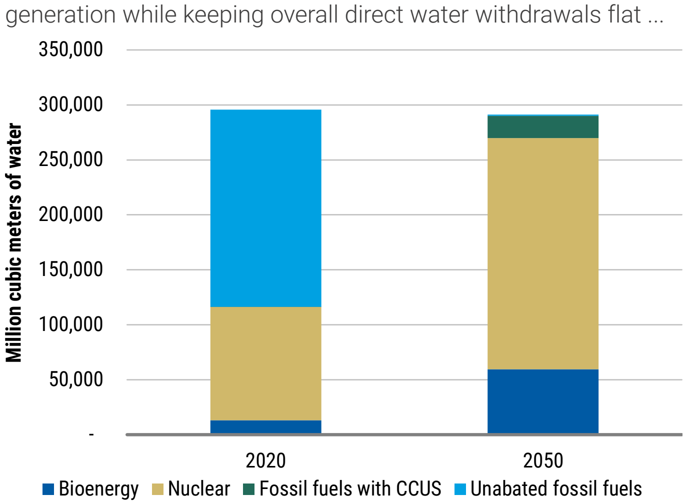
7 World Bank

8 https://www.ft.com

9 https://www.reuters.com

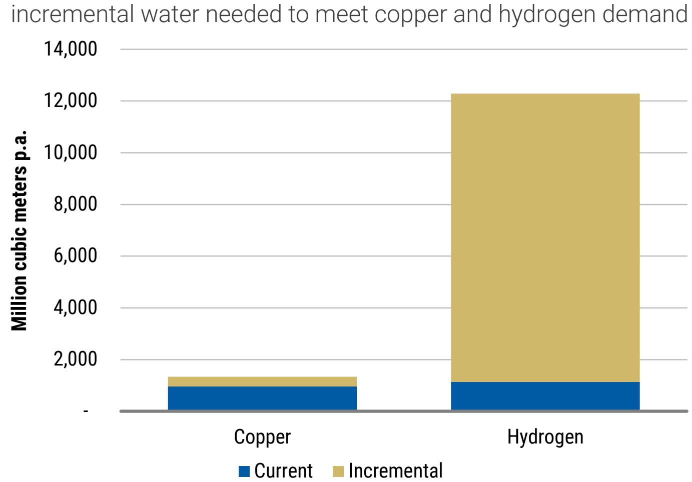
10High and Dry: Climate Change, Water and the Economy, The World Bank, 2015

Exhibit 5: Achieving net zero should change the use mix of power generation while keeping overall direct water withdrawals flat ...



Source: IEA net zero scenario, Morgan Stanley Research

Exhibit 6: ... but water scarcity could make it hard to access the incremental water needed to meet copper and hydrogen demand



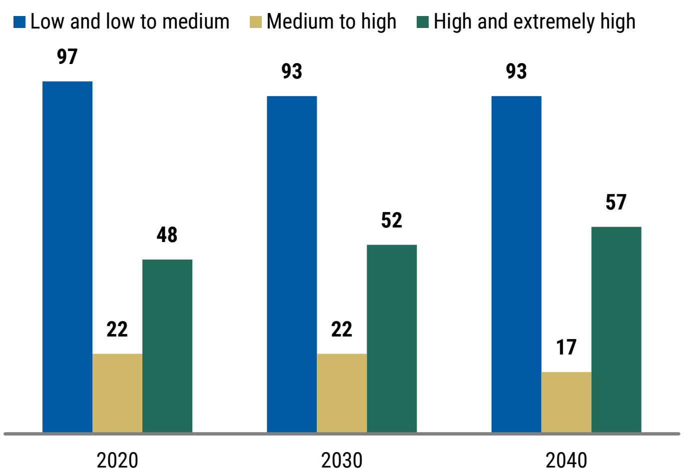
Note: please see "Water and the Energy Transition" for methodology. Source: IEA net zero scenario, Morgan Stanley Research, company data, Hydrogen Council

What Are The Solutions?

Infrastructure investment is needed to address water inequality – the water cost curve is steep

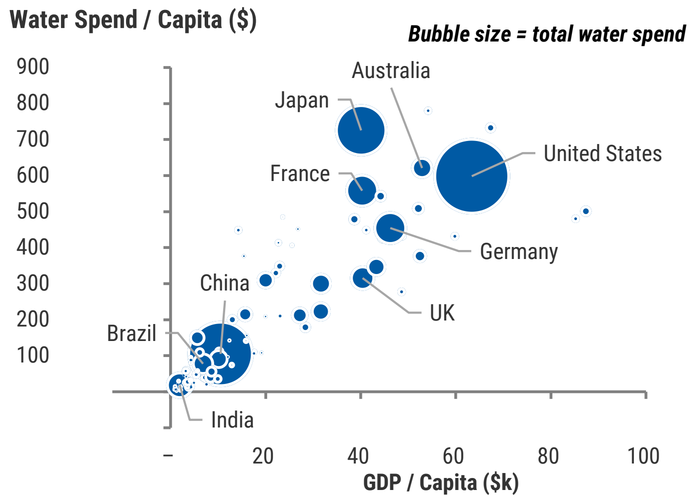
Over the next 4 years, we estimate $1.4 trillion will be invested in expanding and improving global water infrastructure. Most countries, regardless of income level, spend around 1% of GDP on water (capex & opex), which implies a global annual growth rate of low single digits. But the cost curve of drinking water resources is steep – the average cost of new supply is double the cost of existing cost of supply, while many solutions are 10-20 times more expensive. Additionally, the dual impacts of global urbanization and low penetration of sanitation services in the developing world will likely require significant development of wastewater treatment networks, which are far more capital-intensive than drinking water provision.

Exhibit 7: Another 9 countries will have high and extremely high water risk by 2040



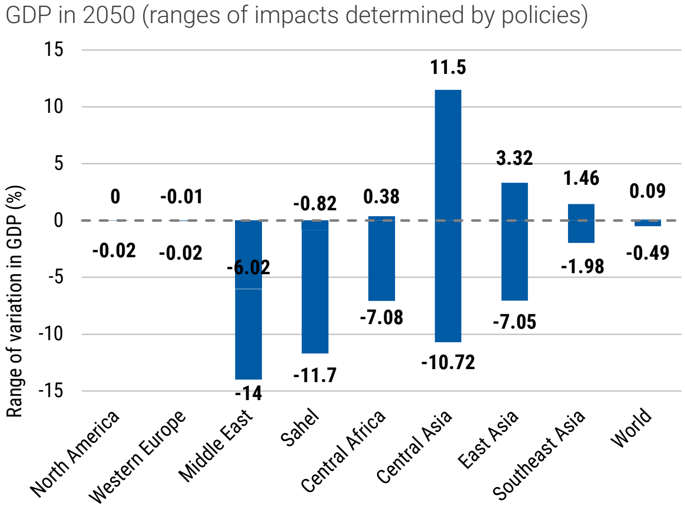
Source: WRI, Morgan Stanley Research

Exhibit 9: Water spend tends to correspond to country level GDP, and we expect spending growth to largely reflect GDP growth …



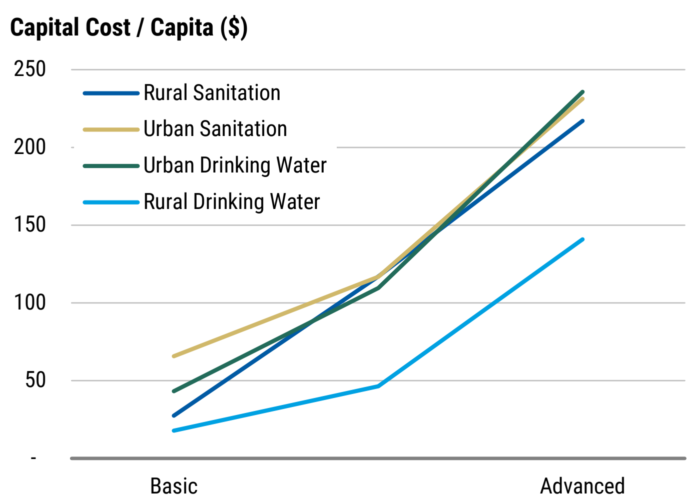
Source: GWI, UN, IMF, AQUASTAT, Morgan Stanley Research

Exhibit 8: How climate-related effects on water could impact GDP in 2050 (ranges of impacts determined by policies)



Source: World Bank 2015a Note: The figure shows the range of potential GDP impacts that could result from climate-related effects on water. It incorporates effects from different growth scenarios (SSP1 and SSP3) as well as different policy scenarios (business-as-usual policies and policies that encourage better water allocation).

Exhibit 10: … but the cost curve is steep, implying that developing countries will increasingly have to fund more expensive services



Source: World Bank Group, Morgan Stanley Research

Pricing water is a complex issue, and this hinders investment. Water is a regionally specific and opaquely managed commodity. Although this is also true for a number of food commodities, the status of water as a naturally-occurring commodity and basic human need means pricing needs to incorporate not only supply and demand but also societal equity. As a result, water rarely covers its costs, limiting financial incentives for investing in expensive water-related infrastructure.

A combination of market-based mechanisms and regulation may be needed. The constraints on supply and need for investment could create upwards pressure on pricing. The UN estimates that, globally, only 14% of water utilities cover their full economic costs without subsidies. Parallels can be drawn with carbon, where it has taken regulatory involvement and the introduction of carbon taxes of various types to accelerate investment in the green transition. Australia already has a relatively sophisticated water market system that has been in operation for decades and allows the trading of water rights on either a temporary or permanent basis through various contracting mechanisms. In the US, Nasdaq launched the Nasdaq Veles California Water Index in late 2020, and the CME Group has begun marketing an affiliated futures contract. This contract attempts to track the spot market prices of water in California, which faces drought-related and overall water-scarcity related concerns.

Industry has a role to play in improving water efficiency

We assess the key challenges and potential solutions by sector and identify front-footed companies in tackling water efficiency. Energy producers and utilities are the most water-intensive companies, but water is also a key resource in chemicals, mining, construction materials, food & beverages, apparel, pharmaceuticals, semiconductors and data centres.

Companies are starting to implement strategies to reduce water consumption or use alternative, more sustainable, water sources. For example, mining companies are implementing water recycling and reuse strategies (supported by thickened tailings technology) but in certain regions are also starting to draw on sea water through the use of desalination technologies.

Exhibit 11: Key water challenges faced by water-intensive industries and potential solutions

Sector	Average water intensity [m3/$]	Problems	Solutions
Utilities	210,118	· Water and electric utilities are the most water intensive sub-industries · "Thermal pollution" (warm water returns to local ecosystems) is a risk to aquaculture	· Dry cooling - fans used to lower the temperature of the steam exiting the turbine · Using sea water (e.g. supported through desalination technologies)
Mining	16,265	· Water used extensively in mineral processing, dust suppression and slurry transport, among others · At a local level, mining operations can strain aquifers, which can lead to operational risk	· Water recycling and reuse (e.g. supported by thickened tailings technology) · Using sea water (e.g. supported through desalination technology)
Cement	4,665	· Water is used in the production of cement but the highest withdrawals are in the production of concrete	· Use water reducing admixtures (plasticizers) · Improve water recycling & water conservation (e.g. supported by closed-loop cooling) · Switching to groundwater away from public water
Pharma	3,715	· Water is a key input in product development (e.g. for processing, formulation and manufacturing) · Manufacturing requires high quality water; but pharma industry impacts local water quality	· Implementation of water purification systems · Installing condenser pumps and metering
Beverages	3,561	· Water is the key ingredient in beer (~90% of beer is water) · Water is also necessary for the growth of other main ingredients (e.g. grain and hops)	· Implementing more efficient techniques (e.g. installing meters to detect leaks) and increasing water recycling rates (e.g. supported by UV-light bacteria elimination technologies) · Implementing water purification systems allowing for saline-contaminated water to be used
Semiconductors	1,869	· Water intensity driven by rinsing & cooling processes and the need for ultra-pure water (UPW) · Wastewater generated in the process can be contaminated/toxic · Lots of production is concentrated in arid areas	· Water reduction, recycling and reuse (e.g. supported by water reclamation technologies)
Apparel	1,046	· Water intensity driven by various aspects - e.g. growing crops (e.g. cotton), raw fiber processing & domestic washing of clothing · Textile industry is responsible for the release of hazardous chemicals into local ecosystems	· Technological innovations can reduce water usage in finishing, fabric dying & other processes (e.g. modifying the bleaching process with the oxidant ozone) · Recycling and reusing water
Data Centres	623	· Regulating the temperature of data centres requires dry or wet cooling systems (highly water intensive) · Data centres are often located in water stressed regions	· Implementing water metering systems

Source: Morgan Stanley Research

Technology solutions are also essential

We look at five potential solutions to water stress – desalination, crop science, smart irrigation, metering & digital solutions, and vertical farming. These technologies are already commercial on a small scale, but we expect to see greater adoption over the next decade.

- **Desalination**. With ~97% of global water sources concentrated in the oceans and seas, desalination is one of the feasible solutions to freshwater shortage. It is one of the most climate-change resilient sources of water provision, independent of changes in weather patterns, drought and rising temperatures. Current capacity is equivalent to ~ 1% of total freshwater demand but is forecast to grow by ~9% a year over the next decade.[11] It will be needed for copper production and hydrogen, but is likely to be too expensive to provide a broad solution for agriculture.
- **Crop Science**. Seed innovation to adjust specific traits and characteristics has driven material yield enhancements in the last 30 years in conventional and genetically modified (GM) seeds. For example, 'Scuba Rice' enables the rice crop to withstand flooding, whereas the Sahod Ulan rice variety is designed to be drought-tolerant.
- **Smart Irrigation.** Many different irrigation methods are used worldwide, but we expect micro-irrigation to grow at a faster pace given its environmental and economic benefits (reduced water loss, improved crop efficiency, reduced labour intensity and lower methane emissions). We estimate the total addressable micro-irrigation market at around US$17 billion by 2025, implying an additional US$10 billion market opportunity versus 2018 levels. This is equivalent to at least another 4.4 million hectares under micro-irrigation, a 40% increase on current levels.
- **Metering & Digital Solutions**. These can improve resource use transparency, infrastructure efficiency and limit non-revenue water losses for municipalities and utilities. Globally, only ~70% of water supply is connected to a meter, and penetration of communicating metering technology (which can track demand in real time) is less than 20%. We expect utilities in developed markets to shift towards communicating metering technology, but non-communicating meters will likely remain a large portion of the global market for some time. Back-end digital solutions that manage data produced by meters are at an earlier phase of adoption, but will likely grow well above historical standalone metering growth (~3.5%). They are becoming increasingly important as water infrastructure solutions, helping utilities with data management and analytics, demand forecasting, leak detection, water analysis and network optimization.
- **Vertical farming**. Vertical Farming is a resource-efficient approach to growing certain types of food produce. It requires a controlled, indoor environment with crops typically grown on a series of stacked layers. This new technology-enabled farming means crops can be grown reliably, supply chains secured, with a materially higher yield per vertical layer than in conventional field farming. Vertical farming technologies can enable water savings of between 80-95% when compared with traditional agriculture.

Solution Stocks and Transition Stocks

Solution stocks

We have identified 78 listed companies that have exposure to the Water investment theme. We provide a list of 35 public companies and highlight a further 51 private companies with revenue exposure to desalination, crop science, smart irrigation, vertical/indoor farming or metering & digital solutions. We then cast the net wider to 43 listed companies exposed to such areas as piping solutions, water utilities and water engineering services. Note that our Solution stocks in Exhibit 12 are not a trading or model portfolio of recommended equity securities, but a selected list of companies that are exposed to the water investment theme.

Transition stocks

For water-intensive companies, we focus on direction of travel. We assess ~1,900 companies on two criteria to identify those with (a) relatively high water intensity levels in a sector context, but also (b) robust water target action plans in place relative to sector peers.

11 Technavio, grandviewresearch, researchandmarkets

Exhibit 12: Solution Stocks: We highlight 78 listed companies that are solution providers for Desalination, Seed Innovation, Smart Irrigation, Metering & Digital Solutions, Vertical/Indoor Farming or Broader Water Infrastructure

Ticker	Company	Mkt Cap USDmn	Stock Price		Rating	Analyst	Region	Revenue Exposure To Water (%)
Desalination								
ABG.MC	Abengoa SA	150	0.02	EUR	NC	NC	Europe	<5%
ANA.MC	Acciona SA	9,261	148	EUR	NC	NC	Europe	<5%
APBS.OM	ACWA Power Barka SAOG	199	0.48	OMR	NC	NC	EMEA	43%
ANDR.VI	Andritz AG	5,585	47	EUR	Overweight	Davies, Robert	Europe	<5%
0371.HK	Beijing Enterprises Water Group Ltd	3,957	3	HKD	Equal-Weight	Hou, Eva	Asia/Pacific	100%
034020.KS	Doosan Heavy Industries & Construction Co Lt	8,746	17,450	KRW	NC	NC	Asia/Pacific	13%
7004.T	Hitachi Zosen Corp	1,099	786	JPY	NC	NC	Asia/Pacific	30%
6303.T	Sasakura Engineering Co Ltd	65	2,410	JPY	NC	NC	Asia/Pacific	32%
2727.HK	Shanghai Electric Group Co Ltd	9,663	2	HKD	Underweight	Hou, Eva	Asia/Pacific	<5%
VATE.NS	Va Tech Wabag Ltd	260	312	INR	NC	NC	Asia/Pacific	100%
VIE.PA	Veolia Environnement SA	25,669	32	EUR	++	Sitbon, Arthur	Europe	42%
Smart Irrigation								
ABBN.S	Abb Ltd	71,175	32	CHF	Underweight	Uglow, Ben	Europe	<5%
AGCO.N	AGCO Corp	8,663	116	USD	Overweight	Yakavonis, Courtney	North America	<5%
ANDR.VI	Andritz AG	5,585	47	EUR	Overweight	Davies, Robert	Europe	<5%
BAYGn.DE	Bayer AG	59,699	53	EUR	Overweight	Quigley, James	Europe	<5%
DE.N	Deere & Co	114,711	372	USD	Overweight	Yakavonis, Courtney	North America	<5%
JAIR.NS	Jain Irrigation Systems Ltd	298	42	INR	NC	NC	Asia/Pacific	65%
LNN	Lindsay Corp	1,371	125	USD	NC	NC	North America	10%
6701.T	NEC Corp	12,032	5,090	JPY	Equal-Weight	Segawa, Hiroto	Japan	<5%
ORBIA.MX	Orbia Advance Corporation SAB de CV	4,769	49	MXN	Overweight	Lippmann, Nikolaj	Latin America	15%
VMI	Valmont Industries Inc	4,449	210	USD	NC	NC	North America	<5%
XYL.N	Xylem Inc	16,132	89	USD	Overweight	Lynagh, Connor	North America	100%
Crop Science								
BAYGn.DE	Bayer AG	59,699	53	EUR	Overweight	Quigley, James	Europe	<5%
BIOX.O	Bioceres Crop Solutions Corp	499	12	USD	NC	NC	Latin America	<5%
CTVA.N	Corteva Inc	36,117	50	USD	Overweight	Andrews, Vincent	North America	<5%
KWSG.DE	KWS SAAT SE & Co KgaA	2,549	68	EUR	NC	NC	Europe	<5%
Metering & Digital Solutions								
BMI.N	Badger Meter Inc	2,912	100	USD	Underweight	Lynagh, Connor	North America	90%-95%
IEX.N	IDEX Corp	15,053	198	USD	Overweight	Lynagh, Connor	North America	10%
ITRI.O	Itron Inc	2,600	57	USD	Equal-Weight	Lynagh, Connor	North America	25%
LANDI.S	Landis+Gyr Group AG	1,898	61	CHF	Underweight	Uglow, Ben	Europe	<5%
9551.T	Metawater Co Ltd	837	2,010	JPY	NC	NC	Asia/Pacific	100%
MWA	Mueller Water Products Inc	2,044	13	USD	NC	NC	North America	<5%
ROP.N	Roper Technologies Inc	46,753	443	USD	NC	NC	North America	5%
TDY.N	Teledyne Technologies Inc	19,683	422	USD	Underweight	Liwag, Kristine	North America	35%
XYL.N	Xylem Inc	16,132	89	USD	Overweight	Lynagh, Connor	North America	100%
Vertical/Indoor Farming								
APPH.O	AppHarvest Inc	309	3	USD	NC	NC	North America	100%
CUB.TO	CubicFarm Systems Corp	159	1	CAD	NC	NC	North America	100%
KALK.OL	Kalera AS	156	7	NOK	NC	NC	Europe	100%
Broader Water Infrastructure & Solutions								
AALB.AS	Aalberts NV	6,774	54	EUR	Equal-Weight	Calderon Tejedor, Aurelio	Europe	<5%
AWR	American States Water Co	3,283	89	USD	NC	NC	North America	92%
AOS	A O Smith Corp	11,756	74	USD	NC	NC	North America	100%
WMS.N	Advanced Drainage Systems Inc	8,067	112	USD	Equal-Weight	Pokrzywinski, Joshua	North America	100%
ALFA.ST	Alfa Laval AB	13,491	294	SEK	Underweight	Davies, Robert	Europe	<5%
AWK	American Water Works Company Inc	28,215	155	USD	NC	NC	North America	100%
CWT	California Water Service Group	3,128	59	USD	NC	NC	North America	100%
0855.HK	China Water Affairs Group Ltd	1,995	10	HKD	NC	NC	Asia/Pacific	93%
SBSP3.SA	Companhia de Saneamento Basico do Estado	4,568	36	BRL	Equal-Weight	Rodrigues, Miguel	Latin America	56%
DHR	Danaher Corp	203,762	285	USD	NC	NC	North America	10%
ECL.N	Ecolab Inc	53,499	187	USD	Equal-Weight	Andrews, Vincent	North America	<5%
ERII.O	Energy Recovery Inc	1,058	19	USD	NC	NC	North America	77%
WTRG.K	Essential Utilities Inc	11,876	47	USD	NC	NC	North America	96%
AQUA.K	Evoqua Water Technologies Corp	5,142	43	USD	NC	NC	North America	58%
FERG.L	Ferguson PLC	33,219	11,190	GBp	Equal-Weight	Vermeulen, Annelies	Europe	<5%
FELE.O	Franklin Electric Co Inc	3,877	84	USD	NC	NC	North America	59%
GEBN.S	Geberit AG	23,516	607	CHF	Underweight	Ekblom, Cedar	Europe	20%
GENG.L	Genuit Group PLC	1,830	545	GBp	NC	NC	Europe	85%
FIN.S	Georg Fischer AG	5,641	1,271	CHF	NC	NC	Europe	54%
0270.HK	Guangdong Investment Ltd	9,134	11	HKD	NC	NC	Asia/Pacific	57%
HLMA.L	Halma PLC	12,409	2,416	GBp	NC	NC	Europe	5%
IR.N	Ingersoll Rand Inc	22,242	55	USD	Overweight	Pokrzywinski, Joshua	North America	<5%
6370.T	Kurita Water Industries Ltd	4,806	4,715	JPY	NC	NC	Asia/Pacific	100%
LIN.N	Linde PLC	151,957	296	USD	Overweight	Andrews, Vincent	North America	<5%
NZYMb.CO	Novozymes A/S	14,351	409	DKK	NC	NC	Europe	<5%
MSEX.O	Middlesex Water Co	1,701	97	USD	NC	NC	North America	100%
6368.T	Organo Corp	780	7,720	JPY	NC	NC	Asia/Pacific	82%
PNN.L	Pennon Group PLC	3,792	1,042	GBp	Equal-Weight	Laybutt, Christopher	Europe	100%
PNR.N	Pentair PLC	9,954	60	USD	Underweight	Pokrzywinski, Joshua	North America	34%
PKI	PerkinElmer Inc	23,030	182	USD	NC	NC	North America	30%
PRMW.TO	Primo Water Corp	2,593	20	CAD	NC	NC	North America	100%
ROR.L	Rotork PLC	3,895	335	GBp	Overweight	Davies, Robert	Europe	13%
SVT.L	Severn Trent PLC	9,464	2,795	GBp	Overweight	Laybutt, Christopher	Europe	100%
SJW	SJW Group	1,971	66	USD	NC	NC	North America	99%
STN.TO	Stantec Inc	5,889	67	CAD	NC	NC	North America	5%
SUN.S	Sulzer AG	3,085	83	CHF	Equal-Weight	Calderon Tejedor, Aurelio	Europe	13%
TTEK.O	Tetra Tech Inc	7,904	146	USD	NC	NC	North America	6%
UU.L	United Utilities Group PLC	9,525	1,033	GBp	Underweight	Laybutt, Christopher	Europe	100%
UPONOR.HE	Uponor Oyj	1,652	20	EUR	NC	NC	Europe	77%
WTS	Watts Water Technologies Inc	5,050	150	USD	NC	NC	North America	13%
WBSV.VI	Wienerberger AG	4,100	31	EUR	Equal-Weight	Ekblom, Cedar	Europe	10%
YORW.O	York Water Co	567	43	USD	NC	NC	North America	100%
ZWS	Zurn Water Solutions Corp	3,764	30	USD	NC	NC	North America	<5%

Prices as at 7th February. NC = Not covered by Morgan Stanley, NA = Not applicable. ++ Stock Rating for this company have been removed from consideration in this report because, under applicable law and/or Morgan Stanley policy, Morgan Stanley may be precluded from issuing such information with respect to this company at this time. Source: ISS, GWI, Morgan Stanley Research

The Supply-Demand Picture Today

Water is a critical resource for sustaining life, industry, agriculture and energy production

The world is entirely dependent on water. 70% of the world's surface area is covered by water, yet only 3% is the freshwater needed to support human life/health and wildlife (source: USBR). Further, water is a key input into agriculture, industries and energy production. But water systems face a significant threat due to overuse or unsustainable management and climate change.

The demand map

Water withdrawals have risen six-fold in the past century

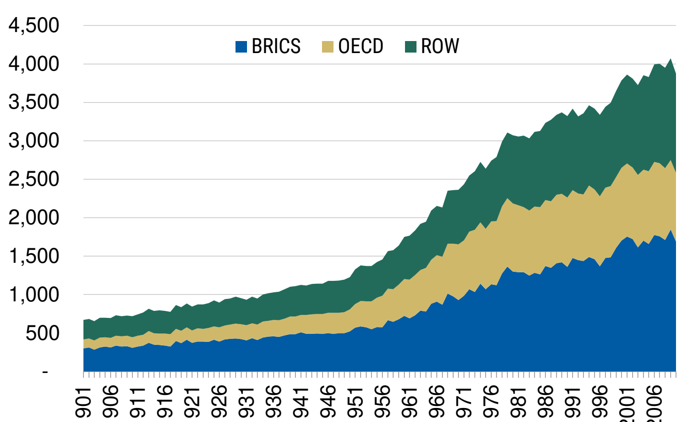
Globally, freshwater usage totalled~700bn cubic metres (m3) of withdrawals in the early 1900s; by 2010 this had increased to nearly ~4,100bn m3, driven by growth in agricultural, municipal and industrial water withdrawals. Most regions of the world have seen significant increases in freshwater usage, but growth has been highest across OECD countries – up by a factor of 8 in the past ~100 years – Exhibit 11 . Per capita water consumption increased by 17% in the OECD countries between 1960 and 2010 (Exhibit 15).

India, China and the US account for 45% of global water consumption. India consumes roughly ~760bn m3 of water a year (nearly 20% of the global total) closely followed by China at ~600bn (15% of the global total). The top 10 countries by water consumption (see Exhibit 16) account for two-thirds of total global consumption, with a country's absolute water consumption levels reflecting economic wealth and population size, among other factors. Per capita trends are murkier, and countries with major oil & gas or mining industries lead the list – for example, Turkmenistan has the highest per capita water consumption, followed by Chile and Guyana. Only the US and Iran appear in the top 10 leading water consumers on both an absolute and per capita basis.

Among the world's 10 largest economies, China, the US and India consume 7.4 times the amount of water used by the other 7 countries on the list on an absolute basis. In total, these 10 economies account for just over half of total global water usage.

Exhibit 14: Freshwater usage has risen six-fold globally since 1901 and eight-fold in OECD countries

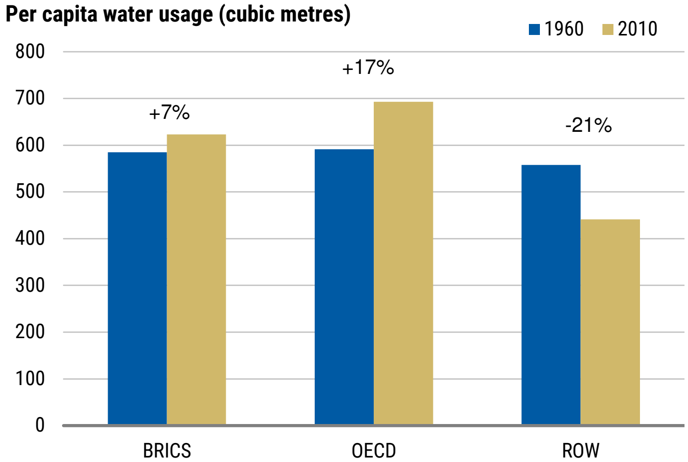
Global freshwater usage (bn cubic metres)



Source: Global International Geosphere-Biosphere Programme (IGB) via Our World in Data

Exhibit 15: Per capita consumption rose by 7% in BRICS countries and 17% in OECD countries between 1960 and 2010

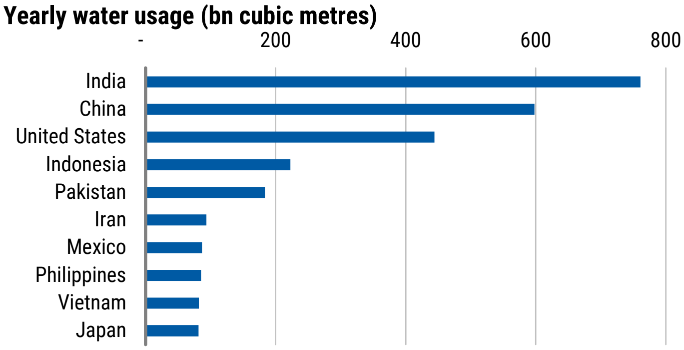
Per capita water usage (cubic metres)



Source: Global International Geosphere-Biosphere Programme (IGB) via Our World in Data, World Bank Development Indicators, Morgan Stanley Research

Exhibit 16: Top 10 water users: On an absolute basis, India consumes as much as the US, Indonesia and Iran combined

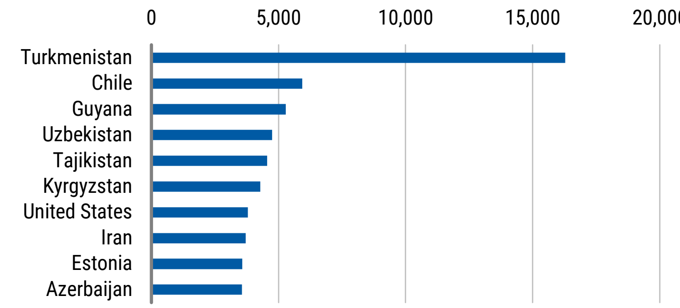
Yearly water usage (bn cubic metres)



Source: World O Meter latest data available for each country up to 2017, Morgan Stanley Research

Exhibit 17: Top 10 water users: On a per capita basis, Turkmenistan leads on water consumption, followed by Chile

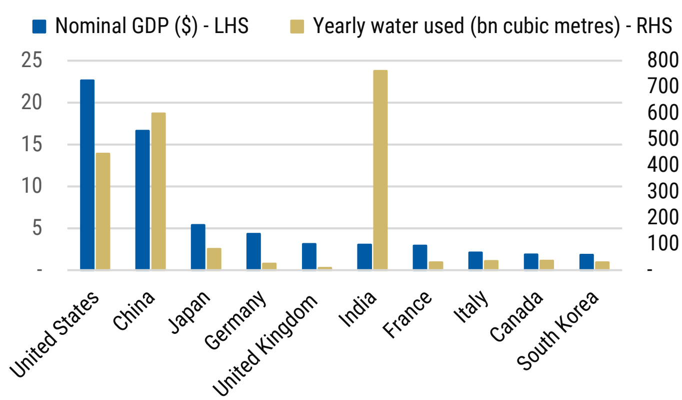
Daily per capita water usage (liters)



Source: World O Meter latest data available for each country up to 2017, Morgan Stanley Research

Exhibit 18: Top 10 largest economies: India has a relatively high absolute water footprint relative to GDP

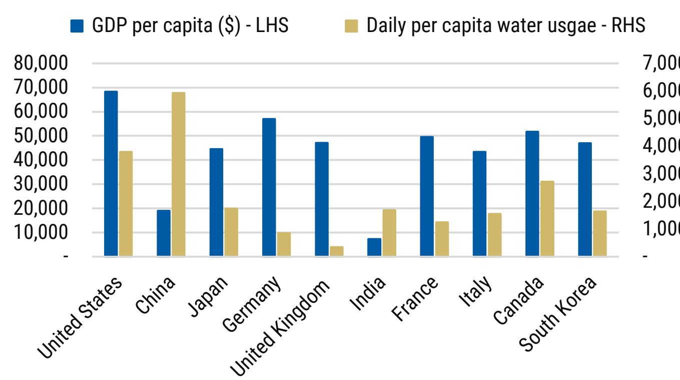
Top 10 largest econonomies: Absolute GDP vs water usage



Source: World O Meter latest data available for each country up to 2017, CMC Markets, Morgan Stanley Research

Exhibit 19: Top 10 largest economies: China has relatively high per capita water consumption relative to GDP

Top 10 largest econonomies: GDP per capita vs per capita water usage



Source: World O Meter latest data available for each country up to 2017, CMC Markets, Morgan Stanley Research

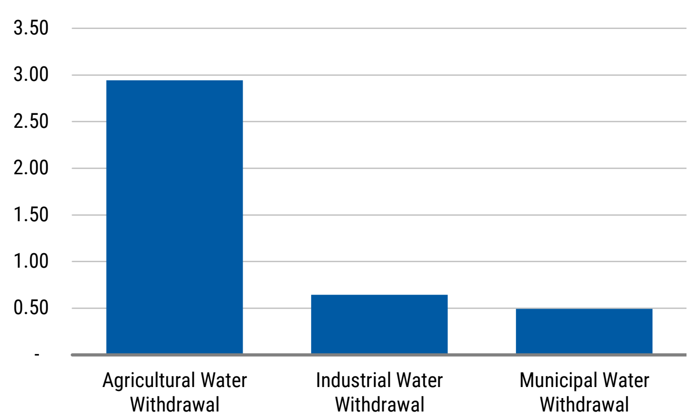
The demand mix by end use

Agriculture consumes ~3 trillion m3 of water globally every year. This is considerably more than total industrial water use (self-supplied industries not connected to the public distribution network) at 0.6 trillion m3 and municipal water use (water withdrawn primarily for direct use by the population) at 0.5 trillion m3 – Exhibit 20 .

This demand mix varies significantly by region, however. Agricultural water withdrawals range from 25% of total water usage in Eastern Europe to 82% in Asia Pacific, while industrial water usage is just 5% in the Middle East and Africa but 49% in Eastern Europe.

Exhibit 20: Agriculture withdraws nearly 3 times more water than industry and municipalities combined ...

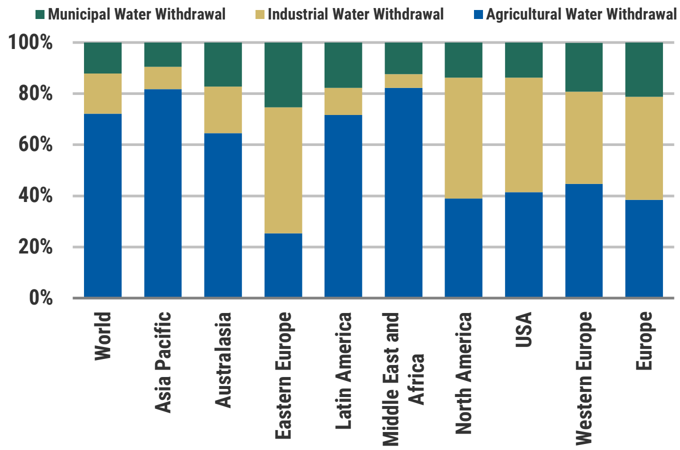
Water withdrawal by sector (trn cubic metres)



Source: Euromonitor 2020, Morgan Stanley Research

Exhibit 21: ... although the demand mix varies by region, with agriculture ranging from 25% to 82% of total withdrawals

% of water withdrawal by sector



Source: Euromonitor 2020, Morgan Stanley Research

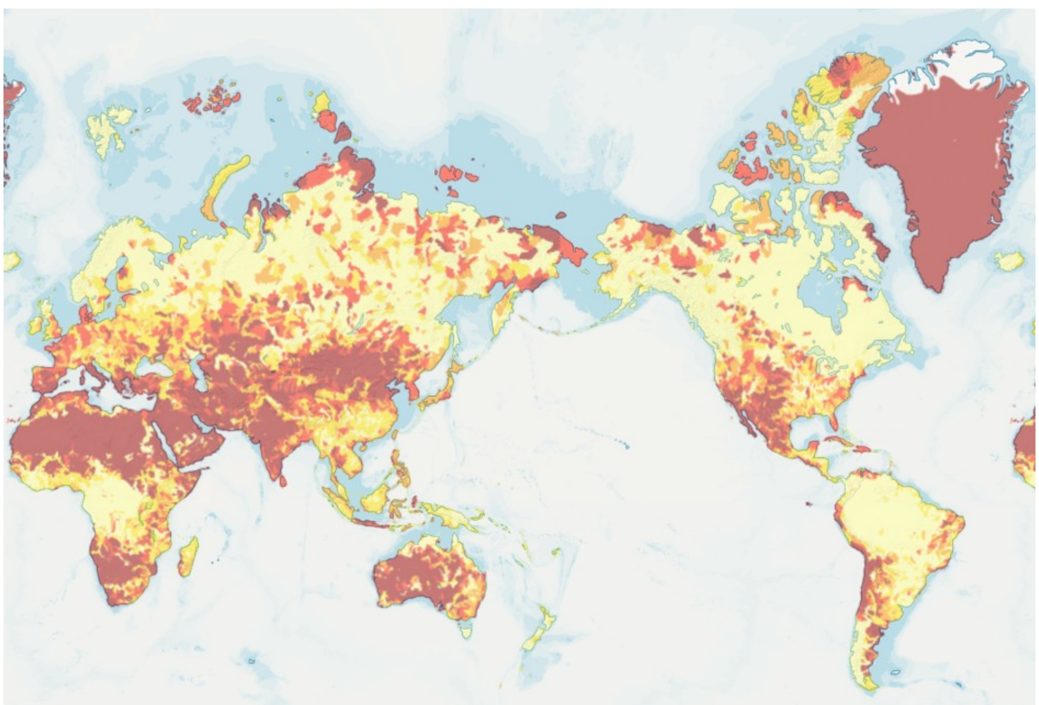
Supply – Where the water is …

Reliable access to renewable freshwater is unevenly distributed and in decline

The quantity of water available varies materially by region and country. The right balance is surprisingly rare – too little water and the area is deemed water scarce; too much water poses a risk of flooding. The WRI aqueduct tool helps visualize this physical water risk (too little or too much water). Exhibit 22 highlights a variety of water-related risks, notably water stress (the ratio of total water withdrawals to renewable water supplies), flood risk and drought risk. Regions just north of the Equator, South Africa, Australia and Greenland are areas of high risk for water quantity.

On water stress specifically, 8 of the 10 largest economies suffer from relatively low access to renewable water supplies. Renewable water resources include flow of rivers and recharge of aquifers generated from precipitation, as well as those water resources that are not generated in the country, such as inflows from upstream countries (groundwater and surface water) and part of the water of border lakes and rivers.[12] Eight of the 10 largest economies globally have lower per capita freshwater resources than the global average (see Exhibit 24). Notably, Germany, South Korea and India have materially low freshwater access, whilst Canada has 14 times more freshwater resources than the global average.

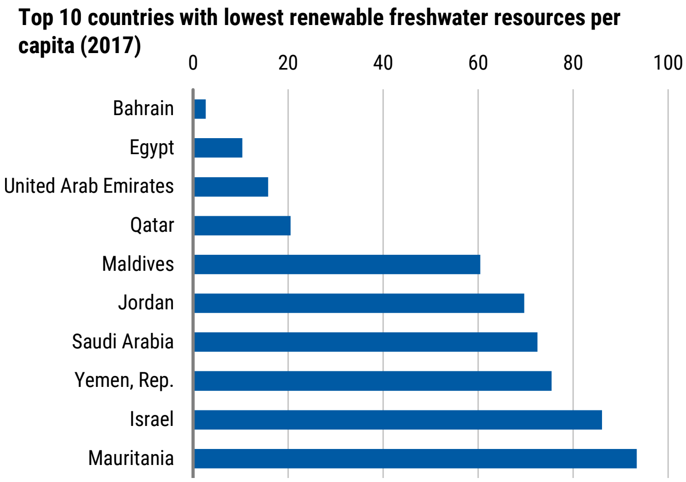
Exhibit 22: Visualizing physical water risks such as water stress, flood risk and drought risk – regions just north of the Equator, South Africa, Australia and Greenland are high risk



Source: Water Risk Atlas. Note: those lighter regions represent areas of low physical risk related to quantity of water, whilst those darker regions are areas of higher risk

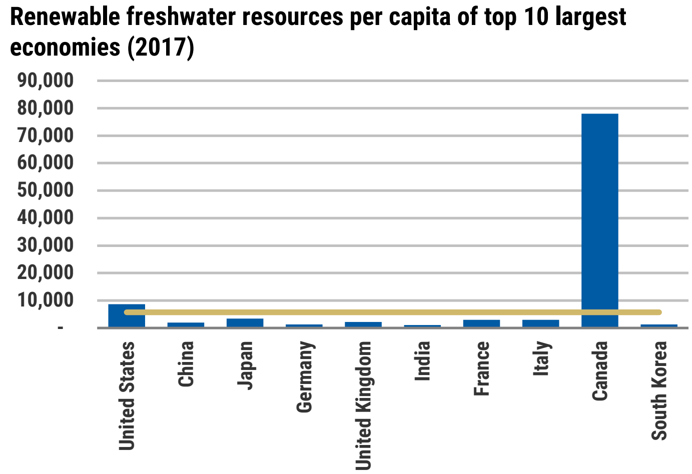
12 World Bank

Exhibit 23: Countries across the Middle East have the lowest access to renewable freshwater resources



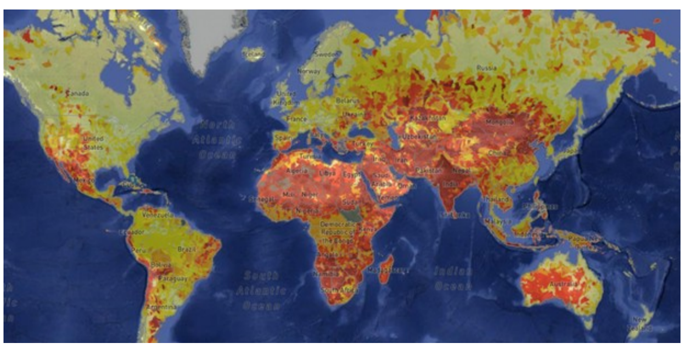
Source: World Bank, Morgan Stanley Research

Exhibit 24: 8 of the 10 largest economies have per capita freshwater resources below the global average



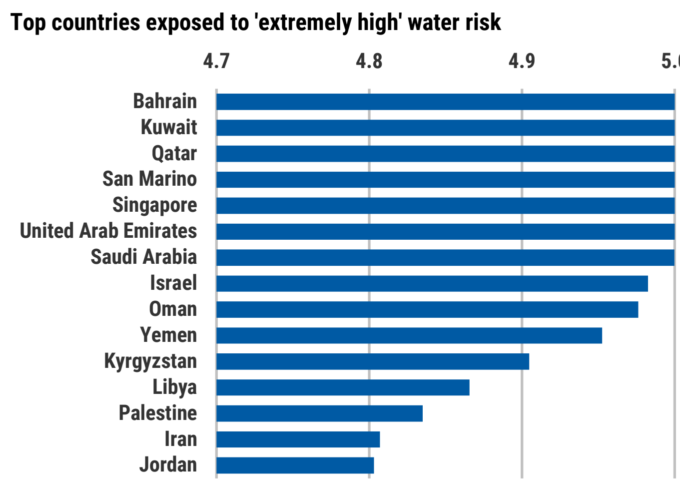
Source: World Bank, Morgan Stanley Research

Exhibit 25: Africa and Asia are experiencing particularly high water stress



Source: Water Risk Atlas. Note: Lighter regions represent areas of low water risk; darker regions are areas of higher water risk

Exhibit 26: Top 15 countries exposed to 'extremely high' water risk



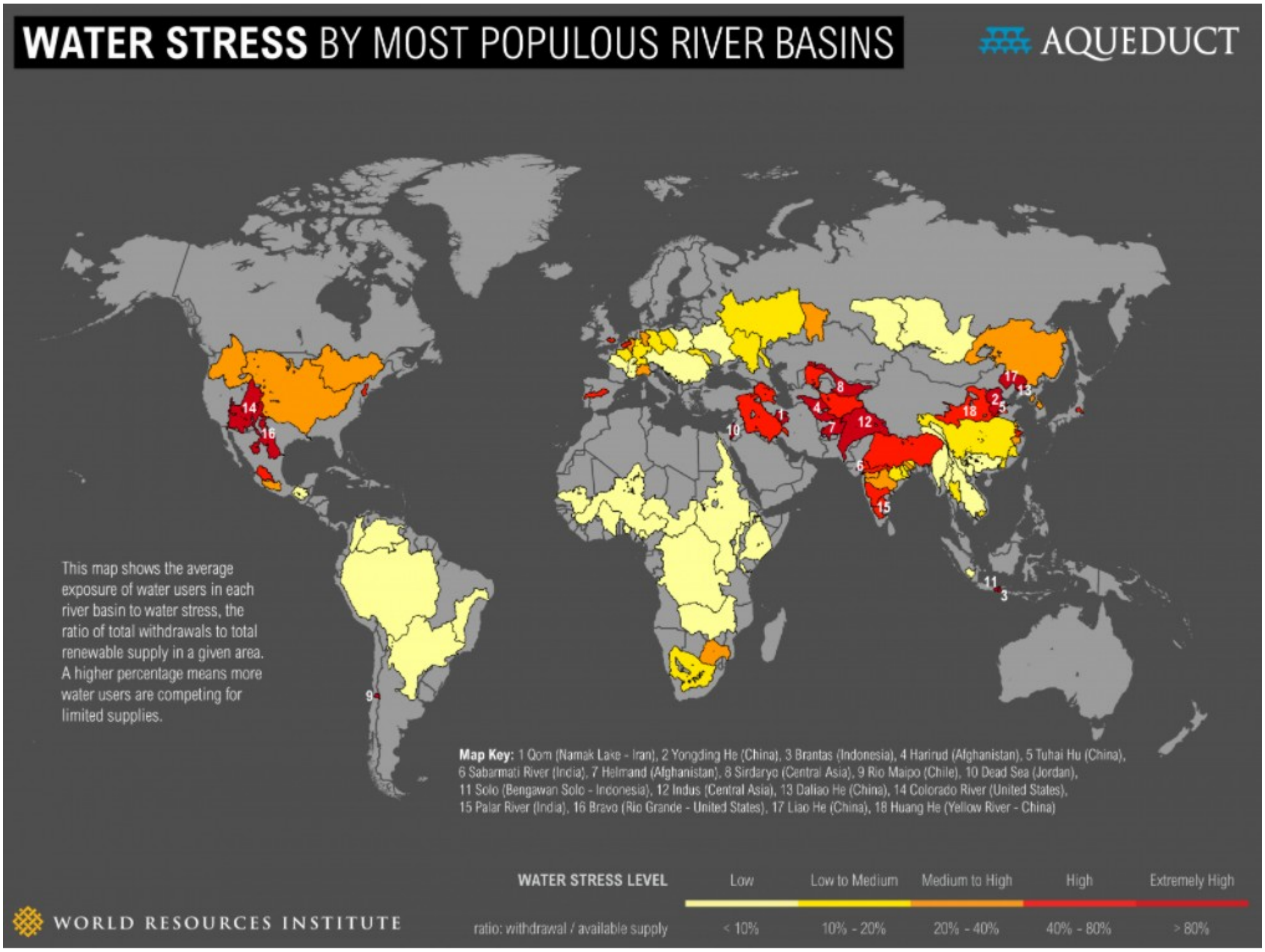
Source: WRI Aqueduct, Morgan Stanley Research

26 countries are exposed to 'extremely high' water risk – in Exhibit 26 we highlight the top 15. Water risk is measured by the WRI using 4 key categories: physical quantity, physical quality and regulatory & reputational risk. Exhibit 25 shows the overall water risk regionally, with darker regions representing areas of high risk. For example, the darkest red regions of India represent areas of 'extremely high' water risk, where up to 80% of available water resources, including groundwater, are used up every year.

Water basins are also increasingly exposed to depletion risk. Another means of assessing water stress is by analyzing the ratio of total water withdrawals in key river basins to total renewable supply. The 100 most populous river basins globally support billions of human lives. The increasing pressure on these water basins means that some are depleting at such a rate that they fail to reach their ocean destinations.[13] Pressures include material rises in water demand from irrigated agriculture, industrialization, and domestic users. In Exhibit 27 , WRI Aqueduct has mapped and scored stresses on water supplies in the 100 most populated water basins (darker regions represent areas of higher water stress).

13 WRI

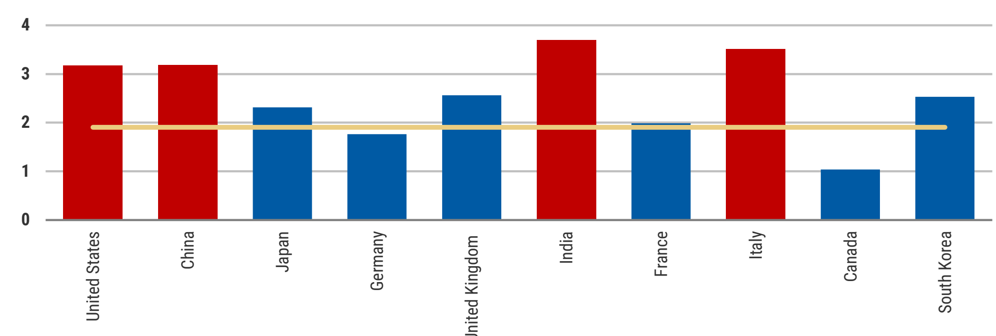
Exhibit 27: The world's 18 most water-stressed rivers



Source: WRI Aqueduct

Exhibit 28: 8 of the 10 largest economies have either the same or higher water risk scores than the global average

10 Largest economies - water risk vs. global average



Note: countries highlighted in red represent high water risk. Source: WRI Aqueduct (2015), Morgan Stanley Research

8 of the top 10 major economies have a water risk score either the same or higher than the global average. Exhibit 28 outlines WRI Aqueduct's water risk scores for the 10 largest economies – the higher the score, the higher the risk. Although none of the major economies is deemed to have 'extremely high' water risk, the US, China, India and Italy are 'high' risk, meaning that 40-80% of available water resources, including groundwater, is used up every year in these regions. None of the major economies is deemed to have 'low' water risk, where less than 10% of available water resources is used up every year.

… and how it reaches the consumer

Water infrastructure is essential to delivering safe water efficiently. Water infrastructure is a broad term that covers systems of water supply, treatment, storage, water resource management, flood prevention and hydropower. It encompasses water-based transportation systems, such as canals and rivers, as well as deep water cooling systems. Water infrastructure is key for supporting human life, which is why the 6th Sustainable Development Goal (SDG 6) focuses on water and sanitation. In particular, it seeks to ensure safe drinking water and sanitation for all, focusing on the sustainable management of water resources, wastewater and ecosystems, and acknowledging the importance of an enabling environment.

But the distribution of water infrastructure varies materially. Exhibit 29 to Exhibit 32 show a selection of key global indicators published by the UN that help visualize the availability and efficiency of water infrastructure currently installed globally.[14] Broadly speaking, these maps show that Africa and countries within South America suffer from poor water infrastructure. Further, only 54% of the world's population uses safely managed sanitation services (where excreta produced is treated and disposed in situ). This is a widespread issue across many countries – shown as the orange and yellow regions in Exhibit 30 . Similarly, the percentage of domestic and industrial wastewater flow safely treated is only 56% globally, as shown by the red areas in Exhibit 30.

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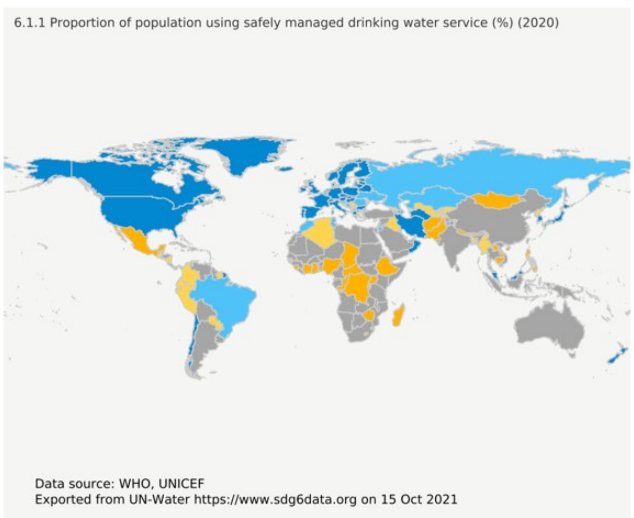
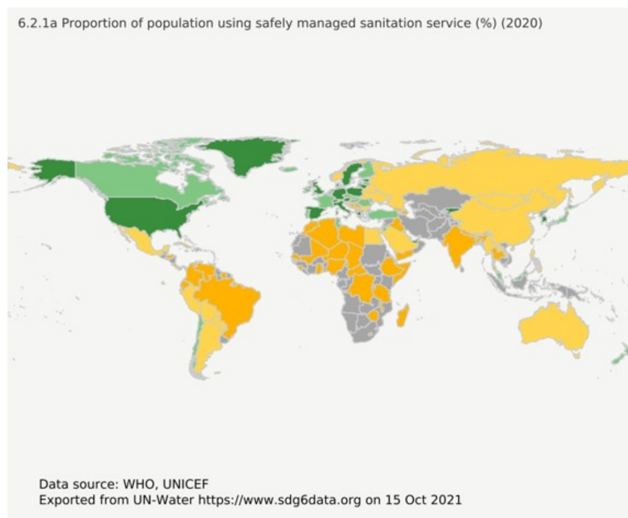
Exhibit 29: Proportion of population using safely managed drinking water service (%) (2007-2020)



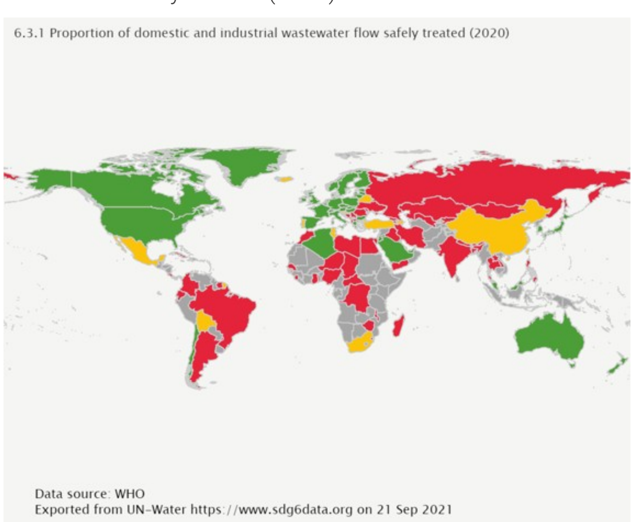
Note: orange regions represent 0-50% of population using safely managed drinking water services. Source: WHO and UNICEF, via UN SDG 6

Exhibit 30: Proportion of population using safely managed sanitation service (%) (2016-2020)



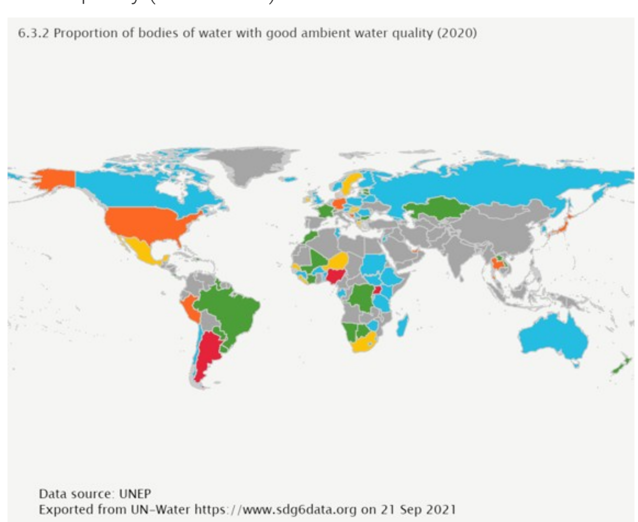
Note: orange regions represent 0-50% of population using safely managed sanitation services. Source: WHO and UNICEF, via UN SDG 6

Exhibit 31: Proportion of domestic and industrial wastewater flow safely treated (2020)



Note: red regions represent 0-50% of domestic and industrial wastewater flow being safely treated. Source: WHO, UN-Habitat and UNSD via UN SDG 6

Exhibit 32: Proportion of bodies of water with good ambient water quality (2017-2020)



Note: red regions represent 0-20% of bodies of water with good ambient water quality. Source: UNEP via UN SDG 6

The Impact of Climate Change: Too Much Water and Too Little

Climate change is linked to increased frequency of extreme weather events, which will put constraints on supply

The earth's lower atmosphere is becoming (a) warmer and (b) moister as a result of rising greenhouse gas emissions caused by human activity. This, in turn, is increasing the frequency and intensity of storms and extreme weather events – heat waves, droughts, wildfires, hurricanes and heavy rainfall and snowfall events (which therefore increase flooding risk).[16]

- **Droughts & wildfires** – a warming climate increases evaporation on land, which can worsen droughts and create conditions for a longer wildfire season.
- **Rain & snowstorms** – a warmer climate is also associated with heavier precipitation, given it increases the air's ability to hold moisture.
- **Hurricanes** – a warmer and moister atmosphere, coupled with warmer oceans, increases the intensity of hurricanes and makes it more likely that hurricanes affect new areas and last longer. That said, whether climate change is responsible for the change in the number of hurricanes every year is an area of ongoing research.
- **Storm surges & flooding** – rising sea levels increase the quantity of seawater pushed onshore during coastal storms. When coupled with increased rainfall produced by storms, this can result in more destructive storm surges and flooding.

Meteorological, hydrological, climatological and geophysical records indicate that weather-related disasters have been rising since 1980. As Exhibit 33 shows, although there are fluctuations on a year-on-year basis, the overall trend between 1980 and 2019 was upwards. The increased frequency of such events, coupled with climate change, means many regions are exposed to drought and coastal flood risk, represented by the darker regions in Exhibit 34 and Exhibit 35 .

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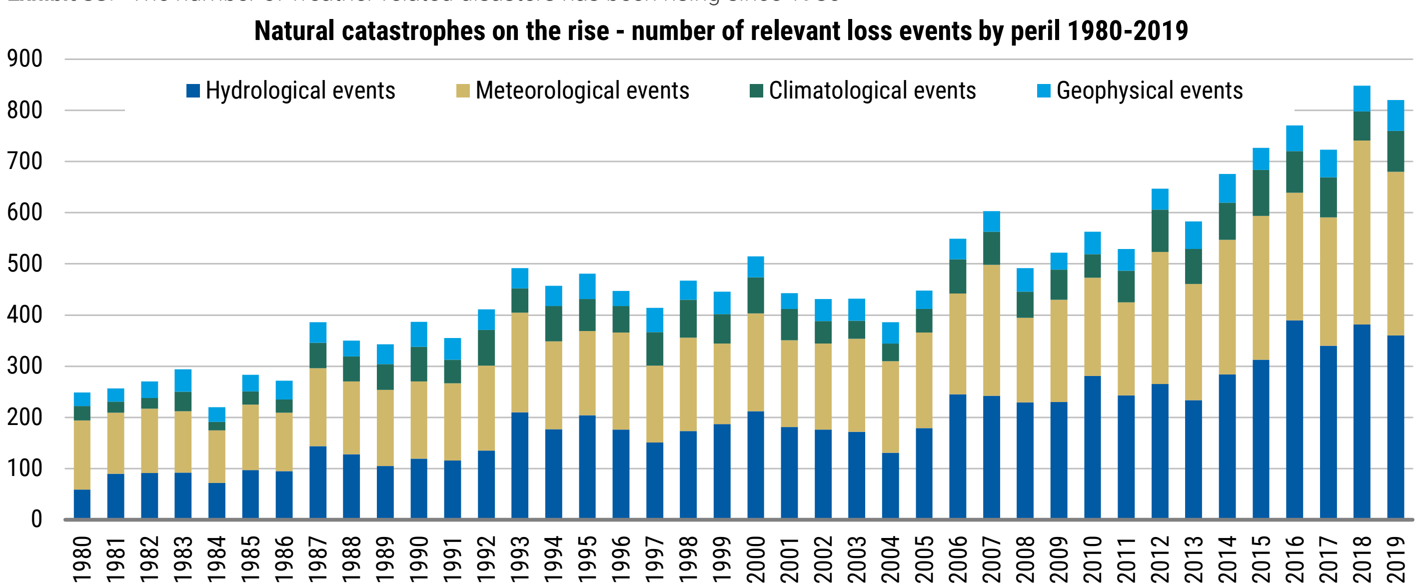
Exhibit 33: The number of weather-related disasters has been rising since 1980

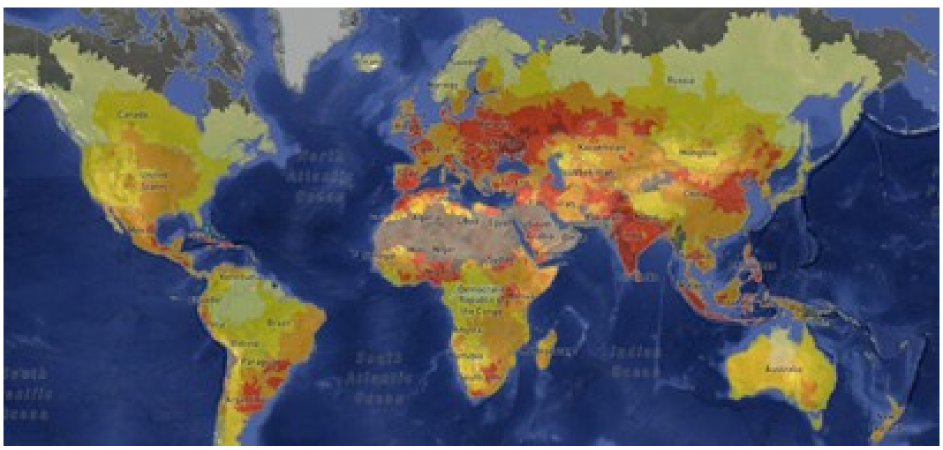


Source: Munich RE

Exhibit 34: Regions exposed to coastal flood risk

Note: Darker red regions represent areas of higher coastal flood risk – measured by the percentage of the population expected to be affected by coastal flooding currently, accounting for existing flood protection standards. Source: Water Risk Atlas

Exhibit 35: Regions exposed to drought risk



Note: Darker red regions represent areas of higher drought risk - where droughts are likely to occur, the population and assets exposed, and the vulnerability of the population and assets to adverse effects. Source: Water Risk Atlas

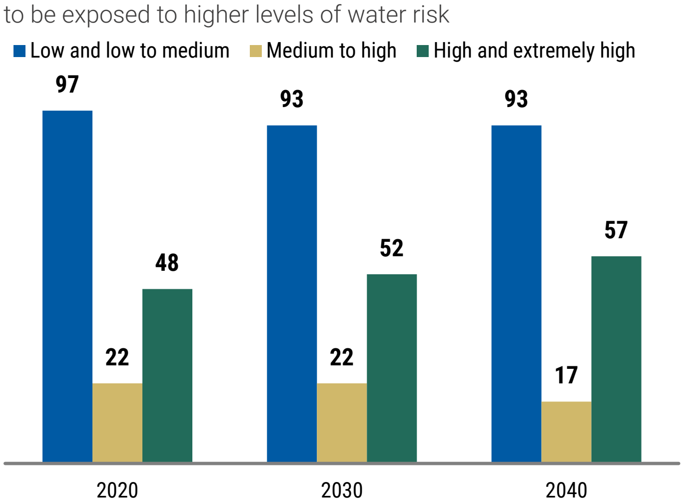
Over time, more countries will be exposed to water risk. The World Resources Institute (WRI) expects that over time a growing number of countries will be exposed to higher levels of water risk (see Exhibit 36). At present, 48 countries have high or extremely high levels of water risk, but by 2040 this will have increased to 57 countries, putting further constraints on water supply.

Hydrological changes due to climatic factors

Although there are global efforts to keep climate change to 1.5 degrees above pre-industrial levels, there is still a strong possibility that the extent of global warming will be much higher. It is exceptionally difficult to forecast hydrological changes accurately (changes in the movement, distribution, and management of water), but the IPCC has highlighted a range of possible impacts under various climate scenarios.[17]

17AR5 Climate Change 2014: Impacts, Adaptation, and Vulnerability

Exhibit 36: Over time, a growing number of countries are expected to be exposed to higher levels of water risk



Source: WRI Aqueduct, Morgan Stanley Research

Exhibit 37: Specifically, an additional 9 countries are expected to be exposed to 'high' or 'extremely high' water risk by 2040

Water Risk	Change in the number of countries between 2020 and 2040
Low and low to medium	-4
Medium to high	-5
High and extremely high	9

Source: WRI Aqueduct, Morgan Stanley Research

Exhibit 38: The range of potential hydrological changes driven by climatic factors under different scenarios

		Global Warming Scenarios					Representative Concentration Pathway				Special Report on Emission Scenarios			
		GW 2.0	GW 2.7	GW 3.5	GW 4.0	GW 5.0	RCP2.6	RCP4.5	RCP6.0	RCP8.5	SRES B2	SRES A1f	SRES A2	
Type of Hydrological Change/Impact	**Explanation**	**Global Warming 2.0°C**	**Global Warming 2.7°C**	**Global Warming 3.5°C**	**Global Warming 4.0°C**	**Global Warming 5.0°C**	**Below 1.5°C throughout the 21st century**	**1.8°C between 2081-2100**	**2°C in the 2060s and 2.5°C in the 2090s**	**2°C in the 2040s and 4°C in the 2090s**	**10.4bn pop by 2100, low GDP**	**7.1bn pop by 2100, mid-high GDP**	**15.1bn pop by 2100, low-mid GDP**	**Summary**
Renewable Water Resources	Decrease of renewable water resources (by at least 20%) for world population expected by 1 degree temp rise		7%											Every 1 degree of global warming is expected to decrease renewable water resources by at least 20% for an additional 7% of the world population
Renewable Groundwater Resources	% of global populations expected to be affected by a decrease of groundwater resources by more than 10% (vs 1980 levels).						24%	26%	32%	38%				By 2080, between 24% and 38% of global populations are expected to be affected by a decrease of groundwater resources by more than 10% (vs 1980 levels).
Exposure To Floods	% global populations expected to be exposed to floods corresponding to the 100-year flood discharge for the 1980s by the 2080s.	0.5%			1.2%		0.4%	0.6%	0.7%	1.2%				In the 2080s, between 0.4% and 1.2% of global populations are expected to be exposed to floods corresponding to the 100-year flood discharge for the 1980s.
Change In Irrigation Water Demand	Expected % change in required irrigation water withdrawals by 2080s (vs 1980s levels)						-0.2% to 1.6%	1.9% to 2.8%		6.7% to 10%				By the 2080s it is expected that required irrigation water withdrawals will change by between -0.2% and 10% (vs 1980s levels).
River flow regime shifts from perennial to intermittent and vice versa	% of global land area affected by river flow regime shifts between the 1970s and 2050s (except Greenland and Antarctica).										5.4% to 6.7%		6.3% to 7%	Between the 1970s and the 2050s it is expected that somewhere between 5.4% and 7% of global land area will be affected by river flow regime shifts (except Greenland and Antarctica).
New Or Aggravated Water Scarcity	% of global populations living in river basins with new or aggravated water scarcity by 2100 (vs 2000 levels).	8%		11%		13%								By 2100, it is expected that somewhere between 8% and 13% of global populations will be living in river basins with new or aggravated water scarcity (vs 2000 levels).

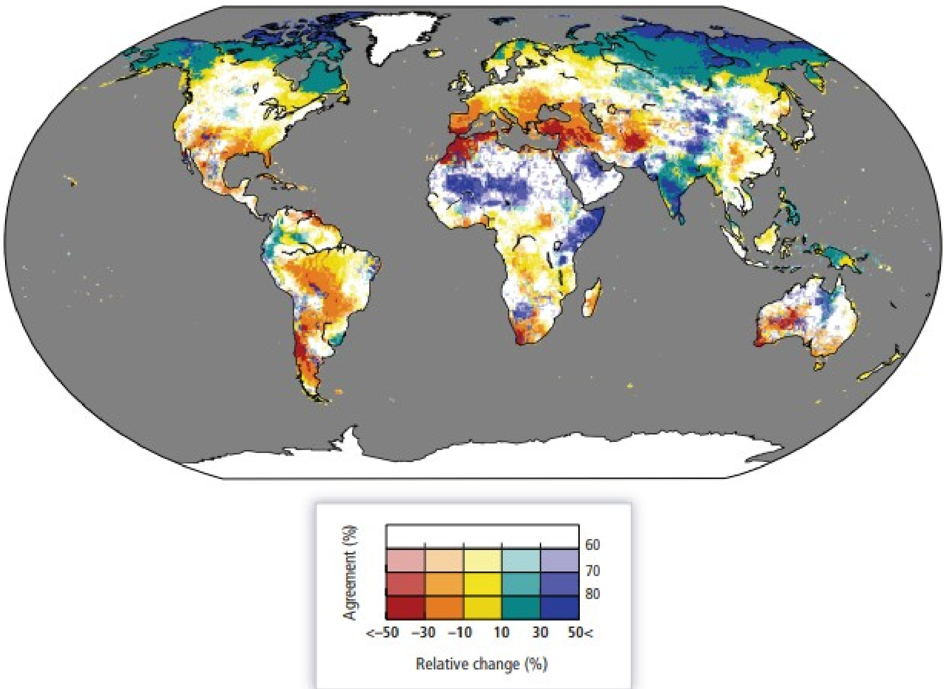
Source: IPCC, Morgan Stanley Research

Evapotranspiration: In an increasingly warm climate, evapotranspiration (the sum of water evaporation and transpiration from a surface area to the atmosphere) over most land areas is very like to increase, which will accelerate the hydrologic cycle (the continuous circulation of water in the Earth-Atmosphere system). The accompanying fall in soil moisture is also linked with an increase in the risk of extreme hot days and heat waves.

Glaciers: If global warming rates remain constant, ice melting per unit area increases, and the total ice-covered area decreases simultaneously. As these glaciers shrink, they become a less dependable water supply source.

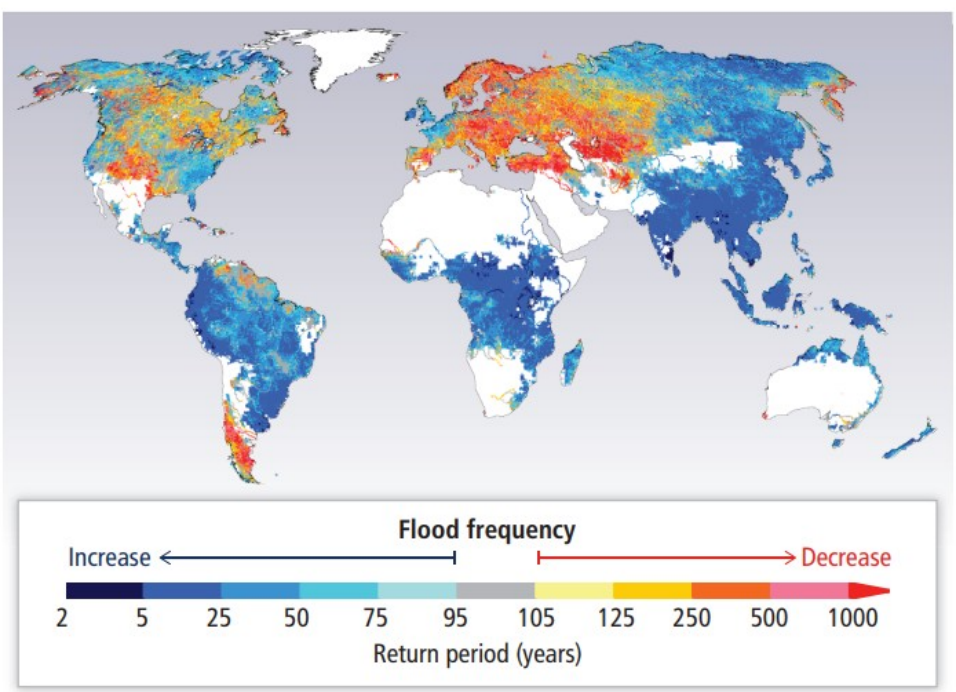
Runoff & Streamflow: Generally speaking, average annual runoff (which occurs when there is more water than the land can absorb) is projected to increase at high latitudes and within the wet tropics, and decrease in most dry tropical regions. However, there is a high degree of uncertainty around this projection, which is visualized in Exhibit 39 . The map shows the average percentage change in the average annual runoff for an increase in global temperatures greater than 2 degrees (versus the 1980-2010 mean) across five climate models and 11 hydrological models.

Exhibit 39: Percentage change in mean annual streamflow for a global mean temperature rise of 2°C above 1980–2010



Source: IPCC

Exhibit 40: Increased flood hazard risk is identified for parts of South and Southeast Asia, tropical Africa, Northeast Eurasia, and South America, whilst decreasing risk is expected for Northern and Eastern Europe, Anatolia, Central Asia, Central North America, and Southern South America



Source: IPCC

Groundwater: The relationship between climate and groundwater (water present beneath the earth's surface in rock and soil pore spaces and in the fractures of rock formations) is relatively under-explored. There is general agreement across studies that areas of increased water runoff tend to coincide with increased groundwater recharge and thus renewable groundwater resources. Decreasing snowfall is a potential risk, leading to lower groundwater recharge (even if precipitation remains stable). Pumping from coastal aquifers is expected to lead to more salinization of groundwater than rising sea levels throughout the 21st century.

Water quality: Water quality projections explored by the IPCC report suggest that the " future negative impacts will be similar in kind to those already observed in response to change and variability in air and water temperature, precipitation, and storm runoff, and to many confounding anthropogenic factors".

Soil erosion: Heavy rainfall is expected to lead to more intense soil erosion. In agricultural lands, soil erosion will likely become more intense in a nonlinear way. For example, in the UK, a 10% increase in winter rainfall might lead to a 150% increase in the erosion of arable land, based on IPCC estimates.

Extreme hydrological events (droughts and floods): Flood hazards could increase over half of the globe, but with material variability. More frequent droughts due to climate change might also challenge existing water management systems.

Water demand will continue to rise, whilst supply is likely to decrease in some regions

The 2030 Water Resource Group expects a 40% water deficit by 2030 versus 2010 levels, based on 2% average annual growth in water withdrawals between 2010 and 2030, and assuming no efficiency gains. In absolute terms, the agricultural sector is expected to see the largest increase in water usage by 2030 (an incremental 1.4trn m3 will be required). However, growth in industrial water usage is expected to outpace that of the other key sectors, with withdrawals nearly doubling between 2010 and 2030 (see Exhibit 42).

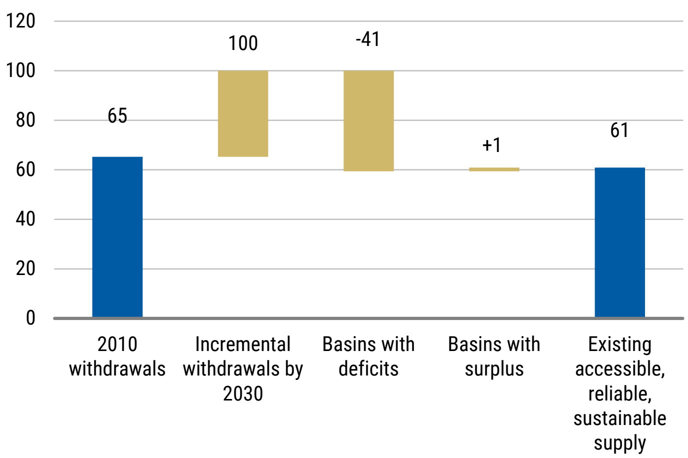
Freshwater supply per capita has been falling for some time

Over the past 50 years we have seen a 57% fall in renewable freshwater resources per capita (internal river flows and groundwater from rainfall divided by World Bank population estimates). Globally, on a per capita basis, the balance between freshwater withdrawal and replenishment has deteriorated, reflecting both population growth as well as increasing agricultural, industrial and domestic water usage.

In some regions water scarcity could impact GDP by up to 11.5% by 2050, on World Bank estimates. Analysis from the World Bank suggests that the constrained supply of water might impact global GDP by -0.49% to 0.09% in 2050, depending on policies adopted. However, this masks significant regional disparities. As Exhibit 44 shows, for Central Asia and the Middle East, the impact could be double-digit percentages of GDP.[18]

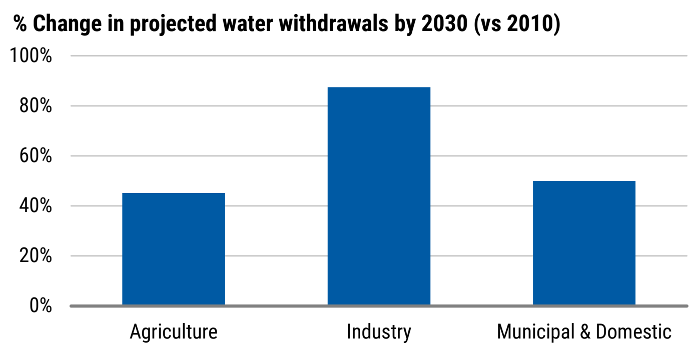
18 High and Dry: Climate Change, Water and the Economy, The World Bank, 2015

Exhibit 41: A 40% gap between demand and renewable supply of water is expected by 2030 (versus 2010)



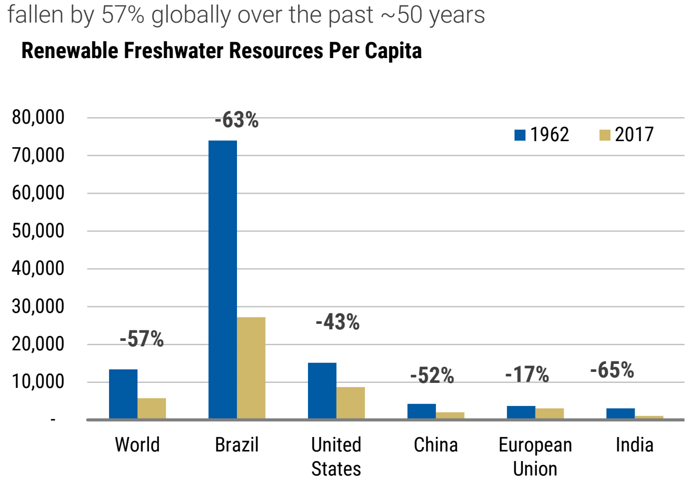
Source: Water 2030 Global Water Supply and Demand model (agricultural production based on IFPRI IMPACT-WATER base case via 2030 water resource group), Morgan Stanley Research

Exhibit 42: The industrial sector will see the highest relative growth in water withdrawals by 2030 (versus 2010)



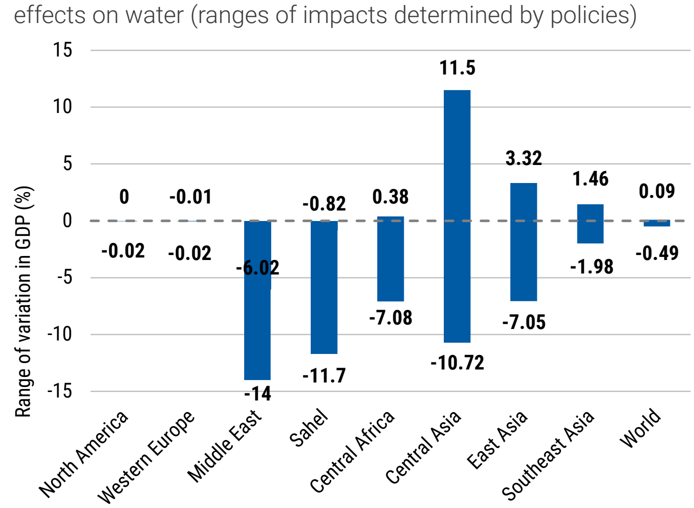
Source: Water 2030 Global Water Supply and Demand model (agricultural production based on IFPRI IMPACT-WATER base case via 2030 water resource group), Morgan Stanley Research

Exhibit 43: Renewable freshwater resources per capita have fallen by 57% globally over the past ~50 years



Source: World Bank, Morgan Stanley Research

Exhibit 44: Potential impact on GDP in 2050 of climate-related effects on water (ranges of impacts determined by policies)



Note: The figure shows the potential impact on GDP from climate-change effects on water for selected regions. It incorporates effects from different growth scenarios (SSP1 and SSP3) as well as different policy scenarios (business-as-usual policies and policies that encourage better water allocation). Source: World Bank, 2015

Water Inequality: The Cost & Investment Opportunity

Underinvested – and facing higher capex costs

~$850bn is spent every a year on providing and maintaining water resources, but this is not enough to meet the world's water needs. Of this $850bn spend, ~$300bn is capital expenditure. For context, this is about a third of what is spent on electricity networks globally or by the fossil fuel industry. In other words, water is capital intensive, but ranks below other major capital-intensive areas of the economy in terms of annual capex. Roughly 2 billion people lack safely managed drinking water, and ~3.5 billion are without safely managed sanitation services. In developed countries, the proportion of the population with access to improved drinking water and sanitation is high, but underinvestment in infrastructure is pervasive.

Most countries, regardless of income level, spend ~1% of GDP on water (capex and opex), with a degree of variation among countries and some exceptions in particularly water-stressed regions, such as the Middle East. This would imply a low to mid single digit growth in spend as a reasonable base case, in line with global GDP growth.

However, the cost curve of drinking water resources is steep ... Many regions are already facing water stress, and the average cost of new supply is double the existing cost of supply, with many solutions 10-20 times more expensive.

... while global urbanization and low coverage by sanitation services in the developing world implies a significant need for development of wastewater treatment networks – a far more capital-intensive endeavour than drinking water provision.

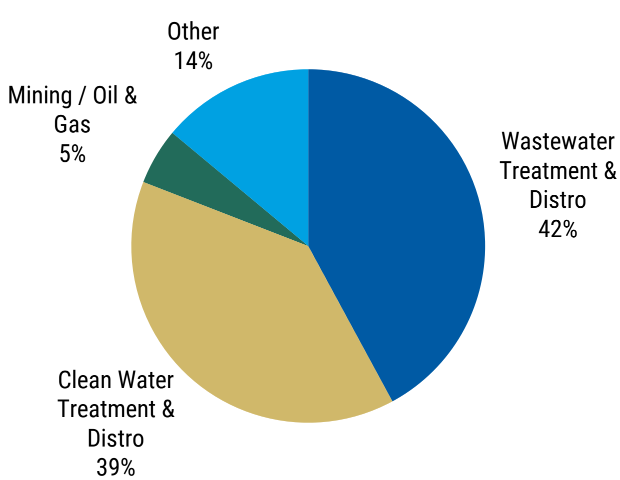
The meaningful gap between what 'should' be spent and what is spent reflects various market failures, which we discuss in more detail in The Complexities of Pricing . The shortfall presents an opportunity for both companies and society at large, but realizing higher spending (and therefore increased water service globally) requires meaningful shifts in water policy and pricing.

We explore these dynamics below. In Appendix I we look at the recent experience in Brazil as a case study in the challenges of water inequality, shortages and efforts to stimulate investment.

What's The World Spending Now?

Exhibit 45: Global water spending: ~40% wastewater, ~40% clean water, 20% other spending.

% of Global Water Spend



Note: "Distro" = "Distribution. Source: GWI (December, 2021), Morgan Stanley Research. "

Globally, total water spending (opex + capex) is ~$850bn, equivalent to around 1% of global GDP. Roughly equal amounts are spent on clean water and wastewater treatment and networks – yet wastewater networks are substantially more capital-intensive per person served. The discrepancy in spending levels versus per-person intensity of wastewater treatment is largely explained by the relatively lower levels of sanitation services supplied globally.

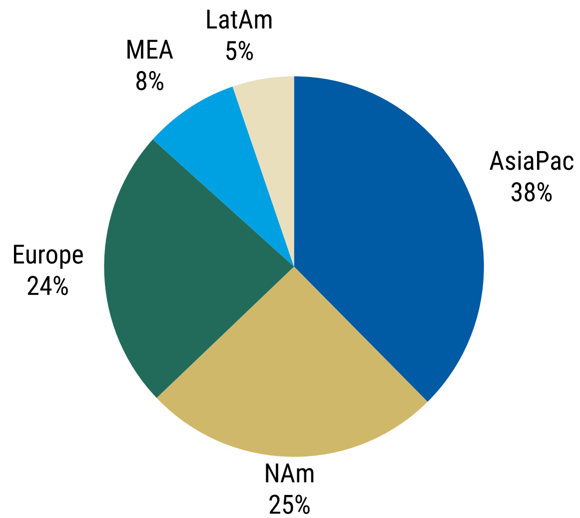
We see wastewater treatment and management as a potential area for catch-up, given global income growth and increased public scrutiny of industrial and municipal wastewater management.

Regionally, spend largely corresponds to population size and wealth. Asia Pacific, which includes the majority of the global population, has the highest level of absolute spend. Spend is also relatively high in North America and Europe, reflecting their higher spend per capita. The United States is the largest market by annual spend, at ~$200bn (almost a quarter of global spend). The three highest spenders – the US, China, and Japan – account for around half of total global investment; no other country contributes more than 5% of global spend.

We observe relatively limited differentiation in where money is spent (i.e. the 40/40/20 rule above is a fairly good proxy across most major geographies). One notable exception is the Middle East & Africa (MEA), which has a substantially higher level of clean water treatment & distribution spend than other regions, given the need for desalination to supply clean water.

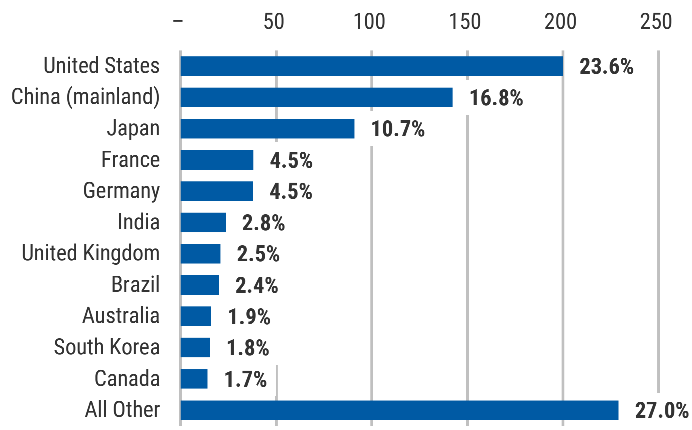
Generally speaking, industry drives around a quarter of global water spend, with water utilities accounting for the rest. It is within this industry spend that regional differences are most apparent – for example, the importance of mining to the water industry in Latin America and of the upstream oil & gas industry in North America.

Exhibit 46: Global water spending largely corresponds to population size and wealth



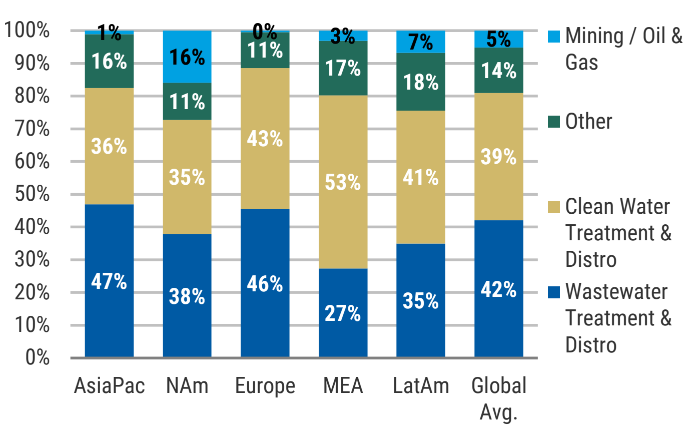
Source: GWI (December, 2021), Morgan Stanley Research

Exhibit 47: The US, China and Japan are by far the largest markets by water spend



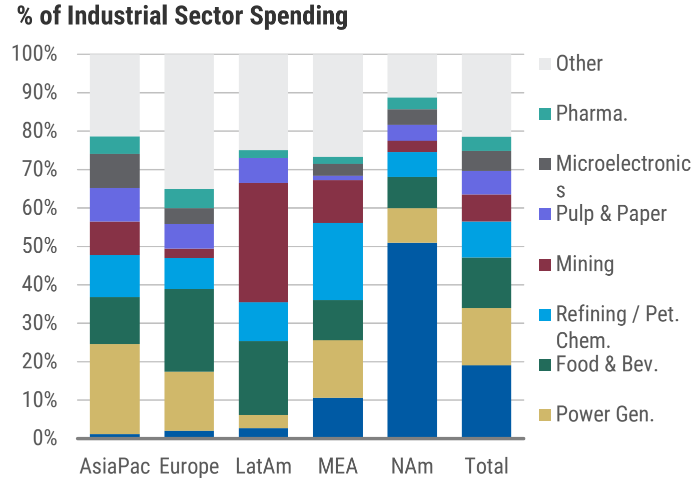
Source: GWI (December, 2021), Morgan Stanley Research

Exhibit 48: The allocation of spend varies somewhat by region, with desalination and oil & gas/mining the main drivers of difference



Source: GWI (December, 2021), Morgan Stanley Research

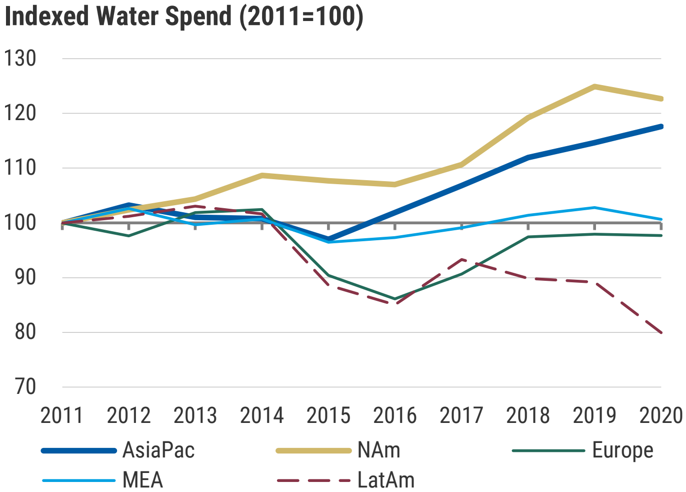
Exhibit 49: Variation is most marked within industrial spend, reflecting different regions' dominant water-consuming industries



Source: GWI (December, 2021), Morgan Stanley Research

How Much Needs To Be Spent?

Exhibit 50: Global water spend has grown at a relatively modest ~1% in the past decade, but this masks major regional differences



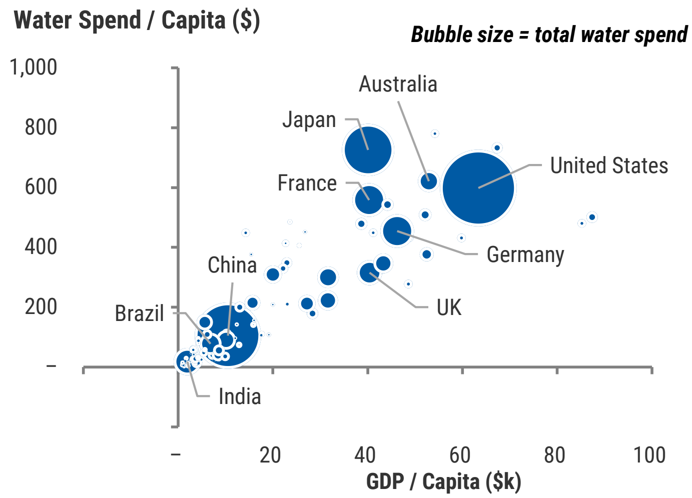
Source: GWI, Morgan Stanley Research

Annual spend in the water industry grew at an average of just 1% a year in 2011-2019, broadly in line with global population growth. Growth varied by region, however, with spend actually declining in Latin America and Europe. Conversely, spending in the two largest markets, Asia Pacific and North America, increased by ~$82bn in aggregate, average annual growth rates of ~1.5% and ~3.0%, respectively. In part, the muted growth rate reflected the downturns in overall oil & gas and mining capex globally following the commodity supercycle of the early 2000s, and this looks set to improve from the very low 2020 base.

A 'naïve' forecast: water spending as a function of income levels. Looking at a cross section of ~100 countries globally, we observe that the single largest predictor of water spending per capita is GDP per capita. This simple relationship explains 75% of the variability in water spending across countries, and suggests that roughly 0.8% of the incremental increase in GDP per capita will be spent on water resources. We find very limited informative value in other indicators (such as water withdrawals or water stress) in explaining the *current* level of spending. So, using this naïve relationship, we can say that global water spending will probably grow at ~3-4%, in line with global GDP.

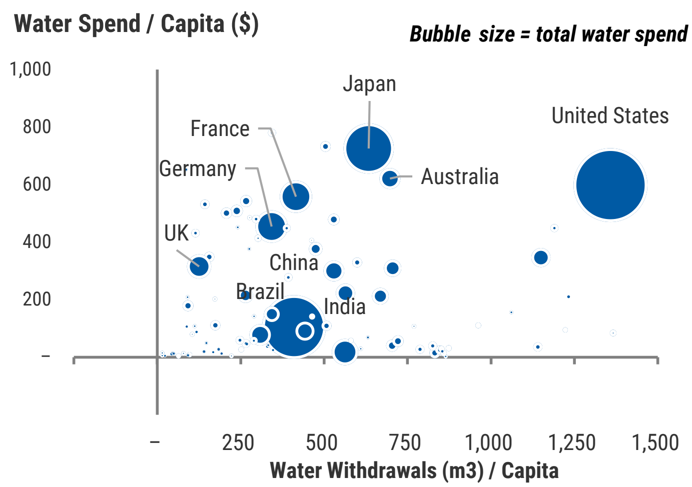
But this assumption overlooks some of the major challenges and pockets of opportunity for suppliers.

Exhibit 51: Water spending is primarily explained by societal wealth – the more a country has, the more it spends on water



Source: GWI, UN, IMF, AQUASTAT, Morgan Stanley Research

Exhibit 52: Meanwhile, other variables, like water withdrawals per capita, are poor explanatory variables for how much is spent on water



Source: GWI, UN, IMF, AQUASTAT, Morgan Stanley Research

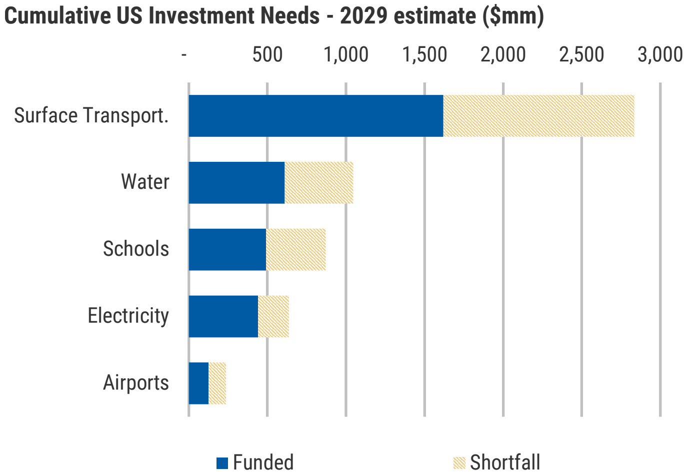
What a simple trend analysis misses: current spending is not enough, and the cost curve is steep. While the assumption that water spend trends in line with population size is a useful starting point, there are two important caveats:

(i) current spending is not sufficient to meet water access goals in developing countries, and is insufficient to maintain infrastructure in developed countries; and

(ii) the water supply cost curve is steep, and the population is set to grow in areas where water stress is already high. We address each of these in detail below:

Current spending is insufficient in both developed & developing countries

Exhibit 53: Even in the US – one of the highest spenders per capita – current water spend is insufficient to meet society's needs for the rest of the decade



Source: American Society of Civil Engineers, Morgan Stanley Research

In developed countries, chronic underinvestment in existing infrastructure has led to rising levels of water loss and a growing funding shortfall for anticipated future spending requirements to modernize water and wastewater networks. In the United States – the largest relative and absolute spender on water – the American Society of Civil Engineers (ASCE) estimates that underinvestment in water infrastructure was ~$81bn in 2019, and this figure is expected to reach $434bn by 2029. The effects of this shortfall are clear – on average, a water main breaks every two minutes in the US, and every day ~6 billion gallons of treated water are lost.

In developing economies, water infrastructure is underbuilt and insufficient to meet the UN's Sustainable Development Goals (SDG's) on water, sanitation, and hygiene (WASH). For example, a 2015 report from the UN Water and Sanitation Program (WASP) attempted to estimate the potential cost of achieving SDG 6.1 and 6.2. The report estimated that extending basic water & sanitation services to the unserved would require capex of ~$28bn a year from 2015 to 2030, while providing safely managed water and sanitation services to this same group would require an incremental ~$87bn. This is a total of ~$114bn a year over the period, with a range of $74-166bn. Although not exactly comparable, this $114bn compares to current capital spending in the affiliated countries of ~$180bn, implying a significant uplift in spending. Note that SDG 6.1 and 6.2 are defined as "(1) achieving universal and equitable access to safe and affordable drinking water for all (target 6.1); and (2) achieving access to adequate and equitable sanitation and hygiene for all and ending open defecation (target 6.2)," so this does not even contemplate full achievement of the UN's development goals.

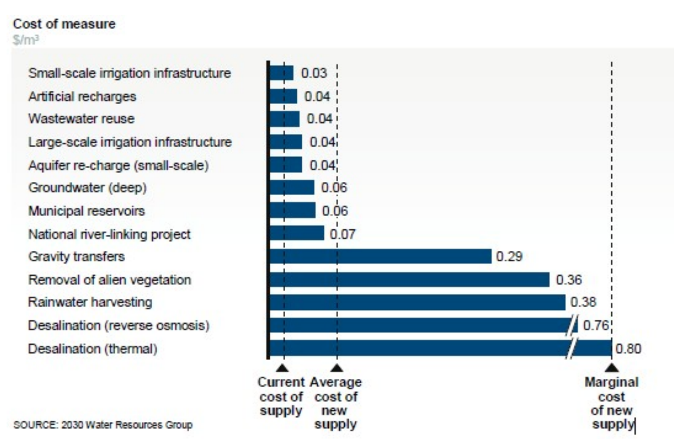
The Water Cost Curve Is Steep

The aggregate level of fresh water and wastewater service will clearly need to increase with population growth. Less obvious is that the incremental cost of expanding service is likely to be higher than current average costs of water. This cost curve effect is difficult to estimate, but a few attempts have been made. We highlight a selected case study from the 2030 Water Resources Group in Exhibit 54 that suggests that the average cost of new supply in India is several times larger than the current average cost of supply.

The WASP reference above attempts to define unit costs for incremental levels of service. While advanced services (such as sewage & water treatment) are obviously more expensive than basic services (for example, pit latrines), the cost of scaling up the level of service is multiple times more expensive (Exhibit 55).

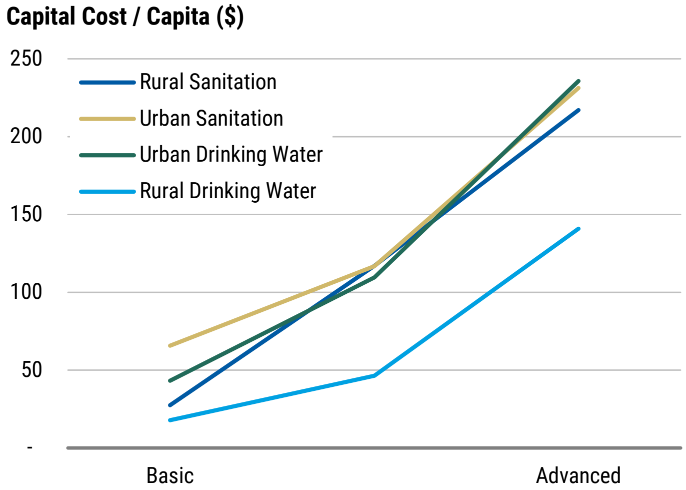
With most population growth centered in areas with lower levels of fresh water and wastewater service (particularly the latter), there is a double impact from both higher absolute service needs and "climbing the cost curve." Moreover, the vast majority of incremental water service demands will come from urban areas (where service expansion is more capital intensive), and will likely be focused on sanitation over fresh water (which again, is more capital intensive). In a similar vein, but still harder to quantify, global population is likely to grow fastest in areas that already face a high degree of water stress (Exhibit 56), further complicating the assumption that water spending will trend with overall GDP.

Exhibit 54: The cost curve for water supply is steep – spending growth will likely accelerate as more of the global population are served



Source: India Case Study by the 2030 Water Resources Group

Exhibit 55: The cost of providing more advanced services – which developing economies will increasingly demand – is several times higher than for basic services



Source: World Bank Group, Morgan Stanley Research

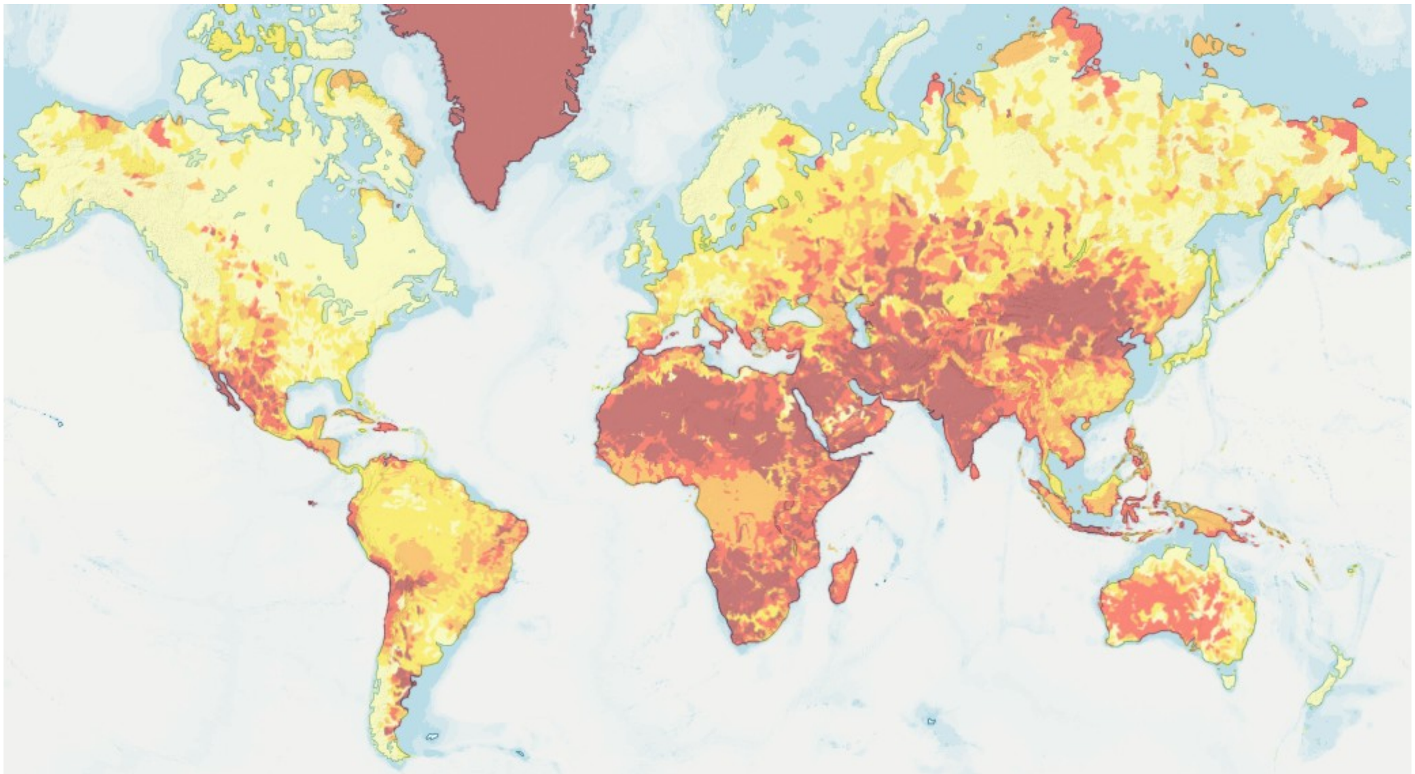
Areas of Likely Spending Growth

In aggregate, water spending has been a slow-growing portion of the overall economy, for reasons we discuss in The Complexities of Pricing . There is potential upside to this low growth of recent history from a combination of greater societal focus, cost-curve effects and enhanced regulation.

Broadly speaking, we see the following areas of potential outsized growth in a scenario of a low-mid single digit overall growth: (i) clean water provision in water-stressed areas such as the Middle East, Africa and India; (ii) wastewater treatment globally, but especially in underserved areas where we expect increasing population and wealth, such as Asia Pacific and Latin America; and (iii) efficiency-enabling technologies for industrial customers.

We show GWI's base case scenario below, which particularly supports points (i) and (ii).

Exhibit 56: Areas expected to see the greatest population growth, such as the Africa, the Middle East, and less-developed countries in Asia currently face challenges of higher freshwater stress, limited wastewater treatment infrastructure, or both



Source: Aqueduct, World Resources Institute

Exhibit 57: Expected Water Capex

		Capex ($B)						
		2019	2020	2021	2022	2023	2024	2025
Clean Water Treatment & Distro	AsiaPac	43.5	44.7	47.2	50.8	52.5	52.7	53.7
	Europe	20.3	20.6	20.2	21.2	21.6	21.7	21.8
	LatAm	4.6	4.2	4.4	4.8	5.1	5.3	5.3
	MEA	12.6	12.1	14.9	16.9	16.8	17.1	17.7
	NAm	17.3	19.1	21.0	22.2	22.9	23.5	24.5
	Total	**98.2**	**100.6**	**107.7**	**116.0**	**118.9**	**120.3**	**122.9**
Wastewater Treatment & Distro	AsiaPac	73.3	77.4	82.1	87.0	91.7	97.2	102.4
	Europe	34.2	34.5	36.6	38.4	39.1	40.3	40.7
	LatAm	6.1	6.0	6.2	6.7	7.0	7.4	7.8
	MEA	9.6	8.8	9.1	10.1	10.1	10.6	11.2
	NAm	28.3	29.4	31.6	32.7	33.7	35.1	36.7
	Total	**151.5**	**156.0**	**165.5**	**174.9**	**181.7**	**190.5**	**198.7**
Mining / Oil & Gas		**11.0**	**10.2**	**10.9**	**11.6**	**12.4**	**13.1**	**13.9**
Other		**25.9**	**26.7**	**28.1**	**30.6**	**31.5**	**32.4**	**33.9**
Total		**286.6**	**293.6**	**312.3**	**333.0**	**344.4**	**356.3**	**369.4**

		Seq. Chg. in Capex						
		2019	2020	2021	2022	2023	2024	2025
Clean Water Treatment & Distro	AsiaPac	7%	3%	6%	8%	3%	0%	2%
	Europe	4%	1%	(2%)	5%	2%	0%	0%
	LatAm	(5%)	(9%)	7%	9%	6%	4%	0%
	MEA	6%	(4%)	23%	13%	(1%)	2%	4%
	NAm	0%	11%	10%	6%	3%	3%	4%
	Total	**5%**	**2%**	**7%**	**8%**	**3%**	**1%**	**2%**
Wastewater Treatment & Distro	AsiaPac	3%	6%	6%	6%	5%	6%	5%
	Europe	3%	1%	6%	5%	2%	3%	1%
	LatAm	1%	(3%)	4%	9%	5%	5%	5%
	MEA	2%	(8%)	3%	11%	(0%)	5%	6%
	NAm	10%	4%	7%	4%	3%	4%	5%
	Total	**4%**	**3%**	**6%**	**6%**	**4%**	**5%**	**4%**
Mining / Oil & Gas		**2%**	**(7%)**	**7%**	**7%**	**7%**	**6%**	**6%**
Other		**6%**	**3%**	**5%**	**9%**	**3%**	**3%**	**5%**
Total		**4%**	**2%**	**6%**	**7%**	**3%**	**3%**	**4%**

Source: GWI estimates, Morgan Stanley Research

Exhibit 58: Expected Water Opex

		Opex ($B)						
		2019	2020	2021	2022	2023	2024	2025
Clean Water Treatment & Distro	AsiaPac	69.7	70.6	72.3	74.0	75.4	76.9	78.5
	Europe	66.5	65.6	67.0	68.2	68.7	69.3	69.9
	LatAm	13.4	11.8	12.3	12.8	13.2	13.7	14.1
	MEA	23.8	24.0	25.0	26.0	26.9	27.8	28.6
	NAm	57.3	58.4	60.1	61.6	63.1	64.5	66.1
	Total	**230.8**	**230.5**	**236.7**	**242.5**	**247.4**	**252.3**	**257.2**
Wastewater Treatment & Distro	AsiaPac	76.3	77.2	78.9	80.7	82.2	83.7	85.3
	Europe	57.6	57.5	59.2	60.5	61.4	62.3	63.2
	LatAm	9.4	8.2	8.6	8.9	9.3	9.6	9.9
	MEA	9.2	9.3	9.8	10.2	10.6	11.0	11.4
	NAm	52.9	54.2	56.0	57.6	59.2	60.9	62.6
	Total	**205.5**	**206.5**	**212.3**	**218.0**	**222.7**	**227.5**	**232.3**
Mining / Oil & Gas		**32.7**	**26.3**	**26.9**	**28.9**	**30.6**	**31.4**	**32.3**
Other		**92.4**	**88.9**	**90.5**	**93.8**	**95.4**	**97.6**	**99.9**
Total		**561.4**	**552.2**	**566.5**	**583.3**	**596.1**	**608.7**	**621.6**

		Seq. Chg. in Opex						
		2019	2020	2021	2022	2023	2024	2025
Clean Water Treatment & Distro	AsiaPac	1%	1%	2%	2%	2%	2%	2%
	Europe	(1%)	(1%)	2%	2%	1%	1%	1%
	LatAm	(1%)	(12%)	4%	4%	3%	3%	3%
	MEA	(0%)	1%	4%	4%	4%	3%	3%
	NAm	2%	2%	3%	2%	2%	2%	2%
	Total	**1%**	**(0%)**	**3%**	**2%**	**2%**	**2%**	**2%**
Wastewater Treatment & Distro	AsiaPac	0%	1%	2%	2%	2%	2%	2%
	Europe	(1%)	(0%)	3%	2%	1%	1%	1%
	LatAm	(0%)	(13%)	5%	4%	3%	3%	3%
	MEA	2%	1%	4%	5%	4%	4%	4%
	NAm	3%	3%	3%	3%	3%	3%	3%
	Total	**1%**	**0%**	**3%**	**3%**	**2%**	**2%**	**2%**
Mining / Oil & Gas		**11%**	**(20%)**	**2%**	**7%**	**6%**	**3%**	**3%**
Other		**1%**	**(4%)**	**2%**	**4%**	**2%**	**2%**	**2%**
Total		**1%**	**(2%)**	**3%**	**3%**	**2%**	**2%**	**2%**

Source: GWI estimates, Morgan Stanley Research

In Appendix 1 we look at the example of Brazil, where water supply is a challenge for both the power and sanitation industries. The power system largely relies on hydroelectric energy, at 60% of installed generation capacity. While this dependence has lessened in recent years (and should continue to do so as other sources expand) recurring droughts have given rise to concerns over power shortages. Droughts have also created shortages in the sanitation sector recently, an area that has also suffered from a lack of investment, with low penetration of basic sanitation services, such as access to treated water and sewage collection & treatment. New legislation should herald some improvements here, with the aim of improving regulation and boosting investment through incentivizing greater private sector participation.

The Complexities of Pricing

"The price of water almost never equals its value and rarely covers its costs." *Oxford Review of Economic Policy*

Water pricing is a complex topic, as water is both a regionally specific and opaquely managed commodity. Although this is also true for a number of food commodities, the status of water as a naturally-occurring commodity and basic human need means pricing needs to incorporate not only supply and demand but also societal equity. Simplistically, the underinvestment in water globally is a result of underpricing – whether implicit or explicit – and the inability of capital providers to recover costs of either new investment or standard repair & maintenance.

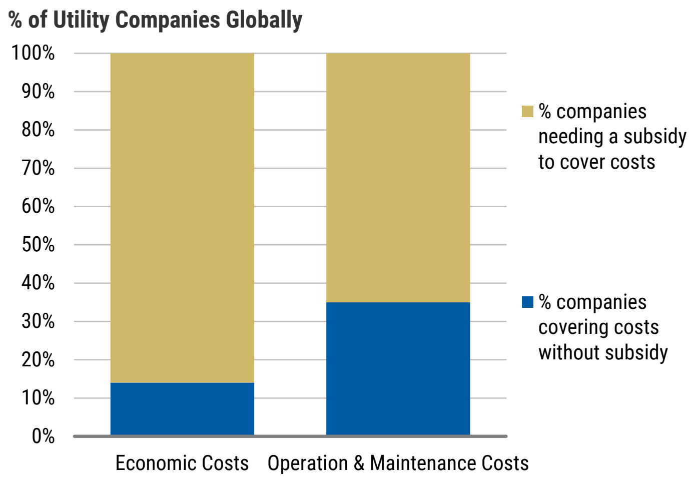
We explore some of these challenges, and look at where observable water pricing has trended and where it may go in the future.

Most pricing today is indirect

Much of water pricing is indirect – many costs are paid via taxes or external aid. Put simply, water industry capex and opex can be funded from three potential areas: (i) tariffs on users, (ii) public expenditure and (iii) external aid (or, the 3 "Ts" – tariffs, taxes and transfers). The public expenditure component is a huge contributor – the UN estimates that, globally, only 35% of water utilities cover their operating & maintenance expenses without subsidies, and only 14% cover their full economic costs without subsidies. In other words, user tariffs very rarely cover the full economic costs of water service. Another UN statistic suggests that, excluding India and China (due to data limitations), somewhere between $289bn and $353bn is spent on water subsidies each year – based on data from GWI, this equates to easily half of these regions' total spending in aggregate, and actually *excludes* capex for infrastructure expansion, which is heavily government financed. As one would expect, these subsidies are disproportionately used in developing countries, where the scarcity of third party capital and the inability of many consumers to afford water tariffs requires a high level of subsidisation. Our objective here is not to weigh on the merits of these subsidies, but to point out that user tariffs, as discussed below, systematically understate the true "price" of water at a societal level.

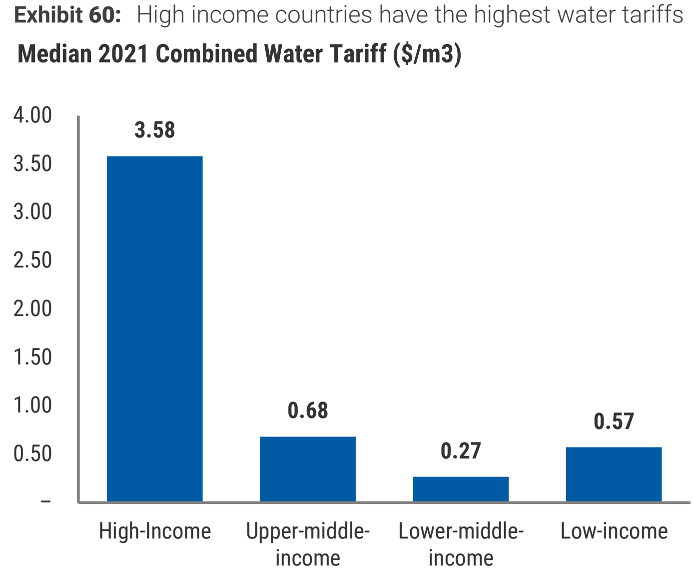
Trends in water tariffs (i.e., the rates charged by water utilities for water service) remain the best way to track water pricing. They are far from perfect indicators, given the costs born by society outside of these tariffs. Additionally, water service in a specific city or region is generally provided by one company – even in privately-managed situations, there is significant regulatory oversight, and thus water pricing, by design, does not change meaningfully year to year. However, a few trends are worth noting:

Exhibit 59: Most water utilities do not generate enough revenue to cover economic or O&M costs



Source: World Bank Group, Morgan Stanley Research

Exhibit 60: High income countries have the highest water tariffs

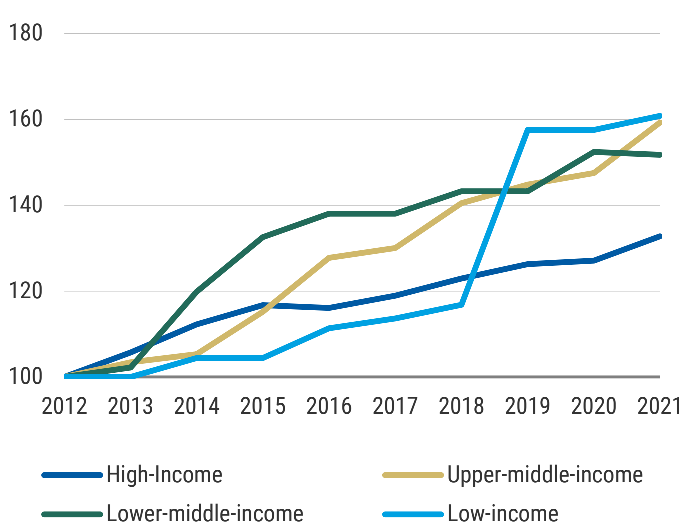


Source: GWI, Morgan Stanley Research

- **High income countries have substantially higher water costs per unit than lower-income countries**. The prevalence of subsidies in developing countries is much more significant than in developed countries, and thus the burden on end-users is substantially less. This in some cases leads to distortions in water use, but water bills in many instances make up a higher percentage of household or business operating costs in lower-income countries, given the lower base effect.
- **Water pricing is steadily increasing year to year, and more so for lower-income countries than high-income countries.** While starting from a lower level, the rate of inflation outside of high-income countries has been noticeably higher than that in high-income countries. Specifically, since 2012, median water tariffs for middle and low-income countries have increased by ~50-60%, while high-income countries have only seen a ~30% increase. Although it is hard to generalize, this likely reflects higher inflation in these countries as well as a need to increase pricing to more sustainable levels over time.
- **Tariff structures are varied, and often regionally specific, but increasing block tariffs are generally the most common structure.** Put simply under an increasing block structure incrementally higher levels of use ("blocks") are charged at higher per-unit rates, with the aim of encouraging efficient water use. These tariff structures are typically more prevalent in Asia, Africa, and Latin America, while North America and Europe have more linear tariffs. Both the latter regions could arguably see greater use of increasing block tariffs to stimulate demand-side efficiency, but change here is likely to be slow.

Exhibit 61: On a relative basis, water tariffs in low-income countries have risen the most since 2012, with much of the increase taking place in the last three years

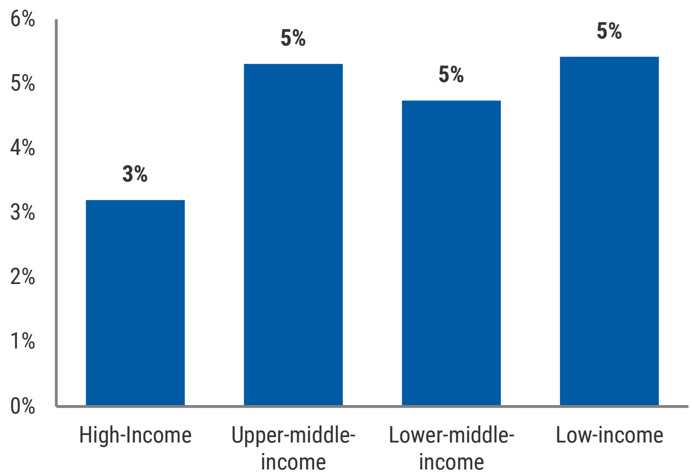
Indexed Median Combined Water Tariff



Source: GWI, Morgan Stanley Research

Exhibit 62: High-income countries excluded, growth in water tariffs has been relatively even across countries grouped by income level

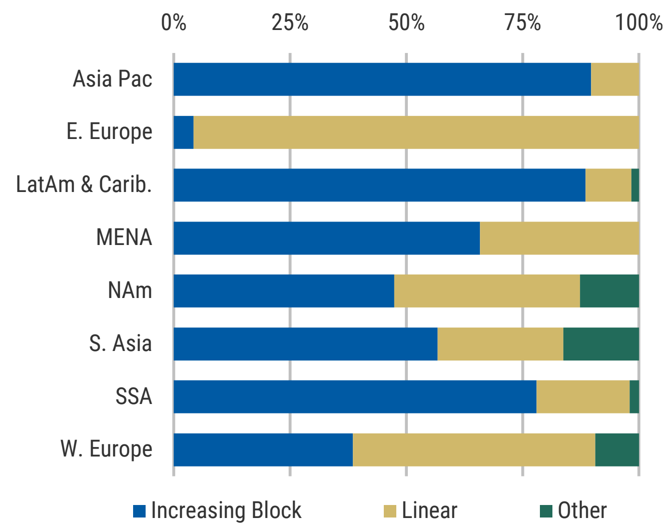
2012-21 CAGR of Median Combined Water Tariff



Source: GWI, Morgan Stanley Research

Exhibit 63: Shifting to increasing block tariff structures could stimulate demand-side efficiency

% of Utilities Using Tariff Structure



Source: GWI, Morgan Stanley Research

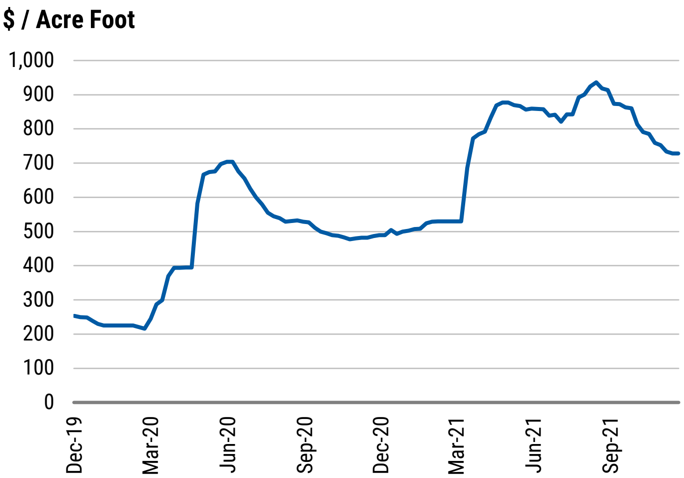
How might pricing change?

In general, academic research focuses on the need for greater transparency and efficiency in water pricing to better encourage conservation and resource distribution. But there is no clear consensus on how to achieve this. For example, increasing block tariffs, as discussed above, are frequently cited as a potential solution to encourage efficiency, and yet some research suggests their efficacy is negligible. Meanwhile, water quality is not necessarily well captured in pure pricing data, but arguably is one of the key drivers of customers' willingness and ability to pay for water resources.

Increasing degrees of water stress may call for new solutions, such as dynamic water pricing, where pricing changes are not only based on a single consumer's use, but also on the status of regional water resources (for example, higher pricing when reservoir levels are lower). While this is logical, it may be difficult to implement in practice, and consumers may have trouble adjusting behavior quickly enough for it to result in anything other than a hardship for lower-income consumers.

From an investment perspective, we think that heavily water-intensive companies should be prepared for potentially more-volatile water pricing over time as more market-based and dynamic pricing mechanisms are put in place, but we doubt that the rate of change at a global level will be significant.

Exhibit 64: The Nasdaq Veles California Water Index tracks spot prices for water in California



Source: Nasdaq, Morgan Stanley Research

Could water markets become more prevalent? Because water is so regionally specific, there is an opportunity for particularly water-stressed regions to engage in more creative, market-based solutions to aid in resource allocation or provide a hedging opportunity for businesses with meaningful exposure. Australia has a relatively sophisticated water market system that has been in operation for decades, and allows the trading of water rights on either a temporary or permanent basis through various contracting mechanisms. The system administrators credit it with substantial improvement in water resource efficiency, but detractors claim that market manipulation and other bad behaviors are too loosely policed.

In the US, Nasdaq launched the Nasdaq Veles California Water Index in late 2020, and the CME Group has begun marketing a futures contract affiliated with it. This contract attempts to track the spot market prices of water in California, where there are drought-related and overall water-scarcity concerns. The objective with any such commodity contract is to afford market participants better price transparency and the potential to hedge the costs affiliated with extreme events in the supply or demand of the commodity. While still quite nascent, this remains an interesting product to watch.

These types of solution are still too niche and regionally specific to be considered a trend, but it is logical that greater potential water risk will see increasing industry demands for mechanisms that better inform stakeholders and allow them to manage risk. We expect solutions such as these to gain in popularity over time.

Lessons from Carbon Pricing Trends

It has taken 30 years from the first carbon pricing initiatives being introduced for carbon schemes to be applied to over 20% of global emissions and to reach a high enough level to start influencing investment decisions.

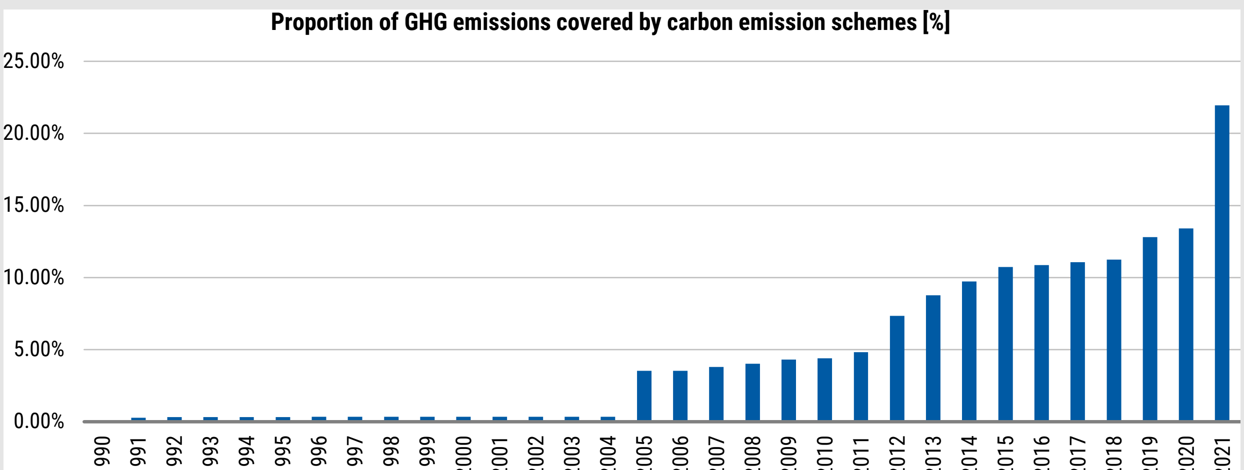
The first carbon taxes were introduced by Poland and Finland in 1990, at €0.07/t (Poland) and €1.12/t (Finland). The following year Sweden and Norway set the much more ambitious rates of €24/t and ~€35/t respectively. These initiatives, together with similar subsequent carbon tax schemes implemented in the 1990s in several European countries, had a limited impact. GHG emissions in these countries (Poland, Finland, Sweden, Norway, Denmark and Slovenia) decreased by less than 1% between 1990 and 1997.

In 2005, the EU Emission Trading Scheme (ETS) was launched – the first cap-and-trade system on a regional scale. Phase 1 of the EU ETS ran from 2005 to 2007 and consisted mainly of free allocations for power generators and energy-intensive industries (~2% of annual GHG emissions globally). Free allowances issued exceeded emissions with no trading demand, and the price of CO2 fell from €16/t to €0/t by 2007.[19] In Phase 2 (2008-2012), a lower cap on allowances and expanded auction volume helped to push the carbon price to €28/t, but prices fell back down to €6/t by the end of the period, due in part to the reduction in industrial activity during the global financial crisis. Phase 3 of the ETS (2013-2020) increased the auction's contribution to the supply of allowances, created natural longs and shorts in the carbon market with free allowances removed from the power sector and allocated relative to industry benchmark. Furthermore, the announcement and launch of the MSR in 2019 was the trigger for price escalation. During that time the CO2 price had reached €32/t. Phase IV started in 2021 and extended the tightening of the emissions market. EUA prices have now reached over €90/t in large part due to the announced "Fit for 55" reform proposals in July 2019 which will further reduce the supply of credits and increase demand. Morgan Stanley's Commodity Strategist Rob Pulleyn expects EUA to hit €130/t by 2030. For more details see Utilities: Carbon in 2022: Time to Consolidate (25 Jan 2022).

Outside Europe, there are 65 carbon pricing initiatives either already implemented or scheduled, covering 45 national jurisdictions and 34 sub-national jurisdictions. For more detail see Sustainability: Global Carbon Primer (17 Mar 2021).

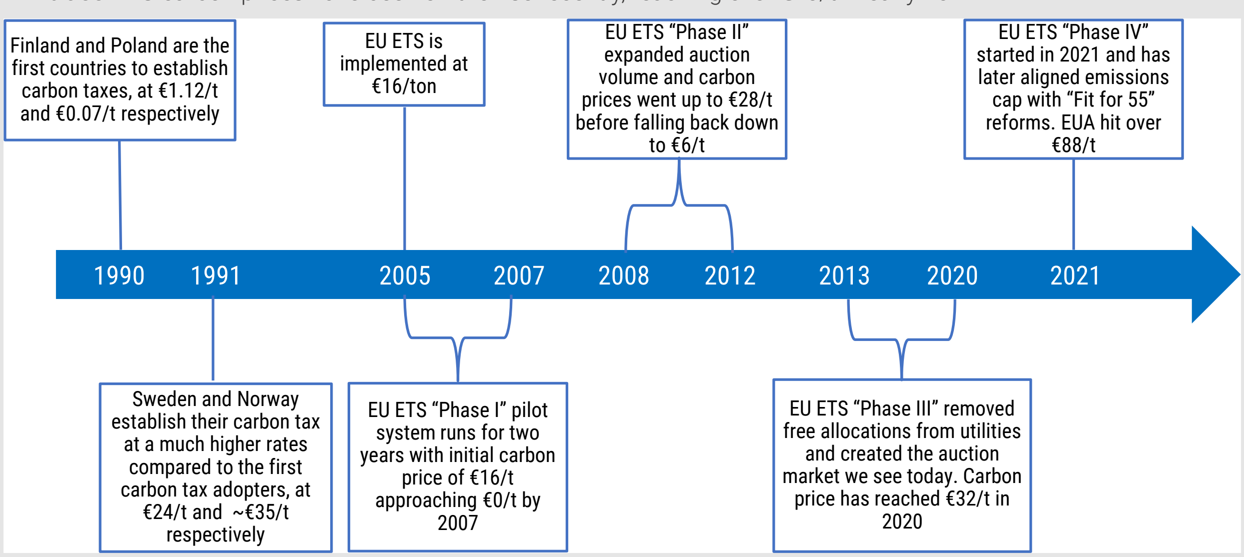
19 European Commission

Exhibit 65: The first carbon schemes were introduced in the 1990s



Source: World Bank, Morgan Stanley Research

Exhibit 66: EU carbon prices have been on the rise recently, reaching over €90/t in early 2022



Source: European Commission, Morgan Stanley Research

Improving Water Efficiency: The Role of Industry

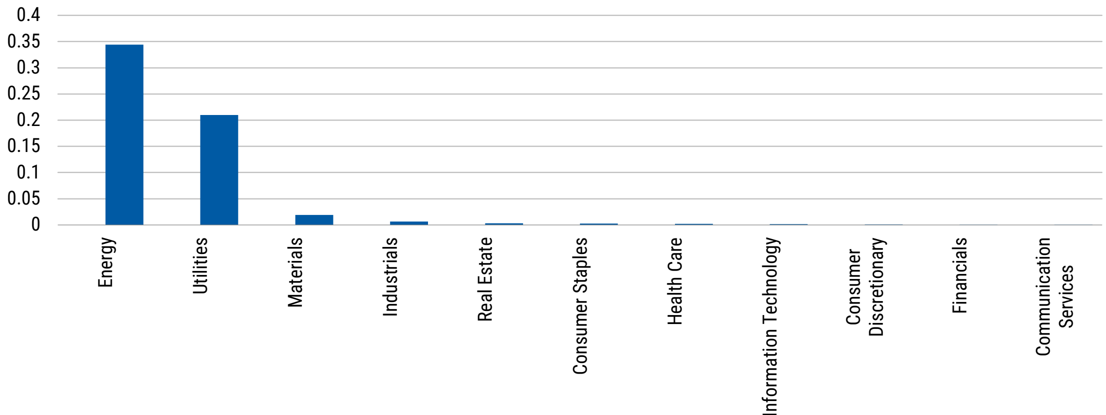
Energy producers and utilities are by far the most water-intensive companies. Water is also a key resource for chemicals, mining, construction materials, food & beverages, apparel, pharmaceuticals, semiconductors and data centres.

Potential supply disruption and possible long-term regulation and price inflation means water-intensive companies need to become more water efficient.

We look at what is being done on the ground in these sectors to improve water efficiency.

Exhibit 67: Energy and Utilities are by far the most water-intensive sectors

Water intensity by sector [mn m3/$]



Source: Thomson Reuters, Morgan Stanley Research

Exhibit 68: Key water challenges faced by water-intensive industries and potential solutions

Sector	Average water intensity [m3/$]	Problems	Solutions
Utilities	210,118	· Water and electric utilities are the most water intensive sub-industries · "Thermal pollution" (warm water returns to local ecosystems) is a risk to aquaculture	· Dry cooling - fans used to lower the temperature of the steam exiting the turbine · Using sea water (e.g. supported through desalination technologies)
Mining	16,265	· Water used extensively in mineral processing, dust suppression and slurry transport, among others · At a local level, mining operations can strain aquifers, which can lead to operational risk	· Water recycling and reuse (e.g. supported by thickened tailings technology) · Using sea water (e.g. supported through desalination technology)
Cement	4,665	· Water is used in the production of cement but the highest withdrawals are in the production of concrete	· Use water reducing admixtures (plasticizers) · Improve water recycling & water conservation (e.g. supported by closed-loop cooling) · Switching to groundwater away from public water
Pharma	3,715	· Water is a key input in product development (e.g. for processing, formulation and manufacturing) · Manufacturing requires high quality water; but pharma industry impacts local water quality	· Implementation of water purification systems · Installing condenser pumps and metering
Beverages	3,561	· Water is the key ingredient in beer (~90% of beer is water) · Water is also necessary for the growth of other main ingredients (e.g. grain and hops)	· Implementing more efficient techniques (e.g. installing meters to detect leaks) and increasing water recycling rates (e.g. supported by UV-light bacteria elimination technologies) · Implementing water purification systems allowing for saline-contaminated water to be used
Semiconductors	1,869	· Water intensity driven by rinsing & cooling processes and the need for ultra-pure water (UPW) · Wastewater generated in the process can be contaminated/toxic · Lots of production is concentrated in arid areas	· Water reduction, recycling and reuse (e.g. supported by water reclamation technologies)
Apparel	1,046	· Water intensity driven by various aspects - e.g. growing crops (e.g. cotton), raw fiber processing & domestic washing of clothing · Textile industry is responsible for the release of hazardous chemicals into local ecosystems	· Technological innovations can reduce water usage in finishing, fabric dying & other processes (e.g. modifying the bleaching process with the oxidant ozone) · Recycling and reusing water
Data Centres	623	· Regulating the temperature of data centres requires dry or wet cooling systems (highly water intensive) · Data centres are often located in water stressed regions	· Implementing water metering systems

Source: Morgan Stanley Research

Utilities

Utilities is one of the most water-intensive sectors in MSCI World and EM indices. Within the sector, water utilities and electric utilities stand out in particular, withdrawing on average 0.45 and 0.25 mn m3 of water per dollar of revenue respectively. The high water intensity of water utilities is clear. For electricity generation, thermal power plants use water extensively in processes to create the steam that spins the turbine and subsequently to cool the steam. Additionally, as we look to the energy transition, water is used in emissions reduction through CCS, which can increase water withdrawal by ~50% compared to unabated fossil fuels.

Risks to aquaculture. Most thermal plants use freshwater from sources such as lakes and rivers. Although the majority of withdrawn water is returned to the system, thermal plants still have a material impact on the ecosystem and nearby water sources. Water is returned to the system at a higher temperature, causing so-called "thermal pollution", which poses a risk to temperature-sensitive biodiversity. According to the study quoted by NRDC, for each 20,000-50,000 gallons per MWh of water withdrawn in a once-through cooling system, 100 fish are killed.[20] In 2010, withdrawals for thermoelectric plants totalled 161bn gallons per day in the US.[21]

20 https://www.nrdc.org

21 https://dx.doi.org

Dry cooling is one solution to reduce the water intensity of thermal plants. In this process, fans are used to lower the temperature of the steam exiting the turbine. There are, however, shortcomings associated with this method. Dry cooling typically lowers the efficiency of the plant and is therefore used only when water resources are stressed; for example, in California and Texas. Desalination perhaps offers a more energy-efficient solution to reducing thermal plants' dependence on freshwater sources. While dry cooling requires additional power of 55-130kWh per gallon of water saved, desalination needs only 4-15kWh.[22] That said, to be able to benefit from desalination, thermal plants need to be located near the coast. The use of desalination also requires a steep initial capex commitment and may pose a challenge to marine biodiversity through thermal pollution and poorly designed intake systems (for more detail see Solution #1: Desalination).

22 Reimers, 2018

Exhibit 69: Water targets for Utilities companies under Morgan Stanley coverage

Ticker	Company name	MS Analyst	Key water targets
NEE.N	NextEra Energy	Byrd, Stephen	No quantifiable water targets found
DUK.N	Duke Energy	Byrd, Stephen	Reduce water withdrawals by our generation fleet by 1tn gallons by 2030 versus 2016, reduce releases of toxic chemicals to water by half by 2030 versus 2016
SO.N	Southern Company	Byrd, Stephen	No quantifiable water targets found
IBE.MC	Iberdrola	Pulleyn, Robert	Reduce water use/ production intensity by 50% by 2030 versus 2019
EXC.O	Exelon	Byrd, Stephen	No quantifiable water targets found
NG.L	National Grid	Laybutt, Christopher	No quantifiable water targets found
AEP.O	American Electric Power	Byrd, Stephen	In 2023, we will retire the Pirkey Plant, which will reduce our water consumption anywhere between an additional 9,400 to 11,170 million gallons per year
SRE.N	Sempra Energy	Byrd, Stephen	Increase recycled water use to at least 90% at all our facilities
ORSTED.CO	Orsted	Pulleyn, Robert	No quantifiable water targets found
XEL.O	Xcel Energy Inc	Byrd, Stephen	Reduce water consumption from electricity generation by 70% by 2030 from 2005 level

Note: Our analysis looks at the 10 largest listed players (by market cap) under Morgan Stanley coverage. Source: Company Data, Morgan Stanley Research

Case study: ENGIE

Water is used extensively in ENGIE's operations – in thermal generation, hydroelectricity, geothermal, district heating and cooling networks. The company has designed a water management methodology to ensure reliable access to water sources and the environmental sustainability of water use. ENGIE has been a member of the CEO Water Mandate since the group was established by the UN in 2007 and has contributed to the OECD Water Governance Initiative. During COP21, the company signed the "Business Alliance for Water and Climate", which commits signatories to measure and report water use data as well as reduce impacts on water in operations and throughout the value chain.

Monitoring water risks. In its own operations, ENGIE has implemented action plans for sites in areas of extreme and high water stress and has measured the water footprint of its activities. In 2018, the company categorized 40 of its sites (5.5% excluding wind and solar) as located in water-stressed areas. Of these 40 sites, only 6 require the use of freshwater, while the rest use water recycling. ENGIE's Kwinana cogeneration plant in Perth, Australia has modified its processes in order to substitute 80% of its freshwater needs with recycled industrial process water. In Chile, ENGIE is selling a portion of the used desalinated water from its Mejillones Conventional plant to a mining site in Antofagasta.

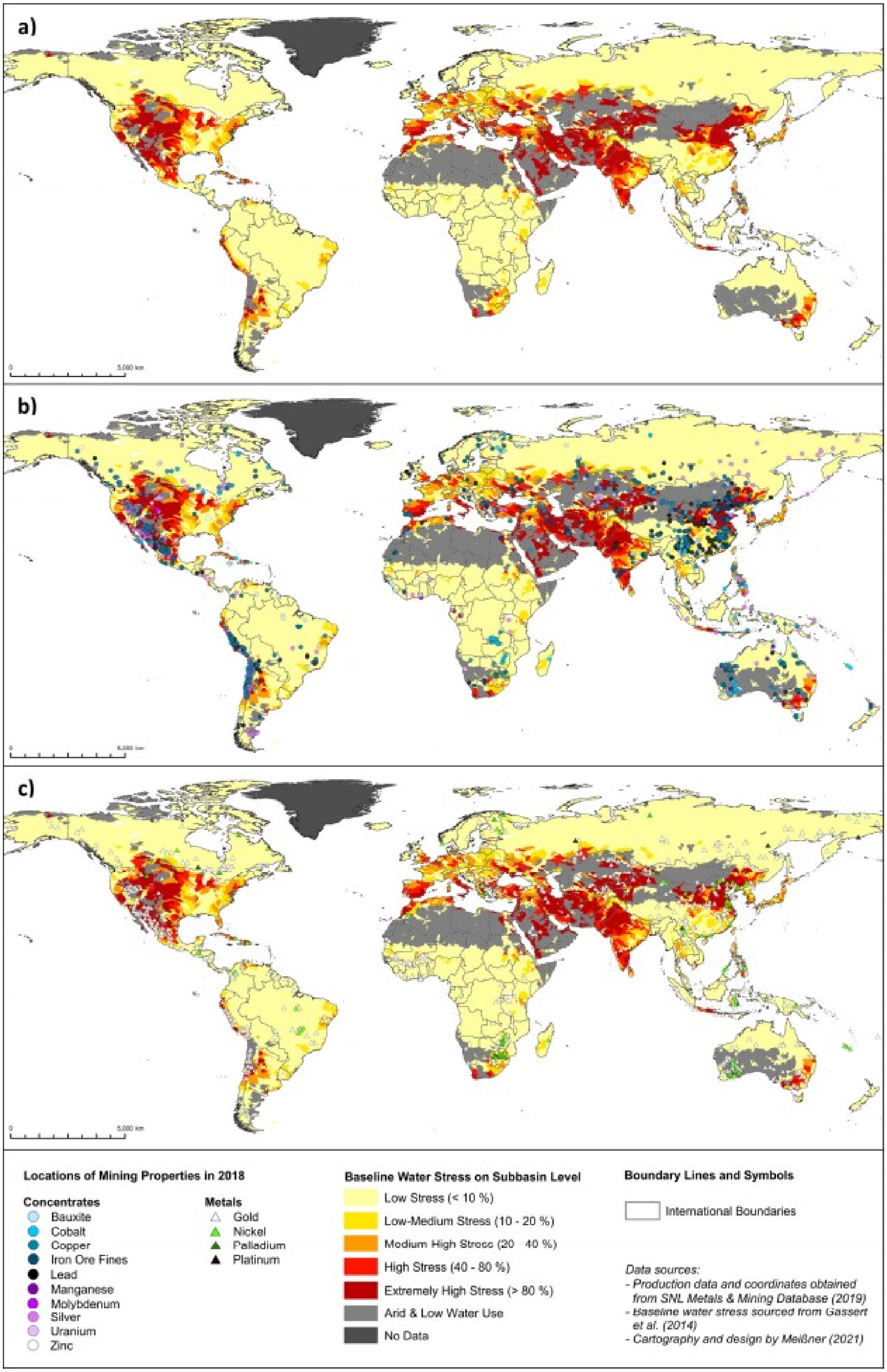
ENGIE has outperformed its initial target to lower water withdrawals, achieving a 39% reduction in 2019 versus the planned 15% by 2020 (compared to a 2012 baseline). In 2020 ENGIE renewed its water policy. It set two new water reduction targets: 15% by 2025 and 30% by 2030 versus 2020 baseline. Additionally, the company has committed to implementing environmental plans for all industrial activities in 80% of its sites by 2025 and in all of its sites by 2030.

Mining

Metals and mining is one of the top 5 most water-intensive industries in MSCI World and MSCI EM universe. Water is used extensively in mineral processing, dust suppression and slurry transport, among other areas. It is a strategic resource and its scarcity poses a considerable challenge.

On a large scale, mining accounts for only a small proportion of global water withdrawals. According to the study conducted in 2015 by the US Geological Survey (USGS), mining is responsible for only 1% of total water consumption in the US. That said, on a local level, mining operations can put a significant strain on aquifers and are likely to experience operational risks at some point as a result of droughts and changing weather patterns. Many mining hubs are located in regions of high water scarcity, such as copper mines in northern Chile and iron ore mines in South Africa (Exhibit 70).

Exhibit 70: Locations of mining sites in 2018 in relation to water stress: (a) water stress at sub-basin level; (b) mining locations of metal concentrates; (c) mining and production locations of refined metals, both related to water stress



Source: Meißner, S. The Impact of Metal Mining on Global Water Stress and Regional Carrying Capacities—A GIS-Based Water Impact Assessment. Resources 2021, 10, 120

Water intensity of mining varies significantly by metal mined, with bauxite consuming as little as 0.4m3 of water per tonne and platinum requiring 313,496m3 of water per tonne.[23] The water intensity of a given metal can also vary significantly depending on mine type and processing technology. Although platinum and palladium stand out as among the most water-intensive metals on a per tonne basis, in absolute terms their impact on water resources is lower than that of iron ore or copper, which are mined in larger volumes.

Exhibit 71: The water intensity of different metals varies to a large extent

Metal	Average water consumption [m3/tn of metal]
Bauxite	0.4
Cobalt	208
Copper	43
Gold	265,861
Iron Ore	1.4
Lead	6.6
Manganese	1.4
Molybdenum	240
Nickel	194
Palladium	210,713
Platinum	313,496
Silver	1,713
Uranium	2,746
Zinc	12

Source: Meißner, S. The Impact of Metal Mining on Global Water Stress and Regional Carrying Capacities—A GIS-Based Water Impact Assessment. Resources 2021, 10, 120

Managing water risks. A growing demand for key metals coupled with a limited water supply mean that mining companies need to establish robust water risk management frameworks. Efforts have been made to increase the efficiency and stability of water supplies. Water recycling and reuse are implemented extensively; Jiangxi Copper, for example, achieved a 95.7% water recycling rate in 2020. There has been a lot of focus on dewatering mine tailings to increase water recovery rates and to reduce the risk of dam failings. Desalination or salt water use have been adopted to some degree, often as contingency solutions.

Exhibit 72: Water targets for Metal & Mining companies under Morgan Stanley coverage

Ticker	Company name	MS Analyst	Key water targets
BHPB.L	BHP Group	Gabriel, Alain	No quantifiable water targets found
RIO.L	Rio Tinto	Gabriel, Alain	By 2023, disclose – for all managed operations – permitted surface water allocation volumes, their annual allocation usage and the associated surface water allocation catchment rainfall runoff volume estimate.
VALE.N	Vale	De Alba, Carlos	By 2030, reduce new water collection by 10%. By 2024, replace wet processing with safer and more sustainable dry processing in 70% of iron ore production.
GLEN.L	Glencore	Gabriel, Alain	All managed operations located in water-stressed regions to finalise the assessment of their material water-related risks, set local targets, and implement actions to reduce impacts and improve performance by the end of 2023.
1088.HK	China Shenhua Energy	Chan, Sara	No quantifiable water targets found
AAL.L	Anglo American	Gabriel, Alain	By 2030, reduce the abstraction of fresh water in water-scarce regions by 50%.
FCX.N	Freeport-McMoRan	De Alba, Carlos	No quantifiable water targets found
SCCO.N	Southern Copper	De Alba, Carlos	No quantifiable water targets found
NKELyq.L	MMC NORILSK NICKEL	Shaw, Dan	Reduce water pollution levels by 25% vs 2019 and achieve max permissible discharge rate of 159 ktpa by 2031; keep water recycling and reuse rates above 80%
FMG.AX	Fortescue Metals Group	Anand, Rahul	Set public, site-specific water management targets for each operating mine by FY23

Note: Our analysis looks at the 10 largest listed players (by market cap) under Morgan Stanley coverage. Source: Company Data, Morgan Stanley Research

Case Study: Antofagasta

In the mining sector, Antofagasta is an example of a company with water scarcity-induced challenges, as all of its mining operations are located in water-stressed areas across Chile – see our extensive analysis here Metals & Mining: Copper & Water – Reflationary trends (25 Feb 2020). The efficient use of water is therefore a core part of Antofagasta's strategy to adapt to climate change so as to ensure sufficient water availability for its operations, local communities and conservation of the environment.

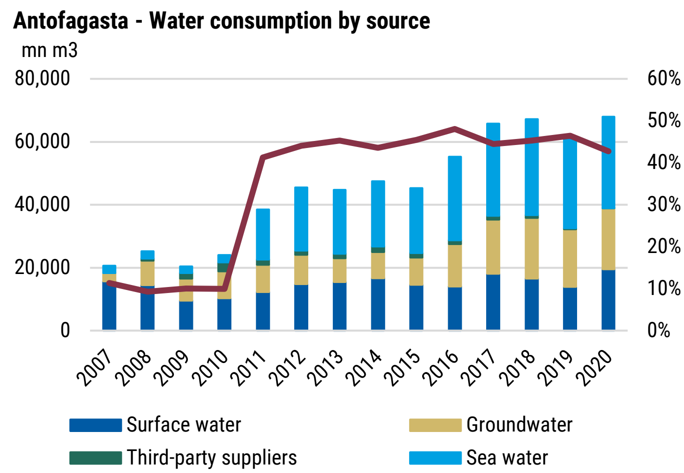
23 Meißner, S. The Impact of Metal Mining on Global Water Stress and Regional Carrying Capacities

One of the major initiatives is the optimisation of freshwater use through increased recycling and reuse rates. In the arid north of the country, Antofagasta's Centinela mine is located in the Atacama desert and was the first operation in the world to use **thickened tailings technology** at a large scale. This technology extracts most of the water from the tailings to produce a paste that is easily stackable and allows a higher percentage of the water to be recirculated back to the processing plant. The recirculation rate is significantly higher than the industry average. Similar initiatives have been employed across the rest of the mining footprint, enabling the company to raise water reuse rates to ~82% by 2020 (Exhibit 74).

In addition to water recycling, Antofagasta has pursued another major lever in reducing its freshwater use. In Northern Chile in the 1990s it pioneered the direct use of sea water (non-desalinated) at its Michilla mine and later rolled out this technology across its greenfield mines, Centinela and Antucoya, with the raw sea water extracted and pumped up to the mine sites. In Central Chile, which is suffering a 12-year drought, Antofagasta's Los Pelambres mining operation co-exists with agricultural activities, and will also begin to use sea water in late 2022, when it is scheduled to complete the first 400-l/s stage of a desalination plant. The company aims to double the plant's capacity to 800 l/s by 2025, enabling Los Pelambres to cease water withdrawals from the Choapa River. The desalination and water pumping infrastructure is set to cost more than US$1bn, with significant implications for capital intensity and unit costs. Following these investments, sea water, in either raw or desalinated form, is expected to account for ~90% of Antofagasta's total water consumption in 2025 (Exhibit 73).

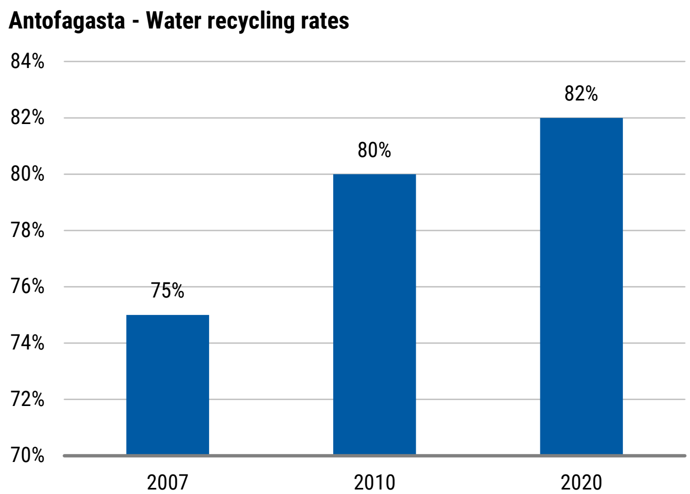
Antofagasta is also engaging in regional water management initiatives, such as the public-private Quitai Anko consortium, which won a bid to implement a five-year programme to develop sustainable solutions to water-related challenges. The focus is on the Choapa Valley, but with a view to their subsequent application in the rest of the Coquimbo Region and the neighbouring Atacama and Valparaíso Regions. The consortium has begun work on five strategic projects that include the recharge of aquifers, a model for calculating the aquifer's water balance and the development of an integrated water information system to help ensure the supply and quality of rural drinking water.

Exhibit 73: Water consumption by source



Source: Company data, Morgan Stanley Research

Exhibit 74: Water reuse rate



Source: Company data, Morgan Stanley Research

Cement

The environmental agenda in cement has been concentrated around decarbonisation, given the industry's high GHG emissions. The total CO_2 emissions from cement need to fall by a third by 2050 in the Paris Agreement 2 Degree Celsius Scenario, but production is on the rise. Cement is mainly used as a binder in concrete production, another carbon-intensive material. It is estimated that concrete production is responsible for 8.6% of the global anthropogenic CO_2 emissions.[24]

24Sabbie A Miller et al 2016 Environ. Res. Lett. 11 074029

But the water footprint of cement is also significant. Water is not only required for the production of cement, it is also a primary component of concrete. Depending on a desired outcome, the water-cement ratio in the production of concrete varies in a range of 0.4 to 0.7. Globally, concrete production uses ~9% of total industrial water withdrawals and ~1.7% of total global withdrawals. In 2012, that corresponded to some 16.6 Gm 3 of water, a figure that is expected to increase by more than 40% by 2050.[25] One way of reducing the amount of water used in concrete mixing is to use water-reducing admixtures, otherwise known as plasticizers. The addition of plasticizers allows reduced water use without affecting the consistency of the mix.

25 Miller et al. (2018) https://www.nature.com

In general, cement companies have made good progress on water recycling and discharge rates. We found that relatively few companies, however, have clearly defined water use targets. Among those that have announced their long-term water ambitions, the creation of water management plans and reduction of water withdrawals are among the most common goals. There is considerable focus on managing water use in water-scarce areas, where many cement production sites are located. It is estimated that by 2050, some three quarters of all cement production will be in water-stressed regions.[26]

26 Miller et al. (2018)

Exhibit 75: Water targets for Cement companies under Morgan Stanley coverage

Ticker	Company name	MS Analyst	Key water targets
CRH.I	CRH	Ekblom, Cedar	100% of companies to have water management plans in place by 2030.
HOLN.S	Holcim	Ekblom, Cedar	By 2030, reduce freshwater withdrawal in cementitious material by 33%, in aggregates by 20% and by 15% in Ready Mix Concrete versus 2018 levels. 75% of sites located in water risk areas will be water positive by 2030. 100% of sites in medium, high and extremely high water risk areas to be equipped with recycling systems by 2030. 100% of water discharged will meet Holcim water quality standards and in-country regulations enhancing water quality and protecting biodiversity by 2026.
0914.HK	Anhui Conch Cement	Zhang, Rachel	No quantifiable water targets found
HEIG.DE	HeidelbergCement	Ekblom, Cedar	No quantifiable water targets found
3323.HK	China National Building Material Company	Zhang, Rachel	No quantifiable water targets found
1101.TW	Taiwan Cement	Wang, Yujie	No quantifiable water targets found
CX.N	Cemex	Lippmann, Nikolaj	By 2030, implement a specific Water Action Plan (WAP) for water-scarce areas. In 2021, aimed to implement WAPs in 1% of sites located in extremely high water stressed zones.
BEAN.S	Belimo Holding	Liu, Pam	No quantifiable water targets found
600801.SS	Huaxin Cement	Zhang, Rachel	No quantifiable water targets found
1313.HK	China Resources Cement Holdings Ltd.	Zhang, Rachel	No quantifiable water targets found

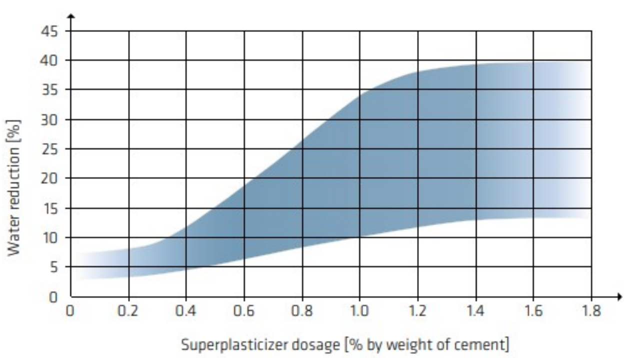
Note: Our analysis looks at the 10 largest listed players (by market cap) under Morgan Stanley coverage. Source: Company Data, Morgan Stanley Research

Case study: Sika

Sika is the largest producer of construction chemicals, with a 9% global market share. The company develops products for bonding, sealing and reinforcing, including concrete admixtures. Concrete admixtures are chemical additives used in concrete mixing which enhance workability and durability. In its portfolio, Sika has developed a range of water-reducing admixtures, including plasticizers and superplasticizers that allow for a significant reduction in water used in concrete mixing. For example, Sika's ultra high range water reducing ViscoCrete technology enables up to a 45% reduction in water content in concrete.[27] There are over 20 products in Sika's plasticizer portfolio under Plastiment, Plastocrete and Sikament brands and close to 100 different superplasticizers. The company claims that over 6bn litres of water are saved annually in concrete production as a result of using its admixtures. [28]

In its own operations, Sika implements water-conservation strategies through closed-loop cioanooling, cooling towers and switching from public water sources to groundwater. The company has reduced its water consumption from almost 0.4m3/t sold in 2018 to a little over 0.2m3 in 2020.

Exhibit 76: Superplasticizers permit a reduction in the water content of a concrete mix without compromising the consistency



Source: Company data

Pharmaceuticals

Water is an essential input into pharmaceutical product development. Water is one of the major commodities used by the pharmaceuticals industry across processing, formulation and manufacture of pharmaceutical products, active pharmaceutical ingredients (APIs) and intermediates, and analytical reagents. Most companies across the sector are actively implementing strategies/targets to reduce water consumption. For example, some are conducting life-cycle assessments (LCAs) to calculate the water footprint across the full life-cycle of pharmaceutical products, including the raw materials used to make drug substances. Others have implemented new internal meters that enable better control of water consumption. Many pharma companies are specifically targeting water-scarce manufacturing regions. Bayer, for example, estimates that 5.7% of its total water consumption comes from water-scarce sources or in areas identified as being threatened by water scarcity. Indeed, its site in Cape Town is in a water-stressed basin, and so water efficiency has been a key area of focus for this site – so far the company has been able to reduce its impact by 53% since 2010.

But water quality is also essential for the industry – both from an 'impact' and an 'impacted' perspective. From an 'impact' perspective, a key area of focus for these companies is ensuring that pharmaceuticals do not enter aquatic environments. This typically involves monitoring discharges from own operations and supplier production sites, and the installation of water filtration systems, such as carbon-filter technologies, to better purify water from active pharmaceutical ingredients. From an 'impacted' perspective, water quality is extremely important for pharmaceutical companies, as water must meet certain quality criteria to be deemed suitable for use.

27https://usa.sika.com

28 Sika Innovative Technologies

Exhibit 77: Water targets for the largest pharmaceutical companies under Morgan Stanley coverage

Ticker	Company name	MS Analyst	Key water targets
JNJ.N	Johnson & Johnson	Harrison, Matthew	No quantifiable water targets found
ROG.S	Roche Holding AG	Purcell, Mark	By 2025, the company aims to reduce water consumption by 15% (water risk weighted m3 per employee).
PFE.N	Pfizer Inc	Harrison, Matthew	No quantifiable water targets found
ABBV.N	Abbvie Inc.	Harrison, Matthew	The company aims to reduce absolute water withdrawal (including non-contact cooling water) by 20% by 2025 and 50% by 2035 (versus 2015 baseline).
NOVOb.CO	Novo Nordisk A/S	Purcell, Mark	No quantifiable water targets found
ABT.N	Abbott Laboratories	Furlong, Cecilia	By 2030 the company aims to achieve water stewardship certification at all of its high-water manufacturing sites operating in water stressed areas.
LLY.N	Eli Lilly Co.	Harrison, Matthew	By 2030 the company intends on having no adverse impact (from a water perspective) on water-stressed areas and no adverse impact from pharmaceuticals in water environments.
MRK.N	Merck Co., Inc.	Harrison, Matthew	By 2025, the company aims to maintain global water use at or below 2015 levels across its internal operations. In the same time period, the company aims for at least 90% of its strategic suppliers with the highest environmental impacts to set their own water use reduction targets.
NOVN.S	Novartis AG	Purcell, Mark	Reduce water consumption in operations by half by 2025 (versus 2016), with no water quality impacts from manufacturing effluents. Be water neutral in all areas of operations by 2030, while actively enhancing water quality wherever it operates.
AZN.L	AstraZeneca Plc	Purcell, Mark	2025 target is to maintain absolute water use at 2015 baseline levels. Longer term, the company hopes to implement Science-Based Targets for Water.

Note: Our analysis looks at the 10 largest listed players (by market cap) under Morgan Stanley coverage. Source: Company Data, Morgan Stanley Research

Case Study: AstraZeneca

AstraZeneca's water strategy is grounded in its materiality assessment – identifying operations in water-scarce regions and prioritizing action within these regions. The company's Water Scarcity Map shows the water scarcity rating for sites that use over 10,000m3 of water per year. WWF's Water Risk Filter also helps the company understand how water risks will change under different climate scenarios – helping to highlight regions in which water efficiency should be a priority moving forward. Examples of specific water-related actions undertaken by AstraZeneca are highlighted below.

Purification of water in West Chester leading to incremental savings of $50,000 a year. At this particular site, purified water generators were optimized to reduce the volume of rejected water when preparing water for the manufacturing process. This exercise helped reduce rejected water flow by 30% without any impact to the quality of purified water. The company expect that these changes will reduce the site's water footprint by 20% or 34,000m3 a year, which represents a saving of $50,000 in costs annually.

Reducing Newark's water footprint by 3% annually through optimization of steam condensate. At its Newark site, AstraZeneca has upgraded its chiller condenser pumps and installed metering, which the company hopes will optimize its steam condensate water consumption. The company expects that these changes will reduce the site's water footprint by 3% or 2,250m3 a year.

Improving water efficiency at the company's Taizhou site through collecting and filtering rejected water. The company's water purification process results in two water types: (1) purified water, which is used in the company's manufacturing process; (2) water rejected due to quality. Equipment was installed at the Taizhou site to collect and filter the rejected water for reuse in the site's cooling towers. The company estimates that this initiative resulted in the site's water footprint falling by 13% or 12,000m3 a year.

Beverages

Water is essential to the Beverage industry, including Brewers. Water is the key ingredient in beer (~90% of beer is water, according to Diageo) and is also necessary for the growth of other main ingredients such as grain and hops. In addition, water is required at multiple stages of the beer production process, including pasteurisation, cooling, bottle washing, and cleaning.

Beverage companies' water strategies and targets largely focus on water use intensity in production and water security. Our table below outlines key water targets among the largest beverage companies under Morgan Stanley coverage.

- **Water use intensity.** Beverage companies can reduce water use intensity in production by implementing more efficient techniques, increasing water recycling rates, and minimising water waste. Water use intensity in production measures the volume of water used to produce a specified unit of the final product, and is usually measured in hl/hl (hectolitres of water used to produce 1 hectolitre of the final product).

- **Water security.** Partnerships (e.g. with communities, local authorities, and NGOs) on projects are aiming to safeguard community water resources and improve water availability, accessibility and quality, particularly in highly water-stressed areas. These partnerships are often linked to community projects that aim to improve or provide access to clean drinking water, sanitation, and hygiene. Risk mapping and assessments enable prioritisation of the highest risk watersheds, and solutions include infrastructure improvements and the restoration of ecosystems. To achieve a net positive water impact in direct operations, some companies are aiming for water replenishment to exceed water withdrawal.

Exhibit 78: Water targets for largest beverage companies under Morgan Stanley coverage

Ticker	Company name	MS Analyst	Key water targets
600519.SS	Kweichow Moutai Company Ltd.	Lou, Lillian	No quantifiable water targets found
KO.N	Coca-Cola Co.	Mohsenian, Dara	The company's 2030 water strategy targets the following: 100% regenerative water use in all leadership locations; 100% compliance with global water stewardship requirements; 100% of priority communities supported with water and sanitation access; 100% WASH (water, sanitation and hygiene) provision in bottling system and supply chain; 100% watershed stewardship implementation in priority watersheds and 100% advanced water management practices for ingredients grown in water-stressed regions.
PEP.O	PepsiCo Inc.	Mohsenian, Dara	By 2025, the company aims to improve water-use efficiency by 15% in its agricultural supply chain (focused on corn and potatoes) in high water-risk areas. In addition, by 2030 the company aims to deliver safe water access to 100 million people, to replenish more than 100% of the water that it uses back into the local watershed in high water-risk areas and to achieve "best-in-class" or "world-class" water-use efficiency at all company-owned and third-party manufacturing facilities.
DEO.N	Diageo PLC	Ergun, Pinar	Reduce water use intensity by 30% by 2030 at all sites (versus FY20), and by 40% at stressed sites. Replenish more water than used in operations at all sites in water-stressed areas by 2026. Complete 150 community water projects by 2030, including providing access to clean water, sanitation, and hygiene.
ABI.BR	Anheuser-Busch InBev SA	Ergun, Pinar	Reduce water use intensity by 2025 to 2.5 hl/hl at all sites (versus 2.7 hl/hl as of FY20), and to 2.0 hl/hl at water-stressed sites. Ensure that 100% of communities in high-stress areas have measurably improved water availability and quality by 2025.
000858.SZ	Wuliangye Yibin Company Ltd.	Lou, Lillian	No quantifiable water targets found
9633.HK	Nongfu Spring Co Ltd	Lou, Lillian	Whilst no quantifiable water targets were identified we note the following from the company's Sustainability Development Public Policy report: "Water-saving objectives and orientations have been specified in our established long-term planning with an aim to continuously improve water utilization and reduce water consumption intensity."
HEIN.AS	Heineken NV	Ergun, Pinar	Reduce water use intensity by 2030 to 2.9 hl/hl at all sites (versus 3.4 hl/hl in FY20), and to 2.6 hl/hl at water-stressed sites (versus 3.1 hl/hl in FY20). Achieve water balance in stressed sites by 2030. Treat 100% of wastewater by 2023.
PERP.PA	Pernod Ricard SA	Ergun, Pinar	Reduce water use intensity by 20% by 2030 (versus FY18). Achieve water balance in 100% of stressed sites by 2030.
KDP.O	Keurig Dr Pepper Inc	Mohsenian, Dara	The company aims to partner with its highest water-risk operating communities to replenish 100% of water used for its beverages in those communities and to achieve a 20% improvement in water use efficiency by 2025.

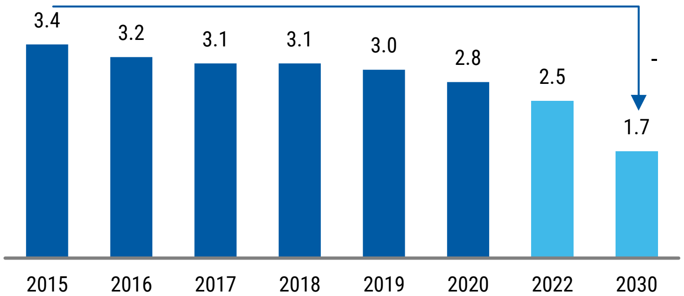
Note: Our analysis looks at the 10 largest listed players (by market cap) under Morgan Stanley coverage. Source: Company Data, Morgan Stanley Research

Case Study: Carlsberg

Carlsberg, the Danish multinational brewer, aims to reduce water use intensity (hectolitres of water used to produce 1 hectolitre of beer/soft drink) by 50% by 2030 compared to a 2015 baseline (see Exhibit 79), as part of the beer company's "Together Towards ZERO" sustainability roadmap. Carlsberg has already achieved an 18% improvement in water efficiency since 2015, and screens reasonably well compared to peers (hl/hl water use efficiency in 2020 was 2.8 for Carlsberg, 2.7 for ABI, and 3.4 for Heineken). Furthermore, Carlsberg currently has the most ambitious target for further improvement (relative to the company's latest performance) within our Consumer Staples coverage. In 2021, CDP awarded Carlsberg an A score for water stewardship, making the brewer one of only 118 of the ~3,400 disclosing companies globally to make the "A-list".

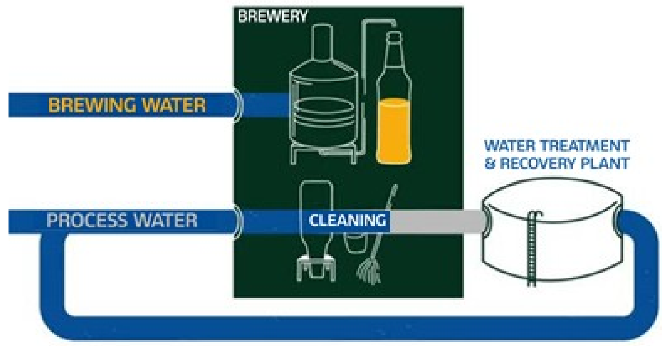
Exhibit 79: Carlsberg water use intensity performance and future targets: the company aims to halve water use intensity in production by 2030

Carlsberg: Relative Brewery Water Use (hl/hl)



Source: Company data: historical performance and future targets. Note: Relative brewery water use = hectolitres of water used to produce 1 hectolitre of beer / soft drinks.

Exhibit 80: Carlsberg's Fredericia brewery water recycling plant recycles 90% of all process water, halving its water consumption



Source: Company website; Morgan Stanley Research.

Best practice improvements are an initial step towards improving water use efficiency. Carlsberg's Dazhulin brewery in China reduced water usage in beer production from 2.7 to 2.2 hl/hl in just four months, through best practice improvements. The team scrutinised processes and pipes in order to identify any inefficiencies or leaks and installed more water meters to gain a greater understanding of water usage at different stages of production. The brewery also collated employee suggestions for areas where water could be saved in production, based on their own first-hand experiences, resulting in the introduction of new measures such as reusing water in cleaning processes.

Water recycling technologies can accelerate progress by significantly reducing water waste. Carlsberg opened a "state-of-the-art" water recycling plant at its brewery in Fredericia, Denmark, in May 2021. The plant recycles 90% of process water at the brewery, reducing relative water use from 2.9 hl/hl to 1.4 hl/hl and making Fredericia the most water efficient brewery in the world, according to the company. The plant uses technology such as applying UV-light to eliminate bacteria in order to clean and recycle process water, which is then used to clean the production facilities (see Exhibit 80). Carlsberg intends to achieve its 2030 water targets by continuing to roll out more water recycling plants and sharing best practice learnings at its other breweries across the world – in 2020, the company built three new wastewater treatment plants in Eastern Europe and one in Bulgaria, and introduced a rainwater harvesting system and extended wastewater recycling at its Alwar brewery in India.

Safeguarding community water resources in high-risk areas is another key priority. Beyond the production process within breweries, Carlsberg is also working to address water security issues. In 2019-20, Carlsberg partnered with local authorities in five provinces in Vietnam to install and repair water infrastructure in order to bring clean water to ~19,500 people. Carlsberg has also now partnered with Desolenator (a technology company using solar power for water purification) on a project in West Bengal, India, that will convert saline-contaminated water into 20,000 litres of clean drinkable water per day. The project will benefit an estimated ~4,000 people in the region, where rising sea levels are contaminating freshwater sources. Carlsberg intends to establish further partnerships to safeguard shared water resources for communities, and aims to have a partnership in place by 2030 in all brewery areas identified as high-risk (17 breweries in Cambodia, China, India, Laos and Nepal).

Semiconductors

Semiconductor producers are one of the most water-intensive companies in the technology sector. On average, a semiconductor factory will use 7k-15k m3 of water per day (Sustainalytics, 2017), with the largest companies such as TSCM withdrawing as much as 200,000m3 of water per day. Water is used mainly for rinsing and cooling, but the former needs a much higher standard of water.

Purity of water is extremely important to avoid contamination of products. The industry uses ultra-pure water (UPW), which is free of minerals and minute contaminants, to rinse wafers after chemical processing. The process of developing ultrapure water is water intensive in itself. It can take as much as 1.25-1.5l of water to produce one liter of ultra pure water.[29]

Wastewater generated in the process of semiconductor production can contain heavy materials and toxic solvents. Regulation requires removing substances such as metals, toxic organic com-

29 Eccles et al. (2012)

pounds, nitrates and sulfides from wastewater before discharge. Companies need to invest in biological treatment systems to mitigate the impact of their operations. There is a significant focus on increasing water recycling rates in semiconductor plants, but there may be a limit to the extent to which water can be reused internally. The production process requires a high level of purity in the water input, and the cost of cleaning the wastewater to such high standards must be taken into consideration.

A lot of production is concentrated in arid areas. China, for example, is one of the major players in semiconductor manufacturing that needs to carefully consider strategy for water use in its chip production. Most of the factories are situated in water-scarce regions in the north-west of the country. Additionally, China's chip factories are on average more water-intensive than their peers in Japan, Taiwan and the US.[30] Changes in weather patterns are also likely have a disruptive effect on water-thirsty semiconductor manufacturing in the near future. Last year, as a result of poor rainfall, authorities in Taiwan restricted water use in Hsinchu and Taichung regions, two large chip-making hubs. Although the impact on manufacturing was contained, the prospects of increasingly common droughts put pressure on factories to reconsider their water management practices and contingency planning.

Among the companies under Morgan Stanley coverage, key water targets concentrate on reduction, recycling and reuse. In North America Intel has set an ambitious goal of being water positive by 2030. In APAC, TSMC has made major strides in water reclamation technologies.

30 Frost and Hua 2017 https://ieeexplore.ieee.org

Exhibit 81: Water targets for Semiconductor companies under Morgan Stanley coverage

Ticker	Company name	MS Analyst	Key water targets
AEVA.N	Aeva Technologies	Moore, Joseph	No quantifiable water targets found
2330.TW	TSMC	Chan, Charlie	Reduce unit water consumption (liter/8-inch equivalent wafer mask layer) by 30% vs 2010, increase the replacement rate of regenerated water by more than 30%, increase water pollution composite indicator 30% above the current standards
NVDA.O	NVIDIA	Moore, Joseph	No quantifiable water targets found
AVGO.O	Broadcom	Moore, Joseph	No quantifiable water targets found
INTC.O	Intel Corporation	Moore, Joseph	By 2030, achieve net positive water use by conserving 60 billion gallons of water and funding external water restoration projects.
TXN.O	Texas Instruments	Moore, Joseph	No quantifiable water targets found
AMD.O	Advanced Micro Devices	Moore, Joseph	No quantifiable water targets found
AMAT.O	Applied Materials	Moore, Joseph	No quantifiable water targets found
MU.O	Micron Technology	Moore, Joseph	By 2030, achieve 75% in water conservation through reuse, recycling and restoration, with an aspiration to reach 100% over the long-term
LRCX.O	Lam Research Corp	Moore, Joseph	By 2025, achieve 17 mn gallons of water savings in water-stressed areas through water efficiency projects vs 2019 baseline

Note: Our analysis looks at the 10 largest listed players (by market cap) under Morgan Stanley coverage. Source: Company Data, Morgan Stanley Research

Case study: TSMC

At 86.4%, TSMC's water recycling ratio was the highest among its peers in 2020. The company has developed a comprehensive water management strategy with the focus on three main pillars: (i) risk management of water resources, (ii) development of diverse water sources and (iii) development of preventive measures.

In line with this strategy, the company has set three 2030 water targets:

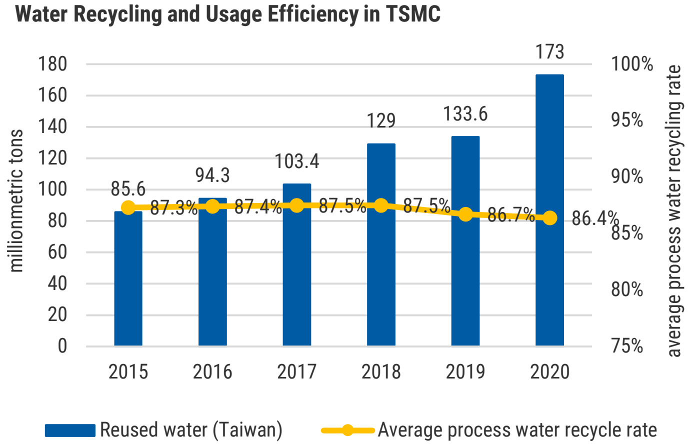
- The reduction of unit water consumption by 30% versus 2010 baseline
- The increase in the replacement rate of regenerated water by over 30%
- Setting water pollution composite indicator reduction rate to 50%

In terms of progress so far, in 2020 TSMC slightly missed its water consumption reduction target (8.9% versus planned 10%) but it exceeded its water pollution reduction rate.

As part of the strategy to diversify water sources, TSMC has been investing in water reclamation technologies since 2015. In 2021, construction started on the TSMC Tainan Science Park Reclaimed Water Plant, a project that aims to supply the company with 67,000m3 of water per day. TSMC expects 10,000 tons of water per day to originate from the plant in 2022 and aims to double this capacity by 2023.

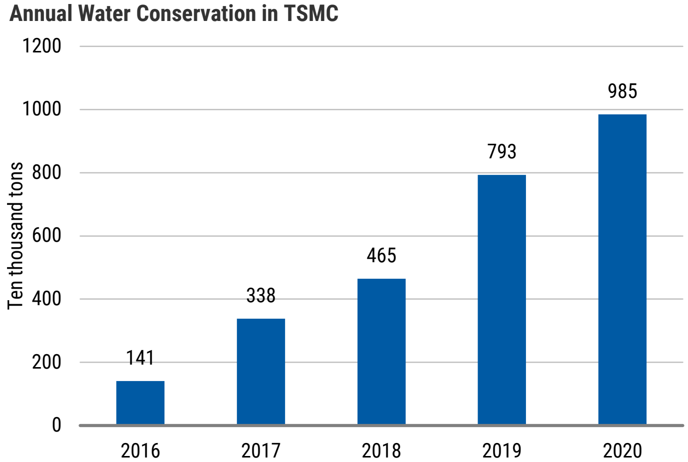
In 2020, the company established a Drought Emergency Response team, which monitors water resources and water truck capacities, and is responsible for reducing water consumption. TSMC has drought contingency measures in place, in line with government response measures, and can reduce water consumption by up to 20% in periods of water stress.

Exhibit 82: At 86.4%, TSMC's water recycling ratio was the highest among its peers in 2020



Source: Company data, Morgan Stanley Research

Exhibit 83: TSMC has made significant progress on water conservation



Source: Company data, Morgan Stanley Research

Apparel

The fashion industry currently uses an estimated ~93bn m3 of water annually (or 4% of freshwater globally)[31] and based on current consumption trends, this is set to double by 2030.[32] There are a variety of water-related demands throughout the apparel life-cycle process, including:

- **Growing crops** – for example, it takes on average 10,000 to 20,000 litres of water to cultivate 1kg of raw cotton (depending on where it is grown). It is estimated by the WWF that ~75% of cotton production is grown on irrigated land, which can exacerbate local water stress.
- **Raw fiber processing** – spinning, dyeing and finishing materials is both water intensive and highly water pollutive. For 1kg of fibre, the processing element requires an estimated 100 to 150 litres of water.[33]
- **Domestic washing of clothing** – a standard washing machine requires 90 litres of water per load.[34]

Apparel water strategies tend to target (1) water intensity and (2) hazardous chemicals in water. In Exhibit 84 we explore the key water targets announced by a selection of apparel companies under Morgan Stanley coverage. Whilst company strategies vary, most focus on the reduction of either absolute water usage or water intensity of the manufacturing process, typically relying on collaboration with suppliers. From a materiality perspective, some strategies (such as Levi Strauss, which we explore as a case study below) specify that emphasis must be placed on manufacturing areas of high water stress. Reducing hazardous chemicals in water is another area of focus for many of the strategies we analysed. Specifically, many refer to the ZDHC (Zero Discharge of Hazardous Chemicals) programme, which collaborates with a variety of stakeholders to enable brands and retailers in the textile, apparel, and footwear industries to implement sustainable chemical management best practice across the value chain.

31 Ellen MacArthur Foundation

32 Global Fashion Agenda

33 Textile Exchange

34 Whirlpool

Exhibit 84: Water targets for apparel companies under Morgan Stanley coverage

Ticker	Company name	MS Analyst	Key water targets
LVMH.PA	LVMH Moet Hennessy Louis Vuitton SA	Aubin, Edouard	By 2030 the company is targeting for 100% of strategic raw materials to be certified to standards guaranteeing the preservation of ecosystems and water resources.
NKE.N	Nike Inc.	Greenberger, Kimberly	Has achieved its previous target of a 20% reduction in freshwater use in textile dyeing and finishing (L/kg per unit of production), now working towards its updated target of 25%. Aims to restore 13bn litres of water through a portfolio of watershed projects that support long-term resilience for water-stressed ecosystems and communities within its extended cotton supply chain. Aims to achieve compliance with the ZDHC Manufacturing Restricted Substances List (MRSL).
HRMS.PA	Hermes International S.C.A.	Aubin, Edouard	The company has the following ambitions: to decouple industrial water consumption from increased business activity; to reduce water consumption by 5% per year over the period 2018 to 2023; to implement a multi-stakeholder approach and co-build with external stakeholders (regional governments, authorities and professional associations).
ITX.MC	Inditex	Mariani, Elena	Cut water used across entire supply chain by 25% by 2025. In 2020, the company achieved its target of zero discharge of hazardous chemicals in compliance with ZDHC.
PRTP.PA	Kering	Aubin, Edouard	No quantifiable, forward-looking water targets found
TJX.N	TJX Companies Inc.	Greenberger, Kimberly	No quantifiable, forward-looking water targets found
ESLX.PA	EssilorLuxottica SA	Mariani, Elena	No quantifiable, forward-looking water targets found
CFR.S	Richemont SA	Aubin, Edouard	The company aims to report water use at all industrial sites (date not identified).
9983.T	Fast Retailing	Shinozaki, Maki	No quantifiable, forward-looking water targets found
ADSGn.DE	Adidas	Mariani, Elena	Through the application of new technologies, the company aims to achieve a 40% reduction in water consumption by 2025 (versus 2017). The company aims for 80% of supplier facilities that manage chemicals in their production process to achieve Level 3 compliance with the Manufacturing Restricted Substances List (MSRL) from ZDHC for their input chemicals by 2025.

Note: Our analysis looks at the 10 largest listed players (by market cap) under Morgan Stanley coverage Source: Company Data, Morgan Stanley Research

Case Study: Levi Strauss

As one of the largest global denim brands, a category of apparel that is particularly water-intensive, Levi Strauss & Co shows how water stress can be addressed at multiple points throughout the supply chain. Levi's focus on water stewardship is driven by its "Water<Less" program that launched in 2011 and provides guidelines, techniques and innovations to address water efficiency. Specifically, Levi Strauss set the following 2025 targets: 1) 50% reduction of water usage in manufacturing base in areas of high water stress by 2025 (vs. 2018); 2) 100% of key fabric and garment suppliers to meet their new contextual Water<Less targets by 2025 (~80% of product volume); and 3) 100% of key factories and fabric mills to become designated Water<Less facilities by 2025. As of the end of 2020, 67% of Levi Strauss products were made using Water<Less techniques and guidelines.

Innovations throughout the garment finishing, fabric dying & other processes help drive down water usage. For example, Levi's Water<Less fabric results in 65% water savings compared to traditional dying processes – saving more than 6 litres of water per garment. By modifying the bleaching process with the oxidant ozone, the company saves an additional 12 litres of water per garment. These are two of some 20 Water>Less innovations that the company has introduced to bring water efficiency to the denim manufacturing process. These innovations are all made publicly available to benefit the entire supply chain.

The company's "Recycle & Reuse" standards establish its core guidelines for water recycling at manufacturing facilities. The guidelines state that manufacturers must follow the Zero Discharge of Hazardous Chemicals (ZDHC) Foundation's wastewater guidelines and recycle more than 20% of water used throughout the manufacturing process. The ZDHC Foundation's guidelines were initially released in 2016 to provide a unified standard for wastewater testing, as water pollution contributes materially to water stress. The implementation of these "Recycle & Reuse" guidelines has led to 8.5 billion litres of total water recycled between 2014 and 2020, including 3.51 billion litres in 2020 alone, up from 0.74 billion in 2018.

By creating transparency throughout its supply chain, Levi Strauss helps to identify higher-impact suppliers and understand impacts at the local level. The company works with an environmental database to monitor its suppliers, and has access to real-time performance data to track air emissions and wastewater discharge. This program covers 100% of the company's higher environmental impact suppliers, with other suppliers disclosing as well. This waste and efficiency data allows Levi Strauss to determine impact levels at each stage of the supply chain and understand regional water stress and wastewater quality.

Exhibit 85: Top 5 Techniques by Water Saving

Rank	Water Savings per Jean (L)	Water<Less™ Technique
1	12.0	Ozone
2	12.0	Ozone Mist
3	11.8	Combine desize & stonewash / enzyme wash
4	11.1	Combine desize, enzyme wash & bleach
5	10.8	Combine enzyme & softener

Source: Levi Strauss & Co

Exhibit 86: Top 5 Techniques by Frequency

Frequency of Use Rank	Water Savings per Jean (L)	Water<Less™ Technique
1	5.9	Remove desize
2	5.8	Spray potassium permanganate on raw garments
3	11.8	Combine desize & stonewash / enzyme wash
4	0	Rigid[1]
5	2.4	Low liquor ratio for stone wash

1. Rigid denim requires no additional water for finishing; it does not accrue savings since it is an unwashed finish. Source: Levi Strauss & Co

Data Centres

A typical data center uses ~3-5 mn gallons of water per day, equivalent to the typical water usage of a town of 30,000-50,000 inhabitants.[35] Data centers are home to thousands of servers. In order for servers to function correctly, their temperature requires regulation. Data center operators are responsible for the temperature regulation process, which involves either a dry or wet cooling system. Dry cooling systems require significant power from nearby power plants and, while these systems avoid water use at the data center, they increase the water usage at the power plant. Wet cooling systems evaporate water on site in the data center to regulate the servers. In both cases, water plays a critical role. Data centers are also highly energy intensive, and these electrical demands drive further water demand as a result of embedded water intensity in different forms of power generation (indirect water usage).

The location of data centers has in the past exacerbated water intensity concerns and caused tension in local communities. Typically, data center locations are selected based on proximity to customers, infrastructure, the cost of land, access to low cost electricity and tax incentives from local government – and not necessarily based on environmental credentials. In the US, for example, many data center operators have been drawn to water-stressed regions in the West – partly driven by availability of wind and solar energy. According to researchers at Virginia Tech, one fifth of data centers are drawing water from medium-high water-stressed watersheds. [36] This has, in the past, been met with resistance from local communities concerned about the impact on local water supplies. For example, in 2017 conservation groups in South Carolina openly criticized Google over its request for a permit to draw 1.5 mn gallons of water per day from what was considered to be a depleted aquifer.[37]

Data centers have been targeting water intensity – aided, for example, by green bond issuance. Reducing water intensity of operations (along with emission intensities) has been a key area of focus for data centers in recent years. Whilst most companies don't disclose specific quantifiable, forward-looking targets (see table below) most have or are implementing water saving strategies.

35 NBC News

36 NBC News

37 NBC News

Exhibit 87: Water targets for data center companies under Morgan Stanley coverage

Ticker	Company name	MS Analyst	Key water targets
EQIX.O	Equinix Inc	Flannery, Simon	No quantifiable water targets found
DLR.N	Digital Realty Trust Inc	Flannery, Simon	No quantifiable water targets found
GDS.O	GDS Holdings Ltd	Liu, Yang	By 2030, 100% of self-developed data centres newly in service since 2020 will apply for green building certifications (water included).
KEPE.SI	Keppel DC REIT	Chang, Derek	No quantifiable water targets found
NXT.AX	NEXTDC Ltd	McLeod, Andrew	The company has stated it will be setting a target in the future.
CD.O	Chindata Group Holdings Ltd	Liu, Yang	No quantifiable water targets found
VNET.O	VNET Group Inc	Liu, Yang	No quantifiable water targets found

Source: Company Data, Morgan Stanley Research

Case Study: Digital Realty

Digital Realty has emphasized its commitment to water conservation, using non-potable water and its engagement with projects that reduce, reuse and recycle water. Digital Realty is aiming at a sustainable balance between water and energy consumption. In 2020, overall 43% of its global water supply was municipally-supplied non-potable or onsite recycled water. At a regional level, over 50% of water used to cool its US data centers and 100% of cooling water for its APAC data centers came from non-potable sources in 2020. Below are some of the specific projects implemented by the company that help support these metrics.

Digital Realty's Global Water Strategy assesses materiality of water issues. This initiative addresses the strategic role that water plays in the company's operations by identifying regions in which water quality and scarcity poses a risk to the reliability of operations. In addition, the strategy creates a pipeline of projects and opportunities to advance the company's position with respect to water conservation, resilience and redundancy in operations.

Its Water Meter Project aims to use data to reduce water usage. The project was implemented to ensure all treated cooling tower and adiabatic systems in North America have appropriate sub-metering to better measure and manage water usage in the region, and to collect data to apply for evaporation credits to capture additional cost savings[38] .

Similarly, other data tools support water conservation. The company is able to make data-driven decisions regarding water management as a result of a variety of data analytic tools at its disposal – the GRESB and Measurable Climate Risk Platforms, a Water Risk Monetizer Tool and a Smart Water Navigator Tool.

Green bond proceeds have financed quantifiable water savings. We note that Digital Realty is the largest issuer of green bonds in the data center industry. By end 2020, the company had issued $5.6bn in cumulative green bonds. The company estimates that the green bond funding has enabled annual water savings of 22,000 kGal.

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Water and the Energy Transition

Over the next 30 years, there will be major shifts in how energy is produced, stored and consumed, driven by the transition to a low carbon economy. This will have implications for water use and investment in various water infrastructure technologies.

We explore how progress to net zero – with the increasing role of nuclear, hydrogen and copper – will impact water withdrawals globally and in particular in water-scarce regions.

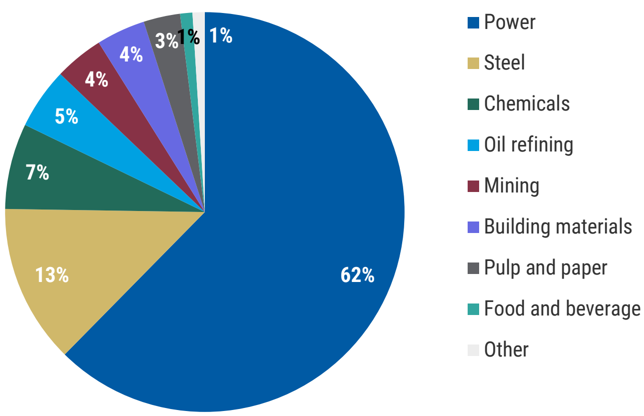
Power Generation – changing demand mix

Achieving Net Zero for global energy will reduce the direct water intensity of power generation

Power generation is the biggest industrial consumer of water, accounting for 62% of global water withdrawals across all industrial sectors.

Exhibit 88: Power generation accounts for almost two-thirds of all industrial water withdrawals

Water withdrawals across industrial sectors



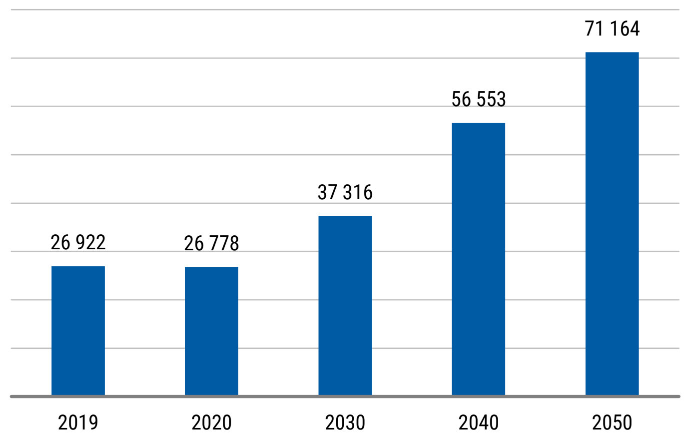
Source: GWI 2017

Achieving net zero emissions requires the electrification of energy. Electricity can be produced using low carbon sources such as solar and wind. But at present only ~20% of global energy is supplied in the form of electricity. To aid the transition to net zero, more energy needs to be electrified, thus enabling it to be provided in a low carbon format. The most obvious example of this is the conversion of passenger cars from combustion engines that use diesel / petrol to electric vehicles.

The IEA's net zero scenario requires total electricity generation to increase at a CAGR of 3.3% between 2020 and 2050 to ~71,000 TWh and represent ~47% of energy supply (versus 16% at present). Under BP's net zero scenario, there would be a 2.6% annual increase in electricity generation to ~61,000 TWh.

Exhibit 89: IEA's Net Zero requires electricity generation to increase by 2.7 times ...

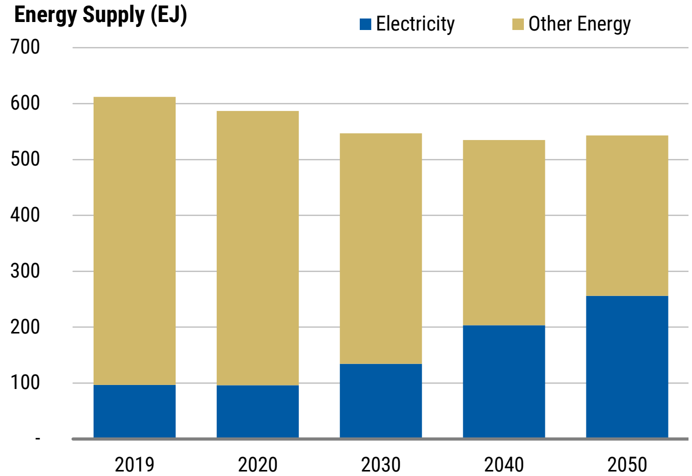
Electricity Generation (TWh)



Source: IEA, Morgan Stanley Research

Exhibit 90: ... and contribute ~47% of total energy supply by 2050

Energy Supply (EJ)



Source: IEA, Morgan Stanley Research

At present, 61% of global power generation comes from fossil fuels, with 29% from renewables and 10% from nuclear. If we assume the same current mix of power generation in 2050 for the higher electricity supply, it implies a 2.3 times increase in water usage over the next 30 years to 680 billion m3.

However, clearly there also needs to be a change in the type of power being generated.

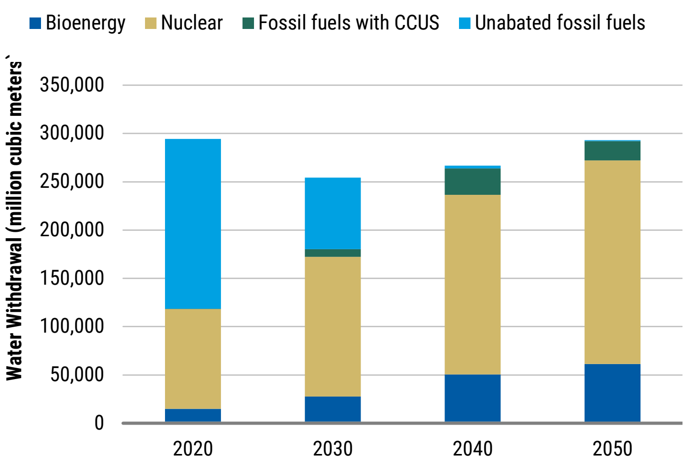
Achieving the IEA's net zero scenario implies water demand for power generation staying flat in 2050 versus 2020 and water intensity falling by 63%.

There are a number of moving parts behind this projection for overall stable water demand.

Water for coal and gas power generation falls by 88% or 158 billion m3. Fossil fuel power generation falls by 90% between 2020 and 2050, under the IEA's net zero scenario. The majority of the remaining fossil fuel power generation uses CCUS, which is ~50% more water intensive than unabated fossil fuels.[39] However, there is still an 88% net decrease in water withdrawals for fossil fuel power generation over the 30-year period – if net zero is achieved.

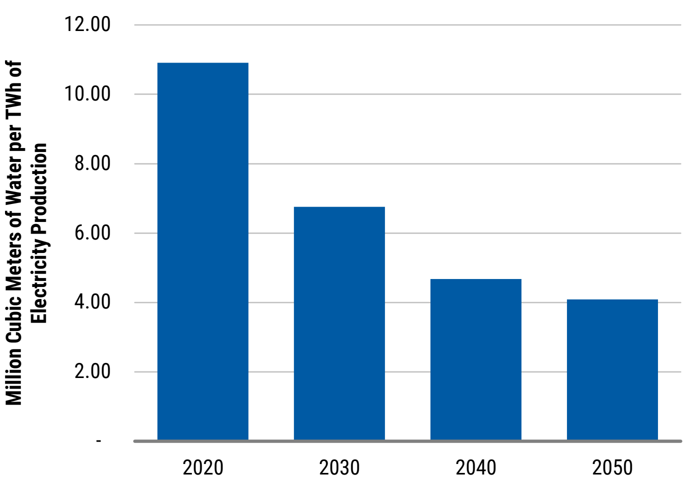
39https://energsustainsoc.biomedcentral.com

Exhibit 91: Total water withdrawals for power generation remain flat under a net zero scenario



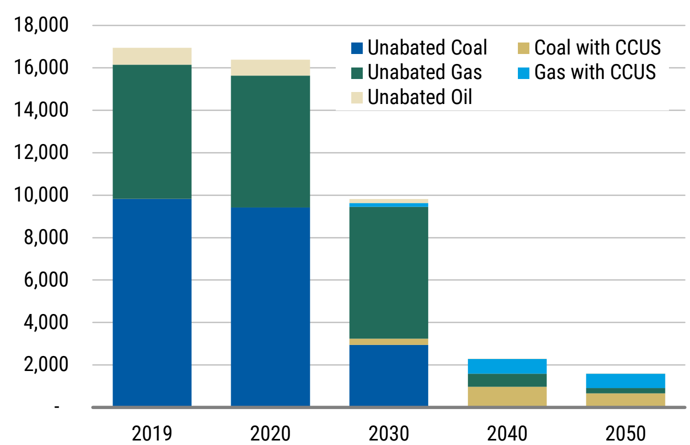
Source: IEA, Morgan Stanley Research

Exhibit 92: But water intensity falls by 63% between 2020 and 2050



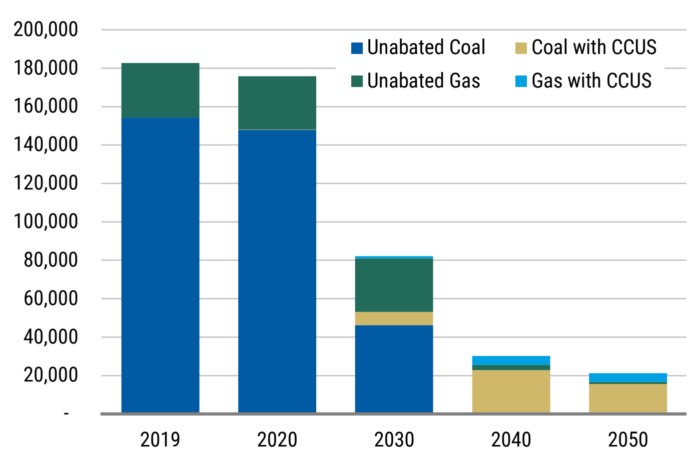
Source: IEA, Morgan Stanley Research

Exhibit 93: Fossil fuel power generation falls by 90% under IEA's net zero scenario ...



Source: IEA, Morgan Stanley Research

Exhibit 94: ... resulting in an 88% reduction in water withdrawals by 2050



Source: IEA, Morgan Stanley Research

However, water for nuclear power increases by 81 billion cubic metres by 2050 in this scenario. The debate around nuclear's role in a low carbon economy continues. On the one hand it satisfies the low carbon criteria. However, there are other challenges – namely cost, long lead-times, safety and water intensity.

Nuclear is the most water-intensive form of power generation at 38 million m3 per TWh of energy. Water is heated by nuclear energy to produce steam, which powers a turbine to make electricity. More water is then used to cool the steam back into water. Eventually the water is returned to its original source, but at a higher temperature.

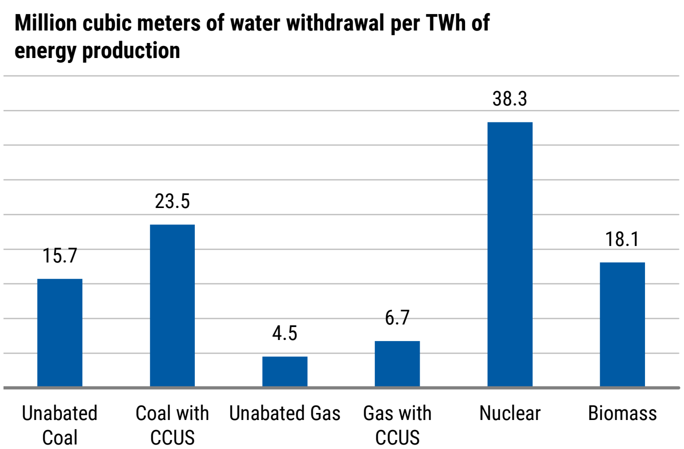
In the IEA's and BP's net zero scenarios, electricity generated by nuclear increases by 2 times and 2.6 times respectively over the next 30 years.

Under the IEA's net zero scenario, nuclear power generation will require ~210 billion cubic metres of water withdrawal per annum in 2050 – close to the total water withdrawal for power generation today, on our estimates.

… and water demand from biomass triples by 2050

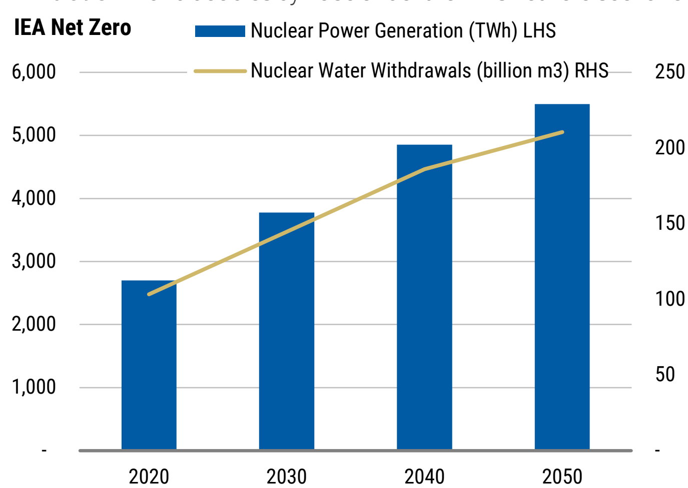
Bioenergy is a carbon-neutral source of renewable energy. Sustainably-managed forests absorb carbon dioxide from the atmosphere. The trees are felled for use in various industries, such as construction. Waste wood and residues are turned into biomass pellets that can then be combusted to generate carbon neutral electricity. Whilst CO2 is emitted during the process, it is simply putting back into the environment the CO2 that was absorbed during the growing phase. There is potential for bioenergy to be carbon negative if carbon capture technology is used alongside it. Bioenergy with carbon capture use and storage (BECCS) accounts for a quarter of bioenergy in the IEA's 2050 net zero scenario, resulting in 572 Mt of CO2 being removed from the atmosphere on an annual basis.

Exhibit 95: Nuclear is the most water-intensive form of power generation …



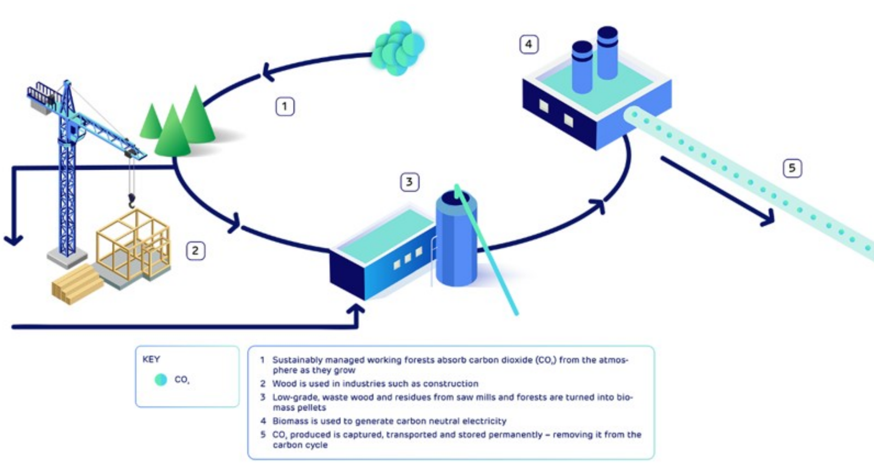
Source: IEA, Morgan Stanley Research

Exhibit 96: … and doubles by 2050 under the IEA's net zero scenario



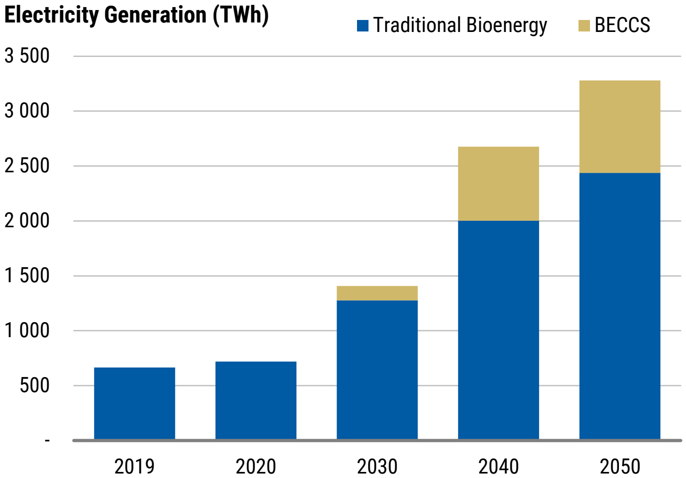
Source: IEA, Morgan Stanley Research

Exhibit 97: How BECCS removes carbon from the atmosphere



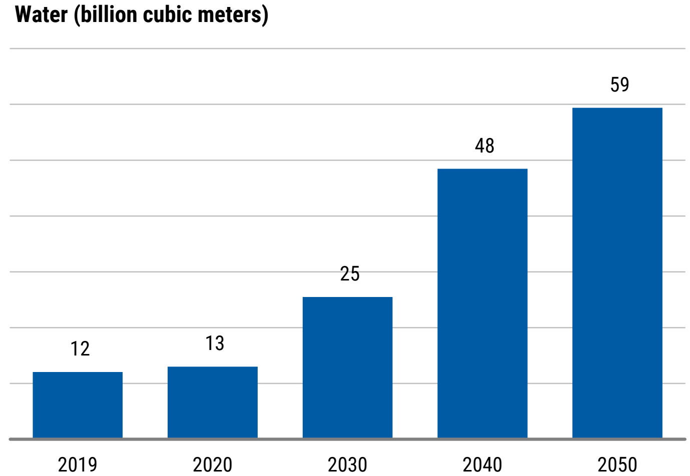
Source: Drax

Exhibit 98: The IEA's net zero scenario estimates bioenergy will increase by >4x by 2050



Source: IEA, Morgan Stanley Research

Exhibit 99: 59 billion cubic metres of water will be needed for bio-energy power generation in 2050



Source: IEA, Morgan Stanley Research

Bioenergy is a water-intensive form of power generation though, second only to nuclear. Bioenergy uses 18 million cubic metres of water per TWh of energy production, compared to 4.5 million m3 for unabated gas and 15.7 million m3 for coal. Most water is used for cooling down steam once it exits the turbine. The steam itself then turns into water, which goes back to the boiler to be re-heated to produce more steam to power the turbine. As such, this water is used in a closed loop system. Cooling water, though, is withdrawn from and returned to the local environment. Care must be taken to ensure there is no damage to ecosystems from raised water temperature, for example.

Under the IEA's net zero scenario, electricity generated from bioenergy increases by over 4 times between 2020 and 2050 to ~3300 TWh.

Overall, the incremental growth of bio-based power generation would increase water withdrawal from 13 billion cubic metres in 2020 to 59 billion cubic metres in 2050 – more than Turkey's total yearly water usage.

Hydrogen – rising water demand

Successful roll-out of blue and green hydrogen could require 12 billion cubic meters of water a year.

Hydrogen will be a key piece of the decarbonisation puzzle. Like electricity, hydrogen is a carrier of energy and it will play an important role in reducing emissions from hard-to-electrify sectors.

There are three different types of hydrogen: grey, blue and green. Around 95-99% of hydrogen today is produced from fossil fuels (mainly SMR or Steam methane reforming) – this is known as grey hydrogen. Blue hydrogen production integrates the use of CCS technologies to capture the carbon dioxide by-product (overall reducing emissions by 90%). To produce green hydrogen, water molecules are broken down into oxygen and hydrogen gas as an electric current flows through water in a device called an "electrolyser." If the electricity is produced using renewable energy sources, the resulting hydrogen is considered "green".

Grey, Blue and Green Hydrogen – What's the difference?

Grey Hydrogen

How it works: SMR or Steam Methane Reforming (Methane plus steam = Hydrogen and Carbon Monoxide) produces between 95-99% of hydrogen today.

Uses: Over 90% of hydrogen demand today comes from the refining industry (to desulfurize fuel) and the chemical industry (to produce ammonia and methanol).

Water: Requires roughly 16kg of water per kg of hydrogen. Water is used primarily in the steam reformation process but also during cooling.

Blue Hydrogen

How it works: Produced by separating hydrogen from methane via SMR, followed by capturing and storing the CO2 by-product, thereby reducing CO2 emissions by 90%.

Uses: It could address stranded gas issues in the US and elsewhere – for example in the Permian, where flaring is prevalent and there is a revenue-generating CO2 sequestration opportunity through enhanced oil recovery.

Water: Requires roughly 31kg of water per kg of hydrogen. This is the most water-intensive form of hydrogen production, with roughly double the water intensity of grey hydrogen. Water is used during the carbon capture phase (which requires cooling and can rely on water-based solvents depending on the technology type) in addition to the water used to produce the hydrogen (as outlined for grey hydrogen).

Green Hydrogen

How it works: Splitting water molecules (H2O) into oxygen and hydrogen gas as an electric current flows through water in a device called an electrolyser. If the electricity is produced by renewable energy sources, the resulting hydrogen is considered green.

Uses: Potentially all of the current uses for grey and blue hydrogen, plus: (1) industry (chemicals, energy, mining, food); (2) mobility (vehicles, buses, trucks and ships); and (3) utilities, power storage & flex generation.

Water: Requires roughly 13kg of water per kg of hydrogen. This is marginally less water intensive than grey but significantly less water intensive than blue. Significant amounts of water are needed for the electrolysis process that splits water into hydrogen gas and oxygen. However, because the energy required to power electrolysis is renewable, water isn't required for the steam reformation process or cooling.

For further detail, see The Hydrogen Handbook: Valuing the Supply Chain (17 Sep 2021)

Projections by the Hydrogen Council suggest hydrogen could enable a global emissions reduction of 6Gt in 2050 (17% of global 2020 emissions) if it reaches capacity of 78 EJ. Key applications of hydrogen include:

- **Industry feedstock**: 45% of global hydrogen offtake today is used by ammonia (ammonia is produced via the Haber-Bosch process, which combines hydrogen and nitrogen). Similarly, hydrogen is also used today in the refining process. One of the options for decarbonizing ammonia production is the substitution of grey hydrogen from natural gas with renewable or low-carbon hydrogen.[40] Other applications include production of methanol, olefins, and BTX using hydrogen and carbon.
- **Transport**: FCEVs (Fuel Cell Electric Vehicles, which generally produce electricity using oxygen and compressed hydrogen) are best positioned to cover long-haul use cases (e.g. long-haul trucking). In addition, fuel cell vehicles are an option to power larger passenger cars, SUVs and vans with

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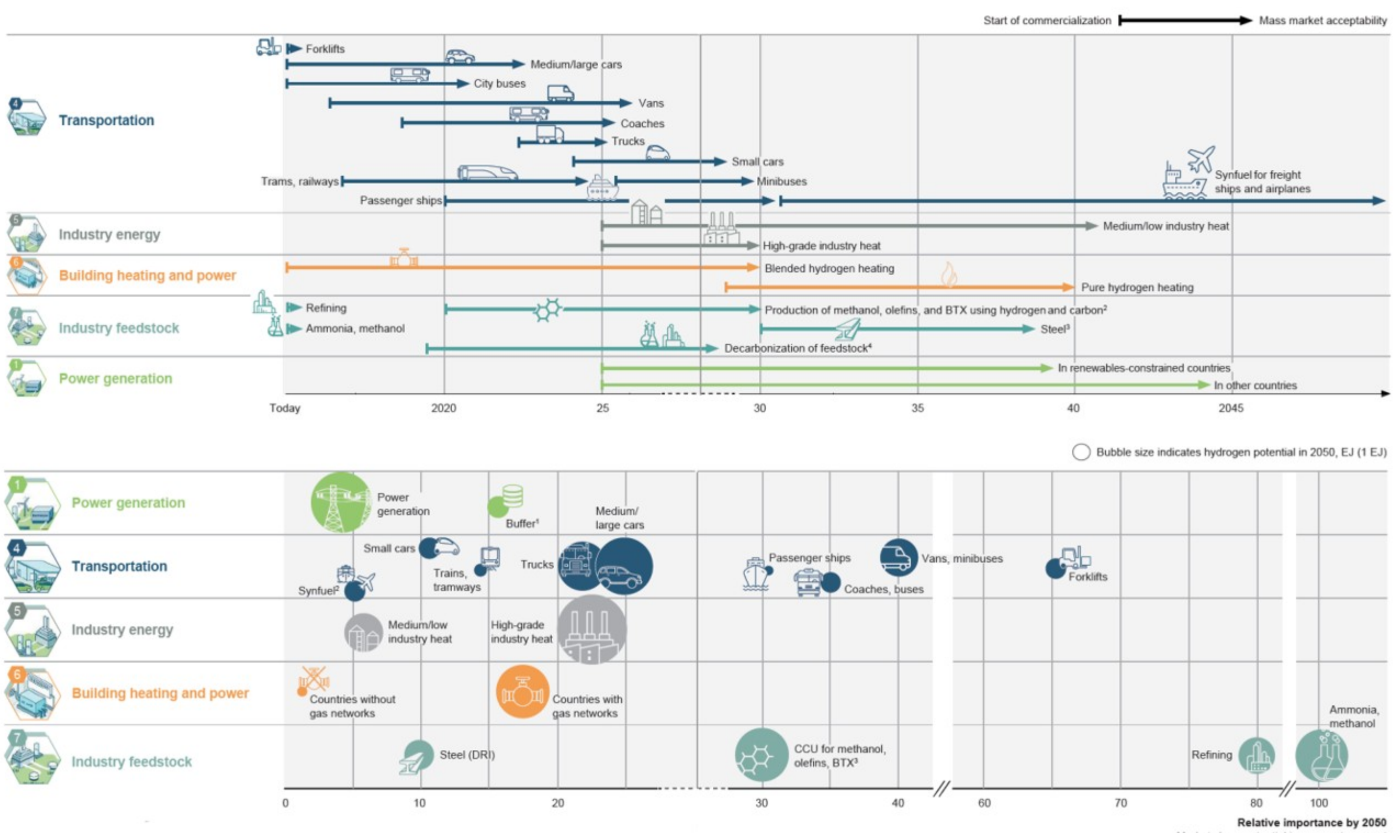
longer-range requirements and heavier use cycles, especially those used in commercial operations such as taxis or ride-sharing. [41] Other applications include forklifts, city buses, coaches, trams/railways, minibuses and passenger ships.

- **Industrial energy**: Hydrogen could be used to reduce emissions from existing industrial processes (across all spectrums of industrial heat). For example, there are two main approaches to decarbonising steel production: an integrated blast furnace (BF) and basic oxygen furnace (BOF) combination, or an electric arc furnace (EAF). DRI-EAF (direct reduced iron electric arc furnace) can be fully decarbonized if steel makers use renewable electricity to power the EAF and then add clean hydrogen or biomass as a reductant to produce DRI.[42]
- **Building heat & power**. At first, hydrogen is likely to be applied to heating in a blended form, transitioning to pure hydrogen heating further down the line. In the UK, for example, multiple landmark projects are piloting the blending of hydrogen into natural gas grids for residential heating.[43]
- **Power generation**: Green hydrogen can help manage electricity grid stability as renewables participation increases, and be used for heating and cooling. It can also be used as alternative green power source in countries that are renewables constrained.

41 Hydrogen Council
42 Hydrogen Council
43 Hydrogen Council

Exhibit 100: Mapping the timeline of key hydrogen applications



Source: Hydrogen Council

The water intensity varies significantly with the type of hydrogen produced, as Exhibit 101 shows.

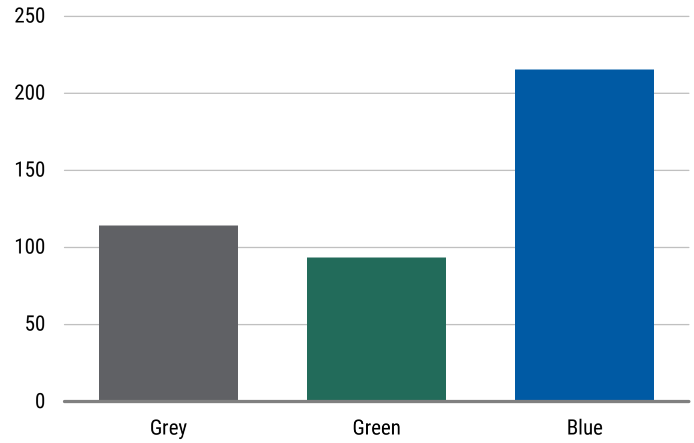
Blue. Blue hydrogen is produced via the same process as grey hydrogen (and so has similar water requirements for this phase), but this is followed by the capture and storage of the CO2 by-product (which requires further water). The water footprint of CCS (carbon capture and storage) technologies varies depending on the means of power production, but is largely driven by the need for cooling along with the use of water-based solvents (required for some forms of CCS technologies), which can then evaporate.

Green. Water demand is driven by: (1) the hydrogen production itself (e.g. the electrolysis process that splits water into hydrogen gas and oxygen); and (2) the energy required to power it (i.e. the type of e.g. renewable power). On this second point, the water intensity of green hydrogen can vary quite significantly – for example, large hydro-power projects can be highly water intensive due to evaporation from the extensive water surface area. We note that electrolysis via nuclear energy requires approximately 270kg of cooling water per kg of hydrogen[44] – hence water intensity estimates for this type of hydrogen are not included in the averages of the chart below. That said, some forms of water electrolysis require only 9kg of water per kg of hydrogen produced.

44 Hydrogen Council

Exhibit 101: Blue hydrogen is twice as water intensive as grey hydrogen, whilst green hydrogen is slightly less water intensive

Water Intensity (million m3 per EJ of Hydrogen)

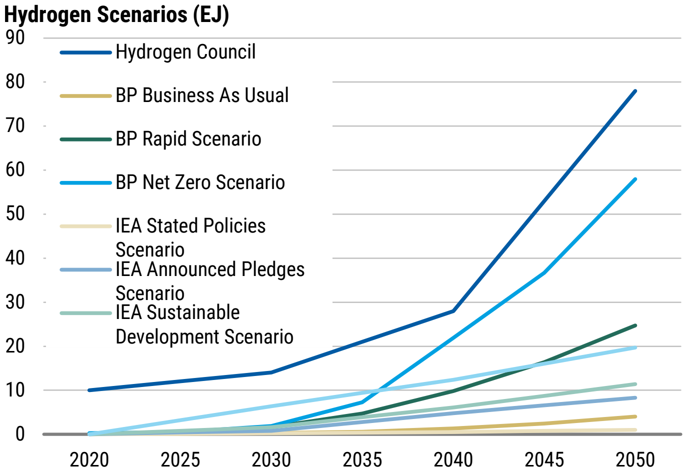


Source: The Hydrogen Council, Morgan Stanley Research

The combination of (1) material growth in hydrogen capacity and (2) the increasing role of blue and green hydrogen means that water demand for hydrogen could reach 12 billion m3 by 2050. Forecasts for the growth trajectory of the hydrogen economy vary materially. The Hydrogen Council estimates that by 2050 hydrogen demand could increase 10 times to 78 EJ, whilst the net zero scenarios from BP and the IEA (Exhibit 102) forecast 60 EJ and 20 EJ by 2050, respectively. Whilst the use cases between the scenarios are broadly the same (power generation, transportation, industrial energy, building heat and power) we note that ~25% of hydrogen under the Hydrogen Council demand will be for feedstock (not in scope for the BP and IEA scenarios), which partially explains the higher forecast.

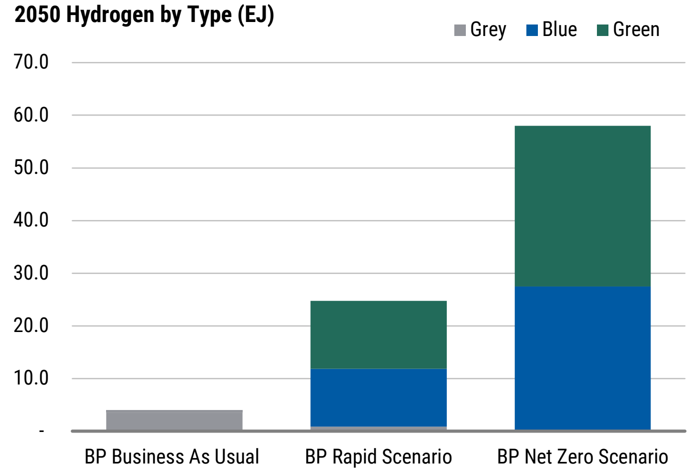
Our analysis of the three scenarios suggests that 4-12 billion m3 of incremental water (versus estimated 2020 water usage) could be required by the hydrogen industry by 2050. The top end of this range is similar to Nigeria's annual water use.

Exhibit 102: The potential growth trajectories for hydrogen vary between 1 EJ and 78 EJ by 2050



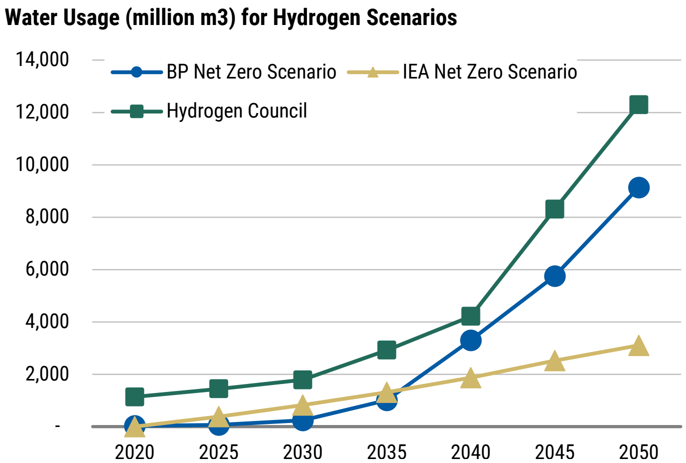
Source: BP Energy Outlook, IEA Energy Outlook, Hydrogen Council, Morgan Stanley Research

Exhibit 103: Green hydrogen could account for between 11% and 53% of total hydrogen by 2050



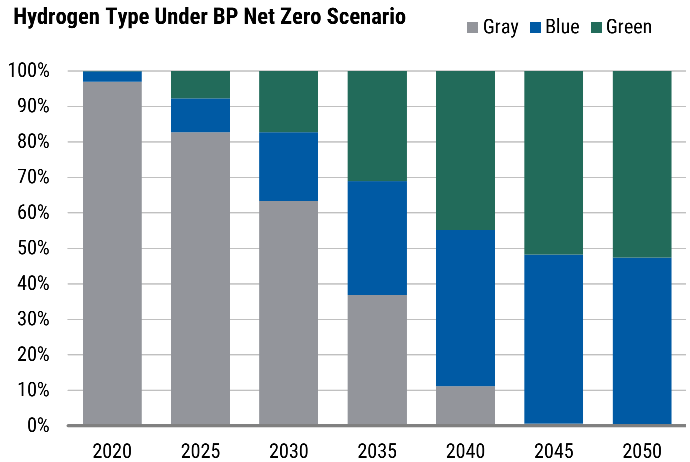
Source: BP Energy Outlook, Morgan Stanley Research

Exhibit 104: Estimates of water usage for hydrogen production by 2050 vary between 3 and 12 billion m3



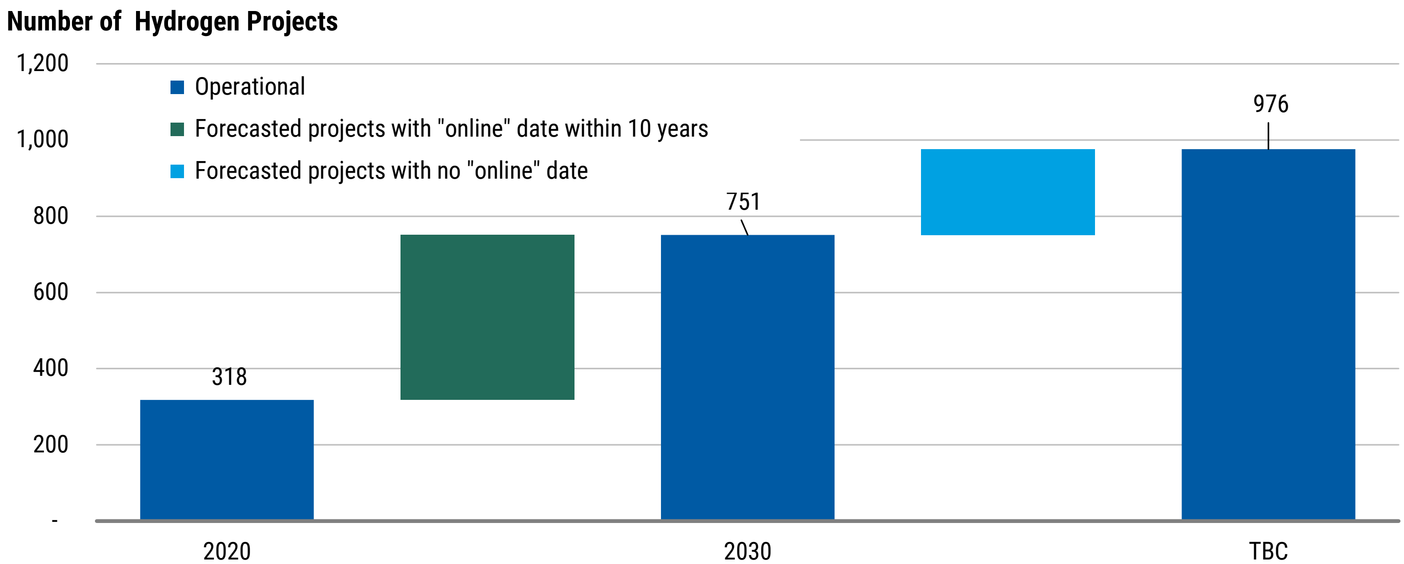
Source: BP Energy Outlook, IEA Energy Outlook, Hydrogen Council, Morgan Stanley Research

Exhibit 105: Grey hydrogen is expected to fall from nearly 100% of the mix to zero by 2050 under BP's net zero scenario



Source: BP World Energy Outlook, Morgan Stanley Research

Exhibit 106: The IEA identified 318 hydrogen projects in 2020, with a further 433 projects planned between 2020 and 2030, and another 225 hydrogen projects with no estimated "online" date



Source: IEA, Morgan Stanley Research

60% of future hydrogen projects identified by the IEA are located in countries of medium-high or extremely-high water stress. The IEA's database of nearly 1,000 hydrogen projects identified 318 projects in operation in 2020, with a further 433 projects due between 2020 and 2030 and a further 225 projects with no "online" date identified.

Current or planned hydrogen projects are located across 65 countries; Germany has the highest number of projects, followed by the US, Japan and Denmark.

Using WRI data for baseline water stress (which is in a range of 0-5, with 5 being extremely high water stress) we estimate that 56% of hydrogen projects in 2020 were located in countries of medium-high to extremely high water stress, but for future projects (both those planned within the next 10 years and those with an undefined timeline) this increases to 60% – see Exhibit 109 Exhibit 109 Exhibit 109 .

We acknowledge, however, that this is based simply on the number of projects and does not account for the size of facilities, which range from 67GW down to minimum levels (testing and R&D facilities) in the database.

According to estimates from Rystad Energy, by 2040 more than 70% of hydrogen electrolyzer projects will be located in water-stressed areas, which could result in nearly 85% of hydrogen capacity by 2040 requiring desalination plants to supply water.

Exhibit 107: Operational hydrogen projects in 2020: Top 10 countries

#	Country	Baseline Water Stress	# Projects Today
1	Germany	2.14	68
2	United States	1.85	27
3	Japan	1.66	25
4	Denmark	2.08	25
5	France	2.19	17
6	United Kingdom	1.40	16
7	Spain	3.74	15
8	Canada	0.88	13
9	China	2.40	11
10	Norway	0.00	9

Note: baseline water stress scores range from 0 (low) to 5 (extremely high). Source: IEA, WRI, Morgan Stanley Research

Exhibit 108: Expected hydrogen projects: Top 10 countries

#	Country	Baseline Water Stress	# Future Projects	# Undefined Projects
1	Germany	2.14	49	24
2	Spain	3.74	37	30
3	Australia	2.67	37	22
4	Netherlands	1.61	46	12
5	United States	1.85	30	17
6	United Kingdom	1.40	24	13
7	China	2.40	21	16
8	France	2.19	25	9
9	Norway	0.00	15	9
10	Denmark	2.08	16	3

Note: baseline water stress scores range from 0 (low) to 5 (extremely high). Source: IEA, WRI, Morgan Stanley Research

Exhibit 109: Around 60% of current and future hydrogen projects are located in countries with medium-high to extremely high water stress

Baseline Water Stress	% Of Projects In 2020	Cumulative	% Of Future Projects (both defined timelines and undefined)	Cumulative
Extremely High	3%	3%	3%	3%
High	12%	15%	22%	25%
Medium-High	41%	56%	35%	60%
Low-Medium	24%	81%	25%	85%
Low	18%	98%	15%	99%
Not Available	2%	100%	1%	100%

Source: IEA, WRI, Morgan Stanley Research

Significant desalination capacity will be required to support the hydrogen economy. Between 4 billion and 12 billion m3 of water will be required to support the hydrogen economy by 2050 under various scenarios, and a significant proportion of hydrogen projects are set to come online in water-scarce regions over the next 10-20 years. Taking these projections together implies that additional desalination technology will be needed to allow hydrogen facilities in water-scarce regions to draw on sea water aquifers. Rystad Energy estimates that demand for desalination could grow fivefold to 536 million m3 by 2040 if all hydrogen projects within regions experiencing water stress levels above medium require such technologies.

Copper – Finding New Sources of Water

Copper will play a key role in the energy transition – it is needed for nuclear and renewable power generation, as well as electric vehicles. The incremental water needed is not significant in a global context, but the location of copper resources in water scarce regions adds complexity and cost.

Conventional power generation (coal/nuclear/hydro) uses around 1-2t of copper per MW of power in new installations, but intensity of use rises significantly for renewable energy generation – see Exhibit 110 .

Exhibit 110: Copper intensity of use in wind and solar power plants

MS Base Case: Intensity of Use	Tons of Copper per MW
Conventional power generation	1.5
Onshore wind power	3.5
Offshore wind power	9.5
Solar power (utility scale)	4.0
Solar power (distributed)	2.0

See our detailed study in Global Commodities: Copper and Renewables, 23 Mar 2021. Source: Morgan Stanley Research, International Copper Association, Rho Motion, Wood Mackenzie

Copper is also a very water-intensive commodity. Water is a critical component in the copper production process. It is used in nearly every stage, from ore mining to finished metal production.

- Mine area: water is used to mitigate dust from roads and in extraction and pumping from underground operations.
- Concentrator plant (pyro-metallurgy process): this is the most water-intensive part of the process, and a key consideration here is an increase in water recycling rates.
- Hydro-metallurgy process: involves the heap leaching, solvent extraction and electrowinning processes used to produce cathodes. Water consumption results from evaporation from the leach pads, which are irrigated with a solution of sulfuric acid and water to dissolve copper contained in the mineral.
- Smelting and refining: the dry concentrate undergoes a pyrometallurgical process to obtain copper in anodes.
- Services/others: this represents a small fraction of water consumption, which encompasses drinking, cooking, washing and watering in camps.

The concentration process is highly water intensive – especially in the flotation stage. In fact, concentration consumes nearly six times more water than hydro-metallurgy. As a result, it accounts for 70% of water usage in the mining industry. Another dimension is the scale of mining operations, with the trend towards larger and hence more efficient copper mines leading to reduced water intensity.

Copper mining is also becoming more water intensive due to declining copper grades and the rising share of copper concentrates. The Chilean Copper Commission (COCHILCO) estimates that copper production will increase at a CAGR of 0.5% in 2022-2029, while water consumption will increase at ~2% p.a. from 22.03 m3/sec to 25.35 m3/sec.

Chile is central to the debate around copper and water availability as: (1) it is the leading copper-producing country, with 28% share of world mined production in 2020; and (2) it suffers from water scarcity in regions with sizeable mining operations. While the mining industry accounts for just 3% of water used in Chile, most mining operations are concentrated in areas where water scarcity is most pronounced, thus exacerbating the impact of water shortages. Northern Chile is one of the driest areas in the world (in spite of recent flash floods), while Central Chile requires vast amounts of water for agriculture and household consumption.

There are three options for reducing the use of freshwater in the copper industry:

1) Recycling: Given the constrained supply of fresh water, the mining industry in Chile has put significant efforts into reducing its consumption rates. One of the key strategies has been to increase recycling rates, though the benefits of such initiatives seem to have plateaued at around 70-75%, and there appears to be limited scope for substantial additional gains.

2) Desalination: The success of this option depends on a number of factors, such as the impact on metallurgical performance, opex/capex intensity, as well as the type of project – greenfield or brownfield (retrofitting could be unattractive). In Chile, seawater is expected to account for 43% of water consumption in 2029 versus 31% in 2020.[45]

3) New technologies to reduce water consumption: Coarse particle flotation (CPF or CPR) technology could lower water intensity by ~20%.[46] However there is currently no proof of industrial scale viability.

How much copper is needed for the energy transition?

There are three areas where copper will be key in facilitating the energy transition. We attempt to put some numbers around the incremental copper that could be needed.

Power generation: Based on the IEA's net zero scenario, installed solar capacity will need to reach ~14,460 GW by 2050 (from ~740 GW currently), while wind capacity will need to rise to ~8,270 GW (from ~740 GW currently). Using simplistic modelling based on average copper intensity of these technologies, compared to installing the same amount of conventional power, an additional 45mn tonnes of copper will be needed, or around 1.5mn tonnes per year (6.6% of 2020 copper demand) – a significant amount. This seems like a very large number, but we note the pull on refined supply will likely be lower, as some existing capacity will probably be recycled over the time period. In addition, over such a long timeframe, there could be technological changes or substitution.

EVs: Copper also plays an important role in electric vehicles, with EVs on the road expected to reach over 1 billion by 2050. Using our Autos team's forecast for EV sales and ICE sales over the next 30 years – and accounting for charging infrastructure plus an assumed 10-year lifespan for an average car and a 50-70% recycling rate – we estimate that additional copper demand for autos due to the rising share of EVs could amount to some 63 mn tonnes over the period, or an additional 2.1mn tonnes per year on average (just under 10% of current demand). Although fleet size is only expected to rise by about 9% between now and 2050, the amount of copper contained in cars on the road could be 240% higher as EV penetration rises.

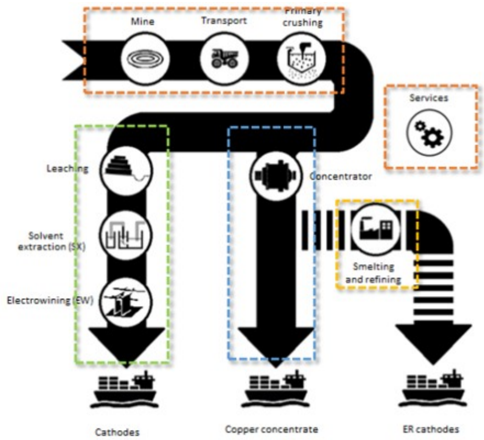
Grid: Upgrades to the grid will also likely be required to support increased electrification globally. The IEA estimates that global electricity networks, which have been built over the past 130 years, will need to more than double in length by 2040, and it sees a further 25% increase by 2050 in its net zero scenario. This will need $1 trillion of investment by 2040, it estimates. Ageing infrastructure will also need to be replaced, although some recycling could take place here (IEA Pathway to Net Zero). Quantities of copper are not given for the net zero scenario, but in its sustainable development scenario, the IEA sees copper demand for the grid rising from ~5mn tonnes a year in 2020 to almost 10mn tonnes a year by 2040. If an average of 2.5 mn tonnes of extra demand is assumed per year, that implies an additional 75mn tonnes of copper demand over the next 30 years.

Bringing this all together implies an incremental ~164mt of copper demand, or 5.5mn tonnes per year on average. This is ~25% higher than the current annual mined output of ~ 22mn tonnes, implying a substantial uplift. In our view, this will likely come through slowly at first but then more rapidly as EV and renewable investment rises. However, we also acknowledge that substitution, recycling and changing technologies could all moderate this too.

45 Comisión Chilena del Cobre

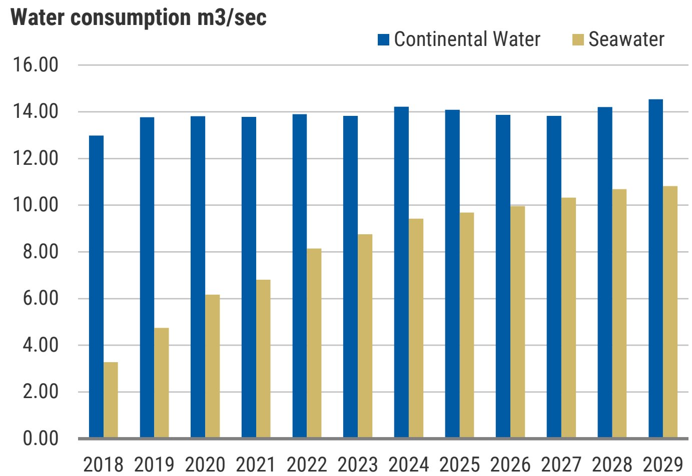
46 International Mining

Exhibit 111: Water is used extensively in copper mining, processing, smelting and ancillary services



Source: Cochilco 2017

Exhibit 112: Water intensity in mining is set to increase with a greater reliance on sea water



Source: Cochilco

Overall water demand for copper could increase by 38%

Currently, the average water consumption for copper mining is 43 m3/t of copper. Going forward, though, we expect water intensity to increase, given declining copper grades and a rising share of copper concentrates. In Chile, for example, we calculate an average water intensity of 92 m3/t of copper. Based on assumed water usage of 68 m3/t of mined output (the average of the two metrics above), the incremental copper for renewables, EVs and the grid would require an additional 370 million m3 of water a year. Though not significant in terms of overall global water withdrawals, this is a ~38% increase from current water consumption levels for copper. It is particularly material for the copper industry, given a significant amount of copper resources are located in water-scarce regions. As we discuss in the section Improving Water Efficiency , desalination plants are already being built for copper mines in Chile, raising the cost of production and the copper incentive price.

For more detail, see Metals & Mining and SRI: Insight: Copper & Water – expensive solutions (22 Jul 2015) and Metals & Mining: Copper & Water – Reflationary trends (25 Feb 2020)

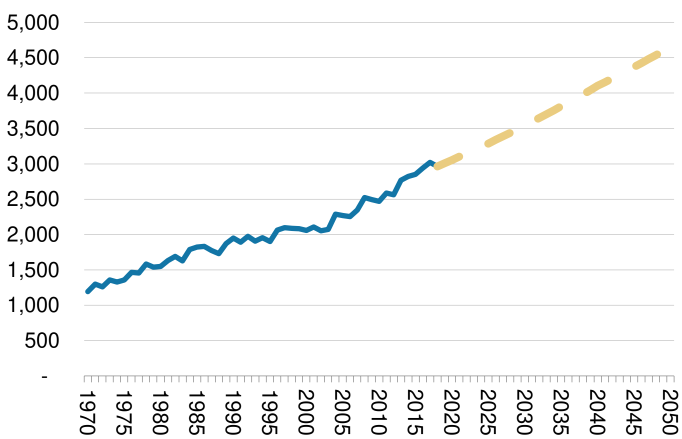
Water and The Future of Food

Nearly 70% of water is used for agriculture, according to Euromonitor. With demand for food set to increase by 50% over the next 30 years, pressure on water supply is going to intensify.

By 2050, 50% more food will be required, according to both the WRI and our own forecasts, which use OECD data as a starting point. This assumes average annual population growth of ~0.8% and incremental food per capita (+0.6% CAGR) with greater wealth and prosperity. (see Exhibit 115). To provide this extra nourishment, agricultural yields will have to increase and potentially more land be used for agriculture. Income growth is typically accompanied by increased consumption of calories and more complex food, which places further pressure on agricultural expansion.

Exhibit 113: Demand for cereal production could increase by 50% over the next 30 years ...

Cereal Production (million tonnes)



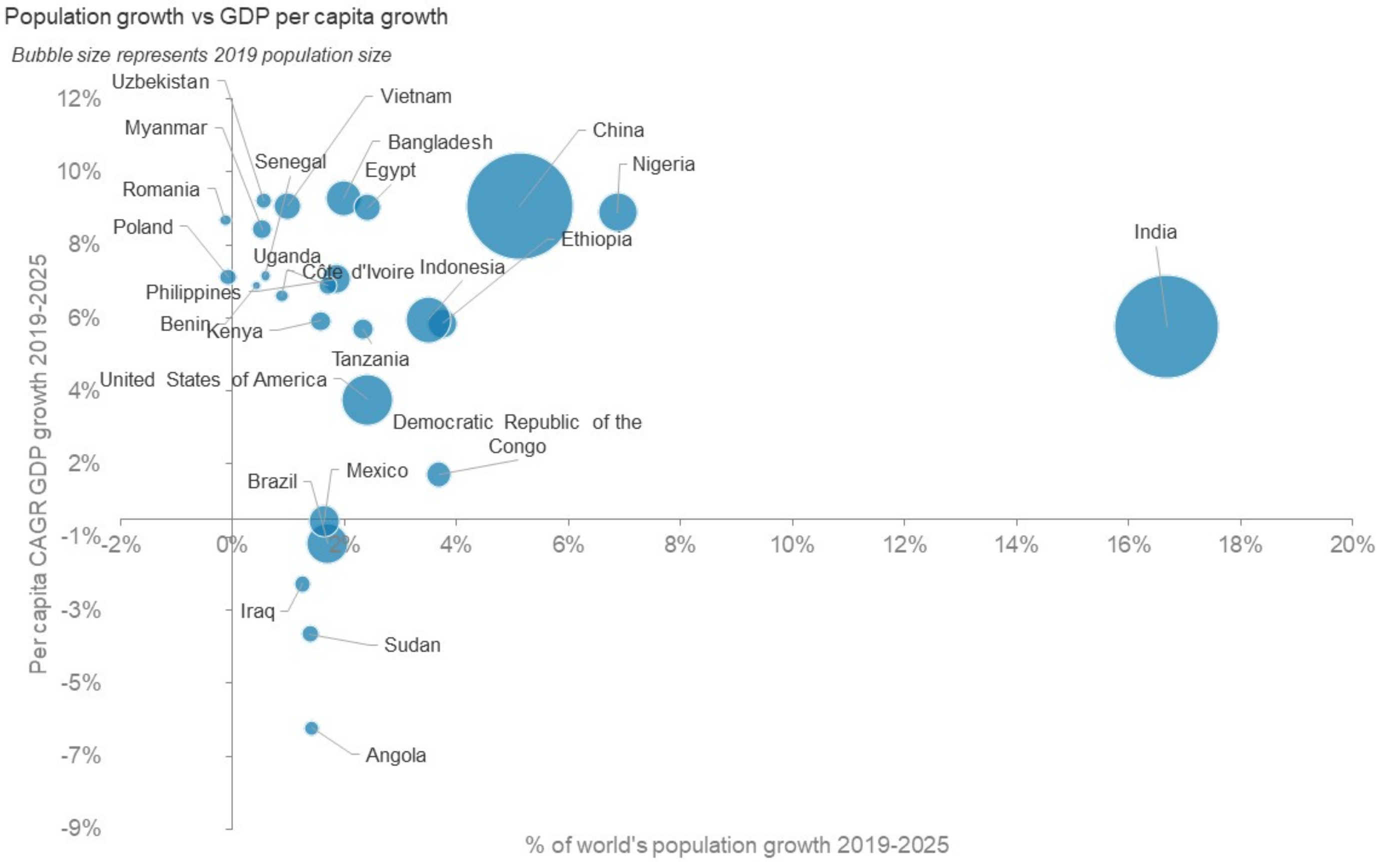
Source: UN Food & Agriculture Organization

Exhibit 114: ... driven by po+pulation growth and increased wealth

	Growth in Cereal Production	Population Growth	Growth in Production per capita
1961-1970	3.5%	2.0%	1.4%
1970-1980	2.7%	1.9%	0.8%
1980-1990	2.3%	1.8%	0.5%
1990-2000	0.5%	1.4%	-0.9%
2000-2010	1.8%	1.3%	0.6%
2010-2018	2.3%	1.2%	1.1%
2018-2030e	1.5%	1.0%	0.6%
2030-2040e	1.5%	0.9%	0.6%
2040-2050e	1.3%	0.7%	0.6%

Source: UN Food & Agriculture Organization, Morgan Stanley Research estimates (e)

Exhibit 115: China, India and several African countries will be among the largest drivers of global population growth over 2019-25 as well as per capita GDP growth



Source: UN, IMF, Morgan Stanley Research

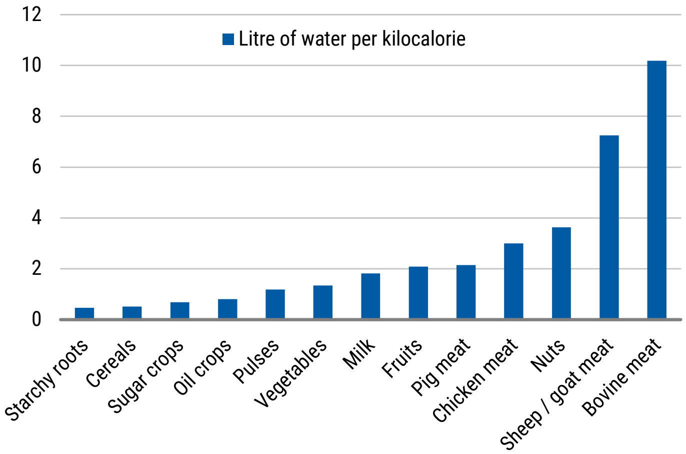
With agriculture accounting for 70% of water withdrawals, this will have material implications for global water consumption. Recent decades have seen increasing agricultural water withdrawals (see Exhibit 117). For example, India's agricultural water withdrawals almost doubled between 1975 and 2010. There are differing views on the future growth in water withdrawals by the agriculture sector. The 2030 Global Water Supply and Demand Model[48] forecasts that water withdrawals from the agricultural sector will rise by 45% by 2030 alone – see Exhibit 119 . Other estimates suggest that global water demand for all uses will increase by up to 30% by 2050, with agriculture demand growing slightly less than industrial and domestic demand.[49]

Water footprint varies materially by protein type. Whilst agriculture generally is very water intensive, changing the mix of (for example) of protein sources can have material implications for overall water usage. Exhibit 120 shows water usage for key protein sources per kilocalorie. At the upper end of the spectrum, bovine meat and sheep/goat meat is highly water intensive, followed by nuts, chicken meat and pig meat. By contrast, starchy roots and cereals are not particularly water intensive (with only 5% of the water footprint of bovine meat, for example).

48 2030 Water Resources Group

49 Boretti and Rosa, 2019

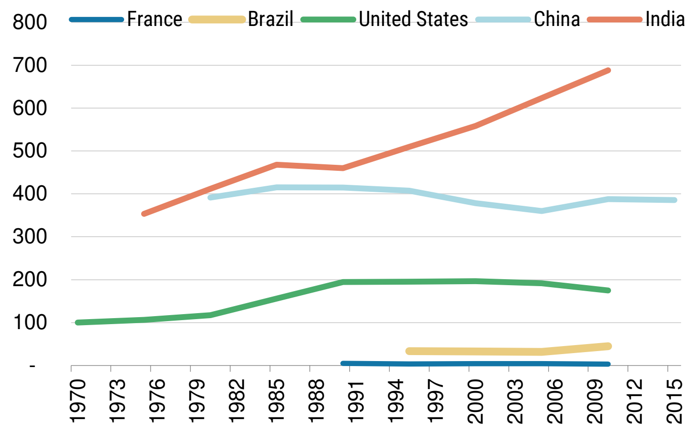
Exhibit 116: Water intensity varies significantly by crop type



Source: Mekonnen and Hoekstra (2010), Morgan Stanley Research

Exhibit 117: Agricultural water withdrawals have been increasing over time in many key food-producing regions

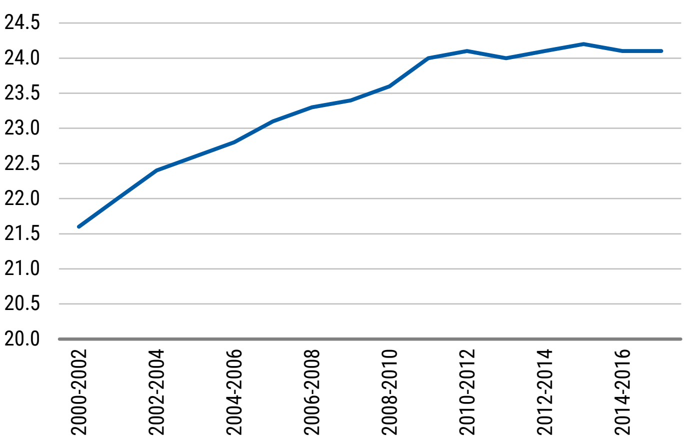
Freshwater use in agriculture (bn cubic metres)



Source: UN Food and Agricultural Organization (FAO) AQUASTAT via Our World In Data, Morgan Stanley Research

Exhibit 118: The amount of arable land requiring irrigation has risen to almost a quarter

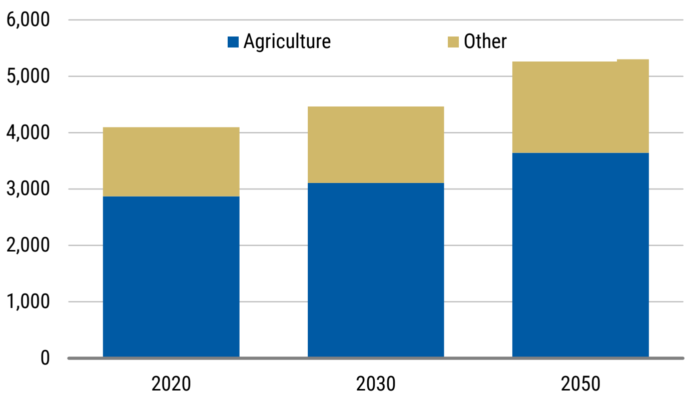
% of arable land equipped for irrigation (3-year average)



Source: UN Food & Agriculture Organization, Morgan Stanley Research

Exhibit 119: Agricultural water withdrawals are expected to increase by 45% between 2010 and 2030

Current and projected water withdrawals (bn cubic metres)



Source: Water 2030 Global Water Supply and Demand model; agricultural production based on IFPRI IMPACT-WATER base case via 2030 water resource group, Morgan Stanley Research

Climate change is likely to put incremental pressure on an already strained system. Our proprietary analysis suggests that 37% of 2017 production value of the four largest food commodities was grown in areas of water risk related to climate change. Rice, maize, wheat and soybean account for ~22% of total agricultural production by gross production value ($855 billion) – see Exhibit 120 . We have analysed at least 64% of the global production of soybean, 62% of wheat, 58% of maize and 55% of rice. By comparing key growing regions with data on flood and drought risk, we calculate that at least 44% of wheat, 43% of rice, 32% of maize and 17% of soybean production is grown in areas of risk (see Exhibit 121). In total, this could represent a minimum loss of $314 billion of production value (see Exhibit 122).

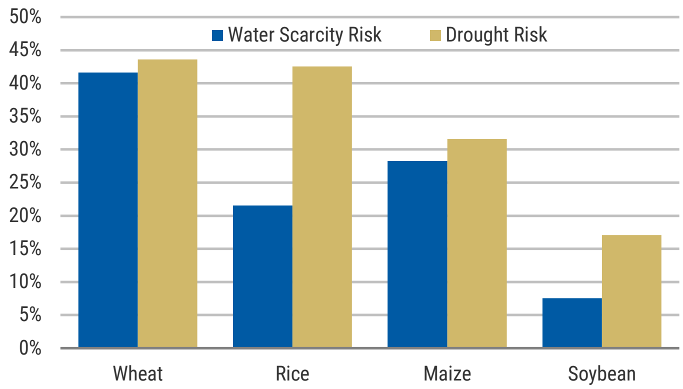
Exhibit 120: The top 4 agricultural products make up ~22% of global agricultural production by value with a combined value of $855 billion

Commodity	2017 Gross Production Value ($mn)	As % of Total Agricultural Production
Rice	356,202	9%
Maize/ Corn	209,500	5%
Wheat	175,263	5%
Soybeans	114,208	3%
Total	855,174	22%

Source: UN Food & Agriculture Organization, Morgan Stanley Research

Exhibit 121: Globally, at least 44% of wheat, 43% of rice, 32% of maize and 17% of soybean production is at risk due to climate change

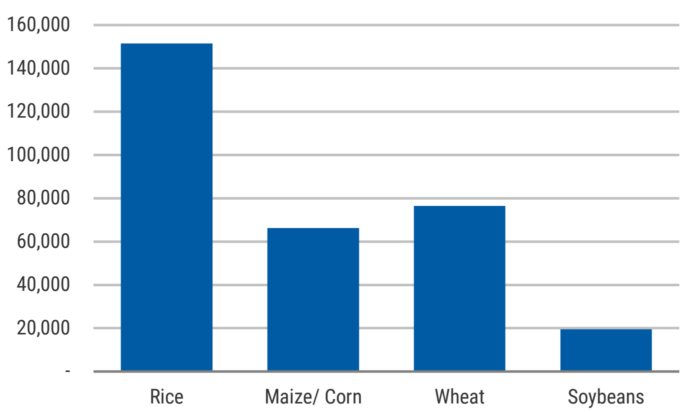
% of global commodity production at risk by type



Source: UN FAO, USDA, WRI, Deutsch et al. (2018), Morgan Stanley Research estimates. Note: We use the WRI's baseline water stress score for agriculture in our analysis

Exhibit 122: In total, at least $314 billion of wheat, rice, maize and soybean production could be lost due to climate change

2017 Gross Production Value at Risk ($mn)



Source: UN FAO, USDA, WRI, Deutsch et al. (2018), Morgan Stanley Research estimates

Irrigation is the primary use of water in agriculture. Irrigated agriculture refers to the process of diverting water sources in order to supply water to agricultural land. For example, areas that are typically relatively dry or arid can become more productive from an agricultural perspective if farmers are able to divert water from local streams, rivers or lakes. Irrigated agriculture accounts for around a quarter of the total cultivated land, and 40% of total food produced worldwide relies on irrigation practices.[50] This is because, on average, irrigated agriculture is twice as productive per unit of land as rain-fed agriculture, which as a consequence allows for more intensive production and crop diversification.[51]

And intensive irrigation depletes water supplies. Groundwater pumping can alter the movement of water between an aquifer and a stream, lake, or wetland. This occurs either through: (1) intercepting groundwater flow that discharges into the surface-water body under more natural conditions; or (2) by increasing the rate of water movement from the surface-water body into an aquifer.[52] Intensive groundwater pumping depletes aquifers and can lead to negative externalities such as biodiversity loss, which can cause major economic impacts.[53] Of the water that is applied to crop fields, roughly 50% returns to surface water or groundwater sources, whilst the remainder is lost by natural processes (evaporation, transpiration and accidents, such as leakages from pipes and spillage).

There are various technologies used for crop irrigation. The traditional and oldest method is flooding a field, which is very popular for rice cultivation. This process is extremely wasteful because only 50% of water used goes to the plant. There are means by which flood irrigation can be made more efficient – for example, by making the land contoured and by controlling the release of water from dams. That said, there are newer and more efficient technologies such as drip irrigation, where water runs through pipes perforated with small holes. When these pipes are buried underground, water can drip from the pipe into the soil near the roots of the plants, meaning water loss is reduced. Another popular form of irrigation is spraying – water passes through a tube and comes out of spray nozzles located along the tubes. Tubes can be fixed in one location, or moved manually or automatically. This method can be relatively wasteful as sprayed water can evaporate or be blown away before it reaches the crop. A more water-efficient spraying method is one in which water is gently sprayed from pipes that are suspended over the crop, allowing for 90% of the water to reach the crop. For more detail, see the section Solution #3: Smart Irrigation.

Innovation in seeds can promote traits around water optimization. Specific traits and characteristics desired in plants can be promoted using seed technology. For example, 'Scuba Rice' is an enhanced seed that enables the rice crop to withstand flooding, whereas the Sahod Ulan rice variety is designed to be drought-tolerant. Bioceres' (BIOX.K, not covered) HB4 technology has enabled the development of the world's only drought-tolerant soybeans and wheat. Likewise, Bayer and Corteva have continuously bred seeds to have better yields in drought-like conditions by improving the root structure of the plant such that it can better withstand low moisture conditions. Further, Bayer's short stature corn requires less land and

50 World Bank

51 World Bank

52 USGS

53 OECD

offers water conservation benefits. For further information on the opportunity presented by innovation in seeds, see the section Solution #3: Seed Innovation .

We think desalination is unlikely to become widespread in agriculture over the medium term for a number of reasons:

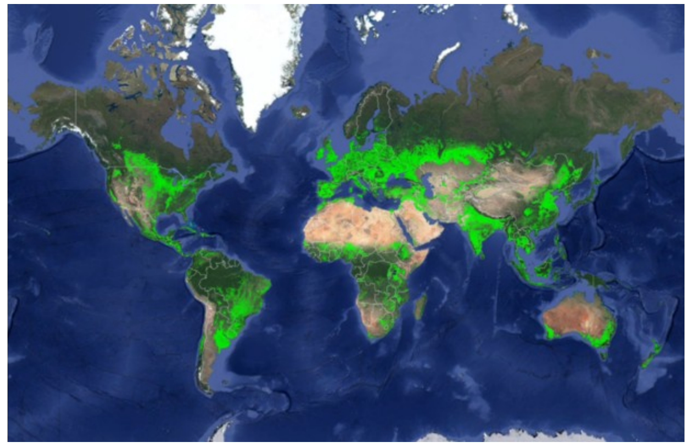
1. Cost: Despite increased efficiency and ever-decreasing costs, desalination is still one of the most expensive sources of water. So far, only greenhouse-grown high value crops make desalination usage for irrigation commercially viable. Because irrigation water does not require the same high level of purity as potable water, it is sufficient to use single-pass systems or limited pre-treatment methods, which significantly lower the cost differential of water extraction. To further reduce the cost, desalinated water is often mixed with groundwater. Brackish water reverse osmosis is the preferred method, as it is cheaper than other technologies.

2. Methods: The single-pass processes make desalination more competitive on cost, but there are concerns over the chemical composition of water desalinated specifically for agriculture. Increased boron concentration, sodicity and low nutrient content are some of the hurdles to widespread implementation. [54]

3. Transport: Point-of-use is also an important factor. Typically, desalination plants are located close to the sea, and the high transportation cost adds to the already expensive desalination bill, making desalination a practical solution only for farmland situated near the coast. Because most cropland areas are situated some distance from the coast (see Exhibit 123), the high transport cost makes seawater desalination as a main irrigation source impractical.

54 Martinez-Alvarez (2020)

Exhibit 123: Most croplands are situated inland, away from the coastal seawater desalination plants



Note: shaded regions show cropland distribution across the world. Source: US Geological Survey

Despite the clear limitations, desalination may provide food security and self-sufficiency in places that have hitherto relied on imports from large agricultural producer countries. The UAE is piloting projects to grow drought-resistant plants that can be watered with saltwater or brine from desalination. Already, desert farms exist that use seawater to maintain vegetable-growing greenhouses. Water condenses and provides precipitation for the plants, while brine acts as a cooling agent. For instance, the seawater greenhouse in Australia's Port Augusta provides 15% of the country's tomato supply.

Please also see The Future of Food: Complexities and Compromises (7 Dec 2020) and Understanding Agri Food Commodities (26 May 2021).

Solution #1: Desalination

Desalination provides a solution for freshwater shortages. The freshwater sources available for human use are only 3% of all water available on Earth. The ever-growing needs of industry and population mean that we are on the cusp of running out of conventional supply. With ~97% of global water sources concentrated in the oceans and seas, desalination is one of the feasible solutions to freshwater shortage. It is one of the most climate-change resilient sources of water, independent of changes in weather patterns, droughts and rising temperatures.

How does desalination work?

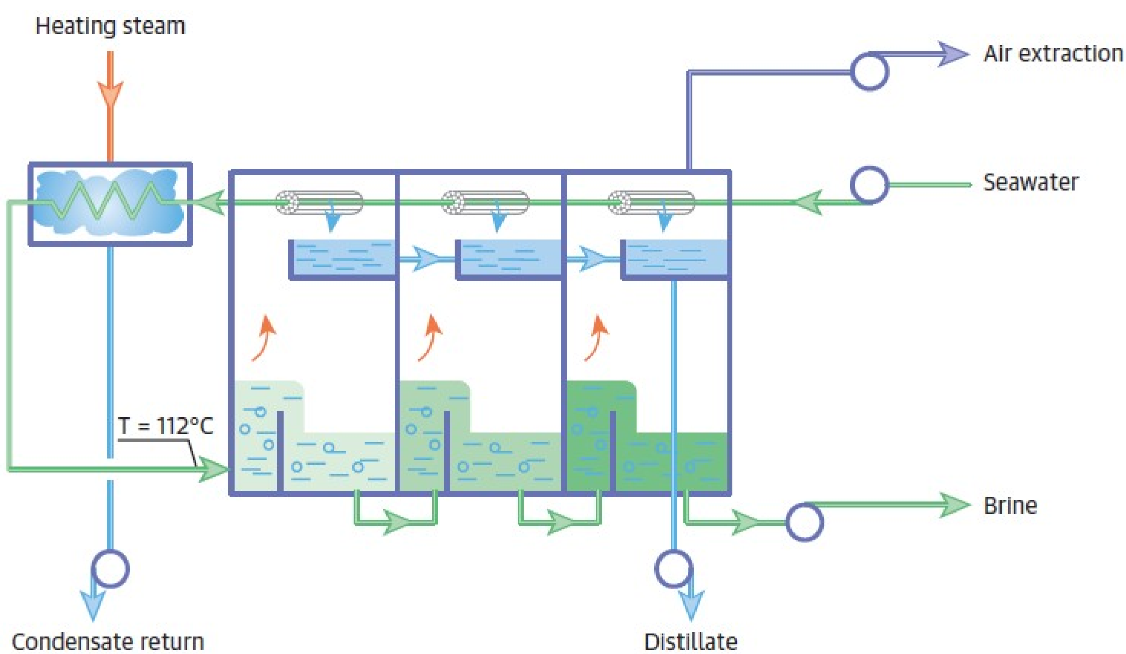
Desalination allows for the separation of salts and solid particles from seawater or brackish water to achieve its potable state. There are two broad desalination techniques: thermal (~30% of global capacity) and membrane (~70% of global capacity). Within these, the main thermal techniques are Multi-Stage Flash (MSF) and Multi Effect Distillation (MED); the membrane technique is Reverse Osmosis (RO). These methods differ in terms of cost, energy efficiency and impact on the environment.

Thermal desalination

Thermal desalination uses energy to heat seawater until it evaporates and condenses, thus separating salt from water. It was one of the first methods ever used in desalination.

Multi-Stage Flash (MSF): Feedwater passes through tubes in a series of heated chambers ("stages"), where it is preheated with steam until it eventually reaches the brine heater. This is where seawater achieves boiling point, resulting in vapour being separated, in the so-called "flashing" process, and then collected. Flashing continues as water passes through the chambers, each at a progressively lower pressure. The resulting steam is condensed against the heat exchange tubes and warms up the feedwater that is constantly being pumped in. Condensed steam is collected as pure water and brine is discharged.

Exhibit 124: In the MSF process, seawater passes through the heated chambers until it reaches the evaporation point and the condensation is collected as pure water



Source: Najafi 2016 in Water Global Practice 2019

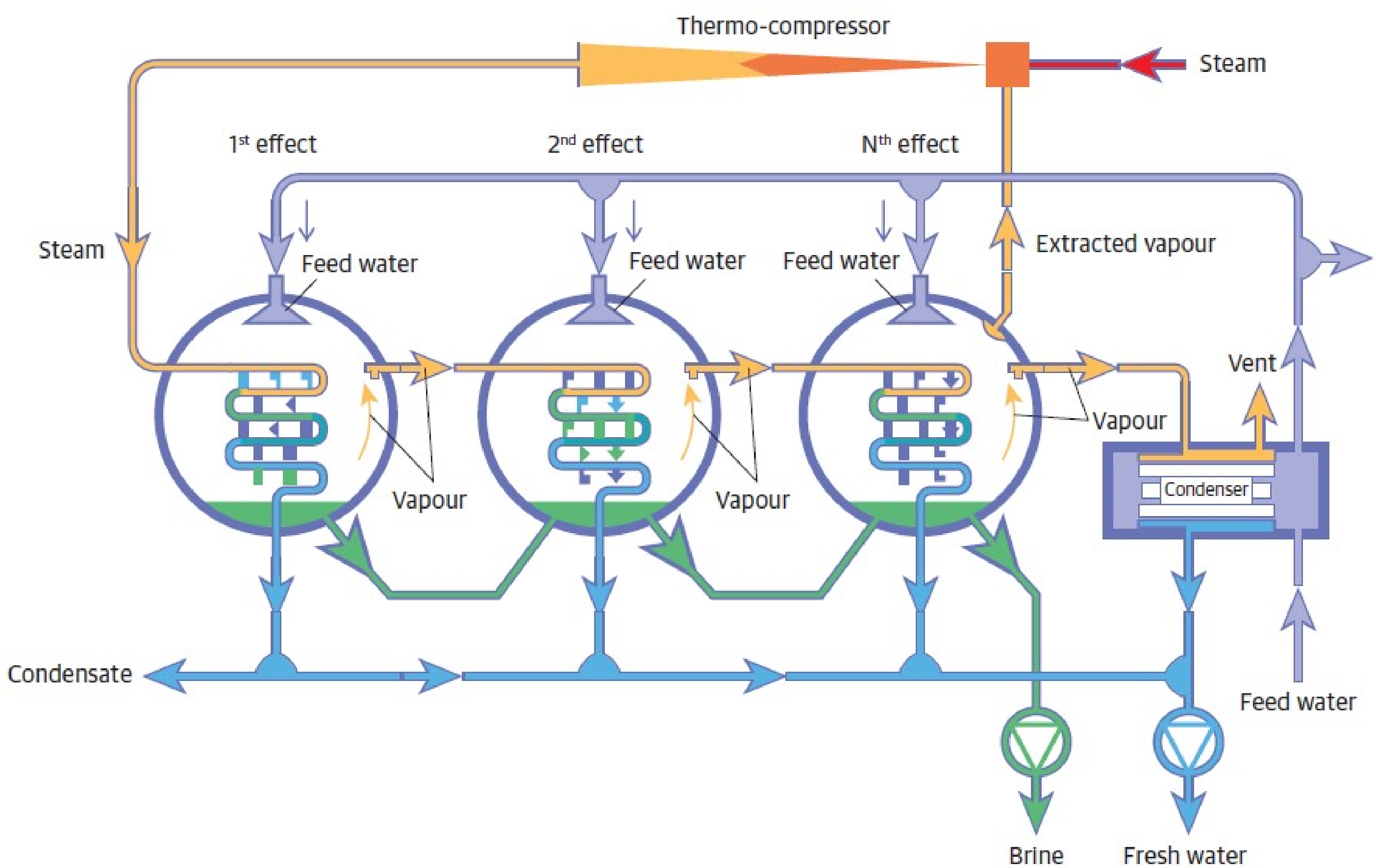
The high temperatures required to transform seawater into vapour make the MSF process energy intensive and therefore costly to operate. The method requires the use of both electrical energy (3.4-4.5 kWh/m3) and thermal energy (5.6-8.0 kWh/m3 electrical equivalent). Study results vary, but it is estimated that MSF, which is typically powered by fossil fuels, produces over three times as much CO_2 as the Reverse Osmosis method.[56]

Although thermal desalination is a fairly simple and established process that requires little pre-treatment of feedwater, inefficiency can be an issue. For each cubic meter of saltwater, only about a quarter of a cubic meter of pure water will be produced, and even though the process can be repeated using the leftover brine, there is a limit to how much pure water can be extracted. As the process is repeated, the brine becomes increasingly salty, which raises the risk of scaling and corrosion damage, as well as making it more costly to rerun.

Multi Effect Distillation (MED): When using the MED process, feedwater does not flow from one heat exchanger to another, but rather is sprayed into each stage ("effect") in equal proportion simultaneously. In the first effect, cold seawater is sprayed onto the hot steam pipe, cooling the steam inside and condensing it into freshwater. At the same time, the hot pipe heats the feedwater, creating vapour in the process. The feedwater that does not condensate is collected at the bottom of the first effect, whereas warm vapour passes through a pipe to the next chamber and heats up the feedwater in the next effect. Water collected at the bottom of the chamber moves from one effect to another, creating a brine, and the chamber temperature cools down with each passage. In the final chamber, a part of the remaining vapour is condensed into fresh water while the rest is reintroduced as steam through a thermo-compressor. Brine is discharged through a separate pipe.

56 Kempton (2010)

Exhibit 125: In the MED process, the feed water is sprayed onto hot pipes. The cooled pipes produce freshwater, and vapour is moved to heat the next stage of the process



Source: Australian Department of the Environment, Veolia Water Technologies in Water Global Practice 2019

MED can be an efficient, although more complex, alternative to MSF. From a technological angle, the main difference between the two methods is the process through which vapour is created. MED uses lower temperatures (70C versus 110C in MSF) and is therefore less energy intensive and causes less scaling. Although it still uses fossil fuels, it consumes only 6.5-11.0 kWh/m3 of energy, compared with 9.0-12.5kWh/m3 in MSF. Similar to other thermal methods, the feedwater requires little pre-treatment and the water recovery ratio is fairly low at 25%.

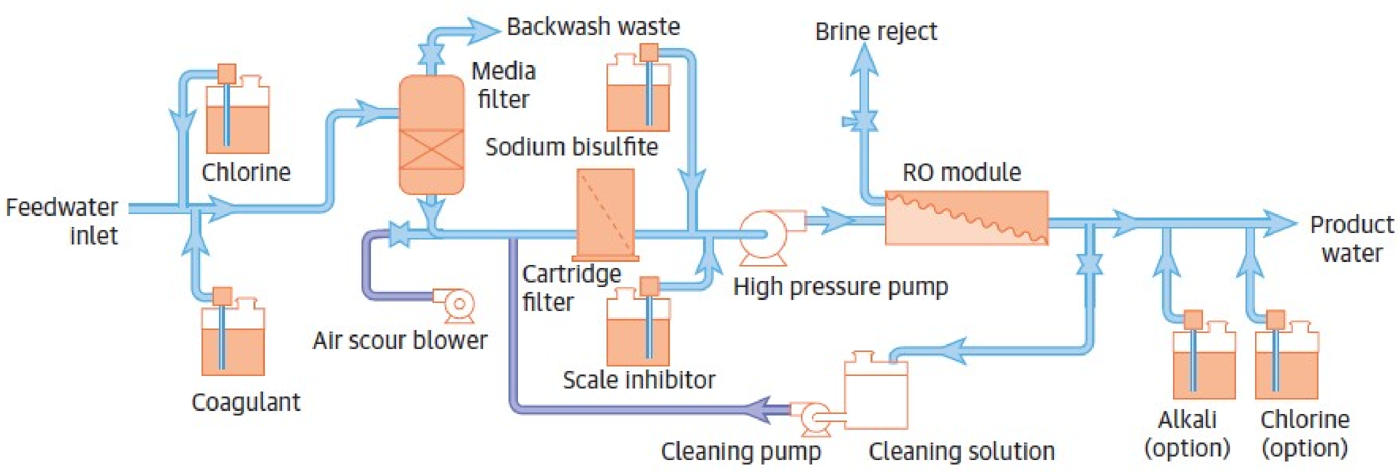
Membrane

In the membrane process, the seawater is pushed under high pressure through a number of membranes that trap salt and allow only pure water to pass. The two main types of membrane desalination are seawater reverse osmosis (SWRO) and brackish water reverse osmosis (BWRO).

Reverse Osmosis (RO): For optimised reverse osmosis performance, feedwater requires pre-treatment with, for instance, chlorine and coagulant that limit organic fouling and microbacterial growth on the membrane. Often, further treatment is needed to ensure water enters the pump without causing damage to the membrane (cartridge filters, scale inhibitors and so on). Once pre-cleaned, seawater is then pumped under high pressure through a membrane to separate salts from fresh water. Brine is rejected while fresh water is remineralised and pH-adjusted. Added alkalinity limits corrosion of the pipes used in water distribution.

Reverse osmosis allows for more efficient desalination, with ~40% of feedwater converted into pure water (versus ~25% for MSF). It is also the most efficient in terms of energy use. Although the process uses more electricity (3.0-7.0 kWh/m3) than thermal plants, overall it consumes less energy, as it does not require thermal energy (total 3.0-7.0kWh/m3 compared with 9.0-12.5kWh/m3 electrical equivalent for MSF). Often, additional purification such as a two-pass system is necessary to achieve a higher quality product. For example, ocean water contains about 35,000ppm (parts per million) of salt, whereas brackish water can have as little as 1,000ppm. For water with lower levels of salinity, a less intensive pre-treatment process is needed. However, the limited source availability of brackish water means it is unlikely to be a large-scale solution for global water shortage.

Exhibit 126: In the RO process, water requires significant pre-treatment before it passes through the membranes, and the remineralisation process then makes it potable



Source: Australian Department of the Environment, Veolia Water Technologies in Water Global Practice 2019

Exhibit 127: Advantages and disadvantages of the most commonly used desalination techniques

	Multi-Stage Flash (MSF)	Multiple Effect Distillation (MED)	Reverse Osmosis (RO)
	THERMAL	**THERMAL**	**MEMBRANE**
Advantages	Simplest to operate – typically less technologically advanced than RO and MED	Less energy intensive than MSF as it operates at lower temperatures (~70C versus 110C in MSF)	Lowest energy consumption; only pumping energy required, no thermal
	Feed water does not need extensive pre-treatment, which lowers operating costs	Less corrosion and scaling due to lower temperatures compared with MSF	More efficient than thermal plants - over 40% of feed water will produce potable water
	Cheapest solution for low quality feed water	Little pre-treatment of feed water required	Corrosion not an issue as plants operate at lower temperatures
	Produces good quality potable water (low levels of total dissolved solids)	Uses fewer chemicals than MSF and RO	No thermal pollution from the discharge
		Produces good quality potable water (low levels of total dissolved solids)	
Disadvantages	Low efficiency – only about 25% of feedwater water will produce potable water	Low efficiency – only about 25% of feed water will produce potable water	Complex and costly technology – multi-pass filtering system is required to achieve good quality water
	Energy-intensive and typically powered by fossil fuels	Energy-intensive and typically powered by fossil fuels	Membrane scaling is a common issue – high pre-treatment cost
	Scaling and corrosion an issue due to high operating temperatures (110C)	More complex to operate than MSF	Best performance with low-salinity source water
	Extensive use of purification and cleaning chemicals		
	Highest thermal discharge footprint		

Source: Water Global Practice 2019, Technavio, Morgan Stanley Research

Exhibit 128: The Reverse osmosis process uses more electricity, but because it does not require costly thermal energy, overall it is less energy intensive

Desalination Method	MSF	MED	SWRO
Electrical energy (kWh/m3)	3.4-4.5	1.5-2.5	3.0-7.0
Thermal energy (electrical equivalent) (kWh/m3)	5.6-8.0	5.0-8.5	none
TOTAL ELECTRICAL EQUIVALENT ENERGY (KWG/M3)	**9.0-12.5**	**6.5-11.0**	**3.0-7.0**

Source: Younes Ghalavand et al. (2015), Morgan Stanley Research

New methods of desalination

Membrane technology currently accounts for ~70% of global desalination market capacity. However, this has not always been the case. The membrane solutions started to outgrow thermal methods in the late 1990s, as more efficient membranes were developed and water recovery ratios increased.

R&D efforts for thermal systems are centred around decarbonisation of existing methods, using solar, wind and geothermal energy. Membrane research, however, has a much wider scope, aiming to increase efficiency, reduce the amount of chemicals used, and extend the durability of materials used in the process. Nanomembranes, membrane distillation and forward osmosis are some of the emerging technologies in the membrane sector.

– **Nanomembranes:** The technology provides a more sophisticated filtration system and can potentially reduce the amount of chemicals used in pre-treatment. It can increase productivity by up to 20% while using 15% less energy.[57]

57 Water Global Practice

– **Membrane distillation**: This is a thermal process in which feedwater is heated and passed through a hydrophobic membrane that allows only vapour to transfer. The vapour then condenses and is collected as freshwater. The process is comparatively energy efficient, extends the durability of the membrane and can be used where feedwater has high salinity levels. However, it does require thermal energy and can lead to high capital cost.[58]

– Forward osmosis: Feedwater is concentrated in a "draw" solution, which creates forward osmosis and pulls out the solid particles from seawater. The process is best suited for feedwater with high levels of impurities. It is low cost and can consume as little as a third of the energy used in conventional processes. However, the process can be prone to membrane fouling and is unsuitable for large-scale water production.[59]

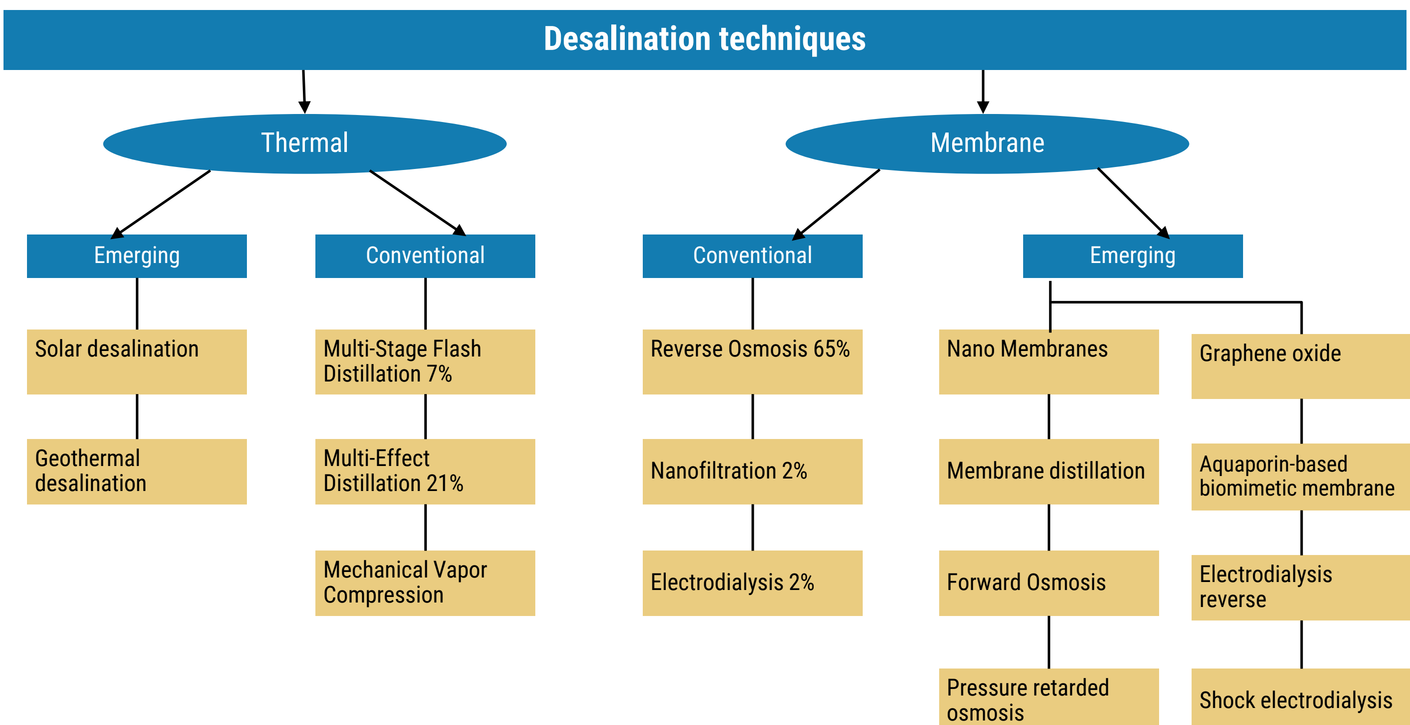
– **Aquaporin-based biometric membranes**: The system is modelled on living organisms; the technology is still in a nascent stage and requires further development.[60]

58 GWI

59 GWI

60 Water Global Practice

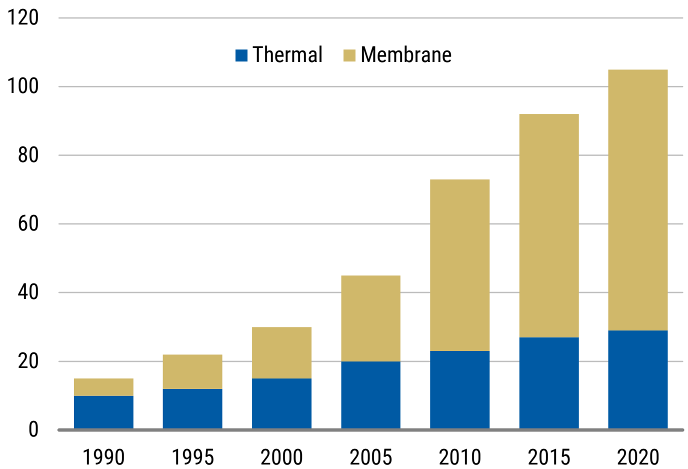
Exhibit 129: Conventional methods account for over 97% of the desalination market, but new technologies are in development



Source: Saavedra et al. (2021)

Exhibit 130: Growth in global desalination capacity has been dominated by the membrane segment since the late 1990s

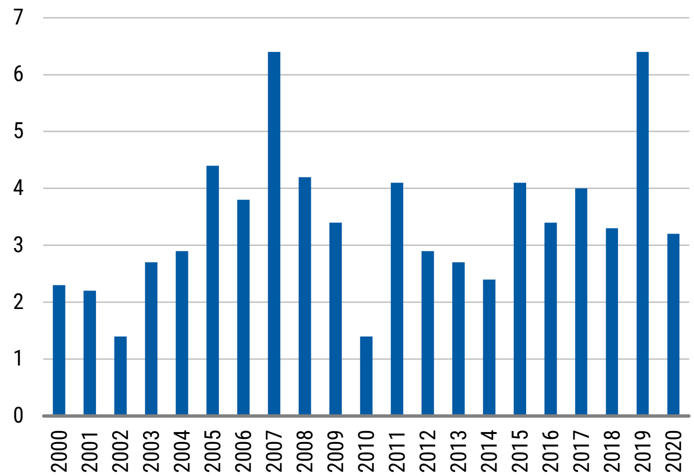
Global Desalination Capacity (mn m3/day)



Source: IDA Water Security Handbook, Morgan Stanley Research

Exhibit 131: 2019 saw the most incremental capacity contracted since 2007

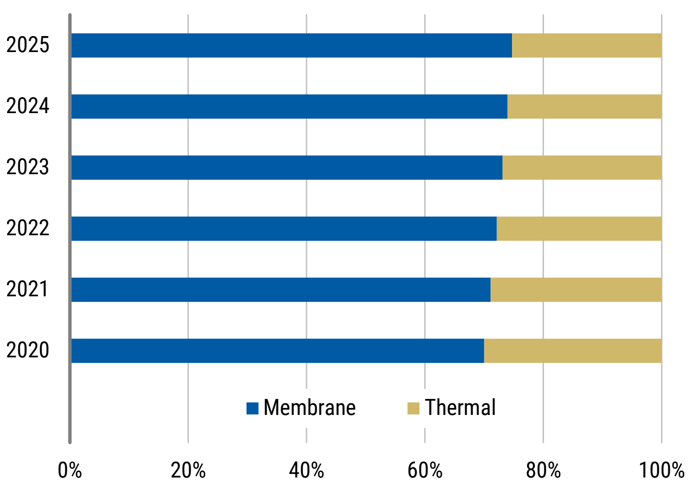
Incremental Contracted Desalination Capacity (mn m3/day)



Source: IDA Water Security Handbook, Morgan Stanley Research

Exhibit 132: Improvements in technology should lead to continued growth in the membrane segment

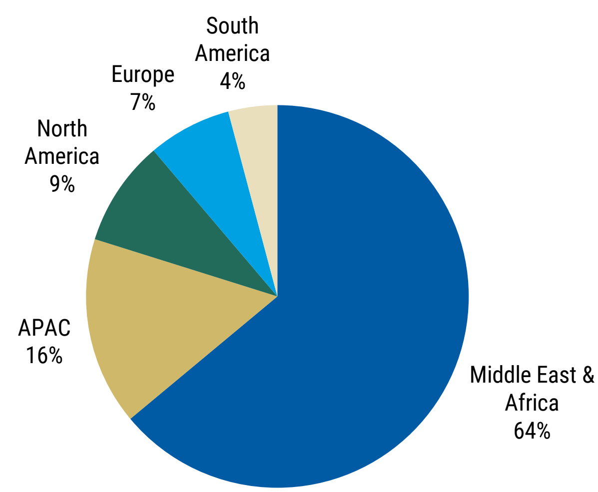
Global Desalination Market by Technology



Source: Technavio, Morgan Stanley Research

Exhibit 133: Middle East and Africa account for more than half of the global desalination market

Global Desalination Market by Region



Source: Technavio, Morgan Stanley Research

The current desalination market

Global desalination capacity had reached 105 million m3 per day across ~20,000 plants in 2020.[61] This is equivalent to ~1% of total global freshwater demand of 10bn m3 per day. The desalination market is projected to grow at a ~9% CAGR between 2020 and 2025, reaching a market value of $22.3bn in 2025 (up from $14.73bn in 2020).[62] There are currently over 150 desalination projects in the pipeline, with a total capacity of over 24mn m3/d. [63]

The market is largely concentrated in the Middle East and North Africa (~64%), where there is limited access to drinking water, demand driven by population growth, comparatively low energy prices and high investment capabilities. With only 1% of global freshwater reserves and 7% of global population, the Middle East and North Africa is one of the most water-scarce areas in the world. The region's population is forecast to grow by 16% in 2020-2030 (to

61 (IDA, 2021)

62Technavio

63 Fitch Solutions Industry Data

609 million) and 43% in 2020-2050 (to 754mn).[64] In 2018, Saudi Arabia, UAE and Kuwait alone accounted for over 30% of global desalination capacity, with over 70% of Saudi Arabia's potable water supply originating from seawater.[65]

In APAC (16% of the global market), China and India are increasingly turning to desalination to meet water demand from a growing population and expanding industry. Both countries face water shortages, with China's yearly freshwater per capita resources at 2,000 m3, less than half the global average; in India, this figure is even lower, at ~1,000 m3.[66] These resources are also depleting quickly. India has exhausted two-thirds of its freshwater resources since 1960s. According to projections by China's government, the country faces freshwater shortages of 21.4bn m3/d by 2030.[67] Incremental desalination is under consideration, but not on a large scale. The 2021-2025 five-year plan includes 1.25mn tonnes a day of additional desalination water capacity, raising China's total desalination output to 2.9mn a day. Although a significant addition, the incremental water supply will meet only ~0.2% of the China's daily demand.

South America (4% of the current market) is one of the fastest-growing regions for desalination, with 9.5% growth expected in 2020-2025, compared to 8.7% for the global market. Growth is expected to be particularly strong for Chile, from where a quarter of the world's copper supply originates.[68] The largest mines are situated in the arid northern area of the country, where progressing desertification and pressure to reduce the impact on groundwater sources have forced the water-intensive copper mining industry to look for solutions in desalination. By 2028, 62% of copper production in Chile is expected to be dependent on desalination. According to the Chilean Ministry of Mining, desalination should increase by 230% over the next decade.[69]

The US has the largest brackish water desalination capacity in the world, with over 2mn m3 of water produced daily. These plants are mainly situated in areas of water strain away from the shore, in states such as Texas, Colorado, Arizona and Iowa. The US is set to remain the largest investor in the brackish desalination market, spending a further $3bn over the next five years.[70] Although more seawater-oriented desalination projects are in the pipeline in the US, including a ~190,000 m3/day Huntington Beach plant, the scale of the US seawater projects is nowhere near the scale of developments in the Middle East. Saudi Arabia alone will spend nearly $18bn in the next five years on seawater plants, while the US is not even among the top 10 spenders.

64 UN

65 Technavio

66 Worldbank

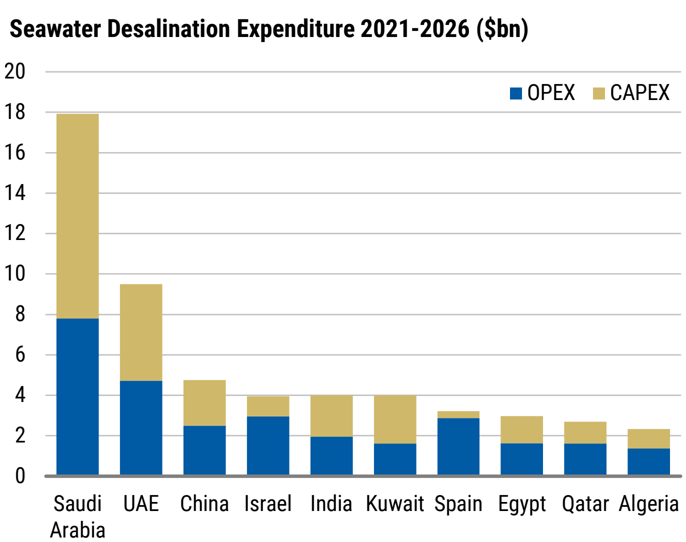
67 MIT Technology Review https://www.technologyreview.com

68 Technavio

69 Cochilco https://www.cochilco.cl

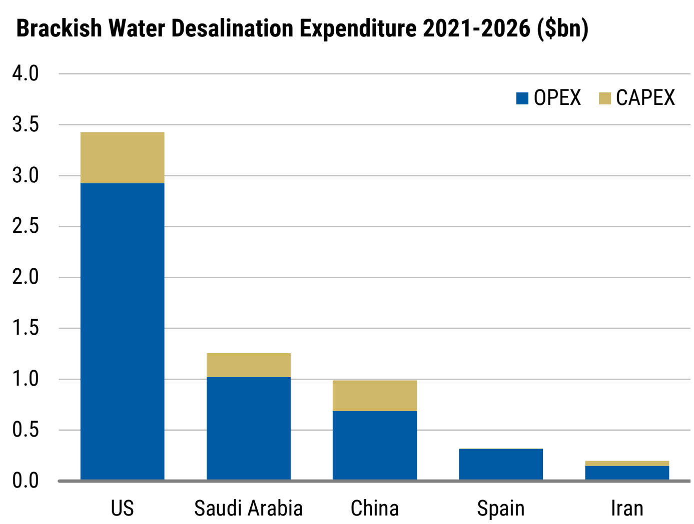
70 GWI

Exhibit 134: Saudi Arabia and UAE will spend the most on seawater desalination ...



Source: GWI, Morgan Stanley Research

Exhibit 135: ... while the US is the biggest investor in brackish water desalination

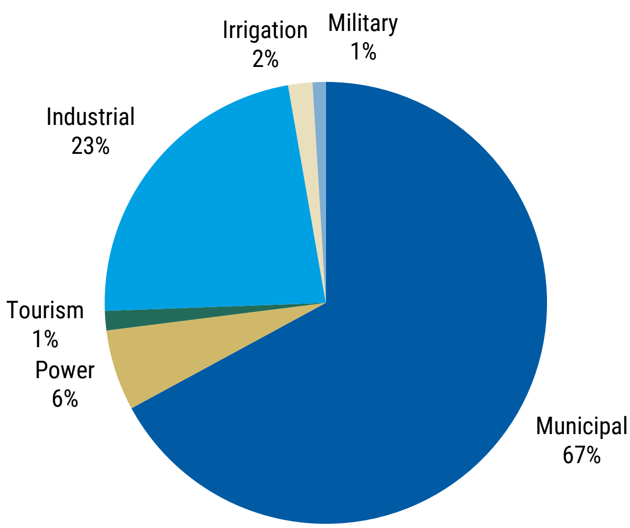


Source: GWI, Morgan Stanley Research

Municipal use is the main demand driver for desalination (~67%), with industry in second place (~23%).[71] Over the past two decades, the use of desalination for utilities has typically exceeded industry use.

Exhibit 136: Desalination is typically used on a municipal level, but is also widely used in industry

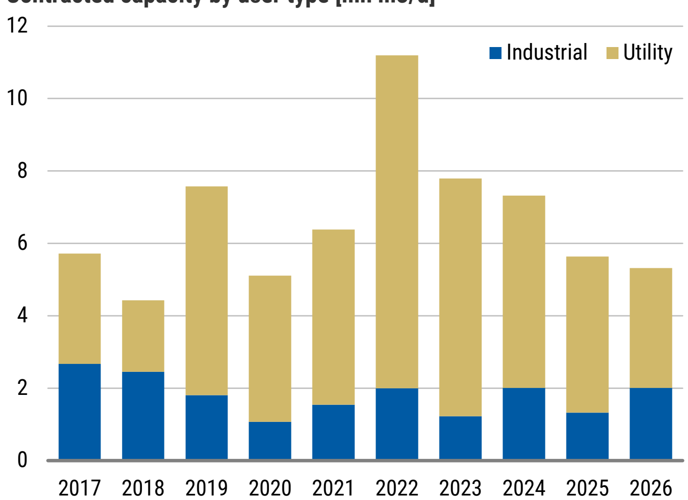
Uses of Desalinated Water



Source: GWI, Morgan Stanley Research

Exhibit 137: The use of desalination by utilities will continue to exceed industry use

Contracted capacity by user type [mn m3/d]



Source: DesalData, Morgan Stanley Research

71 GWI

Biodiversity challenges to desalination

The ecological impact of desalination remains unclear. While it provides undeniable benefits and a possible solution to water shortages, desalination brings a number of environmental impacts.

- **Salinity:** Once a fraction of feedwater is separated into pure water and salt, the remaining salty brine is pumped back out to sea through the outflow pipes. On average, thermal plants produce a higher volume of brine than do membrane plants. The brine can be twice as salty as seawater (depending on the location and method used). Because of the high salt concentration, brine is heavier than seawater and settles on the seafloor, causing damage to organisms living there. That said, there are set standards on permissible levels of salinity within a specified radius from the pipes. The brine discharge pipes are supposed to be situated in areas lacking sensitive marine ecosystems and with significant ocean flow, so that salt disperses immediately in the water. Despite these efforts, the salinity of seas close to plants has been shown to rise. For example, the Persian Gulf is some 25% saltier than average seawater, owing to the concentration of desalination plants in the region.[72]
- **Chemical and heat pollution:** Salt is not the only problematic by-product of desalination. Brine also contains chemical by-products of the process, such as chlorine or heavy metals from equipment corrosion. There are ongoing projects to turn brine into a commodity and extract a range of minerals from it (similar to the way oil refineries operate, for example) in MIT labs[73] and in the Saline Water Conversion Corporation in Saudi Arabia.[74] However, large-scale commercial operations for extracting minerals are not currently economically viable. In addition, discharged brine from thermal plants is often warmer than seawater due to its thermal treatment, which can pose a risk to temperature-sensitive organisms.
- **Animal entrainment:** There are also concerns over the intake of feedwater. Filters can protect larger fish, but the force of

72 Scientific American (2019) https://www.scientificamerican.com

73 MIT News (2019) https://news.mit.edu

74 IDA (2021) https://idadesal.org

water inflow sucks in tiny organisms such as larvae and smaller coral parts. A study by West Basin Municipal Water District in California estimated that the operation of a 170,000 m3/d RO plant with an unscreened intake can result in entrainment of up to 800mn fish eggs and 10mn fish larvae per year. [75] There are, however, possible improvements in design of intake systems. Reduction in the membrane mesh size or specifically designed small-mesh wedge wire screens mounted on the inlet intake system can minimise entrainment.[76] The slow velocity suction heads at the intake, whose power is comparable to the ambient sea current, also reduce entrainment by allowing smaller organisms to swim or drift away.[77]

Desalination currently provides just 1% of the global potable water supply. Should the world become more dependent on this technology, the environmental issues will increase. Critics of desalination highlight that there are other greener solutions to water shortages, such as water recycling, rainwater harvesting and renovation of leaky pipes.

How expensive is desalination?

Desalination is one of the most expensive methods of potable water extraction – it is multiple times more expensive than the conventional groundwater supply.

Capex

The upfront investment in desalination plants will vary, depending on the size of the plant, technology employed, permitting and location. The latter is of particular importance, as a plant far away from the coast needs significant additional investment in pipeline to transport the water to the point of consumption. For example, capex costs for desalination plants across the copper industry vary from $7,000 to $16,500 per m3/day, when looking at the pipeline of selected projects (Exhibit 138). Often, these projects are located in arid deserts at significant distance from the coast. Typical utility-dedicated plants in coastal locations require much lower capex, in a range of $800 to $2,300 per m3/day.[78]

Exhibit 138: Capital intensity of copper desalination projects

Capital intensity of desalination projects in mining	Capacity (LpS)*	Capacity m3/ day	Capex USD mn	Capex $mn / m3 day	Capex $mn/ 100 m3 day
Escondida	2,500	216,000	3,430	0.016	1.59
Candelaria	500	43,200	300	0.007	0.69
Mantoverde	120	10,368	100	0.010	0.96
Los Pelambres	400	34,560	520	0.015	1.50
Spence	1,000	86,400	1,430	0.017	1.66

*lps - litres per second. Source: Company data, Morgan Stanley Research

Operational costs

The groundwater pumping and treatment costs vary, depending on the depth of the well and technology, but typically pumping costs are below $0.10/m3 and treatment is ~$0.20/m3 for conventional supply. Pure water from a modern MSF plant is more costly, ranging from $0.52 to $1.75 per m3.

Technology is developing and costs are falling. The technology to increase cost efficiency of desalination has been progressing quickly, for both thermal and membrane methods. The Soreq 2 seawater reverse osmosis plant in Israel targets a cost as low as $0.41/m3, and the new Hassyan project in Dubai promises to deliver desalinated water at a record low $0.28/m3.[79] This would still be more expensive than conventional supply, but the price gap between the two water sources is closing. Making $0.40/m3 the global benchmark price for seawater desalination is one of the challenges the industry aims to address in the medium term.[80] That said, it may still be impossible to provide desalinated seawater to everyone at these lower prices. Water has a high bulk-to-value ratio and is therefore expensive to transport. It may be difficult for municipalities or industries to take advantage of desalinated water if they are not located close to the ocean.

75 Intake effects assessment report, Consultant's Report Prepared for the West Basin Municipal Water District (2005)

76 State Water Resources Control Board (2013) https://www.waterboards.ca.gov

77 IDE (2013) https://www.ide-tech.com

78 GWI, Kaya et al, Caldera & Breyer, Almar Water Solutions

79 Utilities-ME https://www.utilities-me.com

80 GWI https://www.globalwaterintel.com

Exhibit 139: The cost of production differs depending on plant capacity and technology used

	Plant capacity (m3/d)	Cost ($/m3)
MED	12,000-55,000	0.95-1.95
	>91,000	0.52-1.01
MSF	23,000-528,000	0.52-1.75
RO	15,000-60,000	0.48-1.62
	100,000-320,000	0.45-0.66

Source: Shatat et al. (2014), Morgan Stanley Research

Exhibit 140: The salinity of water has a significant influence on the cost of reverse osmosis

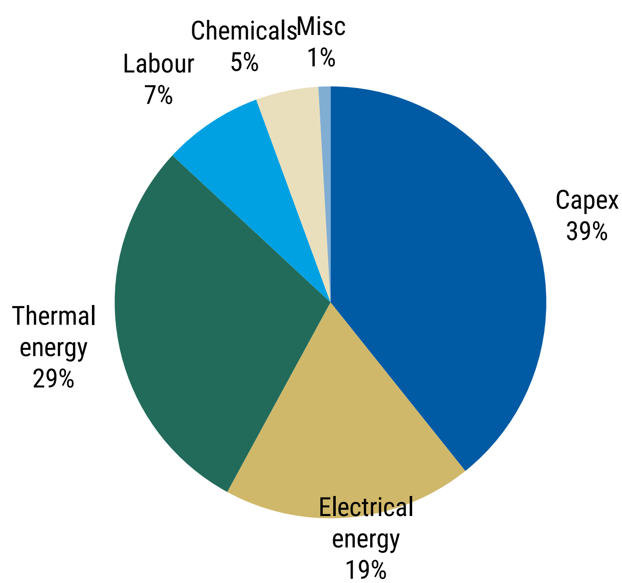
	Type of Feed water	Plant capacity (m3/d)	Cost ($/m3)
RO	brackish	40,000-46,000	0.26-0.54
	seawater	15,000-60,000	0.48-1.62
		100,000-320,000	0.45-0.66

Source: Shatat et al. (2014), Morgan Stanley Research

There are several factors affecting the cost of desalinated water. Key considerations include size of plant, technology, location, source of energy used and purity of feed water.

- **Size:** Larger plants benefit from material economies of scale across all methods of desalination. For the SWRO process, a 100,000-320,000 m3/d plant can produce water at $0.45-$0.66 per m3, while a smaller 15,000-60,000m3/day plant has a wider cost range of $0.48-$1.62.[81] Similarly, for MED plants with a capacity of over 91,000m3/day, the cost ranges between $0.52/m3 and $1.01/m3, while for smaller plants (12,000-55,000m3/day) the cost can be twice as high, at $0.95-$1.95 per m3.[82]
- **Technology:** Reverse osmosis method is generally more cost competitive than thermal plants, predominantly because it requires less total energy and has a higher efficiency ratio. While the SWRO process can cost as little as $0.45/m3, the thermal plants typically start at $0.52/m3 and can go up to $1.95 for smaller MED plants. [83]
- **Location:** Higher water temperatures require lower pressure and hence can decrease the efficiency of the membrane process. For these reasons, in the warm and highly saline waters of the Gulf region, thermal plants can be competitive on cost compared with SWRO.
- **Source of energy:** Energy is the highest proportion of opex for both thermal and membrane technologies. So far, lower fossil fuel prices have contributed to better economics for thermal plants in the Middle East; however, there is a significant focus on developing solar plants in the region. The use of renewable energy can decrease the operating cost over the lifetime of the system. The solar-powered NEOM plant targets record low costs at $0.34/m3.[84]
- **Purity:** The differences in salinity of source water can also significantly contribute to the cost of the process. For increased purity, a more sophisticated process is required. Higher quality water produced via the two-pass RO system with ion exchange and measuring only 39mg/l TDS (total dissolved solids – a measure of water purity) can be 1.5 times more expensive than water produced with single-pass RO and measuring 500mg/l TDS.

Exhibit 141: Energy accounts for almost half of the costs of a thermal MSF plant



Source: Water Global Practice 2019, Morgan Stanley Research

81 Shatat et al. (2014)

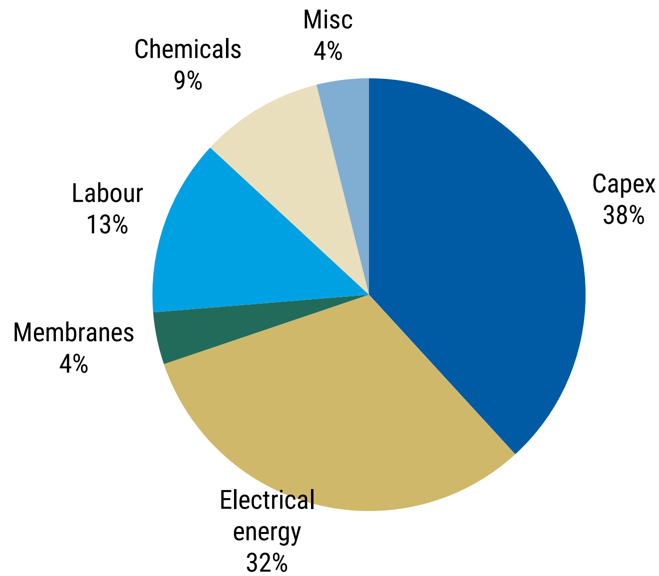
82 Shatat et al. (2014)

83 Shatat et al. (2014)

84 Neom Press Release (2020) https://neomsaudicity.net

Exhibit 142: In a membrane RO plant, the energy costs are lower, at 32%

Cost Structure of a RO Plant



Source: Water Global Practice 2019, Morgan Stanley Research

Decarbonising desalination

Renewable energy is needed to decarbonise desalination plants. Desalination of 1000m3 of water a day consumes an equivalent of 10,000 tonnes of oil per year, and each 1000m3 of desalinated water produces ~6.7 tonnes of CO2.[85] There is a pressure on desalination plants to decarbonise as water authorities around the world commit to net zero.[86]

85Tal, 2018)

86WI https://www.globalwaterintel.com

There are already plants running on renewable energy, but the technology has lacked scale and is costly. Recent technological advances are about to make large-scale sustainable projects possible. For example, Saudi Arabia's 500,000m3/d solar-powered desalination plant will not only be carbon neutral, but it is also expected to produce freshwater at a cost of $0.34/m3, considerably less than some of the most efficient reverse osmosis plants. Currently, only 1% of plants use renewable electricity, but the IDA (International Desalination Association) has set a goal for 20% of new plants to be powered by sustainable energy between 2020 and 2025. Apart from solar, which powers 51% of global renewable desalination capacity, there are plans to extract freshwater from the ocean using floating wind turbines. The WINDesal project targets 50,000m3/day capacity from its semi-submersible floating modules (currently wind energy accounts for 30% of the total renewable desalination). Despite these promising new technologies, further development of energy storage capacity is required to allow large-scale desalination plants to operate purely on renewable energy sources.

Outlook for the sector

The global desalination market is forecast to grow at a +9% CAGR to around $30 billion by 2030.[87]

Successful rollout of green hydrogen could require 26 million m3/day of incremental desalination capacity. Green hydrogen production is still in its early stages, and the resulting water withdrawals are largely manageable without a significant dependence on desalination. However, this will likely change with ambitions for green hydrogen by 2050 and the fact that many of the plants in the pipeline are located in water-stressed regions. Based on the IEA's 2050 Net

87 Technavio, researchandmarkets, grandviewresearch, visiongain, adroitmarketresearch, marketsandmarkets

Exhibit 143: Cost of SWRO desalination can increase significantly depending on a desired purity of the end-product

Target product water quality	Target TDS (mg/l)	Construction cost (ratio)	O&M costs (ratio)	Cost of water (ratio)
Single-Pass RO System	500	1	1	1
Partial Second-Pass RO System	250	1.15-1.25	1.05-1.10	1.10-1.18
Full Two-Pass RO System	100	1.27-1.38	1.18-1.25	1.23-1.32
Full Two-Pass RO System with ion exchange	30	1.40-1.55	1.32-1.45	1.36-1.50

Source: Voutchkov (2018) in Water Global Practice 2019, Morgan Stanley Research

Zero scenario, hydrogen production will require over 1.9 billion m3 of water per year by 2040 and 3.1 billion m3 by 2050 (Exhibit 104). According to Rystad, nearly 85% of the 2040 capacity will require desalination plants. This would imply ~4.3 million m3/day of new desalination capacity by 2040 and 7.2 million m3/day by 2050 (if we assume that the proportion of capacity requiring desalination in 2050 is also 85%). Using the Hydrogen Council's higher forecasts for hydrogen production by 2050, 12 billion cubic meters of water annually will be required by 2050. This in turn may need an additional ~26 million m3/day of desalination capacity (a 25% increase on current global desalination capacity of 105 million m3/day).

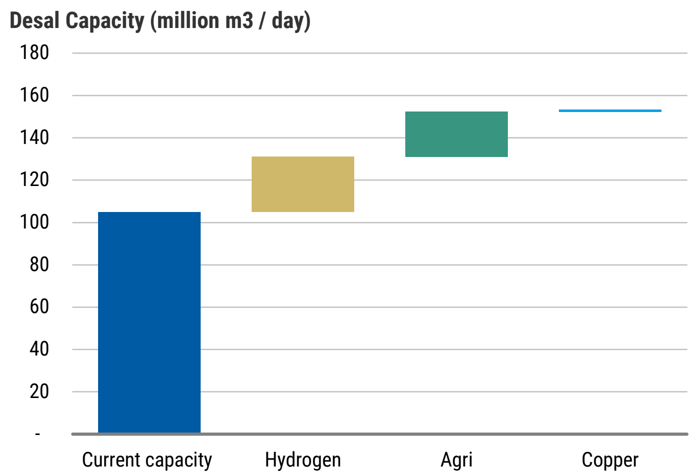
No incremental desalination capacity is expected for power generation. Currently, desalination is used for less than 1% of the water requirements for power generation globally. Although total power generation will increase by 2.7 times between 2020 and 2050 under the IEA's Net Zero scenario, the mix shift means that on a global basis we expect relatively stable water withdrawals for power generation in 2050 versus 2020. Note, however, that this analysis does not take into account regional differences in energy mix shifts and water scarcity.

Desalination will be required though for copper – an enabler of green energy. As climate change leads to more frequent and prolonged droughts (Chile, African Copperbelt, Australia) and as ore grades continue to decline, access to water will become an increasing strain for the water-intensive copper mining industry. Chile is the largest producer of copper, with 27% share of world mined production in 2019. While the mining industry accounts for just 3% of water used in Chile, most mining operations are concentrated in areas where water scarcity is most pronounced, thus exacerbating the impact of water shortages. Northern Chile is one of the driest areas in the world (in spite of recent flash floods), while Central Chile requires vast amounts of water for agriculture and household consumption.

One solution is to use desalinated seawater – Cochilco expects seawater consumption to increase by ~10.5% a year between 2018 and 2029. Assuming that all new copper capacity in Chile and Peru requires desalination, the copper incentive price could increase by 3%, based on estimates from our Metals & Mining team. For more detail, see Metals & Mining: Copper & Water – Reflationary trends (25 Feb 2020).

Agriculture presents an unknown. Some ~2% of desalinated water is used for agriculture globally, but we estimate that this is <0.02% of total agricultural withdrawals. With water withdrawals for food expected to rise by up to 30% over the next 30 years desalination could play a bigger role in agriculture. Even if only 1% of incremental water comes from desalination, this would imply ~21 million m3/ day of new capacity in the next 30 years (vs ~1.1mn m3 for agriculture today). However, there are limitations on the use of desalination for agriculture, such as the comparatively high cost of desalination and in particular the high transportation cost to farmlands situated away from coastal areas. See the section Water and The Future of Food for further detail.

Exhibit 144: Potential demand drivers for new desalination plants



Source: GWI, IEA, Cochilco, Rystad, WRG, Company Data, Morgan Stanley Research

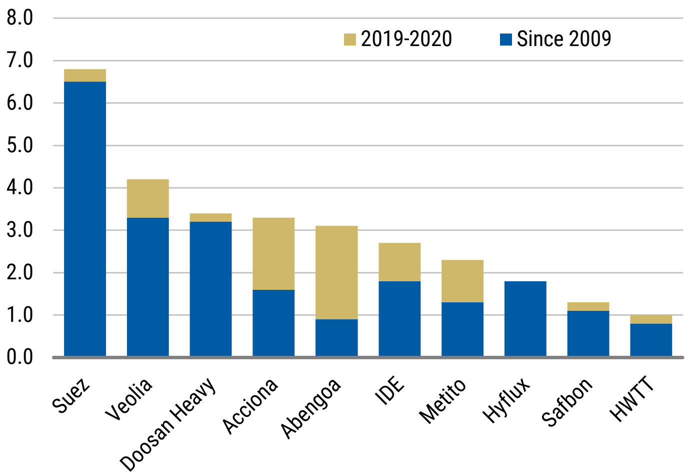
Key companies in the market

There are few pure-play public companies in the desalination market, with key vendors offering desalination services as a part of a wider utilities or industrial portfolio. Despite the low penetration of desalination projects in Europe (7% of the global market), European companies such as Veolia, Suez and Acciona are the dominant listed players in the space. Veolia has the largest exposure, operating over 1900 plants across thermal and membrane technologies with a total daily capacity of 6.75mn m3/day. Suez and Acciona operate reverse osmosis plants with a 5mn m3 daily capacity each. Outside Europe, Doosan Heavy Industries and IDE are key players.

Historically, Suez and Veolia have been the two leading plant suppliers, but over the past two years Abengoa and Acciona have secured some large-scale projects. Abengoa is supplying the ~900,000m3/d Taweelah and ~600,000m3/d Jubail and Rabigh plants, while Acciona has secured a range of smaller projects, including Khobar, Shuqaiq, and Umm al Houl, with respective capacities of 630,000, 450,000 and 280,000m3/d.

Exhibit 145: Historically, Suez and Veolia have led the market ...

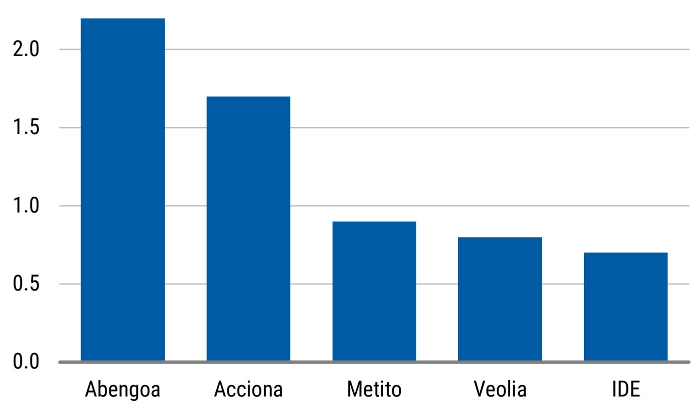
Seawater Desalination Expenditure 2021-2026 ($bn)



Source: IDA Water Security Handbook, Morgan Stanley Research

Exhibit 146: ... but Abengoa and Acciona have secured some large-scale projects recently

Top 5 Plant Suppliers by Awarded Desalination Capacity 2019-2020 (mn m3 / day)



Source: IDA Water Security Handbook, Morgan Stanley Research

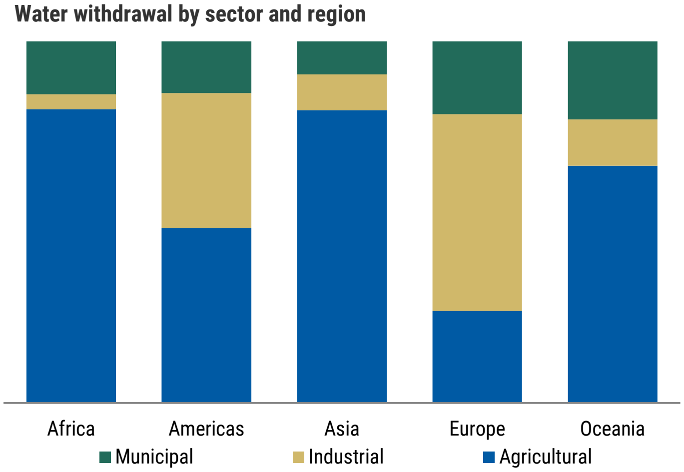
Solution #2: Smart Irrigation

Meeting growing demand for food with finite quantities of land and water presents a challenge for agriculture in the coming decades. Irrigation and cropping efficiency are key for the future of food, and will need to expand and evolve towards more innovative methods, such as micro-irrigation (drip) and smart controller systems.

Micro-irrigation systems will continue to grow rapidly. Their advantages include: 1) reduced water loss; 2) support from governments and agencies; 3) a contribution to lower methane emissions; 4) improved crop efficiency; 5) operating efficiencies and reduced labour intensity.

Globally, we estimate the total addressable micro-irrigation market in the region of US$17 billion in 2025 – an additional US$10 billion market opportunity versus 2018 levels. This is equivalent to at least 4.4 million hectares of incremental micro-irrigated land in the next 5 years, roughly a 40% increase from current levels.

Exhibit 147: Agriculture accounts for ~70% of water withdrawals, largely explained by patterns in Africa and Asia

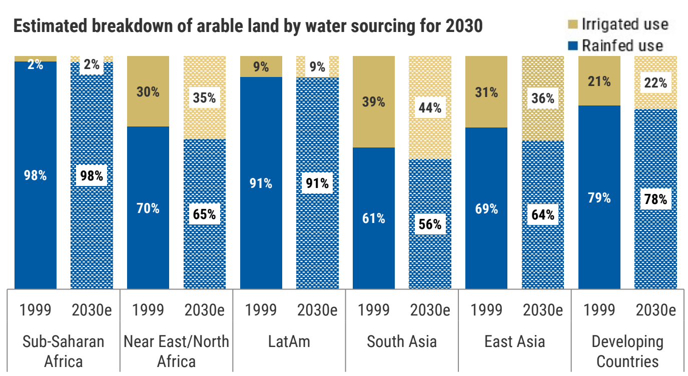


Source: Food and Agriculture Organization of the United Nations, Morgan Stanley Research

Population growth and the steadily increasing demand for food and agricultural products place water usage and efficiency at the centre of sustainability discussions. Agriculture accounts for 70% of freshwater withdrawals (industry accounts for 19%, municipal needs 11%). However, only ~20% of agricultural land is irrigated. In other words, 80% of the world's cultivated areas are rain-fed agriculture, and these areas account for 60% of crop production. The contribution by irrigated areas to total crop production (at 40%) remains below that of rain-fed agriculture, despite the benefits to environmental sustainability, productivity and national economies.

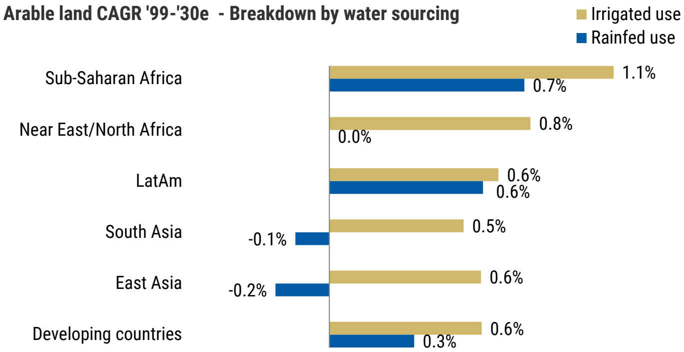
The fast pace of water pumping from the largest aquifers poses a risk to agriculture, which will require an expansion in irrigated areas and more efficient irrigation systems to meet food demand. Climate change has increased dependence on surface and groundwater resources in more arid and warmer regions. About ~71% of water used across these regions comes from surface water, and 25% comes from groundwater (the remainder comes from desalinisation, drainage and treated water). Thus, water depletion will likely increase the focus on new irrigation methods to improve efficiency and crop yields. The UN Food and Agriculture Organization (FAO) estimates that irrigated land will grow at a faster pace than rain-fed land in the coming decade, especially in Africa, Latin America and Asia.

Exhibit 148: FAO estimates see irrigated land becoming more relevant in Asia and Africa in 2030 ...



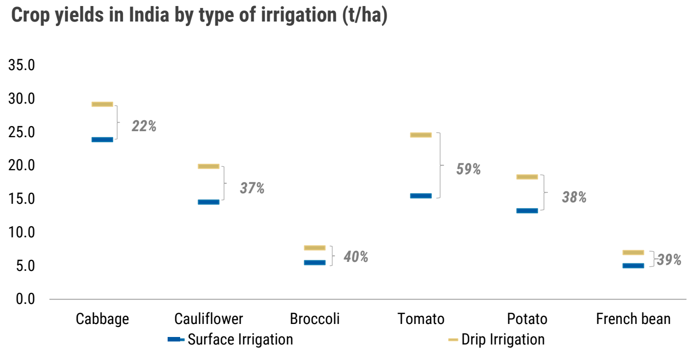
Source: Food and Agriculture Organization of the United Nations, Morgan Stanley Research

Exhibit 149:... with irrigated land growing at a faster pace than rain-fed land in all regions



Source: Food and Agriculture Organization of the United Nations, Morgan Stanley Research

Exhibit 150: Innovative irrigation methods can help improve crop yields



Note: Cabbage, cauliflower and broccoli yields are average figures for the period 2016-2018. Tomato, potato and french bean yields as of 2017. All studies were conducted in India. Source: International Journal of Agricultural Science and Research, Morgan Stanley Research

Given fixed quantities of land and water, irrigation and cropping efficiency are therefore key for the future of food. New operating measures and innovative methods will be required to improve irrigation systems and crop yields. Irrigation structures have provided multiple advantages, including reduced water usage, greater control over crops (which helps boost crop yields), and lower labour intensity and energy investments (especially as new automatised irrigating systems are developed). More recently, micro-irrigation and smart irrigation systems have cut down on wasted water and fertiliser usage (and ultimately contributed to lower methane emissions).

Many different irrigation methods are used worldwide, but we expect micro-irrigated land to grow at a relatively faster pace.

Exhibit 151: Types of irrigation methods used worldwide

	Surface or flood irrigation	Sprinkler	Micro irrigation or drip
Description	This is one of the oldest methods of irrigation. Water is applied to the surface covering the entire area with ponded water. It is considered the "lowest-tech" method, yet is one of the most popular. While it is cheap and simple, and thus used in less developed regions, it is also a method that wastes a large amount of water. It requires land to be leveled and is not suitable for crops that are sensitive to waterlogging	Sprinkler irrigation systems spray water evenly across the soil surface like rainfall. Sprinkler systems follow a basic composition: a pump to draw water from the source, a mainline that delivers water from the pump to laterals (made of **aluminium, steel or plastic**), lateral pipelines to deliver water to sprinklers (similar materials as mainline) and sprinklers that spray water.	This system applies water to plants individually. Water is directed at low rates to avoid pond formation and minimize distribution tubes. It is the more advanced technique and, for certain crops, it is more efficient than traditional sprays.
Types	**Basin** Consists in applying water to fields bounded by dikes. Depth in basins can be wide but usually kept at 5-10cm. Built surrounding crops and drains from field to field like cascades. Water applications are frequent. Preferred when soil infiltration is moderate/low.	**Hand move** Designed to be moved. Laterals are made of aluminium to allow one person to move it. Usually used to irrigate wide fields and orchard crops. Low capital cost and easy to use, but labour intensive	**Drip** Water is applied slowly through small emitter openings from **polyethylene** tubing. Tubing and emitters can be laid in the surface, buried or suspendend.
	Furrow Small channels or furrows direct water across fields. Low slopes require soils with low infiltration rate. Large slopes can result in soil erosion. Water is directed to 5-10 furrows from ditches or gated pipes with siphon tubes made of **aluminium** or **polyethylene.** Rigid gated pipe usually is made from either 4-mm-thick aluminum or 8-mm-thick **PVC**. PVC pipe must have ultraviolet inhibitors to prevent deterioration in the sun.	**Center pivot** These systems have only one lateral made of galvanized **steel** rotating in circles around a fixed point in the middle of the field/crop. Enhances uniform watering. Water is supplied by a buried mainline or from a well near the pivoting point.	**Microspray - Microsprinkler** Water is sprayed over the surface, generally used when plants are widely spread. Emitters spray water over 2m-6m diamater circles or partial circles.
	Border Border irrigation systems divide land by parallel dikes. Each strip is irrigated separately upstream until the entire strip is covered. Suitable for crops that can withstand flooding. For extreme infiltration rates (extremely high and very low rates). Border irrigation has become unpopular in recent years.	**Rain gun** Uses a large sprinkler and covers very wide areas. Relatively low cost and not labour intensive. Adapt to supplemental irrigation.	

Source: CIGR Handbook, USGS, Netafim, Lindsay Corporation, Valmont, Morgan Stanley Research

Exhibit 152: Principal irrigation systems: Advantages and disadvantages

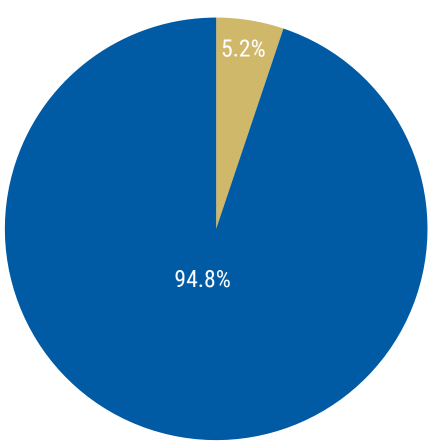
Surface or flood irrigation	Sprinkler	Micro irrigation or drip
Advantages	**Advantages**	**Advantages**
Relatively easy to design	Not dependent on soil infiltration	Reduce irrigation water usage and operating costs
Low initial investment	Land leveling is not required	Increase yield and quality of crops
Foliage stays dry which avoids damaging leaves	Requires little labor or unskilled labor	Reduce cost of labor as the systems need to be maintained only (automatic operations)
	Can leach salts from saline soils more than any other method	Reduce pollution hazards due to fertilizer control placement
		Reduce weed and the use of fertilizers
		Require less energy than sprinkler systems
		Used for fertigation and chemigation
Disadvantages	**Disadvantages**	**Disadvantages**
Where rainfall is abundant, a high network of surface drainage should be provided to avoid waterlogging and soil aeration problems	Windy conditions cause water loss	High initial investment costs
Low control of water quantity as flow is unknown at times. Can only be controlled with "timings" of irrigation	High initial costs	Complex equipment
Labor intensive	Irregular field shapes result in more expensive systems	Monitoring is required
Furrows require control over slope to have leveling precision and prevent uncontrolled channeling	Certain waters are more corrosive for metal pipes. Difficult to tropicalize	Energy costs are higher than with surface irrigation
Rarely used for fertigation and chemigation	Requires reserves of water if not continuously available	Prone to clogging on the back of water minerals which reduce discharge rates
Difficult to move across crops because of furrows	Water containing trash or sand must be cleaned to avoid clogging	
	Can damange foliage as water remains on the leaves	

Source: CIGR Handbook, USGS, Netafim, Lindsay Corporation,Valmont, Morgan Stanley Research

Micro-Irrigation and Smart Controller Systems

Exhibit 153: Micro-irrigation systems are only ~5% of total agricultural machinery

Global agricultural machinery market (2018,% of total)



Source: Companies, FAO Aquastat, Technavio, Morgan Stanley Research

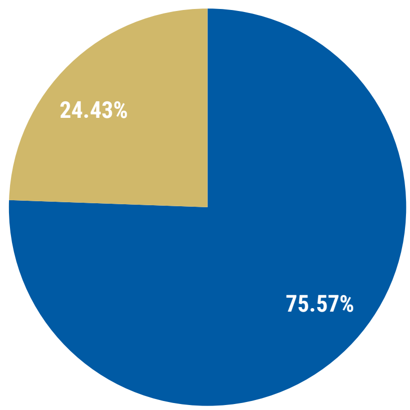
Penetration of smart irrigation (especially drip) systems is still low .... Micro-irrigation systems were just 5% of total agricultural machinery, based on 2018 data. The penetration of these alternatives remains low, but has slowly gained traction, especially in North America, Asia Pacific and Oceania. Within micro-irrigation systems, micro-sprinkler irrigation systems represent the lion's share (~76%); however, several studies indicate that the growth potential for drip irrigation is more meaningful. Drip irrigation is expected to be adopted at a much faster pace for orchard crops and to a lesser extent for grasses and forage crops.

... but should see relatively rapid growth: 1) These systems ensure proper water application to the soil and thus reduce water loss (i.e., they cover a greater area using less water); 2) some agencies and governments around the world have promoted and even regulated the use of water. Some have even launched schemes that encourage farmers to invest in micro-irrigation systems (see The Big Maharashtra Opportunity Announced, Implementation Holds the Key); 3) These systems are often used for fertigation and chemigation. A more focalized application of chemicals has also proven to reduce excessive use of substances, contributing to lower methane emissions.

Drip irrigation is more often used for orchard crops. The main driver is not only linked to water efficiency but also related to achieving better control of weeds, and more optimal use of fertilizers and labour. In addition, smart irrigation systems include digital tools that help control and monitor tree and plant nutrition. The entire irrigation operation is automated, allowing for increased insight into every tree at every stage of its life-cycle.

Exhibit 154: Drip irrigation is around a quarter of the total micro-irrigation market

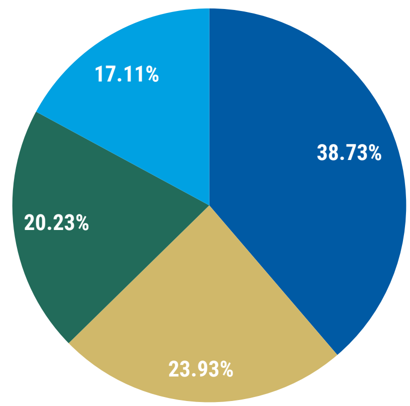
Global micro-irrigation: Market share by product (2018,% of total)



Source: Technavio, Morgan Stanley Research

Exhibit 155: Drip irrigation is used for orchard and field crops, as it affords farmers better control of plant nutrition

Global micro-irrigation: Market share by application (2018, % of total)



Source: Technavio, Morgan Stanley Research

Despite the clear opportunities and benefits of micro-irrigation, there are also some challenges. The equipment needed in micro-irrigation systems is more complex than that used for 'low tech' alternatives. It therefore requires maintenance services (often provided by the supplier/installer of the project) and replacement of components as needed. In addition, micro-irrigation systems can become clogged as large particles of sand and other solids block the emitter opening. The US dollar cost/hectare to install micro-irrigation systems is several times higher than that of surface irrigation systems, and so they have not gained as much traction in less developed regions.

Exhibit 156: Selected irrigation controller solutions

Solution	Company
SmartBox	Jain Irrigation Systems
FieldNet	Lindsay
NetBeat	Netafirm
LNK	Rain Bird
SmartConnect	The Toro Company
AgSense	Valmont Industries

Source: Company data, Morgan Stanley Research

The impact of micro-irrigation systems can be improved in combination with other technologies:

- **Photovoltaic-powered drip irrigation.** These systems combine the efficiency of drip irrigation with the benefits of a solar-powered water pump. Thus, this technique could grow at a fast pace in rural off-grid areas. Because solar radiation is the main driver of the water pump, the volume of water pumped increases on hot days when plants need more water, and vice versa. Thus, in some cases, this technique can be a battery-free configuration.
- **Irrigation controller (Smart Irrigation).** These systems are equipped with timers and sensors to help control water supply for each landscape. Frequency of irrigation, start time and duration can be regulated. Controllers can be weather based or sensor based and can be used for agricultural and non-agricultural crops. Irrigation controller vendors typically offer a variety of products: 1) smart controllers (sensor based or weather based), and 2) tap timers and basic controllers (typically weather based).

Global micro-irrigation – total addressable market

Globally, we estimate a total addressable micro-irrigation market opportunity in the region of ~US$17 billion by 2025. According to our industry sources, the total irrigation market globally was worth US$166 billion in 2018, of which US$9 billion can be associated with micro-irrigation. Smart controller irrigation was a small portion of the global irrigation market, at just 0.5% in 2018. For simplicity, in our TAM estimate we assume average annual growth in 2018-25 in a range of 5% to 15% (assuming a +/-5% band around Orbia's 10% long-term growth target for Netafim).[88] This range embeds low to mid teen growth rates in the smart controller irrigation segment. These assumptions suggest global micro-irrigation revenue in 2025 of US$13-24 billion, or an additional US$10 billion market opportunity versus 2018 levels at the mid-point of the range. Our estimates assume slightly faster growth in Asia Pacific and in the Middle East & Africa than in the Americas and Europe. If this mid-point scenario plays out, assuming an average initial installation cost of $2,100 per hectare, by 2025 a total area of 4.4 million hectares could be using micro-irrigation systems, a 37% increase from current levels.

Exhibit 157: Global Micro-Irrigation: Total addressable market estimate

US $ million

	2025	2025	2025	2025	2025
Global Irrigation Market	213,823	251,748	295,298	345,154	402,058
CAGR 2018-2015	4%	6%	8%	10%	13%
Global micro-irrigation	**12,829**	**15,105**	**17,718**	**20,709**	**24,123**
Estimated CAGR 2018-2025 range	6%	8%	10%	13%	15%

Source: Company data, FAO Aquastat, Technavio, Morgan Stanley Research estimates

Competitive Landscape

Consolidation (especially in North America and Europe) has become more evident in recent years, with larger and more dominant players acquiring smaller participants. However, the market remains highly fragmented. Jain Irrigation, Lindsay, Netafim (controlled by Orbia), Rain Bird, The Toro Company, Valmont are some of dominant players globally in the space.

88 ORBIA.MX is covered by Nikolaj Lippmann

Exhibit 158: Competitive landscape by region

LatAm	North America	Europe	Asia-Pacific	Middle East
ABB Water Meters Inc	ABB Water Meters Inc	ABB Water Meters Inc	ABB Water Meters Inc	ABB Water Meters Inc
AGCO	AGCO	AGCO	AGCO	AGCO
Badger	AquaSpy	Andritz	Andritz	Andritz
Bayer	Badger	Badger	Antelco	Badger
EPC Industries	Banyan Water	Bayer	Badger	EPC Industries
Jain Irrigation Systems	Bayer	CropX	Bayer	Grundfos
John Deere	Scotts Miracle-Gro	EPC Industries	Chinadrip Irrigation	**Jain Irrigation Systems**
Lindsay	Calsense	Grundfos	EPC Industries	**Lindsay**
Nelson Irrigation	Delta-T Devices	Irritec	Grundfos	Nelson Irrigation
Netafim	**Jain Irrigation Systems**	**Jain Irrigation Systems**	**Jain Irrigation Systems**	**Netafim**
Rain Bird	Hunter Industries	**Lindsay**	**Lindsay**	T-L Irrigation
The Toro Company	HydroPoint	Nelson Irrigation	NEC	**Valmont Industries**
Valmont Industries	**Lindsay**	**Netafim**	**Netafim**	Xylem
	NEC	**Rain Bird**	Shanghai Huawei	
	Netafim	Rivulis	**The Toro Company**	
	Orbit	Saturas	**Valmont Industries**	
	Rachio	SupPlant	Xylem	
	Rain Bird	**The Toro Company**		
	Rain Machine	T-L Irrigation		
	Skydrop	**Valmont Industries**		
	The Toro Company	Xylem		
	Valmont Industries			
	Weathermatic			
	Xylem			

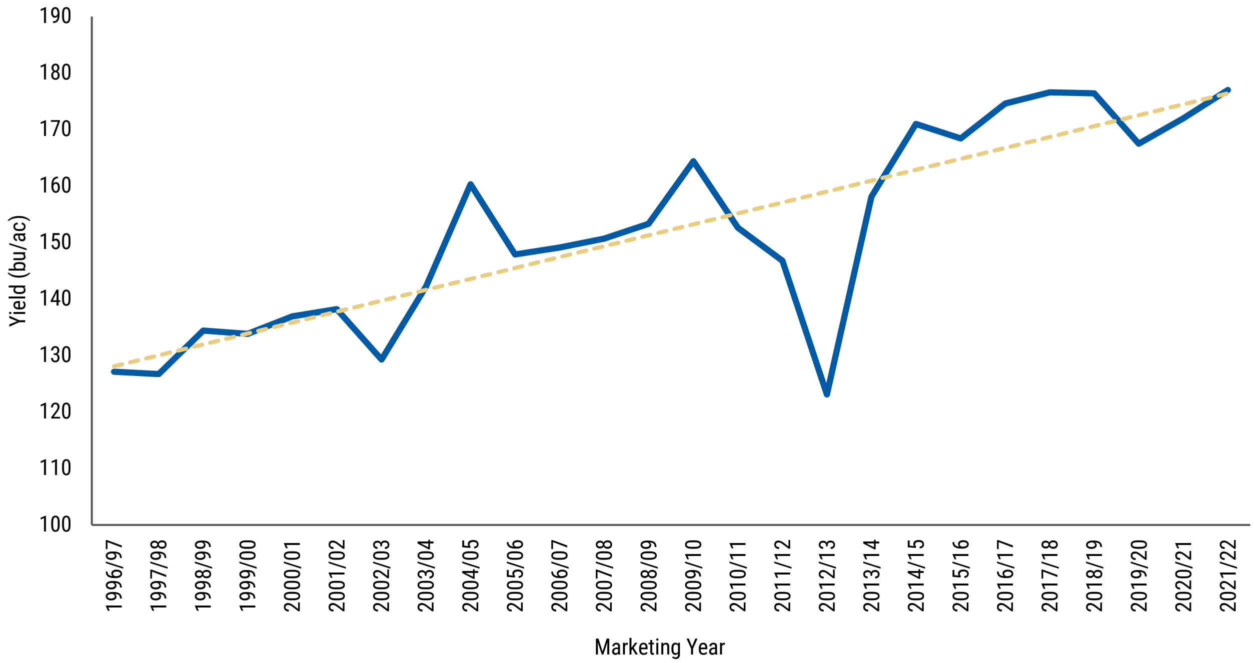
Dominant players

Source: Company filings, Technavio, Morgan Stanley Research

Solution #3: Crop Science

Innovation in seeds has driven material yield enhancements over the last 30 years for both conventional and genetically modified (GM) seeds. Seeds and traits aim to improve agricultural yields, thus helping to produce more food for a growing and increasingly wealthy population. Specific traits and characteristics can be adjusted for intended outcomes, such as optimising water use. For example, 'Scuba Rice' is an enhanced seed that enables the rice crop to withstand flooding, whereas the Sahod Ulan rice variety is designed to be drought-tolerant. We expect crop science companies will continue to make annual improvements in plants' ability to tolerate water stress.

Exhibit 159: Innovation in seeds has helped boost US corn yields (bu/ac by marketing year)



Source: USDA, Morgan Stanley Research

The opportunity for a step change in plant water consumption could come from Bayer's short stature corn, which it is developing through traditional breeding, biotechnology and gene editing approaches. The company tested it in the US corn belt during 2021 and has a beta launch of its traditionally bred VITALA product in Mexico. Short stature corn, as its name would suggest, is shorter than the traditional corn plant but still allows for improved yields versus the traditional corn plant. This is because: i) it has superior production stability in high winds (this was demonstrated in the 2020 derecho wind storm in Iowa and again during the 2021 growing season); ii) it allows for input applications (fertilizer and crop chemicals) far later into the growing season than a traditional height plant; iii) it uses less land and water than the traditional plant, which also allows for greater seed/plant density per acre.

Seed definitions

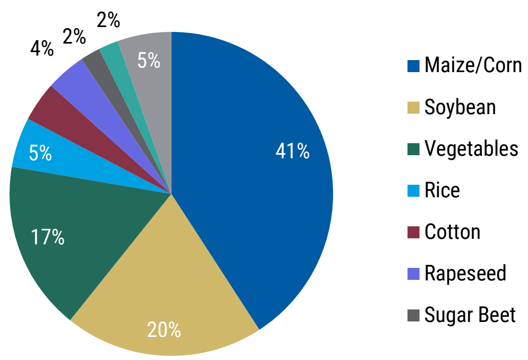
Genetically modified (GM) seeds: Genetic material is altered to enhance certain characteristics and improve tolerance of herbicides, make plants resistant to insects, or increase tolerance to drought, heat or salinity, for example.

Non-GM hybrid seeds: Hybrid seeds are a cross between two or more plants, which results in a seed that carries favourable traits.

Varietal seeds: The OECD Schemes for the Varietal Certification of Seeds has established a set of harmonised procedures for producing seeds.

Exhibit 160: Maize/Corn made up 41% of the global seed market in 2020

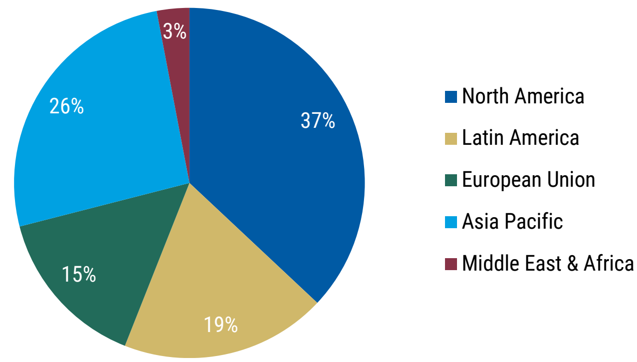
GlobalSeed Market by Crop (2020)



Source: IHS, Morgan Stanley Research

Exhibit 161: North America made up 37% of the global seed market in 2020, followed by Asia Pacific at 26%

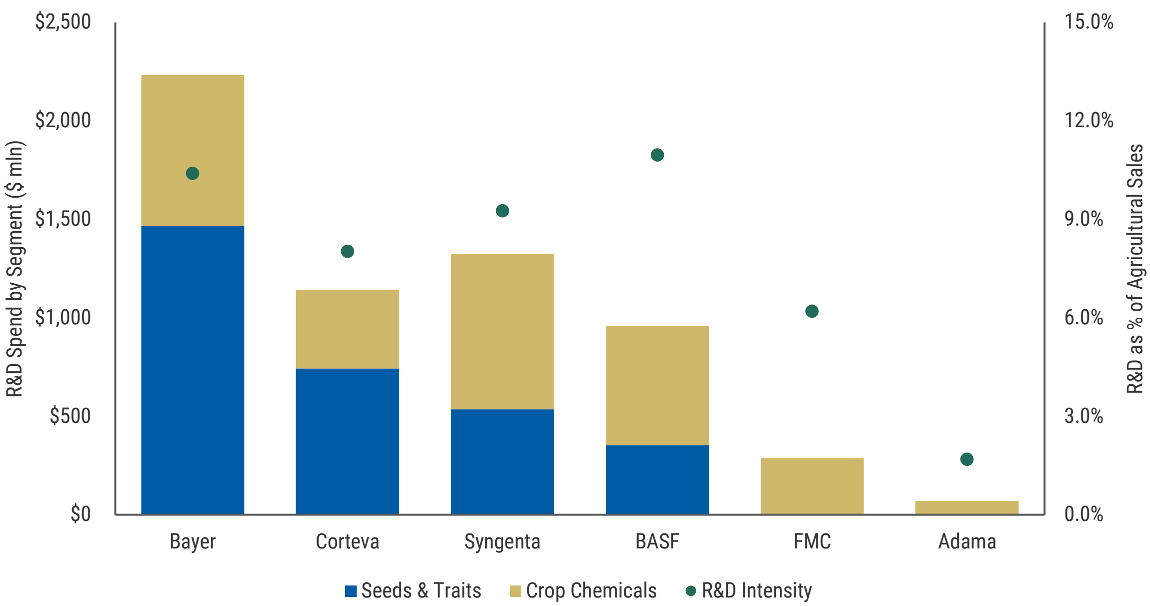
GlobalSeed Market by Geography (2020)



Source: IHS, Morgan Stanley Research

Exhibit 162: Of the largest Ag Chem companies, BASF has the highest R&D expenditure as a % of sales (11%)

2020 R&D Spend



Source: Phillips McDougall, Morgan Stanley Research

Seeds and crop chemistry is naturally a highly R&D-intensive sector, but capex light. Ag Chem companies typically spend between 1% and 11% of sales on R&D (see Exhibit 162), and discovery to product launch can take 10-14 years at a cost of $200-300 million.

GM accounts for one-third of seeds. Genetically modified seed accounts for one-third of seeds. GM foods are made from plants and animals whose genetic material has been altered in some way. Typically this has been done in order to improve crop production – for example, by adding a gene for toxins that kill insects. As such, GM foods are viewed as a solution for the need to produce more food. The US, Brazil and Argentina are the world's biggest producers of GM crops, which are principally corn, soybeans, cotton, canola (oilseed rape) and sugarbeet. Some countries, including Germany, France and Italy, have banned the sale of GM seed.

A number of concerns have been expressed around GM crops, including biodiversity loss, the increased use of chemicals in agriculture, and the risk of the modified gene impacting other non-target organisms. However, we note that GM crop use leads to less crop chemical use, is less expensive than traditional farming methods, and no longer requires farmers to till their land post-harvest (tilling of the soil increases fertiliser and crop chemical run-off, as it brings those molecules to the surface, allowing rain to capture them more easily in run-off).

From a social perspective, some observers have also expressed concern around farmers becoming financially dependent on certain seed products.

The GMO industry is heavily regulated to ensure that genetically modified foods are safe from both an environmental and health perspective.

A new and developing biotechnology is gene editing (or 'CRISPR'). This technique alters or deletes DNA within a species, rather than introducing new DNA from a different species. In 2019, the EU ruled that crops produced using gene editing must be regulated in the same way as other GMOs. So far, there has been limited success, but it is an area to watch going forward.

The overall seed market is forecast to grow at ~6% per year, with the highest growth forecast for non-GM / hybrid seeds.[89]

We view seed innovation as a key solution for producing more sustainable food at scale. Over the last 30 years, the majority of yield growth has come from advances in conventional seed breeding and biotechnology. Investment in R&D continues to improve productivity. For example, Bayer's Short Stature R&D project is developing both GMO and non-GMO corn that could improve plant 'standability' (and thus reduce crop loss), increase the precision of crop protection products, and optimise the use of nitrogen, land and water.

As part of its Farm to Fork strategy, the EU is carrying out a study into the potential of new genomic techniques, and has also committed to facilitate the registration of seed varieties.

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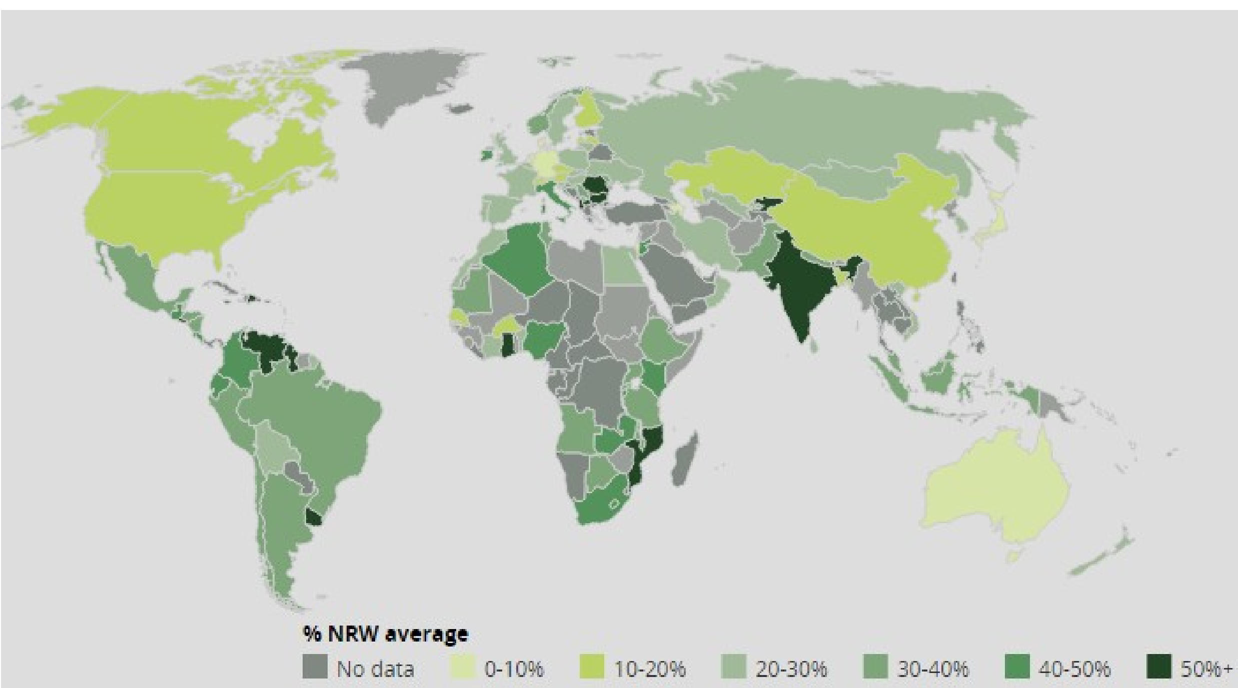
Solution #4: Metering & Digital Solutions

The increased focus on water consumption and resource management will heighten the need for municipalities and utilities to invest in technologies that improve resource transparency and infrastructure efficiency. Upgrading and expanding existing metering infrastructure is a necessary first step. More sophisticated metering and data management offers the opportunity to (i) better understand demand patterns, (ii) reduce water system costs, (iii) manage water budgets via more accurate billing, and (iv) monitor water quality.

Meters allow utilities and users to track resource usage. Water meters, for instance, track the water flow rates and household usage over a given period of time. The metering market is becoming increasingly digitized, with shifts in investment toward smart meters. Advanced Metering Infrastructure (AMI) allows for a network of communicating devices that can relay information to and from utilities. In addition to physical meter units, many meter providers are expanding their product suite to include data management, SaaS and other digital solutions.

Utilities fail to charge for much of the water they provide. The problems with pricing water discussed in an earlier section are directly related to the fact that utilities fail to charge for much of the water provided to customers. There are three typical sources of this "non-revenue water": billing deficiencies, theft and metering inaccuracies, and system loss due to leaks. The first two of these can be addressed by better metering and related solutions. The regulatory process for raising water pricing is often complex, and realized price increases are generally small. Compared to the typical low to mid-single digit tariff increases realized, improving the percentage of service that is actually billed and paid for by end customers can have a material impact. In Exhibit 163 , we show GWI's estimates of non-revenue water globally. While levels are generally low in China, North America, and Australia, in much of the world 20-50% of water service is "non-revenue." Metering offers the opportunity to improve this by providing a more accurate measurement of customer use and identifying the discrepancies between provided service and billed service.

Exhibit 163: The problem of non-revenue water (NRW) is acute – globally, a significant portion of water service ultimately goes unbilled



Source: GWI

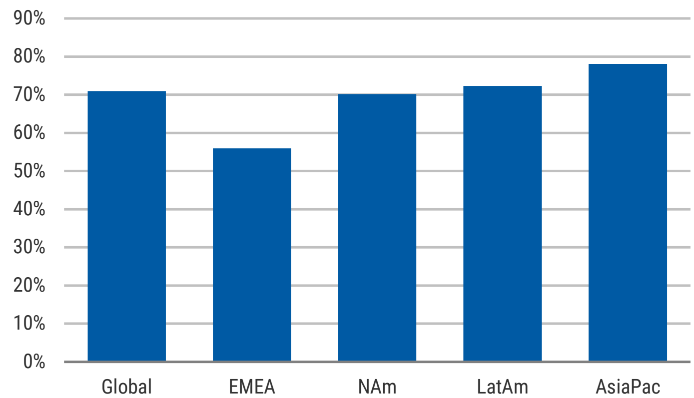
The installed base of metering infrastructure only covers ~70% of water supply globally. Although we would not view full coverage as a reasonable or necessary target, we do anticipate the need to increase metering coverage, especially in regions of high population growth or water scarcity. Geographically, EMEA has the lowest connection coverage (~45% of water supply is unconnected to metering), while Asia Pacific has the highest, at ~80%. Incremental adoption could be a powerful driver of growth in the industry – just to bring EMEA into line with global averages would imply a ~25% increase in metering coverage.

Communicating meter technology is a critical first step towards more efficient water management. Communicating meters are equipped with some form of radio transmission device, which helps utilities to track demand in real-time (or at least closer to real-time than a manual meter reading by a technician in a person's home). However, this technology is still less than 20% of the global installed base. North America, which accounts for ~10% of global meters, is the only region with over 50% penetration. Across the remaining regions (~90% of installed base), ~85% of installed meters are non-communicating. We recognize that in many locations, basic water meters are more than capable of meeting utility needs. However, we believe that in many locations, the advantages of communicating meters will help shift demand for both replacement meters and new installations going forward, driving a conservative amount of upgrading towards newer metering technology across the installed base.

In addition, the back-end digital solutions that manage data produced by meters are becoming increasingly important as water infrastructure solutions. While these offerings are in an earlier phase of adoption, they offer an efficient solution for utility companies looking to leverage data generated throughout their respective networks. Solutions include data management and analytics, demand forecasting, leak detection, water analysis and network optimization tools. We expect these software-based tools to become an increasingly important part of the solutions adopted by utilities to solve the non-revenue water problem.

Exhibit 164: Globally, only ~70% of water supply is connected to a meter

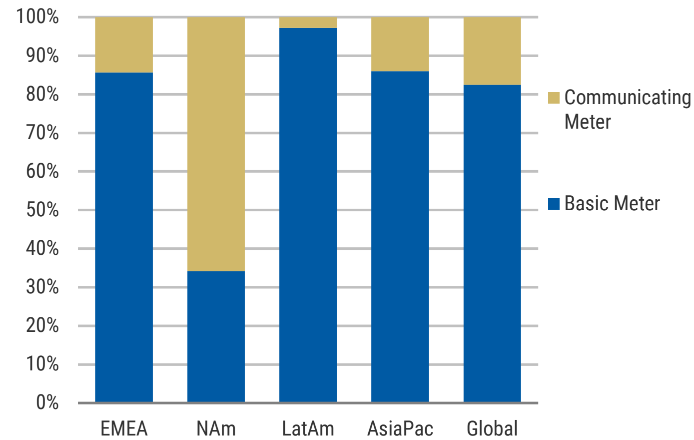
Water Supply Connected to Meters (%) - 2020



Source: Omdia, Morgan Stanley Research

Exhibit 165: The penetration of communicating meters varies by region, with North America leading by a wide margin

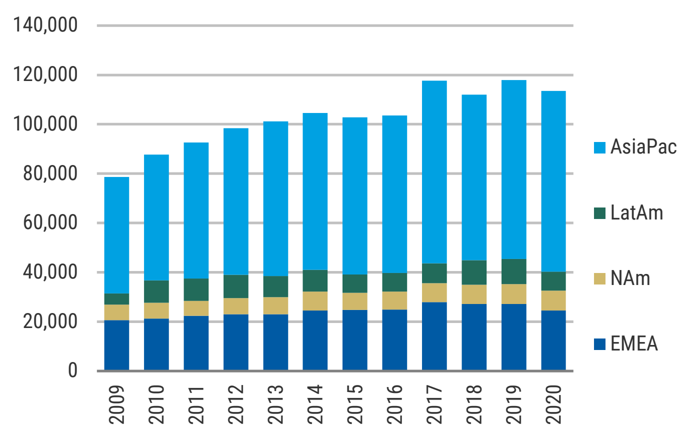
Global Installed Base 2020



Source: Omdia, Morgan Stanley Research

Exhibit 166: Meter demand has grown at an average ~3.5% a year since 2009, largely driven by Asia Pacific

Total Meters Shipped (thousands)



Source: Omdia, Morgan Stanley Research

Solution #5: Vertical Farming

Vertical farming technologies can enable water savings of between 80-95% when compared with traditional agriculture. Vertical Farming is a resource-efficient approach to growing certain types of food produce. It requires a controlled, indoor environment with crops typically grown on a series of stacked layers. This new technology-enabled farming means crops can be grown reliably, supply chains secured, with a materially higher yield per vertical layer than in conventional field farming.

Through vertical farming techniques, the optimum growing environment can be achieved for food crops, all year round. A synthetic light source (horticultural LEDs) is used in replacement of sunlight, but without supply restrictions. In theory, this light source can be switched on all day, every day, if the crops require it – an advantage over sunlight. Horticultural specialists design a light spectrum recipe specific to the crop in question, which can be altered throughout its life-cycle to optimise yield, taste and quality, synthetically providing the crops with what they need. This results in significant crop yield gains and growth cycle reduction.

Temperature can also be maintained to provide a year-round Spanish summer to an indoor farm located in Northern Scandinavia, which would typically suffer from harsh winters, or in harsh heat environments such as the Middle East where local food supply of fresh fruit and vegetables can be limited.

Importantly, vertical farming enables significant water savings compared with traditional agricultural (between 80% and 95% depending on the technology used). Over half of indoor farming revenues are now considered to be driven by vertical farms, while 41% derive from soil-based indoor farms (e.g. traditional greenhouses) – see Exhibit 167 . The three key types of vertical farming technologies, which we explore below, all provide material water savings.

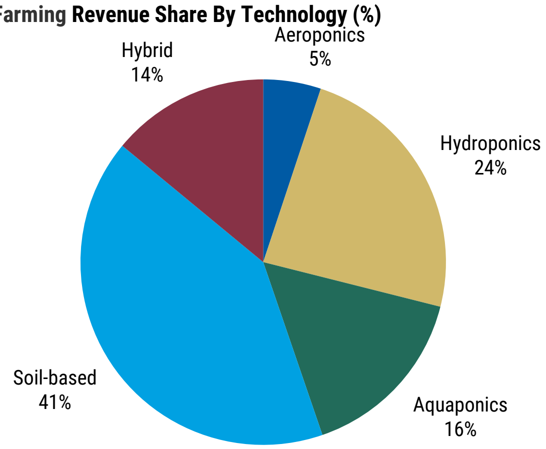
#1 Hydroponic (24% of the indoor farming market) – 80% water savings versus conventional farming. This growing technique does not rely on soil for cultivating plants (nor does it require pesticides). Instead, plants are grown in mineral nutrient solutions in an aqueous solvent. According to BrightFarms, this growing method requires 80% less water than conventional farming.

#2 Aquaponic (16% of the indoor farming market) – 95% water savings versus conventional farming. Aquaponics makes use of both aquaculture (raising aquatic animals in controlled tanks) and hydroponics (see above). Simply put, the fish produce waste, which is then mixed with the right organisms (such as microbes and worms) to be converted into fertilizers for the plants. These plants filter the water, which is returned back to the fish. Garden Fresh Farms estimates that this growing technique reduces water usage by 95% compared with traditional farming. Some Aquaponic systems are able to provide pesticide-free and non-GMO products.

#3 Aeroponic (5% of the indoor farming market) – 95% water savings vs traditional farming. This is the process of growing plants in an air/mist environment without the use of soil or an equivalent medium. This growing technique is primarily used for growing leafy vegetables. Aeroponics offers water savings of 95% versus traditional farming, according to Aerofarms. That said, this technology still represents a small fraction of the overall market at 5% (see Exhibit 167). We think this is less common because a) the technology is less proven and so carries greater risk to adoption; b) the technology entails additional expense versus hydroponics; c) potential execution risks – if the mist supply is temporarily cut, the crops are prone to drying out more quickly than hydroponic methods, where crops typically sit in water. That said, this technology is expected to see the highest growth among indoor farming technologies over the next 5 years (albeit from a smaller base) – see Exhibit 168 .

Exhibit 167: Hydroponic technologies are currently the most common form of vertical farming technologies, followed by aquaponics

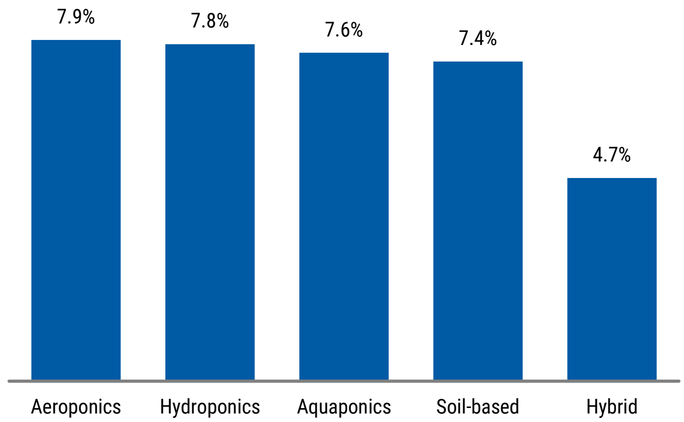
Indoor Farming Revenue Share By Technology (%)



Source: Mordor Intelligence

Exhibit 168: Starting from a small base, aeroponics is expected to see the highest growth in 2021-2026 (7.9% CAGR)

Market Growth - CAGR (2021-2026)



Source: Mordor Intelligence

In addition, there are other environmental and social attributes associated with vertical farming. Beyond the water and pesticide savings that we highlight above, vertical farming offers the following benefits:

- **Additional shelf life**. Localised growing adds 1-3 days to produce shelf life, as transportation time to the consumer is cut. In addition, shelf life is typically extended as the local vertical-farmed food does not endure temperature volatility and mishandling in transportation. There is potential to co-locate food distribution centres and vertical farms to optimise food distribution, and consequently we are seeing an increasing number of food retailers interested in this space.
- **Maximizes yields**. Indoor farming techniques provide productivity gains over traditional field farming. Estimates on the yield uplift vary, but a 2013 study by Chirantan Banerjee and Lucie Adenaeuer noted a yield 516 times more than expected from a quarter hectare footprint, due to stacking and multiple harvests. Vertical farms are often using 5-12 vertical layers, positioned to provide enough growing space for crops, maintaining ventilation and air circulation while also increasing yield.
- **Reduces land usage**. Crops are grown vertically in a stacked formation rather than grown horizontally.
- **Resistant to challenges posed by climate change**. Given that crops are grown indoors, they are less exposed to increasingly frequent and extreme weather events (such as droughts and flooding).
- **Reduced emissions**. Growing the food closer to the consumer (e.g. by building vertical farms on distribution centres) can materially reduce emissions, both by cutting the transportation miles and by reducing the need for refrigerated storage.

To date, the focus has been on growing leafy greens, herbs and microgreens ... Although in theory almost all crops could be grown in a vertical farm environment, the decision around what to grow ultimately depends on turnover time, plant density and the price of the crop. Leafy greens (such as arugula, bok choy, romaine, kale, spinach, lettuce) are typically very quick to grow (meaning more product can be sold each year) and tend to have strong demand throughout the year, making them an attractive proposition to indoor farmers. Similarly, herbs are 'fast-turn' crops, meaning many vertical farms also grow these (in particular, cilantro, basil, thyme and parsley are popular choices). Microgreens too have a quick turnaround (even faster than leafy greens), can be grown densely and have a higher price per kilo.

... but this is starting to change. Examples of new crops emerging from vertical farms include soft fruits. For example, Plenty has announced a joint development with Driscoll (a California-based seller of fresh strawberries and other berries) to grow Driscoll's proprietary flavorful strawberries year-round in Plenty's vertical indoor farms. These will be delivered to a variety of regions, including those where year-round strawberry cultivation isn't possible. Elsewhere, Infarm has previously stated an interest in entering the mushroom, tomato and chilli markets, while Kalera is in the discovery phase for peas, quinoa and cucumbers. Guy Galonska (founder of Infarm) told Bloomberg in March 2021, "The idea is that in the mid term, we're going to cultivate the entire fruit and vegetable basket".[90]

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Solution Stocks

Exhibit 169: We highlight 78 companies that are solution providers for at least one of the following areas: Desalination, Seeds, Smart Irrigation, Metering & Digital Solutions, Vertical/Indoor farming and Broader Water Infrastructure/Other

Ticker	Company	Mkt Cap USDmn	Stock Price		Rating	Analyst	Region	Revenue Exposure To Water (%)
Desalination								
ABG.MC	Abengoa SA	150	0.02	EUR	NC	NC	Europe	<5%
ANA.MC	Acciona SA	9,261	148	EUR	NC	NC	Europe	<5%
APBS.OM	ACWA Power Barka SAOG	199	0.48	OMR	NC	NC	EMEA	43%
ANDR.VI	Andritz AG	5,585	47	EUR	Overweight	Davies, Robert	Europe	<5%
0371.HK	Beijing Enterprises Water Group Ltd	3,957	3	HKD	Equal-Weight	Hou, Eva	Asia/Pacific	100%
034020.KS	Doosan Heavy Industries & Construction Co Lt	8,746	17,450	KRW	NC	NC	Asia/Pacific	13%
7004.T	Hitachi Zosen Corp	1,099	786	JPY	NC	NC	Asia/Pacific	30%
6303.T	Sasakura Engineering Co Ltd	65	2,410	JPY	NC	NC	Asia/Pacific	32%
2727.HK	Shanghai Electric Group Co Ltd	9,663	2	HKD	Underweight	Hou, Eva	Asia/Pacific	<5%
VATE.NS	Va Tech Wabag Ltd	260	312	INR	NC	NC	Asia/Pacific	100%
VIE.PA	Veolia Environnement SA	25,669	32	EUR	++	Sitbon, Arthur	Europe	42%
Smart Irrigation								
ABBN.S	Abb Ltd	71,175	32	CHF	Underweight	Uglow, Ben	Europe	<5%
AGCO.N	AGCO Corp	8,663	116	USD	Overweight	Yakavonis, Courtney	North America	<5%
ANDR.VI	Andritz AG	5,585	47	EUR	Overweight	Davies, Robert	Europe	<5%
BAYGn.DE	Bayer AG	59,699	53	EUR	Overweight	Quigley, James	Europe	<5%
DE.N	Deere & Co	114,711	372	USD	Overweight	Yakavonis, Courtney	North America	<5%
JAIR.NS	Jain Irrigation Systems Ltd	298	42	INR	NC	NC	Asia/Pacific	65%
LNN	Lindsay Corp	1,371	125	USD	NC	NC	North America	10%
6701.T	NEC Corp	12,032	5,090	JPY	Equal-Weight	Segawa, Hiroto	Japan	<5%
ORBIA.MX	Orbia Advance Corporation SAB de CV	4,769	49	MXN	Overweight	Lippmann, Nikolaj	Latin America	15%
VMI	Valmont Industries Inc	4,449	210	USD	NC	NC	North America	<5%
XYL.N	Xylem Inc	16,132	89	USD	Overweight	Lynagh, Connor	North America	100%
Crop Science								
BAYGn.DE	Bayer AG	59,699	53	EUR	Overweight	Quigley, James	Europe	<5%
BIOX.O	Bioceres Crop Solutions Corp	499	12	USD	NC	NC	Latin America	<5%
CTVA.N	Corteva Inc	36,117	50	USD	Overweight	Andrews, Vincent	North America	<5%
KWSG.DE	KWS SAAT SE & Co KgaA	2,549	68	EUR	NC	NC	Europe	<5%
Metering & Digital Solutions								
BMI.N	Badger Meter Inc	2,912	100	USD	Underweight	Lynagh, Connor	North America	90%-95%
IEX.N	IDEX Corp	15,053	198	USD	Overweight	Lynagh, Connor	North America	10%
ITRI.O	Itron Inc	2,600	57	USD	Equal-Weight	Lynagh, Connor	North America	25%
LANDI.S	Landis+Gyr Group AG	1,898	61	CHF	Underweight	Uglow, Ben	Europe	<5%
9551.T	Metawater Co Ltd	837	2,010	JPY	NC	NC	Asia/Pacific	100%
MWA	Mueller Water Products Inc	2,044	13	USD	NC	NC	North America	<5%
ROP.N	Roper Technologies Inc	46,753	443	USD	NC	NC	North America	5%
TDY.N	Teledyne Technologies Inc	19,683	422	USD	Underweight	Liwag, Kristine	North America	35%
XYL.N	Xylem Inc	16,132	89	USD	Overweight	Lynagh, Connor	North America	100%
Vertical/Indoor Farming								
APPH.O	AppHarvest Inc	309	3	USD	NC	NC	North America	100%
CUB.TO	CubicFarm Systems Corp	159	1	CAD	NC	NC	North America	100%
KALK.OL	Kalera AS	156	7	NOK	NC	NC	Europe	100%
Broader Water Infrastructure & Solutions								
AALB.AS	Aalberts NV	6,774	54	EUR	Equal-Weight	Calderon Tejedor, Aurelio	Europe	<5%
AWR	American States Water Co	3,283	89	USD	NC	NC	North America	92%
AOS	A O Smith Corp	11,756	74	USD	NC	NC	North America	100%
WMS.N	Advanced Drainage Systems Inc	8,067	112	USD	Equal-Weight	Pokrzywinski, Joshua	North America	100%
ALFA.ST	Alfa Laval AB	13,491	294	SEK	Underweight	Davies, Robert	Europe	<5%
AWK	American Water Works Company Inc	28,215	155	USD	NC	NC	North America	100%
CWT	California Water Service Group	3,128	59	USD	NC	NC	North America	100%
0855.HK	China Water Affairs Group Ltd	1,995	10	HKD	NC	NC	Asia/Pacific	93%
SBSP3.SA	Companhia de Saneamento Basico do Estado	4,568	36	BRL	Equal-Weight	Rodrigues, Miguel	Latin America	56%
DHR	Danaher Corp	203,762	285	USD	NC	NC	North America	10%
ECL.N	Ecolab Inc	53,499	187	USD	Equal-Weight	Andrews, Vincent	North America	<5%
ERII.O	Energy Recovery Inc	1,058	19	USD	NC	NC	North America	77%
WTRG.K	Essential Utilities Inc	11,876	47	USD	NC	NC	North America	96%
AQUA.K	Evoqua Water Technologies Corp	5,142	43	USD	NC	NC	North America	58%
FERG.L	Ferguson PLC	33,219	11,190	GBp	Equal-Weight	Vermeulen, Annelies	Europe	<5%
FELE.O	Franklin Electric Co Inc	3,877	84	USD	NC	NC	North America	59%
GEBN.S	Geberit AG	23,516	607	CHF	Underweight	Ekblom, Cedar	Europe	20%
GENG.L	Genuit Group PLC	1,830	545	GBp	NC	NC	Europe	85%
FIN.S	Georg Fischer AG	5,641	1,271	CHF	NC	NC	Europe	54%
0270.HK	Guangdong Investment Ltd	9,134	11	HKD	NC	NC	Asia/Pacific	57%
HLMA.L	Halma PLC	12,409	2,416	GBp	NC	NC	Europe	5%
IR.N	Ingersoll Rand Inc	22,242	55	USD	Overweight	Pokrzywinski, Joshua	North America	<5%
6370.T	Kurita Water Industries Ltd	4,806	4,715	JPY	NC	NC	Asia/Pacific	100%
LIN.N	Linde PLC	151,957	296	USD	Overweight	Andrews, Vincent	North America	<5%
NZYMb.CO	Novozymes A/S	14,351	409	DKK	NC	NC	Europe	<5%
MSEX.O	Middlesex Water Co	1,701	97	USD	NC	NC	North America	100%
6368.T	Organo Corp	780	7,720	JPY	NC	NC	Asia/Pacific	82%
PNN.L	Pennon Group PLC	3,792	1,042	GBp	Equal-Weight	Laybutt, Christopher	Europe	100%
PNR.N	Pentair PLC	9,954	60	USD	Underweight	Pokrzywinski, Joshua	North America	34%
PKI	PerkinElmer Inc	23,030	182	USD	NC	NC	North America	30%
PRMW.TO	Primo Water Corp	2,593	20	CAD	NC	NC	North America	100%
ROR.L	Rotork PLC	3,895	335	GBp	Overweight	Davies, Robert	Europe	13%
SVT.L	Severn Trent PLC	9,464	2,795	GBp	Overweight	Laybutt, Christopher	Europe	100%
SJW	SJW Group	1,971	66	USD	NC	NC	North America	99%
STN.TO	Stantec Inc	5,889	67	CAD	NC	NC	North America	5%
SUN.S	Sulzer AG	3,085	83	CHF	Equal-Weight	Calderon Tejedor, Aurelio	Europe	13%
TTEK.O	Tetra Tech Inc	7,904	146	USD	NC	NC	North America	6%
UU.L	United Utilities Group PLC	9,525	1,033	GBp	Underweight	Laybutt, Christopher	Europe	100%
UPONOR.HE	Uponor Oyj	1,652	20	EUR	NC	NC	Europe	77%
WTS	Watts Water Technologies Inc	5,050	150	USD	NC	NC	North America	13%
WBSV.VI	Wienerberger AG	4,100	31	EUR	Equal-Weight	Ekblom, Cedar	Europe	10%
YORW.O	York Water Co	567	43	USD	NC	NC	North America	100%
ZWS	Zurn Water Solutions Corp	3,764	30	USD	NC	NC	North America	<5%

Prices as at 08 Feb, 2022. NC = Not covered by Morgan Stanley, NA = Not applicable. ++ Stock Rating, Price Target, or Estimates for this company have been removed from consideration in this report because, under applicable law and/or Morgan Stanley policy, Morgan Stanley may be precluded from issuing such information with respect to this company at this time. Source: ISS, GWI, Morgan Stanley Research. Source: ISS, GWI, Morgan Stanley Research

Below we list companies with revenue exposure to the technology solutions we have explored in the previous sections, as well as those with exposure to the broader water investment theme. We include public and private companies. Note that our Solution stocks list presented in Exhibit 169 is not a trading or model portfolio of recommended equity securities, but a selected list of companies that are exposed to the water investment theme.

Desalination

Public companies

Acciona (ANA.MC, not covered). Acciona is a multinational conglomerate dedicated to the development and management of infrastructure and renewable energy. As part of its construction arm, the company offers solutions in RO (reverse osmosis) desalination, and has built desalination plants capable of treating about 5 million m^3/day, sufficient to supply a population of about 25 million people.

Andritz (ANDR.VI, covered by Robert Davies). Andritz is a leading supplier of plant, equipment, systems and services for hydropower stations, the pulp and paper industry, the metalworking and steel industries, and solid/liquid separation in the municipal and industrial sectors as well as for animal feed and biomass pelleting. The company provides pump solutions for desalination, wedge wire and perforation solutions and brine solution for desalination plants.

Beijing Enterprises Water Group Ltd (0371.HK, covered by Eva Hou). Beijing Enterprises Water Group Limited is an investment holding company principally engaged in water across three segments: Sewage and Reclaimed Water Treatment and Construction Services, Water Distribution Services, and Technical and Consultancy Services. As part of this offering, the company helps construct seawater desalination plants.

Doosan Heavy Industries (034020.KS, not covered). Doosan Heavy Industries is a leading thermal desalination specialist with a strong position in the MENA region, especially Saudi Arabia. Doosan is an EPC (engineering, procurement and construction) contractor with businesses covering all desalination technologies, including MED (Multiple Effect Distillation), MSF (Multi-Stage Flash distillation) and RO (Desalination by Reverse Osmosis), as well as hybrid plants. Its water business (which generated 18% of revenues in 2019, according to GWI) operates across seawater desalination, municipal, and industrial water & wastewater treatment markets. Doosan's acquisition of Enpure Limited in 2012 brought exposure to biological treatment, media filtration, flotation and anaerobic digestion.

Hitachi Zosen (7004.T, not covered). Hitachi Zosen is an industrial EPC (engineering, procurement and construction) contractor of large water and wastewater treatment plants. The company focuses on delivering desalination plants primarily in the Middle East and Japan. As part of the IWPP (Independent Water and Power Project) in Qatar, the company is constructing a hybrid desalination facility featuring multi-stage flash and reverse osmosis technology. GWI estimates that 30% of revenues are derived from its water business (2020).

Sasakura Engineering (6303.T, not covered). Sasakura Engineering is engaged in research and development of marine equipment, desalination plants, air-cooled heat exchangers and other environmental protection devices. Its technologies can be used by a range of sectors, such as municipal plants and offshore units for industrial wastewater and landfill leachate treatment. GWI estimates that 32% of revenues are derived from its water business (2021).

Shanghai Electric Power Generation Group (2727.HK, covered by Eva Hou). Shanghai Electric is a major Chinese electricity provider, but the company also has expertise in thermal and membrane desalination plants in its domestic market. In addition, the company has MED (Multiple Effect Distillation) systems for industrial complexes in Brunei and Yemen.

VA Tech Wabag (VATE.NS, not covered). According to GWI, Wabag is the largest water and wastewater engineering, procurement, and construction (EPC) contractor in India. The company has expertise in operation and maintenance and project development and also in the municipal, desalination and heavy industry sectors. The Chennai Nemmelli seawater desalination plant is an example of a project the company has been involved in. GWI estimates that 100% of revenues are derived from its water business.

Veolia (VIE.PA, covered by Arthur Sitbon). Veolia Water Technologies is a subsidiary of Veolia and has a range of over 350 proprietary technologies for serving the water and wastewater sectors. This is in addition to the company's EPC (engineering, procurement, and construction) segment. GWI estimates that 42% of revenues are derived from its water business.

Private companies

Aqua-Chem – Aqua-Chem has a footprint in industrial water treatment, including technologies such as reverse osmosis, electrodeionisation and vapour compression distillation. Originally, the company entered the water industry by designing mobile distillation units for the US military. GWI estimates that 100% of revenues are derived from its water business.

AquaSwiss – The company provides solutions such as desalination and zero liquid discharge systems on an EPC (engineering, procurement, and construction), O&M (operation & maintenance) and BOT (build operate transfer) / BOO (build own operate) basis. The company expanded its capabilities when it acquired exclusive rights to use IDE's desalination technologies in selected jurisdictions in the Middle East, Southeast Asia and North Africa.

Aquatech International – Aquatech is a leader in water purification systems and wastewater treatment technology for industrial and infrastructure markets. The company focuses on desalination, reuse and zero liquid discharge, which includes modular and mobile solutions for produced water treatment.

Arvind Envisol – Arvind Envisol is a subsidiary of Arvind Ltd (an Indian textile company, ticker ARVN.NS). Areas of expertise include proprietary polymeric film-coated evaporators.

Condorchem Envitech – Condorchem Envitech is a technology solutions provider for industrial wastewater treatment and air emission treatment. For the water industry specifically, the company offers solutions for water pre-treatment, the production of ultrapure water (purification) and water supply. In addition, the company provides zero liquid discharge and biological wastewater treatment services.

Demont – Demont gained exposure to the thermal desalination business with the acquisition of Reggiane Desalination Plants and Sowit/ Aster in 2012.

Doosan Heavy Industries – Doosan Heavy Industries operates within the power plant and desalination business segments. For water specifically, it provides water solutions as an EPC (engineering, procurement and construction) contractor, responsible for the entire process from design through procurement and commissioning for desalination and water treatment plants.

EvCon – EvCon has created a patented Vacuum Multi Effect Membrane Distillation (VMEMD) water solution. The company's UPWaterSystem technology produces pure and ultrapure water, predominately for the pharmaceutical industry. The company also provides planning, building, commissioning & implementation services for ultrapure water production and desalination facilities.

Fan Niroo – Fan Niroo is a contractor and technology supplier. It designs, manufactures, installs and commissions multi-effect distillation (MED) systems. Fan Niroo's technology solution offering includes NF (nanofiltration), RO (reverse osmosis), UF (ultrafiltration), EDI (Electrodeionization)/IX, and MBR (Membrane bioreactor technology) systems.

Fisia Italimpianti – Fisia Italimpianti is an EPC (engineering, procurement and construction) contractor specialising in the design and execution of water treatment and desalination plants. Historically, the company has specialised in multi-stage flash (MSF) but the company shifted its strategy, owing to a market trend towards the use of membranes. As at 2018, the company had completed projects with a total treatment capacity of 6,000,000 m3/d of water. GWI estimates that 100% of revenues are derived from its water business.

IDE Technologies – IDE offers solutions in the development, engineering, construction and operation of sea and brackish water desalination facilities, industrial water treatment and water reuse plants. GWI estimates that 100% of revenues are derived from its water business.

MECO – MECO provides solutions in the engineering and manufacturing of water purification solutions for industrial, pharmaceutical, oil and gas, military, and food and beverage companies. The company's products use reverse osmosis, ion exchange, distillation, and ultrafiltration technologies for ultrapure water production.

Metito – Metito is a UAE-based company with a strong presence in the Middle East and Northern Africa. It specializes in reverse osmosis of both seawater and brackish water. According to its website, it was the first company to introduce RO technology outside of the US in 1972, and it has led the development of mega RO plants in the Middle East. Its product range includes antiscalants, cleaners, biocides and pre-treatment, as well as solutions for thermal plants.

Zhonghe Seawater Desalination Engineering – Zhonghe Seawater Desalination Engineering is a contractor involved in the design and build of brackish and seawater desalination projects. The company has its own proprietary multiple effect distillation (MED) technology.

Smart Irrigation

Public companies

ABB (ABBN.S, covered by Ben Uglow). The company manufactures digital water meters and management systems in drought-prone regions, as part of its ABB Business Unit Metering. ABB has designed automated flowmeters that can be monitored from a central control room and can measure every drop accurately.

AGCO Corp (AGCO.K, covered by Courtney Yakavonis). AGCO Corporation is a manufacturer and distributor of agricultural equipment and related replacement parts. The company sells a range of agricultural equipment, including precision agriculture projects, which help reduce water consumption/waste, among other benefits.

Andritz (ANDR.VI, covered by Robert Davies). Andritz is a leading supplier of plant, equipment, systems and services for hydropower stations, the pulp and paper industry, the metalworking and steel industries, and solid/liquid separation in the municipal and industrial sectors as well as for animal feed and biomass pelleting. As part of its Hydro business, Andritz supplies pumps for irrigation, water supply and flood control.

Bayer AG (BAYGn.DE, covered by James Quigley). The company has developed FieldView, a software and application hub that provides real-time data on climate patterns, soil and irrigation conditions. The software is monitored by Bayer-Monsanto's owned in-field sensors, meters and satellites. The tool also offers a subscription to the central agricultural data hub.

Deere & Co (DE.N, covered by Courtney Yakavonis). Deere & Company is engaged in equipment operations and financial services within the Agriculture and Construction equipment markets. The company operates through three business segments: agriculture and turf, construction and forestry, and financial services. The company offers solutions within the drip irrigation space. For example, in 2008 it acquired T-Systems International, a leader in the agricultural irrigation market, offering drip irrigation systems, moisture management systems, crop management equipment and other related solutions.

Jain Irrigation Systems (JAIR.NS, not covered). Jain Irrigation Systems Limited is an agri-business company operating across a range of segments, including Hi-Tech Agri Input Products, Industrial Products and Non-conventional Energy. The High-Tech Agri Input Products segment consists of micro and sprinkler irrigation systems, polyvinyl chloride (PVC) pipes, tissue culture and other agri inputs. It is one of the leading micro-irrigation players globally and offers a wide range of precision-irrigation products as well as services such as soil surveys, engineering design and agronomic support. The company runs a 2,300 acre Hi-Tech Agri Institute; a Farm Resource R&D, Demo, Training & Extension Centre. It also undertakes turnkey projects for agricultural and irrigation development.

Lindsay (LNN, not covered). Lindsay Corporation, along with its subsidiaries, offers a selection of water management and road infrastructure products and services. The company operates primarily through two key segments: irrigation and infrastructure. Lindsay's irrigation segment includes the manufacture and marketing of center pivot, lateral move, and hose reel irrigation systems, primarily used in the agricultural industry.

NEC (6701.T, covered by Hiroto Segawa). NEC is a leading player in the IT service market in Japan, offering system integration services, mainly to government agencies. In collaboration with Dacom and Kagome, NEC has developed environmental sensors and big data analytics software to maximize crop yields. The company's smart farming management division aims to innovate in digital agriculture with its CropScope solution as well as its Crop Decision Support System.

Netafim (owned by publicly listed Orbia, covered by Nikolaj Lippmann). Netafim is a precision irrigation company (80% owned by Orbia). It manufactures irrigation equipment and provides irrigation system services as well as digital agricultural technologies aimed at improving crop yields while using less water and fertilizer. Products include drippers, driplines, sprinklers and micro-sprinklers, special emitters, valves and water meters.

Valmont Industries (VMI, not covered). Valmont Industries, Inc offers products and services within the infrastructure and agriculture markets. The company operates primarily through four segments: The Engineered Support Structures (ESS), Utility Support Structures (Utility), Coatings, and Irrigation. Its Irrigation segment manufactures agricultural irrigation equipment, parts, services, tubular products, water management solutions, and technology for precision agriculture.

Xylem (XYL, covered by Connor Lynagh). Xylem designs, manufactures, and services engineered solutions across the water cycle, including collection, distribution, use, and return of water to the environment. Xylem's products include water and wastewater pumps, treating and testing equipment, industrial pumps, valves, heat exchangers, and dispensing equipment.

Private companies

Antelco – Antelco provides solutions for high quality, low volume, micro-irrigation products for efficient water distribution. Its product offering includes drippers, sprays, sprinklers, recycled water systems, fittings, valves and accessories.

AquaSpy – AquaSpy's ag-tech solutions monitor soil moisture, to give live updates on plant health. This enables customers to make informed choices about when/how to water and fertilize crops.

Banyan Water – Banyan Water provides management software and services for all businesses. This enables customers to reduce water spend, prevent leaks and easily access data for portfolio wide water system improvements.

Calsense – Calsense offers a range of products (such as irrigation controllers), which enable its customers to conserve water, manage labour and save money.

Chinadrip Irrigation – The company is an irrigation system manufacturer and supplier based in China. It supplies a wide range of irrigation products to over 60 countries worldwide, including micro-sprinkler systems, drip tape irrigation line systems, filter systems, fertilizer systems, tubing and fittings.

CropX – CropX is an ag-analytics company that develops cloud-based software solutions integrated with wireless sensors, designed to boost crops yields and save water and energy. Its product offering includes advanced adaptive irrigation software services, designed to increase crop yields, and water and energy cost saving services. The company also generates irrigation maps to automatically apply the right amount of water to different areas of a field. Its soil sensors can increase crop yields while simultaneously cutting water usage by a third.

Delta-T Devices – Delta-T Devices provide sensors and loggers for environmental science. The company specialises in soil moisture, agronomy, solar energy, meteorology and horticulture and irrigation. For example, the company provides instruments to measure growing conditions and provide critical data to support watering decisions.

EPC Industries – Mahindra EPC is a Mahindra group company also known as "EPC Irrigation Limited". The company is a pioneer of micro-irrigation in India, providing complete solutions for agriculture with a focus on micro-irrigation, pumps and inter-related requirements for fertigation and agronomic support.

Grundfos – Grundfos is a water technology company offering a range of solutions including high-efficiency pumping solutions that work with modern irrigation systems for agricultural and non-agricultural applications.

Hunter Industries – Hunter Industries is a manufacturer of irrigation and outdoor lighting equipment, amongst other products, for the landscaping, residential, commercial, agricultural, and golf course industries.

HydroPoint – HydroPoint Data Systems provides landscape irrigation efficiency as well as advanced monitoring and reporting to show effective savings and a projected ROI, using sensor data analytics.

Irritec – Irritec's core business is around implementing efficient solutions for the optimization of water resources and manufacturing processes in the irrigation sector. The company designs, manufactures and sells innovative irrigation products for maximum water efficiency.

Manna Irrigation – Based upon its proprietary satellite models and sensor-free approach, the company provides growers with a high-resolution, integrated view of the entire field rather than readings from isolated disparate locations. This data enables growers to make "smart decisions" on water irrigation.

Nelson Irrigation – The company is an irrigation equipment manufacturer offering solutions across mechanized irrigation, high volume, field crop, tree & vine and nursery irrigation along with automation and control systems.

Orbit Irrigation Products LLC – The company developed the B-hyve ecosystem of smart technology products for retail watering. It provides the B-hyve smart flood sensor, B-hyve smart indoor/outdoor irrigation controller and B-hyve smart house watering timer. It offers products in various categories such as drip irrigation, sprinklers, controllers for landscape watering, and connected home.

Rachio – Rachio is a software and hardware company focused on improving the water efficiency of homes. For example, the company's Smart Controller enables the control of an outdoor sprinkler system from an app. The company's cloud-based software allows customers to manage their sprinkler systems remotely.

Rain Bird – Rain Bird Corporation is a manufacturer and provider of irrigation products and services for landscapes, golf courses, sports fields, and agriculture, which are designed to minimize water consumption.

Rain Machine – Rain Machine offers a range of solutions that enable remote watering control via a variety of products such as touch-screen systems with a smartphone app and an adaptive user interface.

Reinke Manufacturing Co – Reinke Manufacturing Company, Inc. is the world's largest privately held manufacturer of center pivot and lateral move irrigation systems.

Rivulis – Rivulis Irrigation provides drip and micro-irrigation solutions with the aim of optimizing operations and output. Rivulis Irrigation offers a full line of irrigation products, including drip lines, drip tapes, filters, hose and tubing, sprinklers, sprays and valves.

Saturas – Saturas is developing a miniature SWP (Stem Water

Potential) sensor that is part of an automatic SWP sensing system. Embedded in the trunks of trees, vines, and plants, the sensor aims to provide accurate information based on statistical analysis for optimized irrigation, reduced water consumption, and increased fruit production and quality.

Senninger Irrigation – Senninger Irrigation is a manufacturer of sprinklers, spray nozzles and pressure regulators for a variety of agricultural uses.

Shanghai Huawei – Via its subsidiaries Shanghai Huawei Water Saving Irrigation Corp and Shanghai Irrist Corp, the company offers integrated irrigation and fertilizing equipment. It has a wide range of products including drip pipes, tapes and fittings, drippers, drip arrows, impulse and mini sprinklers, micro spray, PVC and PE pipes, fertilizer machines and valves.

Skydrop – Skydrop produces intelligent sprinkler controllers through its Skydrop Smart Watering Technology, which connects through Wi-Fi to monitor local weather stations every hour for real-time local weather data.

SupPlant – SupPlant's AI-powered system uses an advanced algorithm that analyzes live data from plants, soil and meteorology sensors, and translates it into irrigation recommendations and actionable insights.

The Toro Company – The Toro Company designs, manufactures, and markets a range of turf maintenance equipment, snow removal equipment, and irrigation system supplies for commercial and residential gardens, public parks, golf courses, sports fields, and agricultural fields.

T-L Irrigation – T-L is an irrigation solutions manufacturer based in North America. The company invented and patented Precision Mobile Drip Irrigation (PMDI) marrying pivot technology with drip irrigation design.

Weathermatic – Weathermatic offers a range of irrigation solutions combining full-line design and manufacturing precision with cloud-based technology and exclusive managed services.

Crop Science

Public Companies

Bayer (BAYGn.DE, covered by James Quigley). Bayer is a life science company operating across Pharmaceuticals, Consumer Health and Crop Science. The Crop Science segment researches, develops and markets crop protection solutions and seeds, and includes the subsidiary Monsanto. As part of this, the company has been breeding seeds designed to produce better yields in drought-like conditions by improving the root structure of the plant to better withstand low moisture conditions. In addition, the company's short stature corn, which it is developing through traditional breeding, biotechnology and gene editing approaches, requires less land and water usage than traditional plants.

Bioceres (BIOX.K, not covered). Bioceres is a provider of crop productivity solutions (including seeds, seed traits, seed treatments, biologicals, adjuvants and fertilizers). The company's HB4 technology has enabled the development of the world's only drought-tolerant soybeans and wheat.

Corteva (CTVA.N, covered by Vincent Andrews). Corteva is a leader in the seed and crop protection markets globally. The seed platform develops and supplies high quality germplasm combined with advanced traits to produce higher yields for farmers around the world. The crop protection platform supplies products to protect crop yields against weeds, insects and disease. As part of its offering, the company has been breeding seeds that seek to have better yields in drought-like conditions by improving the root structure of the plant so that it can better withstand low moisture conditions.

KWS SaaT SE & Co. KGaA (KWSG.DE, not covered). KWS is a family-owned business (the family holds 54.4% of the shares) that is active in plant breeding, deriving a combined ~85% of sales from corn and sugarbeet crops and generating 66% of sales in Europe (including Germany). KWS is the fifth-largest seed company in Europe (a non-GMO market) and number 5 globally (behind Bayer, Corteva, Syngenta, and Vilmorin). Its core skill-set is plant breeding, focusing on sustainable food production (including improvement of drought tolerance).

Metering & Digital Solutions

Public Companies

Badger Meter (BMI.N, covered by Connor Lynagh). Badger Meter is a provider of equipment and solutions for water flow measurement, quality, and other parameters through both hardware and software / digital offerings. BMI's primary market is the United States, and ~80% of its sales are for utility water solutions.

IDEX Corp (IEX.N, covered by Connor Lynagh). IDEX Corporation designs and manufactures equipment and products related to fluid and metering processes, as well as other components and engineered products. The company's products include industrial pumps, lubricant systems, banding and clamping devices, as well as rescue tools. IEX serves the water industry through its Fluid & Metering Technologies segment.

Itron (ITRI.O, covered by Connor Lynagh). Itron provides equipment and services that help utilities and cities measure, manage, and analyze the flow and consumption of critical resources, including electricity, water, and gas. Itron's main market is North America (roughly two-thirds of revenue), but it has a meaningful international footprint, with customers in 100 countries, and generates ~25% of revenue from EMEA.

LANDIS GYR GROUP (LANDI.S, covered by Ben Uglow). Landis+Gyr is a provider of metering technology and related software for electricity, gas and water utilities. The company has a relatively diverse geographic distribution, with significant operations in the Americas, EMEA, and APAC. Its core expertise has historically been for electricity customers, but it has recently expanded its product capabilities for water.

Metawater Co Ltd (9551.T, not covered). The company is primarily engaged in the design, construction, repair, maintenance and operation management of mechanical and electrical equipment for water purification plants, sewage treatment plants, waste treatment facilities and recycling facilities.

Mueller Water Products Inc (MWA.N, not covered). Mueller Water Products is a manufactures products and services used in the transmission, distribution and measurement of water. The company operates through two segments: Infrastructure and Technologies. The technologies segment offers residential and commercial water metering, water leak detection and pipe condition assessment products, systems and services. Mueller manufactures water technology products under both the Mueller and Hersey brand names.

Roper Technologies Inc (ROP.N, not covered). Roper's Industrial Technology segment produces water and fluid handling pumps, equipment and consumables for materials analysis, leak testing equipment, flow measurement and metering equipment and water meter and automatic meter reading ("AMR") products and systems. Roper primarily serves the water utility industry through Neptune Technology Group.

Teledyne Technologies Inc (TDY.N, covered by Kristine Liwag). Teledyne is a provider of sophisticated instrumentation, digital imaging products and software, aerospace and defense electronics, and engineered systems. The company operates across a variety of markets, including air and water quality environmental monitoring.

Xylem (XYL.N, covered by Connor Lynagh). Xylem provides equipment and services for the movement, treatment, analysis, and monitoring of water across utility, industrial, and residential & commercial building applications. It has one of the more diverse end-market and geographical exposures among North American companies, and just over 50% of revenue comes from outside the United States.

Vertical Farming/Indoor Farming

Public Companies

AppHarvest Inc (APPH.O, not covered). AppHarvest is an ag-tech company focusing on building indoor farms. It operates a 60-acre controlled environment agriculture facility in Morehead, Kentucky.

CubicFarm Systems Corp (CUB.TO, not covered). CubicFarm Systems Corp. is a Canada-based agriculture technology and vertical farming company. It develops, employs, and sells modular growing systems to provide predictable crop yields for farms around the world.

Kalera (KALK.OL, not covered). Kalera uses advanced automation and data collection system with Internet of Things (IoT), Cloud, Big Data Analytics, and Artificial Intelligence to optimize plant nutrition with the ultimate aim of improving yields and quality from its indoor farming facilities. The company grows lettuces year-round and serves the restaurant and food trade, including resorts and the cruise industry.

Private Companies

AeroFarms is a certified B Corporation based in the US and sells products produced via its patented aeroponic technology under its brand "Dream Greens".

Bowery Farming is a vertical farming company based in the US and has a proprietary software, the BoweryOS system, which uses sensors, vision systems, automation technology, robotics and machine learning to monitor plants and all the variables that drive their growth 24/7.

BrightFarms is an indoor farming (hydroponic) company engaged in supplying grocery for retailers with packaged salad greens. The company delivers fresh, pesticide-free packaged greens to supermarkets after harvest.

Dream Harvest Farming is an indoor hydroponic vertical farm based in Texas, growing leafy greens including kale, lettuce and asian greens. It is powered using wind energy and uses 95 times less water than a conventional farm.

Freshbox Farms is a hydroponic farm providing fresh, hyper local, non-GMO based produce.

Gotham Greens builds and operates sustainable greenhouses across the US, which are data-driven and climate-controlled. The company operates 8 greenhouses across New York, Rhode Island, Maryland, Illinois and Colorado.

Infarm develops indoor vertical farming systems to grow herbs, lettuce, vegetables, and fruits. The company's modular farming units can be stacked to meet different spaces or demand for restaurants, supermarkets and warehouses. Each hydroponic farm is monitored and controlled through the company's central farming platform.

Planet Farms is a European operator of vertical farms based in Italy. It grows plants in multi-layered structures under controlled environments, which are fully automated, meaning that the customer is the first to touch the crop.

Plenty Inc is a US-based vertical farming company. It offers various greens, including baby arugula, baby kale, mizuna mix and crispy lettuce. The company grows its leaves hydroponically on walls (instead of stacked horizontal planters), which allows it to use gravity to supply nutrients to its plants (rather than pumps). According to Plenty, its newest farm can grow 1 million plants at a time in a facility around the size of a basketball court and additionally can process 200 plants per minute, thanks to updates in its automation.

Spread Co's commenced its large-scale indoor farming production in 2007 and created the next-generation farming system Techno Farm (along with other organisations) in 2018. The company is working with technology and business partners to achieve the mid-term goal of constructing 20 factories with a total production capacity of 500,000 heads of lettuce per day in Japan.

Broader Water Infrastructure & Solutions

The companies in this section produce a range of products and services that are exposed to the challenges we have discussed in this report, but fall outside the four specific solutions we explore above. Examples of products and services include piping solutions, water utilities and water engineering services.

Public Companies

A O Smith Corp (AOS.N, not covered). A. O. Smith Corporation is a provider of water heating and water treatment solutions. It manufactures and markets a range of residential and commercial gas and electric water heaters, boilers, tanks, and water treatment products.

Aalberts NV (AALB.AS, covered by Aurelio Calderon Tejedor). The company sells products from 5 niche technologies: 1. hydronic flow control; 2. piping systems; 3. fluid control; 4. surface technologies; 5. advanced mechatronics. It sells into 4 markets: 1. eco-friendly buildings; 2. industrial niches; 3. sustainable transport; 4. semicon efficiency.

American States Water Co (AWR, not covered). This a holding company and its principal segments include water, electric and contracted services.

Advanced Drainage Systems Inc (WMS.N, covered by Joshua Pokrzywinski). Advanced Drainage Systems is a manufacturer of thermoplastic corrugated pipe, providing a suite of water management products and drainage solutions for use in the underground construction and infrastructure marketplace.Its product line includes single, double and triple wall corrugated polypropylene and polyethylene pipe and a variety of additional water management products including, storm retention and septic chambers; PVC drainage structures; fittings; and water quality filters.

Alfa Laval AB (ALFA.ST, covered by Robert Davies). Alfa Laval is engaged in the development, manufacture and marketing of products and solutions for heat transfer, separation and fluid handling. Its solutions include the treatment of wastewater, and its operations are divided into three business divisions that serve external customers: Food & Water, Energy and Marine & Diesel.

American Water Works Company Inc (AWK.N, not covered). American Water Works Company is a water and wastewater utility.

Its business segments include Regulated Businesses, which involves the ownership of utilities that provide water and wastewater services to residential, commercial, industrial, public authority, fire service and sale for resale customers. The company also owns the physical assets used to store, pump, treat and deliver water to its customers, and collects, treats, transports and recycles wastewater. In addition, the company has contracts with municipal customers to operate and manage water and wastewater facilities.

California Water Service Group (CWT.N, not covered). California Water Service Group is a holding company. The bulk of the business consists of the production, purchase, storage, treatment, testing, distribution and sale of water for domestic, industrial, public and irrigation uses, and for fire protection.

China Water Affairs Group Ltd (0855.HK, not covered). China Water Affairs Group is an investment holding company principally engaged in city water supply operation and construction. It operates through three segments: City Water Supply Operation and Construction, Environmental Protection and Property Development and Investment.

Companhia de Saneamento Basico do Estado de Sao Paulo (SBSP3.SA, covered by Miguel Rodrigues). Sabesp is a water and sewerage utility that collects and treats water sewage in Brazil's São Paulo state. It is considered one of the world's largest sanitation companies in terms of population served. Sabesp is controlled by the São Paulo state government, which holds 50.3% of its voting shares.

Danaher Corp (DHR.N, not covered). Danaher operates through three segments: Life Sciences, Diagnostics and Environmental & Applied Solutions, which offers products and services that help protect resources such as food and water supplies.

Ecolab Inc (ECL.N. covered by Vincent Andrews). Amongst many other products and services, Ecolab provides solutions in the sanitation space.

Energy Recovery Inc (ERII.O, not covered). Energy Recovery, Inc. creates technologies that solve challenges for industrial fluid-flow markets. The company's segments include Water and Emerging Technologies.

Essential Utilities Inc (WTRG.K, not covered). Essential Utilities is the holding company for regulated utilities providing water, wastewater or natural gas services. The company operates primarily through two segments: Regulated Water and Regulated Natural Gas.

Evoqua Water Technologies Corp (AQUA.K, not covered). Evoqua Water Technologies provides a range of product brands and water and wastewater treatment systems and technologies, in addition to mobile and emergency water supply solutions and service contract options.

Ferguson PLC (FERG.L, covered by Annelies Vermeulen). Ferguson plc is a British distributor of plumbing and heating products. It serves the repair, maintenance and improvement (RMI) market and the construction market.

Franklin Electric Co Inc (FELE.O, not covered). Franklin Electric Co designs, manufactures and distributes water and fuel pumping systems, consisting of submersible motors, pumps, electronic controls and related parts and equipment.

Geberit AG (GEBN.S, covered by Cedar Ekblom). Geberit produces and sells bathroom Sanitary Systems and Bathroom Ceramics. The company is exposed to the water thematic via its exposure to piping.

Genuit (GENG.L, not covered). Genuit Group PLC (previously known as Polypipe Group plc) provides sustainable water and climate management solutions for the built environment, such as piping systems for the residential, commercial, civil and infrastructure sectors.

Georg Fischer AG (FIN.S, not covered). The company operates through three business segments: GF Piping Systems, GF Casting Solutions, and GF Machining Solutions. GF Piping Systems is a supplier of piping systems made of plastics and metal predominately for the safe transport of water, chemicals and gas, as well as offering associated services.

Guangdong Investment Ltd (0270.HK, covered by Eva Hou). Guangdong Investment mainly supplies water to Hong Kong, Shenzhen, and Dongguan. The company also has investments in power generation, property, department stores, hotels, and toll roads. It has operating rights to supply water to Hong Kong for a 30-year period, which may be extended beyond the current expiration date of August 2030. The revenue for supplying water to Hong Kong is a fixed amount, negotiated every three years between the governments of the Hong Kong SAR and Guangdong province.

Halma PLC (HLMA.L, covered by Robert Davies). Halma is split across 4 divisions (1) Process Safety, (2) Infrastructure Safety, (3) Medical, (4) Environmental & Analysis. The latter group includes solutions for environmental data recording, water quality testing and ultraviolet (UV) water treatment.

Ingersoll Rand Inc (IR.N, covered by Joshua Pokrzywinski). Ingersoll Rand Inc. is a diversified, global provider of mission-critical flow creation products and industrial solutions. The company manufactures compressor, pump, vacuum and blower products. Its segments include Industrial Technologies and Services (IT&S) and Precision and Science Technologies (P&ST). The IT&S segment designs, manufactures, markets and services a broad range of air and gas compression, vacuum and blower products, fluid transfer equipment, loading systems, power tools and lifting equipment. The P&ST segment designs, manufactures and markets specialized positive displacement pumps, fluid management equipment, liquid and precision syringe pumps and compressors, and aftermarket parts.

Kurita Water Industries Ltd (6370.T, not covered). Kurita Water Industries is engaged in the provision of water treatment-related products, technology and maintenance services. The company operates through two segments: Water Treatment Chemicals and The Water Treatment Equipment. The Water Treatment Chemical segment manufactures water treatment chemicals and related equipment and also provides maintenance services. The Water Treatment Equipment segment manufactures equipment and facilities related to water treatment, the provision of ultra-pure water, chemical cleaning and precision cleaning services, the purification of soil and groundwater, as well as maintenance services for water treatment facilities.

Linde PLC (LIN.N, covered by Vincent Andrews). Linde plc is an industrial gases and engineering company that operates through its subsidiaries. The company provides atmospheric gases (oxygen, nitrogen, argon and rare gases) and process gases (carbon dioxide, helium, hydrogen, electronic gases, specialty gases and acetylene). The company has exposure to water and wastewater treatment.

Novozymes A/S (NZYMb.CO, not covered). Novozymes is a biotechnology company engaged in the production and sale of industrial enzymes, microorganisms and biopharmaceutical ingredients. Examples of exposure to the water theme include laundry solutions that replace chemicals and contribute to cleaner water.

Middlesex Water Co (MSEX.O, not covered). Middlesex Water Company is a water utility company which owns and operates regulated water utility and wastewater systems primarily in New Jersey and Delaware.

Organo Corp (6368.T, not covered). The company is mainly engaged in water treatment engineering (manufacture, sale, maintenance and management of filtration equipment, pure water system equipment and other water treatment related equipment) and functional products (sale of standard water treatment equipment, water treatment chemicals and food additives).

Pennon Group PLC (PNN.L, covered by Christopher Laybutt). Pennon Group owns South West Water, which is a fully regulated UK water company. The merged water company of South West Water and Bournemouth Water provides water and wastewater services to a population of c.1.7 million in Cornwall, Devon and parts of Dorset and Somerset and water-only services to c.0.5 million people in parts of Dorset, Hampshire and Wiltshire. Pennon Water Services is a business water specialist, providing water retail services for business customers' water management needs.

Pentair PLC (PNR.N, covered by Joshua Pokrzywinski). Pentair plc is a diversified industrial manufacturing company. The company is engaged in Water Quality Systems business and Flow and Filtration Solutions business. The Water Quality Systems business designs, manufactures, markets and services water system products and solutions to meet filtration and fluid management challenges in food and beverage, water, swimming pools and aquaculture applications. The Flow and Filtration Solutions business is involved in the entire water, water treatment and wastewater system from filtration, desalination, water supply to water disposal, process and control.

PerkinElmer Inc (PKI, not covered). PerkinElmer is a provider of products, services and solutions for the diagnostics, life sciences and applied markets. The company operates through two segments: Discovery & Analytical Solutions and Diagnostics. The company offers solutions to support water quality analysis.

Primo Water Corp (PRMW.TO, not covered). Primo Water Corporation is an American-Canadian water company offering multi-gallon bottled water, water dispensers, self-service refill water machines, and water filtration appliances.

Rotork PLC (ROR.L, covered by Robert Davies). Rotork provides flow control and instrumentation solutions for oil & gas, water and wastewater, power, chemical process and industrial applications. The company operates through three divisions: Oil & Gas, Water & Power, and Chemical, Process & Industrial (CPI).

Severn Trent PLC (SVT.L, covered by Christopher Laybutt). Severn Trent is a regulated water company based in England. It also has a growing renewables footprint.

SJW Group (SJW, not covered). The company's segments are Water Utility Services and Real Estate Services. Its Water Utility Services segment offers water utility and utility-related services to its customers through SJW Group's subsidiaries, SJWC, Connecticut Water, CLWSC, Maine Water, HVWC, Avon Water, NEWUS.

Stantec Inc (STN.TO, not covered). The company provides professional services in infrastructure and facilities for clients in the public and private sectors (including environmental services).

Sulzer AG (SUN.S, covered by Aurelio Calderon Tejedor). Sulzer is a global leader in fluid engineering applications. It specializes in pumping, agitation, mixing, separation and application technologies for fluids of all types with a network of 50 manufacturing facilities and 100 service centers.

Tetra Tech Inc (TTEK.O, not covered). Tetra Tech provides consulting and engineering services focused on water, environment, sustainable infrastructure, renewable energy, and international development. The company operates through two segments: Government Services Group (GSG), and Commercial/International Services Group (CIG).

United Utilities Group PLC (UU.L, covered by Christopher Laybutt). United Utilities Group PLC is a water and wastewater company. Through its subsidiary, United Utilities Water Limited (United Utilities Water), it manages the regulated water and wastewater network in the North West of England, providing services to around seven million people and businesses. It owns over 56,000 hectares of land around its reservoirs. It collects water from the environment, cleans and distributes it to its customers before collecting it, treating it, and then returning it back to the environment.

Uponor (UPONOR.HE, not covered). Uponor a supplier of plumbing and heating systems. It operates through three segments: Building Solutions Europe, Building Solutions North America and Infrastructure Solutions. The Infrastructure Solutions business' products and services include high-pressure pipes and sewage and waste water treatment systems, which are sold to construction and renovation customers.

Watts Water Technologies Inc (WTS, not covered). Watts Water Technologies is a supplier of products, solutions and systems that manage and conserve the flow of fluids and energy into, through and out of buildings in the commercial and residential markets. Its products include water pressure regulators, leak detection products, custom heat and hot water solutions and water re-use products. The latter comprise drainage and engineered rainwater harvesting solutions for commercial, industrial, marine and residential applications. Water quality products include point-of-use and point-of-entry water filtration, conditioning and scale prevention systems for commercial, marine and residential applications.

Wienerberger AG (WBSV.VI, covered by Cedar Ekblom). Wienerberger is the world's largest producer of bricks and the market leader in clay roof tiles in Europe as well as concrete pavers in Central-Eastern Europe and pipe systems in Europe. The company is exposed to the water thematic via its exposure to piping.

York Water Co (YORW.O, not covered). The York Water Company is an investor-owned water utility in the United States. The company's primary aim is to ensure safe drinking water and distribute water.

Zurn Water Solutions (ZWS,N not covered). Zurn Water Solutions (previously known as Rexnord Corporation) supplies a range of advanced water system solutions to protect human health and the environment. Examples include products that improve water quality, safety, flow control and conservation.

Transition Stocks

Product solutions versus operational improvements. In our Solution Stocks section, we highlight companies that offer products/services to help solve some of the major challenges associated with water. But in order to actually reduce water consumption, companies, individuals and municipalities will need to reduce water usage, either through implementing some of the technologies/services solutions we explore or by simply implementing practices that enable less water usage.

Focus on direction of travel for the most water-intensive companies. In Exhibit 172 - Exhibit 181 , we assess ~1,900 companies on two criteria to identify those with (a) relatively high water intensity levels (in comparison with the rest of the sector), but also (b) robust water target action plans in place (also relative to the rest of the sector).

1) How water intensive is the company? For this we look at average water usage to revenues as a proxy (Datastream data).

2) Does the company have targets and actions plans in place for improving freshwater use? This evaluates the existence and quality of the company's freshwater use reduction targets and action plans to achieve these targets. For example, for the maximum grade awarded by ISS (A+), the company must have set clear freshwater use reduction targets, including information on the time frame and the base year. Further, it must have implemented a comprehensive action plan to reduce freshwater use, comprising subgoals, planned measures to achieve water use reductions (changes in processes and technologies, for example), and progress reports (ISS data).

Overall, Exhibit 171 shows that the energy sector is the most water intensive, but also on average has the lowest levels of commitments around water reduction, when compared with other sectors. We highlight 6 stocks as potential 'transition' stocks relative to sector peers (see Exhibit 170).

Exhibit 171: The energy sector is both highly water intensive (as measured by water usage to revenues) but also scores lowest on ISS assessments of plans in place to reduce water usage

Sector	Average water use to revs USD mn (water intensity)	Water Targets / Action Plan
Energy	412,294	1.0
Utilities	174,699	1.7
Health Care	114,778	3.1
Materials	31,994	2.0
Real Estate	12,309	2.3
Consumer Staples	5,661	3.5
Industrials	4,740	2.0
Consumer Discretionary	1,506	3.3
Information Technology	1,147	2.9
Communication Services	288	1.2

Source: ISS, Datastream, Morgan Stanley Research estimates

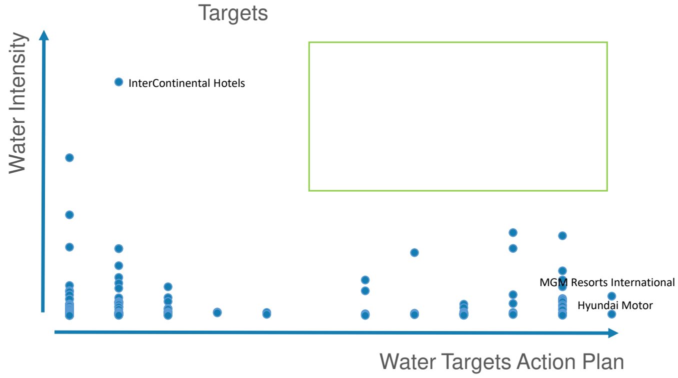
Exhibit 170: We have identified 6 'transition' stocks that are water intensive but have robust water target action plans (relative to sector peers)

Ticker	Company Name	Morgan Stanley Analyst	Sector	Company Description	Water use to revs USD mn	Water Targets Action Plan Score
ABF.L	Associated British Foods plc	Mariani, Elena	Consumer Staples	Associated British Foods is a diversified international food, ingredients and retail group that operates internationally through five segments: Sugar, Grocery, Retail (Primark), Agriculture and Ingredients.	45,284	C+
MAHB.KL	Malaysia Airports Holdings	Not Covered	Industrials	An investment holding company that operates through Malaysia Operations and Overseas Operations. Malaysia Operations includes duty free and non-dutiable goods, airport services, agriculture and horticulture, hotel, and project and repair & maintenance services. Overseas Operations includes project and repair & maintenance, and airport services.	20,721	C+
WAF	Siltronic Ag	Not Covered	Information Technology	A producer of hyperpure silicon wafers. The company produces polished wafers, epitaxial wafers and annealed wafers, among others.	15,874	A+
6488.TWO	GlobalWafers Co., Ltd.	Chan, Charlie	Information Technology	Principally involved in the design, research, development and manufacture of semiconductor rods and wafers. The company's main products include semiconductor ingot products, semiconductor chip products and other products.	11,219	A
600309.SS	Wanhua Chemical Group Co. Ltd.	Lu, Jack	Materials	The company is principally engaged in the manufacture and distribution of chemical products. Its main products are diphenyl methane diisocyanate (MDI), including pure MDI and polymerized MDI, applied in the manufacture of polyurethane (PU).	613,366	B
DUK.N	Duke Energy Corporation	Byrd, Stephen	Utilities	Duke Energy Corporation generates, transmits, and distributes electricity; transports and sells natural gas; and pursues merchant power generation. It operates throughout the Americas, but has a large portion of its assets in Ohio, North Carolina, South Carolina, Indiana, and Kentucky. Its main segments are International Energy, Commercial Power, and U.S. Franchised Electric and Gas.	776,969	C+

Source: ISS (Water Action Plan scores), Datastream, Morgan Stanley Research

Exhibit 172: Consumer Discretionary: comparing water intensity against freshwater use reduction targets and action plans

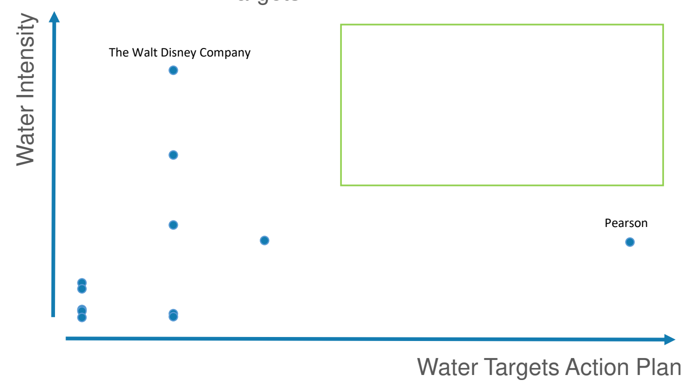
Consumer Discretionary: Water Intensity vs Water Targets



Source: ISS, Datastream, Morgan Stanley Research

Exhibit 173: Communication Services: comparing water intensity against freshwater use reduction targets and action plans

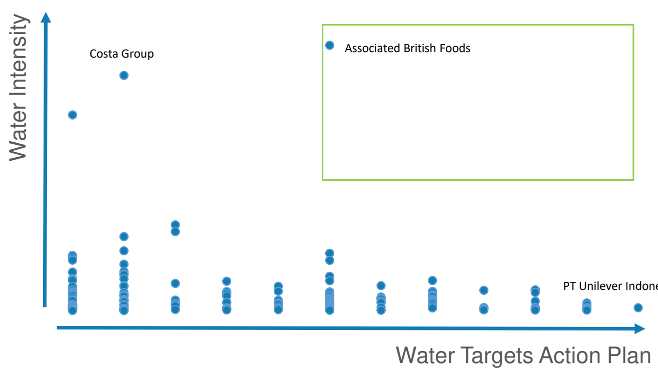
Communication Services: Water Intensity vs Water Targets



Source: Datastream, Morgan Stanley Research. Note: Singapore Press Holdings removed as outlier in terms of water intensity

Exhibit 174: Consumer Staples: water intensity against freshwater use reduction targets and action plans

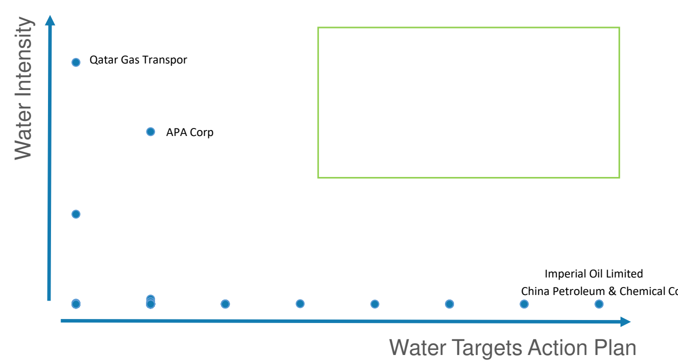
Consumer Staples: Water Intensity vs Water Targets



Source: ISS, Datastream, Morgan Stanley Research. Note: Adecoagro & Mowi removed as companies are outliers from a water intensity perspective

Exhibit 175: Energy: comparing water intensity against freshwater use reduction targets and action plans

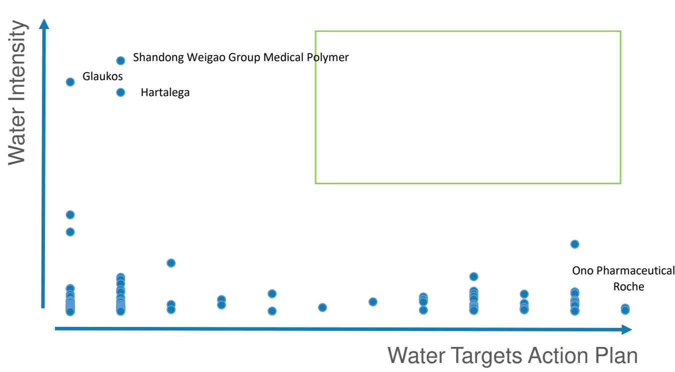
Energy: Water Intensity vs Water Targets



Source: ISS, Datastream, Morgan Stanley Research

Exhibit 176: Healthcare: comparing water intensity against freshwater use reduction targets and action plans

Healthcare: Water Intensity vs Water Targets

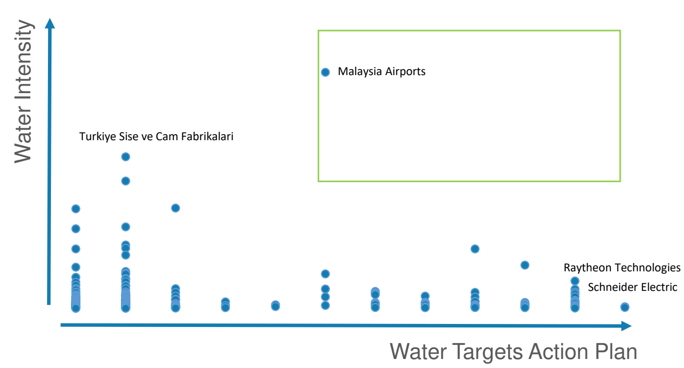


Source: ISS, Datastream, Morgan Stanley Research

Note: Omnicell & CanSino Biologics removed as companies are outliers from a water intensity perspective

Exhibit 177: Industrials: comparing water intensity against freshwater use reduction targets and action plans

Industrials: Water Intensity vs Water Targets

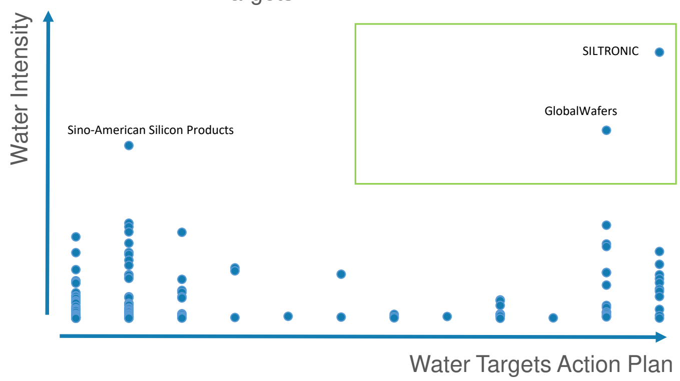


Source: ISS, Datastream, Morgan Stanley Research

Note: Cintas Corporation, Abengoa & AGC removed as companies are outliers from a water intensity perspective

Exhibit 178: IT: comparing water intensity against freshwater use reduction targets and action plans

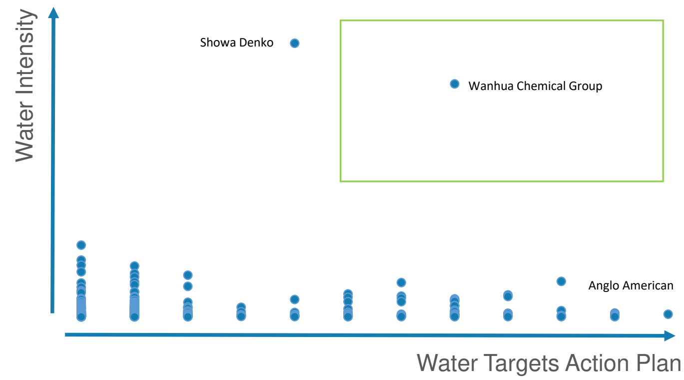
Information Technologies: Water Intensity vs Water Targets



Source: ISS, Datastream, Morgan Stanley Research

Exhibit 179: Materials: comparing water intensity against freshwater use reduction targets and action plans

Materials: Water Intensity vs Water Targets

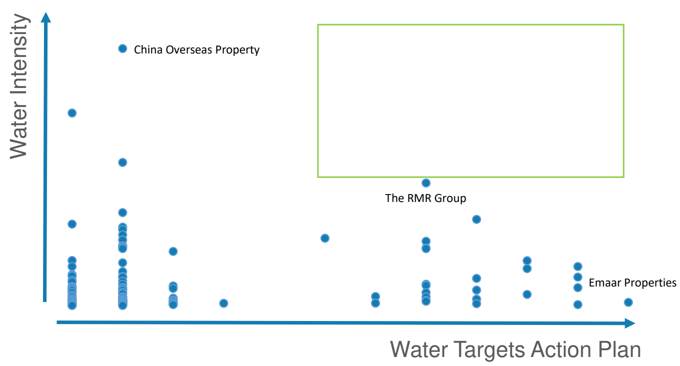


Source: ISS, Datastream, Morgan Stanley Research

Note: Grupo Argos removed as outlier in terms of water intensity

Exhibit 180: Real Estate: comparing water intensity against freshwater use reduction targets and action plans

Real Estate: Water Intensity vs Water Targets

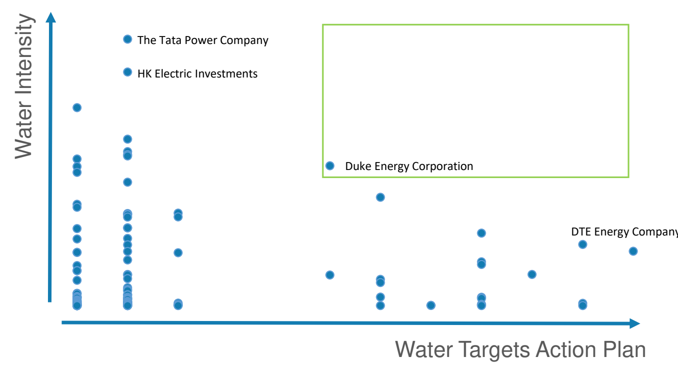


Source: ISS, Datastream, Morgan Stanley Research

Note: Hang Lung Group & Camden Property removed as companies are outliers from a water intensity perspective

Exhibit 181: Utilities: comparing water intensity against freshwater use reduction targets and action plans

Utilities: Water Intensity vs Water Targets



Source: ISS, Datastream, Morgan Stanley Research

Appendix 1 : Water Challenges in Brazil

Water supply is a challenge for both the power and sanitation industries in Brazil. The power system largely relies on hydroelectric energy, at 60% of installed generation capacity. While this dependence has lessened in recent years (and should continue to do so as other sources expand) recurring droughts have given rise to concerns over power shortages. Droughts have also created shortages in the sanitation sector recently, an area that has suffered from a lack of investment, with low penetration of basic sanitation services, such as access to treated water and sewage collection & treatment. New legislation should herald some improvements here, with the aim of improving regulation and boosting investment through incentivizing greater private sector participation.

Water Utilities

Only 24% of the Brazilian population has access to the full scope of sanitation services, including access to treated water, sewage collection and sewage treatment. We highlight the following figures: i) 60 million people (29% of the population) have access to treated water and sewage collection, but without sewage treatment; ii) 67 million (32%) have access to water services only; and iii) 33 million (16%) have access to neither water nor sewage services. This has clear negative implications for public health and the environment.

The required investments are ~R$140bn in water and R$215bn in sewage services by 2033, according to the Federal Government's National Sanitation Plan. This equates to average annual investment of ~R$28bn. Between 2007 and 2019, however, only R$13bn was invested, on average, with several underinvested regions across the country. Nationwide, the penetration of water services currently stands at 84%, compared to 54% for sewage collection and 49% for sewage treatment. The objective is to raise this to 99% for water and 90% for sewage by 2033.

New legislation and a regulatory framework that could boost investment. Approved by Congress in June 2020, the new Sanitation Framework has brought a number of benefits for the industry:

i) Attracting private sector investment, as it fosters participation by private players in competitive bids for concessions by ending the automatic renewal of contracts between municipalities and SOEs.

ii) Improving regulation, by assigning to a Federal body (ANA, the National Water Agency) the responsibility to set guidelines for regulation, indemnification for non-amortized assets, and governance, among other things. While the guidelines have not yet been published, we expect them to bring clarity and stability to rules that are currently defined at the municipal or state level.

iii) Making privatization feasible in practice, as it eliminates the previous automatic expiration of contracts in the event of privatization.

iv) Setting water / sewerage service universalization targets, which will require significant levels of investment.

Water losses are a material source of inefficiency in Brazil. Currently, water losses are 39% – measured as a percentage of water captured in reservoirs that does not reach the final consumer – due to leakage or other problems. The National Ministry of Regional Development has a published target to reduce this ratio to 25%. If achieved, this would be enough to supply potable water to 39 million people for one year (or around 18% of the Brazilian population).

The increase in investments, better regulatory environment and better management of water companies could improve the outlook. According to a study published by Instituto Trata Brasil, reducing water losses could drive gross benefits of up to US$16bn by 2033 (optimistic scenario). The net benefits, after deducting investments to achieve such efficiencies, could still be around US$8bn.

Exhibit 182: Brazil's water losses – reduction scenarios

Scenarios	Water Losses (2019)	Water Losses (2034)	Reduction (%)	Gross benefit (US$bn)	Nets benefit (US$bn)
Optimistic	41%	15%	63%	16.2	8.1
Base case	41%	25%	38%	9.8	4.9
Pessimistic	41%	35%	14%	3.5	1.8

Source: Instituto Trata Brasil (2021 Study on Water Losses, based on 2019 figures)

Exhibit 183: EPE forecasts for Brazil's centralized generation capacity*

Brazil's Centralized Generation Installed Capacity Evolution*

	2020		2030E		CAGR	Δ Mkt. Share
	Installed Capacity (GW)	Market Share (%)	Installed Capacity (GW)	Market Share (%)	20-30E	20-30E
HPPs	101.9	61.7%	106.4	53.9%	0.4%	-7.8 p.p.
Wind	15.9	9.6%	32.2	16.3%	7.3%	6.7 p.p.
Natural Gas	14.3	8.7%	22.0	11.1%	4.4%	2.5 p.p.
Biomass/Biogas	13.9	8.4%	15.1	7.6%	0.8%	-0.8 p.p.
SHPPs	6.6	4.0%	8.9	4.5%	3.0%	0.5 p.p.
Solar	3.1	1.9%	8.4	4.3%	10.5%	2.4 p.p.
Coal	3.0	1.8%	0.7	0.4%	-13.7%	-1.5 p.p.
Others	6.4	3.9%	3.7	1.9%	-5.4%	-2.0 p.p.
Total	165	100.0%	197.4	100.0%	1.8%	-
Renewables	39.5	23.9%	64.6	32.7%	5.0%	8.8 p.p.

Source: EPE, Morgan Stanley Research. (*) Includes capacity from the regulated market and free market; does not include self-production capacity of exclusive use.

Electric Utilities

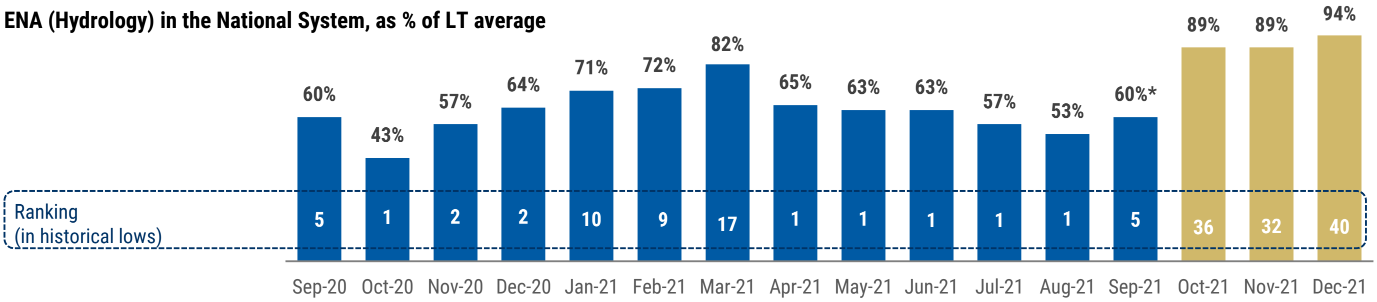
Brazil's power generation capacity is still highly dependent on hydro generation plants. Large hydro power plants are ~60% of Brazil's total generation installed capacity, which implies a relatively clean energy matrix compared with other countries. However, environmental regulatory constraints mean that large water reservoirs have not been approved recently, given potential environmental issues related to the extension of large flooded areas (such as deforestation). Although new hydro plants should still be added to the system, according to forecasts by EPE (the federal body responsible for energy research), the government expects to develop mostly run-of-the-river hydro projects (without water reservoirs). This reduces the average generation potential of a particular hydro plant as well as its contribution to the reliability of the energy matrix, as reservoirs play a storage role for the system.

Renewables should gain relevance in the future, reducing hydro exposure. According to EPE, renewables' total installed capacity, including wind, solar, biomass and small hydro, should reach ~65GW in 2030, or ~33% of Brazil's total energy matrix (from ~24% in 2020). Besides being more environmentally friendly, renewables expansion faces relatively low environmental hurdles and easier approval than large hydro. This expansion is strongly supported by the lower investment/operating costs for the development of renewable sources (especially wind and solar), coupled with higher efficiency ratios, such as high load factors.

Thus, EPE expects the following trends in the expansion of the power matrix in Brazil: i) hydro should lose market share as a percentage of total capacity; ii) renewables, especially wind and solar, will likely gain significant market share and become key sources of future capacity growth; and iii) in order to ensure power supply reliability, renewables will need to be combined with fossil fuel capacity, which should largely consist of natural gas fired projects.

Droughts have recently put power supply at risk. Brazil faced one of its worst hydrology crises ever in 2021. Rainfall that is effectively converted into reservoir levels is referred to as the natural energy inflow (ENA). Thus, the evolution of reservoir levels is highly dependent on the effective ENA, especially during the rainy season, from December to April. The monthly ENA in the National System (SIN) in the 2020-2021 season was consistently below the long-term average (100%) and marked record lows for several months (i.e. the worst measured hydrology for a particular month since 1931).

Exhibit 184: ENA in the National System, as % of LT average



Source: PSR, Morgan Stanley Research; (*) PSR forecast

Exhibit 185: Evolution of reservoir levels for the National System (SIN)

SIN	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2021*	**30%**	**38%**	**45%**	**44%**	**42%**	**40%**	**35%**	**29%**	**24%**	**25%**	**26%**	**33%**
2020	28%	43%	55%	59%	60%	60%	57%	51%	40%	30%	25%	25%
2019	31%	34%	44%	49%	52%	53%	50%	43%	35%	27%	23%	24%
2018	32%	39%	44%	46%	44%	42%	37%	31%	27%	25%	28%	32%
2017*	**35%**	**38%**	**39%**	**39%**	**41%**	**42%**	**38%**	**33%**	**23%**	**17%**	**19%**	**22%**
2016	42%	50%	57%	56%	55%	53%	49%	44%	38%	34%	31%	32%
2015*	**21%**	**23%**	**30%**	**35%**	**37%**	**38%**	**41%**	**36%**	**32%**	**29%**	**28%**	**29%**
2014*	**43%**	**38%**	**40%**	**42%**	**42%**	**43%**	**40%**	**34%**	**29%**	**23%**	**19%**	**22%**
2013	38%	46%	55%	62%	61%	63%	60%	55%	49%	44%	40%	42%
Avg 02-12	64%	72%	79%	81%	81%	78%	73%	65%	57%	51%	48%	51%
2001*	**41%**	**42%**	**42%**	**39%**	**36%**	**35%**	**34%**	**30%**	**26%**	**27%**	**28%**	**35%**

Source: ONS, Morgan Stanley Research; (*) previous years with deteriorated hydrology. Note: SIN level estimates based on the proportional contribution of each region to the system.

Exhibit 186: Evolution of reservoir levels for the SE/CW region (SIN)

SE/CW	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2021*	**23%**	**29%**	**35%**	**35%**	**32%**	**29%**	**26%**	**21%**	**17%**	**18%**	**19%**	**25%**
2020	25%	40%	51%	55%	55%	53%	48%	42%	33%	24%	18%	19%
2019	27%	29%	40%	45%	47%	47%	45%	39%	31%	22%	19%	20%
2018	31%	37%	42%	44%	43%	40%	34%	28%	23%	20%	24%	27%
2017*	**37%**	**40%**	**41%**	**42%**	**43%**	**42%**	**39%**	**34%**	**24%**	**17%**	**18%**	**22%**
2016	44%	51%	58%	58%	57%	56%	52%	46%	40%	35%	33%	34%
2015*	**17%**	**21%**	**29%**	**34%**	**36%**	**36%**	**37%**	**34%**	**32%**	**28%**	**28%**	**30%**
2014*	**40%**	**35%**	**36%**	**38%**	**37%**	**36%**	**34%**	**30%**	**25%**	**19%**	**16%**	**19%**
2013	37%	46%	54%	63%	63%	64%	61%	55%	49%	45%	42%	43%
Avg 02-12	65%	73%	80%	82%	81%	78%	73%	65%	58%	51%	48%	52%
2001*	**32%**	**34%**	**35%**	**32%**	**30%**	**29%**	**27%**	**23%**	**21%**	**21%**	**23%**	**33%**

Source: ONS, Morgan Stanley Research; (*) previous years with deteriorated hydrology

Ultimately 2021 passed without any power supply issues. After a period of high concern around power rationing and blackouts (particularly during 3Q21), the combination of improved hydrology, weak power demand, and preventative measures adopted by the government (energy imports, for example) allowed a significant recovery in reservoir levels. In the SE/CW regions, reservoirs ended 2021 at 25.6%, compared to 18.8% in December 2020. This was much better than 3Q21 expectations, when forecasts pointed to reservoir levels of 12-20% for December 2021. In the National System (SIN), reservoirs ended 2021 at 31%, compared to 24% in December 2020. This is also better than 3Q21 expectations, which pointed to 20-25% for December 2021.

2022 Outlook: While the Brazilian power system will remain exposed to hydrology, given the configuration of its power matrix (~60% hydro), we expect power supply conditions to continue strengthening during 2022, supported by new generation and transmission capacity. Installed generation capacity is expected to grow by least 7.5GW (or ~4.5% of current capacity), of which only 0.3 GW is hydro, and the transmission connection between the Northeast / North regions and the Southeast should increase by ~3GW (~25% of current capacity).

Appendix 2: Investor Positioning

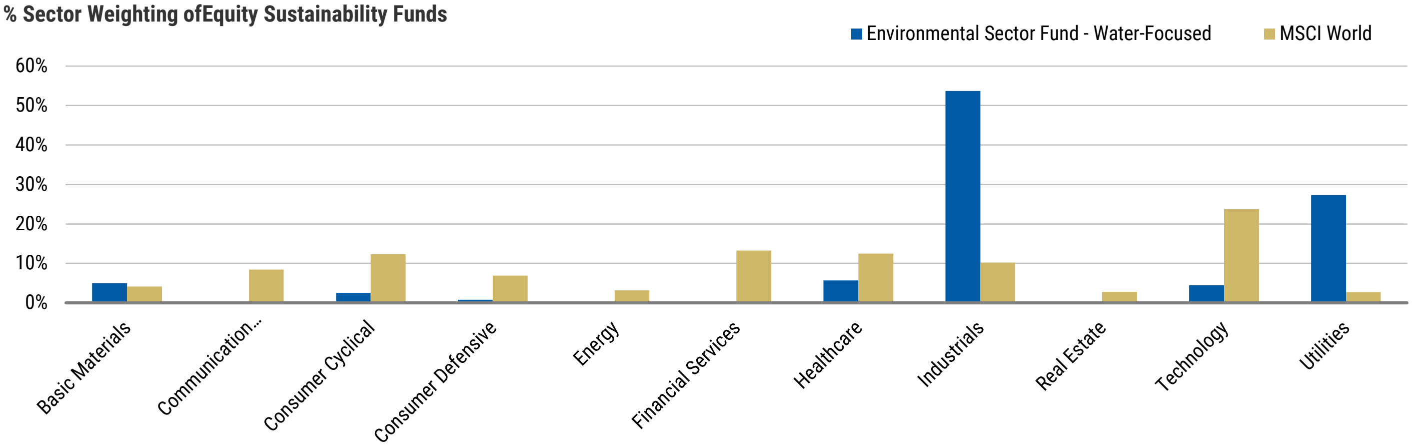
Which stocks are most preferred by sustainable water funds?

We try to answer this question from three different perspectives:

1. How do the sector weightings of water funds compare to MSCI World? (Exhibit 187)
2. What are the most commonly held stocks by water funds? (Exhibit 190)
3. What stocks represent the largest average portfolio weighting across water funds? (Exhibit 189)

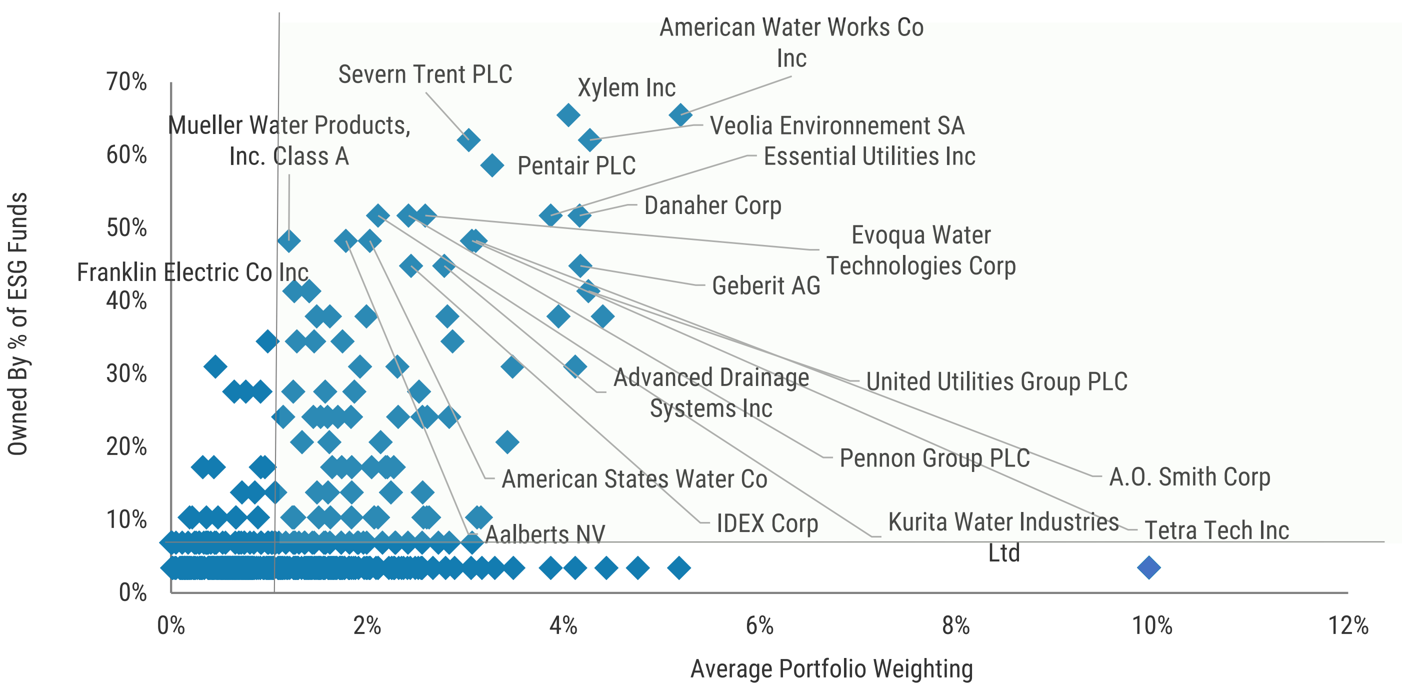
Exhibit 187: Water-focused funds tend to be overweight industrials (+43.5pp) and utilities (+24.6pp) versus the benchmark of MSCI World

% Sector Weighting ofEquity Sustainability Funds



Source: Morningstar, MSCI, Morgan Stanley Research

Exhibit 188: Utility and Industrial stocks such American Water Works, Xylem, Pentair, Severn Trent PLC and Veolia tend to be most commonly owned by ESG funds with a particular focus on water



Source: Morningstar, Morgan Stanley Research

Exhibit 189: Top 20 stocks based on the average portfolio weighting in our selected universe – Spinnova, American Water Works and RusHydro lead

Stock	Ticker	Sector	Average Portfolio Weighting %
Spinnova Oyj Ordinary Shares	SPINN	Consumer Cyclical	10.0%
American Water Works Co Inc	AWK	Utilities	5.2%
RusHydro PJSC ADR	HYDR	Utilities	5.2%
Ingersoll Rand Inc	IR	Industrials	4.8%
Athens Water Supply & Sewerage Co	EYDAP	Utilities	4.4%
Ecolab Inc	ECL	Basic Materials	4.4%
Veolia Environnement SA	VIE	Industrials	4.3%
United Utilities Group PLC	UU.	Utilities	4.3%
Geberit AG	GEBN	Industrials	4.2%
Danaher Corp	DHR	Healthcare	4.2%
Ferguson PLC	FERG	Industrials	4.1%
Suez Environnement Co SA	SEV	Utilities	4.1%
Xylem Inc	XYL	Industrials	4.1%
Roper Technologies Inc	ROP	Industrials	4.0%
Essential Utilities Inc	WTRG	Utilities	3.9%
Energy Company of Minas Gerais ADR	CIG	Utilities	3.9%
Aqua America Inc	WTRG	Utilities	3.5%
Halma PLC	HLMA	Industrials	3.5%
Waters Corp	WAT	Healthcare	3.4%
Entegris Inc	ENTG	Technology	3.3%

Source: Morningstar, Morgan Stanley Research

Exhibit 190: Top 20 stocks based on the % of water funds that own the stock in our selected universe – American Water Works, Xylem and Veolia lead

Stock	Ticker	Sector	% of Funds
American Water Works Co Inc	AWK	Utilities	66%
Xylem Inc	XYL	Industrials	66%
Veolia Environnement SA	VIE	Industrials	62%
Severn Trent PLC	SVT	Utilities	62%
Pentair PLC	PNR	Industrials	59%
Danaher Corp	DHR	Healthcare	52%
Essential Utilities Inc	WTRG	Utilities	52%
Evoqua Water Technologies Corp	AQUA	Industrials	52%
Pennon Group PLC	PNN	Utilities	52%
Kurita Water Industries Ltd	6370	Industrials	52%
A.O. Smith Corp	AOS	Industrials	48%
Tetra Tech Inc	TTEK	Industrials	48%
American States Water Co	AWR	Utilities	48%
Aalberts NV	AALB	Industrials	48%
Mueller Water Products, Inc. Class A	MWA	Industrials	48%
Geberit AG	GEBN	Industrials	45%
Advanced Drainage Systems Inc	WMS	Industrials	45%
IDEX Corp	IEX	Industrials	45%
United Utilities Group PLC	UU.	Utilities	41%
Franklin Electric Co Inc	FELE	Industrials	41%

Source: Morningstar, Morgan Stanley Research

Exhibit 191: Morningstar's Sustainable Investment Framework

Level 1		Sustainable Investment	
Level 2	ESG Fund	Impact Fund	Environmental Sector Fund
Level 3	ESG Incorporation	Gender & Diversity	Renewable Energy
	ESG Engagement	Low Carbon/Fossil-Fuel-Free	Water-Focused
		Community Development	General Environmental Sector
		Environmental	
		Other Impact Themes	

Source: Morningstar

How is this analysis conducted?

The starting point for our analysis is the Morningstar sustainability universe, which covers roughly ~8,000 funds globally across a variety of asset classes. Note, Morningstar defines an investment as being sustainable if the fund "is described as focusing on sustainability, impact, or considering ESG factors in its prospectus, offering document, or regulatory filings" (Morningstar Sustainable Attributes).

There are various levels of "sustainable attributes" awarded by Morningstar to a sustainability fund (see Exhibit 191). It is important to note that sustainability funds can be tagged with more than one "sustainable attribute", meaning a fund might be tagged as low carbon/fossil-fuel-free under the Level 2 Impact Fund definition and could also be tagged as having a water focus under the Level 2 Environmental Sector Fund definition. For the purposes of this analysis, we focus on the 29 equity funds tagged *solely* as being an "Environmental Sector Fund" at the Level 2 definition and "Water-Focused" at the Level 3 definition (defined as "strategies that intend to invest in companies with clean water practices").

Overall, water-focused funds tend to be overweight industrials (+43.5pp) and utilities (+24.6pp) versus the benchmark of MSCI World.

American Water Works, **Xylem Inc** and **Veolia** are the most commonly held stocks within our universe of ESG water funds, owned by a respective 66%, 66% and 62% of the 28 funds.

From a materiality perspective **Spinnova**, **American Water Works** and **RusHydro** have the largest average portfolio weighting across the 10 water funds we analyzed, at 10%, 5.2% and 5.2% respectively.

Solutions stocks not owned by water funds. We compare the full list of stocks held by at least 1 of the 29 water funds against our list of Solution stocks highlighted in Exhibit 169 . Below we highlight Solution stocks that were not owned by any of the water funds in our analysis above. We note that all of the metering & digital solution stocks were held by at least one water fund, in contrast to many agri-related (seeds, smart irrigation and vertical/indoor farming) and desalination stocks.

Exhibit 192: Stocks from our Solutions list not held by any of the water funds

Ticker	Company	Mkt Cap USDmn	Stock Price		Rating	Analyst	Region	Revenue Exposure To Water (%)
Desalination								
ABG.MC	Abengoa SA	150	0.02	EUR	NA	NA	Europe	<5%
APBS.OM	ACWA Power Barka SAOG	199	0.5	OMR	NA	NA	EMEA	43%
034020.KS	Doosan Heavy Industries & Construction Co Ltd	9,106	17300	KRW	NA	NA	Asia/Pacific	13%
6303.T	Sasakura Engineering Co Ltd	65	2410	JPY	NA	NA	Asia/Pacific	32%
2727.HK	Shanghai Electric Group Co Ltd	9,434	2	HKD	Underweight	Hou, Eva	Asia/Pacific	<5%
Seeds								
BAYGn.DE	Bayer AG	59,129	53	EUR	Overweight	Quigley, James	Europe	<5%
BIOX.O	Bioceres Crop Solutions Corp	497	12	USD	NA	NA	Latin America	<5%
CTVA.N	Corteva Inc	36,628	50	USD	Overweight	Andrews, Vincent	North America	<5%
Smart Irrigation								
BAYGn.DE	Bayer AG	59,129	53	EUR	Overweight	Quigley, James	Europe	<5%
JAIR.NS	Jain Irrigation Systems Ltd	293	43	INR	NA	NA	Asia/Pacific	65%
6701.T	NEC Corp	12,367	5080	JPY	Equal-Weight	Segawa, Hiroto	Japan	<5%
Vertical/Indoor Farming								
APPH.O	AppHarvest Inc	298	3	USD	NC	NC	North America	100%
CUB.TO	CubicFarm Systems Corp	164	1	CAD	NC	NC	North America	100%
KALK.OL	Kalera AS	162	7	NOK	NC	NC	Europe	100%

Source: Morningstar, Morgan Stanley Research

Appendix 3: Water Regulation

There is an established body of regulation and guidelines that sets standards for water cleanliness and ensures universal access to drinking water. In recent years, focus has shifted to pollution prevention and improving water quality, with an emphasis on implementation and compliance.

UN support for water regulation. National and local policy makers receive substantial support from intergovernmental bodies, such as UN and WHO in particular, to design their water management laws and regulations. The WHO-issued set of blueprint reports such as "Guidelines for drinking-water quality" and "Guidelines for sanitation and heath" provide a how-to guide for setting water cleanliness and sanitation standards.

Water regulation continues to evolve and tighten. Europe, US and China established the basis of their water laws in the 1970s and 1980s, with the US Clean Water Act of 1972, China's Water Pollution Prevention and Control Law of 1984 and the EU's Surface Water Directive of 1975. However, for the EU and China, significant developments took place at the turn of the century when both entities signed their landmark regulations for water use. The increasing water stress and a wider acknowledgement of climate change over the past two decades have forced policy makers to refine existing laws and take action to curb pollution and improve water access and quality. In the EU, the Taxonomy will provide a clearer definition on what constitutes the sustainable use of water resources. In the US, the Biden administration has ramped up the funding for clean water infrastructure. China continues to raise the bar for water cleanliness targets in its five-year plans.

Global

SDG Goal 6

The UN's Agenda for Sustainable Development was launched in 2015 with an ambition to "end poverty, protect the planet and improve the lives and prospects of everyone, everywhere". The 6th of the UN's 17 Sustainable Development Goals aims to ensure access to water and sanitation for all. By 2030, the UN targets universal and equitable access to safe and affordable drinking water and to adequate and equitable sanitation and hygiene. In its most recent report on SDG progress, the UN has acknowledged that, without significant acceleration from the current rate of progress, the Goal 6 targets will not be met. The poor record of implementation, insufficient funding, high levels of water stress and the lack of transboundary cooperation between countries are among the causes cited for the slow progress so far.

Guidelines for drinking-water quality (GDWQ)

The WHO guidelines aim to form a basis for setting national regulations and standards for water safety. Initially published in 1984, the report builds on the previous "International standards for drinking water" from 1958. It is a practical guide for developing countries and communities. GDWQ outlines the framework for implementation, sets the health-based targets and elaborates on the proposed risk management systems as well as independent surveillance approaches. It provides technical measures and limits on the presence of chemicals and bacteria in drinking water. The most recent (4th) edition was published in 2017.

Guidelines for sanitation and health

These UN guidelines are designed to assist decision makers with developing, implementing and monitoring sanitation standards and regulations. The document provides evidence on the correlation between sanitation and health, provides comprehensive advice and highlights good practice actions. Published in 2018 by the WHO, the guidelines set four principal recommendations, including the integration of sanitation into regular local government-led planning and service provision.

UN Resolution 64/292

Adopted in 2010, the resolution recognizes water and sanitation as a human right. The General Assembly has appealed to the states to engage financial and technical resources to accelerate efforts to provide safe, clean, accessible and affordable drinking water and sanitation for all. Since the passing of the resolution, several states have updated their frameworks to reflect water and sanitation as human rights.

Europe

Water Framework Directive

Adopted in 2000, the Water Framework Directive requires all member states to protect and improve water quality in all waters to achieve good ecological status. The initial compliance deadline had been set for 2015; however, this target was missed and subsequently extended to 2027. The River Basin Management Plans (RBMS), based on a six-year cycle, span national borders and set out objectives and timescales required to meet the targets.

Drinking Water Directive

The legislation was introduced in 1998 to protect consumers and ensure cleanliness and safety of water by reviewing and tightening quality standards. The documents set standards and establish limits to microbiological and chemical matter that can be found in drinking water. Water needs to be monitored and tested regularly for the most common pollutants.

EU Taxonomy

The EU Taxonomy, as a classification system, provides definitions for which economic activities can be considered environmentally sustainable. Water protection is embedded in the EU Taxonomy through one of the final four objectives. The goal of the third environmental objective "The sustainable use and protection of water and marine resources" is to ensure at least good status for all water bodies by 2027, and good environmental status for marine waters as soon as possible; and to prevent the deterioration of bodies of water that already have good status or marine waters that are already in good environmental status. The taxonomy defines activities that protect from any contamination of water intended for human consumption and ensure that water is free from any microorganisms, parasites and substances that constitute a potential danger to human health. Some of the examples of substantially contributing activities would be factories treating wastewater from another installation, renaturation of rivers or installation of water-efficient irrigation systems. The Water Framework Directive represents the primary regulation for the third Taxonomy objective. A second delegated act for the four remaining objectives (including the one concerning water) is expected to be published later in 2022.

US

Clean Water Act (CWA)

In the US, basic guidelines for surface water quality and pollution discharge are regulated by the Clean Water Act from 1972. The legislation prohibits discharging pollutants into navigable waters without a permit, and has created a National Pollutant Discharge Elimination System, which issues such permits for wastewater and stormwater discharges. Section 303 of the Clean Water Act requires states to identify "impaired waters" or waters where current pollution technologies cannot be used to meet water standards. Biodiversity protection, including wetlands preservation, is safeguarded by Section 404.

Safe Drinking Water Act (SDWA)

The Safe Drinking Water Act (SDWA) was passed by Congress in 1974, with amendments added in 1986 and 1996. The legislation sets the minimum standards for drinking water quality and monitors states, local authorities, and water suppliers who enforce those standards. SDWA protects underground drinking water from sources of contamination and regulates permitting, construction and operation of fluid storages and injection wells. Under SDWA, EPA needs to consider a detailed risk assessment when developing standards.

National Primary Drinking Water Regulations

The regulation establishes maximum amounts of microorganisms, disinfectants and organic as well as inorganic chemicals that can be present in drinking water. The regulation is reviewed every six years and lays out treatment requirements for each kind of contaminant. Additionally, the non-mandatory National Secondary Drinking Water Regulations establish guidelines for aesthetic or taste standards in water.

Infrastructure Investment and Jobs Act

President Biden's Infrastructure Bill was signed into law in November 2021. The legislation dedicates $55 billion to clean drinking water infrastructure and $21 billion to removing pollution from water. Some of the increased appropriations include the Clean Water State Revolving Fund (SRF) and Drinking Water SRF, each receiving a guaranteed $11.7 billion over five years. There is a funding provision specifically dedicated to eliminating lead service pipes and dangerous chemicals (PFAS).

California emergency water use regulations

The California State Water Resources Control Board announced new mandatory water restrictions in early 2022. Lawn watering during the 48 hours after a storm, car washing with hoses without shut-off nozzles and the use of drinking water to clean sidewalks can all be fined up to $500 per day.[92] The mandates are expected to last for one year unless renewed.

Brazil

New Sanitation Legal Framework

Brazil's New Sanitation Legal Framework was approved by Congress in June 2020 and aims to achieve the universalization of sanitation and water supply in Brazil by 2033. It hopes to achieve this by attracting public and private investment of $128bn over the next 10 years. The new legal framework aims to reform the procurement of water and sanitation services by prohibiting the provision of sanitation services through program agreements and establishing that service concessions must be awarded via a public bidding process with the participation of public and private companies. In addition, the New Sanitation Legal Framework is intended to establish new guidelines for the federal regulatory institution, the National Waters Agency (ANA).

China

China Water Law

The 2002 China Water Law is a revision of the previous version from 1988. It regulates planning, development and utilisation of water resources. Additionally, it establishes a framework for protection of water and for settlement of disputes over water. Although it was considered a milestone when adopted, the law did not cover a range of issues, such as droughts and floods, among others. The lack of a clear implementation path and a very general legal framework for management of water were cited as some of the shortcomings of the law.[93]

Water Pollution Prevention and Control Law (WPPCL)

When the law was adopted in 1984 it was China's first legislation on pollution prevention and control to establish standards and measures for surface and ground water pollution. Contamination arising from growing industry has received a particular focus. In its subsequent revisions, the law has strengthened the role of local governments in environmental protection and introduced more stringent fines on polluters.

Ten-point water plan

In 2015, China's cabinet outlined a ten-point action plan to curb water pollution and improve the state of water sources. The plan has set specific parameters, such as an objective for 93% of urban drinking water sources and 70% of water in seven key rivers to reach Grade III or above by 2020. In the longer term, China has set a target for improvement of the overall quality of the ecological environment by 2030 and for full improvement by mid-century. In the 14th five year plan (2020-2025), the target for the proportion of water bodies with good surface water quality (grades I-III) was been raised to 85%.[94]

Saudi Arabia

Saudi Arabia, despite being one of the most water-scarce countries in the world, has among the highest water consumption rates per capita, 907m3 a year compared with the global average of 556.[95] In 2019, the Kingdom announced its ambitious water-use reduction plan. Qatrah, is an initiative of the Ministry of Environment aiming to promote water conservation and to reduce the country's consumption to 150l per capita per day by 2030 (from 263l today).[96] Smart metering, rationalization, promotion of sustainable agriculture practices and public education are some of the levers that Saudi Arabia plans to pull to meet is reduction target.

Chile

Chile is currently undergoing a constitutional reform process, and water rights are in the spotlight. The new constitution is expected to establish water as a human right and introduce limits on its use in industry. Earlier this year, the congress passed a bill to limit water allocations to a 30-year cap and to empower authorities to suspend rights if water sources are at risk.[97] In February, the environmental committee approved the proposal to annul previously established water rights for companies. The new regulation will prioritise the use of water for human consumption and require mines, agribusiness and utilities to receive permits to use water in their operations. The referendum on a new constitution will be held in the third quarter of 2022.

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92 https://www.theguardian.com

93Wouters, P., Hu, D., Zhang, J., Tarlock, A. D., & Andrews-Speed, P. (2004). The new development of water law in China. University of Denver Water Law Review, 7(2), 243-308

94 https://cset.georgetown.edu

95 Our World in Data

96 National Water Company

97 https://www.miningweekly.com

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(as of January 31, 2022)

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Stock Rating Category	Count	% of Total	Count	% of Total IBC	% of Rating Category	Count	% of Total Other MISC
Overweight/Buy	1498	42%	401	46%	27%	650	42%
Equal-weight/Hold	1508	42%	385	44%	26%	695	45%
Not-Rated/Hold	0	0%	0	0%	0%	0	0%
Underweight/Sell	554	16%	89	10%	16%	213	14%
Total	3,560		875			1558	

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Morgan Stanley

The Americas
1585 Broadway
New York, NY 10036-8293
United States
Tel: +1 (1) 212 761 4000

Europe
20 Bank Street, Canary Wharf
London E14 4AD
United Kingdom
Tel: +44 (0) 20 7 425 8000

Japan
1-9-7 Otemachi, Chiyoda-ku
Tokyo 100-8104
Japan
Tel: +81 (0) 3 6836 5000

Asia/Pacific
1 Austin Road West
Kowloon
Hong Kong
Tel: +852 2848 5200