INTERNATIONAL TRADE ADMINISTRATION

TopMarkets
A Market Assessment Tool for U.S. Exporters

2019 Top Markets Report
Environmental Technologies

A Market Assessment Tool for U.S. Exporters

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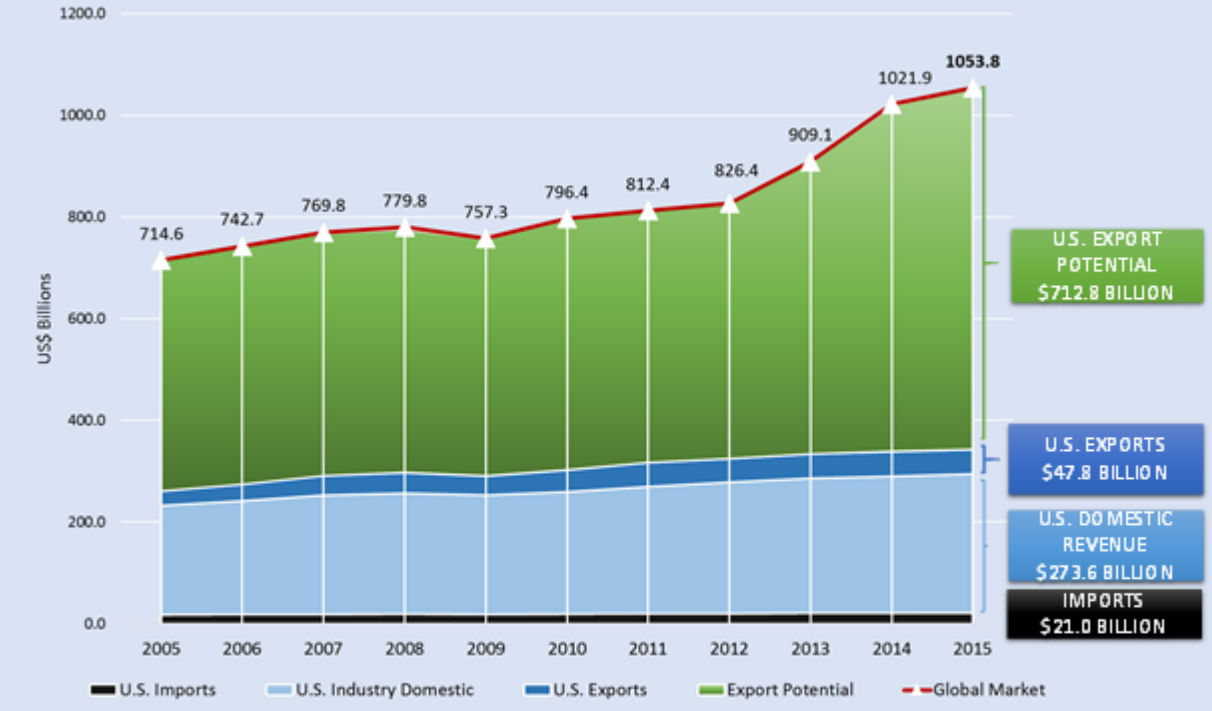


Source: Environmental Business International with ITA analysis

Introduction

The global market for environmental technologies goods and services reached $1.12 trillion in 2017. The United States hosts the single largest market, accounting for approximately a quarter of the global market. The U.S. industry is a global leader in the sector, yielding $342.2 billion of revenue in 2017. U.S. environmental companies exported $47.8 billion worth of goods and services and maintained a trade surplus of $26.9 billion in 2015 (the most recent year data were available). The U.S. industry for environmental technologies employs approximately 1.6 million people. [1]

The 1992 Amendments to the Export Enhancement Act (the Statute) declares that it is U.S. policy to foster the export of U.S. environmental technologies goods and services. To support this policy, the Statute mandates the creation of the Environmental Technologies Working Group (ETWG), an interagency subcommittee of the Trade Promotion Coordinating Committee (TPCC). The ETWG'sgoal isto address all issues with respect to the export promotion and export financing of U.S. environmental technologies, goods, and services, and to develop a strategy for expanding such items. Under the Statute, the Secretary of Commerce also must publicize information on existing and emerging markets and market trends to address issues and develop strategies related to environmental technologies goods and services, as well as a description of the export promotion programs agencies in the ETWG to develop in support of the ETWG's goals.

The U.S. Department of Commerce's International Trade Administration (ITA) and the U.S. Environmental Protection Agency (EPA) co-chair the ETWG. The interagency collaboration under the ETWG leverages the U.S. EPA's experience in addressing challenging environmental problems with the ITA and other TPCC agencies' trade policy, promotion, and finance capabilities.

To achieve the goals for the ETWG within the context of finite government resources, the interagency team has targeted trade policy and promotion programs that enhance the international competitiveness of the U.S. environmental technologies industry. In so doing, the ETWG seeks to help mitigate global pollution problems, striking a balance between energy and industrial development and maintaining clean water, air, and soil. Specific activities include the dissemination of U.S. technical knowledge and expertise to foreign environmental regulatory organizations, the identification and removal of trade barriers, and the provision of targeted industry-specific export promotion services to U.S. companies.

Top Markets: Key Findings and Methodology

This "Top Markets Report" supports the efforts of the ETWG by identifying and ranking export markets where focusing finite government resources will have the greatest impact in terms of increasing commercial opportunities for U.S. companies. This report distills market forecasts and quantitative assessments into overall market scores that rank export markets relative to three critical traits: first, markets that are large and growing in absolute terms; second, those that have a defined and increasing need for imported technology and services; and third, those where U.S. exports are lower than expected based on markets with similar characteristics. This last component indicates that policy and trade barriers might exist, and where U.S. government intervention on behalf of U.S. exporters would be most helpful.

Figure 2: Environmental Technologies Top 25 Markets

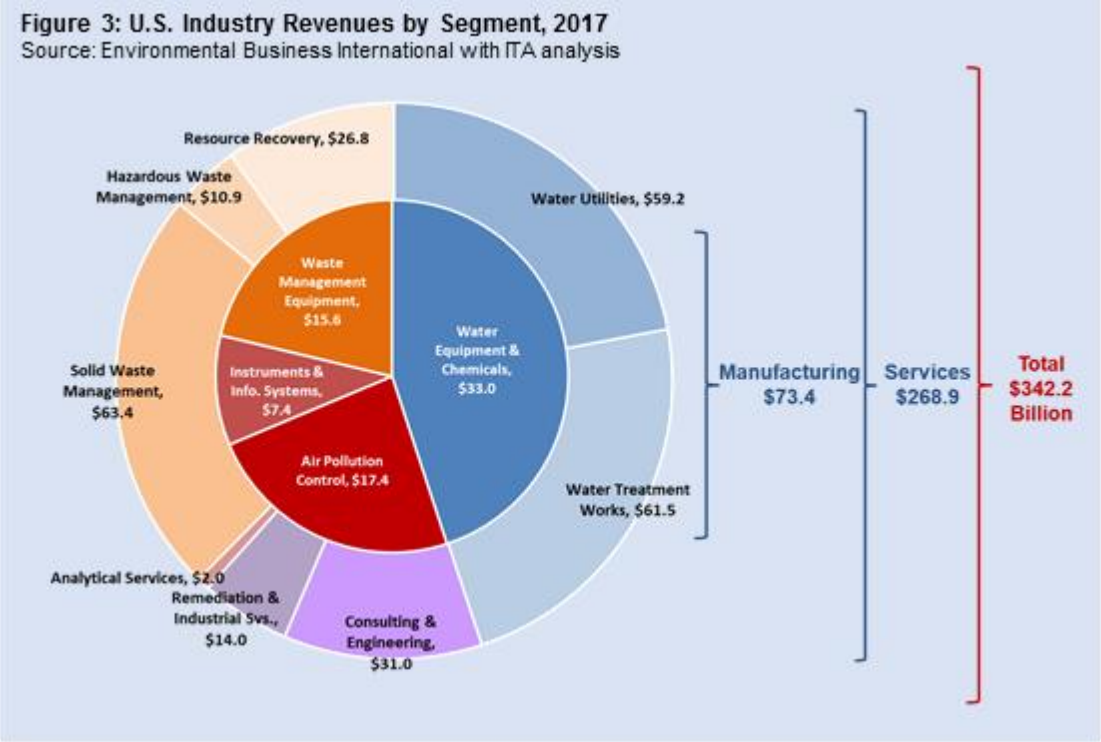
The rankings are filtered further to adjust for mature markets that are large and open to U.S. products and services and that boast relative ease of doing business overall. For the purposes of this report, these markets are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. The result of this analysis is a list of large and growing markets where the scope of opportunity for American companies is restricted by the presence of policies or other barriers to exports. These are the markets where U.S. government initiatives aimed at reducing trade barriers and promoting exports have the highest potential for impact. These markets and their environmental subsectors are scored on a scale from zero to 100, with 100 being the highest score in the Composite Environmental Technologies ranking. Utilizing these scores, readers can assess the relative contribution of a given market's subsectors to its composite score and can compare both subsectors and composite scores across markets. (See Figure 2 for a visual representation of the top 25 markets, with the top 10 highlighted in dark blue. See Appendix I for the full rankings list and Appendix II: Methodology for a detailed description of this report's methods.)

The next step is a qualitative assessment of opportunities and challenges in the top 10 ranked markets. Industry and market experts collaborated on this effort to define the scope of opportunity for U.S. companies, as well as to identify barriers and obstacles that should be addressed by the U.S. government. This analysis leads to the identification of programmatic and policy remedies best suited to address both the challenges and opportunities in these critical markets. This suite of programs forms a nexus of trade promotion and policy interventions that are mutually reinforcing. By considering both promotion opportunities and policy barriers in this context, and by developing a holistic response, this report serves as a strategic guide to drive interagency coordination for promoting exports of U.S. environmental goods and services.

Understanding Global Environmental Markets

Before a government strategy to address the opportunities and challenges to environmental technology exports can be developed, a common definition of the environmental technology industry must be established. This is particularly important for environmental technologies, since the term could include any permutation of goods and services that might fall under the nebulous category of being environmentally friendly or beneficial. In practice, producers of environmental technologies have a clear definition for their sector. From an industry perspective, environmental technologies are defined as all industrial goods and services that:

1. Foster environmental protection and physical resource efficiency in industrial settings;
2. Generate compliance with environmental regulations;
3. Prevent or mitigate pollution;
4. Manage or reduce waste streams;
5. Remediate contaminated sites;
6. Design, develop and operate environmental infrastructure; and
7. Afford the provision and delivery of environmental resources.



Source: EBI Data with ITA analysis.

Environmental technologies generally are categorized by the three environmental mediums they are designed to protect or provide: water, air, and soil.

SECTOR SNAPSHOTS

Water, Wastewater and Industrial Water

The water medium category addresses the water and wastewater treatment subsector with key segments being municipal drinking water delivery and treatment, municipal wastewater conveyance and treatment, ground and surface water remediation, industrial process water treatment, and industrial wastewater treatment. U.S. industry revenue in the water and wastewater treatment subsector in 2017 was $162.4 billion. This figure includes analytical services, wastewater treatment services, consulting and engineering, equipment and chemicals, instruments and information systems, and utilities. [1]

Municipal drinking water treatment and delivery, municipal wastewater conveyance and treatment, and ground and surface water remediation are distinct from industrial water treatment. The former deals mostly with public-sector clients concerned with provision of water for human consumption and use and the protection of water as an ecological and social resource. The public utility aspect of these markets generally translates into a low degree of market flexibility and innovation due to a relatively higher regulatory burden that is applied to protect human health.

Alternatively, industrial process and wastewater (sometimes called "produced water") speak to water's value as an economic input for a variety of industries. Industrial water treatment solutions typically are more diverse and sophisticated than municipal treatment systems and are usually higher on the value chain for generating revenue for suppliers. The cost and complexity of treatment technologies are dependent on the quality of water needed for specific industrial processes, the contaminants introduced, and the regulatory requirements placed on industrial effluents, i.e., water released back into the environment.

Key Market Trends and Themes for the Global Water Industry

Zero Liquid Discharge, Reuse and Resource Recovery
Water scarcity, increasing costs of fresh water for industrial uses, and growing costs to meet stringent effluent discharge regulations are driving a trend toward Zero Liquid Discharge (ZLD). ZLD applies a process-tailored suite of advanced treatment technologies – such as evaporators, brine concentrators, and crystallizers – to treat industrial effluent to a high degree of purity for reuse. Companies employing ZLD systems produce no effluent, and thereby avoid effluent permitting and regulatory costs altogether. ZLD is a rapidly expanding technology suite utilized in industrial settings, especially in the power generation, oil and gas, and chemicals industries. ZLD also provides companies with extracted organic or mineral solids, which can be reused on sighton-site to produce energy or as a potential manufacturing input that can be sold on the open market.

In the municipal sector, there is a trend toward resource recovery, where wastewater treatment plants recover and use or sell energy, organic solids, minerals, and nutrients. These facilities are now referring to themselves as water resource recovery facilities (WRRF) rather than wastewater treatment plants. Growing technology areas for WRRFs include nutrient recovery and anaerobic digestion with combined heat and power.

Smart Water Technologies

The deployment of smart water technologies is being driven by the growing trend toward improved water pricing, efficiency, and conservation and loss. Smart water technologies include systems that automate monitoring and metering, treatment, distribution, loss, and leakage. These 'smart' components include a suite of automation and monitoring technologies that are linked into a network that includes human interfaces and controls.

In utility and industrial settings, smart water is governed by supervisory control and data acquisition (SCADA) systems. Consumer-sector interfaces can take the form of any combination of smart meter and consumption management technologies, including web-enabled versions for personal mobile devices.

Climate Adaptation

Climate vulnerability is forcing utilities to fundamentally rethink how they move, treat, and store water and wastewater products. Climate vulnerability poses three major challenges to water service providers: (1) disruption of service resulting from infrastructure failures caused by severe weather events such as hurricanes; (2) combined sewer overflow due to increased frequency and severity of precipitation events; and (3) water shortages caused by prolonged drought.

Climate concerns are leading to a paradigm shift in the configuration of water infrastructure and in how water is managed. New investments are being made in modular and mobile systems for emergency response; evaporation prevention technologies; water storage systems; groundwater recharge systems; storm water management; smart metering for billing and automated shutoff systems; and a slew of adaptive technologies for treatment processes with increased durability and the ability to treat variable rates of flow and volumes.

Public Private Partnerships (PPPs)

PPPs in water infrastructure are typically defined as an arrangement between the government and a private entity (often an Engineering, Procurement, and Construction (EPC) firm or private operator). In these arrangements, a private entity invests in partial or whole ownership of a capital development project or utility service in exchange for a share of tariff revenue. There is no standard model for how PPPs are structured to handle the division of capital, service responsibilities, project and asset risk, and revenue sharing. PPPs can therefore range from basic operations concessions to "Build-Own-Operate" models where the private entity is the wholesale owner of the water infrastructure and utility service.

PPP projects are growing rapidly throughout the world. Governments turn to PPPs to address funding gaps for infrastructure projects, to provide more efficient service to consumers, and to defray project and asset risks. Businesses find PPPs to be lucrative long-term investments where tariff rates are optimized, and tariff avoidance is low. The scope of opportunity for PPPs rests in the quality and consistency of the rate payer; the government's ability to create incentives for PPP projects through balancing risk and financial incentives; and the private sector's willingness to navigate a complex contractual system of asset and revenue ownership and operation and transfer to maximize profitability.

Air Pollution Control

The air medium category deals with air pollution monitoring and control technologies for both stationary and mobile pollution sources. Stationary sources include emissions from thermal energy generation and industrial sources such as boilers, incinerators and smelters. Mobile sources include everything from automobiles to heavy duty vehicles to ships.

Monitoring technologies make up a substantial segment of the industry, including instrumentation and software required for public applications that monitor ambient air quality. This segment includes industrial and fence-line monitoring systems and software that assess specific industrial sites and applications, as well as fence-line monitors for trans-boundary sources. U.S. industry revenues for air pollution control in 2017 totaled $20.7 billion, including equipment, instruments, and attendant services. [1]

Air pollution control technologies are determined by the scale of emissions and types of pollutants that need to be captured. Large emitters, such as concrete producers and coal-fired power plants, deploy systems that are the size of a city block and cost millions of dollars to install and operate. Smaller operations, such as those attached to medical incinerators, have a substantially lower emissions footprint and cost profile. Mobile sources – including marine diesel engines, non-road diesel engines and automobile engines – are primary examples of scale-driven systems based on unit pricing. An example of a scalable control technology is the catalytic converter in passenger vehicles.

Key Market Trends and Themes for the Global Air Pollution Control Industry

Emissions Control for Coal-Fired Power Plants
Parts of Asia, especially China and India, continue to use coal as their primary source of power. Approximately three-quarters of all currently planned coal-fired power plants worldwide are slated to be installed in one of those two countries. Depending on the stringency of the regulatory environment, these plants are likely to result in an abundance of both retrofit and new installation opportunities for stationary source emission reduction and control technologies in the next five to 10 years. The types of technologies needed for a given power plant will depend on regulatory requirements. The type of coal to be burned is also relevant, as pollutant levels vary for different kinds of coal. In addition to the demand for more traditional technologies used to limit or control NOx, SOx, particulate matter and mercury emissions, state-of-the-art emerging technologies – particularly those designed for multi-pollutant control – are likely to be of great interest to foreign buyers. Emerging technologies include non-carbon sorbents for removal of flue gas mercury, and non-thermal plasma and activated coke for multi-pollutant removal.

Municipal Solid Waste, Hazardous Waste, Recycling, and Resource Recovery

The soil media category includes solid and hazardous waste management, recycling and resource recovery, and soil pollution prevention and remediation technologies. Like municipal water treatment, municipal solid waste is subject to a high degree of regulatory burden due to the public policy considerations related to waste management. The technologies needed by this sector depend on the composition and properties of the waste generated. Revenues for the U.S. solid waste and recycling industry equaled $97.7 billion in 2017, predominantly from waste management services. [1]

The recycling industry is driven by demand from materials markets and its growth is dependent on the price of commodities and other economic factors. The U.S. hazardous waste management industry, which deals with industrial wastes that require independent treatment and storage technologies due to the potential for contamination, accounted for $20.3 billion in revenues in 2017. [1]

Key Market Trends and Themes for the Global Waste Management and Recycling Industry

Sustainable Materials Management

Sustainable materials management (SMM) is a systems-wide approach that meets the needs of society while simultaneously reducing materials use, waste generation and negative environmental, social, and economic impacts. Materials and resources (including land, energy and water) are used and reused effectively and efficiently throughout their life cycles (including extraction, processing, design, manufacturing, production, use, reuse, end-of-life management and all transportation). Historically, societies have viewed the life cycle of a product as linear, *e.g.* from production, to use, to disposal. SMM is an alternative approach that emphasizes the productive use and reuse of materials throughout their lifecycle. Beginning with materials extraction and following with each stage in a product's life, the product – or more precisely, the materials from which it is made – are viewed as key and valuable inputs for other processes. The goal is to minimize the amount of materials involved and all associated environmental impacts and waste generation. SMM has become popular among policymakers and the public to address life cycle environmental impacts of materials. It can also help industries decrease costs associated with the purchase of typically expensive virgin materials, as well as enhance efficiency and reduce materials losses during production.

Conversion Technologies

Solid waste conversion technologies include gasification, plasma arc gasification, anaerobic digestion, pyrolysis, and thermal depolymerization. These technologies differ from traditional waste incineration processes because they do not involve combustion. Instead, they typically use thermal degradation or electric current to convert the solid waste to liquid fuels, syngas, biogas, heat, electricity and/or chemical products, depending on the inputs and the process. Most of these conversion technologies are proven for homogenous waste streams and are operating commercially in several locations outside of the United States. There is limited data on their effectiveness for mixed waste or municipal solid waste feedstocks, particularly on a larger scale. Market opportunities for conversion technologies are likely to expand with the increase of waste generated by the growing global population. According to the Global Energy Council's 2016 Waste-to-Energy report, in 2013 the global waste-to-energy market (including

both traditional incineration as well as conversion technologies) was valued at $25.32 billion.

Monitoring and Instrumentation

Crosscutting the three media categories is the monitoring and instrumentation subsector, which includes monitors and testing equipment for the air, water, and soil; metering technology for water treatment and conveyance; and laboratory equipment and testing services. U.S. industry revenues in 2017 for instruments and information systems totaled $7 billion, led by instruments for water and wastewater management at $2.5 billion, followed by those for air quality at $1.4 billion and remediation at $1.2 billion. [1]

Air pollution control technologies are determined by the scale of emissions and types of pollutants that need to be captured. Large emitters, such as concrete producers and coal-fired power plants, deploy systems that are the size of a city block and cost millions of dollars to install and operate. Smaller operations, such as those attached to medical incinerators, have a substantially lower footprint and cost profile. Mobile sources – including marine diesel engines, non-road diesel engines and automobile engines –are primary examples of scale-driven systems based on unit pricing. An example of a scalable control technology is the catalytic converter in passenger vehicles.

Environmental Consulting and Engineering

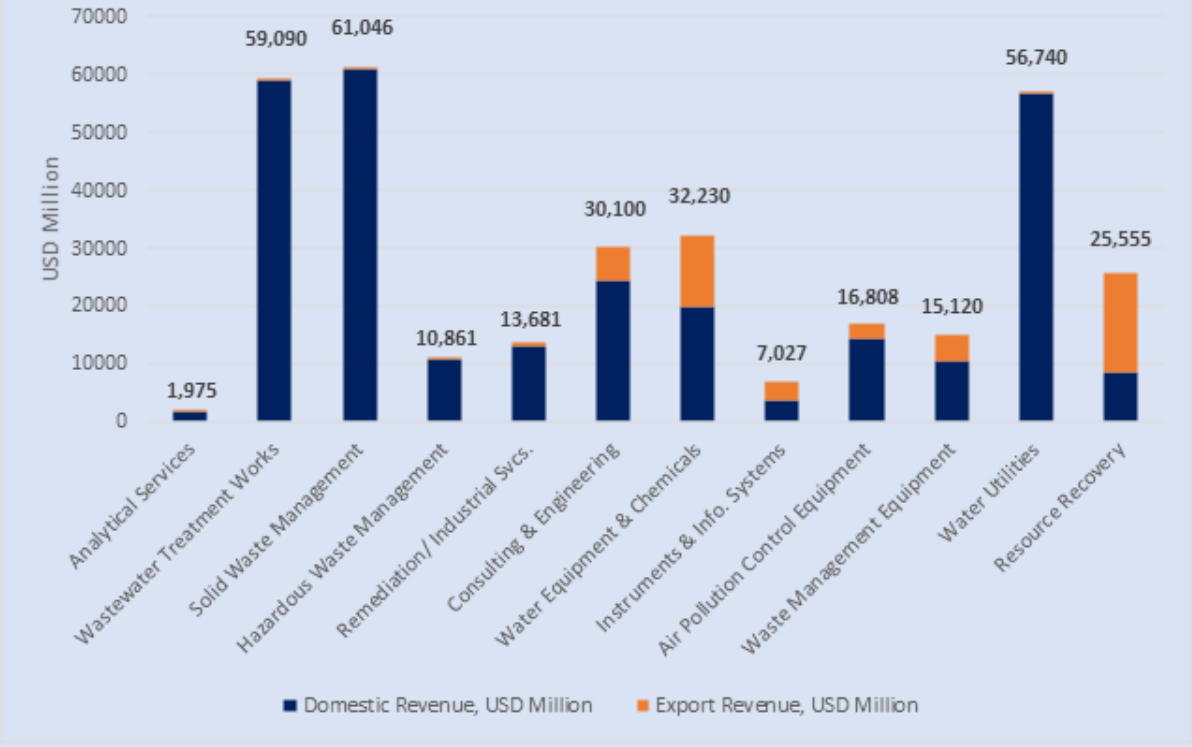
Environmental consulting and engineering also cut across the three mediums categories. The industry is comprised of practitioners who design, develop and operate environmental infrastructure and systems that can be free-standing or part and parcel of larger projects.

An example of a free-standing environmental project includes the site assessment, design, engineering, construction, and operation of a wastewater treatment facility, whether municipal or industrial. An example of a part-and-parcel project is a site environmental impact assessment and sustainability design component for a new building.

The variability of projects and services of this environmental sector contributes to difficulty in establishing reliable market figures. Nonetheless, Environmental Business International's (EBI) survey of the industry reports 2017 U.S. revenues of $30.1 billion for environmental consulting and engineering.

Though interrelated in terms of their collective impact on ecology, the environmental technology medium subsectors and segments generally function as independent markets driven by both regulation and demand from client industries. The implications for an environmental technology export promotion strategy are that these diverse and complex markets must be complemented by a promotion strategy appropriate to their respective market drivers.

Figure 4: U.S. Environmental Technologies by Segment - Domestic and Export Revenue



Source: EBI Data with ITA analysis.

UNDERSTANDING EXPORT PROMOTION STRATEGIES IN THE CONTEXT OF GLOBAL MARKET DRIVERS

Rules Supersede Needs in the Global Market for Environmental Technologies

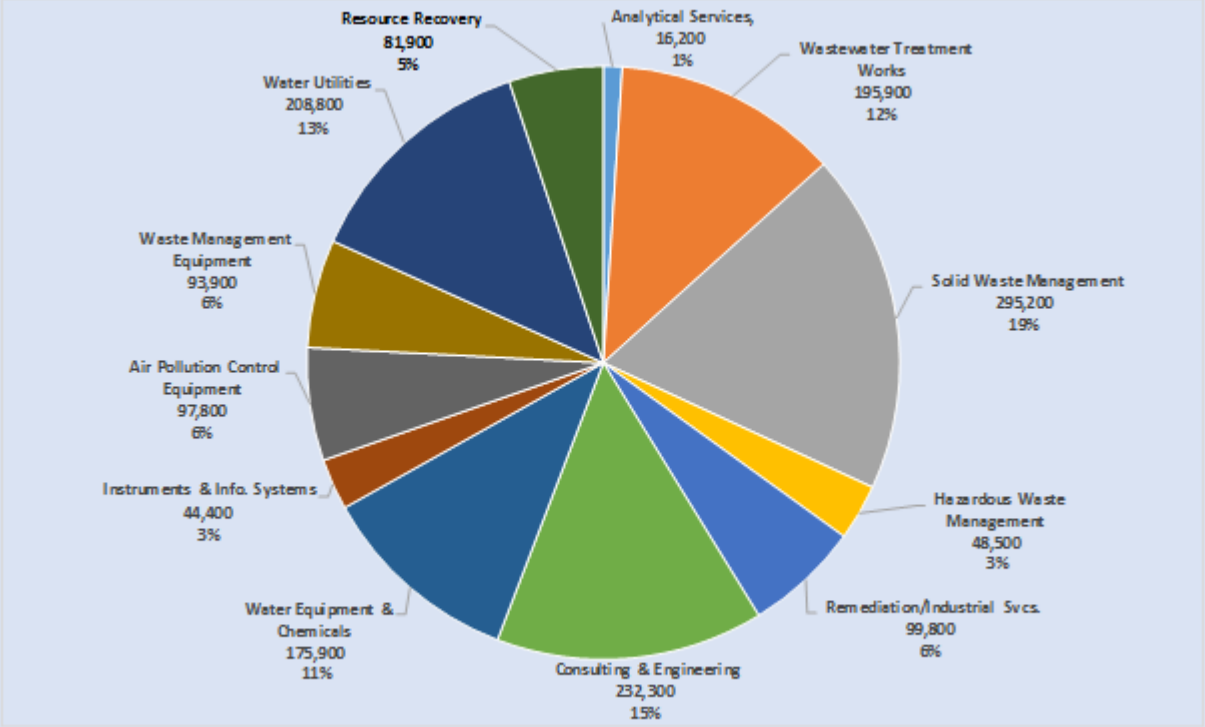
To establish an effective export promotion strategy for U.S. environmental technologies, there must be an understanding of how environmental markets function. These markets are not driven by environmental needs, like the lack of potable water, nor are they driven by conservation philosophies, such as the desire to protect natural resources for future generations. Instead, markets for environmental technologies are driven by environmental regulations. Specifically, environmental markets develop in settings where the cost of non-compliance with environmental rules exceeds that of compliance. The health of a market is determined by a functional system of enforcement.

In the absence of enforcement, compliance failures negate the implementation and maintenance of environmental protection systems regardless of the scope of environmental challenges in a market. A recent example of this is air pollution control in China. The Chinese government passed its first air pollution control law in 1987 followed by revisions in 1995, 2000, and 2015. Weaknesses in the earlier statutes that fostered the absence of an effective enforcement mechanism led to China's pervasive and widely reported air pollution problems. Data from the U.S. Embassy in Beijing show that from April 2008 to March 2014, only 25 days qualified as "good" air quality days using U.S. standards. [2] The implication for export promotion is that needs-based approaches fail to accurately anticipate market opportunity.

Therefore, this report not only tracks needs but also monitors new legislation, implementation, and government enforcement efforts.

While regulatory enforcement incentivizes environmental markets, finance ultimately is the catalyst for market growth and development. Environmental technology markets fail to accelerate without resources to fund public-sector environmental infrastructure projects and private-sector environmental compliance requirements. For this reason, this study emphasizes national mechanisms to finance public infrastructure projects required to meet national environmental goals.

Figure 5: U.S. Environmental Industry Employment



Source: EBI data with ITA Analysis

Resource Scarcity is an Emerging Driver of Environmental Technologies

Resource scarcity and the corresponding demand for resource efficiency are important drivers of environmental technology markets. Since environmental resources play an integral role in industrial production, their value as an input creates demand for technology that enables their efficient use and reuse. An example of this relationship is the boom in investment and development of water treatment and reuse technologies for the recovery of natural gas through hydraulic fracturing. The productive value of a cubic meter of water in the hydraulic fracturing process is estimated to be about $1.54. [3] Comparatively, a cubic meter of water used in agriculture has a productive value of approximately $0.13, demonstrating that investments in water efficiency enhance profits for natural gas producers. [3] Between 2005 and 2012, the Office of Energy and Environmental Industries at the International Trade Administration estimates that U.S. venture capital firms made $415.1 million in R&D investments for new treatment technologies aimed at promoting the reuse of produced water and better managing the cost of process water in extractive industries, based on publicly reported venture capital deals.

Similarly, the recycling industry is predicated on the price of materials and the cost of non-virgin materials as productive inputs. Historically, as the price of virgin materials has risen along with energy and other associated costs, the demand for recycled materials has grown along with the technologies required to produce them. This effect is compounded by the overall scarcity of materials.

Capital efficiency and the demand for industrial hygiene also can drive demand for environmental technologies. An example is the requirement for mercury removal in natural gas-fired power plants, since even low levels of mercury in the fuel stream can destroy heat exchangers and other essential equipment.

Demand for resource efficiency-driven environmental technologies is expected to increase as resource scarcity is compounded by demographic, social, and ecological trends, including climate variability, population growth, urbanization, per capita income growth, and changes in consumption patterns.

CHALLENGES FOR U.S. ENVIRONMENTAL TECHNOLOGIES AND SERVICES ABROAD

Figure 6: Challenges and Opportunities Matrix

Source: Environmental Technologies Trade Advisory Committee (ETTAC) and ITA analysis

The United States hosts a comparatively advanced and sophisticated environmental technologies industry. The U.S. brand is highly valued in global markets. U.S. environmental products are recognized for their excellence in innovation, engineering, and durability. Global buyers recognize the U.S. brand for the services associated with U.S. environmental technologies, which emphasize long-term business and engineering relationships over short-term sales opportunities. Despite the recognized excellence of the U.S. industry, companies face a variety of challenges in the international market.

Business Time Horizons

The time horizon for fostering a business relationship that leads to the sale of an environmental system typically is one to five years. For international markets, this translates into substantial corporate investment in time and resources to develop business partnerships. It also leads to statistics indicating relatively poor success in U.S. export promotion activities and a correspondingly diminished interest within government to support programs for the industry. The success horizon often exceeds the typical three-year limit for harvesting results from U.S. export programs.

Preferential Procurement Practices and Cost/Quality Trade-offs

The sophistication of U.S. products coupled with the cost of production in the United States has a corresponding effect on price. The high price differential for U.S. technologies and systems can negate competitiveness in low-income markets. U.S. products may also be passed over in the short-term for lower-cost and less durable alternatives despite the long-term operational cost competitiveness of U.S. products. Similarly, preferential procurement practices that favor domestic competitors or competitors from aid-donor countries can create an overall environment of unfair competition for U.S. companies.

Tariffs
Tariffs remain a substantial and limiting barrier to trade in environmental technologies. The United States Trade Representative (USTR) reports tariff peaks in environmental technologies among World Trade Organization (WTO) members of 20% for air pollution control, waste management and recycling, and monitoring and instrumentation products. [4] Tariffs for water and wastewater products are as high as 21%. In many markets, high tariffs compound the price differential for U.S. environmental technologies, making U.S. products prohibitively expensive in many markets or eroding profitability of U.S. goods in export markets.

Standards, Regulation, and Certification
Beyond tariffs, substantial and often insurmountable barriers exist for U.S. companies with respect to different standards regimes, lack of regulatory compatibility, and failure to provide mutual recognition of product and professional certifications.

The United States drives innovation in part through its approach to standards, which emphasizes performance-based measures of conformity where practicable, and predicates standards and testing protocols on the principles of science, risk assessment, and cost-benefit analysis. This creates conflict in foreign markets that emphasize design-based standards models and utilize the precautionary principle in developing standards and regulation – an approach that eliminates the practicability of performance-based design, stymies innovation and narrows the field of applicable technologies to those developed within the destination market. It also imposes onerous additional fees for testing and conformity assessment to similarly performing technologies and equally rigorous professional certifications.

Data Gaps and Asymmetrical Market Information
Weak trade and market data have plagued the environmental technologies industry for some time. Neither the Harmonized Tariff System (HTS) nor the North American Industrial Classification System (NAICS) accurately address the breadth of technologies and services within the industry. Determining market size and opportunity is a persistent problem. (See the Methodology section for how these gaps are addressed in this study.)

The U.S. market is large and, until recently, substantial enough to support the business aspirations of many U.S. environmental technology providers. Saturation of the U.S. market, however, coupled with explosive growth in emerging markets, makes international growth inextricably linked with companies' growth. Small- and-medium-sized enterprises need to identify markets where their technologies are in demand and develop business relationships that will lead to future sales. The lack of market data makes it difficult to determine the best foreign market opportunities and makes it difficult for individual companies to discern where their specific products could be most in demand.

U.S. Government Resources and Coordination
U.S. agencies that are members of ETWG face a variety of challenges in promoting environmental exports. These challenges include a lack of resources needed to effectively conduct interagency coordination; different missions (which may subordinate export promotion as a priority); diminishing staff and budget resources for program implementation; and limited mechanisms to transmit market information to industry and individual companies.

THE ROLE FOR U.S. GOVERNMENT IN EXPORT PROMOTION

Successful export promotion of environmental technologies has four critical components:

1. Policy dialogue and development with foreign governments;
2. Technical assistance to foreign governments for regulatory development and environmental management;
3. Direct market promotion and advocacy; and
4. Financial vehicles for project development and export finance.

Figure 7: Environmental Technologies Export Promotion Process

Policy Dialogue and Development

The export promotion objectives of policy dialogue and development are two-fold: identify and eliminate existing foreign trade barriers, and prevent new barriers from being created.[1] This occurs through regular bilateral dialogues, regional discussions, and negotiations with foreign governments and stakeholders.

Technical Assistance for Regulatory Development and Environmental Management

The regulatory nature of the industry means that the U.S. government can be particularly effective in facilitating the creation and expansion of environmental export markets by providing technical assistance that creates opportunities to encourage the development of compatible foreign regulatory approaches. Technical assistance to foreign regulatory bodies increases the understanding of the efficacy of U.S. approaches, particularly the emphasis on solutions underpinned by science. Technical assistance can also yield favorable market results when it facilitates the creation of strong legal authorities and effective mechanisms for enforcement, as well as knowledge and expertise for the maintenance and management of environmental systems.

[1] Capacity building efforts of agencies such as the U.S. EPA are primarily driven by environmental benefits, including reducing transboundary pollution.

The interagency ETWG provides technical resources to the public such as the U.S. Environmental Solutions Toolkit (www.export.gov/envirotech_toolkit). This is an online searchable database that combines the U.S. EPA's scientific and regulatory expertise with a catalog of U.S. technology providers for specific environmental applications. There are a variety of memoranda of understanding between the U.S. EPA and foreign regulators to provide them with technical know-how. There are also stand-alone technical assistance programs such as the U.S. Trade and Development Agency's (USTDA) Global Procurement Initiative (GPI).

Because the failure of environmental control systems can harm human health, the higher risks associated with new technologies can prevent their introduction. Similarly, a lack of technological know-how is a formidable barrier to the development and implementation of environmental systems. The USTDA works to address these challenges by funding demonstration projects in select emerging markets and educating foreign officials and buyers through reverse trade missions (RTMs).

Direct Promotion and Policy Advocacy

Direct promotion and policy advocacy facilitate company and industry export sales by identifying and advocating for the removal of trade barriers, as well as by describing market opportunities and facilitating business relationships. The ITA and other TPCC agencies provide businesses with market information, trade counseling, and opportunities to develop international business relationships.

Provision of Financial Vehicles for Project Development and Export Finance

The lack of finance limits U.S. environmental technologies exports. The Overseas Private Investment Corporation (OPIC) helps fill the gap by funding foreign development and construction of infrastructure projects. Direct export finance is provided to U.S. companies through the Export-Import Bank of the United States, which provides a suite of export finance and insurance products to facilitate export transactions.

TOP MARKETS IN CONTEXT

The subsequent chapters of this report provide a market and policy overview of the top 10 overseas markets where U.S. trade policy and promotion intervention can yield the best results for the U.S. environmental industry. The analysis of each country's market is supplemented with an overview of existing ETWG programs that support export policy and promotion to these markets along with recommendations for additional government programs to eliminate trade obstacles that would lead to more export opportunities for U.S. companies.

COUNTRY CASE STUDIES

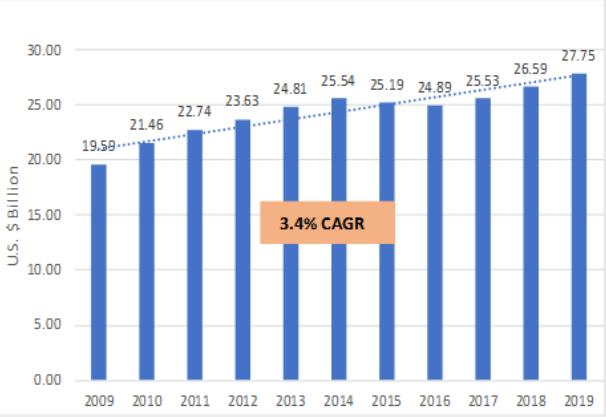
Brazil Case Study

Brazil ranks third overall in the 2019 Top Markets Report. With a score of 3.2, Brazil ranks fourth for waste and recycling technologies market. It ranks fifth for both air pollution control and water technologies markets, with scores of 19.2 and 12.0, respectively (see Appendix 1 for global rankings). Brazil's environmental technologies market is sizeable and growing, but opportunities are tempered by recent political and economic instability, as well as widely variable levels of enforcement, technical capacity issues, and other challenges.

Brazil's environmental technologies market (including goods and services) is estimated to be valued at $27.75 billion in 2019. [1] The size of Brazil's market makes it worth including in this report in spite of its slightly lower compound annual growth rate (CAGR) as compared with other included markets. However, the scale of Brazil's market largely can be attributed to its population of 208.8 million [5] and its growing middle class, as opposed to strong adherence to environmental laws.

Brazil's GDP dropped steadily after 2010. However, in 2017, Brazil's economy began to show signs of recovery. In November 2018, the Brazilian government forecasted a 2018 growth rate of 1.4%. [6] Brazil's market potential for U.S. environmental technology producers is juxtaposed with chronic political instability at the national level and varying levels of technical capacity, enforcement capability, and available financing for environmental projects at the regional level. Tariff and non-tariff market barriers also impede the competitiveness of U.S. firms. As this report will delineate, opportunities are great across all sectors, but uncertainty around implementing and financing advanced environmental systems remains.

Figure 8: Brazil's Environmental Technologies Market



Source: Environmental Business International with OEEI Analysis, 2019.

State of the Environmental Regime

The Brazilian government has high ambitions in terms of environmental policy development but limited means at this time to fulfill that ambition. Enforcement shortfalls, variable technical capacity to implement environmental rules, and limited public finance for environmental projects continue to hobble the country's sizeable market potential.

Environmental authority in Brazil is vested in the National Environmental System (SISNAMA), a multi-level, whole-of-government institution created by the 1981 National Environment Plan to (NEP) to protect against environmental degradation. Within SISNAMA, the National Environment Council (CONAMA) is the interagency working group that advises policymakers on environmental issues, rules, and standards. The main oversight body in the environmental sector is the Ministry of the Environment (MMA), however certain responsibilities

related to natural resource management and conservation are delegated to the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA). As the majority of implementation is completed by local- and-state-level governments, these bodies function independently but answer to their national-level counterparts on statutory issues.

The Organisation for Economic Co-operation and Development (OECD) Environmental Policy Stringency Index, which ranks environmental regimes on a scale from 0 to 6 (with 0 being not stringent and 6 being the highest degree of stringency), gave Brazil a score of 0.54 in 2015. While unimpressive, this does represent a 0.12-point improvement over its ranking of 0.42 in 2005. [7]

The Yale Environmental Performance Index (EPI) benchmarks a nation's ability to protect the environment through effective policymaking. It uses 10 categories to evaluate different aspects of environmental health and ecosystem vitality. In 2018, Brazil ranked 69th in the world with an overall score of 60.70, showing ample room for policy improvement. It was also ranked seventh in Latin America, placing it below several of its economically weaker neighbors. [8]

Brazil's enforcement and implementation woes emanate from the fragmentation of environmental authority among federal, state, and municipal entities. As a result, there is generally higher capacity to adopt advanced environmental solutions in the urban, southeastern parts of the country such as Rio de Janeiro, São Paulo, and Minas Gerais as compared to more rural states.

One issue that continues to affect environmental compliance across Brazil is that environmental authorities conduct investigations *ex post facto* – based on direct complaints of contamination or after the closure of an industrial facility – rather than regulating in advance via permit requirements. As a result, oil spills, gas leakages, and the inadequate storage of hazardous wastes are both frequent and widely reported in the Brazilian media. [9] Instituting regular monitoring of industrial sites would improve compliance.

Market Barriers

Market barriers in Brazil are persistent and prohibitive for U.S. exporters in many cases. The Department of Commerce's Environmental Technologies Trade Advisory Committee (ETTAC) and the U.S. Foreign Commercial Service in Brazil identified the following barriers as particularly problematic for U.S. environmental technologies companies:

1. **Tendering Practices Favor Competition from Small, Local Businesses**
   Small Brazilian businesses benefit from preferential treatment in public tenders. Contracts involving up to 80,000 Brazilian Real (approximately $21,000) are channeled exclusively to small Brazilian companies and are afforded additional points on commercial evaluation. Further, small companies are prioritized in local and regional contracting if their offer is less than 10% higher than the lowest-cost option. However, legislation also allows a margin of preference of up to 25% for locally made products and services in certain cases. Small local businesses also benefit from tax advantages such as Brazil's "Simple Tax Scheme," which eliminates taxes for companies below a certain annual revenue threshold.

2. **Import Authorization Challenges**
   Registering environmental remediation products at IBAMA is a very lengthy and cumbersome process. Recent changes have made the process stricter, delaying approvals that are now taking

up to one year on average to complete. CONAMA Resolution 463 requires that these products receive registration before being sold or imported in Brazil. Research and tests associated with such products are also subject to IBAMA standards. Additionally, the use of any product would need authorization from the relevant environmental agency at the federal, state, or municipal level.

3. **Local Certifications and Safety Approvals Fail to Recognize International Standards.**
Local electrical and safety approvals are applicable to most products that have electrical components and mechanical parts. Brazil does not accept certification from equivalent U.S. certification and testing organizations, forcing redundant evaluation and imposing additional, onerous costs on U.S. businesses. For example, despite certification from relevant and globally accepted international certification bodies, products that have transmitting and/or receiving devices must obtain approval from ANATEL (Brazil's National Telecommunications Agency). ETTAC advisors also highlight a Brazilian preference for ISO standards even where other equivalent international standards exist. Complications with the certification of transmitting and receiving devices handicaps the sale of U.S. continuous monitoring and automated control devices and systems, an area of competitive advantage for U.S. providers.

Figure 3: ETTAC Illustrative Examples of Market Barriers

Certification Type	Brazilian Agency	U.S. Product(s)	Reported Costs to U.S. Business	Associated Unnecessary Delays
ISO 17025	Inmetro	Monitoring and testing instrumentation	$250,000	1 -2 Years
Generic New Technology Accreditation	Inmetro	Various	**Per Product:** $3,000 $250 per semester recurring $1,750 per inspection **Laboratory expenses:** $17,500	-
Transmitter Technology Certification	ANATEL	Satellite Transmitter to remotely transmit environmental/metrology data	$7,500	4 – 6 Months

Market Opportunities - Air Pollution Control

Given Brazil's heavy reliance on hydroelectric power and relatively low use of conventional combustion in its electricity sector, air pollution in Brazilian cities primarily originates from industrial and mobile sources. [10] Key air quality legislation includes Resolution ANVS/DC #176 of Oct. 24, 2000, which provided reference standards on indoor air quality; CONAMA Resolution #4 of June 15, 1989, which established the "National Air Quality Control Program" (PRONAR); and CONAMA Resolution #3 of June 28, 1990, which defined air quality standards for air pollutant concentrations.

Mobile Source Emissions Control

Relevant legislation related to vehicle emissions includes CONAMA Resolution 18/86, which established the Vehicle Air Pollution Control Program (PROCONVE) and which is complemented by other CONAMA resolutions, and Federal Law #8723 of October 2003, which defines the emissions limits for light and heavy-duty vehicles. Currently, Brazil's diesel engines must follow the Euro V emission parameters, corresponding to the Automotive Air Pollution Control Program (PROCONVE L6 for automobiles and P-7

for heavy vehicles). In February 2017, São Paulo's environmental agency (CETESB) announced new vehicle emissions standards (PROCONVE P-8) to bring standards up to Euro VI equivalent, beginning with heavy-duty vehicles in 2019. However, later that year IBAMA called for public comments on a proposal with a four-year delay to the previously-planned implementation date. [11] The new deadline for PROCONVE-8 is January 2022. When implemented, this new standard should reduce PM and NOx emissions by as much as 90% for new vehicles and significantly reduce air pollution-related deaths. [12]

Technologies and Services in Demand:

- Mobile-source emissions control technologies, especially for heavy-duty vehicles

Air Quality Monitoring and Stationary Source Emissions Control

Addressing air pollution is a recent priority for local governments, generating increased demand for gas emission monitoring technologies, gas analyzers, and air pollution control technologies. In 2013, the state of São Paulo independently established the "New Standards for Air Quality," which is similar to the U.S. Environmental Protection Agency's (U.S. EPA's) National Ambient Air Quality Standards (NAAQS). In January 2015, CETESB publicly released a study called "Emission Reduction Plan for Stationary Sources" (PREFE). The plan evaluates the ambient air quality and lists the non-compliant state regions, as well as the priority sectors for policy moving forward. The PREFE also has a sector program for controlling vapor emissions generated by gas stations, as well as a program for the industries in the Santa Gertrudes Ceramic Pole.

According to CETESB, the principal industrial sources of air pollution in the region include sugar and alcohol plants, laundries, foundries, oil storage terminals, waste and sewage treatment facilities, aluminum smelters, chlorine and soda plants, glass and paint plants, pulp and paper plants, cement plants, and fertilizer plants. As a result, the agency decided to expand its air monitoring program through the acquisition of 10 new monitoring stations. In-demand instruments for these new stations include ozone analyzers, nitrogen oxide analyzers, multi-calibrators, air purifiers, inhalable particle analyzers at particulate matter (PM) 2.5 and 10, wind sensors, humidity and temperature sensors, barometric pressure sensors, and UVA sensors. CETESB estimates that roughly one-third of the market for air pollution control equipment in Brazil is in the state of São Paulo. [13]

São Paulo is not the only state with an environmental agenda. INEA (Rio de Janeiro's environmental authority) has a continuous monitoring network of 21 stations that are supplemented by fence-line monitoring applications at high-emissions industrial sites. Monitors assess criteria pollutants and their precursors , including ozone(O_3), nitrogen oxide (NOx), sulfur dioxide (SOx), carbon monoxide (CO), Volatile Organic Compounds (VOCs), hydrofluorocarbons, and PM. Additionally, several climate change initiatives, including the September 2011 Climate Decree issued by the Rio de Janeiro State Environmental Secretary, will require improved capabilities to measure and control greenhouse gases (GHGs).

Technologies and Services in Demand:

- Air pollution control equipment
- Continuous emissions monitoring systems
- Ambient air quality monitoring equipment
- Source emissions measurement technologies
- Analytical and laboratory testing goods and services
- Fuel vapor control systems

Market Opportunities – Water and Wastewater Treatment

Water and Wastewater Infrastructure

The National Water Resources Plan 2016-2020 includes provisions to address the country's water shortages and improve government integration to meet future water challenges. [14] However, despite the fact that the government has prioritized sanitation services – including water, wastewater, drainage, and waste management services – many projects have struggled due to a lack of funding. For example, the Ministry of Cities reports that the average annual investment in sanitation is around $4.5 billion, or $2.5 billion less than the government of Brazil estimates is necessary to meet its goal of universal access to sanitation services by 2030. [9]

Brazil's recent budget deficits have prevented the Brazilian government from investing in the country's infrastructure. To stimulate economic activity and attract much needed investment to this sector, in September 2016, then-President Michel Temer announced a package of infrastructure concessions and privatization programs. The package included design and construction of wastewater collection systems and treatment facilities as well as upgrades to existing equipment, pumps, and asbestos-contaminated pipes. He also created the "The Investment Partnership Program" (*Programa de Parcerias de Investimentos* or "PPI") for monitoring projects. PPI is part of the President's office, reflecting the high priority the administration attaches to infrastructure.

The new government, under President Jair Bolsonaro, has adopted the PPI, focusing on concessions in the transportation and mining sectors. However, the new Minister for Regional Development announced that by April 2019, the Brazilian government will have compiled a list of 114 water sector projects. This is related to the 2014 National Water Security Plan that aims to guarantee Brazil's water supply by 2035. Total investment is expected to amount to 25 billion Brazilian Real (approximately $6.54 billion), including existing projects. It is anticipated that the Bolsonaro Administration will play more of a supervisory role with individual ministries having more technical oversight of bid specifications.

According to the National Water Agency (ANA), an estimated total of $5.76 billion will be needed in order to avoid urban water shortages by 2025. [15] The National Bank for Economic and Social Development (BNDES) estimated that $14 billion would be invested in the water treatment sector between 2015 and 2018. [16] As of April 2017, fewer than half of the planned tenders for PPP contracts or asset sales had been awarded, suggesting political uncertainty and economic factors had delayed the privatization schedule. [17] President Bolsonaro is expected to continue with privatization plans, which could offer opportunities for water companies. However, concerns about potential rollbacks of environmental regulations, including discharge standards, may reduce the pressure to implement wastewater treatment solutions in the near term. [18]

Products, Services, and Technologies in Demand:

- Engineering, procurement, and construction services
- Operations services
- Pipes, valves, and pumps

Wastewater Treatment and Sanitation Services

In Brazil, there are 27 state-owned water utilities that collectively serve 76% of the population. *Companhia de Saneamento Básico do Estado de São Paulo* (SABESP) in São Paulo state is the largest water utility in the world. It serves more than 24.1 million people and has a global market share of around 0.3%. [15] Local municipal and private sector utilities serve an additional 10% of the population. Thus, only 86% of Brazil's population is served by any water utility, leaving the remainder without access to piped drinking water or sanitation services.

The Brazilian sanitation law and implementation plan, *Plansab*, attempts to bridge the sanitation gap and sets a formal target of universal sanitation services by 2030. [19] With just over a decade remaining, only 39% of wastewater is currently being treated. [15] *Plansab* has forecast that $57.5 billion will need to be invested in drinking water and $86 billion in wastewater transmission and treatment technologies and services to meet the universal access goal. [20] Municipalities and state governments have received $221 billion in federal funds to develop projects in wastewater treatment and sewage. However, though the federal government requires states and municipalities develop local plans to implement *Plansab*, it stops short of penalizing municipalities that failed to do so by the federal deadline. [21] The largest obstacle is a lack of technical capacity for development and implementation.

The likelihood of meeting universal sanitation goals is also threatened by financial shortfalls. Between 2013 and 2017, more than 60 billion Brazilian Real ($17 billion) has been spent on sanitation projects. Fifty-nine percent of *Plansab* is financed by the federal government, with the remaining 41% left to municipalities and regional governments. [21] Data from the Brazilian Ministry of Cities shows that average annual investment in basic sanitation is around $4.5 billion. [16] Meanwhile, the federal government estimates annual expenditure levels of $7 billion will be necessary to reach the 2030 goal of providing basic sanitation services to every citizen. [16] This finance gap in Brazil has led to some creative and fairly successful PPPs for the provision of municipal services. [15] But it has also led to several prominent market failures where planned projects have remained "planned" indefinitely due to limitations in technical capacity and shortfalls in available private sector finance.

In early 2017, the National Bank for Economic and Social Development (BNDES) launched a request for proposals for contracting consulting services that was intended determine how the private sector would enter the water and sanitation market in advance of privatization or PPP contracts that were to be put to bid in 2018. Subsequently, however, 10 of the 18 state governments that originally had signed up to participate in the program have pulled out. Water operators in the remaining eight states submitted consultancy plans to their respective state governments, with tenders expected to be released sometime after the October 2018 elections. [22]

Since then, the interagency working group that monitors *Plansab*'s implementation has planned public hearings for February 2019, with approval by the health, environment, and water resource councils scheduled for April. The group has proposed that the set date for universal sanitation services be postponed until 2033.

Technologies and Services in Demand:

- Headworks
- Aerators and sedimentation technology
- Smart water technologies
- Advanced filtration
- Membrane filtration

- Waste-to-energy technology
- Biological treatment
- Anaerobic digestion
- Nitrification/denitrification
- Integrated Fixed Film Activated Sludge
- Thickeners and dewatering devices
- Sludge dryers and incinerators
- Monitoring equipment
- Testing equipment

Municipal Water Efficiency and Smart Water

Reducing non-revenue water is a top priority for the country. Mitigating leaks in distribution networks is the focus, particularly among motivated cities seeking projects to ensure more efficiency within their water distribution system. Water loss issues are compounded by severe drought, water scarcity problems in arid regions, and increased demand for affordable potable water sources in urban areas. Water stolen or lost in transmission bears a significant cost for Brazilian municipalities as total non-revenue water estimates reach nearly 40%. [23]

This has put enormous pressure on Brazil's state water companies to implement efficiency-enhancing systems and technologies that address non-revenue water, such as smart water software and monitoring equipment. During a two-year drought in 2015, the local utility in São Paulo, SABESP, introduced market-based control measures, including providing discounts for water savings and surcharges for overuse, which reduced water consumption by 30%. SABESP also sought technology-based solutions to this shortage by identifying best practices in water reuse. Droughts and water scarcity are increasingly likely to occur in São Paulo, compounding the need for greater efficiency and conservation of water resources. [24] Severe drought also has plagued the capital city of Brasilia. According to the local water utility (CAESB), despite water rationing measures and infrastructure investments of approximately $36 million in 2017, shortages persisted through 2018. [25]

The likelihood of drought also is increasing local demand for desalination technology. Both Rio de Janeiro and São Paulo have expressed interest in developing desalination capacity to bridge the gap in freshwater demand. [26]

Technologies and Services in Demand:

- Water efficiency and reuse engineered solutions
- Water efficiency and reuse system training and maintenance services
- Smart water systems and software
- Energy efficient physical treatment
- Leak detection equipment and software
- Water loss prevention solutions
- Advanced metering technology and software
- Intelligent valves
- Rainwater collection systems
- Advanced filtration
- Membrane filtration
- Reverse osmosis

- UV disinfection

Process Water, Industrial Wastewater Treatment and Water Reuse
As Brazil's industrial base continues to grow and become more sophisticated, there is increasing demand for water treatment to quality levels specific to the industrial processes as well as for water reuse and efficiency, as industrial water consumers pay the highest rate per cubic meter for freshwater. [16] Key client industries include aerospace, electronics, oil and gas, petrochemicals, mining, metallurgy, textiles, sugar and ethanol, food and beverage, automotive, pharmaceuticals, and pulp and paper.

Industrial effluent laws in Brazil impose high tariffs on companies for effluent disposal in water bodies, making on-site tertiary treatment cost-effective for compliant industrial facilities. From a base of $317.4 million in 2010 and an estimated compound annual growth rate (CAGR) of 9.4%, the industrial wastewater market was estimated to have reached annual revenues of $595.0 million in 2017. [27] Water treatment in the pharmaceutical sector was expected to grow at 9.8% annually between 2014 and 2018 and to reach $38.9 million by 2018. [28]

Water scarcity and adduction costs make desalination and water reuse attractive, particularly in the highly water-intensive extractive sectors. For instance, the average large mining project in Brazil requires approximately $800 million in water technology and infrastructure. [29] Brazil also is expected to be the fastest-growing global market for offshore water treatment in the oil and gas sector with a combined annual growth rate of 8.5%. [30] Global Water Intelligence estimates that capital expenditures on offshore systems for sulfate removal reached $190 million in 2015. [30] Two significant projects that came online subsequently in 2016 and 2017, respectively, are FPSO Cidade de Marica and P76 Petrobras, with a combined sulfate removal capacity of over 71,000 cubic meters per day. [31]

Technologies and Services in Demand:
- Engineering, procurement and construction services
- Water efficiency and reuse engineered solutions
- Water efficiency and reuse system training and maintenance services
- Smart water systems and software
- Advanced filtration
- Membrane filtration
- Reverse osmosis
- UV disinfection
- Ozone disinfection
- Anaerobic digestion
- Aerators and sedimentation technology
- Incinerators and dryers
- Chemical sludge treatment
- Sludge collection systems
- Thickeners and dewatering devices

Market Opportunities – Waste Management and Recycling

Brazil's need for improved waste management is vast. Of Brazil's 26 states, only 10 had solid waste management plans as of July 2017. [32] According to the Brazilian Association of Urban Cleaning (ABRELPE), solid waste generation in Brazil is estimated at 62 million metric tons per year.

Approximately 90% of solid waste is collected, with 37% destined for unsanitary landfills, posing a substantial threat to human health and the environment.

In 2010, Brazil finalized its National Solid Waste Policy, Law 12,305, a measure intended to reduce national waste production and improve solid waste management practices. The law also mandates that municipalities build sanitary landfills and support the development of a formal recycling sector. As a result, investments in solid waste treatment technologies and waste-to-energy projects in sanitary and hazardous landfills are expanding significantly. The Brazilian government plans to invest $870 million in solid waste treatment projects, replacement of landfills, introduction of selective waste collection services, and financing cooperatives of waste collectors.

In addition to the National Solid Waste Policy, other notable regulations include CONAMA Resolution #5 of 1993, which determines that the residue generator be responsible for the preparation and execution of a waste management plan. Environmental Crime Law 9605 of Feb. 13, 1998, establishes penalties for inadequate disposal of solid, liquid, or gas waste. This regulation is complemented by the technical standards of the Brazilian Association of Technical Standards (ABNT), which provides standards for treatment and disposal of residues. There are also regulations, laws, and resolutions at the federal, state and municipal levels on industrial waste treatment and disposal. ABNT/NB - 843 establishes the requirements for landfill operation, including the adequate treatment of liquid and gas effluents. At the beginning of 2017, São Paulo's Secretariat of Environment also issued a resolution requiring entities that carry out activities related to solid waste management to obtain an environmental license. [14]

Recycling is also an area of key importance. The Brazilian Institute for Geography and Statistics (IBGE), states that 18% of the population currently has access to recycling programs. [33] According to ABRELPE, approximately 70% of municipalities have collection initiatives for separating trash from recyclables, which can entail either formalized pickup services or informal partnerships with *catadores*, Brazil's garbage pickers. [32] *Catadores* are estimated to collect as much as 90% of the recyclables in Brazil, and thanks to their collective efforts Brazil has one of the highest aluminum recycling rates in the world, above 90%, as well as a 63.4% rate for paperboard, and a 51% rate for Polyethylene Terephthalate, better known as PET. [32]

According to BNDES's sector analysis, current technologies for waste collection (i.e., compactor trucks) and sanitary landfills (i.e., earth moving equipment, polyethylene landfill liners with leachate and gas collection pipes) are all made in Brazil. Some new waste valorization technologies, however, are being imported. For example, power generators with a 1-Megawatt capacity or greater are imported to produce energy from biogas. The use of container-mounted power modules used in landfills is relatively common in Brazil.

Loga and Ecourbis, two concessionaires in charge of waste management in the city of São Paulo, invested $20 million in building two automated waste separation plants, the first of their kind in the country. The equipment was imported from Germany, France, and Spain. São Paulo plans to build two additional plants soon, representing a market opportunity for U.S. industry. However, investment has slowed recently as the economic recession, reduced municipal tax collections, and ongoing corruption investigations add uncertainty to the business climate. As a result, the deadlines imposed by the National Solid Waste Policy were not met. [16] For example, the policy originally required that municipalities submit their solid waste management plans by the end of 2012, but as of 2018, only 3,152 out of 5,570 municipalities had complied. [34]

Municipal Solid Waste

To comply with the National Solid Waste Policy, several municipalities in Brazil are adopting measures to improve segregated collection, recycling, and organic waste recycling. For example, the municipality of São Paulo planned to have collection of recyclable waste extended to all city districts by June 2016. The municipality was to invest BRL 11 million ($3 million) in trucks, security equipment, uniforms, and warehouses. [16] BNDES lent BRL 41 million ($11 million) for the construction of three waste sorting plants and the refurbishing of 10 existing plants. With investments of BRL 59 million ($22 million), the municipality opened two automated recyclable waste sorting and bailing plants in 2016. Together, they provided the capacity to process 500 million tons of waste per day. The economy has slowed the pace for certain projects. Two additional plants in São Paulo were originally scheduled to begin construction in 2016, but the project is paused because of the economic recession. [16]

Like *Plansab*, the National Solid Waste Policy requires that municipalities develop local solid waste management plans, but in general development and implementation is slow-going. Brazil's National Institute of Geography and Statistics reports that only 32% of the 5,565 municipalities in Brazil have some sort of selective waste collection system, and that a mere 10% met an August 2012 deadline to present a solid waste management plan to the Environmental Ministry as articulated in the National Solid Waste Policy. More than half of Brazilian municipalities dispose of waste without proper precautions in open dumps known as *lixões*. Less than 12% of Brazilian cities have the infrastructure to separate recyclables from organic waste. Further, less than one percent of all municipalities in Brazil have facilities to compost organic waste. [33] In the capital of Brasilia, Governor Rodrigo Rollemberg closed the aging Estrutural dump, the largest dump in Latin America, this past January and opened a new engineered landfill outside of the city to replace it. [35] Market analysts have expressed pessimism that most municipalities will comply with legal standards such as replacing dumps with sanitary landfills and implementing selective waste and recycling programs, requirements thatwere scheduled to be met by mid-2014. [36]

Despite the slow pace of compliance, opportunities remain in solid waste management. Municipal waste management services are currently valued at 10 billion dollars annually with the expectation that the market would have been worth $22 billion annually by 2016 if Law 12,305 had been enforced. The Brazilian government expects that income from recycling activities will increase from $1.1 billion to $4.7 billion annually. [36] In 2017, annual revenues of Brazil's recycling sector was estimated at $3.4 billion, according to CEMPRE (Compromisso Empresarial para Reciclagem, or Brazilian Business Commitment for Recycling). As an estimated 80% of solid waste management in Brazil is currently conducted by private companies, there is a clear need for capacity building, increased funding, and improved enforcement at all levels of government. [32]

Technologies and Services in Demand:

- Waste collection technologies
- Sanitary landfill systems
- Environmental monitoring and analytical equipment
- Sorting machines
- Crushing and grinding machines
- Materials handling equipment
- Collection services, containers, and vehicles
- Recycling process expertise
- Waste incinerators

Hazardous and Medical Waste Management
Brazil's National Solid Waste Policy outlines the development of a system that compels companies that produce hazardous waste to register in the "National Registry of Hazardous Waste Operators" and prove their technical capability in managing hazardous waste streams. [37] This enhanced focus on the management of hazardous waste affords opportunities for U.S. companies capable of providing relevant hazardous waste management systems and services.

In 2001, CETESB initiated a Reference List for soil and groundwater pollution levels. CETESB publishes a list on its website at www.cetesb.sp.gov.br with the amounts of chemical substances in the soil and groundwater, which serve as a reference to determine if an area is clean, requires attention, or needs intervention. This list is revised every four years and is based on the U.S. EPA model. Thresholds for chemical products are based on the risk analysis for the specific area.

Improved access to medical treatment in Brazil will also increase the need to address chemical and biological healthcare waste. According to the Brazilian Association of Urban Cleaning and Waste Treatment Companies, only 32% of the 1,059 million tons of healthcare waste generated per day in Brazil is treated. Brazil's overall goal to provide safe waste management practices society-wide will drive focus in reducing the public health risks associated with poorly managed medical waste.

Technologies and Services in Demand:
- Hazardous waste handling equipment
- Hazardous waste treatment technologies
- Brownfield site remediation design and equipment
- Soil contamination testing and monitoring equipment
- Hospital and medical grade incinerators
- Industrial autoclaves

Industrial Waste Management
In Brazil, the private sector addresses waste policy compliance by setting industry standards within respective industry trade associations for the treatment and disposal of industrial wastes. Industry associations thus provide a market for feasibility studies and consulting and design for de-manufacturing and reverse logistics methods. Associations act as critical market multipliers, as they will often determine where waste collection points will exist for their industries and what technologies will be deployed for industry specific waste management practices. Involvement in industry association decision-making on waste management policies may provide downstream opportunities for implementation of waste management technologies and services.

Technologies and Services in Demand:
- Environmental engineering and consulting
- Waste handling equipment
- Waste management services
- Waste incinerators
- Recycling equipment

Market Opportunities – Environmental Consulting and Engineering

In Brazil, the environment is classified as a common usage asset and governed by the National Environment Policy of 1981, as outlined in Federal Law No. 6,938/81. Environmental law in Brazil stipulates that obtaining an environmental license is mandatory for constructing, installing, enlarging, modifying, and operating facilities that use environmental resources or could cause environmental damage. Activities that may result in significant environmental impact must present an Environmental Impact Assessment and Report ("EIA/RIMA") during the licensing process. The report or assessment will describe potential environmental damage or impact and proposed preventive and control measures to reduce the effects. Certain activities are required to provide a biannual assessment to the environmental agency.

In response to the sluggish investment climate, Brazil has experienced a temporary decline in the demand for construction and, correspondingly, in its market for Environmental Impact Assessment (EIA) and related environmental engineering and consulting activities. However, assuming political uncertainty does not lead to further economic instability, growth rates are improving, and it is likely that the construction industry will rebound.

Technologies and Services in Demand:

- Environmental Impact Assessments

ETWG Agency Initiatives and Programs

U.S.-Brazil Commercial Dialogue

The U.S.-Brazil Commercial Dialogue was created in 2006 to provide the U.S. Department of Commerce and the Brazilian Ministry of Economy, Industry, Foreign Trade, and Services, a forum to work together to grow bilateral trade and investment. Since its inception, the Commercial Dialogue has fostered successful cooperation between Commerce and the Ministry of Environment (MOE) and has served as a mechanism for addressing cross-cutting issues affecting the movement and competitiveness of goods and services, including for the environmental industry.

WEFTEC International Buyer Program (IBP)

WEFTEC, the largest water technology exhibition in North America, works with the U.S. Department of Commerce's IBP to encourage foreign participation in the show. This platform is leveraged to exchange relevant technical information and to advance U.S.-Brazilian water cooperation through targeted activities at WEFTEC.

Waste Expo IBP

Waste Expo, one of the leading U.S. waste management trade shows, has partnered with the U.S. Department of Commerce's IBP to encourage foreign participation in the show. This platform is leveraged to exchange relevant technical information and to advance U.S.-Brazilian waste management cooperation in ongoing bilateral and multilateral forums.

U.S. Environmental Solutions Toolkit

The Toolkit is an online searchable database that marries U.S. Environmental Protection Agency (U.S. EPA) expertise on solving environmental challenges and developing environmental rules with a catalog of U.S. technology providers. In late 2014, ITA and U.S. EPA introduced a Portuguese version of the Toolkit. It is used as a reference tool in bilateral engagements that focus on increasing Brazilian capacity to address environmental concerns, including follow-up to the U.S.-Brazil Joint Initiative on Urban Sustainability (JIUS), the U.S.-Brazil Commercial Dialogue, and others. In 2019, an enhanced version of

the Toolkit will be released that will include an updated database of solutions providers and the capability for foreign buyers and government officials to contact them directly via the online interface. U.S. companies interested in participating in the Toolkit can find out more at www.export.gov/envirotech.

Deal Team

Brazil was one of the first countries to pilot the Deal Team initiative – a program whose focus is to increase and strengthen U.S. private sector participation and competitiveness in major projects worldwide. By working in collaboration with other USG agencies, the Deal Team aims to disseminate information on potential and existing tenders and offer U.S. companies improved access to export and project finance. Environmental technologies are a priority sector for the Brazil Deal Team with Commercial Service Brazil's Environmental Technologies Specialist regularly monitoring and alerting the Team to project opportunities for U.S. companies in the sector.

Market Contacts and Program References

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Ministry of Regional Development
A newly created Ministry that will replace the Ministry of the Cities and National Integration. It will develop strategies for regional and urban development and be the liaison of the Federal Government with the 5,570 municipalities in Brazil. It will coordinate water security and coordinate sanitation services in Brazil.

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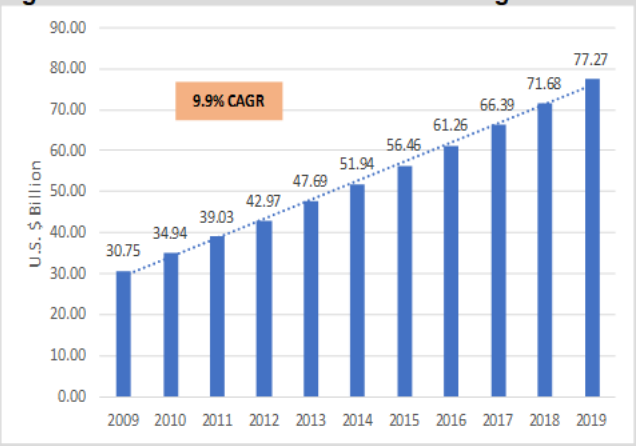
China Case Study

China ranks first overall on the 2019 Top Markets Report, with a Composite Environmental Technologies Score of 100. China also ranks first for the water sector, with a score of 51.5. China ranks second for both the air pollution control and waste and recycling markets, with scores of 43.4 and 5.1, respectively (see Appendix 1 for global rankings).

China is the largest and one of the fastest-growing emerging markets for environmental technologies. The overall environmental technologies market in China (including goods and services) is estimated to be valued at $77.27 billion in 2019. [1] The scope, size, and expected growth of China's market for environmental technologies is unmatched, but market barriers – particularly those related to protection of intellectual property – continue to make China a challenging market in which to operate.

State of the Environmental Regime

Figure 10: China's Environmental Technologies Market



Source: Environmental Business International with OEEI analysis, 2019.

China's environmental regime has improved significantly in recent years with the development of a national legal framework that supports the mitigation of pollution across all three environmental mediums, coupled with significantly stronger enforcement of related rules and regulations.

China fundamentally restructured its approach to environmental enforcement with the introduction of its amended Environmental Protection Law (EPL) in 2014. The revised EPL took effect at the beginning of 2015. It serves as an enabling statute that could yield stronger adherence to environmental rules, if incentives and penalties therein ultimately prove to be greater than the cost of non-compliance. The legal text of the EPL highlights:

- Improved efforts at monitoring
- A path toward legal recourse to address public harm imposed by polluters
- Authority to halt projects that exceed pollution limits,
- Requirements for key point sources to publicly disclose their primary pollutants,
- Accountability of local officials to higher-level officials, and,
- Daily fines toward polluters who exceed the cost of compliance.

There is evidence that the government is stepping-up enforcement of the EPL. Over the past three years, China carried out a series of environmental inspections covering 31 provinces under a national campaign that resulted in more than 100,000 cases of fines, suspension, criminal investigation, and administrative detention based on environmental infractions. [38] In 2018, more than 4,000 businesses were ordered to reduce capacity or shut down temporarily. [38] In the same year, authorities arrested

over 15,000 people for environmental crimes and prosecuted 42,195 people for environmental offenses, an increase of 51% and 21%, respectively, over the previous year. According to environment Minister Li Ganjie, fines for environmental offences totaled RMB 15.28 billion ($2.26 billion) in 2018, up 32% over 2017. [39] Barring increasingly prohibitive market barriers and assuming improved overall trade relations, this elevated rigor in environmental enforcement should present opportunities for environmental technology and services providers. However, the long-term effectiveness of the EPL remains to be seen as these enforcement actions largely were driven by political pressure and often were hastily carried out and only temporarily implemented. For example, in advance of high-profile events, authorities would simply force companies to briefly cease production to reduce pollution for a few days, then resume after the event was over.

In addition to the EPL, China also set relatively ambitious environmental goals in its 13th Five Year Plan (2015). The 13th Five Year Plan lays out China's targets to improve air, water and soil quality by limiting overall energy use, setting higher goals for "good" air quality ratings, limiting water consumption, reducing water pollutants such as chemical oxygen and ammonia nitrogen, taking a national census on soil pollution conditions, and limiting the amount of land that can be used for construction.

On the policy front, a new Environmental Protection Tax Law and new policies intended to protect water and soil came into effect in 2018 and 2019. The new Tax Law came into force on Jan. 1, 2018, and aims to reduce pollution by incentivizing more environmentally-friendly business decisions. Rather than paying variable "pollution discharge fees" at the local level, under the new tax law polluters are subject to a uniform national levy system. The law also encourages emissions reduction by lowering taxes on companies that emit 30-50% less than the set limits. [40] A revised Water Pollution Prevention and Control Law, a revised Soil Pollution Prevention and Control Law, and a draft Solid Waste Pollution Prevention and Control Law came into effect in 2018 and 2019, as well. At the local level, some regional governments began implementing rules and standards that are viewed as stricter than international standards to show alignment with central government policy. Some U.S. companies have noted they have found these new standards difficult to meet even with the most advanced environmental technologies. [41]

Last year also was a year of structural change for China's environmental regime. In March 2018, the central government consolidated environmental policymaking under a new Ministry of Ecology and Environment (MEE). In addition to maintaining all the responsibilities delegated to the former Ministry of Environmental Protection (MEP), the new MEE covers climate change and emissions reduction policies that previously were the purview of the National Development and Reform Commission (NDRC). The new ministry also oversees a variety of areas, including underground water pollution, agricultural pollution, marine conservation, and watershed protection, for which other agencies previously had been responsible. [42] Beijing also has empowered and resourced a new Central Ecology and Environmental Protection Inspection Office under MEE to coordinate central government-led compliance inspections throughout the country, year-round, and to crack down on lax enforcement by local officials. [43]

Market Barriers

Market barriers in China are persistent and prohibitive in many cases. At the time of drafting this case study, China had levied tariffs on many environmental technologies, ranging from 5-25%. The U.S. Department of Commerce's Environmental Technologies Trade Advisory Committee (ETTAC), along with industry experts in the Office of Energy and Environmental Industries (OEEI), have identified the

following barriers as most problematic for environmental technologies companies attempting to export to, or do business in China:

1. **Challenging Intellectual Property Environment**
   Intellectual property rights (IPR) infringement remains rampant due to widespread lack of respect for intellectual property and weak enforcement. This continues to adversely affect U.S. businesses working in China and complicates operations in the country.

2. **Technical Barriers to Utilization of Advanced Environmental Technologies**
   Chinese authorities use a series of reference technologies to identify which environmental solutions should be applied in a given process. The introduction of new technologies and processes often requires the development of a demonstration project – at the expense of the company – to prove the efficacy of the technology. Since environmental rules are enforced at the municipal and provincial level, it is often necessary to repeat this process in several provinces.

3. **"Strategic Emerging Industries," State Owned Enterprises, and Preferential Procurement**
   Exporters to China may also face headwinds from State-Owned Enterprises (SOEs) seeking to crowd out competitor technologies and establish a state-sponsored monopoly. This effect is likely to increase in the future because environmental technologies have been designated as one of the government's seven strategic industries intended to generate growth based on domestic consumption (as opposed to China's export-led policies of the last 30 years). Furthermore, government tenders often exhibit open or explicit preference for domestic bidders over foreign tenders.

4. **Local Certifications and Safety Approvals not Recognized as Exporting Market Equivalents**
   The ETTAC reports that many certifications, such as the CMC certificate, are available only for locally produced products. Furthermore, government tenders sometimes demand special certifications, which are only granted to local products.

5. **Lack of Compliance Culture and Price Sensitivity**
   Historically, Chinese companies are used to ignoring environmental rules and standards through local government protection, bribery, and weak enforcement. Decades of such practices make it difficult for many Chinese companies to change their way of thinking and operating. As a result, Chinese companies are also particularly sensitive to the cost of improving their facilities to meet new rules and standards, and therefore often choose low-cost Chinese products and solutions over more effective, but pricier, foreign products and solutions.

6. **Corruption and Lack of Transparency**
   Despite President Xi Jinping's forceful anti-corruption campaign, corruption is so entrenched that it continues to be a hurdle for businesses. In addition, China has not made real efforts to reform its legislative process to make it more transparent. Real channels for stakeholders to provide input or feedback are still very much lacking. China ranked 87 out of 180 countries on Transparency International's 2018 Corruption Perceptions Index. The Index ranks countries based on perceptions of public sector corruption, with 1 being highly transparent and 180 being highly corrupt. To compile the Index, Transparency International gives each country an individual score that indicates, on a score of 1 to 100, the level of corruption present. A score of 100 is very clean, while a score of 0 is highly corrupt. For 2018, China had a score of 39, placing it between Argentina and Indonesia. [44]

Market Opportunities – Air Pollution Control

Air pollution arguably is the most egregious environmental problem plaguing China. Smog in urban areas has become so bad that flights have been grounded and children have been taken to hospitals. Protests also have broken out, particularly in opposition to construction of new chemical plants and solid waste incinerators. The central government has placed improving air quality as a priority on its agenda for the next several years, with China's Premier pledging in March 2017 to "bring back blue skies" and "work faster to address air pollution." [45]

In international fora, China has taken important steps in its commitments to reduce greenhouse gas emissions. In September 2016, China ratified the Paris Climate Agreement. [46] Then, in October 2016, 170 countries, including China, committed to phase down the use of hydrofluorocarbons (HFCs) over the next three decades under the Kigali Amendment to the Montreal Protocol. This was a major concession from China, which is the world's largest producer of HFCs. [47] Additionally, implementation of China's climate policy and carbon emissions reduction goals, along with regulation of air pollution, are now the purview of a single agency – MEE – which should improve coordination and accountability going forward.

In its 13th Five Year Plan (FYP), China requires cities to reach 80% of "good" or "excellent" air quality days by 2020 and for the first time, including Volatile Organic Compounds (VOCs) as a target for emission reduction (the 13th FYP aims to reduce VOC emissions by 10% over the next five years). The addition of VOCs is ambitious because its reduction will require regulating many more sources of pollution than does managing sulfur dioxide and nitrogen oxides. [48]

Ambient Air Quality Monitoring

In late 2013, the State Council issued a four-year Airborne Pollution Prevention and Control Action Plan. The plan stipulated a 25% reduction in particulate matter for the Beijing-Tianjin-Hebei region, a 20% reduction for Shanxi and Shandong, and a 10% reduction for Inner Mongolia. The 2018-2020 Three-Year Action Plan for Winning the Blue Sky War builds on the 2013 plan and expands its scope to 338 cities, placing increased pressure on the 231 cities that have not yet reached the government's PM 2.5 standard. [49] The new plan also adds a specific target for VOC emissions reduction of 10% compared with 2015. Notably, the Three-Year Plan does not mention the Pearl River Delta and instead highlights a new key region, the Fen-Wei Plains, which include parts of Shaanxi, Henan and Shanxi Provinces. This region relies heavily on coal and heavy industry and suffers from some of the country's highest levels of SO_2 and PM 2.5 pollution. [49]

China's amended Air Pollution Prevention and Control Law took effect in early 2016 and places the onus directly on city and municipal governments to improve local air quality. Under the revised law, local governments are subject to oversight by a national-level coordinating body accountable to the State Council. In addition, major emitters are required to install automated monitoring equipment and to publish their emissions data. [50] China's National Environmental Monitoring Center operates 1,436 State-level monitoring stations across the country, but there are over 5,000 monitoring points managed at the state, provincial, city and, county levels. [51] Pollution forecast and early warning systems also have been established in three key regions: Jing Jin Ji, Yangtze River Delta, and Pearl River Delta. However, to help address an economic slowdown, in 2018 the central government removed blanket bans on heavy industry production, decentralized monitoring, and started allowing local governments to set their own targets. [52] Assuming that this rollback does not foreshadow future relaxation of

restrictions, if implementation of the Three-Year Plan and Air Pollution Law continues, it will require the development of a series of ambient air monitoring networks, and should yield opportunities for U.S. air pollution monitoring and instrumentation companies.

Technologies and Services in Demand:
- Continuous emissions monitoring systems
- Ambient air quality monitoring equipment
- Source emissions measurement technologies
- Analytical and laboratory testing goods and services
- Air pollution control equipment
- Fuel vapor control systems

Industrial Air Pollution Reduction

In its Nationally Determined Contribution (NDC) for the December 2015 Paris Climate Agreement, China committed to reach peak carbon emissions by 2030 or earlier. China's NDC also calls explicitly for the control of emissions from key industries – specifically iron and steel, nonferrous metals, building materials, and chemicals. The 2016 amended Air Pollution Law follows on China's NDC commitments by expanding the list of centrally controlled pollutants beyond solely nitrogen oxides (NOx) and sulfur oxides (SOx) to include particulate matter, VOCs, and greenhouse gases. [53] If properly enforced, this emissions-reduction effort will require the implementation of control technologies at industrial sites. Industries that will be of the highest interest for the application of control technologies include iron, cement, and steel plants; oil refineries; non-ferrous metallurgical plants; coal boilers; and petrochemical plants. China's 13th Five Year Plan on the Development of Energy Efficient and Environment Protection Industries also calls for the development and promotion of VOC management technology in the oil and gas, vehicle painting, and printing industries.

Key Technologies in Demand:
- Wet/dry scrubbers (particularly systems that remove multiple pollutants)
- Carbon injection systems (for reduction in mercury and organics)
- Particulate matter control systems (particularly new bagging systems)
- NOx, mercury, CO_2 and particulate matter monitoring and continuous monitoring systems
- Selective catalytic and non-catalytic reduction controls
- Oxygen enrichment, fuel injection, and other efficient combustion technologies
- Innovative specialty cements
- Mixing technologies
- Pumping and fluid handling equipment
- Engineering and plant design
- Leak detection equipment
- Alternative fuel technologies used to fire cement kilns

Power Plant Emissions Reduction

The anticipated shift in China's economy away from manufacturing and construction, as well as China's commitments under the Paris Climate Agreement and its domestic policy efforts to decrease coal reliance, in concert, have led some experts to conclude that China has reached peak coal use. [54] Despite these developments, the Chinese power generation sector remains heavily reliant on coal and over half (56%) employs subcritical technology. [55] According to Forbes, though China's coal demand has remained essentially flat since 2013, coal-fired power generation actually has been rising at six

percent per year. China now accounts for nearly half of the world's coal-based electricity generation and has 210,000 MW of new coal capacity planned. [56] Coal is expected to remain the dominant fuel in China's power sector in the foreseeable future. [57] In the past, China applied few, if any, central measures to reduce particulates and other criteria pollutants, such as SOx, NOx and mercury, significantly contributing to air quality issues in the region. Thus, reducing coal-fired based emissions is a key focus of China's recent series of air pollution related reforms.

Though China has prohibited the building of new coal-fired power plants around three major cities – Beijing, Shanghai and Guangzhou – to alleviate air pollution affecting major urban areas along the east coast, coal-fired capacity still is increasing closer to the inland coal-producing centers. Despite the efforts of the National Development and Reform Commission and the National Energy Administration in 2016 and 2017 to halt plans to construct approximately 200 new coal-fired power generators, accelerate the closing of outdated coal plants, and delay the approval of new projects in 13 provinces until after 2017, coal-fired power plants continue to develop at an increased pace due to loopholes in the policy. [57] Indeed, China's coal-power generation capacity is set to grow as much as 19% over the next five years, even with its aggressive expansion of non-fossil fuels as alternative sources of power. [57]

Nevertheless, air quality remains a key concern for China's leaders. Premier Li vowed to cut both SOx and NOx emissions by three percent each year in both 2017 and 2018. [58] The central government also tightened regulations on both new and existing coal-fired power plants, including reducing allowed levels of particulate matter (PM) in certain areas to 5 mg/Nm3. [59] The 2016 amended Air Pollution Law requires all older coal-fired plants to be retrofitted to meet environmental standards. In its 2018 annual report, NDRC said that the government would close all coal-fired power plants with capacity below 300,000 KW if they failed to meet emissions standards. [58] The Hebei region in particular relies heavily on coal-fired power to fuel the nation's steel industry but has committed nonetheless to a reduction in coal consumption of 40 million tons. Maintaining production while reducing coal consumption will require switching to cleaner burning fuels and administering control technologies. The tightening of standards for conventional pollutants under the 2011 Emission Standard of Air Pollutants for Thermal Plants (GB 13223-2011) and the 2014 Emission Standard of Air Pollutants for Boilers (GB 13271-2014) will likely accelerate construction of high-efficiency PM, SO_2 and NOx control technologies, which will also serve to advance mercury control. [60] Similarly, the Beijing Air Pollution Control Action Plan stipulates an approach to power generation that includes fuel switching to natural gas.

The Chinese government also has ratified the Minamata Convention on Mercury (the Convention). The Convention is an international and legally binding instrument to reduce mercury use and emissions. The text of the Convention was adopted by over 150 countries, including China, in January 2013. Given that coal-fired power plants represent a major source of airborne mercury and other toxins, the implementation of this instrument will further foster Chinese interest in air pollution control emission control technologies. The global market for mercury removal is expected to grow robustly through 2025, especially in China where the potential market for coal gasification is large. [61]

Key Technologies in Demand:

- Continuous emissions monitoring systems
- Dry sorbent injection technologies
- Flue gas desulfurization equipment
- Activated carbon injection technologies
- Inspection, adjustment, maintenance, and repair services

- Selective catalytic reduction technologies
- Wet and dry electrostatic precipitators including horizontal wet electrostatic precipitators (WESPs)

Mobile Source Emissions Control

China's amended Air Law includes provisions covering emissions from motor vehicles and non-road machinery. Enforcement and compliance with regulations in this area traditionally have been lacking. The amended Air Law shifts responsibility for regulation of air pollutants to local officials, who must be incentivized to push for compliance. If the proper incentives are put into place, the government would be empowered to recall vehicles in violation of regulations and could issue substantial fines to violators. [62] In Beijing, on-road vehicles currently account for a significant percentage of pollutant emissions, including 86 percent of carbon monoxide, 57% of nitrogen oxide and 31% of PM 2.5, according to the International Council on Clean Transportation. As part of its progressive program to continue to reduce vehicle emissions, in late 2015 Beijing proposed more stringent light-duty vehicle emission standards (Beijing 6/VI) that are based on California's emissions standards. The new standards were implemented in early 2017. [63] Later that year, Tianjin and 26 cities in Hebei, Shanxi, Shandong, and Henan provinces put the new China VI fuel requirements into effect. All other provinces must implement the standard by 2019, which should create an important opportunity for U.S. emission technologies on new gasoline vehicles sold in China. [64]

In July 2018, MEE released the final rule for the China VI emissions standards for new heavy-duty vehicles. It is among the world's most stringent and combines best practices from both U.S. and European regulations. The new rule includes a reduction in NOx and PM emission limits by approximately 70% compared with the China V standard. It also requires installation of improved on-board diagnostic (OBD) systems and introduces a multi-component compliance program involving agency and manufacturer-run emission tests from pre-production through in-use stages. [65]

Key Technologies in Demand:

- Emissions control technologies for motor vehicles and diesel non-road l vehicles and machinery

Market Opportunities – Waste Management and Recycling

Municipal Solid Waste and Waste-to-Energy

China's municipal solid waste (MSW) generation is expected to increase on pace with its rapidly growing and urbanizing population and is likely to reach 1.39 million tons per day by 2025. [66] According to the World Bank's What a Waste 2.0 report, approximately eight percent of China's solid waste is disposed of in open dumps, with 60% sent to landfills, three percent composted, and the remaining nearly 30% incinerated. In 2017, the government began taking steps to develop a domestic solid waste management and recycling market. The State Council issued a plan in March 2017 to make sorting household waste a requirement, and in July of 2018 NDRC released a new regulation requiring cities and towns to establish a comprehensive fee-based system for household waste collection and processing by 2020. [67] The government recently tightened limits on landfills, and 46 cities have established recycling quotas, including Beijing and Shanghai. [68] In 2017, China also announced a ban on the import of most types of scrap and recoverable materials, including most plastic, paper, and metals. By 2020, all materials classified as "solid waste" are expected to be banned from importation. The ban already has severely impacted global recycling commodities markets and presented significant challenges for U.S. recyclers.

The Chinese government is particularly interested in waste-to-energy (WTE) to address the country's increasing MSW generation. China's 13th Five Year Plan calls for $41.3 billion in investment in development of incineration plants by 2020. [69] The country more than doubled its WTE capacity between 2011-2015, though in 2014 WTE (incineration) represented less than two percent of China's renewable energy production. [70] WTE projects often rely on a public-private partnership (PPP) model. [69] Given the central government's ambitious plans for the build-out of WTE infrastructure, China is likely to remain the world's largest and fastest-growing market for WTE technology until at least 2020. [71] Solid waste in China has a relatively high moisture content and thus delivers low calorific values when incinerated. Companies with expertise in managing such combustion efficiency challenges are likely to find opportunities in this sector.

Key Technologies in Demand:
- Waste pile design and sampling
- Composting equipment
- Sorting machines
- Crushing and grinding machines
- Materials handling equipment
- Collection services, containers, and vehicles
- Recycling process expertise
- Waste-to-Energy technologies and expertise

Recycling of Discarded Electronics

According to the 2017 Global E-Waste Monitor report, China is the world's top producer of e-waste, generating 7.2 million tons annually. [72] In 2011, the Chinese government implemented a series of regulations to guide the domestic processing of discarded electronics and electrical appliances called the Rules on the Administration of the Recovery and Disposal of Discarded Electronic and Electrical Products (or China WEEE). China's electronic scrap recycling infrastructure is dominated by small-scale collection operations, informal recycling facilities and outdoor recycling markets. However, the formal e-waste recycling sector is growing. Recent documentation shows that approximately 18% of e-waste is now collected, treated, and recycled. [72] The State Council also unveiled an Extended Producer Responsibility (EPR) Plan in late 2016, with electronics as one of the first target industries. The government launched several EPR pilot programs in 2017, including an official e-waste recycling system in Beijing. [73] Guided by MEE and funded by a levy on electronics sold throughout the country, the central government intends to replace current recycling infrastructure with a large network of sophisticated electronics recycling facilities. The associated expansion of Chinese demand for equipment and recycling services presents opportunities to U.S. companies with experience in providing equipment or services used in the safe and efficient recovery of valuable materials from discarded electronics.

Key Technologies in Demand:
- Sorting machines
- Crushing and grinding machines
- Materials handling equipment
- Collection services, containers, and vehicles
- Recycling process expertise

Hazardous Waste Management
In 2017, China's Ministry of Environmental Protection (now MEE) said that the country generates about 40 million tons of hazardous waste annually, with just 40% treated properly. Experts put that amount even lower, with only 15% landfilled or incinerated under the proper licenses. [74] With current disposal capacity at approximately one-third of the total generated, there is an urgent need to develop capacity commensurate to the scope and size of waste production. Between 2016-2020, the hazardous waste management market is expected to be worth about RMB 200 billion ($31 billion). [75]

U.S. companies report that hazardous waste disposal capacity is currently a major challenge for manufacturing in China. This challenge exists because only central government-approved SOEs are allowed to operate in this space. These SOEs don't have the ability to accommodate large industrial parks, and they lack interest in handling small amounts of hazardous waste. [41] This is further exacerbated by rules limiting transportation and storage of hazardous waste.

Key Technologies in Demand:
- Waste handling equipment
- Waste treatment technologies
- Brownfield site remediation design and equipment
- Soil contamination testing and monitoring equipment

Scrap and Recyclables
In 2017, Chinese central government issued an extremely aggressive plan to ban certain imported solid waste, implement stricter standards for imported scrap and recyclables, and strengthen domestic recycling capabilities with the goal of domestic self-sufficiency for scrap and recyclables by 2020. [76] Due to extreme political pressure, implementation of the plan has been strong and swift, causing a dramatic decrease of U.S. scrap and recyclables exports to China, and resulting in the shuttering of thousands of small-scale solid waste processing facilities in-country. China's demand for scrap and recyclables continues to be strong. The country's recycling infrastructure is burgeoning but immature. Although much remains uncertain, foreign recycling equipment providers may find opportunities in China's developing recycling capacity going forward.

Key Technologies in Demand:
- Sorting machines
- Crushing and grinding machines
- Materials handling equipment
- Recycling process expertise

Market Opportunities – Water and Wastewater Treatment

The State Council issued its highly anticipated Water Pollution Prevention and Control Action Plan in April 2015. [77] The plan sets a series of ambitious targets for 2030, including achieving excellent water quality in seven major water sheds, elimination of "black and odorous" water and achieving an overall water quality of level-3 or better for 95% of point sources in urban areas. [78] The Action Plan delineates 26 detailed requirements and 238 measures [77] to achieve improved water quality and promote water stewardship. Key themes are improved industrial effluent management, wastewater treatment, water reuse, enhanced monitoring, and new enforcement mechanisms. By 2020, China is aiming for a wastewater treatment rate of 70% for most urban areas, which will include towns for the first time. To

support this, there is an intended increase of 23% in urban wastewater treatment capacity. [79] Additionally, China's 13th Five-Year Plan set new targets for wastewater effluent quality, sludge management and drinking water quality. The central government forecasts that reaching these new targets will require over $230 billion in direct purchases of products and services, and an indirect investment of over $80.6 billion. [80] In late 2016, the State Council also approved a revision of the Water Pollution and Prevention Control Law. The revised law came into force on Jan. 1, 2018. [81]

Municipal Water and Wastewater Treatment and Plant Development

Aggressive construction of water treatment plants continues as China works to improve water quality and enhance access to drinking water and sanitation services. In 2014, the Ministry of Environmental Protection (now MEE) announced that it would invest $329 billion in addressing water pollution, including treating municipal and industrial wastewater. In 2016, the 13th Five-Year Plan established a new discharge standard for wastewater treatment plants (WWTPs) that that was expected to be met by the end of 2017 and was estimated to cost approximately $20.73 billion in addition to $10.3 billion in annual operational costs. [80] Membrane bioreactors are highly favored in new water reuse facilities as a means to meet these standards. [17] In the coming years, China seeks to protect drinking water sources and improve the water quality in centralized sources, including the expansion of protections for and management of key water resources. Rural wastewater is still neglected, however, with a treatment rate of 22%. [79] The government aims to increase this coverage to 70% by 2020. This goal has driven the need for decentralized solutions and PPP models. Procurement of a PPP wastewater contract may include a package of treatment plants in several towns and villages. The foreign technology often emphasized is pre-fabricated membrane aerated biofilm reactors (MABR) and decentralized solutions from Japan (Johkasou technology). [17] Additionally, the South-to-North Water Diversion Project mandates the construction of 426 wastewater treatment plants along the eastern route to treat heavily polluted surface waters. [82] By the end of 2016, 350 wastewater treatment plants and 150 waste treatment plants had been constructed. Ultimately, tightening of national regulations will provide retrofit opportunities for existing plants to move beyond mechanical treatment alone and introduce improved chemical and biological methods.

Key Technologies in Demand:

- Waste handling equipment
- Engineering, procurement, and construction services
- Advanced filtration
- Membrane filtration
- Waste-to-Energy technology
- Anaerobic digestion
- Nitrification
- Biological denitrification
- Monitoring equipment
- Testing equipment
- Air flotation

Water Transmission and Storm Systems

The Water Pollution Prevention and Control Action Plan outlines several major initiatives to reduce non-revenue water, expand wastewater collection capacity and manage storm water. The plan calls for remediation or replacement of all transmission pipelines in service for more than 50 years with a goal to reduce non-revenue water to 10% by 2020. Another ambitious goal is to provide universal wastewater

collection and treatment capacity. The plan calls for collection and treatment levels to reach 85% in semi-rural and suburban areas and 95% in urban areas by 2020. The plan also outlines an accelerated goal for the Beijing-Tianjin-Hebei region, the Pearl River Delta, and the Yangtze River Delta, which are set to achieve 95% collection and treatment levels by 2019. Furthermore, cities and provincial capitals with independent planning status were expected to achieve universal collection and treatment by the end of 2017. The plan also requires the elimination of combined sewers and the introduction of distinct storm water systems that include storage and reuse capabilities where feasible, as well as designing storm water drainage systems that contribute to groundwater recharge. There is a marked opportunity for smart water solutions in China, especially as its utilities face increasing pressure to reduce non-revenue water rates and improve drinking water quality. There have been several commercial trials of NarrowBand Internet of Things (NB-IoT) smart water metering projects in various cities across the country. The intention is for these trials to support the facilitation and implementation of advanced metering infrastructure. Notably, the PPP model for smart water solutions provides a degree of autonomy in terms of project scope. [17]

Key Technologies in Demand:
- Engineering, procurement, and construction services
- Pumps, pipes, and valves
- Storage technologies
- SCADA systems
- In-line monitoring systems
- Leak detection equipment
- Trenchless technologies
- Catchment design and construction
- Pipe rehabilitation technologies

Sludge Treatment

The market for sludge treatment in the Asia Pacific is expected to grow by eight percent, driven largely by China's new targets. [17] China discharges over 40 million tons of sludge annually, of which only about 20% is treated. [83] Sludge remains a growing and persistent environmental challenge. Recent government action has led to the development of technology standards for sludge treatment, a requirement that municipalities install sludge treatment systems and a central government capital development investment of RMB 60 billion ($9.6 billion) for sludge treatment facilities. The Water Pollution Prevention and Control Action Plan calls for enhanced processing of 90% of sludge from cities and prefectures, including sludge stabilization, disinfection, and resource recovery, by 2020. The 13th Five-Year Plan also requires an increase in wastewater tariffs across the country as of the end of 2016 to cover sludge treatment costs. [83] Nonetheless, lack of domestic operational expertise and technology for sludge treatment remains a challenge for China and thus could provide sludge treatment opportunities for U.S. firms. Moreover, recent changes to private sector involvement, notably increased outsourcing and Build-Operate-Transfer (BOT) models for sludge treatment plants, also provide a potential market for U.S. companies. [17]

Key Technologies in Demand:
- Engineering and design
- Sludge disinfection systems
- Sludge dewatering and drying systems
- Anaerobic digestion

- Bio-gas/natural gas recovery
- Nitrogen and phosphorus recovery technologies

Groundwater Monitoring, Pollution Prevention, and Remediation

The central government recently has begun to focus on over-exploitation and heavy pollution of groundwater. [80] Pollution has degraded most of China's groundwater resources, limiting their use as a reliable source for drinking water. In 2016, the Ministry of Water Resources reported that more than 80% of groundwater was unfit for drinking or daily use due to contamination from agricultural and industrial discharge. [84] Of the wells tested, 47.3 percent were found to have fifth grade, or "extremely bad," water quality and nearly one-third had fourth grade, or "bad" quality. [85] These estimates are significantly higher than the 60% figure that previously was released by the then-Ministry of Environmental Protection. MEE has regulatory authority over groundwater pollution control, river basin management, water function planning, discharge outlet setup, and agricultural non-point source pollution, [86] which should help to streamline and improve enforcement. Additionally, the National Groundwater Contamination Prevention and Remediation Plan calls for an RMB 34.7 billion ($6.2 billion) investment through 2020. Groundwater protection efforts primarily are focused on monitoring, source control, and remediation.

The 12th Five-Year Plan delineated the study of pollution assessment, monitoring, and simulation in order to establish a national monitoring system and quality standards. Source control research has focused on hazardous waste storage, landfill contamination, oil and gas extraction, mining, agriculture and underground piping, and disposal systems to establish control techniques and rules. New groundwater exploitation programs in agricultural, industry, and the service sectors are no longer permitted in northern China, where overexploitation is particularly bad. Authorities were expected to outline a list of areas where groundwater exploitation is partially or totally prohibited by the end of 2017. [80] China stands to considerably influence the mining flow control and treatment market, which was expected to have topped $13 billion in 2017. [87] U.S. Superfund experience in environmental remediation creates a competitive advantage for U.S. companies.

Key Technologies in Demand:

- Monitoring equipment
- Source pollution control technologies
- Sparging
- Bioremediation
- Chemical treatment
- Flushing
- In-situ air stripping
- Multiphase extraction
- Permeable reactive barrier
- Phytoremediation
- Pump and treat

Water Efficiency and Reuse

China's scarce fresh water resources have made water efficiency and reuse a national priority designed to limit further economic disruptions due to water shortages. The Water Pollution Prevention and Control Action Plan sets a reuse goal of 20% or more in water scarce areas by 2020. The seriousness of the economic impact of water scarcity led the State Council to note in the plan that water conservation

is now a performance metric for municipal and provincial governments. The plan explicitly calls for water reuse in coal-mining, metal production, textiles, tannery, pulp and paper, chemical, and petroleum industries. In addition, a 2015 central government policy states that new water-intensive industrial facilities in the coastal areas cannot draw local surface water and are required to provide their own water supplies. [88]

These priorities will be a boon to membrane, non-revenue water management, and industrial water efficiency technologies. One source estimates that water reuse led to 30% annual growth in the membrane technology market between 2012-2017. [82] Beijing is following through with plans to emphasize water reuse, with the Miyun Yunxi Zutuan and Changping water reuse projects that are worth an estimated $25.9 million and $64.8 million, respectively. [89] Both projects began construction in 2015, and parts of the Changping project have also started operations. [90] Tianjin and Ningxia have major plans to meet the new 13th Five-Year Plan reuse targets. Beijing plans to build 27 new water reuse plants and 472 km of supporting pipelines by 2019. [80]

Desalination capacity also grew by approximately 70% each year from 2006 to 2010. However, China missed its target of producing 2.2 to 2.6 million tons of desalinated water per day by 2015. As of 2016, capacity stood at only 1.03 million tons per day. [88] Additionally, the central government has called for at least 70% domestic innovation in desalination equipment (the current figure is closer to 15%, as based on intellectual property patents). Chinese scientists have also stated they use foreign equipment initially and then perform their own research until they can reproduce the same effects domestically. [88] An emphasis on increasing domestic capacity may minimize market penetration opportunities for foreign investors in China's desalination market.

Key Technologies in Demand:
- Engineering and design
- Monitoring equipment
- Non-revenue water control software
- Membranes
- Advanced filtration
- Low-loss distribution equipment
- Storage equipment
- Zero Liquid Discharge (ZLD) technology

Process and Produced Water

The aggressive stance of the Water Pollution Prevention and Control Action Plan on industrial water treatment and reuse combined with new effluent standards and better enforcement thereof are driving growth in process and produced water treatment. The plan calls for strengthened pollution control, effluent treatment and reuse in many of its water-intensive industries, particularly in petroleum refining, chemical production, pharmaceuticals, chemical fiber manufacturing, non-ferrous metallurgy, textiles, pulp and paper, cooking, fertilizer production, food and beverage, tanneries, pesticide production, and electroplating.

The plan also calls for a systematic approach toward ports, industrial clusters and special economic zones, including export processing zones. Those areas will be serviced by central wastewater and solid waste processing facilities with continuous monitoring capabilities, and manufacturers therein will be subject to pre-treatment requirements for industrial effluent. The plan requires the implementation of

treatment and monitoring capabilities, indicating that there may be ambitious efforts on the part of Chinese manufacturers to acquire and implement improved monitoring and treatment technologies.

Key Technologies in Demand:
- Engineering, design, and construction services
- Pumps, pipes, and valves
- Storage technologies
- SCADA systems
- In-line monitoring systems
- Anaerobic digestion
- Advanced chemical treatment and rectification
- Membrane technology
- Advanced filtration

Soil Remediation

As a result of and lax rules governing agricultural runoff and weak or non-existent waste management strategies, including the failure to develop sanitary landfills, there is prevalent soil pollution in China. In 2015, the Ministry of Environmental Protection (now MEE) and the Ministry of Land Resources jointly released a national soil survey report stating that 16.1% of China's soil is polluted and of this total, 19.4% of arable land is polluted. [91] Much of this contamination is non-organic with the most prevalent pollutants being cadmium, nickel, and arsenic. Soil pollution threatens the safety of agricultural products and contributes to groundwater pollution through leaching.

In 2014 and 2015, the central government allocated RMB 130 million (about $19.8 million) to support six national pilot projects in the Hunan, Shandong, Hubei, Guizhou, Zhejiang, and Guangdong provinces, and RMB 2.8 billion (about $425.7 million) to support 30 regional pilots focused on remediation of heavy metals in soil. China released its National Soil Pollution Prevention and Treatment Action Plan in May of 2016, which aims for safe use of 90% of currently contaminated farmland by 2020. The Action Plan required all provinces to develop treatment and remediation plans and to submit a project database to the MEP by the end of 2017. [92] Then on Jan. 1, 2019, a new Law on the Prevention and Control of Soil Pollution came into force. The law builds on the action plan, adopting a 'protection-first' and 'polluter-pays' approach and providing more detail to hold polluters accountable. It makes local governments responsible for maintaining lists of soil pollutants, soil pollution regulators, and construction and remediation risks for specific sites. [93] The law also requires MEE to establish mandatory national standards for soil pollution risk control according to soil contamination status, public health risks and ecological risks. Local governments are authorized to develop even stricter standards. [94]

In 2016, the central government allocated $1.3 billion for soil remediation. However, this is far short of the estimated $89.4 billion investment needed for soil remediation projects over the next five years. Full remediation of contaminated land will cost an estimated $1.1 trillion. [95] The new soil pollution control law includes a mechanism for funds to be set up at the central and provincial level to address pollution of agricultural land, though it remains unclear where the funds themselves would come from. Nevertheless, going forward this substantial remediation effort is likely to yield opportunities for U.S. providers of remediation technology and services.

Key Technologies in Demand:
- Engineering and design

- Monitoring equipment

Market Opportunities – Environmental Consulting and Engineering

The 2015 Environmental Protection Law (EPL) stipulates that all new construction projects must undergo an Environmental Impact Assessment (EIA) before construction permits can be issued. [96] However, in 2016 the central government revised China's Environmental Impact Assessment Law such that EIAs are no longer a prerequisite for other approvals, which some experts say will weaken the EIA system. Though EIAs are still required, if developers already have obtained the financial and construction permits, it could be more difficult to apply EIA results to veto large projects. [97] Assuming the EIA system remains robust, the EPL will generate a substantial industry for EIAs, an area where U.S. environmental engineering and consulting firms have substantial expertise.

Key Technologies in Demand:

- Environmental impact assessment

ETWG Agency Initiatives and Programs

Industrial Park Initiative

China's recently strengthened environmental regime has put pressure on the country's 219 national industrial parks and hundreds of lower-tier industrial parks to alter their operations and procure environmental solutions to achieve compliance. The U.S. Foreign Commercial Service (FCS) in China saw this trend as a potential opportunity for U.S. companies and launched the Industrial Park Initiative in 2018. Under the Initiative, FCS has reached out to industrial parks all over the country to better understand each park's specific needs. The goal of the Initiative is to invite U.S. environmental firms to participate in each park's procurement of environmental solutions. Companies interested in joining the Initiative can apply to become members of the Working Group, which includes access to special Industrial Park Initiative events and programs.

CIEPEC U.S. Pavilion

The 17th China International Environmental Protection Exhibition & Conference (CIEPEC 2019), as the highest-level national brand exhibition in China with a 32-year track record, was held on June 12-14, 2019 in Beijing's China International Exhibition Center. CIEPEC 2019 has over 800 exhibitors and is expected to attract over 70,000 visitors. CIEPEC 2019 is a Department of Commerce Certified Trade Fair and the U.S. Commercial Service in Beijing recruited U.S. environmental companies interested in the China market to attend the show and participate in the exhibition.

IE Expo

IE Expo is one of the leading Environmental Technology Exhibition and Conference in Asia. It was held on April 15-17, 2019, at Shanghai's New International Exhibition Center. The Department of Commerce has certified the show for the past two years. This year, the U.S. Commercial Service in Shanghai organized a workshop on the Industrial Park Initiative in addition to on-site counseling and matchmaking services.

U.S. Environmental Solutions Toolkit

The Toolkit is an online searchable database that marries U.S. Environmental Protection Agency (U.S. EPA) expertise on solving environmental challenges and developing environmental rules with a catalogue of U.S. technology providers. In 2015, the ITA and U.S. EPA introduced a Mandarin Chinese

version of the Toolkit to expand its usability in China. It serves as a reference tool in bilateral engagements that focus on increasing Mexican capacity to address environmental concerns. In 2019, an enhanced version of the Toolkit will be released that will include an updated database of solutions providers and the capability for foreign buyers and government officials to contact them directly via the online interface. U.S. companies interested in participating in the Toolkit can find out more at www.export.gov/envirotech.

Waste Expo International Buyer Program
Waste Expo, one of the leading U.S. waste management trade shows, has partnered with the U.S. Department of Commerce's International Buyer Program to encourage foreign participation in the show. This platform was leveraged to exchange relevant technical information with Chinese participants and to introduce Chinese buyers to U.S. waste management technology providers.

Water Environment Federation Technical Exhibition and Conference (WEFTEC) International Buyer Program
The U.S. Department of Commerce, through the IBP, leads a delegation of Chinese officials and business representatives to WEFTEC to explore relevant U.S. technologies and work with U.S. exporters on approaches to water resource management.

Green Cement Best Practices Guide
The stated goal of the Chinese Ministry of Environmental Protection is to create a Green Cement Best Practices Guide. For years, the U.S. government has worked to support green cement efforts in China, including funding the development of the "BEST" tool (Benchmarking Energy Efficiency Standards Tool), which recommends best practices to improve cement kiln combustion efficiency and limit air pollutants. These activities are being leveraged to support the completion of a Chinese Best Practices Guide and are utilized in various bilateral forums to introduce Chinese end users to relevant environmental solutions providers.

Mercury Reduction Engagement
The United States and China are exchanging experiences in tackling various environmental concerns caused by mercury, highlighting existing approaches and required technologies. Improperly handled solid-state mercury can contaminate the environment, as can airborne mercury falling back to earth. This engagement is advancing goals related to commitments made during recent international mercury reduction negotiations and supports the Chinese efforts to improve hazardous waste management and remediation practices.

Market Contacts and Program References

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http://english.mee.gov.cn/

China Solid Waste
http://www.solidwaste.com.cn/

Water China
http://www.h2o-china.com/

China City Water

http://www.chinacitywater.org/

Commercial Service Market Contacts

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Colombia Case Study

Colombia ranks 10th overall in the 2019 Top Markets Report, with a Composite Environmental Technologies Score of 14.3. Colombia's new position within the report's top 10 is influenced by the November 2016 peace accord between the Colombian government and the Revolutionary Armed Forces of Colombia (FARC). Parts of the country formerly influenced by FARC have opened for market development, creating new opportunities for the extractive industries and new environmental challenges for this developing country.

Overall Rank	Air Pollution Control
10	15
Water	**Waste & Recycling**
7	16

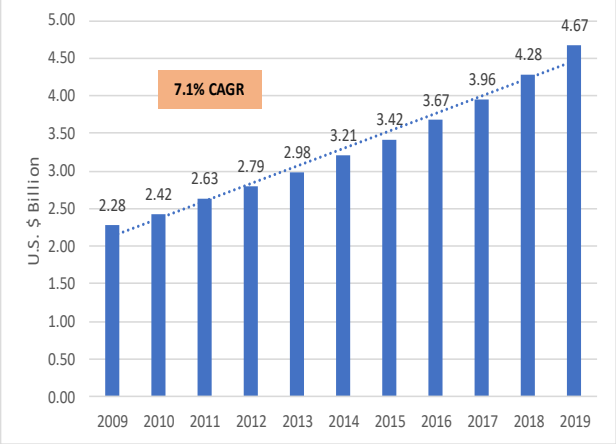
State of the Environmental Regime

Over the past 10 years, Latin America has included some of the fastest-growing emerging markets for U.S. exporters of environmental technologies. Colombia has fared particularly well due to its recent implementation of sound macroeconomic policies and institutional reform. Over 2019-2020, the World Bank expects that Colombia's growth will accelerate at a gradual pace, strengthened by increasing private consumption, an improved export climate, and recovering oil prices.

On May 15, 2012, the U.S.-Colombia Trade Promotion Agreement (CTPA) entered into force and more than 80% of U.S.-originating consumer and industrial products exported to Colombia became duty-free overnight. The remaining 20% of goods is intended to follow within 10 years. Free Trade Agreements (FTAs) help to facilitate the trade of environmental goods and services by eliminating tariffs, thus increasing the overall competitiveness of U.S. technologies in partner markets.

However, strong environmental regimes ultimately drive demand for environmental technologies. The Yale Environmental Performance Index (EPI) measures the capacity of countries to confront environmental issues, with an emphasis on the protection of human health and ecosystems. In 2018, Colombia ranked 42nd in the world with a score of 65.22. Colombia also placed second in Latin America, surpassing every country except Costa Rica. The EPI's report noted Colombia as an especially promising case due to how the government is using the post-conflict disarmament, demobilization, and reintegration (DDR) process to encourage ecotourism and sustainable agriculture.

Figure 11: Colombia's Environmental Technologies Market



Source: Environmental Business International with OEEI Analysis, 2019.

Colombia also became a member of the Organisation for Economic Co-operation and Development (OECD) in May 2018, and thereafter joined the OECD's Environmental Policy Committee. Requirements for accession included issuing its National Policy for the Integrated Management of Solid Waste and National Policy for Risk Management Associated with the Use of Chemical Substances, and carbon and plastic bag taxes. [14] Colombia's accession to the OECD will increase pressure on the government to comply with OECD standards and instruments, thus continuing to strengthen the country's environmental regime.

Peacetime in Colombia promises steady industrial and economic growth, improved regulatory and enforcement capabilities, and greater resources for many environmental agencies, vastly improving market prospects for U.S. environmental solutions providers. The water and wastewater sectors are expected to be the most directly impacted due to ongoing expansion of the mining and oil and gas industries, if the government enhances the environmental licensing process and compliance to environmental regulations. This is reflected in Colombia's ranking of seventh for water with a score of 10.2. Colombia also appears to be taking a long-term perspective on green growth and sustainability, which feature heavily in the country's most recent National Development Plan (2014-2018 NDP). An expanding U.S. presence in Colombian water projects could therefore favor U.S. companies in future opportunities across the broader environmental technologies market.

Market Barriers

The CTPA has significantly reduced or eliminated the majority of tariff and non-tariff market barriers for U.S. exports. However, challenges remain in the following areas:

1. **Intellectual Property Rights (IPR) Protection and Enforcement**
   The U.S. Trade Representative's Special 301 Report is an annual review of the state of IPR protection and enforcement in U.S. trading partners. Despite strong FTA IPR protection provisions, Colombia was included on the 2018 Special 301 Priority Watch List due to lack of progress regarding effective enforcement of certain provisions CTPA, particularly in the areas of online piracy and trafficking in illicit goods.

2. **Corruption**
   Corruption is a pervasive problem in Latin America that creates a real barrier to market participation for U.S. companies. In Transparency International's 2018 Corruption Perceptions Index, the only three countries in Central and South America that scored above 50 on a scale from 0 to 100, with 100 being extremely clean, were Costa Rica (56), Chile (67), and Uruguay (70). Colombia scored much lower at 36, ranking 99th out of 180 countries. Efforts to improve transparency and rule of law in Colombia would significantly improve the business climate and drive future opportunities for the trade of environmental technology.

3. **Import License and Certification Obstacles**
   According to the U.S. Commercial Service, the challenge of navigating the Colombian bureaucracy often results in delayed or detained shipments. Colombia is in the process of consolidating and simplifying its tariff rate schedule, which is complicated by its numerous, overlapping economic integration agreements. Currently, approximately 97% of the Colombian Harmonized Tariff Schedule (CHTS) products can be imported without an import license; however, import tariffs and VAT may still apply.

Market Opportunities – Air Pollution Control

Emissions Reduction

While Colombia has low greenhouse gas (GHG) emissions per capita, the level of GHG emissions per unit of GDP remains above the OECD average according to the OECD's Colombia Environmental Performance Review. This is largely a result of Colombia's developing economy. Colombia is Latin America's largest coal producer and fourth largest exporter of oil. Extractive industries, particularly those for fossil fuels and gold, as well as power plants, are significant contributors to GHG emissions. It is expected that

without intervention, GHG emissions could increase by 50% of 2000 levels by 2020 without even considering deforestation, an increasingly significant source of emissions in Colombia. Further, the emissions standards for industrial and thermal sources that currently exist are outdated and/or poorly enforced.

In 2017, the Colombian government officially committed to the reduction of its GHG emissions by 20% by 2030. The target would increase to 30% with a threshold level of international financial and technical support. [14] Within this, the government of Colombia is developing Nationally Appropriate Mitigation Actions (NAMAs) to cover the industrial sectors with the highest GHG emissions: Transport, Building, Waste, Agriculture, and Energy. So far, only three NAMAs have reached the implementation stage according to the online NAMA registry: The Transit-oriented Development (TOD) NAMA, the Sustainable Road-based Freight Transport NAMA, and the NAMA for the domestic refrigeration sector. The remaining eight NAMAs are still in various stages of the development process. [98]

As the regulatory regime around greenhouse gas emissions improves, the demand for emissions control technologies will increase, particularly in the extractive sectors. Paired with enhanced enforcement and compliance measures, this could create new opportunities for U.S. environmental solutions providers to enter the Colombian market where they would be competitively advantaged by existing trade agreements.

Key Technologies in Demand:

- Continuous emissions monitoring equipment
- Ambient air quality monitoring equipment
- Source emission measurement technologies
- Analytical and laboratory testing goods and services

Air Quality Monitoring and Pollution Control

In 2010, Colombia developed its national Air Pollution Control and Prevention Policy. The document was broad and comprehensive, covering air quality assessment, monitoring, standardization of air quality inventories, fuel-quality improvement, and implementation of incentive programs for environmental control and monitoring. [99]

The capital city, Bogota, has 14 active air quality monitoring stations, most of which measure particulate matter (PM10), ozone, and nitrogen dioxide. Some also measure sulfur dioxide but only one monitors PM2.5. Approximately 90% of the city's air pollution is attributed to mobile sources. [100] The government is making efforts to address the issue through stricter emissions regulations and other measures. In 2013, Resolution 1111 established that all light- and-heavy-duty vehicles must adhere to Euro IV emissions standards as of 2015.

Environmental management via the country's National Environmental System (SINA) is complex and challenging, particularly for priority issues such as air quality. Full implementation of SINA necessitates collaboration and information sharing and production across the 33 regional autonomous corporations with highly variable levels of capacity, accountability, and funding. [101] The government recently has placed greater emphasis on sustainable growth, including in its 2010 to 2014 and 2014 to 2018 National Development Plans (DNP). However, there is likely to be low demand for air pollution control technologies without the introduction of updated emissions standards, stronger institutional

accountability, and increased incentives to comply with environmental regulations.

On Nov. 1, 2017, the Ministry of the Environment enacted Resolution 2254, setting the maximum allowable emission limits for PM10, PM2.5, Sox, NOx, O3 and CO. It also created emission limits and corresponding alert levels for emergency action. [102] In February and March of 2019, events in Bogota and Medellin triggered the emergency system. The cities responded by improving fuel inputs for the Bus Rapid Transit system with plans to adopt the Euro VI fuel quality standard by 2021. However, given the age and condition of many of the trucks, buses and other large vehicles in Colombia, mobile source air pollution is likely to remain a significant challenge to environmental protection in the region.

Key Technologies in Demand:

- Ambient air quality monitoring equipment
- Source emission measurement technologies
- Particulate matter control systems

Market Opportunities – Waste and Recycling

Municipal Solid Waste Management

The OECD noted in its Colombia Environmental Performance Review that per capita municipal waste generation is "less than half the OECD average." However, according to a recent report by the World Bank, around 79% of Colombia's 27,000 tons of daily urban solid waste generation is landfilled. In 2014, Colombia produced a total 13.8 million tons of solid waste, and the figure is projected to reach 18.8 million tons by 2030. One-fifth of Colombian municipalities lack adequate waste disposal, and approximately 30% of the country's landfills are not properly managed, do not comply with environmental regulations, and are located predominantly in rural areas. [99]

On Nov. 21, 2016, Colombia passed the CONPES 3874, Colombia's National Policy for Integrated Solid Waste Management. The document represents one of the country's first national frameworks for waste management and includes four key priorities: preventing waste generation, minimizing disposal, promoting reuse, and avoiding GHG emissions. The policy is implemented by the Ministry of Housing, City, and Territory (MVCT), the Environmental and Sustainable Development Ministry (MADS), and the National Planning Department (DNP). The National Education Ministry, Mining and Energy Ministry, and the National Statistics Administrative Department also participate. CONPES 3874 calls for a short-term $62.5 million investment between 2016 and 2030 to implement the policy, which is likely to generate opportunities for U.S. environmental solutions providers. However, in the long-term, the government foresees a funding gap of as much as $1.1 billion for treatment processes, final waste disposal, service coverage expansions, and other CONPES 3874-related investments.

Technologies and Services in Demand:

- Waste collection technologies
- Sanitary landfill systems
- Environmental monitoring and analytical equipment
- Sorting machines
- Crushing and grinding machines
- Materials handling equipment
- Collection services, containers, and vehicles

Landfill Diversion and Recycling
Informal recycling is a key feature of Colombia's waste management sector. Approximately 26,000 informal and independent recyclers (*recicladores*) account for an estimated 55% of all recycled municipal waste, helping to balance the lack of formal source separation in cities and towns. [103] Colombia also was one of the first countries in Latin America to implement a national e-waste recycling program. The policy has four objectives: consumer education, instrument development, strengthening the recycling industry, and promotion of PPPs.

As part of Colombia's Nationally Determined Contribution (NDC) under the Paris Climate Agreement, the Ministry of the Environment and Sustainable Development and Ministry of Housing, City, and Territory jointly have pursued the creation of a Solid Waste Nationally Appropriate Mitigation Action (NAMA). Colombia first announced its new waste diversion strategy in Copenhagen at the 2013 Global NAMA Financing Summit. The NAMA was intended to achieve "waste sector carbon neutrality" while also reducing environmental degradation, increasing landfill life by 100% and generating economic activity in the sector by encouraging new technologies and management processes.

The NAMA advocates for broad sectoral reform. It encourages construction of mechanical biological treatment (MBT) facilities that would reduce landfilling by recycling non-organic waste, composting organic waste, and creating refuse-derived fuel (RDF) to "replace coal/fossil fuels" in the long-term. To accomplish this, Colombia intends to "undertake ambitious regulatory reform" around alternative processes, "progressive regulations like Extended Producer Responsibility (EPR)" and financial incentives for sustainable solid waste management practices. The Colombian government has requested $25 million in climate finance support to implement the Solid Waste NAMA.

In March 2016, the national government reviewed 380 Integrated Solid Waste Management Plans (PGIRS) from across the country and selected several pilot cities for Phase I (Cali) and Phase II (Barranquilla, Medellin, Bucaramanga). As of March 2019, the international NAMA database says the strategy remains "under development" and has not yet been sent to the United Nations Framework Convention on Climate Change (UNFCCC) registry.

It is unclear when the Solid Waste NAMA will be finalized, submitted and funded. Nevertheless, when the Solid Waste NAMA eventually is implemented, demand will increase for the necessary environmental impact consulting, engineering, procurement, and construction (EPC) services, as well as MBT-specific equipment and technology, creating new opportunities for U.S. environmental solutions providers.

Key Technologies in Demand:
- Environmental Impact Assessments
- Engineering, Procurement, and Construction Services
- Mechanical Biological Treatment Technologies
- Recycling process expertise
- Waste-to-Energy systems

Hazardous Waste Management
Title 2 of Decree 1077 (2015) sets the general regime for the management of conventional solid waste, including storage and disposal rules, while Title 6 of Decree 1076 sets forth rules for handling, storage, and treatment of hazardous waste. The rules include obligating generators to prepare a complete

Hazardous Waste Management Plan, as well as to register as a hazardous waste generator with the relevant environmental authorities. Public utilities are charged with collecting and transferring all hazardous waste to disposal sites. The Ministry of Environment also recently issued regulations regarding collection and management of several types of household hazardous waste, including pesticides, acid lead batteries, pharmaceuticals, batteries, tires, light bulbs, and electrical and electronic consumer products. [104] The policy environment continues to evolve, but it seems likely that demand for hazardous waste management technologies will continue to increase to keep pace with generation.

The extractive industries are a major source of soil pollution in Colombia. The country's Antioquia administrative department registers as the world's largest mercury polluting area per capita, largely due to the prevalence of small-scale artisanal gold mining. [105] The adoption of Law 1658 in 2013 was an important step toward mercury reduction, as it aims to phase out the use of mercury in mining by 2018 and in all production processes by 2023. As of 2019, Colombia lacks a coherent national framework for land contamination management but increasing concern for environmental and ecosystem protection has brought the issue into greater prominence and is likely to be receptive to positive regulatory and policy developments in this area.

Key Technologies in Demand:

- Sanitary landfill design and associated technologies
- Collection services, containers, and vehicles
- Waste handling equipment
- Waste treatment technologies
- Mercury reduction

Market Opportunities – Water and Wastewater Treatment

Historically, Latin America has been considered a freshwater-abundant region, holding more than 99% of the world's tropical glaciers. However, because of rising global temperatures, Colombia has lost more than 20% of its glacier cover over the past seven years. If trends continue, estimates suggest that the country will lose all its ice within the next 25 years. This will severely reduce the country's freshwater supply and put enormous stress on economically important, but water-intensive sectors, like agriculture and mining.

There are many intervention strategies that would make Colombia's water sector more resilient. Millions of citizens still lack access to basic water and sanitation services, particularly in rural communities. According to the OECD, "a mismatch between population concentration and water availability … leaves more than one-third of the urban population … under moderate to high water stress." [103] The United Nations Development Programme (UNDP) claims that as much as 42% of the population has no access to drinking water. [106] To address this, the government of Colombia has planned more than $13 billion in water sector projects over the next 10 years with the hope that public investment will spur an increase in private sector participation. [107]

Municipal Water and Wastewater Treatment

The wastewater treatment rate is low in Colombia at approximately 33%. As a result, many of the water sources remain heavily polluted, including those in in densely populated urban areas like Bogota, Medellin and Cali. Pillar 2 of the 2014-2018 National Development Plan focuses on measures that will "improve the environmental factors that affect health" as well as "institutions and policy shortcomings that undermine policy effectiveness."

One of the government's main objectives under Pillar 2 of the 2014-2018 NPD is to construct wastewater treatment plants in the country's principal cities, while the Autonomous Regional Corporations (CARs) are planning projects in other areas. [15] Mercury is a particularly serious problem due to its extensive use in gold mining. World Bank estimates suggest that mercury pollution-related economic costs in the Antioquia region alone range between $43 million and $122 million, representing up to 14% of the total value of the regional metallurgical industry.

Wastewater treatment is an important priority for the Colombian government under the 2004 National Action Plan for Municipal Wastewater Management. The Plan establishes an ambitious target of 50% for wastewater treatment by 2019. The latest figures from the National Development Plan (PND), prepared by the National Planning Department (DNP), indicate wastewater treatment coverage of 42.6% in 2017, up from 37.2% as of 2015 and eight percent in 2002. Public expenditure on water and sanitation has more than doubled in the past decade, but investment levels remain lower than in other emerging economies. [103] As a result, the World Bank believes the goal is still unlikely to be met because of insufficient project financing. Additionally, several of the wastewater treatment facilities that have been built remain un-operational due to funding obstacles.

To address this, Colombia is trying to increase the number of PPPs in the country's water sector. Changes to the PPP law in 2012 support greater private sector participation by delineating clear guidelines for the deployment of PPPs in water and sanitation. [108] The Colombian government anticipated $6.3 billion of investment in water projects between 2015 and 2018, noting that approximately 30% was expected to be financed privately. [108]

Colombia's interest in encouraging greater private sector participation in the water sector is part of a broader government strategy to improve urban water quality, restore major tributaries such as the Bogotá River, and expand sanitation services and sludge treatment nationwide. [109] The preeminent infrastructure opportunity is the development of the Canoas wastewater treatment plant of Empresa de Acueducto y Alcantarillado de Bogotá (EAAB). On March 12, 2019, the Regional Autonomous Corporation of Cundinamarca (CAR) announced its commitment to fund up to COP 1.5 billion (approximately $481,000) for the financial closure of the Canoas plant, or about one-third of the total estimated cost of COP 4.5 billion (approximately $1.5 million). CAR will partner with the Bogotá Mayor's Office (*Acueducto de Bogotá*) and the Governor of Cundinamarca in the development of this project. The U.S. Commercial Service in Bogota expects that the facility would be completed by late 2025, but a primary treatment process may come online by late 2023.

On March 17, 2015, the Ministry passed Resolution 0631, [110] which establishes the maximum allowable pollution levels from point sources into superficial bodies of water and public sewer systems. Resolution 0631 aims to reduce pollution loads to improve water quality and calls for more advanced industrial and municipal treatment processes. The resolution provided for up to 3.5 years of transition time for the 73 targeted production activities in the country. Enforcement and compliance therefore will begin in mid/late 2019. Nevertheless, given historical regional inequities and the difficulty of acquiring the necessary funding and technical expertise in-house, the transition process is likely to continue well beyond the deadline, creating a sustained need for environmental goods and services. Additionally, between 2015 and 2024, over 20 water utility concessions are set to expire, which will allow for new concession opportunities. [15]

Key Technologies in Demand:

- Filtration
- Advanced filtration
- Chemical disinfection
- Pumps, pipes and valves
- Primary and secondary treatment technologies
- SCADA systems
- In-line monitoring systems

ETWG Agency Initiatives and Programs

U.S. Environmental Solutions Toolkit

The Toolkit is an online searchable database that marries U.S. EPA expertise on solving environmental challenges and developing environmental rules with a catalogue of U.S. technology providers. In 2015, ITA and U.S. EPA introduced a Spanish-language version of the Toolkit to expand its usability in Latin America. It serves as a reference tool in bilateral engagements that focus on increasing Colombian capacity to address environmental concerns. In 2019, an enhanced version of the Toolkit will be released that will include an updated database of solutions providers and the capability for foreign buyers and government officials to contact them directly via the online interface. U.S. companies interested in participating in the Toolkit can find out more at www.export.gov/envirotech.

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Water Environment Federation Technical Exhibition and Conference (WEFTEC) IBP

The U.S. Department of Commerce, through IBP, leads a delegation of Colombian officials and business representatives to WEFTEC to explore relevant U.S. technologies and work with U.S. exporters on approaches to water resource management.

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www.dnp.gov.co

Ministry of Environment and Sustainable Development

www.minambiente.gov.co

Ministry of Housing, City and Territory

http://www.minvivienda.gov.co/

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www.cra.gov.co

Acueducto de Bogotá
www.acueducto.com.co

Empresas Públicas de Medellín (EPM)
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www.export.gov/colombia

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India Case Study

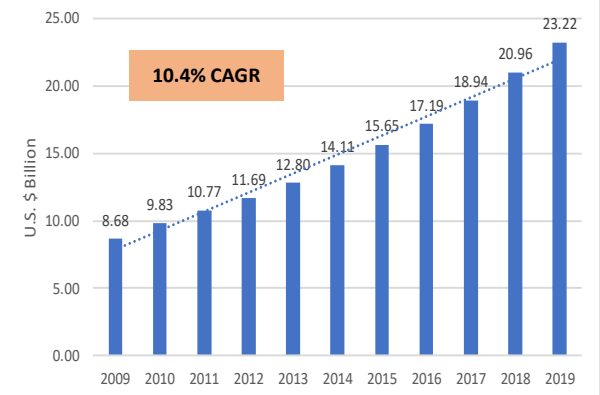
Persistent and mounting pollution problems will lead to steady growth in India's fragmented environmental technologies market. The overall environmental technologies market in India, including goods and services, is estimated to be valued at $23.22 billion in 2019. India ranks sixth overall in the 2019 Top Markets Report, with a Composite Environmental Technologies Score of 29.3. India ranks second for water, with a score of 16.5; ninth for air pollution control; and eighth for waste and recycling markets, with scores of 10.1 and 2.7, respectively (see Appendix 1 for global rankings).

State of the Environmental Regime

India's complex environmental regulation hinges on five major pieces of legislation: The Environment (Protection) Act, 1986; Forest (Conservation) Act, 1980; Wildlife (Protection) Act, 1972; the Water (Prevention and Control of Pollution) Act, 1974; and the Air (Prevention and Control of Pollution) Act, 1981. The federal government established the National Green Tribunal in 2010 to better uphold these environmental protections. The Tribunal is an increasingly integral force in the effort to create a more sustainable national development path. [111] More recently, India launched an Environmental Sustainability Index at the state level to focus on population pressures, waste management, and environmental budgeting. [112]

The regime is steadily improving as evidenced by the OECD Environmental Policy Stringency Index, which ranks environmental regimes on a scale from 0 to 6 (with 0 being lax and 6 being the most stringent). India scored a 1.82 in 2015, a 1.15-point improvement from its 2005 score of 0.67. [7]

Figure 12: India's Environmental Technologies Market



Source: Environmental Business International with OEEI Analysis, 2019.

However, the 2018 Yale Environmental Performance Index (EPI) ranked India 177th out of 180 countries (where 180 is the worst performer). The EPI compiles its index by considering the capacity of countries to confront environmental issues, with emphasis on the protection of human health and ecosystems. [8]

The Ministry of Environment, Forest and Climate Change (MoEFCC) is the federal agency responsible for implementation and oversight of environmental laws in India. Enforcement, however, is delegated to the state level through State Pollution Control Boards (SPCBs), or Pollution Control Committees (PCCs) in the seven union territories that answer to state government heads rather than the federal authority. This decentralizes enforcement practices and contributes to fragmentation and inconsistent application of rules across provinces, lack of transparency in regulations and practices, poor implementation of regulations, weak regulatory compliance, and corruption in some areas. India's environmental laws are challenging to

enforce because regulators lack the resources to address issues of asymmetric information and assert authority. [113]

Market Barriers

The following barriers have been identified by the Environmental Technologies Trade Advisory Committee (ETTAC), the U.S. Department of Commerce's Office of Energy and Environmental Industries (OEEI), and the Commercial Service India as the most problematic for environmental technologies companies attempting to export to or work in India:

1. **High Tariffs**
   India has relatively high tariffs for environmental technologies, particularly in monitoring and instrumentation. High import taxes also diminish the price competitiveness of higher quality, and thus pricier, U.S. environmental technologies.

2. **Regional Market Fragmentation**
   Environmental technology markets in India are highly fragmented and it can be difficult to find a representative or distributor that can provide national sales coverage. Successful companies expend additional resources to develop export strategies on a region-by-region basis.

3. **Lack of Transparency, Price Sensitivity and Corrupt Practices in Tenders**
   Transparency in how tenders are bid is an ongoing issue in India that is further complicated by regional fragmentation. Tenders are also plagued by a lowest bidder mentality with little assessment of cost/quality trade-offs. U.S. companies have reported that public tenders are rife with institutional corruption that hinders U.S. companies' ability to compete, as well.

4. **Limited Capacity of Local Industry**
   Local partners are tacitly, if not formally, required in tenders. However, many national players in the Indian water market are new to the sector and may have no prior experience developing or implementing water projects. This creates additional management burdens for U.S. companies entering into joint ventures and partnerships.

Market Opportunities – Air Pollution Control

The most significant laws regulating air pollution control are the 1987 Air Prevention and Control of Pollution Act and the National Ambient Air Quality Standards, revised in 2009. [114]

Air Quality Monitoring

The Central Pollution Control Board is responsible for the National Air Quality Monitoring Programme (NAMP) the network consists of 731 operating stations covering 312 cities and towns across the country. [115] In April 2015, the Indian government launched the country's first Air Quality Index (AQI). The AQI focuses on four major pollutants (SO2, NOx, and particulate matter (PM 2.5 and PM10)) and initially covered 10 cities. It will eventually expand to more than 60. Each city will install six to seven continuous monitoring stations with AQI display boards, and the data collected must be made available to the public daily via an online portal. [116]

The Indian government seeks to establish baseline data on ambient air quality and pollution sources. This information will be used to determine cost-effective source reduction opportunities and

investments, assist policy makers in evaluating health and economic impacts of various air pollution control approaches, and foster accountability for air quality improvements. [117] The growing need to monitor and control emissions from India's coal-fired power plants and petroleum-refining operations provides opportunities for U.S. technology providers.

Key Technologies in Demand:
- Fenceline monitoring equipment
- Continuous emissions monitoring equipment
- Ambient air quality monitoring equipment
- Source emission measurement technologies
- Inspection, adjustment, maintenance, and repair services

Air Pollution Control

Coal is India's primary energy source, [10] accounting for more than 70% of generation in the power sector. [118] India is projected to become the largest source of growth in global coal use over the next 25 years. [119] However, most of the country's coal has low to medium heat values and high ash content. Poor-quality coal contributes to decreased efficiency in power generation and higher local emissions. [118] Furthermore, with more than 85% of India's coal-fired power plants employing subcritical technology, average efficiency for the generating fleet is currently less than 35%. [118]

Uncertain supply and high end-use tariffs have encouraged self-sufficiency in many energy-intensive industries, including steel, cement, chemicals, sugar, fertilizer, and textiles. Wealthier households also typically employ back-up diesel generators, increasing particulate matter emissions, and worsening local air quality. [118]

The government's "Make in India" initiative aims to increase domestic manufacturing as a percentage of GDP to 25% by 2022. [120] The program was launched in 2014 and targets several key sectors, including mining, oil and gas, power generation, pharmaceuticals, chemicals, and construction. Expansion of infrastructure – including energy infrastructure – to build-up the country's manufacturing base will require significant involvement of coal-consuming sectors such as cement and steel, which are substantial contributors to air pollution.

As part of the December 2015 Paris Climate Agreement, India committed to a Nationally Determined Contribution (NDC) of reducing its emissions intensity by 33-35% from 2005 levels. To accomplish this by the 2030 deadline, India will apply stricter rules to emissions from coal-fired power plants built after 2016. [121] For example, recent regulations set sulfur dioxide limits contingent on the age and size of boilers. Since the nation is water-scarce, many coal power plants are expected to invest in dry flue gas desulfurization (FGD) techniques, creating particular growth in that market. [122] In 2018, the Central Electricity Authority revised the implementation plan for the installation of FGD, including over 400 units representing more than 160,000 megawatts of generation capacity that are required to adopt the technology by 2022. [123] At an estimated capital cost of $53,800 (INR 3.5 million)/MW, Indian utilities will spend $8.5 billion on installation of FGD systems over a 7- to-10-year timeframe. Weak financials of state-owned power utilities and revenue model based on pre-FGD mandate of independent power producers are potential stumbling blocks. Other hindrances to rapid installation of FGD systems include requirement of reagents and availability of steel.

India has also initiated a large NOx control program. [124] Operators of the existing 187,000 MW of plants will have to spend $8 billion collectively to meet the new standards. While small units built prior

to 2003 are tasked with reductions as low as 15%, units larger than 500 MW will have to make NOx reductions of 50% or more. Further, plants built after 2015 will need to remove 85% of NOx at an estimated annual investment of $1.5 billion. Due to the recently mandated reductions in NOx emissions, it will be necessary to install selective catalytic reduction (SCR) systems in all new and many existing power plants, including those currently under construction. [125]

The government also has identified 17 high-polluting industry sectors in need of greater oversight and air pollution control measures. These include aluminum smelting, pharmaceuticals manufacturing, chlor-alkali/caustic soda, cement (≥ two hundred tons/day), copper smelting, dyes and dye intermediate, fermentation (distillery), fertilizer, integrated iron and steel, leather processing – including tanneries – oil refinery, pesticide formulation and manufacturing, pulp and paper (≥ thirty tons/day), petrochemical, sugar, thermal power plants, and zinc smelting. A 2015 assessment showed that industrial combustion contributes to nearly half of India's particulate matter (PM 10) emissions. [114] As rules for these industries evolve and are enforced, opportunities in control technologies will develop. Fresh demand for tens of billions of dollars' worth of new NOx controls and FGD technologies are predicted to increase the value of India's air pollution control market to more than 70 billion dollars within the next seven years. [126]

Key Technologies in Demand:
- Wet and dry scrubbers
- Bag houses
- Filters
- Flue Gas Desulphurization (FGD)
- Selective catalytic reduction technologies
- Selective non-catalytic reduction controls
- Urea to ammonia reagent systems
- Zero Liquid Discharge (ZLD) systems
- Dry sorbent injection (DSI)

Market Opportunities – Waste Management and Recycling

Solid Waste Management and Recycling

The waste management and recycling sectors remain underdeveloped in India. Challenges include inefficient waste management infrastructure, lack of coordinated planning, and an increasing rate of solid waste generation per capita. [127] The country generates about 62 million tons of municipal solid waste (MSW) per year, [128] which includes 5.6 million tons of plastic waste, 0.17 million tons of biomedical waste, 7.9 million tons of hazardous waste, and 1.5 million tons electronic waste. [129] Furthermore, India reportedly is responsible for 60% of the plastic dumped into the world's oceans every year. [130] Formal and industrial recycling processes are fairly limited. Urban waste management services spend between $7-21 per ton of municipal solid waste. Out of this, 60-70% is spent on collection, 20-30% on transportation, and almost nothing on treatment and disposal. Short-term standardization is unlikely as a widespread informal recycling industry provides income to many of India's poorest households. The government has allocated approximately $1.11 billion for solid waste management projects in urban areas. [131] The U.S. Commercial Service in Kolkata estimates this to be about one-third of the total investment needed.

The sector is regulated by the 2016 Municipal Solid Waste (Management and Handling) Rules, issued by the Ministry of Environment and Forests under the 1986 Environment (Protection) Act. The Rules were revised after 16 years to designate specific responsibilities for waste generators, provide detailed criteria for setting up solid waste processing and treatment facilities, lay down landfill and landfill closure specifications and rehabilitation of old dump sites, and emphasize waste-to-energy conversion technologies. The Ministry of Urban Development has set a target of 511 MW of power to be generated from waste-to-energy by 2019. Municipalities have the primary responsibility for managing solid waste with assistance from state-level urban development authorities. The Rules have created opportunities for U.S. waste management equipment and service companies.

Key Technologies and Services in Demand:
- Waste handling equipment
- Gasification, pyrolysis, and incineration technologies
- Waste treatment technologies
- Waste management systems design expertise
- Landfill design and engineering

Electronic Waste (E-Waste) Recycling
MoEFCC implemented the E-Waste Management and Handling Rules in 2011, revising it to the E-Waste (Management) Rules in 2015. These directives outline responsibilities of electronics producers, discarded electronics collection centers, recyclers and other relevant entities to limit environmental and health issues potentially created by improperly discarded or recycled electronic equipment. The 2011 law originally sought to establish a formal electronics recycling framework to promote safe handling of discarded electronics and growth in related economic activities nationally. The 2015 revision increased producers' responsibility under an Extended Producer Responsibility (EPR) program, setting up Producers Responsibility Organizations (PRO) and an e-waste exchange.

According to former Environment Minister Prakash Javadekar, the 2015 rules place "absolute responsibility" on the producer to manage the full life of e-waste, from generation to safe disposal. [132] Increased demand for equipment and recycling services presents opportunities to U.S. companies with experience in safely and efficiently recovering valuable materials from discarded electronics.

Key Technologies in Demand:
- Waste handling equipment
- Waste treatment technologies
- Brownfield site remediation design and equipment
- Soil contamination testing and monitoring equipment

Hazardous and Medical Waste Management
Economic and industrial development in India has led to increased focus on proper management of hazardous wastes. In 2008, the national government implemented the Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, outlining the responsibilities of various entities relevant to disposal, collection, and treatment of hazardous wastes. Additionally, expanded access to healthcare in India created an estimated 80 billion-dollar industry as of 2012, with an expectation that it will reach $280 billion by 2020. [133] Helping India institute systems for managing the resulting hazardous and medical waste may present market opportunities for U.S. companies.

Key Technologies in Demand:
- Waste handling equipment
- Waste treatment technologies
- Brownfield site remediation design and equipment
- Soil contamination testing and monitoring equipment

Market Opportunities – Water and Wastewater Treatment

According to U.N. definitions, India is currently "water stressed" and heading toward "water scarcity." [134] A growing population, rapid urbanization, increased per capita income, continuing industrialization, and agricultural development are all driving water demand. [135] Currently, nearly 40% of industrial water and 63% of municipal wastewater is discharged untreated. The Indian water and wastewater sectors have ambitious plans to develop comprehensive public and private water and wastewater treatment and distribution infrastructure. India has at least 155 water treatment and transmission, desalination, and industrial reuse projects in its tendering pipeline – including 28 PPPs – with a cumulative estimated value of over $4.3 billion. [136]

Realizing implementation at this level will require unprecedented levels of investment in public infrastructure, as well as new financial vehicles that make water, wastewater, and reuse projects profitable endeavors.

Municipal Water and Wastewater Treatment and Plant Development
Growth in the municipal water and wastewater treatment sector is driven by shortfalls in drinking water and sanitation access, as well as growing concerns over surface water pollution and efficiency demands related to overall water scarcity in India. While 94% of the population has access to clean drinking water, less than 40% has access to sanitary wastewater systems, [137] a disparity that emphasizes the dire need for improved wastewater treatment systems. Current treatment capacity is estimated to be about 31% of wastewater generation. [134] If implemented, plans to introduce wastewater tariffs and combine them with drinking water tariffs will lead to steady and robust infrastructure growth over the next five years. The emphasis on improving wastewater treatment is reflected in the segment's expected growth curve of 15.3% CAGR between 2015 and 2020. [138] Global Water Intelligence estimates that the value of the wastewater treatment segment will reach $6.4 billion in 2022, almost doubling its 2016 value of $3.5 billion. [17]

The drinking water treatment and supply segment will grow more slowly, nevertheless likely to reach $9.4 billion in 2020 from a 2015 base of $5.5 billion. The Indian Planning Commission estimates that $126 billion of capital investment is required over the next 15 years to meet India's basic potable water

and sanitation needs. [139] In the short run, lack of consumer confidence in municipal sources of drinking water will continue to fuel a robust point-of-use water technology market in India.

The Jawaharlal Nehru National Urban Renewal Mission (JNNURM), formerly the largest source of financing for municipal water and wastewater projects, has been replaced by the Modi government's Atal Mission for Rejuvenation and Urban Transformation (AMRUT) and, to a lesser extent, the Smart Cities Initiative. AMRUT has budgeted more than $7.7 billion for interventions in 500 towns and cities nationwide, combined with the additional $7.4 billion for planned smart infrastructure initiatives in 100 cities. [138]

The Modi government's model for funding the National Mission for Clean Ganga seeks to entice investors by relying on a "hybrid annuity-based PPP model." The central government will finance 40% of the capital costs for facility construction, followed by a release of remaining funds in annuity-style payments subsequent to commissioning. [140] Three billion dollars initially were allocated to the Ganga River conservation mission until 2020, with intentions to employ this model for approximately 20 municipalities in total. [134] However, due to challenges associated with funding deployment in the past 12 months, in early 2019 the government reduced the program's provisional budget for the 2019-2020 fiscal year. Bringing projects to completion over the past five years since the inception of the program has proved to be an ongoing problem. [141] By the end of 2018, just 14% (31 out of 136) of planned sewage treatment plants had been built, though a number of others are still under construction. The results of this spring's national elections will determine the future pace of investment in the program. [142]

Technologies and Services in Demand:
- Engineering, procurement, and construction services
- Operations services
- Advanced filtration
- Membrane filtration
- Waste-to-Energy technology
- Anaerobic digestion
- Nitrification
- Biological denitrification
- Monitoring equipment
- Testing equipment

Municipal Water Efficiency

Energy shortage and water loss issues plague Indian municipalities. The government of India estimates that between 50 to 70 percent of water supply costs come from the electricity needed to pump water. Additionally, reported non-revenue water is 30 to 50 percent, with actual non-revenue water likely to be even greater. The National Action Plan for Climate Change states a goal of improved management that will increase water use efficiency by 20 percent during the Five-Year Plan period. Coupled with other investments in infrastructure and the vast national build-out of water treatment facilities, the demand for water efficiency technologies will rise rapidly in the coming years.

Technologies and Services in Demand:
- Monitoring technology
- Leak resistant transmission systems

Industrial Process and Wastewater Treatment and Reuse

Industrial process and wastewater is a rapidly growing segment of the Indian water market, estimated to reach two billion dollars in revenues by 2020 [138] and expected to grow 20-25% per year. [143] The market for process water is driven by process demand and influent quality as surface water meets 41% of industrial demand. [139] Meanwhile, the market for wastewater and reuse is driven more by the relative scarcity of water than strict effluent guidelines provided by the government. This point is underscored by that – although encouraged in official planning; industrial reuse is not articulated in any state or national regulation. [138] India's Niti Aayog has proposed universal adoption of smart water meters by 2021 and benchmarks for water use in water intensive industries. [144]

Weak regulations and enforcement of industrial effluent is expanding the scope of pollutants and increasing treatment complexity and burdens on municipalities. Plans to implement a tariff system for industrial effluent that penalizes low-treatment quality and provides industrial credits for water reuse is a key pillar of the National Water Policy. Consistently, the Modi government has recommended that heavily-polluting industries embrace zero liquid discharge technologies to avoid effluent release into surface sources entirely. Water-intensive industries, such as power generation, oil and gas refining, petrochemical production, pharmaceuticals, and steel, are already implementing reuse strategies to meet locally-imposed freshwater limits and address scarcity issues. Nevertheless, several power plants are under threat due to water shortages, presenting opportunities for alternative water sources such as desalination and the use of treated municipal wastewater. [145]

There are also emerging opportunities for improved wastewater management in the "new industrial cities." The primary example is the Delhi-Mumbai Industrial Corridor (DMIC). The DMIC plans to establish seven new industrial cities with estimated forthcoming water and wastewater capital investments of $90 billion. DMIC will provide a series of Engineering, Procurement, Construction (EPC) and Build, Own, Operate, Transfer (BOOT) contracts for water supply networks, drainage schemes, and effluent treatment plants. [80] While the program still appears promising, the projects have not moved substantially beyond the planning stages, nor have they resulted in considerable industrial water spending. [17]

Industries that exhibit demand for treatment technologies include power plants, oil and gas extraction and refining, food and beverage, pharmaceuticals, textiles, steel and aluminum production, and mining. These industries favor high-end products that meet rigorous international standards for quality and technical efficacy.

Technologies and Services in Demand:

- Engineering and construction services
- Water reuse equipment and services (process specific)
- Advanced filtration
- Membrane filtration
- Reverse osmosis
- UV disinfection
- Anaerobic digestion
- Nitrification
- Biological denitrification
- Membrane bioreactor systems

Groundwater Maintenance and Recharge
India is withdrawing groundwater resources at an unsustainable level. Currently, India has the highest rate of groundwater extraction of all of the G20 countries, over twice that of second-place China. [134] According to India's official Ground Water Resources Assessment, more than one-sixth of the country's groundwater supply is currently overused. [146] Eighty-five percent of drinking water comes from aquifers, which are being heavily depleted. [147] Water levels have declined by approximately a fourth in the Ganges basin as a result of significant extraction. Much of the water is also contaminated with arsenic and fluoride. [147] An absence of adequate infrastructure, along with weak environmental governance and little technical expertise to manage pollution pressures, has resulted in the rapid deterioration of water quality. [148]

In the short term, the government plans to address shortages by creating a comprehensive groundwater monitoring system and groundwater recharge projects. This will translate to demand for groundwater mapping services, monitoring technology, and early phase recharge demonstration projects. Additionally, in December 2018, India's Central Ground Water Authority (CGWA) proposed a fee to regulate the extraction of groundwater starting on June 1, 2019, which could provide a renewed boost for reuse and non-revenue water reduction projects. [149]

The Government of India has also launched the "Groundwater Development and Management" project with an estimated cost of $470 million to prepare aquifer management plans, quantify water availability and water quality, and to facilitate sustainable management of groundwater with active stakeholder engagement. However, the pace of program implementation needs to be accelerated. [150]

Technologies and Services in Demand:
- Hydrological mapping services
- Monitoring equipment
- Groundwater recharge technology

Market Opportunities – Environmental Consulting and Engineering

The construction market in India is expected to grow twice as fast as China's, largely due to rapid urban population growth. India is also expected to become the world's third largest construction market overall by 2021. [151] If held to requirements for environmental impact assessments in the creation of environmental infrastructure in the water and waste management sub-sectors, India's environmental engineering and consulting needs could increase exponentially. There are several large consulting engineering companies in India, some even world-class, seeking state-of-the-art technology for use in their projects.

Technologies and Services in Demand:
- Environmental impact assessment
- Water and wastewater treatment plant design and construction
- Municipal and industrial hazardous waste treatment and disposal facilities
- Smart city projects
- Hydro-geological studies

ETWG Agency Initiatives and Programs

U.S. Environmental Solutions Toolkit
The Toolkit is an online searchable database that marries U.S. Environmental Protection Agency (U.S. EPA) expertise on solving environmental challenges and developing environmental rules with a catalogue of U.S. technology providers. In 2019, an enhanced version of the Toolkit will be released that will include an updated database of solutions providers and the capability for foreign buyers and government officials to contact them directly via the online interface. U.S. companies interested in participating in the Toolkit can find out more at www.export.gov/envirotech.

Power-Gen International Buyer Program
Power-Gen, one of the leading U.S. power generation equipment and services trade shows, has partnered with the U.S. Department of Commerce's International Buyer Program (IBP) to encourage foreign participation in the show. This platform is leveraged to discuss policies and exchange technical information regarding power plant emissions control with Indian participants and to foster business relationships between Indian end-users and U.S. emissions control providers. Waste-to-energy technologies is another segment of interest.

Waste Expo International Buyer Program
Waste Expo, one of the leading U.S. waste management trade shows, has partnered with the U.S. Department of Commerce's International Buyer Program to encourage foreign participation in the show. This platform was leveraged to exchange relevant technical information with Indian participants and to introduce Indian buyers to U.S. waste management technology providers.

WEFTEC International Buyer Program
The U.S. Department of Commerce, through IBP, leads a delegation of Indian officials and business representatives to WEFTEC to explore relevant U.S. technologies and work with U.S. exporters on approaches to water resource management.

Market Contacts and Program References

Ministry of Housing and Urban Affairs
http://mohua.gov.in/

Central Pollution Control Board
http://www.cpcb.nic.in/

Environmental Information System – ENVIS: India
http://envis.nic.in/

National Mission for Clean Ganga
http://nmcg.nic.in/

Smart Cities Mission
http://smartcities.gov.in/

Atal Mission for Rejuvenation & Urban Transformation (AMRUT)
http://amrut.gov.in

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http://niti.gov.in/writereaddata/files/coop/India_ActionAgenda.pdf

USAID
http://www.usaid.gov/india

JICA
http://www.jica.go.jp/india/english/

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Indonesia Case Study

The overall environmental technologies market in Indonesia (including goods and services) is estimated to be valued at $6.87 billion in 2019. Indonesia ranks seventh overall on the 2019 Top Markets Report with a Composite Environmental Technologies Score of 29.3. Indonesia ranks seventh for air pollution control and eighth for water markets with scores of 13.6 and 9.1, respectively. Waste & recycling ranks first with a score of 6.6 (see Appendix 1 for global rankings).

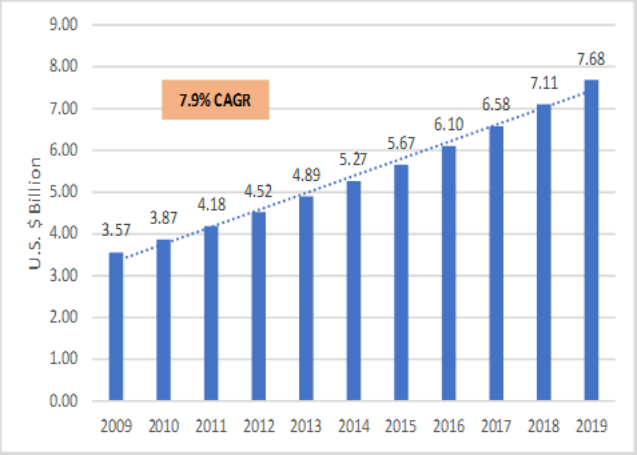
Overall Rank	Air Pollution Control
7	7
Water	**Waste & Recycling**
8	1

Despite ongoing efforts to establish a modern environmental regime, Indonesia faces both weak technical capacity and poor asset management in the public sector. As a result, the application of environmental technologies is likely to remain the purview of the private sector and donor organizations, at least in the short-term.

State of the Environmental Regime

The Ministry of Environment and Forestry (MoEF) is the primary administrator of environmental policy in Indonesia. The MoEF and its authorities are responsible for environmental protection and management, and the supervision of compliance by parties responsible for business and activities conducted within their administrative areas. The principal law regulating environmental protection is Law No. 32 on Environmental Management and Protection.
Domestic and foreign advocates for environmental protection have faced several obstacles to policy implementation in Indonesia, including weak commitment by sector agencies, low awareness in local governments, and capacity challenges at all levels. [152]

Figure 13: Indonesia's Environmental Technologies Market



Source: Environmental Business International with OEEI Analysis, 2019.

The 2018 Yale Environmental Performance Index (EPI) ranked Indonesia 133rd out of 180 countries (where 180 is the worst performer). The EPI compiles its index by considering the capacity of countries to confront environmental issues, with emphasis on the protection of human health and ecosystems. [8]

Despite these challenges, Indonesia's environmental regime is improving in both regulatory development and enforcement. The OECD Environmental Policy Stringency Index, which ranks environmental regimes on a scale from 0 to 6 (with 0 being not stringent and 6 being the highest degree

of stringency), gave Indonesia a score of 1.08 in 2015. This is a 0.64-point improvement over its score of 0.44 in 2005. [7]

Market Barriers

Market barriers in Indonesia are substantial and often insurmountable in the public sector. The Office of Energy and Environmental Industries (OEEI), together with the Indonesia Desk and the U.S. Commercial Service Jakarta, identifies the following barriers as most problematic for environmental technologies companies attempting to export to or do business in Indonesia:

1. **Weak Technical Capacity to Implement Advanced Environmental Systems**
   The technical capacity to implement advanced environmental solutions varies by sector, with public providers of environmental services exhibiting low to medium capabilities. This shortfall in capacity contributes to delays in project development and weak oversight of existing projects. Delays are especially challenging due to the high rate of turnover in the public sector.
2. **Poor Asset Management in Public Projects**
   Indonesia is plagued by poor asset management in the public sector and, in many cases, a lack of any asset management policy or attendant know-how. This has led to a variety of premature infrastructure failures. The decoupling of construction from downstream maintenance and operations divorces accountability between those that develop infrastructure and those responsible for maintaining it. [36]
3. **Perpetual Delays in Announced Projects**
   Indonesia developed an ambitious national agenda for environmental infrastructure development centered on a PPP model; however, repeated failures to secure financing have mired projects in the conceptual stage. The flaw in Indonesia's PPP model is a wholesale transfer of risk to the private sector without appropriate profit incentives. [36]
4. **Difficulty Capturing Business with Client Industries**
   The most promising areas for environmental technologies originate from client sectors such as oil and gas or mining. However, it can be difficult for new-to-market exporters to develop relationships that lead to export sales with these clients.
5. **Local Content Requirements**
   Over the past several years, the Indonesian government has introduced regulatory changes mandating local content requirements across the energy sector. This hinders market development overall and limits the ability for U.S. solutions providers to gain a foothold in Indonesia.
6. **Lack of Regulatory Implementation, Transparency, and Corruption in Public Tenders**
   U.S. companies have reported that many public tenders suffer from murky requirements and corrupt practices. A long history in the region or a suitable local representative is often necessary to be able to bid. Furthermore, project administration and regulatory enforcement technically fall under the command of governors or district heads, but actual implementation at the local level in Indonesia remains poor due to opposition by private interest groups.

Market Opportunities – Air Pollution Control

The national action plan on greenhouse gas (GHG) emissions reduction is delineated in Presidential Regulation (PERPRES) No. 61/2011 and the GHG inventory is provided through Presidential Regulation

(PERPRES) No. 71/2011. [153] Indonesia has pledged a voluntary emission reduction of 26% against the business as usual scenario by 2020.

Indonesia's Nationally Determined Contribution (NDC) under the December 2015 Paris Climate Agreement aims to unconditionally reduce emissions by 29% against a 2030 business-as-usual (BAU) scenario. The level increases to 41% with international assistance. [154]

While ambitious, unsustainable domestic practices threaten the viability of Indonesia's aggressive emissions reduction strategy. If continued, the current rate of clearing forests and peat could eliminate 25% of the current forest area by 2030. Furthermore, emissions are estimated to increase by as much as 70% above the 2010 level by 2030 because of forest clearing and emissions from growing energy and industrial sectors. [155]

In 2015, forest clearing in Indonesia released more CO_2 over a few weeks than Germany does in a year. The subsequent haze and trans-boundary air pollution sickened nearly half a million people and blanketed Singapore and Malaysia in smoke. As a result of this incident, the national government instituted a peat drainage moratorium in 2016, which reduced the drop in tree cover by 60%in 2017 as compared with the previous year. [156] Nevertheless, palm oil and paper and sugar plantation development continues, with three million new hectares planned for Papua going forward. Together with the expansion of its coal-fired power fleet and the energy and transportation demands of the growing middle class, [157] Indonesia will require control and monitoring technologies across the board if it is to meet its stated emissions targets. [112]

Power Plant Emissions Reduction

Indonesian coal production has increased five-fold in recent years, from approximately 90 million tons in 2000 to 507 million tons in 2018, of which approximately 20% went to domestic use. Indonesia is currently the fourth-largest coal producer in the world, the largest exporter of thermal coal for power stations, and a key fuel source for coal-fired power plants in India, China, and elsewhere. Indonesian coal accounts for about seven percent of global output. [158]

Indonesia's domestic coal consumption also is expected to increase to 60% of national production in the coming years. Indonesia currently has 53.1 gigawatts (GW) of installed generation capacity and electrification has reached about 88%. [159] However, many remote areas still have very limited access to electricity, and those that are connected to the grid suffer from power shortages. [160]

In 2006, the government embarked upon the first phase of its "fast track" plan, designed to address shortages by accelerating power plant development. Electricity sector demand for coal more than doubled by 2014 because of the added coal-fired generation capacity. [161] Fifty-eight greenfield coal-fired power plants are expected to come online by 2027, increasing capacity to more than double from approximately 24 MW in 2018 to nearly 52 MW in 2027. Domestic coal consumption for power generation is expected to grow at an 8.3% CAGR between now and 2027. [162] Natural gas fired power generation also is expected to increase to nearly 27% of the energy generation mix by 2026. [163]

An estimated 80% of power plants built in Indonesia over the next decade will use fossil fuel combustion, further opening the market for U.S. air pollution control technologies and services. Indonesia is expected to invest heavily in new electrostatic precipitators over the next few years, presenting a critical opportunity for U.S. companies. [164] However, the deployment of air pollution

control technologies is contingent on further improvements in both capacity and enforcement – areas where the United States has engaged bilaterally since the 1990s. [165]

Key Technologies in Demand:
- Continuous emissions monitoring systems
- Dry sorbent injection technologies
- Flue gas desulfurization equipment
- Activated carbon injection technologies
- Inspection, adjustment, maintenance, and repair services
- Selective catalytic reduction technologies
- Selective non-catalytic reduction controls
- Urea to ammonia reagent systems
- Electrostatic precipitators (wet and dry)

Air Quality Monitoring

The U.S. EPA collaborated with the Ministry of Environment and Forestry on a 2013 study, which showed that 60% of Jakarta's population suffered from various air pollution-related health effects, including asthma and coronary disease. The study concluded that the total direct-health cost of these illnesses was 38.5 trillion rupiah (about $2.8 billion) a year. [166]

In 2006, Indonesia launched an urban air quality improvement initiative that included installation of air quality management systems in 10 cities. The system, however, never operated effectively due to its high costs, and it lacked the capacity to monitor fine particulate matter (PM). [166] The International Atomic Energy Agency (IAEA) worked with Indonesia's National Nuclear Energy Agency (BATAN) to add nuclear analytical techniques to the national air quality monitoring program. The project included collaboration with local cities, provincial environmental protection agencies, MoEF and BATAN. There are now sampling locations in 16 cities across Indonesia's largest islands, and the project is expected to expand to a total of 34 cities by 2020. [166]

Improved monitoring already has helped to lower legal thresholds of lead concentrations in ambient air, and it will continue to serve as a foundation for tracking air quality and developing corrective actions going forward. The City of Jakarta recently purchased two PM2.5 air monitors and has indicated its plans to budget for the purchase of additional monitoring equipment. U.S. technology providers interested in developing a foothold in this market should pursue opportunities through official tenders as well as through donor efforts, including those of the Asian Development Bank, the World Bank, technical facilities within Asia Pacific Economic Cooperation (APEC) and the U.S. Agency for International Development (USAID).

Key Technologies in Demand:
- Fenceline monitoring
- Continuous emissions monitoring
- Ambient air quality monitoring equipment
- Source emissions measurement technologies

Mobile Source Emissions Reduction

The primary cause of air pollution in Jakarta and other major cities is vehicle emissions. According to MoEF, 70% of the country's urban air pollution originates from the transportation sector. Ninety percent of that transportation pollution then comes specifically from land transportation. This is largely the

result of lenient emissions and fuel quality standards as compared with other Asian megacities, as well as lax enforcement. In March 2017, MoEF signed a long-awaited regulation that moved forward Euro IV emission standards adoption, which will be a significant improvement from the Euro II standard it has had since 2005. [167] All new gasoline vehicles must meet Euro 4 emission standards as of September 2018 and all new diesel vehicles must meet Euro 4/IV emission standards starting in April 2021. [168] Additionally, Indonesia's state-owned oil and gas corporation, Pertamina, is upgrading its refineries and distribution networks to ensure supply of Euro 4 standard fuel across the country. [169] Considering the double-digit growth of vehicle sales in Indonesia since 2007, [170] successful policy reform could offer significant opportunities for U.S. companies in the medium-term.

Key Technologies in Demand:

- Emissions control technologies for passenger cars, light duty vehicles (LDVs), and heavy-duty vehicles (HDVs)

Market Opportunities – Waste Management and Recycling

Municipal Solid Waste and Landfill Management

As of 2015, 69% of the 64 million tons of solid waste generated in Indonesia each year was sent to largely unsanitary landfills. Jakarta city residents dump up to 7,000 tons of untreated solid waste every day into Bantar Gebang, the country's largest landfill, which is on track to reach capacity by 2021. [171] The national recycling rate hovers at around two percent, with a marginally higher rate (7.5%) in urban areas. [172] However, waste picking in open dumpsites is common and sustains an unregulated, informal recovery sector.

Waste management is a serious concern for the Indonesian government as the country's disposal sites prove increasingly unable to handle the volume of waste generated. Plastic waste also continues to rise, making Indonesia the world's second largest contributor of plastic marine litter after China. [172] To help address this problem, in September 2016 the Indonesian government began imposing a national tax on plastic carrier bags. [173] In early 2017, the government also pledged up to one billion dollars a year to help reduce the amount of plastic and other waste products polluting its waters, [174] with a goal of 70% reduction by 2025. By the end of 2018, the government also was expected to release a new extended producer responsibility (EPR) regulation with the goal of reducing the 3.22 million metric tons of mismanaged plastic waste the country produces annually. The new law would require producers and retailers to redesign their products and packaging to increase the proportion of recycled materials and draw up 10-year plans to improve their recycling practices. [175] Currently, the EPR standard is voluntary with only Danone, Coca Cola, and Tetra Pak in verified compliance.

The Indonesian government passed the Waste Management Law of 2008 Regarding Waste Management ("Regulation 18"), which focuses on the management of municipal solid waste streams and encourages recycling. The law seeks to establish a national framework under which new technologies can address environmental issues while creating economic value from waste. In doing so, it charges the national government and local authorities with the implementation of proper waste management procedures and facilities.

In 2011, the government introduced a municipal "garbage bank," or *bank sampah,* program to encourage source separation. Under the program, households weigh and record their non-organic solid waste, which is then dropped off at local collection points in exchange for funds deposited into household accounts. A system based on GPS technology is being created to improve participation rates

and coordinate waste banks across the country. [174] A robust national *bank sampah* program would help centralize waste collection in communities and facilitate the development of waste management infrastructure.

Key Technologies in Demand:
- Waste collection technologies
- Environmental monitoring and analytical equipment

Waste-to-Energy (WTE)
In its Nationally Determined Contribution (NDC) to the December 2015 Paris Climate Agreement, Indonesia committed to "develop a comprehensive [waste management] strategy to improve policy and institutional capacity at the local level." The NDC text specifically refers to reduction of the amount of waste sent to landfill, reduction of waste-based greenhouse gas emissions, and addition of renewable sources into Indonesia's energy mix, specifically including waste-to-energy. While waste-to-energy can be part of a more comprehensive waste management strategy, source reduction and recycling are recognized as preferable methods for solid waste management. Additionally, any waste-to-energy solutions should give adequate attention to the related air pollution and climate risks.

WTE projects have been difficult to implement in Indonesia because of high capital costs and low technical capacity. Furthermore, projects face local testing requirements, inconsistent policies and opaque procurement processes. Nevertheless, Indonesia is a prime market for WTE investors because of the significant waste challenges associated with its rapid economic development. With better information, coordination, and capacity-building measures, WTE may become a viable waste management strategy. [176]

In early 2016, the government submitted draft legislation to President Widodo focusing on developing WTE power plants in seven pilot cities: Jakarta, Bandung, Tangerang, Semarang, Surabaya, Surakarta, and Makassar. [177] In December 2016, Jakarta partnered with Finnish energy company Fortum to build an intermediate treatment facility (ITF) in Sunter, North Jakarta. [178] Building on pre-existing legislative support for PPPs (Perpres 38/2015) [179], the 2016 law was expected to increase private sector engagement for additional projects. However, in late 2016 the regulation was found to be in violation of the Indonesian Environmental Law by the Indonesian Supreme Court, destabilizing the market and severely reducing demand for waste-to-energy projects. In 2018, Presidential Regulation 18 was replaced by Presidential Regulation 35. The new directive introduced a new feed-in tariff and nearly doubled the planned development of waste-to-energy facilities to include 12 major cities. Together with the government's ambitious power generation goals and its increased emphasis on waste reduction, WTE is likely to offer opportunities for U.S. firms moving forward.

Key Technologies in Demand:
- Waste-to-Energy technologies and equipment
- Environmental engineering and design services

Market Opportunities – Water and Wastewater Treatment

Municipal Water Treatment and Transmission Systems
Indonesia's sewage coverage is one of the lowest in the world. Only one percent of total urban wastewater and four percent of total urban septage in the country was collected and treated in 2013.

[80] National development goals have set a target to increase access to improved sanitation from 60.5-100% by 2019. [80] A new central government regulation that came into force on Jan. 1, 2019, requires local governments to meet minimum service provision standards, including for water supply, to attempt to meet the ambitious 2019 goals. In additional to expenditures by local entities, the central government has channeled Special Allocation Funds (DAK) for this purpose. A significant share is also expected to come from private sources. Water supply projects from the national PPP program such as Bandar Lampung and West Semarang, as well as business-to-business model projects, made some progress in 2018. [180]

After basic infrastructure and supply needs are met, the predominant concern for Indonesia is likely to be drinking water quality. For the 20% of the population that has a water main connection, the quality of the municipal water supply is low, and drinking water directly from the tap is discouraged. [181] In the short-term, this will continue to fuel a strong Point-of-Use (POU) technology market. In the longer-term, utilities will need to grapple with improving water quality and reliability and reducing non-revenue water.

The country's National Medium-Term Development Plan, the *Rencana Pembangunan Jangka Menengah Nasional* (RPJMN), set the goal of reaching universal access to drinking water and sanitation services by 2019. Drinking water and sanitation access were 72.04% and 76.92%, respectively, as of 2017. [182] This lofty goal is estimated to spur nearly $36 billion of investment in the water and wastewater sector. [80] In June 2018, the World Bank approved a $100 million loan that will support local governments and local government-owned water supply enterprises in their efforts to improve access and performance in under-served urban areas. [183] Indonesia also has an estimated $225.5 billion of water supply investments planned and is electing to use PPP models to finance approximately 35% of the projects. [184] A significant portion of large water treatment plants are funded by the private sector and the government has committed to encouraging further private sector investment. [80] A total of $14.6 billion has been allocated for the wastewater treatment sector for 2015 to 2019, of which approximately 50% will come from the central government, 12% will come from local or regional governments, and 35% will be financed by communities. [80]

The Ministry of National Development Planning's (BAPPENAS) PPP Book lists 15 planned water infrastructure projects with a combined total value of $1.59 billion. [185] The majority of projects are focused on drinking water storage, treatment and transmission, leaving wastewater treatment as the next hurdle in satisfying Indonesia's need for basic water and sanitation services. A few wastewater treatment projects in urban areas are listed, such as the DKI Jakarta Sewage Treatment Plant, a planned $512 million tender. [185]

In practice, however, Indonesian PPP projects have generally been financed through bilateral and multilateral aid agencies [186] and tendered at a much more gradual pace than envisioned in national development plans. Presidential Regulation (PR) number 38/2015 broadens the type of infrastructure projects for which PPP is available to include social infrastructure and allows for forms of payment other than end-user fees. [187]

A new water law was scheduled to be implemented in 2017. This new law considers lessons learned from the 2004 Law on Water Resources and introduced minimum standards for utility service performance, as well as increased accountability in the drinking water sector. [80] The 2004 law was struck down by the Indonesian Supreme Court in 2015, which argued that consequent privatization

efforts had unfairly disadvantaged poor communities. As the pre-existing law from 1974 does not recognize private water rights for commercial purposes, the Indonesian water supply market will remain uncertain until the appeals process is completed, or the decision is ultimately adopted by the government and new legislation is put forward. As of March 2019, private operators still maintain exclusive rights to water resources.

Technologies and Services in Demand:
- Engineering, procurement, and construction services
- Operations services
- Advanced filtration
- Membrane filtration
- Sludge dewatering equipment
- Waste-to-Energy technology
- Anaerobic digestion
- Nitrification
- Biological denitrification
- Monitoring equipment
- Testing equipment
- Point-of-Use devices

Process and Produced Water

The Indonesian government's Master Plan identifies 22 key industries for priority expansion and investment. Among those sectors, several are key client industries for the water sector, especially mining of nickel and copper, coal, oil and gas, food and beverages, textiles, and steel and aluminum smelting. [188] Coupled with government emphasis on water resource protection, influent treatment technologies, effluent management and water reuse are all likely to be growth markets.

The burgeoning oil and gas sector should provide growing opportunities for process-based water treatment as well, particularly as offshore development continues. The prevalence of international oil companies working in Indonesia could provide an effective sales conduit for qualified producers of process water technologies. Furthermore, the government recently initiated four shale gas study projects and expected commercial shale gas production to begin by 2018. [10] Shale gas development could yield opportunities for both process and produced water treatment. Additionally, demand for desalination is expected to grow in tandem with plans to increase the country's power generation capacity. [80]

Technologies and Services in Demand:
- Wastewater treatment technologies
- Advanced filtration
- Membrane filtration
- Purification equipment
- Petrochemical and mining effluent treatment systems

Market Opportunities – Environmental Consulting and Engineering

Environmental impact assessments are administrated by the AMDAL Appraisal Commission, which evaluates environmental proposals and documentation to provide the MoEF with input and recommendations on the feasibility of business activities. When obtaining a business license, if business activities might damage the environment, a special permit is required. Indonesian environmental law stipulates that everyone has the right to access documentation related to such licenses, such as environmental impact analysis, reports, and evaluation results. The MoEF works to encourage citizen participation.

With high expected growth in its construction sector, which is expected to surpass Japan by 2030, Indonesia may also become a center for environmental engineering and consulting services contingent on government stringency on-site assessments for forthcoming projects.

Technologies and Services in Demand:

- Environmental Impact Assessment (EIA) and Analysis

ETWG Agency Initiatives and Programs

U.S. Environmental Solutions Toolkit

The Toolkit is an online searchable database that marries U.S. EPA expertise on solving environmental challenges and developing environmental rules with a catalogue of U.S. technology providers. In 2019, an enhanced version of the Toolkit will be released that will include an updated database of solutions providers and the capability for foreign buyers and government officials to contact them directly via the online interface. U.S. companies interested in participating in the Toolkit can find out more at www.export.gov/envirotech.

Power-Gen International Buyer Program

Power-Gen, one of the leading U.S. power generation equipment and services trade shows, has partnered with the U.S. Department of Commerce's IBP to encourage foreign participation in the show. This platform is leveraged to discuss policies and exchange technical information regarding power plant emissions control with Indonesian participants and to foster business relationships between Indonesian end-users and U.S. emissions control providers.

Waste Expo International Buyer Program

Waste Expo, one of the leading U.S. waste management trade shows, has partnered with the U.S. Department of Commerce's International Buyer Program again in 2019 to encourage foreign participation in the show. This platform encourages the exchange of relevant technical information with Indonesian participants and introduces key Indonesian buyers to U.S. waste management technology providers.

WEFTEC International Buyer Program

WEFTEC**,** the Water Environment Federation Technical Exhibition and Conference, offers thousands of water quality professionals from around the world with unparalleled water quality education and training. Also recognized as the largest annual water and wastewater exhibition and conference in the world, the expansive show floor provides access to cutting-edge technologies in the field, serves as a forum for business opportunities, and promotes networking between its attendees.

U.S. EPA Collaboration

The U.S. EPA has worked with the Indonesian government through the "Breathe Easy Jakarta" program

to facilitate improved technical capacity to implement an air monitoring network. Other areas of collaboration have included training in environmental enforcement, environmental impact assessment and site remediation. U.S. EPA also cooperates with Indonesian partners and the United Nations Environment Programme (UNEP) under the Global Partnership for Clean Fuels and Vehicles (PCFV) and Climate and Clean Air Coalition (CCAC).

Market Contacts and Program References

BAPPENAS
https://www.bappenas.go.id/id/

Ministry of Energy and Mineral Resources
https://www.esdm.go.id/en

Indonesian Petroleum Association
http://www.ipa.or.id/

U.S. Foreign Commercial Service Jakarta
http://www.export.gov/indonesia/

USAID Indonesia
https://www.usaid.gov/indonesia/environment

South Korea Case Study

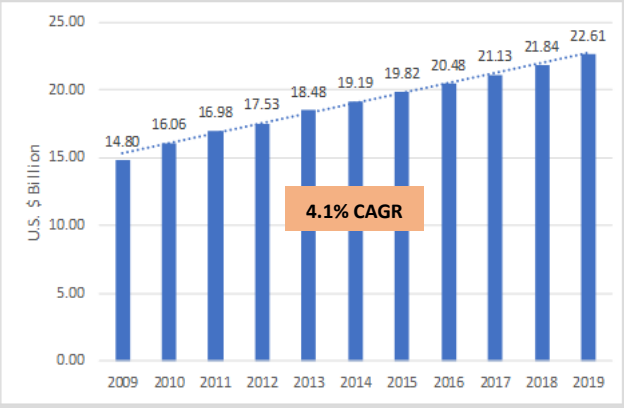
The overall environmental technologies market in South Korea including goods and services is valued at $22.6 billion in 2019. South Korea ranks fourth overall on the 2019 Top Markets Report with a Composite Environmental Technologies Score of 32.1. It ranks third for air pollution control and ninth for water markets with scores of 23.3 and 7.6, respectively. It ranks thirteenth for waste and recycling with a score of 1.3 (see Appendix 1 for global rankings).

Since 2010, South Korea has worked to integrate green growth into its overall industrial development strategy. As a result, the market is making great strides in the implementation of advanced water treatment systems, air pollution control measures, and waste management and recycling. With an overall market valued at $22.6 billion and the U.S. – Korea Free Trade Agreement (KORUS) in place, Korea presents significant opportunities for U.S. environmental technologies exporters.

State of the Environmental Regime

The main foundation of South Korea's environmental regulatory regime is the Framework Act on Environmental Policy. The Ministry of Environment (MOE) is the agency that establishes environmental regulations and enforces environmental laws. The local governments in provinces and cities also play an important role in enacting local regulations, administering permits, and enforcing laws.

Figure 14: South Korea's Environmental Technologies Market



Source: Environmental Business International with OEEI Analysis, 2019.

From the 1990s to the early 2000s, South Korea made major progress in addressing air, water, and waste management in urban areas through issuing and enforcing new environmental legislation. As a result, Korea has a well-established regulatory environment that has been further improved upon in the last decade to create a more sophisticated and inclusive framework. As noted by the OECD, Korea has a robust liability regime for soil contamination that is targeted at environmental remediation. Korea has also strengthened chemical safety regulations through its 2015 Act on the Registration and Evaluation of Chemicals (Korea REACH). Furthermore, Korea has shifted the burden of proof from victims to polluters under its 2016 Liability and Relief Act, thereby making it easier for victims to gain compensation for environmental damages to health, welfare, and property. [189]

More recently, the country has prioritized cooperation efforts within the global environmental protection regime. South Korea houses the Global Green Growth Institute, a treaty-based organization dedicated to promoting green growth in developing countries, and the Green Climate Fund, a fund under the framework of UNFCCC to assist developing countries with practices to mitigate effects of climate variability. South Korea also ratified the Paris Agreement in November 2016.

The United States – Korea Free Trade Agreement (KORUS FTA) was implemented on March 15, 2012. Under KORUS FTA, by 2017 over 95% of tariffs on U.S. exports of consumer and industrial products to South Korea, [190] including environmental goods, were eliminated. [191] KORUS FTA has expanded opportunities for trade in services, improved transparency in South Korea's regulatory system, strengthened intellectual property protection, and enhanced market access for U.S. exporters of all sizes. [192] KORUS FTA also includes an Environmental Cooperation Agreement, thus strengthening the relationship and work between the U.S. EPA and MOE. [193]

South Korea's environmental regime is above average for an emerging market, with a 2015 score of 3.07 on The OECD Environmental Policy Stringency Index, which ranks environmental regimes on a scale from 0 to 6 (with 0 being not stringent and 6 being the highest degree of stringency). This score is a 0.17-point improvement over its ranking of 2.9 in 2005. [7]

Market Barriers

Potential challenges for foreign firms wishing to enter the market derive from the need for specialized, locally-focused knowledge about South Korea's business sector. [194] Industry experts in the Office of Energy and Environmental Industries (OEEI) have identified the following potential barriers for environmental technologies companies attempting to export to, or work in, South Korea:

1. **Price Sensitivity**
   Expectations by South Korean buyers for high quality at "rock bottom" prices may make contract negotiations challenging and may adversely impact the competitiveness of U.S. technologies as compared with lower-priced alternatives.
2. **Unique Standards and Marking Requirements**
   The Korean Agency for Technology and Standards (KATS) requires separate, often redundant, safety certifications for certain electrical products. Additional testing for products that already meet international standards can be required and, together with Korea-specific labeling stipulations, can be burdensome for U.S. companies.
3. **Korean government plans to nurture Korean companies**
   The Korean government implemented programs for the promotion of domestic cleaner technology R&D and nurturing domestic environmental sub-sectors and technologies in water and wastewater, solid waste, hazardous waste, air pollution, and environmental engineering and consulting services. As a result, Korea gained competitiveness in 20 different technologies such as liquid phase injection systems, low emission engines, recycling of electronic wastewater, and water filtration membranes.

Market Opportunities – Air Pollution Control

Air quality is a troubling problem for South Korea. The Yale Environmental Performance Index (EPI) ranked South Korea 173rd out of 180 countries in terms of air quality in 2016 (where 180 is the worst performer). The EPI compiles its index by considering the capacity of countries to confront environmental issues, with emphasis on the protection of human health and ecosystems. [112] Out of all of the OECD countries, Korea has seen the largest increase in CO_2 emissions since the 1990s. This is largely due to reliance on coal-fired power plants and diesel fuel.

Korean society recognizes air pollution as a major problem for its cities. The South Korean media often highlights the importance of foreign sources of air pollution, in addition to domestic industry. [195] Consequently, more than half of the population is exposed to unsafe levels of fine particulate matter (PM 2.5). [112] Premature deaths due to outdoor air pollution are expected to triple by 2060. [189]

The importance of addressing air pollution helped President Moon Jae-in win the 2017 Korean presidential election. Upon entering office, President Moon Jae-in ordered the temporary closure of eight ageing coal power plants in South Korea for 30 days, and announced that 10 plants would be shut down for a third of each year starting in 2018. [196] In September 2017, the government introduced a five-year plan, the "Comprehensive Action Plan on Fine Dust," intended to curb particulate emissions by closing coal fired power plants, sidelining diesel cars, and capping NOx emitted from industrial sources such as steel plants and petroleum refineries. [197] In early November 2018, the government capped operations at 11 fossil fuel fired power plants across the country for a day due to high levels of PM 2.5. [198]

In February 2019, the South Korean government implemented the "Special Act on the Reduction and Management of Fine Dust." The act implements an emergency response plan for days where the average concentration of PM2.5 exceeds 50 micrograms per cubic meter and is forecast to surpass that level for the next 24 hours. The plan empowers city and provincial governments to take actions including banning vehicles or asking industrial point sources to reduce operation hours. Those who violate the regulations could face fines. [199]

Air Quality Monitoring

In its Nationally Determined Contribution (NDC) under the December 2015 Paris Agreement and the 2016 amendments to the Green Growth Act, South Korea committed to reduce its greenhouse gas (GHG) emissions by 37 percent from a business-as-usual level across all economic sectors by 2030. However, this target has been criticized as insufficiently ambitious, as it is the same goal the country set in 2009 for 2020, except that the target end date was delayed by 10 years. [200] Korea is also a member of the Kyoto Protocol, but because it was classified as a developing country under the agreement, it was exempted from mandatory CO_2 emission reductions and Annex 1.

In 2010, the government implemented its National Strategy for Low Carbon Green Growth (the Strategy), including medium and long-term greenhouse gas emissions targets. Objectives of the Strategy include expanding the green technology sector and integrating standards for low GHG emissions into industries such as transportation, finance, and tourism. The Strategy emphasizes working with small and medium enterprises to help "green" their businesses. In 2014, South Korea developed a roadmap to achieve its GHG reduction targets that includes the building, transportation, agricultural, industrial, and waste sectors. The government aims to manage large GHG emitters and energy consumers that are not covered by the emissions trading scheme through a national-level GHG and Energy Target Management System (TMS). In 2015, it launched a nationwide Emissions Trading Scheme (ETS) that includes 525 of the country's largest polluters in 23 sectors and accounts for two-thirds of the nation's non-vehicular emissions. [201] In December 2017, the Ministry of Energy promulgated a draft proposal calling for an increase of renewable energy sources in the country's power generation mix to 58.5 gigawatts by 2030. The share of natural gas fired power also is expected to increase, though most relevant changes will not be introduced until after 2022. [202]

The government has paid increasing attention to urban air quality in recent years, including through setting up monitoring stations in and around Seoul and other cities and making the data publicly

available online. Seoul's First Metropolitan Air Quality Control Master Plan (2005-2014) emphasized reduction of PM10 and nitrogen dioxide concentrations, with a goal of reaching 40 micrograms per cubic meter and 20 parts per billion, respectively, by the end of the plan period. The Second Master Plan (2015-2024) added ultrafine particles (PM 2.5) and ozone to the list of managed pollutants, which also includes SOx, NOx and Volatile Organic Compounds (VOCs). The Second Master Plan aims to reduce the emission of each pollutant by 34-56% of business-as-usual. [203] Air quality monitoring tenders are listed on South Korea's Public Procurement Service (PPS) website.

Technologies and Services in Demand:
- Continuous emissions monitoring systems
- Ambient air quality monitoring equipment
- Source emissions measurement technologies
- Analytical and laboratory testing goods and services
- Air pollution control equipment
- Fuel vapor control systems

Mobile Source Emissions Control

According to the International Energy Agency (IEA), Korea has some of the most stringent emission standards in the world. The major policy in place is "Special Measures for Metropolitan Air Quality Improvement." Despite such standards, diesel vehicles are the source of 29% of fine particulate matter (PM 2.5) in Korean cities. Nearly 42% of all vehicles in South Korea run on diesel fuel. [204]

In 2016, the Korean government announced measures to bring South Korea's air quality to Western European levels within the decade. To aid in this effort, the government raised its target for eco-friendly car vehicles to 30% of new car sales by 2020, up from the current 2.6%. Furthermore, the government has proposed supporting the green car industry with a 10-fold increase in new charging stations. By 2019, the South Korean government intends to scrap diesel vehicles that were launched before 2005. Buses now run on compressed national gas instead of diesel, a policy achieved through effective tax incentives and subsidies. [189]

Following the revelation that several major car companies had fabricated documents for emission tests, particularly Volkswagen and Mercedes Benz, South Korea banned the sale of 10 models sold by Nissan, BMW, and Volkswagen in January 2017. The government also blocked the sales of 80 Volkswagen models. [204]

As of Sept. 1, 2018, all compact and mid-size diesel vehicles in South Korea are subject to the Worldwide Harmonized Light Vehicles Test Procedure (WLTP), which limits NOx emissions to 0.08 grams per kilometer. [205] U.S. producers of advanced control technologies may see increased opportunities as the government cracks down on diesel vehicle emissions.

Key Technologies in Demand:
- Selective Catalytic Reduction (SCR)
- Exhaust Gas Recirculation (EGR)
- Lean NOx Trap (LNT)
- Other emissions control equipment for diesel vehicles

Industrial Air Pollution Reduction

Under the National Strategy for Low Carbon Green Growth, South Korea has seen an expansion of the pollution control equipment industry, with imports accounting for about 10% of the total market. Japan and the United States are the leading foreign suppliers at 50% and 30% market share, respectively. Local manufacturers are seeking advanced products and technologies to meet the government's increasingly strict standards.

Control measures to achieve the goals set forth in the National Strategy consist of automobile management, including a project to reduce exhaust gases from vehicles in operation; management of emission facilities, including the total load management system for large establishments; and management of eco-friendly energy and cities. Projects to simultaneously reduce air pollutants and greenhouse gases will be carried out to improve air quality and make a positive contribution to climate change. Examples include distribution of low NOx burners to households in Seoul, equipping vehicles with idle stop and go systems, and expanding green spaces in urban regions.

In Seoul, the Second Metropolitan Air Quality Control Master Plan also aims to manage high-risk pollutants distributed throughout everyday surroundings. The city government has introduced strict control measures for VOC sources, such as laundry shops, gas stations, painting facilities, printing offices, and everyday consumables. [203] To help reduce total PM 2.5 emissions, the city offered subsidies to help 10 thousand Korean barbeque restaurants and 1,135 bathhouses install filters in 2015. [206]

The OECD reports that industry is the largest producer of several types of air pollutants in South Korea. [189] A national chemical emissions survey conducted in 2010 found that approximately 61% of the 50 thousand tons of annual emissions of 388 hazardous air pollutants (HAPs) were fugitive emissions from non-smokestack facilities and processes. [207] The government responded by amending the Clean Air Conservation Act in 2012. The amendments introduced facility management standards for HAP-emitting facilities, effective as of January 2015. Each facility now is responsible for meeting the permissible emission levels, installation, and operation of reduction technologies, leakage monitoring, and maintenance standards.

According to the U.S. Foreign Commercial Service, highly customized solutions for specific applications offer potential opportunities for U.S. exporters.

Key Technologies in Demand:
- Carbon Capture and Storage (CCS)
- VOC control
- Dioxin abatement
- Advanced sulfur oxides/nitrogen oxides abatement in power plants and steel mills
- Energy saving and waste-to-energy in steel mills and municipal landfills
- Pollution-free and low-emission vehicles and engineering technology
- Pollution abatement technologies for the automobile and oil refinery industries
- Environmentally friendly construction materials

Power Plant Emissions Reduction
According to the U.S. Energy Information Agency, coal-fired power plants currently make up about 28% of South Korea's total generation capacity. Some estimate that as much as 60% of the country's air pollution is caused by pollution from power generation. In 2017, coal-fired power as a percentage of the

country's generation mix hit a new high (43.2%) as three new thermal plants came online and the government suspended operations at 11 of 24 nuclear power plants. However, the administration of President Moon Jae-in has stated that it is seeking to increase the use of renewable sources from 6-20% by 2030 and to close coal-fired power plants older than 30 years. The Ministry of Energy also has stated that it will convert four existing coal-fired power plants to natural gas, and two new nuclear reactors will open in 2022. Additionally, existing coal plants will be required to reduce carbon dioxide emissions by 40% by 2022 and 58% by 2030. [208] South Korea will need advanced abatement technologies to meet its emissions reduction and climate targets.

Key Technologies in Demand:

- Continuous emissions monitoring systems
- Dry sorbent injection technologies
- Flue gas desulfurization equipment
- Activated carbon injection technologies
- Inspection, adjustment, maintenance, and repair services
- Selective catalytic reduction technologies
- Carbon capture and storage systems
- Fuel switching engineering services and technologies

Market Opportunities – Waste Management and Recycling

South Korea is a resource- and-land-limited country, so the proper handling of waste has been a priority for the government. Legislation focused on reducing municipal waste production has been highly successful in generating results. However, challenges remain with respect to hazardous waste, specifically nuclear waste storage. This largely is due to South Korea's emphasis on nuclear power development to offset dependence on imported energy sources.

Solid Waste and Recycling

Over the past two decades, the South Korean government has made substantial efforts to increase recycling and reuse of waste, reduce landfilling, and improve waste-to-energy capacity. The combined volume of commercial, industrial, and construction waste generated has increased over 46% since 2000, from 180 to 339 thousand tons per day in 2014. Despite the country's strong economic growth, per capita household waste production has increased only marginally since 1995 due to the implementation of the Volume Based Waste Fee (VBWF) system, which operates under the "producer pays" principle. The Extended Producer Responsibility (EPR) system, implemented in 2003, currently requires manufacturers and importers to recycle certain product categories, including 27 electrical and electronic devices, as well as tires, lubricant, batteries, fluorescent lamps, Styrofoam float, and packaging materials. The Ministry of Environment sets a mandatory recycling ratio for each EPR product category annually. As a result, South Korea recovers more than 80% of its waste. [189]

In 2002, the government established the "Allbaro" system, an online mechanism that tracks waste from generation to transport to disposal. The system has streamlined the waste treatment verification process and served as a basis for domestic waste-related policy development. However, there is a large informal recycling sector in the country, which causes some e-waste to escape the official system. [189] Despite many of the advanced waste management technologies in place, data on waste management and material flows is not fully integrated, hampering attempts to effectively handle waste streams and improve recycling efforts. [189]

The government actively has facilitated waste-to-energy (WtE) initiatives as well, increasing capacity from just 0.7 million tons in 1995 to 3.1 million tons at 35 WtE plants in 2010. In 2014, waste-to-energy plants generated 696 GW of electricity. [209] While WtE can be part of more comprehensive waste management strategies, source reduction and recycling are recognized as preferred methods for solid waste management ("Reduce, Reuse, Recycle"). Additionally, any waste-to-energy solutions should give due attention to air pollution and climate risks.

Key Technologies in Demand:

- Waste collection technologies
- Sanitary landfill systems
- Environmental monitoring and analytical equipment
- Sorting machines
- Crushing and grinding machines
- Materials handling equipment
- Collection services, containers, and vehicles
- Recycling process expertise
- Waste incinerators
- Waste-to-Energy technology

Hazardous Waste Management

The South Korean government has set objectives to reduce pollution generated by industrial activity and restrict the use of hazardous materials in manufacturing. It has supported the development of cleaner technologies, including drafting a strategy to reduce or substitute the use of rare metals used in electronic appliances and automobile manufacturing. As of January 2016, certain types of hazardous waste – including acidic and alkaline waste, spent oil and organic solvents, synthesized high molecular compounds, dust, and sludge – must be physically separated from other solid wastes under the country's Waste Control Act. [210]

The Ministry of Environment also established a national-level institutional framework for mercury management (2016 to 2020), per the provisions of the Minamata Convention on Mercury. South Korea is a signatory, though it has not yet ratified the Convention. The plans include environmental monitoring, emissions reduction, more environmentally-friendly disposal of mercury – including a take-back program for, and the ultimate phase-out of, mercury-containing products. [211]

Despite this progress, South Korea's challenges with respect to nuclear waste management remains. South Korea is the world's fifth-largest user of nuclear power, and its nuclear program currently supplies 30% of the country's electricity. [189] South Korea's nuclear waste storage over the past 30 years has relied entirely on on-site temporary storage sites, which will be at capacity by 2021. [189]

At the end of 2015, a new nuclear waste disposal facility was opened in Gyeongju to help alleviate the burden of storing low- and-medium-risk nuclear waste. Plans to build a facility to handle high-level radioactive waste are also underway, with the permanent disposal facility expected to open in 2053; however, additional long-term solutions for storing spent nuclear fuel are still needed.

Key Technologies in Demand:

- Waste handling equipment

- Waste treatment technologies
- Brownfield site remediation design and equipment
- Testing and monitoring equipment
- Nuclear waste storage and disposal technologies

Market Opportunities – Water and Wastewater Treatment

While Korea has abundant rainfall, high population density has led to the second-lowest renewable freshwater resources per capita in the OECD. Furthermore, water responsibilities are fragmented across various ministries, and an attempt to establish an overarching legal framework has been unsuccessful. To combat these issues, the Korean government created a Water Management Committee in 2015. [189]

Municipal Water and Wastewater Treatment

South Korea hosts a comprehensive water treatment system with 92.1% of the population connected to a sewage system and 95.7% of the population connected to a municipal drinking water system. [80] This is particularly impressive considering that in 1962, only 18%of the population was connected to piped water and there was no sewage system. [212] However, there is a disparity in water services and quality between urban and rural areas. [189] This may provide a unique opportunity for foreign suppliers of water technology, particularly for small-scale facilities.

The private sector is a major player in the provision of public water systems with the government typically favoring build-own-operate-transfer (BOOT) structured contracts. The federal government typically covers 50% of construction costs, with the balance covered by the contractor. [80] High adherence to rate paying among the population has made public water a profitable endeavor in South Korea. The *Chaebols*, as well as smaller companies, are increasingly participating in the water technologies market. There is strong demand among these players for more advanced technologies for which they look to potential foreign suppliers. [213]

The government also is implementing advanced treatment processes for drinking-water plants nationally. Since 2013, this effort has resulted in the application of advanced treatment processes in 32 plants, a total of three percent of all facilities. The government plans to increase the ratio up to 62% by 2023. [214] The Ministry of Environment also reports that between 2017 and 2029, the government will invest approximately $2.6 billion to upgrade aging local waterworks infrastructure, including pipelines and drinking water treatment plants. [215]

There is a market for sludge management that has emerged as result of legal changes prohibiting landfill disposal and limiting the volume of sludge discharged into the ocean. Korea used to discharge an estimated 2.5 million tons of sewage sludge per year, 72% of which was discharged into the ocean. Because of regulatory changes, demand for advanced solutions for volume reduction and recycling of sewage sludge has increased. However, the market is largely occupied by Korean companies and barriers to entry remain high.

Furthermore, private sewage treatment facilities are constructed where public sewage systems are cost-prohibitive. As of 2012, there were 416,075 private sewage treatment facilities operating outside of the sewage service zone. Since 2007, any private sewage treatment facility of a certain size or larger must have a designated specialist manager and must be constructed by professional service companies. [216]

Key Technologies in Demand:
- Testing equipment
- Engineering, procurement, and construction services
- Advanced filtration
- Membrane filtration
- Waste-to-Energy technology
- Sludge dewatering/reduction systems
- Membrane bioreactors
- Anaerobic digestion
- Nitrification
- Biological denitrification
- Biogas and natural gas recovery

Process Water, Industrial Wastewater Treatment, and Water Reuse

Korea's vast high-tech industrial base and stringent effluent standards [216] fuel a robust process and industrial wastewater treatment industry. According to South Korea's Ministry of Environment, there are more than 155 registered industrial complexes and approximately 47,000 operating facilities for small- and-medium-sized wastewater management firms. Korean industry implements the spectrum of water treatment technologies. There is also demand for ultrapure water treatment technologies to complement the electronics sector.

The government is developing non-traditional water resources, as well. The Pohang water reuse facility – the first of its kind in Korea – opened in 2014 under a Build-Transfer-Operate (BTO) PPP. It supplies 100,000 cubic meters per day of treated industrial wastewater to businesses in the region. A reuse facility is under construction at the Boryung sewage treatment plant in western Chungcheong province. When it is completed in 2019, 3.65 million cubic meters per day from the Boryung Dam will bolster the country's domestic water reserves. [215]

Key Technologies in Demand:
- Engineering and construction services
- Water reuse equipment and services (process specific)
- Advanced filtration
- Membrane filtration
- Reverse osmosis
- UV disinfection
- Anaerobic digestion
- Nitrification
- Biological denitrification
- Testing equipment.

Desalination

South Korea is investing heavily in desalination technology. In 2014, the country completed construction of its first commercial seawater desalination plant. The plant employs ultrafiltration, reverse osmosis, and seawater reverse osmosis methods to supply approximately 30,000 tons of industrial water a day. [217] The government is setting out to develop new desalination technology using natural gas hydrate. From 2011 to 2016, the Ministry of Land, Transport, and Maritime Affairs (now the Ministry of Land, Infrastructure, and Transport, or MOLIT) planned to provide $9.2 million to the Korea Institute of

Industrial Technology, a state-run think tank, to further develop the technology. [218] MOLIT plans to increase this amount to approximately $27 million by 2030. [219] South Korea also has developed a small nuclear reactor design for cogeneration of electricity and potable water. [220]

Key Technologies in Demand:
- Engineering and construction services
- Advanced filtration
- Membrane filtration
- Reverse osmosis
- UV disinfection
- Flash distillation

Market Opportunities – Environmental Consulting and Engineering

The Integrated Environmental Impacts Assessment Act came into force in July of 2012. The new law streamlines the Environmental Impact Assessment (EIA) process and covers three categories: Strategic Environmental Assessment (SEA) for public and private development projects, EIA, and small-scale EIA. [221] Administrative plans as targets of SEA are divided into policy plans and development master plans based on plan characteristics. As of 2011, main EIA project categories included urban development (156 projects in 2011), road construction (33 projects), industrial complex development (33 projects), ports (39 projects), and public water projects (36 projects). Target projects are determined in advance based on type and size. EIAs are required for 17 development categories:

- Urban and comprehensive regional development projects;
- Industrial site development;
- Infrastructure projects, specifically energy projects, as well as port, road, water resources, rail and airport construction;
- Stream use and development;
- Land and public water reclamation;
- Tourism complexes;
- Mountain area development and mining of soil, sand and minerals;
- Sports facility construction projects;
- Waste treatment facility development; and
- Defense and military construction projects

In 2017, Korea broadened its system of environmental impact assessment (EIA) and strategic assessment (SEA), but certain shortcomings persist. Industrial facilities are subject to EIA based on site size rather than environmental impact, which may enable smaller industrial facilities to generate more pollution with limited consequences. Moreover, SEA does not manage sector policies or a sizeable segment of local land-use plans – limitations which raise concerns about uncontrolled development in environmentally sensitive areas. There is no public participation in environmental permitting, and public engagement in EIA remains limited to local residents. [189]

Integrated permits for 19 industrial sectors will be introduced gradually and are intended to streamline the permitting process for large facilities. At the same time, however, small- and-medium-sized enterprises are still held to complex, medium-specific standards. [189]

Key Technologies in Demand:
- Engineering and construction services
- Environmental Impact Assessments (EIAs)

ETWG Agency Initiatives and Programs

KORUS-AQ

The U.S. Environmental Protection Agency collaborates with South Korea to protect public health and the environment. U.S. EPA, the Ministry of Environment of Korea, EXIT and partner agencies in both countries cooperate to improve air and water quality, and reduce exposure to toxic chemicals. Through KORUS-AQ (Korean-United States Air Quality Study), the U.S. EPA collaborates with South Korea's National Institute of Environmental Research (NIER), NASA, and other organizations to integrate different methods of air quality monitoring, such as technology, satellites, aircrafts, and modeling. [193]

U.S. Environmental Solutions Toolkit

The Toolkit compiles the U.S. EPA's environmental regulations, related underlying research and a directory of U.S. companies that provide technologies necessary to implement similar environmental regulatory actions abroad. In 2019, an enhanced version of the Toolkit will be released that will include an updated database of solutions providers and the capability for foreign buyers and government officials to contact them directly via the online interface. U.S. companies interested in participating in the Toolkit can find out more at www.export.gov/envirotech.

Waste Expo IBP

Waste Expo, one of the leading U.S. waste management trade shows, has partnered with the U.S. Department of Commerce's International Buyer Program to encourage foreign participation in the show. This platform was leveraged to exchange relevant technical information with South Korean participants and to introduce Korean buyers to U.S. waste management technology providers.

Water Environment Federation Technical Exhibition and Conference (WEFTEC) IBP

The U.S. Department of Commerce, through IBP, leads a delegation of Korean officials and business representatives to WEFTEC to explore relevant U.S. technologies and work with U.S. exporters on approaches to water resource management.

Market Contacts and Program References

Ministry of Environment

http://eng.me.go.kr/eng/web/main.do

Ministry of Land, Infrastructure and Transport (MOLIT)

http://www.molit.go.kr/english

Korea National Cleaner Production Center

http://www.kncpc.or.kr/en/main/main.asp

K-water

http://english.kwater.org.kr/eng/main.do

ENVEX, International Exhibition on Environmental Technology and Green Energy
http://www.envex.or.kr/eng/about/ENVEX.asp

Clean Air Expo
http://www.cleanairexpo.co.kr/

Public Procurement Service (PPS)
http://www.pps.go.kr/eng/index.do

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Mexico Case Study

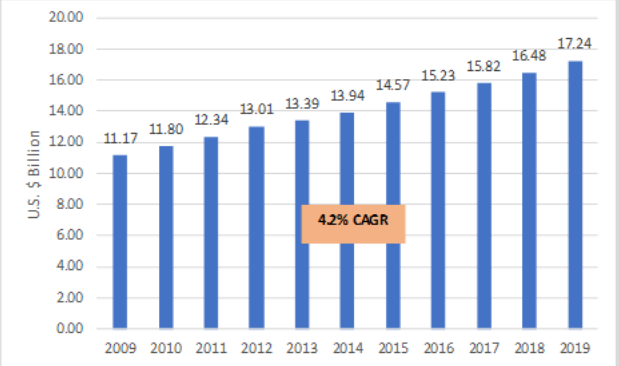
The overall Mexican environmental technologies market, including goods and services, is estimated to be valued at $17.24 billion in 2019. Mexico ranks second overall in the 2019 Top Markets Report, with a composite environmental technologies score of 88.0. Mexico's air pollution monitoring and control market is the most prominent environmental technology segment and ranks Mexico first globally, with a score of 72.3. Mexico's water sector ranks fourth overall, with a score of 13.9. For waste and recycling, Mexico ranks 10th , with a score of 1.7 (see Appendix 1 for global rankings).

Unprecedented investment in environmental infrastructure has catapulted Mexico to second place in the Environmental Technologies Top Market Report for the second time. However, while U.S. environmental technologies exporters benefit from close commercial ties with Mexico, lagging technical capacity in the environmental sector could limit the implementation of sophisticated projects and attendant opportunities for U.S. businesses. Nevertheless, the United States-Mexico-Canada Agreement (USMCA) includes first-ever articles to improve air quality, prevent and reduce marine litter, support sustainable forest management, and ensure appropriate procedures for environmental impact assessments, and may create the foundation necessary for improved environmental trade relations in the years to come.

State of the Environmental Regime

Mexico's environmental standards are improving, but compliance remains a challenge. This is reflected in the OECD's Environmental Stringency Index, which ranks environmental regimes on a scale from 1 to 6 (with 1 being lax and 6 being among the most stringent). Mexico scored a 4.0 on the 2012 EBJ-OECD survey, a 0.7-point improvement over its 2005 score. [7] Furthermore, the 2016 Yale Environmental Performance Index (EPI) ranked Mexico 67th out of 180 countries (where 180 is the worst performer). The EPI compiles its index by considering the capacity of countries to confront environmental issues, with emphasis on the protection of human health and ecosystems. [8]

Figure 15: Mexico's Environmental Market



Source: Environmental Business International with OEEI analysis, 2019.

Mexico's environmental regime is based on two pieces of legislation: The General Law of Equilibrium and Environmental Protection (LGEEPA) and the General Law for Prevention and Integral Management of Wastes (LGPGIR). In 2012, President Calderon signed the first General Climate Change Law (LGCC) in Mexico. The law accelerated the implementation of air pollution monitoring and control programs.

Since the 2015 Paris Agreement, Mexico has introduced further environmental legislation, most notably the National Strategy on Climate Change, Vision 10-20-40, and the Special Climate Change Program (for 2014 to 2018). In April 2018, Mexico's Senate approved modifications to the LGCC to include its Nationally Determined Contribution (NDC) commitments, [222] which promote the acquisition, modification, and innovation of technology in support of climate adaptation initiatives across areas such as infrastructure protection, water, transport, and soil recuperation. [223]

To limit greenhouse gas emissions (GHG), the Mexican Congress introduced a carbon tax, which is expected to reduce annual carbon emissions by 1.6 million tons and generate almost one billion USD annually. Authorities also established MEXICO$_2$, a voluntary exchange that provides carbon credits to companies that are developing environmentally friendly projects. [224] On June 21, 2017, Mexico became the 30th member country, and the first in Latin America, of the International Energy Agency (IEA) of the OECD. [14]

The Mexican Ministry of Environment and Natural Resources (SEMARNAT) governs and implements environmental regulation. It is also responsible for issuing environmental tenders for air pollution monitoring, soil remediation, waste management, and any projects that fall under the national Climate Change Strategy.

Water tenders are the purview of the National Water Commission (CONAGUA). CONAGUA manages water resources at a federal level and is the only entity authorized to delegate or grant concessions for water use. Municipal governments provide water services to communities through decentralized municipal water utilities known as *organismos operadores.* These water utilities are tasked by law with developing water service infrastructure. However, due to subsidized and inadequate water rates, commercial inefficiencies, and a lack of technical capacity, CONAGUA has been the de facto developer and financier of water infrastructure projects throughout the country.

Market Barriers

The North American Free Trade Agreement (NAFTA) has removed many barriers to trade with Mexico, and the new United States-Mexico-Canada Agreement (USMCA), if ratified and implemented, will continue to benefit U.S. firms. However, Environmental Technologies Trade Advisory Committee (ETTAC) members and analysts for the Office of Energy and Environmental Industries (OEEI) have identified the following barriers still facing environmental technologies companies attempting to export to or do business in Mexico:

1. **Local Partnership is Encouraged in Public Tenders**
   While not a formal requirement, local partnership in public tenders is strongly encouraged in Mexico. U.S. companies hoping to develop consortia relationships with Mexican companies should seek assistance through the U.S. Commercial Service to identify appropriate and credible partners for engineering, procurement and construction (EPC) contracts.
2. **Value Added Taxes Diminish Competitive Pricing of U.S. Environmental Technologies**
   A Value Added Tax (VAT) of 16% is imposed on domestic and foreign goods alike. This erodes the price competitiveness of higher quality, and thus more expensive, U.S. environmental technologies.

3. **Finding a Credible Distributor with National Reach Can Be Difficult**
   The overall acceptance of U.S. products, as well as low tariffs obtained through NAFTA, often causes U.S. exporters to underestimate the challenge posed by Mexico's size and diversity. It can be difficult to find a single distributor or agent to cover this vast market, and assistance with locating the appropriate distributor for a given product segment is often required. Mexican companies are extremely price conscious, seek financing options, tend to push for exclusive agreements, and value outstanding service and flexibility.
4. **Presumption of Conformity is not Extended for International Standards in Mexico**
   Companies exporting to Mexico will need to meet Mexican standards and demonstrate conformity. The cost of accreditation for a single product in Mexico through *Entidad Mexicana de Acreditación* is approximately $4,875. Mexico hosts a national NSF International office, which can help ease the accreditation and conformity assessment process. Mexico does not explicitly extend the presumption of conformity. Therefore, it is recommended that U.S. companies work with NSF Mexico or another relevant testing and certification organization to determine a cost-effective path toward meeting Mexican standards and certification requirements.

Market Opportunities – Air Pollution Control

Mexico has paid considerable attention to air pollution and climate variability. In 2012, Mexico became the first developing country to pass comprehensive climate legislation. Three years later, it became the first developing country to release a post-2020 climate action plan in its Intended Nationally Determined Contribution (INDC) under the Paris Agreement. [225] On Sept. 21, 2016, Mexico ratified the Paris Agreement and the INDC, and in April of 2018, the Mexican Congress reformed the LGCC to include INDC commitments. This commits Mexico to reduce greenhouse gas emissions by 22% and black carbon by 51% from business-as-usual levels by 2030 and identifies Mexico's peak GHG emissions year as 2026. [225]

LGEEPA states that authorities must implement programs to reduce air pollutant emissions from sources under federal jurisdiction. With this objective, the federal government has developed management programs to improve air quality, known as *ProAire*, to reverse the deterioration of air quality in major Mexican cities. *ProAire* programs incorporate specific measures for the reduction and control of pollutant emissions. The programs are based on the relationship between specific pollutant emissions, their sources, and their impact on air quality and the health of local communities.

In its 2016 National Air Quality Strategy (ENCA), SEMARNAT announced that it was considering more than 100 measures to address air quality in the "Megacity" (the region comprised of Mexico City and the states of Hidalgo, Mexico, Morelos, Puebla, and Tlaxcala) over the short-and medium-term. [226] They include:

- Requiring the Ministry of Health, the Communications and Transport Ministry (SCT), and the Agricultural, Territorial and Urban Development Ministry (SEDATU) to participate in federal actions to improve air quality;
- Creating 200 health units to conduct epidemiological surveillance of diseases associated with air pollution throughout Mexico City;

- Allocating 11 billion pesos (approximately $589 million) to Mexican development banks (NAFIN, BANOBRAS and FONADIN) for infrastructure projects and the modernization of public transportation;
- Funding FONADIN (the National Infrastructure Fund) with 150 and 50 million pesos (approximately $8 million) to support the expansion of air quality monitoring networks; and
- Publishing new standards for the control of volatile organic compounds (VOCs) and particulate matter (PM).

SEMARNAT, in coordination with other federal agencies, is responsible for implementing programs to reduce emissions from industries under federal jurisdiction, as well as verifying vehicle emissions. U.S. companies can access detailed information on *ProAire* programs, including description, location, contact information and information about future projects, by visiting SEMARNAT's webpage: http://www.semarnat.gob.mx/temas/gestion-ambiental/calidad-del-aire/programas-de-gestion-para-mejorar-la-calidad-del-aire.

Air Quality Monitoring

The ambient air quality of many large metropolitan areas in Mexico – particularly Mexico City, Guadalajara, Toluca, and Monterrey – is quite poor. For example, the concentration of nitrogen dioxide (NO_2) in Mexico City is above the national standard nine out of every 10 days. Most metropolitan areas in Mexico have air quality monitoring mechanisms and local regulations in place. However, enforcement is often weak, as many municipalities do not have sufficient resources or technical capacity for consistent air quality monitoring.

Official ambient air quality monitoring is conducted by SEMARNAT, which tenders openly to U.S. businesses. The Climate Change Strategy's Program for the Strengthening of the Environment of States (*Programa de Fortalecimiento Ambiental de las Entidades Federativas*) provides funding for projects at the municipal, state, and federal levels for compliance with environmental rules, [227] which should increase opportunities for U.S. companies as local governments ramp up their monitoring efforts.

Technologies and Services in Demand:

- Continuous emissions monitoring systems
- Ambient air quality monitoring equipment
- Source emissions measurement technologies
- Analytical and laboratory testing goods and services

Air Pollution Control

Mexico's environmental regime mandates vehicle emissions testing, catalyzer replacement programs, and reduction of industrial pollutants. Inconsistent enforcement, however, has moderated demand for these technologies. The government emphasizes emissions controls for vehicles and other mobile source control measures; however, meeting Mexico's goals for reducing harmful emissions will require implementation of control technologies for industrial sources.

The LGCC aims to decrease the country's output of carbon dioxide by 51 million tons by forcing Mexican companies to report and reduce their emissions. The law also focuses on the reduction of short-lived climate pollutants like black carbon, methane, tropospheric ozone, hydrofluorocarbons (HFCs) and VOCs. Compliance with the LGCC requires industries to institute improved monitoring and control

technologies, opening a variety of opportunities for in-line and end of pipe industrial monitoring systems.

Key Technologies in Demand:
- Air pollution control equipment
- Fuel vapor control systems
- Selective Catalytic Reduction
- In-line monitors and software
- Electrostatic precipitators
- Thermal oxidizers
- Catalytic converters
- Scrubbers

Mobile Source Emissions Control
Recent studies show that more than a decade of previous driving restrictions in Mexico resulted in effectively zero emissions reductions because citizens found ways to circumvent them. [228] Now the Mexican government is paying special attention to air pollution caused by vehicle emissions in Mexico City and the surrounding metropolitan area. In early 2016, the municipal government of Mexico City announced an expansion of the existing vehicle inspection program known as *hoy no circula.* The objective of the vehicle inspection program is to measure the level of emissions from vehicles to restrict the use of cars emitting above the threshold. All vehicles are required to pass inspection every six months.

In February 2018, the Mexican government published final emissions standards for engines used in heavy-duty trucks, buses, and complete vehicles, NOM-044-SEMARNAT-2017. Beginning Jan. 1, 2021, all new heavy-duty vehicles sold in Mexico will be required to meet standards equivalent to U.S. 2010 and Euro VI, which will be introduced in 2019. US 2007 and Euro V options also will be made available at that time, but only to help facilitate the two-year transition period. [229]

Key Technologies in Demand:
- Emissions control technologies for passenger cars, light-duty vehicles (LDVs), and heavy-duty vehicles (HDVs)

Market Opportunities – Water and Wastewater Treatment

Currently, though nearly 90% of the population has access to drinking water and 86% has access to sewage services, large gaps remain in rural areas where both water resources and infrastructure are scarce. The government estimates that nine million Mexicans do not have access to potable water and that 11 million do not have access to sewage lines. The overall Mexican municipal water and wastewater market was expected to grow seven percent annually between 2013 and 2018 as the government implemented its National Water Plan (PNH 2014-2018). Mexico's new government is expected to release an updated National Development Plan by April 2019, which will serve as the strategic foundation for other planning documents, such as a National Infrastructure Plan, that should include a forward-looking water strategy. [230]

Subsequent projects are to be financed through PPPs, a model recently adopted through the Public and Private Partnership Law. The PPP model anticipated $950 million of private investment in 2014 to match

CONAGUA's allocation of $6 billion. [227] During the 2015 to 2018 period, CONAGUA's budget for water infrastructure development was $4 billion, which was intended to be leveraged to develop 1,200 new potable water treatment plants, upgrades to wastewater treatment plants, and construction of new desalination plants, water pipelines, and dams. [231] According to CONAGUA, between 2015-2018, 1,100 of those projects were completed. Only 100 upgrades of wastewater treatment plants were cancelled or left unfinished. U.S. companies interested in developing PPPs should work with CONAGUA, which will remain the tendering agency for these projects.

Since 2012, the government has taken a harder stance on enforcement of environmental regulations, including better testing methods and a requirement that industries submit a monthly report from certified labs on discharges into national water bodies. [15] This generates demand for industrial water treatment solutions, particularly along the U.S. border in the industrial zones of northern Mexico. [15]

Municipal Drinking Water Treatment

Drinking water conveyance and distribution are expanding at a steady rate in Mexico. Total mains water consumption was expected to rise from 169,356 million cubic meters in 2014 to nearly 194,546 million cubic meters by 2018. This was largely due to the continued expansion of the pipeline network and increasing number of households connected to water mains. [232]

Nationwide, water treatment facilities also are upgrading to improve coverage. CONAGUA and Mexico's Secretariat of Social Development (SEDESOL) planned to invest $200 million in upgrades to the country's existing 874 drinking water plants. [227] In 2016 alone, CONAGUA planned to upgrade 80 existing plants with a budget of $100 million. The plants are in the states of Coahuila, Guerrero, Mexico City, Morelos, Puebla, Sinaloa, Tamaulipas, Veracruz, and Zacatecas. [233]

Mexico City provides unique insights into the complexity of the Mexican water system. Approximately 40% of the water in the Mexico City pipeline network is lost due to leaks. The current water provision system will encounter severe problems in the next few decades due to rapid urbanization and population growth. At the same time, scholars, officials, locals, and conservationists are arguing against the expansion of the Cutzamala reservoir system, the single largest source of water for Mexico City, and are instead pressing for rainwater collection, lake expansion, and smaller-scale sustainable ventures. [234] Nevertheless, CONAGUA is moving forward with the installation of the third line of the Cutzamala system, citing improved water supply security. [235]

However, consumer confidence in the ability of municipalities to deliver safe potable water remains low, driving double-digit growth in residential treatment options and creating opportunities for U.S. environmental solutions providers.

Technologies and Services in Demand:

- Engineering, procurement, and construction services
- Pipes, pumps, and valves
- Clarifiers and flocculators
- Sedimentation systems
- UV disinfection
- Ozone disinfection
- Meters and monitoring equipment
- Point-of-Use treatment equipment

Municipal Wastewater Treatment and Plant Development
As the least developed segment of Mexico's water sector, wastewater treatment is an environmental priority. Despite the fact that Mexico has almost doubled its treatment capacity in the last decade, recent estimates suggest that only 53% of wastewater receives treatment, indicating that expansion is still not keeping pace with demand. [15] Mexico's 2013 National Water Plan sets treatment goals of 100% for municipal waters by 2030, requiring a near $500 million public annual investment in wastewater treatment plants.

Currently, over $1.7 billion is invested in wastewater infrastructure. Approximately two-thirds, or $1.1 billion, went toward improving sewers and the remaining $621 million is allocated to treatment plants. These funds cover the development of new wastewater plants in the states of Puebla, Colima, Yucatan, Quintana Roo, State of Mexico, Nayarit, Guerrero, Colima, and Mexico City, [227] as well as an additional $150 million in upgrades to existing wastewater plants in the states of Aguascalientes, Chihuahua, Guanajuato, Jalisco, Nuevo Leon, Oaxaca, Puebla, and Mexico City. [227] Through 2018, CONAGUA and SEDESOL continued upgrades of existing municipal wastewater treatment plants in over 1,250 municipalities in the states of Guerrero, Oaxaca, Veracruz, Chiapas, and Michoacan with an estimated budget of $200 million. [236]

The $530 million Atotonilco wastewater treatment plant in Hidalgo State, potentially one of the largest of its kind in Latin America, is currently in its testing phase. Once completed, the portion of treated local sewage will increase dramatically from 11-57% percent. [237]

Technologies and Services in Demand:
- Engineering, procurement, and construction services
- Advanced filtration
- Membrane filtration
- Waste-to-Energy technology
- Anaerobic digestion
- Nitrification
- Biological denitrification
- Monitoring equipment
- Testing equipment

Desalination and Water-Efficiency
Mexico is faced with increasing water scarcity, and heavy reliance on agriculture is straining an already troubled system. [238] Unsustainable extraction from ground and surface sources has threatened the stability of the conventional water supply. Areas facing significant water shortages include large urban centers in northern and central Mexico and the western Baja California Peninsula. As a result, Mexico is turning to alternative sources of fresh water and promoting efficient water use by industry and citizens. Building complementary efficient local water utilities is a government priority.

One relevant area of opportunity for U.S. solutions providers is desalination technology. In the National Water Plan (PNH 2014-2018), desalination is one of CONAGUA's five main water supply strategies. [15] Water scarcity in the northwestern region, as well as a growing population and tourism industry, together make desalination a viable option. CONAGUA is planning new projects with the state governments of Baja California Norte, Baja California Sur and Sonora. [15]

Baja California is moving forward with a desalination plant in Rosarito Beach. The first phase of construction should be completed in 2019 and the second in 2024. The plant will cost approximately $463 million and rely on reverse-osmosis. It will be the largest desalination plant in the Western Hemisphere and produce up to 100 million gallons of water daily. The facility contract relies on a PPP. In addition, the State of Baja California has invested 517 million pesos (approximately $27 million) in the Ensenada desalination plant, which is currently under construction and expected to benefit 72,000 people. [235]

An RFP has been issued for the 21,600 cubic meters per day Empalme & Guyamas Plant ($24 million) and the 34,560 cubic meters per day extension of the Cabo San Lucas Plant was scheduled for 2018. [89] The 17,280 cubic meters per day La Paz Plant ($32 million) is a priority desalination project and currently in the planning phase. [15] There are also several municipal desalination plants in the conceptual stage. However, these are not likely to be tendered within the next couple of years. [15]

In northern Mexico, authorities are coping with water scarcity through the construction of new reservoirs and costly transport infrastructure, implementation of complex purification technologies, and increases in tariffs to improve supply and encourage conservation. An example of this can be found within the 2015 to 2016 project pipeline period via the $78 million La Laja Dam project, which will create an additional freshwater source for 120,000 residents of the Ixtapa-Zihuatanejo metropolitan area. [89]

Similarly, several areas of northeast Mexico rely on the use of sophisticated water purification technologies because the available water requires the elimination of contaminants such as heavy metals and arsenic. Considering this, U.S. solutions providers could be well-positioned to help Mexico develop relevant infrastructure.

Key Technologies in Demand:
- Water reclamation technologies
- Engineering and construction services
- Water reuse equipment and services (process specific)
- Advanced filtration
- Membrane filtration
- Reverse osmosis
- UV disinfection
- Anaerobic digestion
- Nitrification
- Biological denitrification
- Testing equipment

Groundwater Monitoring and Pollution Prevention

Water scarcity necessitates comprehensive monitoring of groundwater sources in Mexico. As of 2014, more than 106 of Mexico's 653 subterranean aquifers were overexploited. [15] These aquifers supply roughly 60% of the groundwater that Mexico relies on for agriculture and drinking water. To address this, the National Water Plan (PNF 2014-2018) emphasized geo-hydrological exploration, groundwater monitoring and an integrated groundwater management plan. Other projects deemed necessary to the maintenance of groundwater resources are artificial aquifer recharge and evapotranspiration management.

CONAGUA has undertaken large-scale studies to assess the nation's aquifers and is expected to create a national aquifer database in the coming years. The database will provide real-time data on withdrawal and recharge rates, as well as groundwater quality. [15]

Technologies and Services in Demand:
- Environmental engineering and consulting services
- Water quality monitoring equipment
- Monitoring wells
- Site characterization technology
- Groundwater recharge technologies

Market Opportunities – Waste Management and Recycling

Municipal Solid Waste and Recycling

The 2003 LGPGIR and the 2012 LGCC regulate waste management in Mexico. The LGPGIR delegates responsibility for managing waste and building the necessary infrastructure to municipalities and states. [239] The LGCC builds on the framework of the LGPGIR and required that by 2018, all municipalities with populations above 50,000 must have developed methane emissions control infrastructure for urban solid waste facilities. [240]

In recent years, there has been a strong push to modernize Mexico's waste management infrastructure to more effectively address the roughly 102,850 metric tons processed each day. [241] Open dumpsites are prevalent and pose a serious threat to human health and the environment. At the beginning of 2017, the Senate proposed a bill to modify the LGPGIR to more effectively govern the management of urban solid and special management wastes. If passed into law, it would designate authority for both types of waste and direct authorities to impose penalties for noncompliance. [14]

SEMARNAT promotes the integrated management of hazardous and municipal solid waste, as well as waste that requires special handling, by emphasizing waste prevention, economic assessment, and adequate disposal. In 2015, the Mexican government earmarked over $100 billion to SEMARNAT for environmental projects, including waste management and recycling. These funds are available to all Mexican states and municipalities through the Program for the Strengthening of the Environment of the States (*Programa de Fortalecimiento Ambiental de las Entidades Federativas*). Initiatives that can be financed with these funds include environmental studies, prevention programs, waste management programs, projects to increase the installed capacity of waste collection, and adequate disposal projects. U.S. companies can access detailed information on funded projects, including description, location, value, and responsible agency, by visiting SEMARNAT's webpage: http://www.semarnat.gob.mx/apoyos-y-subsidios/pef/beneficiarios

Key Technologies in Demand:
- Waste handling equipment
- Cranes, crushers, and shredders
- Odor control systems
- Bio-gas capture technologies
- Separators
- Protective equipment for separating lines
- Garbage trucks with compactors
- Engineering services

- Waste collection technologies
- Sanitary landfill systems
- Environmental monitoring and analytical equipment
- Sorting machines
- Crushing and grinding machines
- Materials handling equipment
- Collection services, containers, and vehicles
- Recycling process expertise
- Waste incinerators

Market Opportunities – Environmental Consulting and Engineering

The Mexican government requires an environmental impact assessment (EIA) as part of the permitting process for projects that involve either an environmental impact or any use of natural resources. However, comprehensive environmental audits are not currently mandatory. The EIA serves as an instrument of environmental policy that establishes the legal framework through which federal or state authorities can evaluate environmentally threatening activities to protect the environment. Under the LGEEPA, environmental regulators have the authority to enforce legislation through fines, closures, forfeitures, suspension or revocation of permits, and implementation of corrective measures. [242]

Key Services in Demand:

- Environmental Impact Assessment

ETWG Agency Initiatives and Programs

WEFTEC International Buyer Program

WEFTEC, the largest water technology exhibition in North America, works with the U.S. Department of Commerce's International Buyer Program to encourage foreign participation in the show. This platform is leveraged to exchange relevant technical information and to advance U.S.-Mexican water cooperation through targeted activities at WEFTEC. Business relationships with U.S. water technology providers are facilitated.

Waste Expo International Buyer Program

Waste Expo, one of the leading U.S. waste management trade shows, has partnered with the U.S. Department of Commerce's International Buyer Program to encourage foreign participation in the show. This platform is leveraged to exchange relevant technical information on the Mexican market and U.S. environmental technology capabilities. Business relationships with U.S. waste management providers are facilitated.

U.S. Environmental Solutions Toolkit

The Toolkit is an online searchable database that marries U.S. EPA expertise on solving environmental challenges and developing environmental rules with a catalogue of U.S. technology providers. In 2015, ITA U.S. EPA introduced a Spanish-language version of the Toolkit to expand its usability in Latin America. It serves as a reference tool in bilateral engagements that focus on increasing Mexican capacity to address environmental concerns. In 2019, an enhanced version of the Toolkit will be released that will include an updated database of solutions providers and the capability for foreign buyers and

government officials to contact them directly via the online interface. U.S. companies interested in participating in the Toolkit can find out more at www.export.gov/envirotech.

Green Expo
Green Expo is Mexico's preeminent environmental technology show. This event is leveraged through the U.S. Department of Commerce's trade fair certification program to promote the development of U.S.–Mexico business relationships in the environmental sector.

Border 2020
The U.S. EPA has awarded over $1.1 million in grants to fund 25 new environmental projects along the U.S-Mexico border with Arizona, California, Texas, and New Mexico. The projects include improving air monitoring, expanding waste collection and recycling, green infrastructure, improving environmental awareness, and education among area residents. U.S. companies seeking a foothold in the market should consider participating in this program.

Market Contacts and Program References

Secretariat of Environment and Natural Resources (SEMARNAT)
https://www.gob.mx/semarnat

The Security, Energy and Environment Agency (ASEA)
https://www.gob.mx/asea

National Water Commission (CONAGUA)
https://www.gob.mx/conagua

National Institute of Ecology and Environmental Change (INECC)
https://www.gob.mx/inecc

Attorney General for Environmental Protection (PROFEPA)
https://www.gob.mx/profepa

Mexican Institute of Water Technology (IMTA)
https://www.gob.mx/imta

National Bank for Public Works (Banobras)
https://www.gob.mx/banobras/

Border Environment Cooperation Commission (BECC) (North American Development Bank)
http://www.nadb.org/

National Council of Industrial Ecologists of Mexico (CONIECO)
http://www.conieco.com.mx

National Association of Water and Sanitation Companies of Mexico (ANEAS)
http://www.aneas.com.mx

The Green Expo
http://www.thegreenexpo.com.mx

ANEAS Expo & Conference
http://www.aneas.com.mx

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Saudi Arabia Case Study

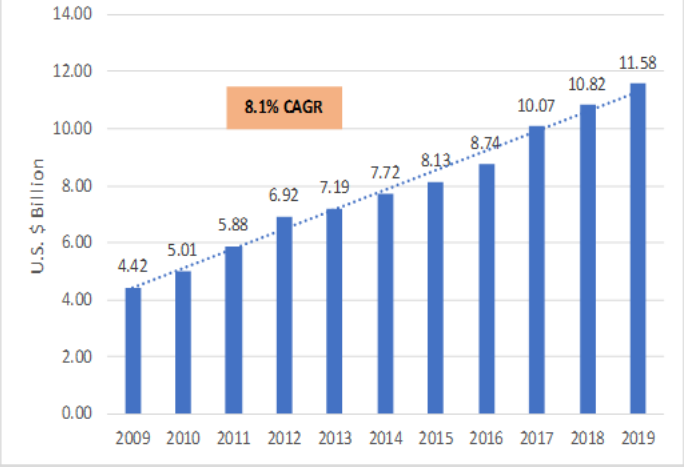
Saudi Arabia ranked eighth globally on the 2019 Top Markets Report with a composite environmental technologies score of 28.2. Within the environmental industry segments, Saudi Arabia ranked third for water with a score of 14.8, highlighting the relatively important role that water and wastewater technology plays in Saudi's desert climate. Saudi Arabia ranked eighth for air pollution control markets with a score of 10.4 and fifth for waste and recycling with a score of 3.0 (see Appendix 1 for global rankings).

Overall Rank	Air Pollution Control
8	8
Water	**Waste & Recycling**
3	5

State of the Environmental Regime

Saudi Arabia's overall environmental technologies market, including goods and services, is estimated to be valued at $11.58 billion in 2019. [1] Saudi Arabia has a limited domestic environmental technologies industry, instead importing the goods and services required to meet its environmental goals. Its preference for imported goods, pronounced water scarcity issues, and vast oil and gas industry make it a top market for U.S. environmental technologies.

Figure 16: Saudi Arabia's Environmental Tech. Market



Source: Environmental Business International with OEEI Analysis, 2019.

The country has a relatively high level of regulatory stringency and enforcement from the perspective of international businesses operating there. This is evidenced by both the government's recent allocation of $300 million for environmental protection and pollution control [243] and its 2009 announcement of the formation of a Green Police unit to improve monitoring and environmental regulation enforcement. [243] Saudi Arabia also named several environmental protection goals in its 10th Development Plan (2015-2019), including improvement of waste management, mobile and stationary source emissions reduction, and protection of coastal and territorial waters.

Saudi Arabia recently unveiled its Vision 2030 objectives, which include addressing the Kingdom's dependence on oil, improving services and support for civil society, and promoting more sustainable socioeconomic development pathways. [244] As part of this effort, Saudi Arabia released its National Transformation Program 2020, which highlights key techniques that will build the institutional capacity necessary to achieve the Vision 2030 goals. [245]

The 2018 Yale Environmental Performance Index (EPI) ranked Saudi Arabia 86th out of 180 countries (where 180 is the worst performer). [8] This represents a significant improvement from Saudi Arabia's

2016 rank of 95. The EPI compiles its index by evaluating the capacity of countries to confront environmental issues, with particular emphasis on the protection of human health and ecosystems. [112]

Market Barriers

The Environmental Technologies Trade Advisory Committee (ETTAC) identified the following barriers as most problematic for environmental technologies companies attempting to export to or do business in Saudi Arabia:

1. **Local partnership is required**
   American exporters are not required to appoint a local Saudi agent or distributor to sell to Saudi companies, but commercial regulations restrict importing for resale and direct commercial marketing within the Kingdom to Saudi nationals, wholly Saudi-owned companies, and Saudi-foreign partnerships where the foreign partner holds 25% equity. [246] Furthermore, the Saudi government appears to favor joint-venture arrangements with Saudi partners in the lead in public tenders over those led by foreign firms. As part of Vision 2030, Saudi Arabia also intends to increase local content requirements in capital and operational projects from 30-40%. [245]
2. **Certification and safety approvals fail to recognize equivalents from the exporting market**
   The Saudi Food and Drug Authority applies unnecessary testing requirements to products that have dual uses in water analysis and medicine such as spectrophotometers. Additional testing imposes undue burden in terms of cost and time-to-market for technologies that are intended for environmental application.

Market Opportunities – Air Pollution Control

Air Emissions Control and Monitoring
A 2016 World Health Organization report on cities with the world's most polluted air ranked three Saudi Arabian cities in the top 20: Riyadh, Al Jubail, and Dammam. [247] The Presidency of Meteorology and Environment (PME) not only monitors and regulates air quality but also issues tenders. In late 2012, PME introduced new ambient air quality and stationary and mobile source emissions standards. In March 2014, the agency decreed that all companies would have five years to meet the new requirements, bringing maximum pollutant levels in line with international benchmarks. [248] The Kingdom is a signatory to the Kyoto Protocol and has undertaken efforts to enforce emissions standards for large-scale industrial facilities.

In its Nationally Determined Contribution (NDC) under the Paris Climate Agreement, the Kingdom committed to achieve mitigation co-benefits of up to 130 million tons of CO_2 equivalent avoided annually by 2030 through economic diversification and adaptation. The NDC specifically emphasizes the need to expedite conversion of its single-cycle power plants to combined cycle as part of its overall emissions reduction strategy. It also includes a plan to build the world's largest carbon capture and use facility, which would purify about 1,500 tons of carbon dioxide per day for use in Saudi Arabia's petrochemical plants.

The Kingdom of Saudi Arabia allocated $300 for environmental protection and pollution controls in 2010 and has ordered all major industrial projects to conform to international air standards. Major sources of

emissions in Saudi Arabia include oil refineries, power generation, petrochemical development, cement plants, and metals foundries. Saudi's annual imports of air pollution control and monitoring equipment is estimated at $50 million, [249] with U.S. companies meeting almost 75% of domestic demand.

Saudi efforts to monitor air quality have increased alongside efforts to develop and enforce environmental standards and regulations, creating demand for ambient air quality surveys and emission source monitoring. The State of the Environment report in 2017 dedicated a chapter to atmosphere and air quality, making specific reference to intended Air Quality Improvements (AQIs) and the expansion of the national ambient air quality monitoring network to "cover all urban cities in the Kingdom's thirteen regions." [250]

The industrial cities of Jubail and Yanbu are prime examples of the adoption of advanced monitoring and control technologies within a finite industrial zone for existing and new facilities, presenting continued opportunities to U.S. technology providers.

Technologies and Services in Demand:
- Continuous emissions monitoring systems
- Fenceline monitoring equipment
- Ambient air monitoring equipment
- Source emissions measurement technologies
- Environmental testing and laboratory instrumentation and services
- Dry sorbent injection technologies
- Flue gas desulfurization equipment
- Activated carbon injection technologies
- Inspection, adjustment, maintenance and repair services
- Selective catalytic reduction technologies
- Selective non-catalytic reduction controls

Market Opportunities – Waste Management and Recycling

Municipal and Industrial Waste
In July 2013, the Saudi Cabinet approved new Municipal Solid Waste (MSW) management regulations. These regulations aim to ensure the implementation of an integrated framework for municipal solid waste management in the country. Studies conducted by the Ministry of Municipal and Rural Affairs in collaboration with the Saudi Arabian Basic Industries Corporation (SABIC) recommended that the ministry establish a joint stock company for the treatment and recycling of solid waste in the Kingdom using the latest technology to dispose of the massive quantity of waste generated in the country in an environmentally friendly manner.

In 2014, the World Bank conducted a study on the state of waste management in Saudi Arabia at the request of the Saudi government. The government subsequently asked the Bank to assist in its development of a National Waste Strategy to advance the study's recommendations. The draft Strategy is based on an integrated solid waste management approach, including minimization, recovery, reuse, and disposal in ecologically-sound engineered landfills. [251]

Recycling and solid waste management is regulated by the Ministry of Municipal and Rural Affairs in conjunction with local municipalities. The Ministry is also responsible for issuing tenders within the

sector. A substantial portion of the multi-billion-dollar budget of Saudi Arabia's Ministry of Municipality and Housing is dedicated to handling, processing, managing, and disposal of solid waste. [249] Saudi Arabia generates about 16 million tons per year, [252] the majority of which ends up untreated and landfilled. [253] In 2017, the Kingdom announced the creation of The Saudi Recycling Company, a new recycling sector initiative established via the Public Investment Fund (PIF) as part of its Vision 2030 program. The new company will form partnerships with the private sector and is intended to focus on materials at all stages of the value chain. [254]

Production of industrial, chemical, and hazardous wastes is also growing in Saudi Arabia. The burgeoning healthcare sector, which generates an estimated 50,000 tons of waste per year, also offers increasing commercial opportunities. As of 2015, the Kingdom currently boasts 2,282 health centers, mostly heavily concentrated around Riyadh. [255] There is also significant market growth in privately managed hospitals, further increasing the demand for a variety of incineration and medical waste handling technologies.

Technologies and Services in Demand:

- Hazardous waste transportation
- Waste sampling, characterization, and analysis
- Waste minimization
- Hazardous waste removal and tank cleaning
- Contaminated land site assessment and remediation
- Industrial and hazardous waste treatment and disposal
- Air pollution control equipment and monitoring devices
- Solid waste management systems

Market Opportunities – Water and Wastewater Treatment

Water resources are regulated by the Ministry of Water and Electricity (MOWE) and tendered by the National Water Company (NWC). The NWC was created in 2008 to oversee water tenders and manage the development of Public Private Partnerships (PPP) for water infrastructure development. [243] The NWC is currently a government-owned entity but is designed to evolve into a private sector holding company as the Saudi water sector becomes completely privatized. [243] Similarly, the Water and Electricity Company (WEC) was created in 2003 as a limited-liability corporation to manage the consumer market for water and power with an overarching mission of keeping tariffs low. [243] The Saline Water Conversion Corporation (SWCC) operates the state's 36 desalination facilities.

Recently, Saudi Arabia moved to restructure water tariffs, which had been among the lowest in the world. The impact of declining oil prices combined with years of wasteful water practices moved MOWE to increase industrial and commercial tariffs by 125%. [256] Increases for residential customers also have been implemented, though they will be negligible up to 15 cubic meters per month. From that point, the new graduated tariff scheme more than doubles for every 15 cubic meters increment. This provides an incentive to limit consumption and fuels a fundamental shift in how water resources are managed in the Kingdom. [257]

To manage and modernize the country's water system, the Kingdom of Saudi Arabia is investing heavily in large water infrastructure projects. According to the NWC's plans, between 2012 and 2020, approximately $66.4 billion will be invested in new water infrastructure and related services, $30 billion

of which will be directed toward capital expenditures. [243] In 2016, Saudi Arabia unveiled a major privatization program as part of a plan to diversify the economy away from its dependence on oil. The government is expected to tender or award half a dozen water projects in 2019. [258]

Municipal Water Treatment and Water Efficiency

Demand for water services in Saudi Arabia is rapidly outpacing supply as urbanization and population growth increases but groundwater resources dwindle. To address this, some efforts are being made to reduce consumption. For example, the government plans to decrease municipal water consumption from 256 to 200 liter/capita/day. [245] Nevertheless, further infrastructure development will ultimately be required. As part of Vision 2030, the Saudi government aims to increase the total available capacity of surface and groundwater from 4.1 to 6.1 billion cubic meters per day. Further, the National Water Strategy seeks to increase urban wastewater coverage from 58% in 2010 to 80% by 2030. [259]

The Saudi government is seeking active private sector participation in water infrastructure. The Saudi Arabia Country Commercial Guide estimated in 2014 that $5 billion will be needed annually over the next 20 years for new water infrastructure investments. With the development of 12 Operations-and-Management joint ventures, in the near-term there should be substantial opportunities for management of existing facilities as well as new facility construction and upgrades. The NWC is expected to invest $12.8 billion in capital expenditures and $17.9 billion in operations expenditures in fresh water treatment and distribution between 2012 and 2020. [260]

The NWC privatization scheme will transfer management to private companies to ameliorate the problem of non-revenue water. Improvements in transmission infrastructure, use of leakage detection systems, and enhancements to revenue collection – including upgrading metering and billing technologies and services – will help to address the issue. There is also an emphasis on improving the sewer system and creating separate systems for storm water management. Approximately 40% of Saudi Arabia utilizes combined sewers, which has exacerbated flooding in recent years. [243]

Technologies and Services in Demand:

- Engineering services
- Operations and management services
- Pipes, pumps, and valves
- Advanced filtration
- Membrane filtration
- Reverse osmosis
- Multiple Effect Distillation (MED)
- UV disinfection
- Ozone disinfection
- Water loss technology
- Smart metering

Desalination

Water demand surpasses renewable water resources by approximately 10 billion cubic meters a year. [261] Saudi Arabia currently meets excess demand through seawater desalination and is already planning to build nine new thermal desalination facilities off the Red Sea. Desalination as a water treatment method also remains critical in the Kingdom due to high groundwater salinity. The SWCC currently operates 36 desalination facilities that meet a collective 60-70% of freshwater demand. [243]

Expansion of the Saudi desalination program will be needed to meet future freshwater needs. [261] This will have important implications for air pollution and emissions controls, as thermal desalination is highly energy intensive and the region remains heavily fossil-fuel dependent.

The SWCC seeks to increase desalination capacity from 5.1 to 7.3 million cubic meters per day by 2020, [243] highlighting the significant opportunities for desalination technology and Engineering, Procurement, and Construction (EPC) firms. The SWCC has traditionally granted large EPC contracts for the development of facilities and continues to do so; however, it has also recently included Build-Own-Operate (BOO) models in its portfolio that will open the desalination market further to the foreign environmental service providers. This trend may accelerate if budgetary shortfalls increase as reduced oil prices create demand for alternative financing models, spurring an increase in centralized public sector spending. As stated in its National Transformation Program, the Saudi government plans to increase the percentage of desalinated water production managed by strategic partners from 16-52% by 2020. [245] Saudi Arabia's Public Investment Fund (PIF) is also planning to increase its stake in water and power project developer ACWA Power from 25-40%. ACWA Power is a leader in the region's recent privately-financed desalination expansion. [262]

In late 2018, the Saudi cabinet approved the tendering of seven desalination projects, with more than 40% of bids coming from international companies, according to the National Center for Privatization and PPP. [258] There are six major projects in the planning stage. The largest is the Jubail 3 thermal and reverse osmosis project estimated to be worth $3 billion, [89] which the Saudi Council of Ministers recently cleared to proceed as a PPP. The remaining five projects are all saline water conversion plants utilizing reverse osmosis. They include Haradh BWRO, $1.6 billion; Rabigh Phase 4, $1.2 billion; Yanbu 4, valued at $900 million; Jeddah 4, valued at $800 million; and Al Khafji Solar-powered SWRO phase 2, valued at $600 million. [89]

A shift to renewables is expected to drive the adoption of membrane technologies in this industry, since they can be powered from the national grid rather than relying on waste heat from a nearby thermal power plant. This shift is largely tied to the country's pioneering exploration of solar desalination. [259] In early 2017, Saudi Arabia completed construction of Ras Al Khair Desalination Plant, the world's first solar-powered desalination plant, which produces 1.025 million cubic meters of drinking water per day for the city of Riyadh. [263]

Technologies and Services in Demand:
- Engineering services
- Management and operations services
- Multistage flash distillation
- Multiple Effect Distillation (MED)
- Reverse osmosis membrane technology
- Solar- and-energy-efficient desalination technology

Industrial Wastewater Treatment and Water Reuse

Wastewater treatment is growing robustly in Saudi Arabia; the NWC is expected to invest $23.9 billion in capital expenditures and $11.9 billion in operations expenditures in wastewater treatment between 2012 and 2020. [260] Wastewater treatment capacity is expected to expand by 12.8% annually. [260] The NWC plans to enhance the economic attractiveness of wastewater projects by facilitating waste-to-energy programs within treatment plants and promoting the sale of treated wastewater for industrial

uses. [264] Waste-to-energy projects are key components of the national wastewater management program and are likely to emphasize biogas combined heat and power facilities. [265]

NWC has signed private sales contracts of treated wastewater to Saudi Aramco and power generation company, Saudi Electric Company. [260] One major project was announced for the 2015 to 2016 tender period was the South Dhahran Wastewater Treatment Plant. The new plant will provide municipal treatment services for Dhahran, and treated effluent will be used by Saudi Aramco for industrial purposes. The project is expected to have a daily capacity of 70,000 cubic meters and is estimated at $28 million. [136] Additionally, the Power and Water Utility Company for Jubail and Yanbu is building a $230 million desalination plant intended to serve 26 petrochemical factories. [263]

Water reuse is another growth market in Saudi Arabia. The Saudi government has instituted treatment standards for various modes of reuse. The National Water Strategy Plan has a target of reusing 100% of treated municipal water and 80% of industrial wastewater by 2030. [259] Reused water is intended to serve industrial purposes and should reduce the amount of saline conversion necessary for potable uses. Membrane-based wastewater treatment is also more economically viable than desalination in terms of operation costs. The NWC intends to play a major role in the water reuse market and estimates that sales from reused wastewater will exceed those for potable water in six large cities by 2030, yielding $900 million in revenue over the forecast period. [243] Major industrial reuse projects announced include the Manfouha WWTP expansion valued at $320 million; the Al Hayer WWTP, Phase 2 valued at $160 million; and the Arana WWTP, Phase 2 valued at $100 million, [89] all of which are being developed with the intention of selling treated effluent to industrial users.

Technologies and Services in Demand:

- Engineering and construction services
- Water reuse equipment and services (process specific)
- Advanced filtration
- Membrane filtration
- Reverse osmosis
- UV disinfection
- Anaerobic digestion
- Nitrification
- Biological denitrification

Market Opportunities – Environmental Consulting and Engineering

Four new Economic Cities are currently in various stages of development throughout the Kingdom: King Abdullah Economic City (KAEC) in Rabigh, Prince Abdulaziz bin Musaid Economic City (PABMEC) in Ha'il, Knowledge Economic City (KEC) in Medina, and Jazan Economic City (JEC). Each city is intended to encourage growth in specific sectors – such as logistics, healthcare, education, energy, and agriculture – that are associated with its theme. The goal is to generate domestic jobs through workforce development, professional training and academic institutions. [246] The Saudi Arabian General Investment Authority (SAGIA) stated that sustainability and energy efficiency are key elements of the cities' development strategy. These massive projects are being built from scratch with significant

potential environmental impact, creating significant demand for construction, engineering, design, and related infrastructure services.

Key Services in Demand
- Environmental Impact Assessment (EIA)
- Engineering, design, and construction services
- Environmental monitoring and analysis

ETWG Agency Initiatives and Programs

U.S. Environmental Solutions Toolkit
The Toolkit is an online searchable database that marries U.S. EPA expertise on solving environmental challenges and developing environmental rules with a catalogue of U.S. technology providers. It serves as a reference tool in bilateral engagements that focus on increasing Saudi capacity to address environmental concerns. In 2019, an enhanced version of the Toolkit will be released that will include an updated database of solutions providers and the capability for foreign buyers and government officials to contact them directly via the online interface. The updated version will offer information in seven languages, including Arabic, to facilitate ease of use in Saudi Arabia. U.S. companies interested in participating in the Toolkit can find out more at www.export.gov/envirotech.

Waste Expo IBP
Waste Expo, one of the leading U.S. waste management trade shows, has partnered with the U.S. Department of Commerce's IBP to encourage foreign participation in the show. This platform was leveraged to exchange relevant technical information with Saudi participants and to introduce Saudi buyers to U.S. waste management technology providers.

Water Environment Federation Technical Exhibition and Conference (WEFTEC) IBP
The U.S. Department of Commerce, through IBP, leads a delegation of Saudi officials and business representatives to WEFTEC to explore relevant U.S. technologies and work with U.S. exporters on approaches to water resource management.

Market Contacts and Program References

Ministry of Municipal and Rural Affairs (MOMRA)
www.momra.gov.sa

Power and Water Utility Company-Jubail and Yanbu
www.marafiq.com.sa

Ministry of Water and Electricity
www.mewa.gov.sa/en/

Water and Electricity Company
www.wec.com.sa

National Water Company
www.nwc.com.sa

ACWA Power- Saudi Arabia
www.acwapower.com

Saudi Aramco
www.saudiaramco.com

Saline Water Conversion Corporation
www.swcc.gov.sa

Royal Commission for Jubail and Yanbu
www.rcjy.gov.sa

WEPower, Dammam, Saudi Arabia
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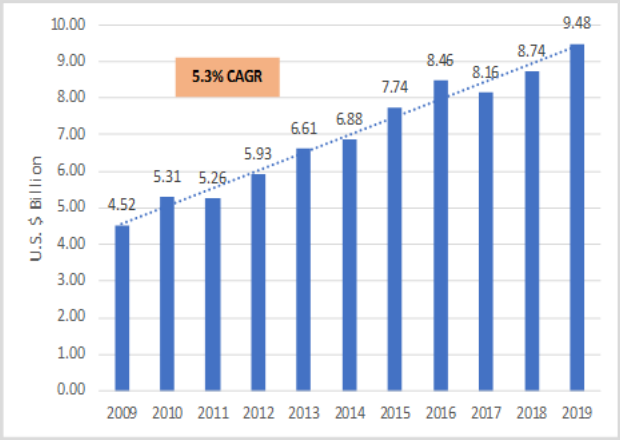
Turkey Case Study

The overall environmental technologies market in Turkey including goods and services is valued at an estimated $9.48 billion in 2019. [1] **Growth in the Turkish market is driven by EU mandates and a national effort to provide basic sanitation services. Turkey ranks ninth in the 2019 Top Markets Report overall with a composite environmental technologies score of 26.8 (see Appendix 1 for global rankings). Turkey ranks fourth for air pollution control markets with a score of 20.4. It ranks 21st for water with a score of 3.5 and seventh with a score of 2.9 for waste and recycling.**

State of the Environmental Regime

Turkey's environmental regime has improved in recent years, both in terms of rulemaking and enforcement, though challenges with its EU accession have also limited progress in this area. Turkey's EU accession agenda technically still seeks to advance both areas as part of the environmental and climate *acquis*. The OECD Environmental Policy Stringency Index, which ranks environmental regimes on a scale from 0 to 6 (with 0 being lax and 6 being the most stringent), scored Turkey a 1.92 in 2015, a 1.09-point improvement from its 2005 score of 0.83. [7] However, the 2018 Yale Environmental Performance Index (EPI) ranked Turkey 108 out of 180 countries (where 180 is the worst performer), declining from its 2016 rank of 99. The EPI compiles its index by considering the capacity of countries to confront environmental issues, with particular emphasis on the protection of human health and ecosystems. [8] Turkey ranked 78 out of 180 countries on Transparency International's 2018 Corruption Perceptions Index with a score of 41 out of 100, where 0 is highly corrupt and 100 is very clean. This is the same score and rank as India and represents a slight decrease from 2017. [44]

Figure 17: Turkey's Environmental Technologies Market



Source: Environmental Business International with OEEI Analysis, 2019.

At the national level, the Ministry of Environment and Urbanization is the procurement agency for environmental projects. On Aug. 11, 1983, the Turkish government published Law Number 2872, better known as the Environment Law. The purpose of this law is to protect and improve the environment. Environmental law is overseen by the Ministry of Environment and Forestry, which was organized in 2003.

While Turkey made substantial progress in the implementation of environmental regulation through 2015, in a 2018 report the European Commission noted that environmental enforcement remains weak and additional national legislation is still needed in the areas of ambient air quality, national emissions ceilings, volatile organic compounds, waste separation, and reducing biodegradables in waste disposal. The report further notes that almost no progress had been made in most of these areas since 2016. The report recommends that Turkey complete its alignment with the directives on water, waste management and industrial pollution, and with the *acquis* on climate change, and strive for harmonization and implementation of cross-cutting legislation, including the *acquis* on public participation. [266]

Market Barriers

As the Turkish regulatory regime progresses towards convergence with the EU *acquis*, more of Turkey's market access barriers relate to differences between U.S. and EU regulations and standards development approaches. The following barriers are most problematic for environmental technologies companies attempting to export to or do business in Turkey:

1. **Failure to Recognize Many International Standards**
   The existing European Regulation on Standardization (EU) No 1025/2012 recognizes international standards from only three European standards bodies: the European Committee for Standardization (CEN), the European Committee for Electrotechnical Standardization (CENELEC) and the European Telecommunications Standards Institute (ETSI). Failure to recognize other international standards bodies limits the application of equivalent U.S. technologies in the market.
2. **A Preference for Design-Based Standards over Performance-Based Standards**
   In the United States, standards for environmental technology generally require a performance threshold, such as mitigation of pollution below a level that the scientific method has determined is consistent with protection of human health. This performance-based approach allows for innovation to meet a specific goal. On the other hand, in the EU many standards require technology to meet certain design specifications, thus potentially preventing use of any technology that performs effectively but lacks the required design specifications.
3. **Application of the Precautionary Principle in Standards and Regulations**
   In Europe, the identification of hazards and subsequent limitations on application is often tied to unknown future harms as opposed to the risk-based approach, which assesses the likelihood of both unknown and known risks against known benefits. Requiring the precautionary principle to be applied in development and adoption of environmental technologies may slow their delivery to market.
4. **EU Assistance and Subsidies for Environmental Projects**
   In an effort to help Turkey meet EU environmental standards, the EU often funds or subsidizes the development of environmental infrastructure. Within tenders, there is a strong preference for European providers, placing U.S. bidders at a competitive disadvantage.
5. **Lag in Implementation of EU Environmental Rules**
   Despite the differences in the regulatory and standards systems of the EU and the United States, adoption of and adherence to EU environmental rules in Turkey would drive development of environmental projects and opportunities for U.S. firms. Turkey's lag in adherence to EU mandates in this area has created a corresponding lag in the development and tendering of projects, thus slowing market growth overall.
6. **Corruption in Public Tenders**
   U.S. companies acknowledge that instances of corrupt practices in tendering do occur for some public sector and local public sector tenders.

Market Opportunities – Air Pollution Control

According to a report conducted by UN Environment, the two primary causes of air pollution in Turkey are urbanization and industrialization. More specifically, transport-related air quality challenges are severe, including vehicle growth, old fleet, dirty fuel, and poor public transport. Euro 6 emissions standards entered into force in 2017, creating additional interest and investment in the mobile source emissions control market. [267] In its Intended Nationally Determined Contribution (INDC) submitted under the Paris Climate Agreement, Turkey proposes a carbon emissions reduction target of up to 21% below business-as-usual levels by 2030. [268] However, Turkey has yet to ratify the Agreement.

Air Quality Monitoring and Emissions Control

Turkey has made great strides in improving monitoring of air quality and has instituted a national air pollution monitoring program. The By-law on Ambient Air Quality Assessment and Management (BAQAM) set air quality standards for 13 pollutants [10] and expanded the network of air monitoring stations. As of 2016, Turkey had in place 249 national stations in its clean air network, including four mobile stations and eight regional Clean Air Centers, with a future target total of 330 stations. [269] Turkey also is in the process of developing and implementing a national monitoring, reporting, and verification (MRV) system. Together with the World Bank Group's Partnership for Market Readiness (PMR), Turkey has mandated for approximately 2,000 firms in the electricity, cement and refining sectors to participate in a MRV pilot prior to launch of a full program. [270] Monitoring for the pilot industries began in 2015 and reporting of 2015 emissions began in 2017. [271]

Although monitoring and control regulation is present, implementation of control measures has been slow, according to the U.S. Commercial Service Istanbul. The main sources of ambient air pollution in Turkey, according to the Ministry of Environment and Forestry, include thermal energy generation through coal-fired power plants, home heating units, motor vehicles, and industrial sources. [272] Turkey reportedly is in the process of aligning its standards with the EU *acquis*, including its national emissions limits and ambient air quality requirements, particularly volatile organic compounds (VOCs). [273] However, in its 2018 report, the European Commission notes that no recent progress has been made in these areas. The government is requiring the installation of flue gas desulfurization (FGD) units on all new and existing thermal power plants, opening high-value projects in the air pollution control market.

Technologies and Services in Demand:

- Continuous emissions monitoring systems
- Ambient air quality monitoring equipment
- Source emissions measurement technologies
- Analytical and laboratory testing goods and services
- Air pollution control equipment
- Fuel vapor control systems

Market Opportunities – Waste Management and Recycling

Municipal Solid Waste

Turkey has two laws governing waste management: the Regulation on General Principles of Waste Management and the Regulation on Solid Waste Control. [274] Implementation of programming mandated by these regulations has been slow, however, and capacity to develop comprehensive waste management systems is lacking. [275] Further work is needed on source separation, reducing biodegradables going into landfills, and on hazardous waste. [273]

According to the World Bank's 2018 "What a Waste 2.0" report, turkey generates approximately 31 million tons of municipal solid waste annually. [252] Of this total, just over half (54%) goes to sanitary landfills, while 44% is sent to open dumps. Approximately one percent is composted. [252] In 2015, the Turkish Statistical Institute noted that 113 controlled landfill sites, four incineration facilities, four composting plants, and 864 other types of recovery facilities were in operation as of 2014. [276]

To meet universal waste management goals via the Waste Management Action Plan, 2.1 billion Euros of investment is needed before the 2023 deadline. The plan stipulates the development of regional solid waste processing and recycling facilities, and sanitary landfills. In addition, 1.9 billion Euros of the Action Plan budget is to be allocated toward landfill creation and management, with the remaining directed toward plastics and packaging recycling facilities. Both Turkey's Climate Change Action Plan and the Waste Management Action Plan stipulate increased resource utilization through recycling.

The remediation and improvement of existing unsanitary landfills is also a major effort the government will undertake within the Waste Management Action Plan. The Ministry of Environment and Urbanization estimates there are 1,400 of these sites, necessitating a 350 million Euro investment for closure and improvement. The EU Landfill Directive is expected to be fully implemented by 2025, creating potential opportunities for both technology providers and environmental services.

Technologies and Services in Demand:
- Waste collection technologies
- Sanitary landfill systems
- Environmental monitoring and analytical equipment
- Sorting machines
- Crushing and grinding machines
- Materials handling equipment
- Collection services, containers, and vehicles
- Recycling process expertise
- Waste incinerators

Market Opportunities – Water and Wastewater Treatment

Turkey's 10th Development Plan (2014 - 2018) outlines a series of challenges in protecting the country's water resources. These include institutional shortcomings, fragmented legal frameworks for water resources management, lack of a common data collection system, and inadequate monitoring systems. Furthermore, there is no national benchmark system for the provision of water and sanitation services. [277] Turkey faces imminent problems with water scarcity and, as a result, plans to implement improved monitoring systems for both surface and groundwater resources. Piped water reaches 91% of Turkey's population, while 84% are connected to sewerage. [259] Approximately 54% of the population has access to treated water. [277]

Municipal Water and Wastewater Treatment

The Ministry of Environment and Urbanization is leading the charge in implementing universal wastewater treatment by the 2023 deadline. Consequently, $50 billion dollars' worth of water infrastructure investments are planned through 2023 for both drinking and wastewater. [275] The Turkish government estimates that approximately $2 billion dollars annually must be invested in water infrastructure projects to meet EU standards. [278] The World Bank notes that Turkey's two national

wastewater standards are more stringent than those of the EU (EU Urban Wastewater Directive) and are applied with even greater stringency. [277] Roughly one-quarter of Turkey's 2,950 municipalities currently have a wastewater treatment plant.

The lack of functional treatment of wastewater has become an issue of national importance, as untreated sewage in recent years has corrupted reservoirs and other surface fresh water sources that large urban populations, such as Istanbul, rely upon. [278] Substantial problems with non-revenue water in its existing infrastructure will drive demand for leak detection systems, smart meters, and loss prevention technologies.

Technologies and Services in Demand:
- Engineering, procurement, and construction services
- Pumps and conveyance systems
- Supervisory control and data acquisition (SCADA) systems
- Metering
- Membrane filtration
- Anaerobic digestion
- Monitoring equipment
- Testing equipment
- Sludge treatment

Process Water, Industrial Wastewater Treatment, and Water Reuse

The Turkish government estimates that the private sector will need to invest $15 billion in water treatment technologies to mitigate pollution to levels required by EU mandates. Key sectors for process and industrial wastewater include power plants, mining, textiles, cement, iron and steel foundries, food processing, automotive sectors, and manufacturing industries.

The Action Plan on Climate Change outlines several strategies to improve water efficiency and promote reuse. Turkey is currently revising its industry strategy document to integrate water efficiency practices and is developing a national strategy to promote the use of treated wastewater and sludge products in agriculture. The plan also calls for the implementation of loss detection technology and the expansion of SCADA water management systems nationally by 2020. [279]

Technologies and Services in Demand:
- Engineering and construction services
- Water reuse equipment and services (process specific)
- Leak detection equipment and services
- SCADA Systems
- Smart meters
- Advanced filtration
- Membrane filtration
- Reverse osmosis
- UV disinfection
- Anaerobic digestion
- Nitrification
- Biological denitrification
- Testing equipment

Market Opportunities – Environmental Consulting and Engineering

Businesses that may cause environmental damage via their operations in Turkey are required to submit Environmental Impact Assessment reports (EIAs). Turkey's EIA requirement was first imposed in 1993, followed by various revisions over time. EIAs are evaluated by the Evaluation and Assessment Commission, which was convened by the Ministry of Environment and Forestry. Ultimately, the Ministry adjudicates the environmental feasibility of the project in conjunction with the Evaluation and Assessment Commission. The Ministry of Environment and Forestry is also responsible for implementing a monitoring program.

On Nov. 25, 2014, further provisions were added to the Environmental Impact Assessment Regulation. These provisions include lower thresholds with respect to the capacity and size of the proposed projects. EIAs also are now required for railways not exceeding 100 kilometers, airport runways not exceeding 2,100 meters, housing projects with a maximum of 500 residences and tourist facilities with a maximum capacity of 100 rooms. Shopping centers and ceramic facilities (with a production activity of 300,000 tons/year) are no longer exempt from EIA regulation.

In 2017, Turkey made several amendments to its EIA reporting requirements. The new regulation broadened the scope of EIA requirements for renewable energy projects to include all wind power plants with 20 or more turbines or installed capacity of 50 MWm and above, as well as all solar power plants with a project area of 20 hectares or more, or an installed capacity of 10 MWe or greater. Further changes to Turkey's EIA policies are expected as it seeks to harmonize with the EU EIA Directive.

Key Technologies in Demand:

- Environmental Impact Assessment (EIA)

ETWG Agency Initiatives and Programs

U.S. Environmental Solutions Toolkit

The Toolkit compiles the U.S. EPA's environmental regulations, related underlying research, and a list of U.S. companies that provide technologies necessary to implement similar environmental regulatory actions abroad. The Toolkit is used by U.S. EPA officials or environmental consultants as a reference tool within bilateral activities that focus on addressing environmental concerns. In 2019, an enhanced version of the Toolkit will be released that will include an updated database of solutions providers and the capability for foreign buyers and government officials to contact them directly via the online interface. U.S. companies interested in participating in the Toolkit can find out more at www.export.gov/envirotech.

Waste Expo IBP

Waste Expo, one of the leading U.S. waste management trade shows, has partnered with the U.S. Department of Commerce's IBP to encourage foreign participation in the show. This platform was leveraged to exchange relevant technical information with Turkish participants and to introduce Turkish buyers to U.S. waste management technology providers.

Water Environment Federation Technical Exhibition and Conference (WEFTEC) IBP
The U.S. Department of Commerce, through its IPB, leads a delegation of Turkish officials and business representatives to WEFTEC to explore relevant U.S. technologies and work with U.S. exporters on approaches to water resource management.

Market Contacts and Program References

Ministry of Environment and Urbanization
http://www.csb.gov.tr/

General Directorate of State Hydraulic Works
http://www.dsi.gov.tr/

Iller Bank
http://www.ilbank.gov.tr/

Environment Protection and Packing Wastes Utilization Foundation
http://www.cevko.org.tr/

Istanbul Water and Sewerage Authority – ISKI
http://www.iski.gov.tr/

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Vietnam Case Study

Vietnam ranks fifth overall in the 2019 Environmental Technologies Top Markets Report, with a Composite Environmental Technologies Score of 30.1. Vietnam ranks sixth in water and air pollution control, and third in waste and recycling, with scores of 10.9, 15.8, and 3.4, respectively (see Appendix 1 for global rankings).

Vietnam's GDP has been growing dramatically since the 1990s. In 2016, it was $202.6 billion with a growth rate of 6.2%. [280] It is one of the fastest-growing emerging economies in Asia and has attracted significant foreign investment. Vietnam's environmental goods and services industry is immature compared to those in developed countries and many other emerging economies. However, several opportunities exist for U.S. firms. The country faces increasing challenges across all three environmental mediums, yet Vietnam's domestic industry often is unable to meet the technological demands posed by these challenges, and the country is thus highly dependent on imported technology and foreign expertise.

State of the Environmental Regime

At the central level, the Vietnam Environment Administration under the Ministry of Natural Resources and the Environment (MONRE) is the main body in the Vietnamese government that issues regulations, standards and permits, and performs inspections. The Ministry of Public Security is in charge of conducting investigations and issuing sanctions to ensure enforcement of environmental protection laws and regulations, while the Ministry of Industry and Trade issues regulations for specific industries and also conducts inspections. [281] This system is replicated at the local government level through subsidiary offices of the three ministries.

Vietnam's Law on Environmental Protection was first enacted in 1994, and thereafter updated and strengthened in 2005 and 2014. [282] Following the enactment of the law, Vietnam issued draft regulations for environmental protection, including Decree 38 on waste management in 2015; Decree 29 in 2008 on the management of industrial parks; and Decree 80 in 2014 on water drainage and wastewater treatment. [281] Central-level attention on protecting the environment also includes setting environmental sustainability goals in its 2015-2020 long-term plan, issued in 2016. [283]

On Feb. 1, 2017, a new Decree No. 155/2016/ND-CP on Sanctioning Administrative Violations in Environment Protection went into effect. The decree puts in place fines up to VND one billion ($44,400) for individuals violating environmental protection, and up to VND 2 billion ($88,800) for organizations – the highest administrative fines ever to be put into effect. [284]

The World Economic Forum's 2013 Index for Regulatory Stringency scores Vietnam as 2.7 on regulatory quality (on a similar scale to that of EBJ-OECD), while Vietnam's score in the same survey for enforcement is 2.9.

Local governments in Vietnam have a great deal of power; so strong enforcement of environmental policies and regulations requires that provincial, district, and municipal governments all follow the national-level requirements. However, since local governments rely on economic measurements for their region's success, there is resistance to increased enforcement because environmental regulation is perceived as limiting local economic and commercial growth. [285]

Overall, Vietnam's economic outlook remains positive for foreign investors. Its economy was slated to grow by six percent in 2018 and forecast to hit seven percent in 2019. [286] [287] Heightened enforcement by the Vietnamese government will support growth in industrial wastewater treatment equipment, chemicals, and the system design and construction industries.

Furthermore, there have been efforts to privatize state-owned water supply and solid waste management enterprises with hopes that the country's environmental infrastructure will reduce its reliance on international development assistance. For over a decade, Vietnam has relied heavily on Official Development Assistance (ODA) from international donors for infrastructure and environmental projects. The country received $45 billion of ODA funds between 2005 and 2015. [288] The World Bank stopped offering low or zero interest rate lending to Vietnam in July 2017 because it reached middle-income status in 2009. [288] The Asian Development Bank (ADB) also halted concessional lending to Vietnam as of January 2019. [289] [290] Losing such preferential loan sources may require Vietnam to finance large projects differently.

Market Barriers

The Office of Energy and Environmental Industries has identified the following barriers as most problematic for environmental technologies companies attempting to export to or do business in Vietnam:

1. **Ineffective Government Agencies, Inadequate Regulations, and Weak Enforcement**
   Vietnamese Ministries' responsibilities overlap and are inconsistent, and they typically do not coordinate well. In addition, they lack the capacity to manage and enforce existing regulations. Related penalties are insufficient to create incentives to adhere to existing regulations. Existing standards, regulations, and technical guidance remain insufficient, as well. [281]
2. **Lack of Transparency and Corruption**
   Vietnam ranked 117/180 on Transparency International's 2018 Corruption Perceptions Index. [44] Corruption and administrative red tape within the government has been a significant challenge for governmental consistency and productivity and for foreign companies doing business in Vietnam, despite the fact that on paper, Vietnam's anti-corruption law is one of the strongest in Asia.
3. **Immature Environment to Support Foreign Investment**
   Investors often run into poorly developed infrastructure, high start-up costs, arcane land acquisition and transfer regulations and procedures, and a shortage of skilled personnel. Vietnam is ranked 69/190 in the World Bank's (Ease of) Doing Business report for 2019. Though its ranking has risen steadily over the past several years, lack of financial transparency and poor corporate disclosure standards still add to the challenges U.S. companies face in performing due diligence on potential partners and clients.

4. **Intellectual Property Rights Protection**
   Many firms operating in Vietnam, both foreign and domestic, have found the insufficient legal framework makes protection of intellectual property rights a significant challenge even though Vietnam has made great efforts to strengthen enforcement.

Market Opportunities – Air Pollution Control

According to the Yale 2016 Environmental Performance Index (EPI), Vietnam ranks 170th out of 180 countries in terms of air quality (with 180 being the worst possible performance). [8] In 2018, the World Health Organization linked more than 60,000 annual Vietnamese deaths to air pollution. In Hanoi in 2016, fine particulate matter was recorded at 102.3 (PM 10) and 47.9 (PM 2.5) micrograms per cubic meter, and in Ho Chi Minh City at 89.8 (PM 10) and 42 (PM 2.5), according to the WHO database. The primary sources of urban air pollution are transportation, industrial activities, construction, agriculture and handicraft production, and poor waste management practices, according to MONRE. [291] The Vietnamese government passed a National Action Plan on Air Quality Management in 2016 to manage and minimize air pollution. [292]

Power Plant Emissions Reduction
Research published by Harvard University in 2017 showed that by 2030, Vietnam will be the ASEAN country most affected by pollution from coal-fired power plants. The study also estimated that coal-related air pollution will cause 188.8 deaths out of every one million people in Vietnam by 2030, which is significantly higher than the second most-affected country in the region. [293]

Despite these predictions, Vietnam continues to rely heavily on coal-fired power generation. In December 2016, the Vietnamese government abandoned its plans to develop the country's first nuclear energy plant due to lack of demand and financial issues. [294] Hydropower capacity in Vietnam also has dwindled and additional potential for development of renewable energy is limited due to the country's high-population density and strained electricity grid. [293] The Vietnam Energy Outlook Report released in 2017 states that electricity demand is expected to increase by eight percent each year until 2035. [295] This has further solidified Vietnam's plan for more than half of the country's total electricity to be generated by coal-fired plants by 2025. [295] The government plans to add 42 GW of coal capacity between 2016 and 2030. [296] As of May 2017, Vietnam had 19 coal-fired power plants. The government has announced plans to build 14 more in the Mekong Delta by 2030, which would add a total capacity of about 18 GW to the southern power grid. Singapore's Sembcorp Development also plans to construct a 1.2 GW coal-fired power plant under a 25-year Build-Operate-Transfer (BOT) model in the Mekong Delta. [297]

Vietnam's Revised Power Development Master Plan VII (PDP 7), a national power program announced by the Vietnamese government in 2017, indicates that between 2016 and 2030 the country is planning to build new thermal power plants with a total generation capacity of approximately 55,000 megawatts (MW). The focus is on high-efficiency ultra-supercritical coal-fired plants and Gas Turbine Combined Cycle (GTCC) plants that help to curb carbon dioxide (CO_2) emissions. An increasing number of the planned projects are receiving Japanese loans or involving the participation of Japanese companies. A trend toward environmental awareness also has expanded demand for flue-gas desulfurization and other air quality control systems equipment, primarily for retrofits in existing coal-fired power plants. [298]

The Vietnamese government has stated that it will pay close attention to the environmental impacts of the planned increase in coal-fired power generation, but it has not provided specific plans to address potential problems. However, to reduce the threat to citizens' health and meet the country's commitment to an eight percent reduction in greenhouse gas emissions by 2030 compared to a business-as-usual scenario, the government will need to come up with sound solutions. Short-term solutions may include replacing outdated, inefficient and polluting generation technology from China, as well as investing in control technologies, which could present opportunities for U.S. companies.

Key Technologies in Demand:
- Particulate matter control systems (particularly bagging systems)
- Flue gas desulfurization equipment
- Activated carbon injection technologies
- Inspection, adjustment, maintenance and repair services
- Selective catalytic and non-catalytic reduction technologies
- Electrostatic precipitators (both wet and dry)

Industrial Air Pollution Reduction

The Ministry of Natural Resources and Environment (MONRE) has drafted a National Action Plan on Air Quality Management (2016 to 2020). The Action Plan includes a 20% reduction target for NOx, SOx, and particulate matter emitted by cement, chemicals, fertilizer, and petroleum production facilities. [299] Separately, a draft National Technical Regulation on Emissions for the Steel Industry is in the works, as well. The latest draft of Vietnam's Environmental Law (55/2014/QH13) also contains air quality management requirements, including point source registration, emissions inventory, and installation of continuous emission monitoring systems for the biggest stationary source emitters. Improving air pollution control also will require industrial parks to install emissions treatment systems. [300] This increasing regulatory stringency is likely to drive growth in the air quality management market and provide opportunities for U.S solution providers, especially in industrial sectors.

Key Technologies in Demand:
- Fenceline monitoring equipment
- Ambient air quality monitoring equipment
- Source emission measurement technologies
- Urea to ammonia reagent systems
- Continuous emissions monitoring equipment
- Wet/dry scrubbers (particularly systems that remove multiple pollutants)
- Carbon injection systems (for reduction in mercury and organics)
- Particulate matter control systems (particularly new bagging systems)
- NOx, mercury, CO_2, and particulate matter monitoring and continuous monitoring systems
- Selective non-catalytic reduction controls
- Oxygen enrichment, fuel injection and other efficient combustion technologies
- Innovative specialty cements
- Mixing technologies
- Pumping and fluid handling equipment
- Engineering and plant design
- Leak detection equipment
- Alternative fuel technologies used to fire cement kilns

Mobile Source Emission Reduction
Although two-thirds of Vietnam's population lives in rural areas, the two major cities – Hanoi and Ho Chi Minh City – are plagued by air pollution from vehicle emissions, largely motorcycles. More than 37 million motorcycles and two million cars are registered in Vietnam, which has a population of over 90 million. [301] The number of cars and motorcycles on the road increased by 16% per year on average from 2000 to 2012 and is unlikely to slow in the near-term. [301] The governments in both Hanoi and Ho Chi Minh City have proposed to ban motorbikes by 2030, though there is not much public support for such drastic measures. [302] [303] As of January 2017, motorbikes must adhere to Euro III emissions standards. Gasoline vehicles were required to meet Euro IV emission standards as of January 2017, and diesel vehicles as of January 2018. The transition to Euro V standards is scheduled for 2022. [304]

Key Technologies in Demand:
- Emission control technologies for motor vehicles and non-road (diesel) vehicles, and machinery

Market Opportunities – Water and Wastewater Treatment

Vietnam's water markets are the most mature compared to other markets in the environmental goods and services industry. Nevertheless, water pollution continues to plague the country. For example, as much as three million cubic meters of largely untreated wastewater is released from 787 cities each day. [305]

Further development of Vietnam's water treatment infrastructure, while necessary, will be challenging due to financial constraints. As much as 80% of current water sector funding comes from international financing institutions, but funding from both overseas and government sources will only cover 25% of the investment required to meet the country's 2020 or 2025 water project targets at current levels. [80] In response to the anticipated loss of the World Bank's preferential lending privileges in July 2017 and pressure from other international lenders, Vietnam is making substantial efforts to mobilize private sector financing for water and water treatment projects.

Municipal Wastewater Treatment
Wastewater management has moved rapidly up Vietnam's political agenda in recent years, culminating in a wide-ranging recent regulation concerning wastewater and storm water.

Vietnam's 2014 version of the Law on Environmental Protection requires that wastewater must be appropriately collected and treated prior to being discharged into the environment. Decree No. 80/2014/NDCP on the Drainage and Treatment of Wastewater (2014) sets further regulations for the drainage and treatment of wastewater in urban areas, industrial zones, and rural residential areas. However, only 1.7% of Vietnam's population currently is connected to a sewage network. [306] The Vietnamese government aims to increase centralized urban wastewater treatment from 10-45% by 2020. [307] By 2025, the government plans to have expanded centralized sewerage to 36 million people. [308]

Marquee opportunities include the Ho Chi Minh City NLTN wastewater treatment plant designed to address pollution in the Nhieu Loc-Thi Nghe Canal. Upon completion, it will become the largest wastewater treatment facility in Southeast Asia with a capacity of 830,000 cubic meters per day. [89] In the PPP arena, the Tan Hoa Lo Gom canal basin wastewater treatment plant in Ho Chi Minh City is

expected to have a capacity of 300,000 cubic meters per day. However, investment of $300 million is needed to bring the project to fruition. [309] Finally, the Yen Xa wastewater treatment system will be Hanoi's largest wastewater treatment plant and attendant sewer network. The plant will have a capacity of 270,000 cubic meters per day and will be situated on approximately 13 hectares of land in the Thanh Tri District of the city, treating the sewage from the districts of Thanh Xuan, Dong Da, Ba Dinh, Hoang Mai, Ha Dong, Tu Liem and Thanh Tri. The project is valued at $635 million. [309]

According to Global Water Intelligence, provincial authorities are planning five large-scale build-operate-transfer (BOT) or build-own-operate (BOO) projects in the Mekong Delta. The combined capacity of all the plants will reach 1.64 million cubic meters per day by 2030. The World Bank has provided $400 million in funding in support of the projects, but the estimated capital cost for all of them has ballooned to $1.7 billion. Thus, the provinces are seeking private sector financing to help fill in the gaps, as well as foreign development expertise and advanced technology to optimize system quality. [310]

Overall, the water infrastructure industry is expected to grow seven percent annually between 2017 and 2026. [311] As of November 2018, the People's Committee of Ho Chi Minh City has been promoting an open-ended tender process. Companies can submit proposals for a series of large-scale wastewater treatment plants with a total projected capacity of over 1 million cubic meters per day. [89] In addition to large-scale wastewater treatment plant projects, there is also a substantial market for small and custom wastewater treatment and reuse solutions, for septage management, and for space-saving techniques such as advanced trenchless technologies. [80]

Key Technologies in Demand:
- Waste handling equipment
- Engineering, procurement and construction services
- Advanced filtration
- Membrane filtration
- Waste-to-Energy technology
- Anaerobic digestion
- Nitrification
- Biological denitrification
- Monitoring equipment
- Testing equipment
- Air flotation

Industrial Wastewater

The country's industrial production has grown at around 14-15% per year over the last decade. Statistics show that as of June 2012 there were 334 industrial parks and export processing zones. [312] Industrial wastewater treatment has emerged as a critical need as 75% of wastewater is being discharged into lakes and rivers without treatment. Vietnam has steadily introduced environmental laws and regulations to reduce industrial water pollution. These measures have resulted in increased investment in wastewater treatment systems at industrial plants and factories.

In April 2016, more than 100 tons of dead fish off the coast of four central Vietnamese provinces were found as a result of untreated wastewater pumped into the sea. [313] The Vietnamese government has termed this incident the worst environmental disaster in the country's history, and it is expected to take a decade to fully recover from the event. [314] The incident caused significant public outcry and demand

for stronger monitoring and enforcement of environmental protection measures, as well as transparency in investigations. [315] Vietnamese Prime Minister Phuc issued an official order later in 2016 requiring the Taiwanese company responsible for the pollutants to pay victims compensation ranging between $130 to $1,600 per person. [313] The MONRE also required some 2,000 projects then under construction to redo environmental impact assessment reports in response to the incident. [316]

In general, the industries that are most in demand of wastewater treatment technologies are power generation, textiles, and industrial zone development projects. [80]

Technologies and Services in Demand:
- Engineering, procurement and construction services
- Operations services
- Waste-to-Energy technology
- Testing equipment
- Water drainage and wastewater treatment systems

Drinking Water and Process and Produced Water
Access to safe drinking water is a problem in Vietnam. Only 10% of rural households and 61% of urban households has access to the water main and piped water. [317] Periodic drought, rapid industrialization and increasing household demand all place pressure on Vietnam's freshwater resources. Total water resources in Vietnam were 919.1 cubic km as of 2014, with more than 90% of the source being surface water. [80] High population density, heavy economic activity, and the lack of pollution controls have led to the deterioration of groundwater quality and volume.

The Vietnamese government has stated that it aims for 95% of urban and 90% of rural area populations to have access to clean water by 2020. [283] It also aims to raise urban piped water supply coverage rate to 85% by 2020 and 100% 24-hour supply by 2025. [307] The estimated cost is $1.6 billion per year to reach Vietnam's 2020 goals. [307]

Large cities in Vietnam have sizeable plans to initiate water supply projects. These projects are now significant opportunities for foreign firms, as the Vietnamese government is permitting foreign investment in projects for secure water pipes. [318] Ho Chi Minh City, for example, will prioritize eight water supply projects worth over VND 32 trillion ($1.4 billion) through 2020. [318]

Government regulations are focused on ensuring efficient water use. The Law on Water Resources No. 17/2012/QH13 (2012) sets the regulatory framework for the management and exploitation of water resources and restrictions on groundwater use. Decree No. 54/2015/ND-CP provides incentives for economical and efficient water use activities and limits these incentives to economical and effective use of water, water reuse and production, and importation of water-efficient equipment and technologies. National Technical Regulation QCVN 01: 2009/BYT (2009) and QCVN 01: 2009/BYT (2009) sets the water-quality standards for drinking and purposes other than drinking and food processing. The Vietnamese government adopted Decision 1929/QD-TTg on the "Orientation for Development of Water Supply in Vietnam's Urban Centers and Industrial Parks Leading to 2025, and Vision for 2050" and Decision 2147/QD-TTg on approval of the "National Unaccounted for Water and Nonrevenue Water Reduction Program to 2025" in order to emphasize efforts to supply clean water to urban cities and towns with less than 15% water loss by 2025. [312]

Key Technologies in Demand:

- Engineering and design services
- Monitoring equipment
- Non-revenue water control software
- Low-loss distribution equipment
- Storage equipment
- Advanced filtration
- Membrane filtration
- Reverse osmosis
- UV disinfection
- Ion exchange technology
- Advanced filtration
- Secondary wastewater treatment
- Sludge treatment technologies
- Reuse technologies

Market Opportunities – Waste Management and Recycling

Solid waste generation in Vietnam is growing on pace with its urbanizing population and economy. However, most solid waste is still inadequately managed. According to the Ministry of Natural Resources and Environment (MONRE), most of the country's solid waste (73.5%) is deposited in open dump sites. Over 23 million tons of household waste and seven million tons of industrial solid waste are discharged into the environment each day in Vietnam. [305] There are presently 458 dump sites and 337 of them do not meet sanitation standards. [305]

In 2009, Vietnam adopted its "National Strategy for Integrated Solid Waste Management to 2025, with a vision toward 2050." [319] The National Strategy sets goals for management of municipal solid waste (MSW), industrial waste, and medical waste, based on specific target years (2015, 2020 and 2025). [319] Decision No. 798/QD-TTg (2011) approved a program for investment in solid waste treatment through 2020. [320] The program's ambitious goals include collecting and treating "up to environmental standards" at least 90% of urban and 70% of rural solid waste, as well as 90% of both hazardous and non-hazardous industrial solid waste and 100% of healthcare waste. [320]

Technologies currently in use include incinerators, combined incineration and composting, and most commonly, composting combined with landfills. [321] Domestic manufacturers produce trash receptacles, while trucks and sorting equipment are imported. [282]

Municipal Solid Waste

More than 60% of Vietnam's rural household waste and 16% of urban household waste is not collected. [322] According to the Ministry of Construction and MONRE, municipal solid waste volume increased from 12.8 million to 29 million tons between 2004 and 2015 and is continuing to increase by 10-16% per year. [323] State agencies in Vietnam play the key role in collecting and treating solid waste, accounting for 60% of the sector's revenue. [323] Urban Environment Company (URENCO) is the state-owned enterprise that manages solid waste collection and treatment in Hanoi. Challenges to the system include aging and insufficient collections equipment. Source separation also is uncommon, resulting in hazardous waste mixing with non-hazardous waste during transportation and disposal. Private sector

growth in this area is limited due to the issuance of only short-term (one-to-three year) collection contracts, which is insufficient time for firms to recoup investments in machinery and equipment. [323]

The Vietnamese government is tightening regulations on waste disposal. For example, on Feb. 1, 2017, it adopted a decree on administrative penalties for individuals violating environmental protection laws and regulations. In the first few days after the measure went into effect, authorities already had issued VND 60 million ($2,600) of fines against 21 people for littering in just one district of Hanoi. [324] MONRE also has taken steps to improve domestic recycling and reduce plastic released into the environment, including a campaign launched in 2018 aimed at reducing non-biodegradable plastic bags used at supermarkets and shopping malls by 65% by 2020. [325] There are also major projects underway to support solid waste management, creating opportunities for foreign firms. For example, in February 2017, Australia's TRisun Green Energy Co. secured approval to build a $520 million solid waste treatment plant outside of Ho Chi Minh City. [326] China's Everbright International also has been awarded the contract to build Vietnam's first waste-to-energy project, a 7.5 MW plant in Can Tho. [327] When built, this plant will have the capacity to handle 400 tons of household waste daily and produce around 60,000 GWh of electricity annually. [327]

Key Technologies in Demand:
- Waste handling equipment
- Waste treatment technologies
- Waste-to-Energy systems
- Gasification, pyrolysis, and incineration technologies
- Waste management systems design expertise
- Landfill design and engineering

Industrial, Hazardous and Medical Waste Management
Rapidly growing industrial production has resulted in an equally robust industrial solid waste management market that was projected to be an impressive 19% compound annual growth rate (CAGR) between 2011 and 2015. [328] Strong market growth is expected to continue in the industrial solid waste management sector in Vietnam going forward. The Vietnamese government also is in the process of developing extended producer responsibility (EPR) requirements for manufacturers and importers of electrical and electronic equipment to help address the country's e-waste in a more sustainable manner.

On hazardous and medical waste, an estimated 47 tons of hazardous waste are discharged from industrial zones, production establishments, businesses and craft villages, as well as medical units, into the environment each day. [305] The Vietnamese government aims to process 85% of hazardous waste and 95-100% of medical waste by 2020. [283] Although specific measures to this effect have yet to be published, there are likely to be opportunities for firms that possess specialized technology and expertise in this area in the near to medium term.

Key Technologies in Demand:
- Waste handling equipment
- Waste treatment technologies
- Brownfield site remediation design and equipment
- Soil contamination testing and monitoring equipment
- Hazardous waste handling equipment
- Hazardous waste treatment technologies

- Hospital and medical grade incinerators
- Industrial autoclaves

Market Opportunities – Environmental Consulting and Engineering

More than 2,000 projects in Vietnam submit environment impact assessment (EIA) reports each year. [305] Domestic engineering and consulting firms can perform EIAs for developers, but foreign developers in particular prefer to work with foreign engineering and consulting firms because domestic firms often do not have the capacity or expertise to perform EIAs to global standards. [282] Thus, foreign environmental impact assessment capabilities will continue to be in demand in Vietnam.

Key Technologies and Services in Demand:
- Environmental Impact Assessment (EIA)

ETWG Agency Initiatives and Programs

WEFTEC International Buyer Program (IBP)
WEFTEC, the largest water technology exhibition in North America, works with the U.S. Department of Commerce's IBP to encourage foreign participation in the show. This platform is leveraged to exchange relevant technical information and to advance U.S.-Vietnam water cooperation through targeted activities at WEFTEC.

Waste Expo IBP
Waste Expo, one of the leading U.S. waste management trade shows, has partnered with the U.S. Department of Commerce's IPB to encourage foreign participation in the show. This platform is leveraged to exchange relevant technical information and to advance U.S.-Vietnam waste management cooperation in ongoing bilateral and multilateral forums.

U.S. Environmental Solutions Toolkit
The Toolkit is an online searchable database that marries U.S. Environmental Protection Agency (U.S. EPA) expertise on solving environmental challenges and developing environmental rules with a catalog of U.S. technology providers.

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www.monre.gov.vn

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www.vea.gov.vn

Vietnam Water Supply and Sewerage Association
www.vwsa.org.vn

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APPENDIX 1. TOP MARKETS RANKINGS

	COMPOSITE SCORE	
1	China	100.0
2	Mexico	88.0
3	Brazil	34.4
4	Korea	32.1
5	Vietnam	30.1
6	India	29.3
7	Indonesia	29.3
8	Saudi Arabia	28.2
9	Turkey	26.8
10	Colombia	14.3
11	United Arab Emirates	13.6
12	Thailand	11.8
13	Singapore	11.7
14	Egypt	11.0
15	Malaysia	10.4
16	Chile	10.0
17	Nigeria	8.5
18	Peru	8.5
19	Algeria	8.0
20	Angola	7.0
21	Belarus	5.7
22	Oman	5.4
23	Israel	4.8
24	Macedonia	4.7
25	Bangladesh	4.2
26	Ghana	4.0
27	Ethiopia	3.4
28	Kazakhstan	3.2
29	Pakistan	2.9
30	Cameroon	2.5
31	Ecuador	2.5
32	Morocco	2.4
33	Trinidad and Tobago	2.0
34	Qatar	1.9
35	Dominican Republic	1.9
36	Kuwait	1.5
37	Sri Lanka (Ceylon)	1.5
38	Guatemala	1.4
39	Uruguay	1.2
40	Kenya	1.1
41	Ivory Coast	1.0
42	Bahrain	0.9
43	Tunisia	0.9
44	Mozambique	0.8
45	Paraguay	0.8
46	Mali	0.7
47	Uganda	0.7
48	Bulgaria	0.6
49	Costa Rica	0.6
50	Estonia	0.6

	WATER RANKING	
1	China	51.5
2	India	16.5
3	Saudi Arabia	14.8
4	Mexico	13.9
5	Brazil	12.0
6	Vietnam	10.9
7	Colombia	10.2
8	Indonesia	9.1
9	Korea	7.6
10	Thailand	7.5
11	United Arab Emirates	7.2
12	Malaysia	7.1
13	Angola	6.2
14	Chile	6.1
15	Singapore	5.9
16	Peru	5.8
17	Algeria	4.7
18	Macedonia	4.2
19	Oman	3.7
20	Nigeria	3.5
21	Turkey	3.5
22	Egypt	3.3
23	Ghana	3.3
24	Belarus	2.8
25	Bangladesh	2.5
26	Ethiopia	2.5
27	Kazakhstan	2.3
28	Cameroon	2.1
29	Pakistan	1.9
30	Morocco	1.8
31	Israel	1.7
32	Trinidad and Tobago	1.5
33	Ecuador	1.5
34	Zimbabwe (Rhodesia)	1.0
35	Sri Lanka (Ceylon)	1.0
36	Qatar	0.9
37	Kenya	0.9
38	Swaziland	0.8
39	Bolivia	0.8
40	Guatemala	0.8
41	Uruguay	0.7
42	Kuwait	0.7
43	Niger	0.7
44	Congo	0.7
45	Bulgaria	0.6
46	Tunisia	0.6
47	Uganda	0.4
48	Gabon	0.4
49	Mali	0.4
50	Dominican Republic	0.4

	AIR RANKING	
1	Mexico	72.3
2	China	43.4
3	Korea	23.3
4	Turkey	20.4
5	Brazil	19.2
6	Vietnam	15.8
7	Indonesia	13.6
8	Saudi Arabia	10.4
9	India	10.1
10	Egypt	6.5
11	Nigeria	5.0
12	Singapore	4.4
13	United Arab Emirates	4.1
14	Chile	3.7
15	Colombia	3.3
16	Israel	2.9
17	Algeria	2.6
18	Malaysia	2.6
19	Peru	2.4
20	Oman	1.6
21	Belarus	1.6
22	Dominican Republic	1.4
23	Thailand	1.3
24	Bangladesh	1.0
25	Philippines	0.9
26	Angola	0.8
27	Ecuador	0.8
28	Kazakhstan	0.8
29	Azerbaijan	0.8
30	Morocco	0.7
31	Kuwait	0.6
32	Libya	0.6
33	Pakistan	0.6
34	Guatemala	0.5
35	Ghana	0.5
36	Mozambique	0.5
37	Bahrain	0.5
38	Trinidad and Tobago	0.5
39	Macao	0.5
40	Ethiopia	0.5
41	Macedonia	0.4
42	Burma (Myanmar)	0.4
43	Uruguay	0.4
44	Panama	0.3
45	Costa Rica	0.3
46	Mali	0.3
47	Ivory Coast	0.3
48	Paraguay	0.2
49	Ukraine	0.2
50	Tunisia	0.2

	WASTE RANKING	
1	Indonesia	6.6
2	China	5.1
3	Vietnam	3.4
4	Brazil	3.2
5	Saudi Arabia	3.0
6	Thailand	2.9
7	Turkey	2.9
8	India	2.7
9	United Arab Emirates	2.3
10	Mexico	1.7
11	Singapore	1.4
12	Belarus	1.3
13	Korea	1.3
14	Egypt	1.2
15	Qatar	1.0
16	Colombia	0.8
17	Algeria	0.7
18	Bangladesh	0.7
19	Malaysia	0.7
20	Ethiopia	0.4
21	Ivory Coast	0.4
22	Pakistan	0.3
23	Philippines	0.3
24	Peru	0.3
25	Sri Lanka (Ceylon)	0.3
26	Chile	0.3
27	Israel	0.2
28	Cameroon	0.2
29	Ecuador	0.2
30	Kuwait	0.2
31	Kenya	0.2
32	Bahrain	0.2
33	Ghana	0.2
34	Dominican Republic	0.1
35	Paraguay	0.1
36	Tunisia	0.1
37	Kazakhstan	0.1
38	Oman	0.1
39	Uganda	0.1
40	Guyana	0.1
41	Bulgaria	0.1
42	Panama	0.1
43	Mongolia	0.1
44	Uruguay	0.1
45	El Salvador	0.1
46	Guatemala	0.1
47	Costa Rica	0.1
48	Croatia	0.1
49	Zambia	0.1
50	Georgia	0.0

APPENDIX 2. METHODOLOGY

The "Environmental Technologies Top Markets Report" was developed to identify a series of export markets where coordinated U.S. government policy and technical assistance interventions could yield the greatest outcome for U.S. businesses in terms of increased goods and services export sales. The resulting "Country Case Studies" were developed to engender coordinated U.S. government programs and activities that address critical policy barriers in the environmental and commercial space for markets identified through the "Top Markets Report." While the case studies provide an in-depth look at key market segments, as well as the U.S. technologies in demand, their functional role is to delineate a series of coordinated projects designed by the agencies of the Environmental Trade Working Group (ETWG) of the Trade Promotion Coordinating Committee (TPCC).

Environmental Technologies Top Markets Report

Developing the list of key foreign markets began by commencing the "Environmental Technologies Top Markets Report." The Report utilizes a three-part methodology that involves both quantitative and qualitative methods to filter for markets that satisfy three general criteria: first, large and growing; second, markets in which U.S. environmental technologies exports can be improved upon; and third, where policy interventions in the commercial or environmental regime are likely to catalyze opportunities for the U.S. industry. Due to challenges inherent to this endeavor, the Department of Commerce's International Trade Administration (ITA) attempted to design a methodology that considered an array of trade, economic, policy, and environmental factors. While historical trade figures can convey some useful information about an environmental market's future potential, many other factors play a role. This methodology sought to account for these additional factors as best possible.

Part I: Dynamic and Growing

The first part of the methodology forecasted the most significant U.S. environmental technology export markets in 2020, as well as the largest foreign country importers of environmental technologies in 2020 (representing a five-year projection based on the most recent 10-year time series). Because the Harmonized System (the most commonly used system to measure trade in goods) rarely designates product codes for specific environmental technologies, ITA selected "proxy codes" for each environmental subsector that it believed provided the best representation of trade in that subsector. For example, the code designated to water filtration and purifying machinery (8421.21) equipment that is used in most water treatment projects around the world was used as the proxy for the water/wastewater treatment sector.

Using these proxy codes, ITA conducted a linear regression analysis of U.S. air pollution control, water/wastewater management and solid waste management equipment exports over a 10-year period (2005 to 2015) and used the results to project disaggregated 2020 U.S. exports in these three sectors to all U.S. trading partners. The same exercise was then conducted for foreign country importers of environmental technologies using disaggregated global import data. The resulting projections were used to predict U.S. annual export growth rates from 2015 to 2020 and annual foreign country import growth rates from 2015 to 2020. The export and import values were then weighted by the average predicted annual growth of U.S. exports and foreign environmental technologies (ET) imports through 2020 to weight the size of the export market against its growth. This analysis provided ITA staff with a sense of the relative size and attractiveness from a growth perspective of specific markets in 2020, thus satisfying the identification of dynamic and growing markets for the Report's purposes.

Part II: Room for Improvement

The second part of ITA's methodology involved an "export gap" analysis. This was used to give staff a sense of unexploited export potential in each environmental technology sub-sector for each U.S. trading partner. Using a gravity model, a tool commonly used to predict bilateral trade flows based on the economic size and geographic distance between two countries, ITA calculated a U.S. "export gap" – the difference between gravity model-predicted exports and actual exports – for each U.S. trading partner in 2015. The resulting export gap values were then given a 10% weight in the overall model. The gravity model employs regression analysis using variables such as economic size and geographic distance. While variables related to environmental quality and infrastructure were included in the initial analysis, most of these variables were found to be statistically insignificant in the model.

Part III: Ripe for Policy Interventions

Following completion of the export market forecasting and export gap analysis, ITA staff developed a shortlist of "high potential" export markets by adding the weighted values for each medium category to provide a medium-based market score and similarly adding together the medium scores for each country to provide a composite environmental technologies score. For this report, the lists were further filtered to exclude markets with highly developed environmental regimes that also host mature environmental technology markets and possess highly developed environmental technology industries of their own by eliminating markets growing at less than four percent annually.[2]

The rationale informing this decision was that well-developed markets, while prime candidates for traditional “export promotion” activities, are already well served by private sector groups and not ideal recipients for targeted technical assistance for market development or similar emerging market policy development efforts. The consensus among U.S. environmental technology companies and associations that ITA consulted suggests that federal government services are most needed in quickly growing emerging markets, which feature nascent environmental regimes and fierce global competition for market share. Countries that are subject to formal USG sanctions were also struck from the list.

Raw scores were then scaled zero to 100, with 100 being the largest possible composite ET market score and with individual market subsector scores totaling to their composite market score. Ranked in descending order, the composite score constituted the "high potential" market ranking of the overall Report and provided a market indicator in which cumulative market and subsector scores can be compared within and across various markets.

Upon completion of "high potential" market shortlists for each of the three environmental technology subsectors, ITA began the third and final stage of analysis, which involved a qualitative assessment of the shortlist by leveraging the sector-specific expertise of ITA industry analysts. Items considered in this analysis included new policy announcements in foreign markets that could impact U.S. exports (e.g. new public sector investments in water infrastructure), perceived ease of doing business (based on experience working with U.S. exporters in a given market), knowledge of "in the pipeline" projects where demand for U.S. goods was anticipated, and political risk assessment of the market. This effort served to substantiate rankings based on real-world factors that impact environmental markets. This research informed background, strategies, and recommendations for each country case study.

[2] Brazil was the only exception to this “four percent growth” requirement. Brazil is a large, developing market in which members of the Environmental Technologies Trade Advisory Committee (ETTAC) have consistently expressed strong interest.

Environmental Technologies Country Case Studies

After the top 10 collective markets for air pollution control, water and wastewater, and waste management were identified through the "Top Markets Report," a "Country Case Study" was developed for each. "Country Case Studies" are comprised of three main components: first, an analysis of the key market segments that provide export opportunities to U.S. firms; second, an assessment of the key technologies in demand for which the United States holds a competitive advantage; and third, a list of coordinated government activities and programs that support development of environmental technologies' export markets through targeted technical assistance, policy development, demonstration programs, and traditional trade policy and export promotion activities.

The market analysis was developed by conducting a literature review of key "Country Case Study" government sources, such as published national plans and reports on environmental rule making. The literature review also included analysis of market reports from key industry journals and media sources and, where relevant, technical reports from donor and nonprofit organizations. The literature review was supplemented by consultations with relevant Foreign Commercial Service and Environment, Science, Technology, and Health (ESTH) officers at U.S. Embassies to get a sense of the "ground reality" that desk research alone cannot provide. After the literature review was complete, Environmental Technology Specialists at the U.S. EPA conducted a review of the key U.S. technologies in demand for each market segment. Based on this research, the agencies of the ETWG, led by the U.S. Department of Commerce and EPA, developed a series of coordinated activities to address the identified opportunities and challenges in the market.

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