INTERNATIONAL TRADE ADMINISTRATION

TopMarkets
A Market Assessment Tool for U.S. Exporters

2017 Top Markets Report
Environmental Technologies

A Market Assessment Tool for U.S. Exporters

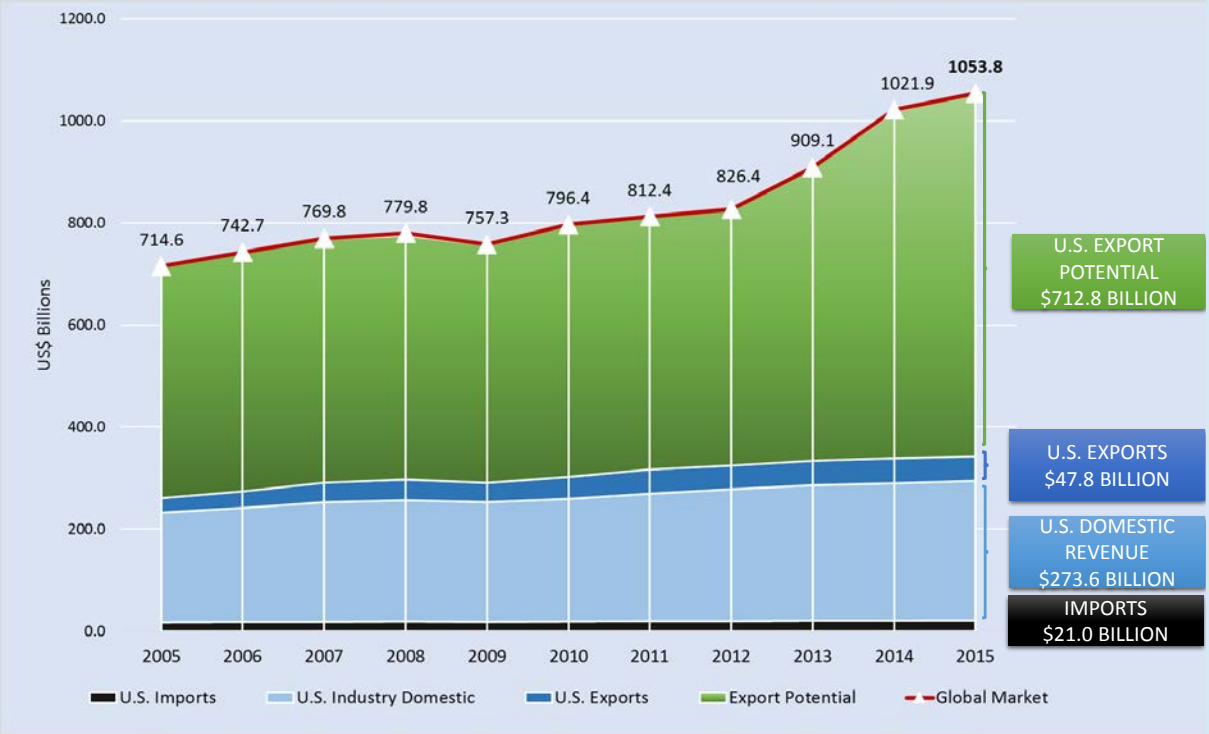
Scan for Full Report

June 2017

Table of Contents

The global market for environmental technologies goods and services reached $1.05 trillion in 2015. The United States hosts the single largest market accounting for roughly a third of the global market. The U.S. industry is a global leader in the sector, yielding nearly $330 billion of revenue in 2016. U.S. environmental companies exported $47.8 billion worth of goods and services in 2015. The U.S. industry for environmental technologies employs approximately 1.6 million people. [1]

Figure 1: Global Environmental Technologies Market Overview



Source: Environmental Business International with ITA analysis

Overview and Key Findings

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's purpose and goals are to 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 make publicly available information on existing and emerging markets and market trends for addressing issues and developing strategies related to environmental technologies goods and services, as well as a description of the export promotion programs agencies in the ETWG develop in support of the ETWG's goals.

The ETWG is co-chaired by the U.S. Department of Commerce's International Trade Administration (ITA) and the U.S. Environmental Protection Agency (EPA). The interagency collaboration under the ETWG leverages U.S. EPA's experience in addressing challenging environmental problems with 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 study 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; 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 American exporters would be most helpful.

Figure 2: Environmental Technologies Top Markets Results

	Water	Δ	2017	2016	Air	Δ	2017	2016	Waste	Δ	2017	2016	Composite Environmental Technologies Score	Δ	2017	2016
1	China	↔	44.0	44.9	China	↑	51.1	47.4	China	↔	4.9	7.7	China	↔	100.0	100.0
2	India	↔	15.7	16.3	Mexico	↑	45.7	26.2	Brazil	↑	4.5	3.6	Mexico	↔	58.2	37.1
3	Brazil	↑	15.2	10.5	Brazil	↑	19.9	15.3	Saudi Arabia	↑	4.0	3.0	Brazil	↑	39.5	29.4
4	Saudi Arabia	↑	13.1	12.0	Korea	↑	19.1	18.3	India	↑	4.0	2.7	India	↓	32.5	31.7
5	United Arab Emirates	↓	11.5	15.8	Turkey	↑	16.8	17.4	Indonesia	↓	3.8	4.2	Saudi Arabia	↑	31.0	25.9
6	Mexico	↑	11.0	9.5	Saudi Arabia	↑	13.9	10.9	Thailand	↓	3.0	3.3	Korea	↓	28.0	27.3
7	Thailand	↑	8.0	6.6	India	↑	12.7	12.8	United Arab Emirates	↓	2.7	.	Indonesia	↔	23.9	23.4
8	Indonesia	↔	8.0	9.3	Indonesia	↑	12.0	9.9	Vietnam	↔	2.4	2.1	Turkey	↓	21.2	22.1
9	Colombia	↑	7.2	3.9	Poland	↑	11.5	8.6	Pakistan	↓	2.1	3.7	Vietnam	↑	18.9	12.9
10	Korea	↔	7.0	6.9	Vietnam	↑	10.4	7.3	Egypt	↓	1.8	1.9	United Arab Emirates	↓	18.7	15.8

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.[2] The final 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 scores and rankings and the Methodology section for a detailed description of this report's methods.)

The next step is a qualitative assessment of opportunities and challenges in the top ten 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 developing a holistic response, this study serves as a strategic guide to drive interagency coordination for promoting exports of U.S. environmental goods and services.

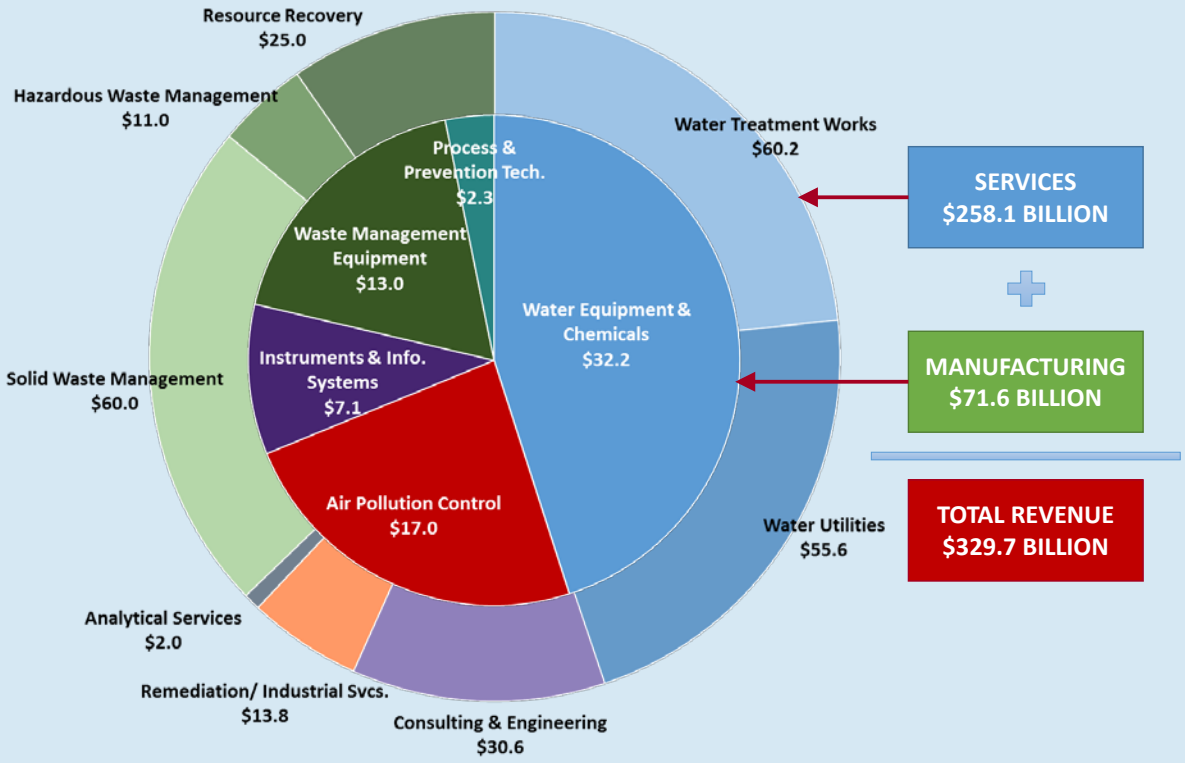
UNDERSTANDING GLOBAL ENVIRONMENTAL MARKETS

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.

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

Figure 3: U.S. Industry Revenues by Segment, 2016



Source: Environmental Business International with ITA analysis

WATER, WASTEWATER AND INDUSTRIAL WATER

The water media 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 2015 was $156.7 billion. This figure includes analytical services, wastewater treatment services, consulting and engineering, equipment and chemicals, instruments and information systems, and utilities.[3]

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 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 precipitative 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 shut-off 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 therefore 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 in order to maximize profitability.

AIR POLLUTION CONTROL

The air media 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.

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 2015 totaled $20.1 billion, including equipment, instruments and attendant services.[4]

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.

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 ten 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 $94.3 billion in 2015, driven predominantly by waste management services.[5]

The recycling industry is driven by demand from materials markets and its growth is dependent on the price of raw materials. 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 $19.6 billion in revenues during 2015.[6]

KEY MARKET TRENDS AND THEMES FOR THE GLOBAL WASTE MANAGEMENT AND RECYCLING INDUSTRY

Sustainable Materials Management/Circular Economy

Sustainable materials management (SMM) is a systemic approach to waste reduction that emphasizes the productive use and reuse of materials throughout their life cycle. 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 employing used materials as a resource, rather than discarding them as waste, in a closed loop or cyclical process. 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 reduce consumption of new materials and generate minimal waste. SMM has become popular among policymakers and the public as a means to address environmental concerns. 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. It may be more difficult to implement on a municipal scale, however, as municipal solid waste reduction is often labor intensive and can be expensive when compared with the cost of disposal, particularly for areas lacking the necessary infrastructure.

Conversion Technologies

Solid waste conversion technologies include gasification, plasma arc gasification, 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 organic portion of 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 increase 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 2015 for instruments and information systems totaled $6.7 billion, led by instruments for water and wastewater management at $2.4 billion, followed by those for air quality at $1.3 billion and remediation at $1.1 billion.[7]

ENVIRONMENTAL CONSULTING AND ENGINEERING

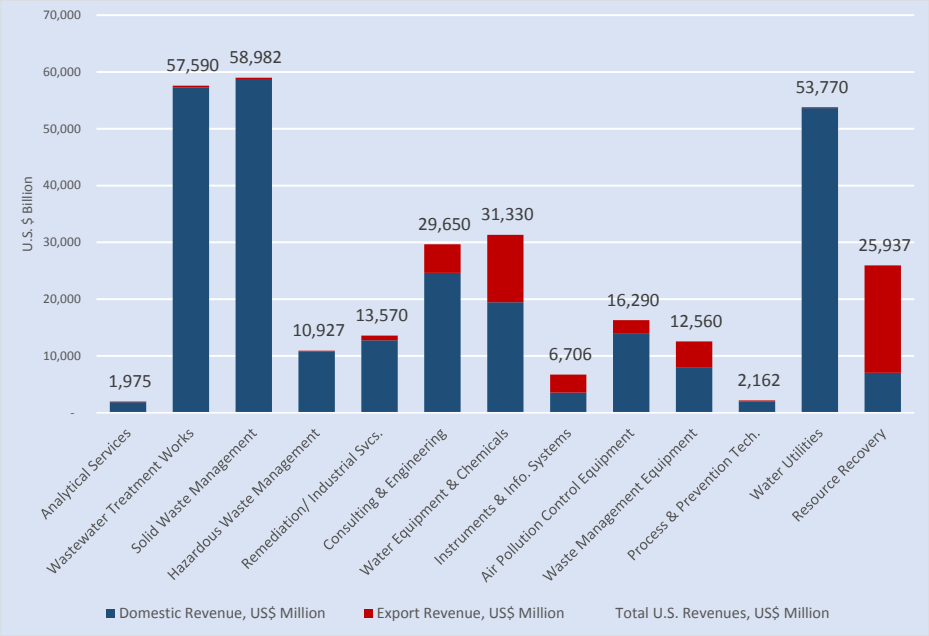
Environmental consulting and engineering also spans the three media categories. The industry is comprised of practitioners who design, develop and operate environmental infrastructure and systems that can be both free-standing or be part-and-parcel of larger projects.

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 2015 U.S. revenues of $29.7 billion for environmental consulting and engineering.

Though interrelated in terms of their collective impact on ecology, the environmental technology media 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 5: U.S. ET Segment Domestic and Export Revenue



Source: EBI Data with ITA analysis

UNDERSTANDING EXPORT PROMOTION STRATEGIES IN THE CONTEXT OF GLOBAL MARKET DRIVERS

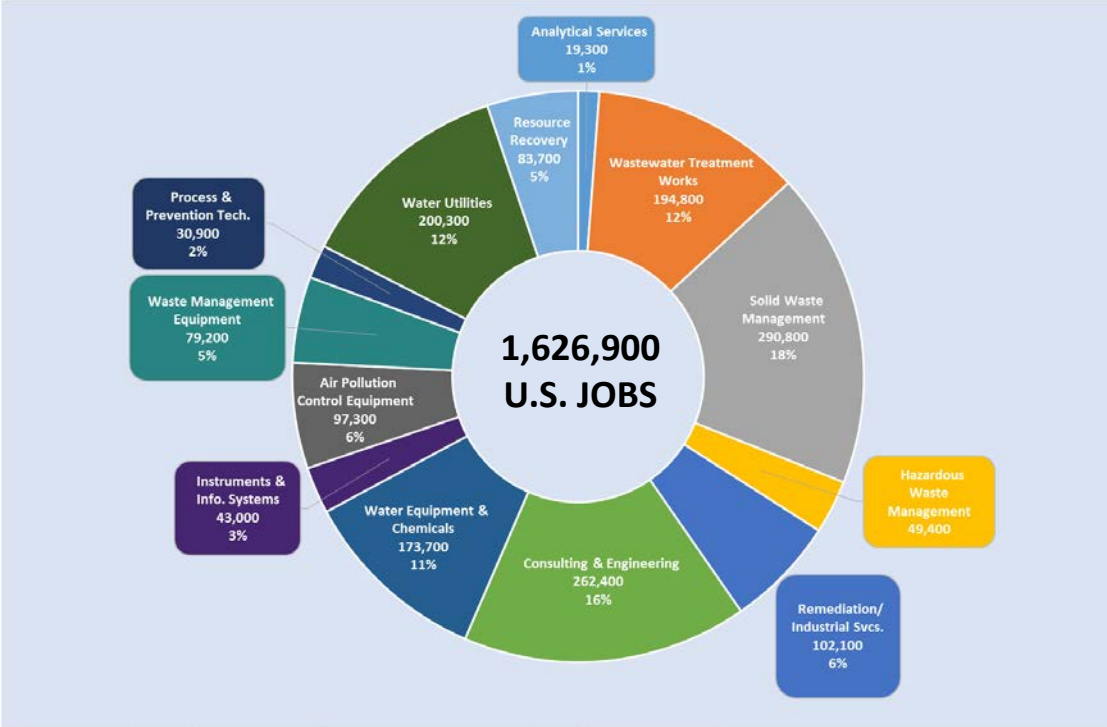
Rules Supersede Needs in the Global Market for Environmental Technologies

To establish an effective export promotion strategy for U.S. environmental technologies, there has to 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 desire to steward 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 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. Despite high legal standards for air pollution mitigation, the absence of an effective enforcement mechanism has 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.[8] The implication for export promotion is that needs-based approaches fail to accurately anticipate market opportunity. Therefore, this report not only tracks the new legislation a foreign government puts in place, but also monitors their 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 4: U.S. Environmental Industry Employment



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.[9] Comparatively, a cubic meter of water used in agriculture has a productive value of approximately $0.13[10], demonstrating that investments in water efficiency enhance profits for natural gas producers. Between 2005 and 2012, U.S. venture capital firms made an estimated $415.1 million in R&D investments for new treatment technologies aimed at promoting the reuse of produced water and better manage the cost of process water in extractive industries.[11]

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.

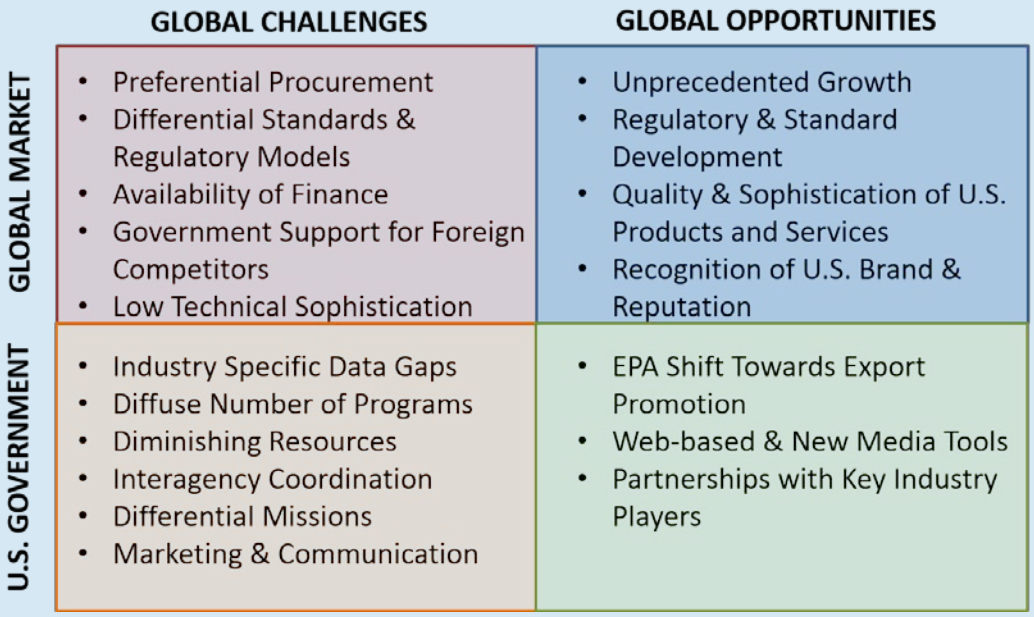
Capital efficiency and the demand for industrial hygiene also can drive demand for environmental technologies. An example is the requirement for mercury removal in natural gas-fired power plants, since even low levels of mercury in the fuel stream can destroy heat exchangers and other essential equipment.

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, and *per capita* income growth and changes in consumption patterns.

CHALLENGES FOR U.S. ENVIRONMENTAL TECHNOLOGIES AND SERVICES ABROAD

The United States hosts a comparatively advanced and sophisticated environmental technologies industry. The U.S. brand itself 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:

Figure 6: Challenges and Opportunities Matrix



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

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 a substantial corporate investment in time and resources to develop a business partnership. It also leads to statistics indicating relatively poor success in U.S. export promotion activities and correspondingly a 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 foregone 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)[12] reports tariff peaks in environmental technologies among World Trade Organization (WTO) members of twenty percent for air pollution control, waste management and recycling, and monitoring and instrumentation products. Tariffs for water and wastewater products are as high as 21 percent. 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 which 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 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 the 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 the Environmental Trade Working Group (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 objectives of policy dialogue and development are two-fold: identify and eliminate existing foreign trade barriers and prevent new barriers from being created. This occurs through regular bilateral dialogues, regional discussions, and negotiations with foreign government 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 mechanisms for enforcement as well as knowledge and expertise for the maintenance and management of environmental systems.

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).

Since 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 facilitates company and industry export sales by identifying and advocating for the removal of trade barriers and by describing market opportunities and facilitating business relationships. The International Trade Administration 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 ten 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.

China Case Study

China ranks first overall on the 2017 Top Markets Report, with a Composite Environmental Technologies Score of 100. China also ranks first across all three media categories, with scores of 51.1, 44.0 and 4.9 for the air pollution control, water, and waste and recycling markets (see Appendix 1 for global rankings).

China is the largest and fastest growing emerging market for environmental technologies. The overall environmental technologies market in China (including goods and services) is valued at $65.78 billion in 2017.[13] The scope, size and expected growth of China's market for environmental technologies are 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

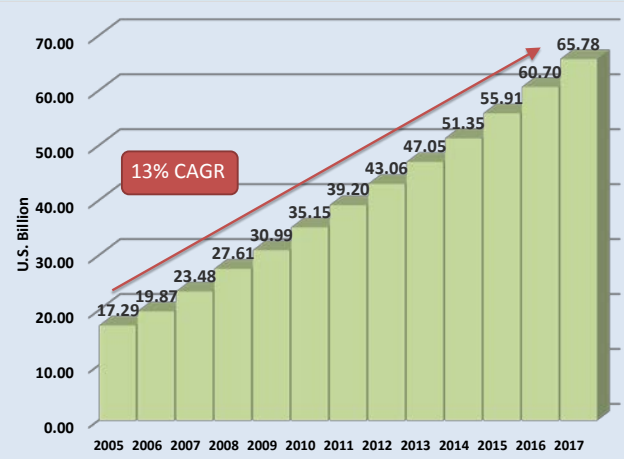
China's environmental regime has improved in recent years with the development of a national legal framework that supports the mitigation of pollution across all three environmental media. Enforcement, however, remains weak as it is delegated to municipal and regional governments whose focus centers on economic development. In 2014, China fundamentally restructured its approach to environmental regulatory enforcement with the introduction of the amended Environmental Protection Law (EPL). The revised EPL took effect on January 1, 2015, and 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.

Addressing environmental concerns will remain a priority for China over the next five years. The country's 13th Five-Year Plan, published in 2015, builds on the ambitions and success achieved in the 12th Five Year Plan with the goal of improving environmental conditions by requiring greater emission reductions of pollutants. Specifically, the plan aims 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. To implement these goals, in 2016, China also published the 13th Five Year Plan on Environmental Protection, which lays out the goals and targets with greater specificity and lists measures to achieve these goals. Also, in 2016 China also published the 13th Five Year Plan on the Development of Energy Efficient and Environmental Protection Industries. This plan identifies air pollution control, water treatment and waste management technologies that the government will support through new preferential tax policies, increasing the availability of capital through loans, encouraging Public Private Partnerships (PPPs), and attracting foreign products and investment.

The OECD Environmental Policy Stringency Index, which ranks environmental regimes on a scale from 0 to 6 (with 0 being lax and 6 being among the most stringent in the world), substantiates the business perception of improved environmental rules in China by giving China a score of 2.16 in 2015, a 1.21 point improvement from its 2005 score of just 0.85.

Though the EPL came into effect more than a year ago, many local authorities still have yet to implement or enforce its provisions. Efforts to encourage public interest environmental lawsuits from non-governmental organizations (NGOs) under the revised law have so far resulted in around 100 court cases thus far.[14] Although the longer-term effectiveness of the EPL remains to be seen, the legal text 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 towards polluters that exceed the cost of compliance. In December 2016, The Supreme People's Court (SPC) issued a judicial interpretation of the EPL that identifies "serious consequences" eighteen types of violations deemed "serious environmental pollution" under China's criminal law, subject to increased penalties. For example, as of January 2017, tampering with or falsifying results from environmental monitoring equipment, which previously would have been subject to civil penalties, is now labeled a serious crime and as such may lead to better enforcement.[15] The Chinese government news outlet, *Xinhua*, also recently reported that the promulgation of the EPL has made facility inspections more effective in pressing local governments and companies to meet their environmental protection obligations.[16]

Figure 1: China's Environmental Technologies Market



Source: Environmental Business International, 2017.

In December 2016, China promulgated its first Environmental Protection Tax Law to strengthen the enforcement of environmental regulations. This law imposes taxes on entities that emit air and water pollutants, solid waste and noise pollution, and will come to effect on January 1, 2018.[17] Taxes collected will be based on the volume of the pollutants discharged.[18] The reliance on monitoring and incentives to reduce emissions should result in opportunities for environmental technology firms.

MARKET BARRIERS

Market barriers in China are persistent and prohibitive in many cases. 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. **Complex Intellectual Property Environment.**
   Intellectual property rights (IPR) infringement remains rampant due to a 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 thirty years). Furthermore, government tenders often exhibit an 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. **Political Disincentives to Enforce Environmental Rules.**
   Enforcement of environmental rules occurs at the city and provincial levels through local Environmental Protection Bureaus (EPBs). The EPBs answer to the mayor or provincial governor, whose promotion potential as a party official is based primarily on demonstrating economic growth. This dynamic assures that environmental goals are almost always subordinated to economic development goals. However, the revised EPL, if fully enforced, may serve as a remedy to systemic weaknesses in enforcement by incentivizing environmental protection in bureaucratic performance measures and penalizing those who fail to enforce the law with demotion, dismissal and potential criminal prosecution.

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 as a result. Protests have also broken out, particularly in opposition to the 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.[19]

In international fora, China has taken important steps in its commitments to reduce greenhouse gas emissions. In September 2016, China ratified the Paris Climate Change Agreement.[20] 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 currently the world's largest producer of HFCs.[21]

In its 13th Five Year Plan, China requires cities to reach eighty percent of "good" or "excellent" air quality days by 2020 and for the first time, included Volatile Organic Compounds (VOCs) as a target for emission reduction (the 13th FYP aims to reduce VOC emissions by ten percent 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.[22]

Ambient Air Monitoring

In late 2013, the State Council issued the Airborne Pollution Prevention and Control Action Plan. This plan stipulated a 25 percent reduction in particulate matter for the Beijing-Tianjin-Hebei region, a twenty percent reduction for Shanxi and Shandong, and a ten percent reduction for Inner Mongolia. In 2015, China also amended its National Air Pollution Prevention and Control Law. The revised law took effect on January 1, 2016, and placed the onus directly on city and municipal governments to improve local air quality, which are now subject to oversight by a national-level coordinating body accountable to the State Council. In addition, major emitters are now required to install automated monitoring equipment and to publish their emissions data.[23] By 2015, there are 1436 monitoring points in 338 cities all around China. The pollution forecast and early warning systems have also been established in three key regions: Jing Jin Ji, Yangtze River Delta and Pearl River Delta. Continued implementation of the state plan and amended Air Pollution Law will thus 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 recently-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, Volatile Organic Compounds (VOCs) and greenhouse gases.[24] 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 called 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

Since it implemented the Air Pollution Action Plan in 2013, China's coal consumption has fallen for three years in a row, with coal now making up 62 percent of China's total energy consumption mix.[25] Nevertheless, the Chinese power generation sector remains heavily reliant on coal. 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. A paper published in Nature Geoscience in July 2016 stipulates that China reached peak coal consumption between 2013 and 2014, meaning China is currently in a post-coal era of growth. The 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, contribute to China reaching peak coal use.[26] Despite these developments, coal is expected to remain the dominant fuel in China's power sector in coming years.[27] Thus, reducing coal-fired based emissions is a key pillar 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—coal-fired capacity is increasing closer to the inland coal-producing centers to alleviate air pollution affecting major urban areas along the east coast. According to the International Energy Agency, China had 200 gigawatts of coal projects under construction as of April

2016.[28] Despite the efforts of the National Development and Reform Commission and the National Energy Administration 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 accelerated pace due to loopholes in the policy.[29] Indeed, China's coal power generation capacity is set to grow as much as 19 percent over the next five years, even with its aggressive expansion of non-fossil fuels as alternative sources of power.[30]

In March 2017, Premier Li vowed to cut both SOx and NOx emissions by three percent this year.[31] The government has already begun tightening 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.[32] The newly-amended Air Pollution Law requires all older coal-fired plants to be retrofitted to meet environmental standards. 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 forty 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 for Air Pollutants for Thermal Plants (GB 13223-2011) and the 2014 Emission Standard for Air Pollutants for Boilers (GB 13271-2014) will likely accelerate construction of high-efficiency PM, SO2 and NOx control technologies by the end of 2017, which will also serve to advance mercury control.[33] Similarly, the Beijing Air Pollution Control Action Plan stipulates an approach to power generation that includes fuel switching to natural gas.

The Chinese government has also 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 and emission control technologies. The global market for mercury removal is expected to grow robustly over the next decade, especially in China where the potential market for coal gasification is large.[34]

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 also 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 in place, the government would be empowered to recall vehicles in violation of regulations and can issue substantial fines to violators.[35] In Beijing, on-road vehicles currently account for a significant percentage of pollutant emissions, including 86 percent of carbon monoxide, 57 percent of nitrogen oxide and 31 percent of PM2.5, 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 vehicle emission standards (Beijing 6/VI) for light-duty vehicles that are based on California's emissions standards. The new standards were implemented on February 15, 2017, and substandard cars are already starting to be removed from the road through annual inspections and spot checks.[36] This should create an important opportunity for U.S. emission technologies on new gasoline vehicles sold in Beijing and, potentially, the surrounding Jing-Jin-Ji capital region.[37]

China's 13th Five Year Plan calls on Chinese oil refiners to produce higher quality gasoline, which will reduce the reduce vehicle emissions. To achieve this, China's governments at all levels are raising fuel standards. The new nationwide standard will be rolled out in 2017 and will permit sulfur content of ten parts per million and should reduce car pollutants by fifteen to twenty percent.[38]

Key Technologies in Demand:

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

WASTE MANAGEMENT AND RECYCLING

Solid Waste and Recycling

Over the next decade, 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.[39] Of the MSW that currently is being collected and recorded by municipalities, approximately 82 percent is landfilled, fifteen percent is incinerated and three percent is composted.[40] China outlined its goals for recycling and solid waste in its 12th Five-Year Plan (2011 – 2015), which included comprehensive resource recovery from bulk solid waste such as public associated mineral resources, coal powder, coal gangue, industrial by-product gypsum, refining and chemical waste, tailings, construction waste, as well as straw, livestock wastes and waste wood. The Government of China aimed to achieve a comprehensive waste utilization rate of 72 percent by the end of 2015. The government issued reports in 2012 and 2014 tracking progress on waste and resource utilization, which showed that China was on track to reach its 12th Five-Year Plan goals.[41] Beijing city's 13th Five-Year Plan aims to treat 30,000 tons per day of residential solid waste by 2020, with an additional goal of recovering resources from sixty percent of that waste. The city also currently has six construction and demolition (C&D) waste recycling plants under construction that collectively would process approximately eight million tons per year.[42]

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

Recycling of Discarded Electronics
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). According to the Global E-Waste Monitor report, China generated about six million tons of e-waste or about 37.5 percent of the total generated in Asia in 2014.[43] China's current electronic scrap recycling infrastructure is dominated by small-scale collection operations, informal recycling facilities and outdoor recycling markets.

Guided by the Ministry of Environmental Protection and funded by a levy on electronics sold throughout the country, the current recycling infrastructure will be replaced by a large network of sophisticated electronics recycling facilities. In 2011, the Institute for Scrap Recycling Industries (ISRI) estimated that 6 percent of U.S. export sales of scrap equipment were destined for China.

The relatively sudden explosion in 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
The Chinese Ministry of Environmental Protection estimates sixty million tons of hazardous waste were generated annually as of 2015. With current disposal capacity at approximately one-third of that amount, there is an urgent need to develop disposal capacity commensurate with the scope and size of waste production. Four billion dollars have been set aside to construct 300 hazardous waste disposal facilities and initiate brownfield remediation projects throughout China.

Key Technologies in Demand:
- Waste handling equipment
- Waste treatment technologies

- Brownfield site remediation design and equipment
- Soil contamination testing and monitoring equipment

WATER AND WASTEWATER TREATMENT

The State Council issued its highly anticipated Water Pollution Prevention and Control Action Plan in April 2015.[44] 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 percent of point sources in urban areas.[45] The Action Plan delineates 26 detailed requirements and 238 measures[46] 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. The Ministry of Environmental Protection estimates that plan implementation is valued at $920 billion over the next five to seven years.[47] Additionally, China's 13th Five-Year Plan (2016-2020) 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.[48] The State Council plans to revise the Water Pollution Prevention Law in 2017.[49]

Municipal Water and Wastewater Treatment and Plant Development

The aggressive construction of water treatment plants continues as China works to improve water quality and enhance access to drinking water and sanitation services. The Ministry of Environmental Protection (MEP) announced in 2014 that it would invest $329 billion in addressing water pollution, including treating municipal and industrial wastewater.[50] In 2016, the 13th Five-Year Plan established a new discharge standard for wastewater treatment plants (WWTPs) that should be met by the end of 2017 and will cost approximately $20.73 billion in addition to $10.3 billion in yearly operational costs.[51] In the coming years, China hopes to protect the drinking water sources and improve the water quality in centralized drinking sources. The government hopes to expand and promote the protection and management of important water resources.

In the 2016 to 2017 tender period, the total value of drinking water, wastewater and desalination projects expected to be tendered is $543.5 million across 18 projects.[52] The marquee opportunity is Guangdong province's Jieyang Waste Water Treatment Package project, which strings together nine waste water treatment plant projects in a single tender worth an estimated $33.3 million.[53] Furthermore, 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.[54] 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 fifty years with a goal to reduce non-revenue water to twelve percent by 2017 and ten percent by 2020. Another ambitious goal is to provide universal wastewater collection and treatment capacity. By 2020, the plan calls for collection and treatment levels to reach 85 percent in semi-rural and suburban areas and 95 percent in urban areas. An accelerated goal has been outlined for the Beijing-Tianjin-Hebei region, the Pearl River Delta and the Yangtze River Delta, which are set to achieve 95 percent collection and treatment levels by 2019. Furthermore, cities and provincial capitals with independent planning status must achieve universal collection and treatment by 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 the design of storm water drainage systems that contribute to groundwater recharge.

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

China discharges approximately 22 to 30 million tons of untreated sludge annually,[55] or about seventy to eighty percent of the total produced sludge,[56] 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 ninety percent of sludge from cities and prefectures, including sludge stabilization, disinfection and resource recovery. The 13th Five-Year Plan also requires an increase in wastewater tariffs across the country by the end of 2016 to cover sludge treatment costs.[57] Nonetheless, lack of domestic operational expertise and technology for

sludge treatment remains a challenge for China that could provide sludge treatment opportunities for U.S. firms.

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

Over-exploitation and heavy pollution of groundwater recently have come into greater focus in the central government's policy agenda.[58] Much of China's groundwater resources have been degraded by pollution, limiting their use as a reliable source for drinking water. The Ministry of Land Resources reports that 57 percent of ground water ranks "bad" or "very bad" in quality estimates.[59] The National Groundwater Contamination Prevention and Remediation Plan calls for an RMB 34.7 billion ($6.2 billion) investment through 2020. Groundwater protection efforts are focused on monitoring, source control and remediation.

The 12th Five-Year Plan delineated the study of pollution assessment, monitoring and simulation 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 over exploitation is particularly bad. Authorities will outline a list of areas where groundwater exploitation or partially or totally prohibited by the end of 2017.[60] China stands to considerably influence the mining flow control and treatment market, which is expected to top thirteen billion dollars in 2017.[61] 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 twenty percent 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.

These priorities will be a boon to membrane, non-revenue water management and industrial water efficiency technologies. It is estimated that water reuse will lead to thirty percent annual growth over the next five years in the membrane technology market.[62] 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.[63] Both projects began construction in 2015, and parts of the Changping project have also started operations.[64] Tianjin and Ningxia have major plans to meet the new 13th Five-Year Plan reuse targets. Beijing in particular plans to build 27 new water reuse plants and 472 km of supporting pipelines by 2019.[65]

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, coking, 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 by the end of 2017, 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

The central government promulgated its Soil Pollution Prevention Action Plan in May 2016 and is also working on a new Soil Pollution Prevention Law that is slated to be released in 2017.[66] Weak or non-existent waste management strategies, including the failure to develop sanitary landfills, has led to prevalent soil pollution in China. The MEP and the Ministry of Land Resources report that 16.1 percent of China's soil is polluted[67] and that of this total, 19.4 percent of arable land is polluted. 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 thirty 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 the safe use of ninety percent of currently contaminated farmland by 2020. The Action Plan requires all provinces to develop treatment and remediation plans and to submit a project database to the MEP by the end of 2017.[68] The central government promulgated its Soil Pollution Prevention Action Plan in May 2016 and is also working on a new Soil Pollution Prevention Law that is slated to be released in 2017.[69] $1.3 billion were allocated for soil remediation in 2016. 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.[70] In the coming years, this substantial remediation effort should yield opportunities for U.S. providers of remediation technology and services.

Key Technologies in Demand:
- Engineering and design
- Monitoring equipment

ENVIRONMENTAL CONSULTING AND ENGINEERING

The 2015 Environmental Protection Law stipulates that all new construction projects must undergo an Environmental Impact Assessment (EIA) before construction permits can be issued.[71] Similar to the U.S. National Environmental Policy Act (NEPA), if fully implemented, EPL will develop a massive 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

U.S. – China Environmental Industries Forum (EIF)

The EIF engages U.S. and Chinese officials and businesses in a series of technical and policy-oriented discussions designed to enhance the U.S.-China commercial and environmental partnership. The goal of the EIF is to facilitate the development of a robust environmental protection regime and corresponding environmental technology markets. Themes and topics of focus for 2017 and future EIF events may include air, water, chemicals, soil and waste.

U.S. Environmental Solutions Toolkit

The Toolkit compiles the U.S. Environmental Protection Agency's environmental regulations, related underlying research and a directory of U.S. companies that provide technologies necessary to implement similar environmental regulatory actions abroad. A Mandarin language version of the Toolkit was recently introduced.

The Toolkit is used by U.S. EPA officials and environmental consultants as a reference tool within bilateral activities that focus on addressing environmental concerns and in fostering U.S.-Chinese partnerships. This includes the U.S.-China Joint Committee on Environmental Cooperation and others.

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 to encourage foreign participation in the show. This platform is leveraged to discuss policies and exchange technical information regarding power plant emissions control with Chinese participants and to foster business relationships between Chinese end-users and U.S. emissions control providers.

WasteExpo International Buyer Program

WasteExpo, 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 its International Buyer Program, 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.

CIEPEC U.S. Pavilion
The China International Environmental Protection Exhibition and Conference (CIEPEC) is the Ministry of Environmental Protection's biennial sponsored trade show and conference. CIEPEC draws officials from all regional Environmental Protection Bureaus (EPBs) and municipalities, providing access to the tendering organizations that are developing water and wastewater treatment plant projects. 2017 CIEPEC will be held from June 13 to 16 in Beijing. A U.S. pavilion during CIEPEC provides U.S. companies with an opportunity to promote their participation in specific projects.

MARKET CONTACTS AND PROGRAM REFERENCES

Ministry of Environmental Protection
http://www.mep.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

Jiangyao Zhang (Beijing)
jiangyao.zhang@trade.gov

Sophia Chen (Shanghai)
shiqiao.chen@trade.gov

Cathy Wang (Guangzhou)
cathy.wang@trade.gov

Mengyue Xu (Chengdu)
mengyue.xu@trade.gov

Xiaolei Zhou (Shenyang)
evelyn.zhou@trade.gov

Jing Wang (Wuhan)
jing.wang@trade.gov

Mexico Case Study

The overall Mexican environmental technologies market, including goods and services, is valued at $15.57 billion in 2017. Mexico ranks second overall in the 2017 Top Markets Report, with a composite environmental technologies score of 58.2. Mexico's air pollution monitoring and control market is the most prominent environmental technology segment and ranks Mexico second globally, with a score of 45.7. Mexico's water sector ranks sixth overall, with a score of 11.0. For waste and recycling, Mexico ranks thirteenth, with a score of 1.5 (see Appendix 1 for global rankings).

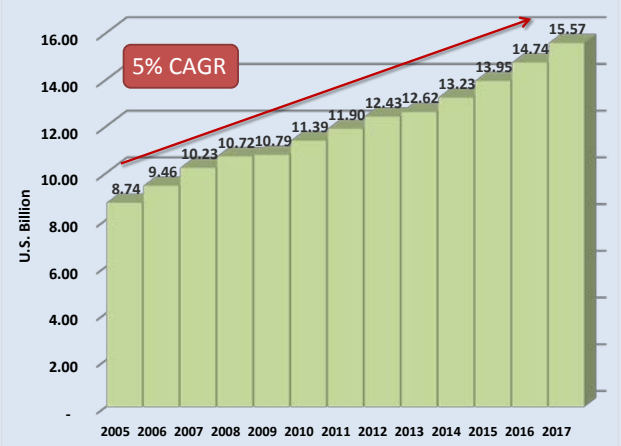
Overall Rank	Air Pollution Control
2	2
Water	**Waste & Recycling**
6	13

Unprecedented investment in environmental infrastructure has catapulted Mexico to the number two rank in the Environmental Technologies Top Market Report. U.S. environmental technologies exporters benefit from close commercial ties with Mexico, but lagging Mexican technical capacity in the environmental sector could moderate the implementation of sophisticated projects and attendant opportunities for U.S. business.

STATE OF THE ENVIRONMENTAL REGIME

Mexico's environmental legal standards are improving thanks to recent legislative efforts, but compliance remains a challenge. This change is reflected in the Environmental Business Journal (EBJ)-OECD's Environmental Stringency Survey, which ranks environmental regimes on a scale from 1 to 7 (with 1 being lax and 7 being among the most stringent). Mexico scored a 4.0 in 2012 on the EBJ-OECD Survey, a 0.7 point improvement from its 2005 score.

Figure 1: Mexico's Environmental Market



Source: Environmental Business International with OEEI Analysis 2017.

Mexico's environmental regime is based upon two fundamental 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 accelerates implementation of programs for air pollution monitoring and control in particular.

The Mexican Ministry of Environment and Natural Resources (SEMARNAT) governs and implements environmental regulation and is also responsible for issuing environmental tenders for air pollution monitoring, soil remediation, waste management and projects that fall under the recently promulgated 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 in many cases, CONAGUA has been the *de facto* developer and financier of water infrastructure projects throughout the country.

MARKET BARRIERS

Over the past twenty years, the North American Free Trade Agreement (NAFTA) has removed many barriers to trade with Mexico. However, Environmental Technologies Trade Advisory Committee (ETTAC) members and analysts for the Office of Energy and Environmental Industries (OEEI) have identified the following persistent barriers 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 sixteen percent 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.**
   U.S. exporters can often underestimate the difficulties arising from Mexico's size and diversity as a result of the benefits of acceptance of U.S. products, as well as low tariffs obtained through NAFTA. 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, however, and 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

In 2015, the Mexican government allocated $100 million to SEMARNAT to support federal, state and municipal environmental projects throughout the country. U.S. firms can access the most current lists of funded projects on SEMARNAT's website.[72]

AIR POLLUTION CONTROL

In recent years, Mexico has paid particular attention to tackling air pollution and climate variability. In 2012, Mexico became the first developing country to pass comprehensive climate legislation, and 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 December 2015 Paris Climate Agreement.[73] On September 21, 2016, Mexico ratified the Paris Agreement and the INDC. The adopted Nationally Determined Contribution (NDC) is significant as it commits to reduce greenhouse gas emissions by 22 percent, black carbon by 51 percent from business-as-usual levels by 2030, and identifies Mexico's peak GHG emissions year as 2026.[74]

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 air quality strategy, SEMARNAT announced more than 100 measures the agency is considering to address air quality in the "Megacity" (the region comprised of Mexico City and the states of Hidalgo, Mexico, Morelos, Puebla and Tlaxcala) in the short- and medium- terms.[75] They include:

- The Ministry of Health, the Communications and Transport Ministry (SCT), and the Agricultural, Territorial and Urban Development Ministry (SEDATU) will participate in federal actions to improve air quality;
- Two hundred health units will conduct epidemiological surveillance of diseases associated with air pollution throughout Mexico City;
- Eleven billion pesos (approximately $589 million) will be allocated to Mexican development banks (NAFIN, BANOBRAS and FONADIN) to support infrastructure projects and modernization of public transportation;
- One hundred fifty million pesos (approximately eight million dollars) will be allocated through FONADIN (the National Infrastructure Fund) to support the expansion air quality monitoring networks; and
- Emerging standards for the control of volatile organic compounds (VOCs) and particulate matter (PM) applicable to sources of federal jurisdiction will be published.

SEMARNAT, in coordination with other federal agencies, is responsible for implementing programs to reduce emissions from industries under federal jurisdiction, as well as for programs to verify 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 (NO2) in Mexico City is above the national standard nine days out of 10. 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.

Official ambient air quality monitoring is conducted by SEMARNAT, which tenders openly to U.S. businesses. Increased opportunities under the Climate Change Strategy's Program for the Strengthening of the Environment of States (Programa de Fortalecimiento Ambiental de las Entidades Federativas), which provides funding for projects at the municipal, state and federal levels for compliance with environmental rules,[76] should emerge 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 various regulatory plans call for vehicle emissions testing, catalyzer replacement programs and reduction of industrial pollutants. Moderate regulatory enforcement, however, has translated into moderate demand for these technologies compared to the overall potential in Mexico's industrial market. The government has emphasized 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 Climate Change Law aims to decrease the country's output of carbon dioxide by 51 million tons, 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 Climate Change Law will require industries to institute improved monitoring and control technologies, opening up 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 have shown that though Mexico has implemented driving restrictions for the past decade, the resulting emissions reductions were effectively zero because citizens found ways to circumvent the restrictions.[77] The Mexican Government now is paying special attention to air pollution challenges caused by the vehicle emissions in Mexico City and the surrounding metropolitan area. During the first half of 2016, the government of Mexico City announced additional restrictions to 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 permitted level. All vehicles are required to pass this inspection every six months to be allowed to continue driving in Mexico City. Additionally, during Phase One of the program (April to June 2016), all vehicles - regardless of technology and year - were restricted from driving at least one day a week, as well as one Saturday of each month.

On July 1 2016, SEMARNAT announced a new emergency Mexican standard for vehicle inspections, NOM-EM-167-SEMARNAT-2016. This standard was initially valid for a period of six months and applied not only to Mexico City but also to the extended metropolitan area known as the "*Megalópolis*". The new inspection criteria included stricter levels of pollutant emissions for motor vehicles, as well as test methods for certification of these levels, specifications of the equipment used for the certification and specifications for the equipment used to measure emissions remotely.[78] In addition, SEMARNAT plans to allocate 100 million pesos (approximately five million dollars) to local governments to support local public transit vehicles such as taxis and buses to help reduce emissions, and one thousand hybrid taxis are to be financed through preferential credits granted by Mexico's National Development Bank.[79]

Key Technologies in Demand:

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

WATER AND WASTEWATER TREATMENT

Currently, though 89.6 percent of the population has connections to drinking water and 86 percent has connections to sewage services, large gaps remain in serving rural areas where both resources and infrastructure are scarce. Lack of access to potable water and sewerage is a fundamental challenge that Mexico is seeking to address through its 2014-2018 National Water Plan. The government estimates that nine million Mexicans do not have access to potable water and that eleven million do not have access to sewerage. The overall Mexican municipal water and wastewater market is expected to grow seven percent annually between 2013 and 2018.

Subsequent projects are to be financed through public-private partnerships (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.[80] During the 2015 to 2018 period, CONAGUA's budget for water infrastructure development is $4 billion, which will 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.[81] 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 line on enforcement of environmental regulations, creating a demand for industrial water treatment and the need for more sophisticated water treatment solutions in water polluting industries, which are particularly concentrated in northern parts of Mexico along the U.S. border.[82] The stepped-up enforcement includes the development of better testing methods and a requirement that industries submit a monthly report from certified labs on the discharges into national water bodies.[83]

Municipal Drinking Water Treatment

Drinking water conveyance and distribution are expanding at a steady rate in Mexico. Total mains water consumption is expected to rise from 169,356 million cubic meters in 2014 to almost 194,546 million cubic meters by 2018. This is largely due to the continued expansion of the pipeline network and increasing number of households connected to water mains.[84] Water infrastructure projects grew at a 4.3 percent rate through 2015 following the 2013 Mexican housing market crash, which negatively impacted the construction industry.[85]

Water treatment facilities are also upgrading to improve coverage. CONAGUA and SEDESOL plan to invest $200 million in upgrades to the country's existing 874 drinking water plants.[86] The push for centrally distributed water services is likely to continue, which will discourage the implementation of decentralized systems.

Consumer confidence in the ability of municipalities to deliver safe potable water is low; this has driven double-digit growth in residential treatment options as a backstop to the water quality issues encountered in urban and suburban areas of Mexico.

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

Wastewater treatment continues to lead in Mexico's environmental priorities, as it is the least developed part of Mexico's water sector. Just 53 percent of wastewater receives treatment,[87] though Mexico has almost doubled the volume of wastewater being treated in the last decade, indicating that expansion of services is not keeping pace with demand. Mexico's 2013 National Water Plan sets treatment goals of 100percent 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, $1.1 billion in sewers and $621 million in treatment plants. Development of new wastewater plants in the states of Puebla, Colima, Yucatan, Quintana Roo, State of Mexico, Nayarit, Guerrero, Colima and Mexico City,[88] as well as $150 million in upgrades to existing wastewater plants in the states of Aguascalientes, Chihuahua, Guanajuato, Jalisco, Nuevo Leon, Oaxaca, Puebla and Mexico City,[89] is also planned.

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 increasingly faced with water scarcity, and the heavy reliance of the agricultural sector on these resources is straining an already troubled system.[90] Unsustainable extraction from ground and surface sources has threatened the stability of the conventional water supply. This has caused Mexico to turn to alternative methods in an effort to protect surface water and aquifer sources while providing fresh water for human consumption and industry use. Areas facing significant scarcity challenges include large urban centers in northern and central Mexico and the western Baja California Peninsula. Promoting efficient water use by industry and citizens and building complementary efficient local water utilities is a key government priority.

In the National Water Plan (PNH 2014-2018), desalination is one of five main water supply strategies that CONAGUA is promoting.[91] Water scarcity in the northwestern region, as well as a growing population and the 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.[92]

Two of these projects are in the tendering process: the 21,600 cubic meters per day San Quintin Plant and the 378,500 cubic meters per day El Rosarito Plant (estimated at $600 million).[93] The 21,600 cubic

meters per day Empalme and Guyamas Plant ($24 million) and the 34,560 m3/d extension of the Cabo San Lucas Plant were scheduled to be tendered in 2016.[94] The 17,280 cubic meters per day La Paz Plant ($32 million) is considered a priority desalination project and is in the planning phase.[95] There are also several municipal desalination plants in the conceptual stage but are not likely to be tendered within the next couple of years.[96]

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 type of infrastructure expansion can be found within the 2015 to 2016 project pipeline period via the $78 million La Laja Dam project, which will create an additional fresh water source for 120,000 residents of the Ixtapa-Zihuatanejo metropolitan area.[97]

Similarly, in several areas of northeast Mexico, the use of sophisticated water purification technologies is needed since the available water requires the elimination of materials such as heavy metals or even arsenic.

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
Scarce water supply in Mexico has necessitated comprehensive monitoring of groundwater availability and quality. As of 2014, Of Mexico's 653 subterranean aquifers, more than 106 were overexploited.[98] Overexploited aquifers produce roughly sixty percent of the groundwater that Mexico relies on for agriculture and drinking water. The National Water Plan has emphasized the promotion of geo-hydrological exploration, increasing 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 invest in creating a national aquifer database in the coming years that will provide real-time data on withdrawal and recharge rates, as well as groundwater quality.[99]

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

WASTE MANAGEMENT AND RECYCLING

Municipal Solid Waste and Recycling

Municipal solid waste in Mexico is administered by local and state governments, which apportion part of their budgets for waste collection and disposal. In recent years, there has been a push to modernize Mexico's waste management infrastructure to more effectively address the roughly 102,850 metric tons processed a day.[100] The open dumpsites prevalent in Mexico pose a threat to human health and the environment and have increased public support for the improvement of waste management infrastructure. At the beginning of 2017, a bill was proposed in the Senate to modify the General Waste Law to strengthen provisions governing the integrated management and disposal 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.[101]

The LGPGIR, passed in 2003, and the LGCC, passed in 2012, are the key laws that regulate waste management in Mexico. The LGPGIR delegates responsibility for managing waste and building the necessary infrastructure to municipalities and states.[102] In the LGCC, one key requirement is that by 2018, all municipalities with populations above 50,000 must develop methane emissions control infrastructure for urban solid waste facilities.[103]

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 in support of 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

ENVIRONMENTAL CONSULTING AND ENGINEERING

As of 2015, while permits were required for environmental impact and the use of natural resources, both of which involve an environmental impact assessment (EIA), environmental audits were not mandatory. The EIA, however, is a required 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 enforce violations of law through fines, closures, forfeitures, suspension or revocation of permits and implementation of corrective measures.[104]

Fernando A. Gonzalez, the CEO of the Mexican building materials company, CEMEX S.A.B. de C.V., explained that "Construction is likely to be one of the most dynamic sectors globally in the next fifteen years and is utterly crucial to the evolution of prosperous societies around the world." The construction sector in Mexico specifically is projected to grow at a quick pace, potentially overtaking Brazil in the Latin American construction market by 2030.

Key Technologies 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 (IBP) 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 at the event.

WasteExpo International Buyer Program
WasteExpo, 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 on the Mexican market and U.S. environmental technology capabilities. Business relationships with U.S. waste management providers are facilitated at the event.

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 2015, the International Trade Administration 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 Mexican capacity to address environmental concerns.

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. Environmental Protection Agency (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 and 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)
http://www.semarnat.gob.mx

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

National Water Commission (CNA)
http://www.cna.gob.mx

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

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

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

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

Border Environment Cooperation Commission (BECC)
http://www.becc.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

Commercial Service Market Contacts
Mr. Francisco Ceron
Francisco.ceron@trade.gov

Ms. Claudia Salgado
Claudia.Salgado@trade.gov

Brazil Case Study

Overall Rank	Air Pollution Control
3	3
Water	**Waste & Recycling**
3	2

Brazil ranks third overall on the 2017 Top Markets Report. With a score of 4.5, Brazil ranks second for waste and recycling. It ranks third for air pollution control markets, with a score of 19.9, and third for water, with a score of 15.2 (see Appendix 1 for global rankings).

Brazil's overall environmental technologies market (including goods and services) is valued at $31.51 billion in 2017.[105] In the last five years, Brazil has been experiencing one of the worst economic recessions in its history. Its GDP has been dropping steadily since 2010, with GDP in 2015 totaling 1.715 trillion, which is a three percent contraction from 2014.

Brazil's ample market size and growing scope of opportunity for U.S. environmental technology producers are juxtaposed with varying levels of technical capacity, enforcement and finance for environmental projects. Persistent tariff and non-tariff barriers also impede U.S. firms' ability to access the Brazilian environmental market.

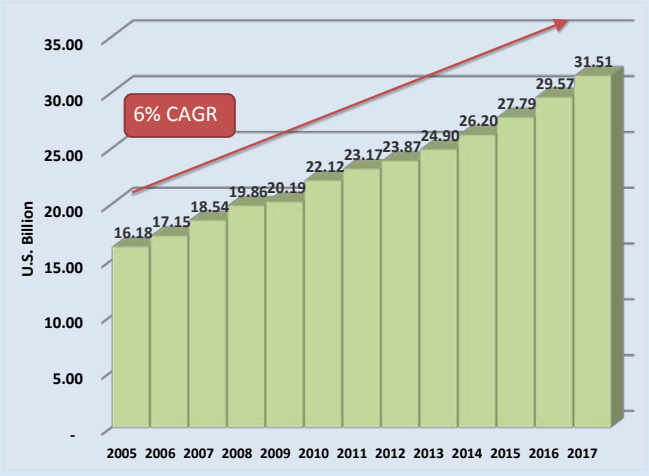
The scale of Brazil's market is due predominantly to its population of 205.8 million[106] and its growing middle class rather than to strong adherence to environmental laws. As this report will delineate, there is high variability within Brazil in terms of the capacity to implement and finance advanced environmental systems.

STATE OF THE ENVIRONMENTAL REGIME

The Brazilian government has high ambitions regarding 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 market potential.

The OECD Environmental Policy Stringency Index, which ranks environmental regimes on a scale

Figure 1: Brazil's Environmental Technologies Market



Source: Environmental Business International with OEEI Analysis, 2017.

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. This score is a 0.12 point improvement over its ranking of 0.42 in 2005. [107]

Brazil's enforcement and implementation woes emanate from the fragmentation of environmental authority among federal, state and municipal entities. As a result, the capacity to adopt advanced environmental solutions varies greatly between states, with generally higher capacity in the southeast of the country in areas such as Rio de Janeiro, São Paulo and Minas Gerais and lower capacity in more rural states.

One issue that affects environmental compliance in 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 of the lack of regulation, the incidence of oil spills, gas leakages and inadequate storage of hazardous wastes are frequent and reported widely in the Brazilian media. [108] Imposing regular monitoring of industrial sites would improve compliance.

Funding gaps for environmental infrastructure are also prevalent in Brazil. While the government has prioritized the provision of sanitation services, including water, wastewater, drainage and waste management services, many of the planned projects have faltered 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, which is a $2.5 billion shortfall from the seven billion dollars the Government of Brazil estimates is necessary annually to meet the government's goal of universal access to sanitation services by 2030. [109]

Investments in the solid waste management sector in Brazil were put on hold in the past two years in

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

part due to the "Car Wash" investigation, where major Brazilian companies were found guilty of corruption and money laundering. The investigation has caused companies to conduct layoffs and significantly reduce or liquidate their investment in construction projects, including in wastewater treatment plants and solid waste management projects.

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) identified the following barriers as most problematic for U.S. environmental technologies companies attempting to export to or do business in Brazil:

1. **Tariff Escalation Tied to Local Content Requirements or Disqualification of Imported Components.**
   The ETTAC observed cases of minimum local content requirements ranging from forty percent to sixty percent of a product's total value; this is applied mostly by government-owned monopolies for fossil fuel production and public procurement projects, such as municipal water treatment. In the absence of sufficient domestic content, much higher tariffs are applied, such as a 22 percent tariff for water pumps. There is evidence that goods that fail to meet local content requirements may be disqualified from competition altogether.
2. **Tendering Practices Favor Local Competition.**
   Small Brazilian businesses benefit from preferential treatment in public tenders. Typically, small local businesses are afforded additional points on commercial evaluation, and small business set-asides are commonly available for public bids below the forty thousand dollar threshold per decree 42.063/2009, Act 123/2006. 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.
3. **Local Certifications and Safety Approvals Fail to Recognize International Standards.**
   Local electrical and safety approvals apply to most products that have electrical components and mechanical parts. Brazil does not accept certification from equivalent U.S. certification and testing organizations, imposing additional and onerous costs on U.S. businesses for redundant testing and certification. Despite certification from relevant and globally accepted international certification bodies, products that have transmitting and/or receiving devices must obtain approvals 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.

MARKET OPPORTUNITIES

AIR POLLUTION CONTROL

Air Quality Monitoring

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.[110] Addressing air pollution has become a priority for Brazilian national and local governments and has generated demand for gas emission monitoring technologies, gas analyzers and air pollution control technologies.

Companhia Ambiental Do Estado De São Paulo (CETESB), São Paulo's environmental agency, is currently expanding its air monitoring program through the acquisition of ten new monitoring stations destined for the interior of the state. Imported instruments in demand 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. 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.

In 2013, the state of São Paulo established "New Standards for Air Quality," which are similar to the EPA National Ambient Air Quality Standards (NAAQS), and they are only applicable in the State of São Paulo. 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 state regions that do not comply with new standards as well as the priority sectors. The PREFE also has a sector program for vapor emissions control generated by gas stations as well as a program for the industries in the Santa Gertrudes Ceramic Pole.

São Paulo also recently launched an online self-reporting protocol for companies operating in that state to report their greenhouse gas (GHG) emissions and climate variability mitigation strategies, including benchmarks, targets and timetables. Executives from DOW, Toyota, Unilever and GE expressed their support for the protocol and their general willingness to participate in the reporting mechanism.

Rio de Janeiro's environmental authority, *Instituto Estadual Do Ambiente* (INEA), 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 pre-cursors, including ozone, nitrogen oxide (NOx), sulfur dioxide (SOx), carbon monoxide, Volatile Organic Compounds (VOCs), hydrofluorocarbons and particulate matter. 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.

Key legislation related to vehicle emissions and air quality includes: CONAMA Resolution 18/86, which established the Vehicle Air Pollution Control Program (PROCONVE) and that is complemented by other CONAMA resolutions; and Federal Law #8723 of October 2003, which defined the emissions limits for light and heavy duty vehicles. As of 2012, Brazil's diesel engines must follow the Euro V emission parameters, corresponding to the Automotive Air Pollution Control Program (PROCONVE P-7). Additionally, Resolution ANVS/DC #176 of October 24, 2000, provided reference standards on indoor air quality; CONAMA Resolution #4 of June 15, 1989, established the "National Air Quality Control Program" (PRONAR); and CONAMA Resolution #3 of June 28, 1990, defined air quality standards for air pollutant concentrations.

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

WATER AND WASTEWATER TREATMENT

The National Council of Water Resources recently published a resolution that approves updated priorities, actions and goals of the National Water Resources Plan 2016-2020. The Plan's top priority includes curbing the country's water shortages and better-integrating government efforts to meet future challenges.[111]

Brazil's current budget deficit prevents the Brazilian Government from investing in the country's infrastructure. In an attempt to stimulate economic activity and attract the much-needed investment in this sector, in September 2016, President Temer announced a package of infrastructure concessions and privatization programs and 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.

Market experts expect a large reorganization of Brazil's water and wastewater market within the next two years, with increased participation of privately owned firms. This year, the National Bank for Economic and Social Development (BNDES) will launch a request for proposals for contracting consulting services that will determine how the private sector will enter this market. Six state-owned water and wastewater utilities initially will be put forth for either privatization, long-term concession or PPPs, after which, five additional companies will be reviewed. This marks exciting opportunities for U.S. firms looking for PPP and merger and acquisition projects.

The "Car Wash" corruption investigation that led to the conviction of some leading Brazilian businessmen in the infrastructure sector also led to some sales of water and wastewater companies, such as Odebrecht Ambiental, which was recently acquired by the Canadian asset management company, Brookfield. CAB Ambiental, a company partially owned by BNDESPAR, the Brazilian

Government investment fund and Galvão Engenharia, is also expected to be put up for sale due to Galvão's involvement in the "Car Wash" scandal.

Municipal Water and Wastewater Treatment

There are 27 state-owned water utilities that serve 76 percent of the population, and a number of municipal and private sector utilities that serve about ten percent of the population. Approximately 86 percent of Brazil's population is served by a water utility, leaving the remainder without access to piped drinking water and sanitation services. SABESP in Sao Paulo state is currently the largest water utility in the world. It serves 24.1 million people and alone has a global market share of around 0.3 percent.[112]

The Brazilian sanitation law and implementation plan, *Plansab*, is attempting to bridge the sanitation gap and sets a formal target of universal sanitation services by 2030.[113] Much needs to be achieved in sewage treatment alone; currently, only 39% of wastewater is being treated.[114] Correspondingly, Plansab has forecast that investments of $57.5 billion in drinking water and $86 billion in wastewater transmission and treatment technologies and services are needed to meet the goal of universal access.[115] The government has provided $221 billion of federal funds to municipalities and states governments to develop projects in wastewater treatment and sewerage.

The federal government has required that states and municipalities develop local plans to implement Plansab, but it has stopped short of penalizing municipalities that failed to do so by the federal deadline.[116] The breach in plan development among municipalities is attributed to a lack of technical capacity to develop and implement such plans. The likelihood of meeting universal sanitation goals also is at risk due to financial shortfalls for project development. 59 percent of Plansab is financed by the federal government, with the remaining 41 percent of financing left to municipalities and regional governments.[117] Data received from the Brazilian Ministry of Cities show that average annual investments in basic sanitation are around $4.5 billion.[118] This is significantly less than the annual spending goal set by the federal government of $7 billion, which it estimates is required through the year 2030 to reach the goal of providing basic sanitation services to every citizen.[119]

Growth in this area is nonetheless expected to be aggressive, with an estimated Compound Annual Growth Rate (CAGR) from 2016 to 2020 of 9.6[120] percent, and a foreseen investment of $8.18 billion in the water sector over the next four years (2016-2019)[121]. At the writing of this report, total contract values of concessions and other tenders announced for 2016 were estimated to be worth $3 billion.[122] According to the National Water Agency (ANA), an estimated total of $5.76 billion will be needed to avoid urban water shortages by 2025.[123] The National Bank for Economic and Social Development (BNDES) estimates that $14 billion will be invested in the water treatment sector between 2015 and 2018.[124] The Global Water Market 2017 report forecasts private sector investment in the period 2014-2018 to be over $520 million annually, reaching $3.9 billion over the five-year period.[125] Investments in infrastructure will include design and construction of wastewater collection systems and treatment facilities as well as upgrades to existing equipment, pumps and asbestos contaminated pipes.

This finance gap in Brazil has led to some creative and fairly successful public-private partnerships (PPPs)[126] for the provision of municipal services. It has also led to several prominent market failures

where planned projects have remained "planned" indefinitely due to failures, again, in technical capacity and shortfalls in available private sector finance.

Technologies and Services in Demand:

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

Water loss issues are compounded by drought, water scarcity problems in arid regions and increased demand for affordable potable water sources in urban areas. Water lost in transmission or stolen is a serious issue for Brazilian municipalities, with water loss totaling 37.57 percent.[127] Reducing non-revenue water is now a top priority for the country, with a clear focus on mitigating leaks in distribution networks, particularly among motivated cities seeking projects to ensure more efficiency within their water distribution system.

These issues have converged to increase demand among Brazil's state water companies for systems and technologies that address non-revenue water and those that enhance water efficiency, such as smart water software and monitoring equipment. In 2015 during a two-year drought, the local utility in São Paulo, SABESP, implemented market-based control measures, including providing discounts for water savings and surcharges for overuse, which allowed water consumption to drop by thirty percent. SABESP also sought technology-based solutions to this shortage by identifying best practices in water reuse. However, water consumption in São Paulo has increased 18 percent since February 2015. Droughts and water scarcity are increasingly likely to occur in Sao Paulo, compounding the need for greater efficiency and conservation of water resources.[128] In October 2016, one of the major Brazilian utilities, SANASA, decided to use solutions provided by American water source management company, Itron, and British firm i20 Water, to reduce water loss.[129] The likelihood of drought also is driving interest in desalination

technology. Both Rio de Janeiro and São Paulo have expressed interest in developing desalination capacity to bridge the gap in freshwater demand.[130]

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 process as well as that for water reuse and efficiency, as industrial water consumers pay the highest rate per cubic meter for freshwater.[131] 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.

Process water had an estimated CAGR of 6.2 percent from 2010 to 2015[132] with estimated revenue of $305.6 million in 2016.[133] 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 CAGR of 9.4 percent,[134] the industrial wastewater market is estimated to reach annual revenues of $595.0 million in 2017. For example, water treatment in the pharmaceutical sector is expected to grow at 9.8 percent annually between 2014 and 2018 and is expected to reach $38.9 million by 2018.[135]

Water scarcity and adduction costs make desalination and water reuse attractive, particularly in water-intense extractive sectors. For instance, an average large mining project in Brazil demands approximately $800 million in water technology and infrastructure.[136] Correspondingly, the capital market for water in mining was estimated at $4.5 billion in 2015.[137] Brazil 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 percent.[138] Global Water Intelligence estimates that capital expenditures on offshore systems for sulfate removal reached $190 million in 2015.[139]

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

WASTE MANAGEMENT AND RECYCLING

Brazil's needs improved waste management are vast. According to the Brazilian Association of Urban Cleaning (ABRELPE), solid waste generation in Brazil is estimated at 62 million metric tons per year. Approximately ninety percent of solid waste is collected, with 37 percent 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 supports 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, the introduction of selective waste collection services and financing cooperatives of waste collectors.

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. With total investments of $20 million, Loga and Ecourbis, two concessionaires in charge of waste management in the city of São Paulo, built two automated waste separation plants, which were 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 in the near future.

Power generators above a one Megawatt capacity to produce energy from biogas are also imported. The use of container-mounted power modules used in landfills is relatively common in Brazil.

Investments in the solid waste management sector in Brazil were put on hold in the past two years, as the economic recession, reduced municipal tax collections and the "Car-Wash" investigation affected

the private companies in the business. As a result, in general terms, the deadlines determined by the National Solid Waste Policy were not met.[140] For example, the policy originally required that municipalities submit their solid waste management plans by the end of 2012, but as of 2015, only 2,202 out of 5,570 municipalities had complied.[141]

In addition to the National Solid Waste Policy, other notable regulations include CONAMA Resolution # 5 of 1993, which determines that the residue generator is responsible for the preparation and execution of a waste management plan. Environmental Crime Law 9605 of February 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, Sao Paulo's Secretariat of Environment also issued a resolution that went into immediate effect requiring entities that carry out activities related to solid waste management to obtain an environmental license.[142]

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 of the city districts by June 2016. The municipality was to invest BRL 11 million ($3 million) in trucks, security equipment, uniforms and warehouses.[143] BNDES lent BRL 41 million ($11 million) for the construction of three waste sorting plants and the refurbishing of ten existing plants. With investments of BRL 59 million ($22 million), the municipality recently opened two automated recyclable waste sorting and bailing plants, with the capacity to process 500 million tons of waste per day, a pioneer process in Latin America. The economy has slowed the pace for certain projects. Two additional plants in Sao Paulo were originally scheduled to begin construction in 2016, but the project is on pause because the economic recession has caused investments in the solid waste management sector to be put on hold.[144]

Similar to *Plansab*, the National Solid Waste Policy requires that municipalities develop local solid waste management plans, but in general, development and implementation of those plans are moving slowly. Brazil's National Institute of Geography and Statistics reports that only 32 percent of the 5,565 municipalities in Brazil have some sort of selective waste collection system and that a mere ten percent met an August 2012 deadline to present a solid waste management plan to the Environmental Ministry as articulated in the National Solid Waste Policy.

Market analysts have expressed pessimism that most municipalities will comply with standards outlined in the law, such as replacing dumps with sanitary landfills and implementing selective waste and recycling programs, requirements which were scheduled to be met by mid-2014.[145]

Despite this slow pace in compliance, significant opportunities remain in solid waste management. An estimated eighty percent of solid waste management in Brazil is conducted by private sector companies.

Municipal waste management services are currently valued at ten 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.[146] However, due to the major economic recession and the "Car-Wash" investigations, much of the enforcement of Law 12,305 has been stalled.

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.[147] 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, São Paolo's environmental authority 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. Amounts of 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 percent of the 1,059 million tons of healthcare waste generated per day in Brazil is treated. Brazil's overall goals to provide safe waste management practices society-wide will drive the 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

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 the obtainment of an environmental license is mandatory for the construction, installation, enlargement, modification and operation of facilities that use environmental resources and 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 proceeding. 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.

Brazil is projected to experience a significant decline in the demand for construction and, correspondingly, in its market for Environmental Impact Assessment (EIA) and related environmental engineering and consulting activities. The strong demographics that supported Brazilian growth appear to be reversing, leading to a plateau effect on the demand for construction over the long-term.

Technologies and Services in Demand:

- Environmental Impact Assessments

ETWG AGENCY INITIATIVES AND PROGRAMS

U.S.-Brazil Commercial Dialogue

In 2014, the International Trade Administration and Brazil Ministry of Industry and Trade initiated a working group to address common areas of interest in the development of environmental markets. The effort is designed to facilitate technical exchanges to improve mutual understanding of U.S. and Brazilian environmental regimes, approaches and markets.

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.

WasteExpo IBP
WasteExpo, 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 multi-lateral 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, the International Trade Administration 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.

MARKET CONTACTS AND PROGRAM REFERENCES

Brazilian Association of Environmental and Sanitation Engineering (ABES)
www.abesrio.org.br
Roberval Tavares de Souza, President
Abes-rj@abes-dn.org.br

Brazilian Association of Private Concessionaires of Sanitation Services (ABCON – SINDICON)
http://abconsindcon.com.br/
Santiago Crespo, President
comunicacao@abcon.com.br

Brazilian Association of Urban Cleaning Companies (ABRELPE)
www.abrelpe.org.br
Carlos Silva, Director President
carlos@abrelpe.org.br

Brazilian Environmental Institute (IBAMA)
www.ibama.gov.br
Suely Araujo, President
Presid.sede@ibama.gov.br

Environmental Authority of the State of São Paulo (CETESB)
www.cetesb.sp.gov.br
Carlos Roberto dos Santos, Director President

info@cetesb.sp.gov.br

Brazilian Association of Solid Waste Treatment Companies (ABETRE)
www.abetre.org.br
Diogenes Del Bel
diogenes@abetre.org.br

U.S. Commercial Service Industry Specialist
Teresa Wagner
Teresa.wagner@trade.gov
www.export.gov/brazil

India Case Study

Mounting and persistent 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 valued at $17.87 billion in 2017. India ranks fourth overall in the 2017 Top Markets Report, with a Composite Environmental Technologies Score of 32.5. India ranks second for water, with a score of 15.7; seventh for air pollution control; and fourth for waste and recycling markets, with scores of 12.7 and 4.0, respectively (see Appendix 1 for global rankings).

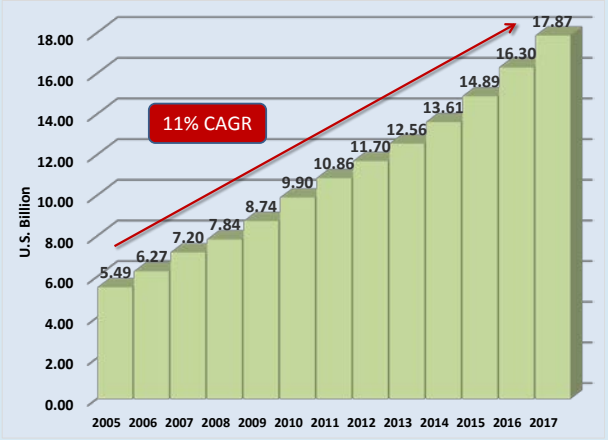
Overall Rank	Air Pollution Control
4	7
Water	**Waste & Recycling**
2	4

STATE OF THE ENVIRONMENTAL REGIME

India's complex environmental regulation is hinged on five major pieces of legislation, including 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 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), which scored India a 1.82 in 2015, a 1.15 point improvement from its 2005 score of 0.67.

Figure 1: India's Environmental Technologies Market



Source: Environmental Business International with OEEI Analysis, 2017.

The Ministry of Environment, Forest and Climate Change (MoEFCC) is India's federal agency responsible for implementation and oversight of environmental laws. Enforcement, however, is delegated to the state level through State Pollution Control Boards (SPCBs) or Pollution Control Committees (PCCs) in the seven union territories which ultimately answer to state government heads rather than the federal authority. This delegation of enforcement to state governments has served to decentralize enforcement practices and contributes to fragmentation and incongruent application of rules across provinces, lack of transparency in regulations and practices, poor implementation of regulations, weak regulatory compliance and corrupt practices in some areas. India's environmental laws have proved challenging to enforce because regulators lack the resources to address issues of asymmetric information and assert authority. [148]

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 the area of monitoring and instrumentation. High import taxes also diminish the price competitiveness of higher quality, and thus pricier, U.S. environmental technologies.
2. **Fragmentation of the Market Across Regions**
   Environmental technology markets in India are highly fragmented across the country, and it is difficult to find a representative or distributor that can truly provide national sales coverage. Companies that succeed in India must 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 also reported that public tenders are rife with institutional corruption that negates U.S. companies' ability to compete.
4. **Limited Sophistication of Local Partners**
   Local partners are tacitly, if not formally, required in tenders, and many national players in the Indian water market are new to the water technology sector and may have no prior experience developing and implementing water projects, creating additional management burdens for U.S. companies entering into joint venture relationships.

MARKET OPPORTUNITIES

AIR POLLUTION CONTROL

The most significant laws regulating air pollution control include the 1987 Air Prevention and Control of Pollution Act and the National Ambient Air Quality Standards, revised in 2009.[149]

Air Quality Monitoring

The Central Pollution Control Board is responsible for operating India's 613 monitoring stations covering 257 cities under the National Air Quality Monitoring Programme (NAMP).[150] In April 2015, the Indian government launched the country's first Air Quality Index (AQI). The AQI covered ten cities initially and eventually will be expanded to more than sixty. As of March 2017, air quality data for 41 cities was available. Each city has been directed to install six to seven continuous monitoring stations with AQI display boards, and the data collected must be made available to the public via an online portal on a daily basis.[151] The Indian government has sought adoption of science-based air pollution control strategies in Indian cities to establish baseline data on ambient air quality and pollution sources. This information will be used to define 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.[152] The AQI will build Indian capacity in assessing and predicting future emissions inventories, developing effective and efficient control strategies, and assessing health benefits of various air pollution control approaches. Particular emphasis has been placed on monitoring and control technologies relevant to coal-fired power plants and petroleum refining operations. India's expanding network of air monitoring stations provides opportunities for relevant U.S. technology providers.

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

Air Pollution Control

Coal is India's primary energy source,[153] accounting for more than seventy percent of energy generation in the power sector;[154] India is projected to become the largest source of growth in global coal use in the next 25 years.[155] Most of the country's hard coal, however, is of poor quality, with low to medium heat values and high ash content, contributing to decreased efficiency in power generation and higher local emissions.[156] With low quality coal and more than 85 percent of India's coal-fired power plants currently employing subcritical technology, the average efficiency for the generating fleet is less than 35 percent.[157] The resulting unreliable electricity supply, together with high end-use tariffs, has led energy-intensive consumers, such as the steel, cement, chemicals, sugar, fertilizer and textile industries, to produce a significant portion of their own electricity. Wealthier households also typically employ back-up diesel generators, contributing to worsening local air pollution, particularly from particulate matter.[158]

The government's "Make in India" initiative aims to increase India's manufacturing as a percentage of GDP to 25 percent by 2022.[159] The program was launched in 2014 and targets a number of key sectors, including mining, oil and gas, power generation, pharmaceuticals, chemicals and construction. Expansion of infrastructure – including energy infrastructure – to support a build-up of the country's manufacturing base will require increased inputs from energy-intensive, coal consuming sectors such as cement and steel, which are substantial contributors to air pollution. If India is to meet its Nationally Determined Contribution (NDC) commitment under the December 2015 Paris Climate Agreement to reduce the emissions intensity of its economy by 33 to 35 percent as compared with 2005 by 2030, emitting facilities will require emissions control technology. The Indian government plans to apply

stricter rules concerning emissions from coal-fired power plants built after 2016.[160] However, despite its commitments and plans, it still may push the pollution reduction deadline for coal-fired power plants beyond its original December 2017 target due to the expense and difficulty of reforms.[161]

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 per day and above), 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 per day) and above), petrochemical, sugar, thermal power plants, and zinc smelting. A 2015 assessment study showed that industrial combustion contributes to nearly half of India's particulate matter (PM) 10 emissions.[162] As new rules for these industries evolve and are enforced, opportunities in control technologies will continue to develop. New regulations are predicted to make India's air pollution control market worth more than seventy billion dollars over the next seven years. In a similar time frame, India is expected to upgrade or build tens of billions of dollars' worth of new NOx controls and flue gas desulphurization technologies.[163]

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)

WASTE MANAGEMENT AND RECYCLING

Solid Waste Management and Recycling

Waste management and recycling is underdeveloped in India. The country generates about 62 million tons of municipal solid waste (MSW) per year,[164] 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 e-waste.[165] Formal and industrial recycling processes are fairly limited, 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,[166] which is about one third of the total estimated amount of investment needed to manage the country's MSW, according to the U.S. Commercial Service in Kolkata.

The Municipal Solid Waste (Management and Handling) Rules, 2016 issued by the Ministry of Environment and Forests under the Environment (Protection) Act, 1986, regulates the sector. The Rules were revised after sixteen 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. Municipalities have the primary responsibility for managing solid waste and are assisted by state level urban development authorities. The new 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

Recycling of Discarded Electronics
The Indian MoEFCC implemented the E-Waste Management and Handling Rules in 2011 and revision as 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 seeks to establish a formal electronics recycling framework to promote safe handling of discarded electronics and growth in related economic activities nationally. The 2015 revision expands producers' responsibility under an Extended Producer Responsibility (EPR) program, including setting up Producers Responsibility Organizations (PRO) and e-waste exchange.

According to Environment Minister Prakash Javadekar, the 2015 rules place "absolute responsibility" on the producer to manage all aspects of e-waste, from generation to safe disposal.[167] The increase in Indian demand for equipment and recycling services presents opportunities to U.S. companies with experience in providing equipment or services used 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
Continued economic and industrial development in India has led to increased focus on properly managing resulting hazardous wastes. In 2008, the Indian 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,

increased access to healthcare in India created an estimated eighty billion dollar industry as of 2012 with an expectation to reach $280 billion by 2020,[168] the wastes of which require effective management.

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

WATER AND WASTEWATER TREATMENT

According to the UN definition, India is currently "water stressed" and heading towards "water scarcity."[169] The Indian water and wastewater sector have high ambitions to develop comprehensive public and private water and wastewater treatment and distribution infrastructure. Currently, nearly 63 percent of municipal wastewater and forty percent of industrial wastewater is discharged untreated. A growing population, increasing urbanization, increased *per capita* income, increasing industrialization and agricultural development are all driving water demand.[170] India has at least 68 water treatment and transmission, desalination and industrial reuse projects in its tendering pipeline with a cumulative estimated value of $6.5 billion.[171] 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. The Indian Planning Commission's Expert Committee Report on Indian Urban Infrastructure and Services underscores this point, estimating that $126 billion of capital investment is required over the next twenty years to meet India's basic potable water and sanitation needs.[172] In real terms, this means that capital expenditure on water and wastewater infrastructure is poised to grow 83 percent from 2015 to 2020, reaching an annual run rate of sixteen billion dollars by 2020.[173] The water and wastewater supply and treatment market size overall is estimated to reach over USD18 billion by 2020, with industrial demand growing at a higher rate than that of the municipal sector.[174]

Municipal Water and Wastewater Treatment and Plant Development

Growth in the municipal water and wastewater treatment sector is being 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 percent of Indians have access to clean drinking water, just under forty percent of the population has access to sanitary wastewater systems,[175] a disparity that emphasizes the dire need for wastewater treatment systems in particular. Current treatment capacity is estimated to be about 31 percent of wastewater generation.[176] Plans to introduce wastewater tariffs and combine them with drinking water tariffs, if implemented, 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 percent CAGR between 2015 and 2020.[177] Global Water Intelligence estimates that the value of the wastewater treatment segment will reach $6.78 billion in 2020, more than doubling its 2015 value of $3.3 billion.[178]

Correspondingly, the drinking water treatment and supply segment will grow at a slower clip, reaching $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 twenty years to meet India's basic potable water and sanitation needs.[179] 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.

Major tenders expected for municipal wastewater treatment and water supply projects include the Ahmedabad City 24X7 water supply project in Gujarat estimated to worth $364 million, the Kochi water supply project in Kerala worth an estimated $300 million, the Malad wastewater treatment plant in Mumbai estimated to be worth $296 million, the Bandra series of wastewater treatment plants also in Mumbai worth an estimated $289 million, and the Bangalore water supply extension with an estimated value of $271 million.

Nearly 63 percent of India's total sewage generated is discharged into surface waters untreated,[180] creating substantial pollution and public health problems. The government of India's approach to the Twelfth Five Year Plan sets a goal of zero discharge of untreated sewage into rivers. This goal has been translated into a series of recently announced municipal reuse projects, including the Hyderabad recycling plants in Andhra Pradesh, with an estimated tender value $453 million. The project calls for the construction of a series of municipal treatment plants that will supply treated effluent that is currently released into local rivers directly to industrial and agricultural users.

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 combined with the Smart Cities Initiative could yield substantial investments in water and wastewater infrastructure depending on the forthcoming project allocation. AMRUT has budgeted $7.7 billion across 500 towns and cities while $7.4 billion has been budgeted across 100 cities for smart infrastructure initiatives.[181]

In the short-term, the state of Bihar plans to develop a series of 112 water, sewerage and storm water drainage projects for tendering of PPP finance models.[182] This plan is confluent with the Modi government's recently announced model for funding the National Mission for Clean Ganga, which seeks to entice investors by relying on a "hybrid annuity-based PPP model" where the central government will finance forty percent of the capital costs for facility construction followed by a release of remaining funds in annuity-style payments subsequent to commissioning.[183] Three billion dollars has been allocated to the Ganga River conservation mission until 2020.[184] Under the national program, this model will be employed for approximately twenty municipalities 185 Thus far, the National Ganga River Basin Authority (NGRBA) has sanctioned a total of 83 projects along the Ganges.[186]

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 consumption and water loss issues plague Indian municipalities. The government of India estimates that between fifty to seventy percent of water supply finances go to electricity to pump water, while reported non-revenue water is thirty to fifty percent (with actual non-revenue water likely to be greater than reported). The National Action Plan for Climate Change states a goal of improved management that will increase water use efficiency by twenty 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[187] and expected to grow 20 to 25 percent per year.[188] The market for process water is driven by process demand and influent quality (surface water meets 41 percent of industrial demand),[189] while 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 the fact that although encouraged in official planning, industrial reuse is not articulated in any state or national regulation.[190]

Weak regulations and enforcement of industrial effluent are expanding the scope of pollutants and increasing treatment complexity and burden 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 to avoid effluent release into surface sources entirely. High water consuming 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 overall issues with scarcity. A number of power plants have been forced to shut down due to water shortages, presenting opportunities for desalination and use of treated municipal wastewater as alternative water sources.[191]

There are also emerging opportunities in the "new industrial cities" for improved wastewater management. The preeminent opportunity is the Delhi-Mumbai Industrial Corridor (DMIC), though cost estimates for tenderable projects have been slow to materialize and many projects remain in the planning and conceptual stage. The DMIC plans to establish seven new industrial cities with forthcoming

water and wastewater capital investments estimated to be worth $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.[192]

Primary 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 treatment technologies and those that meet high 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 a faster rate than recharge occurs. Currently, India has the highest rate of groundwater extraction of all of the G20 countries, with withdrawal rates over twice that of China, which ranks second.[193] In the short term, the government plans to rectify shortages by creating a comprehensive groundwater monitoring system and groundwater recharge projects. This will translate into demand for groundwater mapping services to assess current resources, monitoring technology and early phase recharge demonstration projects.

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

ENVIRONMENTAL CONSULTING AND ENGINEERING

The construction market in India is expected to grow twice fast as China's leading up to 2030, while India's urban population is projected to grow by 165 million inhabitants by 2030. India is also expected to become the world's third largest construction market by 2021.[194] If bound to requirements for environmental impact assessments and the creation of environmental infrastructure in the water and waste management sub-sectors, this coming boom of construction activity could correspondingly grow India's environmental engineering and consulting exponentially.

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 compiles the U.S. Environmental Protection Agency's (U.S. EPA) 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 and environmental consultants as a reference tool within bilateral activities that focus on addressing environmental concerns.

Power-Gen International Buyer Program (IBP)

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 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.

WasteExpo IBP

WasteExpo, 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 Indian participants and to introduce Indian 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 its International Buyer Program, 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.

MDCP Assisted Development of Drinking Water Standards

Through the International Trade Administration's Market Development Cooperation Program (MDCP), the American Water Works Association (AWWA) is implementing a program to help Indian utilities develop and meeting AWWA standards for drinking water treatment.

MARKET CONTACTS AND PROGRAM REFERENCES

Ministry of Urban Development

http://www.moud.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

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

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

U.S. Commercial Service Industry Specialist
Arup Kumar Mitra
arup.mitra@trade.gov

Saudi Arabia Case Study

Saudi Arabia ranked fifth globally on the 2017 Top Markets Report with a composite environmental technologies score of 31.0. Within the environmental industry segments, Saudi Arabia ranked fourth for water with a score of 13.1, highlighting the relatively important role that water and wastewater technology play in Saudi's desert climate. Saudi Arabia ranked sixth for air pollution control markets with a score of 13.9 and third for waste and recycling with a score of 4.0 (see Appendix 1 for global rankings). Recent budgetary tightening resulting from lower oil prices, however, could slow implementation of the project pipeline.

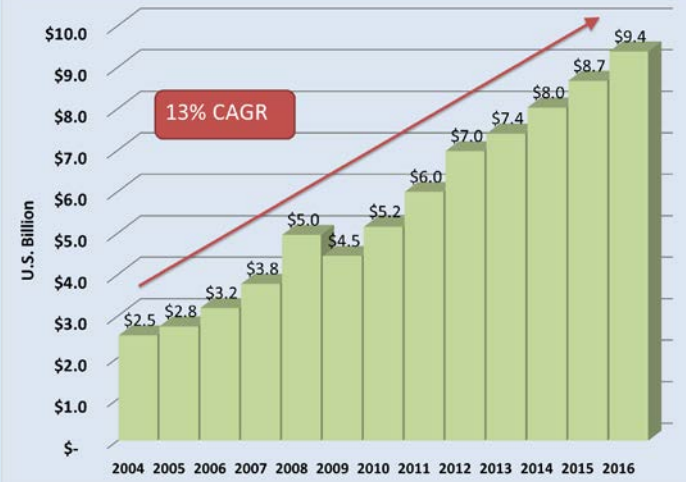
Overall Rank	Air Pollution Control
5	6
Water	**Waste & Recycling**
4	3

STATE OF THE ENVIRONMENTAL REGIME

Saudi Arabia's overall environmental technologies market, including goods and services, was valued at $9.4 billion in 2016.[195] Saudi Arabia has a limited domestic environmental technologies industry and therefore imports the balance of 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.

The country has a relatively high level of regulatory stringency and enforcement from the perspective of international businesses operating there. This is evidenced both by the government's recent allocation of three hundred million dollars for environmental protection and pollution control[196] and its 2009 announcement of the formation of a Green Police unit to improve monitoring and enforcement of environmental rules.[197] Saudi Arabia also named several environmental protection goals in its 10th Development Plan (2015-2019), including improvement of waste management and mobile and stationary source emissions reduction and protection of coastal and territorial waters.

Figure 1: Saudi Arabia' Environmental Technologies Market



Source: Environmental Business International with OEEI Analysis, 2016.

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 percent equity.[198] 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.
2. **Certification and safety approvals fail to recognize equivalents from the exporting market.**
   The Saudi Food and Drug Authority applies unnecessary additional testing requirements for products that have dual use in water analysis and medical applications, such as spectrophotometers. Additional testing imposes an undue burden regarding cost and time-to-market for technologies that are applied to environmental rather than medical uses.

MARKET OPPORTUNITIES

AIR POLLUTION CONTROL

Air Emissions Control and Monitoring

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 into line with international benchmarks.[199] The Kingdom is a signatory to the Kyoto Protocol and has undertaken an effort to enforce emissions standards for large industrial facilities.

In its Nationally Determined Contribution (NDC) under the December 2015 Paris Climate Agreement, Kingdom committed to achieving mitigation co-benefits of up to 130 million tons of CO_2 equivalent avoided annually by 2030 through contributions to economic diversification and adaptation. The NDC specifically emphasized the need to expedite the conversion of its single cycle power plants to combined cycle as part of its overall emissions reduction strategy. It also included a plan to build the world's largest carbon capture and use facility, which would capture and purify about 1500 tons of carbon dioxide per day for use in Saudi Arabia's petrochemical plants.

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 Saudi government allocated three hundred million dollars for environmental protection and pollution controls in 2010 and had ordered all major industrial projects to conform to

international air standards. Major emitting industries 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 are estimated at fifty million dollars,[200] with U.S. companies meeting almost 75 percent of demand.

The industrial cities of Jubail and Yanbu are prime examples of 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

WASTE MANAGEMENT AND RECYCLING

Municipal and Industrial Waste

In July 2013, the Saudi Cabinet approved new Municipal Solid Waste (MSW) management regulations. The new 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. The ministry is known to be finalizing the executive bylaws for the management of solid waste.

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.[201]

Recycling and solid waste management are regulated, and related tenders are issued by, the Ministry of Municipal and Rural Affairs in conjunction with local municipalities. A substantial portion of the three billion dollar budget of Saudi Arabia's Ministry of Municipality and Housing is dedicated to handling,

processing, managing and disposal of solid waste.[202] Saudi Arabia generates 15.3 million tons per year, the majority of which ends up untreated and landfilled.[203]

While few recycling initiatives exist, there is increasing demand for incineration technologies to deter the creation of more landfills. Production of domestic, industrial, chemical and hazardous wastes is also growing in Saudi Arabia. The burgeoning healthcare sector, which generates an estimated 50,000 tons of healthcare waste per year, also offers increasing commercial opportunities. The Kingdom currently boasts 1,850 health centers, with 79 hospitals under construction, and plans to establish an additional 250 new primary care centers,[204] creating 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

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.[205] 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.[206]

According to the NWC's plans, between 2012 and 2020 approximately $66.4 billion will be invested in new water infrastructure and related services, thirty billion dollars of which will be directed towards capital expenditures.[207] 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.[208] The Saline Water Conversion Corporation (SWCC) operates the state's 36 desalination facilities.

Most recently, Saudi Arabia moved to restructure water tariffs, which have been among the lowest in the world. The impact of declining oil prices combined with years of wasteful overuse has moved MOWE to increase industrial and commercial water tariffs by 125 percent.[209] Increases for residential customers have also been implemented, though they will be negligible up to 15 cubic meters per month. From that departure point, the new graduated tariff scheme more than doubles for every 15 cubic meters increment providing users ample incentive to limit consumption and fueling a fundamental shift in how water resources are managed in the Kingdom.[210]

Municipal Water Treatment and Water Efficiency

Demand for water services in Saudi Arabia is high as urbanization and population growth increases, but groundwater resources dwindle. The National Water Strategy intends to increase urban wastewater coverage from 58 percent in 2010 to eighty percent by 2030.[211] The 2014 Saudi Arabia Country Commercial Guide estimated that five billion dollars would be needed annually over the next twenty years for new water infrastructure investments. With the development of twelve 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.[212]

The NWC privatization scheme will transfer management to private companies to ameliorate the problem of non-revenue water. This will be achieved by improvements in transmission infrastructure, use of leakage detection systems and enhancements to revenue collection, which include upgrading metering and billing technologies and services. There is also an emphasis on improving the sewer system and creating separate systems for storm water management. Approximately forty percent of the Saudi Arabia utilizes combined sewers which have exacerbated flooding in recent years.[213]

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 ten billion cubic meters a year.[214] Saudi Arabia meets excess demand through seawater desalination, though desalination remains critical for groundwater treatment in the Kingdom as well due to high groundwater salinity. The SWCC currently operates 36 desalination facilities that address sixty to seventy percent of freshwater demand.[215] Expansion of the Saudi desalination program will be needed to meet future fresh water needs.[216]

The SWCC plans to invest $11.7 billion in capital expenditures and $4.5 billion in operations expenditures through 2020,[217] highlighting the vast 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 expand the desalination market further into services. This trend may accelerate as budgetary shortfalls as a result of falling oil prices create demand for alternative financing models.

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.[218] 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.[219]

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.[220]

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

Saudi Arabia's lack of a fee system for wastewater treatment services makes it a difficult economic prospect for privatization without government subsidies, but new fees for industrial freshwater make effluent treatment and reuse an attractive prospect.

Wastewater treatment is growing robustly in the Kingdom; 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.[221] The Kingdom's wastewater treatment capacity is expected to expand by 12.8 percent annually.[222] 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.[223] Waste-to-energy projects are key components of the national wastewater management program and are likely to emphasize biogas combined heat and power facilities.[224]

NWC has signed private sales contracts of treated wastewater to Saudi Aramco and power generation company, Saudi Electric Company.[225] One major project was announced for the 2015 to 2016 tender period: the South Dhahran Wastewater Treatment 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.[226]

Water reuse provides growing opportunities. The Saudi government has instituted treatment standards for various modes of reuse. The National Water Strategy Plan has a target of 100 percent and eighty percent reuse of treated municipal water and industrial wastewater, respectively, by 2030.[227] Focusing water reuse on industrial purposes has the intended impact of reducing the amount of saline conversion necessary for potable uses and is economically more viable in terms of the operational costs associated with desalination versus membrane-based wastewater treatment. 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 revenues over the forecast period.[228] 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,[229] 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

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.[230] The Saudi Arabian General Investment Authority (SAGIA) has stated that sustainability and energy efficiency are key elements of the cities' development strategy. All of these massive projects are being built entirely from scratch, creating huge demand for construction, engineering, design and related 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 compiles the U.S. Environmental Protection Agency's (U.S. EPA) 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 2017, an Arabic-language version of the Toolkit will be introduced to facilitate ease of use in Saudi Arabia.

Power-Gen International Buyer Program (IBP)

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 to encourage foreign participation in the show. This platform is leveraged to discuss policies and exchange technical information regarding power plant emissions control with Saudi participants and to foster business relationships between Saudi end-users and U.S. emissions control providers.

WasteExpo IBP

WasteExpo, 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 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 its International Buyer Program, 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

Saline Water Conversion Corporation

www.swcc.gov.sa

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.mowe.gov.sa

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

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

Saudi Water and Power (SWPF), Jeddah, Saudi Arabia
www.ksawpf.com

WEPower, Dammam, Saudi Arabia
www.wepower-sa.com

WETEX, Dubai, UAE
www.wetex.ae

Commercial Service Market Contacts
Habeeb Saeed (Riyadh)
Habeeb.Saeed@trade.gov

Mohammed Shujauddin (Dhahran)
Mohammed.Shujauddin@trade.gov

Mai AbuDabat (Jeddah)
Mai.AbuDabat@trade.gov

South Korea Case Study

The overall environmental technologies market in South Korea including goods and services is valued at $21.49 billion in 2017. South Korea ranks sixth overall on the 2017 Top Markets Report with a Composite Environmental Technologies Score of 28.0. South Korea ranks fourth for air pollution control and tenth for water markets with scores of 19.1 and 7.0, respectively. It ranks eleventh for waste and recycling with a score of 3.8 (see Appendix 1 for global rankings).

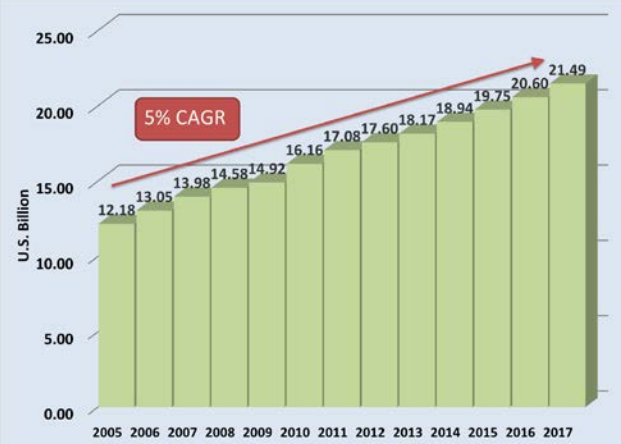
Overall Rank	Air Pollution Control
6	4
Water	**Waste & Recycling**
10	11

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 $21.8 billion and the U.S.–Korea Free Trade Agreement (KORUS) in place, Korea presents significant opportunities for U.S. environmental technologies exporters. Domestic competition, however, is highly sophisticated, and understanding how to work within the Chaebol system is necessary.

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 1: South Korea's Environmental Technologies Market



Source: Environmental Business International with OEEI Analysis, 2017.

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. 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.

KORUS was implemented on March 15, 2012. Under KORUS, by 2017, 95 percent of tariffs on U.S. exports of consumer and industrial products to South Korea,[231] including environmental goods, will have been eliminated.[232] KORUS 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.[233] KORUS also includes an Environmental Cooperation Agreement, thus strengthening the relationship and work between the U.S. EPA and MOE.[234]

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).[235] This score is a 0.17 point improvement over its ranking of 2.9 in 2005.[236]

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, including the language and culture, as well as the workings of its Chaebol system.

In addition, 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, environmental engineering & consulting services. As a result, Korea gained competitiveness in twenty 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 ranked South Korea 173 out of 180 countries in terms of air quality in 2016. 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. Korea also has often failed to recognize air pollution as a major problem for its cities, especially as the media tends to blame China for any pollution spikes instead of examining the domestic sources of pollution.[237]

Air Quality Monitoring

In its Nationally Determined Contribution (NDC) under the December 2015 Paris Climate 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, only now the target end date has been delayed by ten years.[238] 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.[239]

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 in particular, with a goal of reaching forty micrograms per cubic meter and twenty 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 to 56 percent of business-as-usual.[240] 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

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 ten percent of the total market. Japan and the United States are the leading foreign suppliers at fifty percent and thirty percent 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 outlined 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 is introducing strict control measures for VOC sources, such as laundry shops, gas stations, painting facilities, printing offices and everyday consumables.[241] To help reduce total PM 2.5 emissions, the city offered subsidies to help ten thousand Korean barbecue restaurants and 1,135 bathhouses install filters in 2015.[242]

A national chemical emissions survey conducted in 2010 found that approximately 61 percent of the fifty thousand tons of annual emissions of 388 hazardous air pollutants (HAPs) were fugitive emissions from non-smokestack facilities and processes.[243] 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 percent of South Korea's total generation capacity. Per the country's proposed new electricity plan, the share of coal capacity will increase to 32.2 percent by 2029.[244] Some estimate that as much at sixty percent of the country's air pollution is caused by pollution from power generation. The government is also sending some mixed signals on the future of coal-fired power plants. While Korean officials have announced plans to close coal-fired power plants older than forty years, they also have put forth plans to build twenty new coal power plants by 2022.[245] South Korea will need advanced abatement technologies if it is to increase its fossil fuel fleet and still attempt to meet its emissions reduction and climate change 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

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 on hazardous waste, specifically nuclear waste storage. This is largely 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 percent 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.

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.

The government has actively 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. 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 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. [246]

The Ministry of Environment also recently announced plans to establish 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. [247]

Despite this progress, South Korea's challenges with respect to nuclear waste management remain. South Korea is the world's fifth-largest user of nuclear power, and its nuclear program currently supplies thirty percent of the country's electricity. [248] South Korea's nuclear waste storage over the past thirty years has relied entirely on on-site temporary storage sites, which will be at capacity by 2021. [249]

At the end of 2015, a new nuclear waste disposal facility was opened in Gyeongju, which should 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;[250] however, additional long-term handling solutions for nuclear waste 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

WATER AND WASTEWATER TREATMENT

Municipal Water and Wastewater Treatment

South Korea hosts a comprehensive water treatment system with 92.1 percent of the population connected to a sewage system and 95.7 percent of the population connected to a municipal drinking water system.[251] This is particularly impressive considering that in 1962, only eighteen percent of the population was connected to piped water and there was no sewage system.[252] 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 fifty percent of construction costs, with the balance covered by the contractor.[253] 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.[254]

The government is also implementing advanced treatment processes for drinking water plants nationally. Since 2013, this effort has resulted in the application of advanced treatment process in 32 plants, a total of three percent of all facilities. The government plans to increase the ratio up to 53 percent by 2017.[255]

There is a robust market for sludge management that has emerged as a result of legal changes prohibiting landfill disposal and limiting the volume of sludge discharged into the ocean. Korea discharges an estimated 2.5 million tons of sewage sludge per year, 72 percent of which is discharged into the ocean. As a result of regulatory changes, demand for advanced solutions for volume reduction and recycling of sewage sludge has increased. The South Korean government constructs more than ten new sewage treatment plants annually, and upgrading existing sewage treatment plants to install tertiary processes, such as activated carbon filtering and advanced disinfection processes, is common.[256]

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.[257]

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 and Industrial Wastewater Treatment

Korea's vast high-tech industrial base and stringent effluent standards[258] 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.

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.[259] 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 planned to provide $9.2 million to the Korea Institute of Industrial Technology, a state-run think tank, to develop the technology further.[260]

South Korea has also developed a small nuclear reactor design for cogeneration of electricity and potable water. [261]

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

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. [262] 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 seventeen 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.

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

ETWG AGENCY INITIATIVES AND PROGRAMS

U.S. Environmental Solutions Toolkit

The Toolkit compiles the U.S. Environmental Protection Agency's (U.S. EPA) environmental regulations, related underlying research and a directory of U.S. companies that provide technologies necessary to implement similar environmental regulatory actions abroad.

Power-Gen International Buyer Program (IBP)

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 to encourage foreign participation in the show. This platform is leveraged to discuss policies and exchange technical information regarding power plant emissions control with South Korean participants and to foster business relationships between Korean end-users and U.S. emissions control providers.

WasteExpo IBP
WasteExpo, 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 its International Buyer Program, 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/main.do

Korea National Cleaner Production Center
http://www.kncpc.or.kr/en/main/main.asp

Public Procurement Service (PPS)
http://www.pps.go.kr/english/

U.S. Commercial Service Industry Specialist
Nathan Huh
Nathan.Huh@trade.gov
http://www.export.gov/southkorea

Indonesia Case Study

The overall environmental technologies market in Indonesia including goods and services is valued at $6.87 billion in 2017. Indonesia ranks seventh overall on the 2017 Top Markets Report with a Composite Environmental Technologies Score of 23.9. Indonesia ranks eighth for air pollution control and water markets with a score of 12.0 and 8.0, respectively. Waste and recycling ranks fifth with a score of 3.8 (see Appendix 1 for global rankings).

Overall Rank	Air Pollution Control
7	8
Water	**Waste & Recycling**
8	5

Despite efforts to establish a modern environmental regime, weak technical capacity in the public sector and poor administration of assets increases the likelihood that the application of environmental technologies in Indonesia for the short term will remain the purview of the private sector and donor organizations.

STATE OF THE ENVIRONMENTAL REGIME

The Ministry of the 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.

Substantial investment in environment and natural resources policy and staff development coupled with strong support for policy and capacity development from both within the government and with international partners has led to only limited success with difficult and slow actual implementation of rules and procedures. This is mainly due to weak commitment by sector agencies, low awareness in local departments and capacity challenges at all levels. [263]

Figure 1: Indonesia's Environmental Technologies Market

Source: Environmental Business International with OEEI Analysis, 2017.

Despite these challenges, Indonesia's environmental regime is improving in both regulatory development and efforts to enforce environmental rules. 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 score is a 0.64 point improvement over its ranking of 0.44 in 2005.

MARKET BARRIERS

Market barriers in Indonesia are substantial and often insurmountable in the public sector. The Office of Energy and Environmental Industries (OEEI), as well as 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 depending on the sector at issue, with public providers of environmental services exhibiting low to medium technical capacity. This shortfall in capacity contributes to delays in project development and weak administration of existing projects.
2. **Poor Asset Management in Public Projects.**
   Indonesia is plagued in the public sector by poor asset management 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 compounds these problems by divorcing accountability between those that develop infrastructure from those responsible for maintaining it. [264]
3. **Perpetual Delays in Announced Projects.**
   Indonesia developed an ambitious national agenda for environmental infrastructure development centered on a Public Private Partnership (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. [265]
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. It can be difficult for new-to-market exporters to develop relationships that lead to export sales with these clients, however.
5. **Local Content Requirements.**
   Over the past several years, the Indonesian government has introduced regulatory changes to mandate local content levels across the energy sector.
6. **Lack of Regulatory Implementation, Transparency and Corruption in Public Tenders.**
   U.S. companies have reported that tender requirements may be murky and that corrupt practices are common in many public tenders. Furthermore, projects and industrial activities and their regulations fall directly under the command of governors or district heads, but the actual implementation of rules and procedures at the local level in Indonesia has been poor.

MARKET OPPORTUNITIES

AIR POLLUTION CONTROL

Power Plant Emissions Reduction

Indonesia's coal consumption now accounts for 22 percent of total energy consumption, surpassing gas as the second most consumed fuel used in conventional thermal generation. Indonesia currently has 51 gigawatts (GW) of installed generation capacity and electrification has reached about 87 percent, [266] but many remote areas still have very limited access to electricity and those that are connected to the grid suffer from power shortages. [267]

To address these capacity issues, in 2006 the government embarked upon the first stage of its "fast track" plan, designed to accelerate power plant development. In the first phase, electricity sector demand for coal more than doubled by 2014 as a result of coal-fired generation capacity additions. [268] The government managed to add 8.1 GW under the first phase and planned to complete Phase One by the end of 2015. Phase Two includes approximately 18 GW of new capacity (sixty percent from coal), expected to come online by 2022. [269] More than a dozen smaller units are to be installed on Sumatera, Kalimantan and Bali during the same timeframe. [270] In mid-2015, President Joko Widodo announced additional installation goals of 36.7 GW by 2019, including twenty GW from coal-fired plants, thirteen GW from gas-fired and 3.7 GW from renewable sources. [271] However, in May of 2016, the President called for a review of this ambitious program in response to progress on only ten percent of target construction. [272] Despite lags in the plan, domestic consumption of coal rose 34.5 percent between January and April 2016. [273]

Eighty percent of the power plants built in Indonesia during the next decade will come from fossil fuel combustion, further opening the market for U.S. air pollution control technologies and services. In particular, Indonesia is expected to make large investments in new electrostatic precipitators over the next few years, which could present an opportunity for U.S. companies. [274] However, the scope for deployment of air pollution control technologies is contingent on improvements in both enforcement and technological expertise – areas where the United States has engaged bilaterally since the 1990s. [275]

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 sixty percent 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.[276] Indonesia launched an urban air quality improvement initiative in 2006 that included installation of air quality management systems in ten cities. The system, however, never operated effectively due to its high costs, and it lacked the capacity to monitor fine particulates.[277] The International Atomic Energy Agency (IAEA) recently 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 covering Indonesia's largest islands, and the project is expected to expand to cover 34 cities over the next three to five years.[278]

Monitoring data has already helped to lower legal thresholds of lead concentrations in ambient air, and it will serve as a foundation for tracking air quality and developing corrective actions going forward. The City of Jakarta recently purchased two PM 2.5 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 continues to be vehicle emissions. According to MoEF, the source of around seventy percent of the country's urban air pollution is the transportation sector, and ninety percent of those emissions come from land transportation. Several factors contribute to worsening pollution in the transportation sector, including lenient emissions and fuel quality standards as compared with other Asian megacities, as well as lax enforcement. MoEF signed a long-awaited regulation in March of 2017 that will move forward Euro IV emission standards adoption, which will be a significant improvement from the Euro II standard it has had since 2005.[279] Pertamina, Indonesia's state-owned oil and gas corporation, is upgrading its refineries and currently is seeking sites for construction of a new oil depot to store imported fuel that meets the higher standard.[280] Considering the double-digit growth of vehicle sales in Indonesia since 2007,[281] if such policy reform is implemented, it 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)

WASTE MANAGEMENT AND RECYCLING

Municipal Solid Waste and Landfill Management

As of 2015, 69 percent of the 64 million tons of the solid waste generated in Indonesia each year was sent to largely unsanitary landfills. The national recycling rate hovers at around two percent, with a slightly higher rate (7.5 percent) in urban areas.[282] Jakarta city residents alone dump approximately 6,700 tons of untreated solid waste every day into a single landfill - Bantar Gebang, the country's largest - which is on track to reach capacity by 2019. Waste picking in open dumpsites is common and sustains an unregulated, informal recovery sector.

Waste management has become an increasing concern for the Indonesian government as the country's declining disposal sites are 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.[283] In response, in September 2016, the Indonesian government began imposing a national tax on plastic carrier bags.[284] Indonesia also announced in early 2017 that it is pledging up to one billion dollars a year to help reduce the amount of plastic and other waste products polluting its waters.[285]

The Indonesian government recently has made efforts to improve the country's management of solid waste. In 2008, it passed Law Number eighteen Regarding Waste Management, which focuses on the management of municipal solid waste, guides the management of solid waste streams and encourages recycling. The law seeks to establish a national framework under which new technologies are utilized to address environmental issues and create economic value from the waste generated by citizens. 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 residents' participation and coordinate waste banks across the country.[286] 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

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 the reduction of the amount of waste sent to landfill, reduction of waste-based greenhouse gas emissions and the addition of renewable sources, including waste-to-energy specifically, into Indonesia's energy mix. While waste-to-energy 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.

In early 2016, the government submitted a draft presidential regulation, *Perpres*, to President Widodo focused on developing waste-to-energy (WtE) power plants as part of an effort to resolve acute waste management issues in seven pilot cities: Jakarta, Bandung, Tangerang, Semarang, Surabaya, Surakarta and Makassar.[287] Fewer than a handful of WtE plants are currently in operation across the archipelago. In December 2016, Jakarta signed a deal for an intermediate treatment facility (ITF), which is scheduled to be built and operated in Sunter, North Jakarta, by Finnish energy company Fortum.[288] A recent directive fostering Public Private Partnerships (PPPs) (Perpres 38/2015)[289] should help to increase private sector engagement for additional projects. Together with the government's ambitious power generation goals (see "Power Plant Emissions Reduction" above) and its increased emphasis on waste reduction, WtE is likely to offer opportunities for U.S. firms going forward.

Key Technologies in Demand:

- Waste-to-energy technologies and equipment
- Environmental engineering and design services

WATER AND WASTEWATER TREATMENT

Municipal Water Treatment and Transmission Systems

Municipal drinking water treatment is expanding in Indonesia, albeit slowly, to meet the country's National Medium-Term Development Plan, the Rencana Pembangunan Jangka Menengah Nasional (RPJMN), which set the goal of 100 percent access to drinking water and sanitation services during the 2015 to 2019 period. This lofty goal is estimated to incur investment in the water and wastewater sector of nearly $36 billion.[290] Drinking water and sanitation access were 87.4 percent and 60.8 percent, respectively, in 2015.[291] Indonesia has an estimated $225.5 billion of water supply investments planned and is electing to use Public Private Partnership (PPP) models to finance approximately 35 percent of the projects.[292] A significant portion of large water treatment plants already are funded by the private sector, and the government has and will likely continue to demonstrate a commitment to encouraging private sector investment.[293] A total of $14.6 billion has been allocated for the wastewater treatment sector for 2015-2019, of which half will come from the central government, twelve percent will come from local or regional governments, and 35 will be financed by communities and unidentified other sources.[294]

Underpinned by Build-Own-Transfer (BOT) models, the Indonesia PPP projects in practice have been financed through bilateral and multilateral aid agencies[295] and tendered at a much more gradual pace than envisioned in national development plans. The government seeks to remedy previous difficulties with PPP projects through its recently promulgated PPP regulation, the Presidential Regulation (PR) number 38/2015. The PR broadens the type of infrastructure projects for which PPP is available, including social infrastructure, and allows for forms of payment other than end-user fees.[296]

Indonesia's sewage coverage is one of the lowest in the world, at one percent total urban wastewater and 4 percent of total urban septage in the country collected and treated in 2013.[297] National development goals have set a target to increase access to improved sanitation from 60.5 percent to 100 percent by 2019.[298] To achieve this, the government has chosen 430 cities for the development of centralized wastewater treatment infrastructure in the next five years.[299]

The Ministry of National Development Planning's (BAPPENAS) PPP Book lists 15 water infrastructure projects planned with a total value of $1.59 billion.[300] 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[301] project to be tendered.[302]

After basic infrastructure and supply needs are met, the predominant concern for Indonesia is likely to be drinking water quality. For the twenty percent of the population that does have a water main connection, the quality of the municipal water supply is low, and drinking water directly from the tap is discouraged.[303] 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.

In 2017, a new water law is scheduled to be implemented. This new law takes into account lessons learned based on the 2004 Law on Water Resources and should include the introduction of minimum standards for utility service performance, as well as increased accountability in the drinking water sector.[304] The next five years are likely to see unprecedented national government investment in the water infrastructure sector, offering a number of opportunities for U.S. companies.[305]

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 22 sectors, several are key client industries for the water sector, especially mining of nickel and copper, coal, oil and gas, food and beverages, textiles, steel and aluminum smelting.[306] Coupled with government emphasis on water resource protection, effluent management and water reuse are likely to be growth markets in addition to influent treatment technologies.

The burgeoning oil and gas sector should provide growing opportunities for process-based water treatment, particularly as offshore development continues. The prevalence of international oil companies working in Indonesia could provide a rational sales conduit for qualified producers of process water technologies. Furthermore, the government recently initiated four shale gas study projects and expects commercial shale gas production to begin by 2018.[307] Shale gas development will necessarily 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.[308]

Technologies and Services in Demand:

- Wastewater treatment technologies
- Advanced filtration
- Membrane filtration
- Purification equipment
- Petrochemical and mining effluent treatment systems

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. To conduct business activities that may damage the environment, a permit is required to obtain a business license. 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.

Coupled 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 the government's stringency with requiring adequate site assessment 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 compiles the U.S. Environmental Protection Agency's (U.S. EPA) 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.

Power-Gen International Buyer Program (IBP)

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 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.

WasteExpo IBP

WasteExpo, 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 Indonesian participants and to introduce Indonesia buyers to U.S. waste management technology providers.

U.S. EPA Collaboration

The U.S. Environmental Protection Agency (U.S. EPA) has worked with the Indonesian government through an MOU on environmental cooperation for over five years to address technical cooperation in areas such as air, environmental enforcement, environmental impact assessment and site remediation.

MARKET CONTACTS AND PROGRAM REFERENCES

BAPPENAS

http://www.indonesia.go.id/en/ministries/ministers/state-minister-for-chairperson-of-the-national-development-planning-agency/1646-profile/277-kementerian-perencanaan-pembangunan-nasional.html

Directorate General of Electricity, Ministry of Energy and Mineral Resources

http://www.djlpe.esdm.go.id/

Foreign Commercial Service Jakarta

http://www.export.gov/indonesia/

USAID Indonesia

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

Indonesian Petroleum Association

www.ipa.go.id

Turkey Case Study

The overall environmental technologies market in Turkey including goods and services is valued at an estimated $7.3 billion in 2016.[309] Growth in the Turkish market is driven by EU mandates and a national effort to provide basic sanitation services. Turkey ranks eighth in the 2017 Top Markets Report overall with a composite environmental technologies score of 21.2 (see Appendix 1 for global rankings). Turkey ranks fifth for air pollution control markets with a score of 16.8. It ranks 28th for water with a score of 2.6 and 12th with a score of 1.8 for waste and recycling.

Overall Rank	Air Pollution Control
8	5
Water	**Waste & Recycling**
28	12

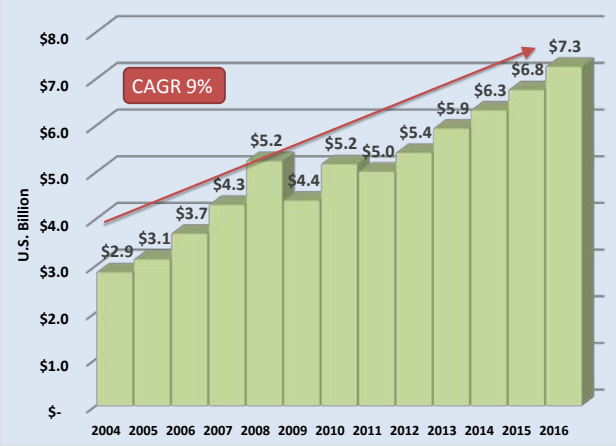
STATE OF THE ENVIRONMENTAL REGIME

Turkey's environmental regime is steadily improving, both in terms of rulemaking and enforcement. Turkey's EU accession agenda is working to advance both areas as part of the environmental and climate acquis. Improvements in this area are evidenced in 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) and scored Turkey a 1.92 in 2015, a 1.09 point improvement from its 2005 score of 0.83.

At the national level, the Ministry of Environment and Urbanization is the procurement agency for environmental projects. On August 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 substantial progress has been made in the implementation of environmental rules, the European Commission notes that additional national legislation is needed in the areas of ambient air quality, national emissions ceilings, volatile organic compounds, waste separation and reducing biodegradables in waste disposal. Furthermore, requirements related to the EU Waste Framework Directive, as well as legislation consistent with both the Mining Waste Directive and the Industrial Emissions Directive, need to be implemented.[310]

Figure 2: Turkey's Environmental Technologies Market



Source: Environmental Business International with OEEI Analysis, 2017.

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 the 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.**
   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 the 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

Air Quality Monitoring

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 thirteen pollutants[311] 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.[312] Turkey also is in the process of developing and implementing a national monitoring, verification and reporting (MRV) system. Together with the World Bank Group's Partnership for Market Readiness (PMR), Turkey has mandated for approximately two thousand firms in the electricity, cement and refining sectors to participate in an MRV pilot before the launch of a full program.[313] Monitoring for the pilot industries began in 2015 and reporting of 2015 emissions will begin in 2017.[314]

Although monitoring and control regulation is present, implementation of control measures has been slow, according to the 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.[315] Turkey 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).[316] The government is requiring the installation of flue gas desulfurization (FGD) units on all new and existing power plants, opening up 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

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. 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 supply reaches 91 percent of Turkey's population, while 84 percent are connected to sewerage.[317]

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, fifty billion dollars of water infrastructure investments are planned through 2023 for both drinking and wastewater.[318] The Turkish government estimates that approximately two billion dollars annually must be invested in water infrastructure projects to meet EU standards.[319] 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.[320] Substantial problems with non-revenue water in its existing infrastructure will drive demand for leak detections 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 fifteen billion dollars 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 and 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.[321]

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

WASTE MANAGEMENT AND RECYCLING

Municipal Solid Waste

Turkey has two fundamental regulations that govern waste management: the Regulation on General Principles of Waste Management and the Regulation on Solid Waste Control.[322] Implementation of programming mandated by these regulations has been slow, however, and capacity to develop comprehensive waste management systems is lacking.[323] Further work is needed on source separation, reducing biodegradables going into landfills and on hazardous waste.[324]

According to the Turkish Statistical Institute, 113 controlled landfill sites, four incineration facilities, four composting plants and 864 other types of recovery facilities were in operation as of 2014. Of the 28 million tons of waste collected by municipal waste collection services that year, 63.5 percent was transferred to controlled landfills, 35.5 percent was disposed of in municipal dumping sites, and 1 percent was disposed of by other methods.[325]

To meet universal waste management goals via the Waste Management Action Plan, 2.1 billion Euros of investment is needed between now and the 2023 goal 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.

Remediation and upgrading of existing unsanitary landfills are also a major effort the government plans to undertake through the Waste Management Action Plan. The Ministry of Environment and Urbanization estimates that 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.

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

ENVIRONMENTAL CONSULTING AND ENGINEERING

Businesses that may cause environmental problems via their operations are obliged to obtain 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 November 25, 2014, further provisions were added to the Environmental Impact Assessment Regulation. These provisions include lower thresholds on 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 five hundred 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. 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. Environmental Protection Agency's (U.S. EPA) 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.

Power-Gen International Buyer Program (IBP)

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 to encourage foreign participation in the show. This platform is leveraged to discuss policies and exchange technical information regarding power plant emissions control with Turkish participants and to foster business relationships between Turkish end-users and U.S. emissions control providers.

WasteExpo IBP

WasteExpo, 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 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 International Buyer Program, 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/

Commercial Service Market Contact
Neil Pickett
Neil.Pickett@trade.gov

Vietnam Case Study

Overall Rank	Air Pollution Control
9	10
Water	**Waste & Recycling**
12	8

Vietnam ranks ninth overall on the 2017 Top Markets Report with a Composite Environmental Technologies Score of 18.9. This is the first year Vietnam has been listed as a top ten priority country in the TMR. Vietnam also ranks 12th in water, 10th in air pollution control and eighth in waste and recycling, with scores of 6.2, 10.4, and 2.4, respectively (see Appendix 1 for global rankings).

Vietnam's GDP has been growing dramatically since the 1990s. In 2015, it was $193 billion with a growth rate of 6.7 percent.[326] It is one of the fastest-growing emerging economies in Asia and as such has been attracting a lot of foreign investment in recent years. Vietnam's environmental goods and services industry is immature compared to those in developed countries and many other emerging economies. However, a number of opportunities exist for U.S. firms. The country faces increasing challenges across all three environmental media, 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.[327] This system is replicated at the local government level through subsidiary offices of the three ministries.[328]

Vietnam's Law on Environmental Protection was first enacted in 1994 and thereafter updated and strengthened in 2005 and 2014.[329] 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.[330] Central-level attention on protecting the environment also includes setting environmental sustainability goals in its 2015-2020 long term plan, issued in 2016.[331]

On February 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.[332]

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 revenues and economic and commercial growth as measurements for their region's success, there is resistance and avoidance to the trend in increased enforcement because environmental regulation is perceived to limit local economic and commercial growth.[333]

Overall, Vietnam's economic outlook remains positive for foreign investors, as its growth rate is set to rebound to seven percent in 2017.[334] Heightened enforcement by the Vietnamese government will strongly 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.[335] The World Bank has stated that it will stop offering low or zero interest rate lending to Vietnam in July 2017 because it began to qualify as a middle-income country in 2009.[336] Other international lending institutions are planning to follow this decision. Losing these preferential loan sources may direct 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.**
   Currently, the 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.[337]
2. **Lack of Transparency and Corruption.**
   Vietnam ranked 113 (out of 176) on Transparency International's 2016 Corruption Perceptions Index.[338] Corruption and administrative red tape within the government has been a vast challenge for governmental consistency and productivity for foreign companies doing business in Vietnam, even though on paper, Vietnam's anti-corruption law is one of the strongest in Asia.
3. **Immature Environment to Support Foreign Investment.**
   Vietnam lacks the climate to attract more investment in the environmental sector. 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 ranked 90th (of 189) in the World Bank's Ease of Doing Business report for 2015. Lack of financial transparency

and poor corporate disclosure standards 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 insufficient legal framework and enforcement have continued to make protection of intellectual property rights a significant challenge even though Vietnam has made great efforts to strengthen enforcement.

MARKET OPPORTUNITIES

The vast majority of revenue and employment for environmental goods and services in Vietnam can be found in services relating to water purification and delivery, sewage and wastewater treatment, and solid waste management. While domestically, Vietnam's technical capacity is improving in the water, wastewater, solid waste, and to an extent in environmental consulting and engineering, most sophisticated technical skills and technology for pollution control, remediation, monitoring and analysis are imported.

AIR POLLUTION CONTROL

In a study covering the years 2011 to 2015, Vietnam's Ministry of Natural Resources and the Environment (MONRE) found that recently, deterioration in air quality has been severe in many urban areas, especially in Hanoi and Ho Chi Minh City.[339] A 2013 National Environment Report showed that air pollution in Hanoi was graded from unhealthy to hazardous for over 265 days of the year.[340] The primary sources of urban air pollution are traffic and industrial activities, according to the Vietnam Environment Administration.[341]

Power Plant Emissions Reduction

Research published by Harvard University in January 2017 showed that by 2030, Vietnam would be the ASEAN country most affected by pollution from coal-fired power plants. The study estimated that coal-related air pollution would cause 188.8 deaths out of every one million people by 2030, which is significantly higher than the second most-affected country in the region.[342]

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.[343] 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.[344] This has further solidified Vietnam's plan for half of the country's total electricity to be generated by coal-fired plants by 2030.[345] Currently, there are 100,000 MW of coal-fired power under development.[346]

The Vietnamese Government has stated that it will pay close attention to the environmental impacts of this increase in coal-fired power generation, but it has not provided specific plans to address potential problems. However, to address the threat to citizens' health, as well as 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 in this sector.

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 Vietnamese government has clear plans to address industrial air pollution. The Ministry of Natural Resources and Environment (MONRE) has drafted a National Action Plan on Air Quality Management (2020 to 2025). The draft Action Plan includes a twenty percent reduction target for NOx, SOx and particulate matter emitted by cement, chemicals, fertilizer and petroleum production facilities.[347] 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.[348] 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 ninety million.[349] The number of cars and motorcycles on the road increased by sixteen percent per year on average from 2000 to 2012 and is unlikely to slow in the near-term.[350] As of early 2017, vehicles are now required to meet Euro IV emission standards.[351] The Vietnamese government has been preparing for this transition since 2011, but experts believe Vietnam does not have sufficient fuel to accommodate the increased number of Euro IV vehicles.[352] If this transition is successful, it may offer opportunities for U.S. mobile source emission control companies.

Key Technologies in Demand:

- Emission control technologies for motor vehicles and non-road (diesel) vehicles and machinery

WATER AND WASTEWATER TREATMENT

Vietnam's water markets are the most mature compared to other markets in the environmental goods and services sector. Nevertheless, major water pollution problems continue to plague the country. For example, as much as three million cubic meters of largely untreated wastewater is released from 787 cities each day.[353]

Further development of Vietnam's water treatment infrastructure, while necessary, will be challenging due to financial constraints. As much as eighty percent 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.[354] 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 strong efforts to mobilize private sector financing to develop 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 stormwater.

Vietnam's 2014 version of the Law on Environmental Protection requires that wastewater must be collected and treated to meet environmental technical regulations before being discharged into the environment.[355] Decree No. 80/2014/NDCP on the Drainage and Treatment of Wastewater (2014) further sets regulations for the drainage and treatment of wastewater in urban areas, industrial zones and rural residential areas. However, only 1.7 percent of Vietnam's population currently is connected to a sewerage network.[356] The Vietnamese Government aims to increase centralized urban wastewater treatment from ten percent to 45 percent by 2020.[357] By 2025, the government plans to have expanded centralized sewerage to 36 million people.[358]

Marquee opportunities include the Ho Chi Minh City NLTN wastewater treatment plant designed to address pollution in the Nhieu Loc-Thi Nghe Canal. With a capacity of 830,000 cubic meters per day

upon completion, it will become the largest wastewater treatment facility in South East Asia.[359] In the public-private partnership (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. Investment of three hundred million dollars is needed to bring the project to fruition.[360] 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.[361]

In November 2015, the World Bank approved a two hundred million dollar financing package for water and sanitation, and the Vietnamese government committed to provide an additional $25.5 million to finance related projects.[362] Approximately 23 major water treatment projects have been announced for the 2016 to 2018 tendering period, ranging in value from $635 million to nineteen million dollars.[363] Overall, the water infrastructure industry is expected to average 5.4 percent growth annually between 2014 and 2018.[364]

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.[365]

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[366]

Industrial Wastewater

The country's industrial production has grown at around fourteen to fifteen percent per year during the last decade. Statistics show that as of June 2012 there are 334 industrial parks and export processing zones.[367] Industrial wastewater treatment has emerged as a critical need as 75 percent 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.[368] 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 recover from the event fully.[369] The incident caused significant public outcry and demand for stronger monitoring and enforcement of environmental protection measures, as well as transparency in investigations.[370] Vietnamese Prime Minister Phuc issued an official order later in 2016 requiring the Taiwanese company responsible for the pollutants pay victims compensation ranging between $130 to $1,600 per person.[371] The MONRE has also urgently required some two thousand projects currently under construction to re-do environmental impact assessment reports in response to the incident.[372]

In general, the industries most in demand of wastewater treatment technologies are power generation, textiles and industrial zone development projects.[373]

Technologies and Services in Demand:
- Engineering, procurement and construction services
- Operations services
- Waste to energy technology
- Testing equipment
- Water drainage and wastewater treatment systems[374]

Drinking Water and Process and Produced Water
Access to safe drinking water is a problem in Vietnam. Only ten percent of rural households and 61 percent of urban households has access to the water main and piped water.[375] Periodic drought, rapid industrialization and increasing household demand all place pressure on Vietnam's freshwater resources. Total water resource in Vietnam was 919.1 cubic km in 2014, with more than ninety percent of the source being surface water.[376] 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 percent of urban and ninety percent of rural area populations to have access to clean water by 2020.[377] It also aims to raise urban piped water supply coverage rate to 85 percent by 2020 and 100 percent 24 hour supply by 2025.[378] The estimated cost is USD1.6 billion per year to reach Vietnam's 2020 goals.[379]

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.[380] Ho Chi Minh City, for example, will prioritize eight water supply projects worth over VND 32 trillion ($1.4 billion) from now until 2020.[381]

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. In June of 2015, the Vietnamese Government issued Decree No. 54/2015/ND-CP, which 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. On World Water Day in 2017, MONRE called on all provinces to launch scientific workshops, seminars and exhibitions on the theme of water resources and mobilize community participation in water resource protection.[382]

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

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), the majority of the country's solid waste (73.5 percent) 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.[383] There are presently 458 dump sites, but 337 of them do not meet sanitation standards.[384]

In 2009, Vietnam adopted its "National Strategy for Integrated Solid Waste Management to 2025, with a vision toward 2050."[385] 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).[386] Decision No. 798/QD-TTg (2011) approved a program for investment in solid waste treatment through 2020.[387] The program's ambitious goals include collecting and treating "up to environmental standards" at least ninety percent of urban and seventy percent of rural solid waste, as well as ninety percent of both hazardous and non-hazardous industrial solid waste and 100 percent of healthcare waste.[388]

Technologies currently in use include incinerators, combined incineration and composting and, most commonly, composting combined with landfills.[389] Domestic manufacturers produce trash receptacles, while trucks and sorting equipment are imported.[390]

Municipal Solid Waste

More than sixty percent of Vietnam's rural household waste and sixteen percent of urban household waste is not collected.[391] 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 increases by ten to sixteen percent.[392] State agencies in Vietnam play the key role in collecting and treating solid waste, accounting for sixty percent of the sector's revenue.[393] 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.[394]

The Vietnamese Government is tightening regulations on waste disposal. A new decree on administrative penalties for individuals violating environmental protection laws and regulations was adopted on February 1, 2017. In the first few days after the measure went into effect on February 1, 2017, authorities already had issued VND sixty million ($2,600) of fines against 21 people for littering in one single district of Hanoi.[395] There are also major projects underway to support solid waste management, including 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.[396] 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.[397] 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.[398]

Key Technologies in Demand:

- Waste handling equipment
- Waste treatment technologies
- Waste-to-Energy System
- 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 percent compound annual growth rate (CAGR) between 2011 and 2015.[399] 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.[400] The Vietnamese Government aims to process 85 percent of hazardous waste and 95 to 100 percent of medical waste by 2020.[401] 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
- Brownfield site remediation design and equipment
- Hospital and medical grade incinerators
- Industrial autoclaves

ENVIRONMENTAL CONSULTING AND ENGINEERING

More than two thousand projects in Vietnam are required to make environment impact assessment (EIA) reports each year.[402] Domestic engineering and consulting firms can perform EIAs for developers, but foreign developers 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.[403] 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

VietWater 2017
Ho Chi Minh City, November 8-10, 2017
http://www.vietwater.com

WEFTEC International Buyer Program (IBP)
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.-Vietnam water cooperation through targeted activities at WEFTEC.

WasteExpo IBP
WasteExpo, 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 and to advance U.S.-Vietnam waste management cooperation in ongoing bilateral and multi-lateral 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.

MARKET CONTACTS AND PROGRAM REFERENCES

Ministry of Natural Resources and Environment
www.monre.gov.vn

Vietnam Environment Administration
www.vea.gov.vn

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

Commercial Service Market Contacts
Ms. Ngo Anh
ngo.anh@trade.gov

United Arab Emirates Case Study

Overall Rank	Air Pollution Control
10	13
Water	**Waste & Recycling**
5	7

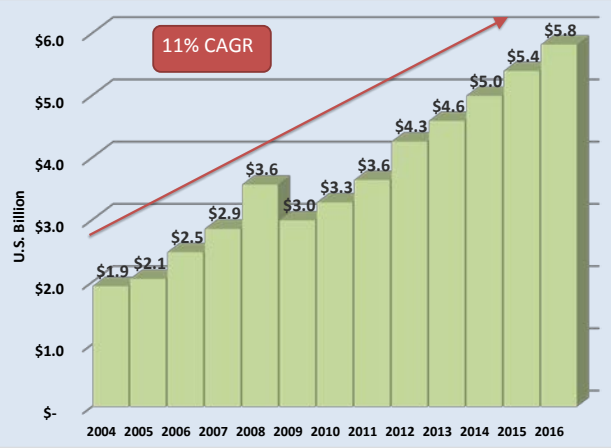
The United Arab Emirates (UAE) environmental technologies market, including goods and services, is valued at $5.8 billion in 2016. UAE ranks tenth overall on the 2017 Top Markets Report, with a composite environmental technologies score of 18.7 UAE ranks fifth in water technology, with a score of 11.5; it ranks 13th in air pollution, with a score of 4.6; and ranks seventh in waste and recycling, with a score of 2.7. (see Appendix 1 for global rankings).

The UAE's high relative score in the water and wastewater segment drives its ranking in this study, as data reporting for both the air pollution monitoring and control market and the waste and recycling market are comparatively lacking. There is evidence, however, that the UAE is host to a robust air pollution control market and growing waste management market, validating its inclusion in this report's top ten priority markets.

STATE OF THE ENVIRONMENTAL REGIME

In 1999, Federal Law No. 24 (the "Federal Environment Law") was enacted, which regulates the protection and development of the environment in the UAE. The Federal Environment Law is the key legislation in the UAE for environmental protection, addressing environmental impact assessments (EIA), protection of the marine environment, pollution from land sources, soil protection, protection from air pollution and the handling of hazardous substances and wastes. The Federal Environment Law has been administered by both the Ministry of Environment and Water (MOEW) and the Federal Environmental Agency. In 2016, UAE leadership expanded the role of the MOEW to also manage international and domestic climate change affairs, and thereafter changed the agency to the Ministry of Climate Change and Environment (MoCCAE).

Figure 1: UAE's Environmental Technologies Market



Source: Environmental Business International with OEEI Analysis, 2016.

Despite coherent national legislation, the UAE's environmental enforcement regime is characterized by fragmentation among its seven emirates. While the MoCCAE maintains federal authority for environmental rules and regulations across the emirates, administration is managed within Emirati-level institutions. Checks and balances are provided by a number of environmental watchdog organizations that ensure sustainability standards are upheld.[404]

Furthermore, environmental protection is an increasingly important feature in both Dubai and the UAE. In March 2014, the then Ministry of Environment and Water received new powers to penalize polluters and develop recycling systems. This bill, which introduced changes to the 1999 Federal Environment Law, includes tougher penalties for offenders.

The UAE is making large strides in developing and implementing environmental policies. The 2014 MOEW report on the State of the Green Economy highlights efforts to establish new rules on waste management, recycling and hazardous waste management.[405] The 2016 edition of this report emphasizes "green innovation" and sustainable resource use.[406] The UAE Green Growth Strategy prioritizes water and electricity efficiency, recycling and protection of natural resources and calls for investment in carbon capture and storage (CCS), waste-to-energy and energy efficient desalination technologies.[407] The UAE Green Agenda 2015-2030 aims to serve as a framework for implementing the Green Growth Strategy in order for UAE to become a successful low carbon green economy.[408] In June 2015, the Emirates Green Development Council was formed, including representatives from six federal ministries and seven emirates.[409] Finally, the UAE's Vision 2021 National Agenda sets ambitious targets for improving air quality, managing water resources and developing sustainable infrastructure.[410]

MARKET BARRIERS

Market barriers are relatively few in UAE. The Environmental Technologies Trade Advisory Committee (ETTAC), along with industry experts in the Office of Energy and Environmental Industries (OEEI) and the Commercial Service Dubai, identified the following barriers as most problematic for environmental technologies companies attempting to export to, or do business in, the UAE:

1. **Disparate Use of International Standards Poses Adherence Challenges.**
   U.S. companies note a lack of country-specific environmental standards favoring international standards from a variety of sources, including the United States, UK, EU, Japan and Singapore. The lack of coherence can make it difficult for exporters to determine the relevant standard and complicates larger projects where a cacophony of standards may be relevant within a given environmental system.[411]
2. **Local Partnerships Encouraged.**
   UAE is generally open to foreign technologies and service providers, but partnership with a local firm is strongly encouraged and brokering contracts demands knowledge of UAE's unique negotiating style and mores.[412]
3. **Market Proximity Benefits European Competitors.**
   The geographic distance between the United States and the UAE compared to European markets makes U.S. products less attractive due to time-in-trade. Marine shipping takes 45 days from the United States versus three weeks for European products.[413]

MARKET OPPORTUNITIES

AIR POLLUTION CONTROL

Ambient Air Monitoring
Air quality is included among the UAE's National Key Performance Indicators for sustainable development under the country's Vision 2021 National Agenda, which sets a goal of increasing the Air Quality Index to ninety percent by 2021 from a base of 66.7 percent in 2014 for four criteria pollutants.[414] The UAE currently maintains a total of 46 air quality monitoring stations.[415] Of these, twenty fixed stations and two mobile stations are located in the Abu Dhabi Emirate. Abu Dhabi's fixed stations are distributed across the city and its suburbs, as well as in Al Ain city and its suburbs, and in major towns in the western region.[416]

In June 2015, the World Bank's Little Green Data Book listed the UAE as having the world's highest mean average of fine particles that are 2.5 micrometers in diameter or smaller (PM 2.5). In 2016, the same report showed large improvements in measured air quality in the UAE.[417] There are currently no established national limits for PM 2.5. The Environment Agency - Abu Dhabi (EAD) publishes air quality reports on a quarterly basis and noted in one of its most recent reports that the desert environment and frequent dust storms in the region are key contributors to elevated PM 10 concentrations, along with traffic, industrial activities and construction. The daily average PM 10 values exceeded federal standards at all of the stations, and 95 percent were two to five times above federal thresholds.[418]

In September 2015, the MOEW signed a memorandum of understanding (MOU) with EAD as well as with the National Centre for Meteorology and Seismology; Dubai, Sharjah and Fujairah Municipalities; and the Municipality and Planning Department in Ajman to launch the UAE Air Quality Network in order to meet the 2021 goal of ninety percent air quality.[419] Eleven new monitoring stations are to be built in Ajman and the Northern Emirates as part of the network.[420]

Key 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
According to the Ministry of Energy, the UAE emitted 199 million tons of carbon dioxide and other greenhouse gases in 2013. Of this total, cement and aluminum production each contributed about eight percent, and the oil and gas sector contributed about fifteen percent. Per capita, greenhouse gas emissions stood at approximately 24 tons.

The UAE is the second largest manufacturer of cement and steel in the Gulf region, after Saudi Arabia. Large deposits of limestone in the northern part of the country facilitate production of construction aggregate, cement, gypsum and rock wool.[421] Cabinet Resolution No. 20 of 2008 and Ministerial Resolution No. 567 of 2014 regulate industrial facilities at quarrying and crusher sites to ensure compliance with operating and environmental regulations. In May 2015, the Ministry of Environment and Water shut down fourteen plants for violating the regulations.

In its Nationally Determined Contribution (NDC) under the December 2015 UNFCC Paris Climate Agreement, the UAE committed to "improve carbon abatement and increase resource efficiency" in its oil and gas sector. Abu Dhabi, in particular, is taking steps to reduce greenhouse gas (GHG) emissions from its oil and gas industry. According to the 2014 Abu Dhabi Air Quality Policy Brief, less than five percent of the emirate's oil and gas facilities were implementing "effective emissions management systems" in 2013. Abu Dhabi's goal is to increase that amount to seventy percent by 2018 and 100 percent by 2030. Separately, Dubai created a Carbon Abatement Committee comprised of representatives from a variety of the emirate's public organizations to provide recommendations for the city's carbon reduction efforts. In 2014, the Committee endorsed a plan to decrease Dubai's carbon emissions by 16 percent over the next six years, in line with the Vision 2021 National Agenda.[422]

The UAE government's increased emphasis on GHG emissions reduction and climate variability mitigation after the Paris Agreement should produce meaningful opportunities for U.S. companies.

Key Technologies in Demand:
- Wet and dry scrubbers
- Carbon injection systems for reduction in mercury and organics
- Particulate matter control systems (particularly new bagging 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
- Carbon Capture Utilization and Storage (CCUS) technologies

Power Plant Emissions Reduction

According to the 2016 World Bank Little Green Data Book, 100 percent of the 110 billion kilowatt hours of electricity generated by the UAE was produced using fossil fuels,[423] largely natural gas. All of the country's currently installed capacity of 27 Gigawatts (GW) is being utilized. Electricity demand has increased at a rate of approximately 8 percent per year since 2007, commensurate with the country's rapid industrial and population growth.[424] To meet rapidly rising demand, the government is investing heavily in its energy infrastructure while at the same time aiming to reduce its dependence on gas-fired generation. The 2012 Dubai Electricity and Water Authority's (DEWA) capital expenditure plan sets a

goal for power generation capacity to triple to 22 GW by 2017. DEWA's current installed capacity is 9,656 Megawatts (MW). It is working to increase that capacity to 10,356 MW with the completion of the M-Station expansion in 2018.[425] Dubai's Integrated Energy Strategy 2030 states that by 2030, natural gas will provide 71 percent of the emirate's total power output, while twelve percent will come from nuclear sources, twelve percent from "clean" coal and five percent from solar energy. In April 2014, DEWA allocated $3.5 billion in funding for a new 1,200 MW "clean"-coal power plant, which is likely to be the largest such plant in the Gulf region by the time it is completed in 2021.[426]

The UAE Energy Plan 2050 aims to cut carbon dioxide emissions by seventy percent, increase clean energy use by fifty percent and improve energy efficiency by forty percent by the middle of the century.[427] The strategy aims to invest AED 600 billion (about $163 billion) to meet demands for energy, ensure sustainable economic growth, and result in savings of AED 700 billion (about $190 billion).[428] The energy equation targeted by the Plan is as follows: 44 percent clean energy, 38 percent gas, twelve percent clean coal and six percent nuclear.[429]

The government's interest in sustainable growth, together with the increase in installed capacity, should generate opportunities for U.S. companies, particularly in Dubai and Abu Dhabi emirates.

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

WASTE MANAGEMENT AND RECYCLING

Solid Waste and Recycling

The UAE's *per capita* solid waste generation rate is among the highest in the world. Local authorities typically coordinate solid waste management. Of the 26 million tons of waste collected in 2012, the majority ended up in landfills or dumpsites.[430] About two-thirds, or seventeen million tons, of the total, was generated by construction and demolition (C&D), and nearly one-quarter (6.2 million tons) was comprised of municipal solid waste (MSW).

Recycling is a relatively new concept in the UAE as a whole. The recovery rate of municipal solid waste in 2014 was just 14.08 percent nationwide.[431] Over the past few years, however, several initiatives have been put into place to create the required infrastructure for recycling and to get the public involved. As part of its Green Growth Strategy, the UAE government aims to achieve a 75 percent recovery rate and 0.9 kg of *per capita* municipal waste generation per day by 2021.[432] Abu Dhabi has set a goal to divert more than eighty percent of solid waste from landfill by 2018 and to increase the percentage of waste that is disposed of in sanitary landfills from less than twenty percent in 2013 to 100 percent by 2018.[433] In 2015, the municipality's waste management authority, Tadweer, the Center of Waste Management-

Abu Dhabi, announced a targeted, ambitious 25-year recycling plan, the first of its kind in the region.[434] It hopes to reduce the generation per capita to 1.5 kg per day.

Waste-to-energy (WtE) is another area of nascent interest in the UAE. A new WtE facility in Abu Dhabi Industrial City is scheduled to begin operating this year.[435] In 2016, Sharjah emirate also announced plans to set up one of the world's largest WtE facilities, which will employ gasification technology. Upon completion, the facility is set to process 500,000 tons of waste per year and generate eighty megawatts of energy.[436] In addition, Sharjah partnered with Abu Dhabi to build a new WtE plant to process 300,000 tons of waste to generate thirty megawatts of energy.[437] Dubai is also planning to build a WtE facility that it expects will be operational by 2020.[438] 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 WtE solutions should give due attention to air pollution and climate risks.

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

Hazardous Waste Management

Abu Dhabi and Dubai generate about 43 percent and 36 percent, respectively, of the approximately 80,000 tons of hazardous waste produced in the UAE annually.[439] That total is likely to grow as the country diversifies its economy going forward. The pharmaceuticals, plastic, pulp and paper and fertilizer industries typically send their waste to municipal landfills, which are not set up to manage it safely and efficiently. Only two landfills – one in Dubai (Jebel Ali) and one near Abu Dhabi – are currently designated to handle hazardous waste.[440] However, anticipated increase in the quantity of hazardous liquid waste has led to the development of hazardous waste treatment plants. A new treatment plant to be commissioned by the end of 2017 is expected to handle 200 cubic meters per three shifts per day of hazardous liquid waste, including acidic, alkaline and oily waste and wastewater.[441]

In close coordination with the U.S. Commercial Service in Abu Dhabi, in April 2016 a HazMat working committee made up of fifteen government agencies and led by the Environment Agency Abu Dhabi visited the United States to look at the U.S. HazMat model and roll out this model in the UAE at the federal level.

The oil and gas sector does process some of the hazardous waste it generates, but much of the industry's processing equipment is aging and does not meet international environmental standards. The UAE government is in the process of updating its hazardous waste management regulations, which should offer opportunities for U.S. solution providers.

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

WATER AND WASTEWATER TREATMENT

Key themes and priorities for water and wastewater in the emirates include promoting the development of Integrated Water and Power Plants (IWPPs), transitioning thermal desalination to reverse osmosis technologies, building out the wastewater treatment network, promoting wastewater treatment and reuse and increasing freshwater efficiency with smart technology.

Budgetary declines related to low oil prices have led to a corresponding decline in the number of projects under development. Recent projects include the Jebel Ali STP Phase 2 (expected completion in 2018), Al Zawra 3 SWRO plant, Ajman Fujairah 3 IWPP and Fujairah Fresh Water SWRO,[442] Jebel Ali SWRO, and Sewerage Network Upgrade Project Phase 5.[443]

Budget woes are also reigniting interest in Public Private Partnerships (PPPs). With so called independent water projects (IWPs) in the gulf region, UAE's Federal Electricity and Water Authority (FEWA), plans to develop a desalination plant with a capacity of 200,000 cubic meters per day in Umm al Quwain utilizing a private or semi-private contract model.[444]

Municipal Wastewater Network and Plant Development

Municipal water and wastewater tenders originate from four major providers in the emirates: Abu Dhabi Water & Electricity Authority (ADWEA), Dubai Electricity & Water Authority (DEWA), Sharjah Electricity & Water Authority (SEWA) and the Federal Electricity and Water Authority (FEWA), which services the emirates of Ajman, Ras Al Khaimah, Umm Al Quwain and Fujairah.[445]

Developing and expanding wastewater collection and treatment networks are major pillars in the effort to manage scarce water resources. Strategic Tunnel Enhancement Programme (STEP), a widespread gravity-driven hydraulic wastewater network, is one of the crucial mega projects in the Abu Dhabi 2030 Plan that is working to address this priority. Led by the Abu Dhabi Sewerage Services Company (ADSSC), the objective of the project is to increase the waste water collection and treatment from nearly 450,000 cubic meters to 800,000 cubic meters of wastewater a day.[446] Once the network is in place, treatment capacity, and corresponding projects to enable it, should expand to meet the 350,000 cubic meters per day of additional wastewater. The pipelines are expected to come online in the first quarter of 2019, enabling Abu Dhabi to collect and recycle 100percent of its wastewater.[447] The project triples the length of the country's sewerage network, at a cost of $1.6 billion.[448] The local office of Austria's ILF Consulting Engineers has been awarded a contract for consultancy services for the fifth phase of Abu Dhabi's sewerage network upgrade.[449]

Similarly in Dubai, the Jebel Ali STP, Phase 2 Project was announced in 2016 to develop a sewage treatment plant with a capacity of 375,000 cubic meters per day valued at $380 million. The plant will feature UV disinfection, activated sludge treatment, anaerobic digestion and methane gas generation technologies. The Dubai Electricity & Water Authority (Dewa) has invited contractors to submit an expression of interest (EOI) and prequalify for a planned new desalination plant in the Jebel Ali area of the UAE.[450] The planned reverse osmosis (RO) plant will have a capacity of forty million imperial gallons a day (MIGD).[451] According to the documents, the prequalification process will run alongside the expression of interest (EOI) stage. Contractors have been invited to submit EOIs by 24 January. The plant is due to be operational by April 2020.[452]

Sharjah announced plans to expand its largest power generation and water desalination plant, Hamriyah. Converting from an open-cycle plant to a combined-cycle facility, it will reach a capacity of 2500 MW of electricity and 140 million gallons of water per day.[453]

The UAE's Ministry of Climate Change and Environment (MOCCAE) has invited companies to submit Request for Proposals (RFP) for the construction of a Wastewater Treatment Plant (WWTP) in Umm Al Quwain emirate. Dubai Municipality has allocated AED 7 billion ($1.91 billion) for infrastructure development, large high-priority projects, and health and environment services.

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

Drinking Water and Desalination

Drinking water and other fresh water needs are met almost entirely by desalination in the UAE, and capacity is expected to increase steadily in the near-term, totaling 96.5 percent of all water produced by 2019[454] from a base of 42 percent in 2014.[455] UAE has seventy major desalination plants accounting for fourteen percent of the world's total production of desalinated water.[456] Much of UAE's capacity, however, relies on energy intensive thermal desalination technologies belying an increasing need to transition to energy efficient desalination technologies. Concerns regarding the energy intensity of thermal desalination and its incongruence with national environmental plans are driving the shift toward reverse osmosis. There recently has been talk from Abu Dhabi Water & Electricity Authority (ADWEA) officials of a potential move to convert half of Abu Dhabi's desalination capacity from thermal to membrane technology within the next five years.[457] The Abu Dhabi government intends to employ the use of membrane technology, which will require new skills and equipment used to produce desalinated water. This will open up opportunities for companies that can meet these needs.[458]

The private sector plays an active role in the provision of desalinated water, mainly through its participation in the development of independent water and power projects.[459] A joint venture between Utico Middle East and Spanish energy firm *Grupo Cobra* announced in 2015 plans to construct an AED 719 million ($196 million) water desalination plant in Ras Al Khaimah.[460] This plant will be the world's largest privately financed independent desalination plant.[461]

Correspondingly, efficient energy and resource management is a major trend in the UAE desalination market. Efforts include shifting existing capacity from thermal to reverse osmosis technology platforms, developing energy-efficient and renewable energy based desalination capabilities, a renewed focus on Integrated Water and Power Plant (IWPP) development and exploring ways to manage saline waste streams. The scope of opportunity during this transition is vast, implementing reverse osmosis technologies where thermal desalination currently predominates would translate to nearly two million cubic meters per day of new reverse osmosis capacity in UAE.[462]

Similarly, the integrated water and power plant (IWPP) market,[463] where desalinated water is produced using excess heat from power generation, is nascent but growing in UAE. The marquee IWPP project is the Fujairah 3 IWPP with a desalination capacity of 318,220 cubic meters per day and valued at $373.9 million.[464] Another key priority is the development of solar-powered desalination technology.[465] A series of demonstration projects is ongoing through Abu Dhabi's Masdar suite of sustainability programs.[466] U.S. technology providers that can demonstrate innovative and energy efficiency desalination technologies through UAE pilot programs, such as those that take place through Masdar, may benefit in the long term from early market entry.

Finally, the saline waste products from desalination are another key priority for which the government is seeking a technological solution. For some time, the saline wastes have been discharged into the Arabian Gulf, and the resulting increased salinity has harmed the local marine environment and impacted fisheries productivity.[467]

Key Technologies in Demand:

- Engineering and design services
- Monitoring equipment
- Production control system
- Non-revenue water control software
- Membranes
- Advanced filtration
- Low-loss distribution equipment
- Storage equipment
- Advanced filtration
- Membrane filtration
- Reverse osmosis
- UV disinfection
- Ion exchange technology

- Saline waste treatment, reuse and disposal

Process and Produced Water
The UAE's growing manufacturing base coupled with its focus on sustainability is driving investment in efficient process and industrial wastewater treatment technologies. High-end manufacturing in electrical machinery, aerospace, biotechnology, telecommunications, pharmaceuticals, aerospace and healthcare will continue to create demand for ultra-pure treatment technologies for process water. The UAE also hosts a large and growing aluminum and steel production industry,[468] which correspondingly drives demand for wastewater treatment and reuse technologies.

Key Technologies in Demand:
- Engineering and design
- Monitoring equipment
- Membranes
- Advanced filtration
- UV disinfection
- Ion exchange technology
- Secondary wastewater treatment
- Sludge treatment technologies
- Reuse technologies

ENVIRONMENTAL CONSULTING AND ENGINEERING
Any business whose operations may affect the environment must obtain a permit or license, which will only be granted after an Environmental Impact Assessment (EIA) has been completed and approved. After approval, the licensee must comply with the strict terms of the license. Any licensed entity that violates the terms of the license will be subject to a fine of between AED 200,000 and 500,000 and a sentence of imprisonment of between two and five years.[469] This prohibition applies to drilling, exploring, testing, extracting and production oil or gas.[470]

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

ETWG AGENCY INITIATIVES AND PROGRAMS
U.S. Environmental Solutions Toolkit
The Toolkit compiles the U.S. Environmental Protection Agency's (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.

Power-Gen International Buyer Program (IBP)
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 to encourage foreign participation in the show. This platform is leveraged to discuss policies and exchange technical

information regarding power plant emissions control with Emirati participants and to foster business relationships between Emirati end-users and U.S. emissions control providers.

WasteExpo IBP
WasteExpo, 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 Emirati participants and to introduce Emirati 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 International Buyer Program, leads a delegation of Emirati 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

UAE Environmental Regulations
https://www.ead.ae/Documents/PDF-Files/Federal-Law-No.-24-of-1999-Eng.pdf

UAE Green Growth Strategy
http://www.moew.gov.ae/assets/e3bd136a/uae-state-of-green-economy-report-2014.aspx

UAE Vision 2021
www.vision2021.ae/en

Dubai Electricity and Water Authority
https://new.dewa.gov.ae/en

Abu Dhabi Electricity and Water Authority
http://www.adwea.ae/

Abu Dhabi Waste Management
https://www.abudhabi.ae/

Dubai waste management
https://www.dm.gov.ae/wps/

Environment Agency Abu Dhabi
https://www.ead.ae/

Ministry of Environment and Water Calendar of Events
http://www.moew.gov.ae/en/media-centre/environmental-events.aspx

World Future Energy Summit, Abu Dhabi (WFES), Abu Dhabi
www.worldfutureenergysummit.com

WETEX, Dubai
www.wetex.ae

Appendix 1: Environmental Technologies Top Markets Ranking

	Water	Δ	2017	2016	Air	Δ	2017	2016	Waste	Δ	2017	2016	Composite Environmental Technologies Score	Δ	2017	2016	
1	China	↔	44.0	44.9	China	↑	51.1	47.4	China	↔	4.9	7.7	China	↔	100.0	100.0	1
2	India	↔	15.7	16.3	Mexico	↑	45.7	26.2	Brazil	↑	4.5	3.6	Mexico	↔	58.2	37.1	2
3	Brazil	↑	15.2	10.5	Brazil	↑	19.9	15.3	Saudi Arabia	↑	4.0	3.0	Brazil	↑	39.5	29.4	3
4	Saudi Arabia	↑	13.1	12.0	Korea	↑	19.1	18.3	India	↑	4.0	2.7	India	↓	32.5	31.7	4
5	United Arab Emirates	↓	11.5	15.8	Turkey	↑	16.8	17.4	Indonesia	↓	3.8	4.2	Saudi Arabia	↑	31.0	25.9	5
6	Mexico	↑	11.0	9.5	Saudi Arabia	↑	13.9	10.9	Thailand	↓	3.0	3.3	Korea	↓	28.0	27.3	6
7	Thailand	↑	8.0	6.6	India	↑	12.7	12.8	United Arab Emirates	↓	2.7	.	Indonesia	↔	23.9	23.4	7
8	Indonesia	↔	8.0	9.3	Indonesia	↑	12.0	9.9	Vietnam	↔	2.4	2.1	Turkey	↓	21.2	22.1	8
9	Colombia	↑	7.2	3.9	Poland	↑	11.5	8.6	Pakistan	↓	2.1	3.7	Vietnam	↑	18.9	12.9	9
10	Korea	↔	7.0	6.9	Vietnam	↑	10.4	7.3	Egypt	↓	1.8	1.9	United Arab Emirates	↓	18.7	15.8	10
11	Peru	↔	6.2	6.5	Algeria	↑	6.4	5.1	Korea	↓	1.8	2.1	Poland	↓	18.0	17.7	11
12	Vietnam	↑	6.2	3.4	Egypt	↑	5.6	4.4	Turkey	↓	1.8	1.8	Thailand	↓	12.3	13.6	12
13	Poland	↓	6.0	8.4	United Arab Emirates	↓	4.6	.	Mexico	↓	1.5	1.4	Algeria	↑	11.6	6.9	13
14	Chile	↑	5.9	4.6	Singapore	↑	4.2	4.1	Belarus	↓	1.4	.	Malaysia	↑	10.6	9.2	14
15	Malaysia	↑	5.8	4.0	Malaysia	↑	4.0	3.6	Argentina	↔	1.1	1.0	Singapore	↓	10.3	10.5	15
16	Singapore	↓	5.5	5.7	Israel	↑	3.2	2.6	Namibia	↓	1.0	.	Colombia	↑	10.3	9.2	16
17	Algeria	↑	4.8	1.8	Peru	↑	3.1	3.1	Papua New Guinea	↓	1.0	.	Egypt	↔	10.2	9.7	17
18	Argentina	↓	4.4	5.4	Argentina	↑	3.1	4.1	Malaysia	↓	0.8	1.6	Peru	↓	10.0	10.2	18
19	Kazakhstan	↑	3.7	4.1	Slovakia	↓	2.9	4.6	Qatar	↑	0.8	0.0	Chile	↑	8.9	7.6	19
20	Israel	↓	3.5	5.7	Kazakhstan	↓	2.7	5.9	Mozambique	↓	0.8	.	Argentina	↓	8.6	10.5	20
21	Oman	↓	3.0	15.3	Nigeria	↓	2.5	3.8	Colombia	↓	0.8	0.9	Israel	↓	6.8	8.5	21
22	Bangladesh	↑	3.0	2.7	Chile	↑	2.3	2.4	Singapore	↓	0.7	0.6	Kazakhstan	↓	6.7	10.5	22
23	Nigeria	↑	3.0	2.2	Colombia	↓	2.3	4.4	Peru	↓	0.7	0.7	Nigeria	↑	5.5	6.4	23
24	Ghana	↑	2.9	2.5	Oman	↓	2.0	.	Bangladesh	↑	0.7	0.4	Oman	↓	5.4	15.6	24
25	Egypt	↓	2.8	3.4	Thailand	↓	1.3	3.8	Azerbaijan	↑	0.7	0.2	Bangladesh	↑	4.8	4.3	25
26	Turkey	↓	2.6	2.8	Guatemala	↑	1.2	0.1	Chile	↓	0.6	0.5	Qatar	↑	4.5	0.5	26
27	Qatar	↑	2.6	0.1	Bangladesh	↑	1.1	1.2	Bolivia	↑	0.5	0.0	Pakistan	↓	4.5	6.8	27
28	Pakistan	↓	2.3	2.5	Qatar	↑	1.1	0.3	Poland	↓	0.5	0.7	Belarus	↓	4.4	4.0	28
29	Morocco	↓	2.3	2.4	Belarus	↓	1.1	1.3	Algeria	↓	0.5	.	Slovakia	↓	3.9	5.7	29
30	Belarus	↓	1.9	2.7	Kuwait	↑	1.1	0.2	Hong Kong	↓	0.4	0.4	Ghana	↓	3.4	3.0	30
31	Macedonia	↔	1.7	1.7	Ecuador	↑	1.1	1.0	Oman	↓	0.4	0.3	Morocco	↓	3.2	3.4	31
32	Ecuador	↑	1.6	1.1	Dominican Republic	↓	1.0	1.9	Morocco	↓	0.4	0.6	Hong Kong	↓	2.9	2.9	32
33	Hong Kong	↓	1.5	2.0	Ukraine	↓	1.0	2.6	Panama	↓	0.3	0.3	Ecuador	↑	2.8	2.4	33
34	Ethiopia	↑	1.4	0.5	Hong Kong	↑	1.0	0.5	Kazakhstan	↓	0.3	0.6	Papua New Guinea	↑	2.2	1.0	34
35	Trinidad and Tobago	↑	1.3	0.9	Libya	↓	0.9	.	Jordan	↓	0.3	0.2	Guatemala	↓	2.1	.	35
36	Philippines	↑	1.3	0.7	Armenia	↑	0.6	0.2	Zambia	↓	0.2	0.3	Ethiopia	↑	2.1	1.0	36
37	Bolivia	↑	1.2	0.5	Bahrain	↓	0.5	0.7	Sri Lanka (Ceylon)	↓	0.2	0.2	Macedonia	↑	1.9	1.9	37
38	Rwanda	↑	1.1	0.5	Cambodia (Kampuchea)	↑	0.5	0.0	Ethiopia	↓	0.2	0.2	Bolivia	↑	1.9	0.8	38
39	Tunisia	↔	1.0	0.8	Morocco	↔	0.5	0.4	Ecuador	↓	0.2	0.3	Philippines	↔	1.7	1.5	39
40	Slovakia	↓	1.0	1.1	Ethiopia	↓	0.5	0.4	Tunisia	↓	0.2	0.2	Trinidad and Tobago	↑	1.7	1.4	40
41	Portugal	↑	0.9	0.7	Philippines	↓	0.5	0.6	Madagascar	↓	0.2	.	Mozambique	↓	1.7	1.6	41
42	Uruguay	↑	0.9	0.7	Papua New Guinea	↑	0.4	0.3	Bahrain	↓	0.2	0.2	Azerbaijan	↓	1.6	3.0	42
43	Guatemala	↓	0.8	1.0	Azerbaijan	↓	0.4	1.2	Kenya	↓	0.2	0.1	Namibia	↑	1.6	0.3	43
44	Panama	↓	0.8	1.7	Uruguay	↑	0.4	0.2	Uganda	↑	0.1	0.0	Kuwait	↔	1.5	1.1	44
45	Papua New Guinea	↑	0.8	0.7	Mozambique	↓	0.4	1.2	Ghana	↓	0.1	0.1	Ukraine	↓	1.5	3.7	45
46	Gabon	↑	0.7	0.3	Trinidad and Tobago	↓	0.3	0.4	Paraguay	↓	0.1	0.2	Panama	↓	1.4	2.2	46
47	Sri Lanka (Ceylon)	↑	0.7	0.4	Kenya	↑	0.3	0.2	Georgia	↑	0.1	0.0	Tunisia	↓	1.4	1.4	47
48	Mongolia	↑	0.6	0.2	Ghana	↓	0.3	0.3	Uruguay	↓	0.1	0.2	Uruguay	↓	1.4	1.1	48
49	Congo	↑	0.6	0.4	Zambia	↓	0.3	0.6	Congo	↑	0.1	0.0	Dominican Republic	↓	1.2	2.3	49
50	Ukraine	↓	0.6	0.9	Mongolia	↓	0.3	0.3	Gabon	↓	0.1	.	Rwanda	↑	1.2	0.5	50

Appendix 2: Methodology

The *Environmental Technologies Top Markets Report* was developed to facilitate the identification of 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 ten-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 as a whole.

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 ten-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 ten percent 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 media category to provide a media-based market score and similarly adding together the media 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 4 percent annually.

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.

Environmental Technologies Country Case Studies

After the top ten 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 non-profit 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. Environmental Protection Agency (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.

Appendix 3: Citations

[1] Environmental Business International Data Pack, 2016.
[2] In 2014 these were: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, and United Kingdom.
[3] Environmental Business International Data Pack, 2016.
[4] Environmental Business International Data Pack, 2016.
[5] Environmental Business International Data Pack, 2016.
[6] Environmental Business International Data Pack, 2016.
[7] Environmental Business International Data Pack, 2016.
[8] The Wall Street Journal. *China Real Time.* " Beijing's Bad Air Days; Finally Counted". April, 14, 2014.
[9] Bloomberg New Energy Finance. "Water Leadership Forum" October 23-24, 2012.
[10] Bloomberg New Energy Finance. "Water Leadership Forum" October 23-24, 2012.
[11] OEEI estimates based on publicly reported venture capital deals.
[12] United States Trade Representative. Accessed 2/6/2015. https://ustr.gov/trade-agreements/other-initiatives/environmental-goods-agreement.
[13] EBI Data Pack, December 2016.
[14] De Boer, Dimitri and Douglas Whitehead. "The future of public interest litigation in China". China Dialogue. https://www.chinadialogue.net/article/show/single/en/9356-Opinion-The-future-of-public-interest-litigation-in-China. Accessed April 14, 2017.
[15] Davies, Paul and Andrew Westgate. "China Focuses on Criminal Enforcement of Environmental Laws." Latham & Watkins LLP. January 12, 2017. http://www.latham.london/2017/01/china-focuses-on-criminal-enforcement-of-environmental-laws/. Accessed March 11, 2017.
[16] See Huaxia, Xinhua Insight: Tightened Supervision Intensifies China's Pollution Fight.
[17] Weining Hu, Cracking Down on Pollutants: Comprehending China's New Environmental Protection Tax Law, China Briefing, Feb. 21, 2017, http://www.china-briefing.com/news/2017/02/21/comprehending-china-new-environmental-protection-tax-law.html
[18] See Environmental Protection Tax Law of the PRC, Dec. 25, 2016, translation available at: http://www.chinalawtranslate.com/2016%E5%B9%B4%E4%B8%AD%E5%8D%8E%E4%BA%BA%E6%B0%91%E5%85%B1%E5%92%8C%E5%9B%BD%E7%8E%AF%E5%A2%83%E4%BF%9D%E6%8A%A4%E7%A8%8E%E6%B3%95/?lang=en
[19] Gretel Kauffman, "China Premier Promises to Make 'Skies Blue' Again", Christian Science Monitor, Mar. 6, 2017, http://www.csmonitor.com/Environment/2017/0306/China-premier-promises-to-make-skies-blue-again
[20] Tom Phillips, "China Ratifies Paris Climate Change Agreement Ahead of G20, September", The Guardian, September 3, 2016, https://www.theguardian.com/world/2016/sep/03/china-ratifies-paris-climate-change-agreement
[21] Coral Davenport, "Nations, Fighting Powerful Refrigerant that Warms Planet, Reach Landmark Deal, New York Times, Oct. 15, 2016.
[22] Seligsohn, Deborah, Hsu, Angel, How China's 13th Five-Year Plan addresses Energy and the Environment, China File, March 10, 2016, https://www.chinafile.com/reporting-opinion/environment/how-chinas-13th-five-year-plan-addresses-energy-and-environment
[23] Zhao, Lijian; Tonny Xie; Jenny Tang. "How China's New Air Law Aims to Curb Pollution". December 30, 2015. *Chinadialogue.net*. https://www.chinadialogue.net/article/show/single/en/8512-How-China-s-new-air-law-aims-to-curb-pollution. Accessed 1/28/16.
[24] Cai, Jingjing and Joyce Tang. "Will China's New Air Law Solve its Pollution Crisis?". *New Security Beat*. China Environment Forum. November 25, 2015. http://www.newsecuritybeat.org/2015/11/chinas-air-law-solve-pollution-crisis/. Accessed 1/28/16.
[25] Gretel Kauffman, "China Premier Promises to Make 'Skies Blue' Again", Christian Science Monitor, Mar. 6, 2017, http://www.csmonitor.com/Environment/2017/0306/China-premier-promises-to-make-skies-blue-again
[26] Ye, Qi and Lu, Jiaqi. "The end of coal-fired growth in China." *Brookings*. August 4, 2016. https://www.brookings.edu/blog/up-front/2016/08/04/the-end-of-coal-fired-growth-in-china/. Accessed 10/3/2016.
[27] U.S. Energy Information Agency. China Report. May 2015.
[28] "China Seeks to Export Power Amid Signs It Built Too Many Coal-Fired Power Plants". Gold Dust. November 2016
[29] Forsythe, Michael. "China Curbs Plans for More Coal-Fired Power Plants" *The New Tork Times*. April 25, 2016.
[30] Aibing Guo. "China Says It's Going to Use More Coal, With Capacity Set to Grow 19%". *Bloomberg*. November 2016. https://www.bloomberg.com/news/articles/2016-11-07/china-coal-power-generation-capacity-may-rise-19-in-5-year-plan. Accessed March 13, 2017.
[31] Gretel Kauffman, "China Premier Promises to Make 'Skies Blue' Again", Christian Science Monitor, Mar. 6, 2017, http://www.csmonitor.com/Environment/2017/0306/China-premier-promises-to-make-skies-blue-again
[32] GoldDust Newsletter, December 2015, McIlvaine Company
[33] "Mercury Control Program in China is Moving Forward." *Gold Dust*. May 2016.
[34] "The Market for Mercury Removal Will be Growing Robustly in the Next Decade." *Gold Dust*. January 2016.
[35] PRC Law on Air Pollution Prevention and Control, NPC Version (Aug 2015)
[36] PTI, "Beijing Bans Higher Emission Vehicles to Control Air Pollution" Economic Times, Feb. 14, 2017, http://economictimes.indiatimes.com/news/international/world-news/beijing-bans-higher-emission-vehicles-to-control-air-pollution/articleshow/57140224.cms
[37] U.S. Environmental Technology Trade Advisory Committee (ETTAC) member input, January 2016

[38] Meng Meng and Aizhu Chen, "Beijing to Adopt China's Tightest Fuel Standards by Jan: Xinhua," Reuters, May 23, 2016. *http://www.reuters.com/article/us-china-fuel-quality-idUSKCN0YE18T*; International Council on Clean Transportation, "China V Gasoline and Diesel Fuel Quality Standards," January 2014. *http://www.theicct.org/sites/default/files/publications/ICCTupdate_ChinaVfuelquality_jan2014.pdf*.
[39] Hoornweg, Daniel and Perinaz Bhada-Tata. "What A Waste: A Global Review of Solid Waste Management". World Bank. March 2012.
[40] Dorn, Thomas, Michael Nelles and Sabine Flamme. "Circular Economy in China". International Solid Waste Association. 2010
[41] China Resource Comprehensive Utilization Annual Report (2014), National Development and Reform Commission, http://www.sdpc.gov.cn/xwzx/xwfb/201410/W020141009609573303019.pdf
[42] "Beijing includes garbage disposal, recycling in urban plan". *China Economic Net*. September 15, 2016. http://en.ce.cn/main/latest/201609/16/t20160916_15955682.shtml
[43] Chinese Ministry of Environmental Protection, 2010.
[44] MarketWatch.com. "Inside China's Grand Plan to Fight Water Pollution". Accessed 1/13/2016.
[45] The State Council of the People's Republic of China. *Action Plan for Water Pollution Prevention.* April 2, 2015.
[46] MarketWatch.com. "Inside China's Grand Plan to Fight Water Pollution". Accessed 1/13/2016.
[47] Stormwater Report. "China Releases Water Action Plan". Water Environment Federation. May 29, 2015
[48] Global Water Intelligence, Global Water Market 2017, Volume 5: Asia Pacific. Page 1558
[49] "China To Create Soil Pollution Prevention Law". *China Daily*. March 8, 2017. http://www.chinadaily.com.cn/china/2017twosession/2017-03/08/content_28479653.htm. Accessed March 14, 2017.
[50] Business Monitor International, Water Industry Forecast, 2015.
[51] Global Water Intelligence, Global Water Market 2017, Volume 5: Asia Pacific. Page 1526.
[52] Global Water Intelligence Project Tracker with OEEI estimates.
[53] Global Water Intelligence Project Tracker with OEEI estimates.
[54] CGTI. *The China Greentech Report 2012. Page 152*. Beijing: The China Greentech Initiative, 2012.
[55] CGTI. *The China Greentech Report 2012. Page* 152. Beijing: The China Greentech Initiative, 2012.
[56] Global Water Intelligence, Global Water Market 2017, Volume 5: Asia Pacific. Page 1526.
[57] ibid
[58] Global Water Intelligence, Global Water Market 2017, Volume 5: Asia Pacific, Page 1535
[59] CGTI. *The China Greentech Report 2012. Page* 147. Beijing: The China Greentech Initiative, 2012.
[60] Global Water Intelligence, Global Water Market 2017, Volume 5: Asia Pacific, Page 1535
[61] "Flow Control and Treatment Mining Market top $13 Billion in 2017." *Gold Dust*. March 2016.
[62] CGTI. *The China Greentech Report 2012. Page* 152. Beijing: The China Greentech Initiative, 2012.
[63] Global Water Intelligence Project Tracker with OEEI estimates.
[64] Zhang, Jiangyao, Foreign Commercial Service
[65] Global Water Intelligence, Global Water Market 2017, Volume 5: Asia Pacific. Page 1534
[66] "China To Create Soil Pollution Prevention Law". *China Daily*. March 8, 2017. http://www.chinadaily.com.cn/china/2017twosession/2017-03/08/content_28479653.htm. Accessed March 14, 2017.
[67] Country Commercial Guide 2014.
[68] Action Plan for Prevention and Control of Soil Pollution, 2016.
[69] "China To Create Soil Pollution Prevention Law". *China Daily*. March 8, 2017. http://www.chinadaily.com.cn/china/2017twosession/2017-03/08/content_28479653.htm. Accessed March 14, 2017.
[70] Koleski, Katherine, 2017. The 13th Five-Year Plan. U.S-China Economic and Security Review Commission, pg. 18-19
[71] Beverage & Diamond. Analysis of the Environmental Protection Law. 2015.
[72] SEMARNAT lists funded environmental projects here: http://www.semarnat.gob.mx/apoyos-y-subsidios/pef/beneficiarios. (U.S. Commercial Service Mexico City 2015).
[73] Taryn Fransen, "Mexico Becomes First Developing Country to Release New Climate Plan (INDC)", World Resources Institute, Mar. 31, 2015, http://www.wri.org/blog/2015/03/mexico-becomes-first-developing-country-release-new-climate-plan-indc
[74] Taryn Fransen, "Mexico Becomes First Developing Country to Release New Climate Plan (INDC)", World Resources Institute, Mar. 31, 2015, http://www.wri.org/blog/2015/03/mexico-becomes-first-developing-country-release-new-climate-plan-indc
[75] Medidas Complementarias para Mejorar la Calidad del Aire. July 12, 2016. gob.mx. https://www.gob.mx/gobmx/articulos/medidas-complementarias-para-mejorar-la-calidad-del-aire?idiom=es
[76] Country Commercial Guide 2014.
[77] Plans to Reduce Air Pollution Chokes in Mexico City, Science Daily, Feb. 2, 2017, https://www.sciencedaily.com/releases/2017/02/170202122751.htm
[78] *NORMA Oficial Mexicana de Emergencia NOM-EM-167-SEMARNAT-2016*. June 7, 2016. Diario Oficial de la Federación. http://www.dof.gob.mx/nota_detalle.php?codigo=5440157&fecha=07/06/2016
[79] Medidas Complementarias para Mejorar la Calidad del Aire. July 12, 2016. gob.mx. https://www.gob.mx/gobmx/articulos/medidas-complementarias-para-mejorar-la-calidad-del-aire?idiom=es
[80] Country Commercial Guide 2014.
[81] Commercial Service Mexico, 2015.
[82] Global Water Intelligence. Global Water Market 2017. "The Americas." Vol 2, pg. 451,476
[83] Global Water Intelligence. Global Water Market 2017. "The Americas." Vol 2, pg. 453-454
[84] *Mexico's Water and Wastewater Sector*. Market Intelligence Latin America S.C. October 2013.
[85] *"Mexico - Water Q2 2014*." Business Monitor International (BMI) Industry View. Published: 07 March 2014.
[86] Country Commercial Guide 2014.

[87] Global Water Intelligence. Global Water Market 2017. "The Americas." Vol 2, pg. 457
[88] Country Commercial Guide 2014.
[89] Country Commercial Guide 2014.
[90] The agricultural sector in Mexico uses approximately 77% of the country's water (http://www.conagua.gob.mx/english07/publications/National_Water_Program_2007-2012.pdf)
[91] Global Water Intelligence. Global Water Market 2017. "The Americas." Vol 2, pg. 451
[92] Global Water Intelligence. Global Water Market 2017. "The Americas." Vol 2, pg. 451
[93] Global Water Intelligence. Global Water Market 2017. "The Americas." Vol 2, pg. 455
[94] Global Water Intelligence. Global Water Market 2017. "The Americas." Vol 2, pg. 455
[95] Global Water Intelligence. Global Water Market 2017. "The Americas." Vol 2, pg. 455
[96] Global Water Intelligence. Global Water Market 2017. "The Americas." Vol 2, pg. 455
[97] Global Water Intelligence Project Tracker.
[98] GWI 2017 Market Report Volume 2, P. 456
[99] Global Water Intelligence. Global Water Market 2017. "The Americas." Vol 2, pg. 455\6
[100] Mexico's Environmental Sector, Executive Summary, Market Intelligence Latin America
[101] Latin American Environmental Regulatory Tracker, Beveridge and Diamond. Feb. 2017
[102] See e.g. LGPGIR Article 10.
[103] LGCC Article three, Section II(b)
[104] International Comparative Legal Guides. https://www.iclg.co.uk/practice-areas/environment-and-climate-change-law/environment-and-climate-change-law-2016/mexico. Accessed April 20, 2016
[105] EBI Global Data Pack 2016
[106] From CIA World Factbook, accessed Sept. 16, 2016. July 2016 estimate: 205,823,665.
[107] See OECD Environmental Policy Stringency Index
[108] TMS Post Survey, 2014
[109] TMS Post Survey, 2014.
[110] U.S. Energy Information Administration, *International Energy Statistic 2010.*
[111] Latin American Environmental Regulatory Tracker, Beveridge & Diamond. Feb, 2017
[112] Global Water Market 2017. "The Americas." *Global Water Intelligence,* 2017. Vol. 2, Page 283
[113] See Brazil National Sanitation Plan, December 2013
[114] Global Water Market 2017. "The Americas." *Global Water Intelligence,* 2017. Vol. 2, Page 283
[115] Global Water Intelligence. "The Bid to Maximise Brazil's PPP Potential." *Global Water Intelligence*, April 2012: Vol. 13, Issue 4, Page 30 - 31.
[116] Global Water Intelligence. "Brazil Comes Around to PSP in Water." *Global Water Intelligence.* November 2014. Vol. 15 Issue 11.
[117] Global Water Intelligence. "Brazil Comes Around to PSP in Water." *Global Water Intelligence.* November 2014. Vol. 15 Issue 11.
[118] Wagner, Teresa. "Top Markets Report Post Survey". U.S. Commercial Service, Sao Paolo. 2016.
[119] CS Sao Paolo. TMS Post Survey, 2016.
[120] Global Water Market 2017. "Companies and Markets." *Global Water Intelligence,* 2017. Vol. 1, Page x.
[121] Global Water Market 2017. "The Americas." *Global Water Intelligence,* 2017. Vol. 2, Page 313
[122] OEEI Global Water Pipeline estimates based on Global Water Intelligence project data 2016.
[123] Global Water Market 2017. "The Americas." *Global Water Intelligence,* 2017. Vol. 2, Page 292
[124] Wagner, Teresa. "Top Markets Report Post Survey". U.S. Commercial Service, Sao Paolo. 2016.
[125] Global Water Market 2017. "The Americas." *Global Water Intelligence,* 2017. Vol. 2, Page 301
[126] Global Water Market 2017. "The Americas." *Global Water Intelligence,* 2017. Vol. 2, Page 283.
[127] Institutto Trata Brasil
[128] Stauffer, Caroline. "Drought ends in Brazil's Sao Paulo but future still uncertain." *Reuters*. February 18, 2016. http://www.reuters.com/article/us-brazil-water-idUSKCN0VR1YJ (accessed October 4, 2016).
[129] Brazilian Utility Selets Itron and i20 Water to Reduce Water Loss, Metering and Smart Energy International, Oct. 12, 2016, https://www.metering.com/news/itron-sanasa-i20-non-revenue-water/
[130] Global Water Intelligence. "Desalters." March 2015. Vol 16: Issue 3.
[131] CS Sao Paolo. TMS Post Survey, 2016.
[132] Hatia, Mohseen. "Brazilian Market Water and Wastewater Technology - Xylem." *Brazil - U.S. Business Council.* April 12, 2012. http://www.brazilcouncil.org/sites/default/files/Xylem.pdf (accessed November 20, 2012).
[133] OEEI estimate based on GWI CAGR.
[134] Hatia, Mohseen. "Brazilian Market Water and Wastewater Technology - Xylem." *Brazil - U.S. Business Council.* April 12, 2012. http://www.brazilcouncil.org/sites/default/files/Xylem.pdf (accessed November 20, 2012).
[135] Global Water Intelligence. "Market Profile: Water for Pharmaceuticals." *Global Water Intelligence*, August 2014: Vol. 15, Issue 8, Page 34.
[136] Global Water Intelligence. "Search for Gold in Latin America." *Global Water Intelligence,* August 2014: Vol. 15, Issue 8, Page 12 – 13.
[137] Global Water Intelligence. "Search for Gold in Latin America." *Global Water Intelligence,* August 2014: Vol. 15, Issue 8, Page 12 – 13.
[138] Global Water Intelligence. "Market Profile: Water for Offshore Oil and Gas." *Global Water Intelligence,* October 2014: Vol: 15, Issue 10.
[139] Global Water Intelligence. "Market Profile: Water for Offshore Oil and Gas." *Global Water Intelligence,* October 2014: Vol: 15, Issue 10.

[140] Wagner, Teresa. "Brazil Country Commercial Guide: Environmental Technologies", Sao Paolo. 2016.
[141] Wagner, Teresa. "Brazil Country Commercial Guide: Environmental Technologies", Sao Paolo. 2016.
[142] Latin American Environmental Regulatory Tracker, Beveridge & Diamond. Feb, 2017
[143] Wagner, Teresa. "Top Markets Report Post Survey". U.S. Commercial Service, Sao Paolo. 2016.
[144] Wagner, Teresa. "Top Markets Report Post Survey". U.S. Commercial Service, Sao Paolo. 2016.
[145] TMS Post Survey, 2014.
[146] TMS Post Survey, 2014.
[147] U.S. Commercial Service, *Brazil Country Commercial Guide 2012*.
[148] Forbes Online 2016. http://www.forbes.com/sites/meghabahree/2014/10/16/indian-govt-sets-up-committee-to-review-environmental-laws-not-everyone-is-happy-with-it/#59197b791306
[149] Mitra, Arup Kumar. "India Market Opportunities for Air Pollution Control and Air Quality Monitoring Technology." U.S. Commercial Service, Kokata/India. January 18th, 2017
[150] Mitra, Arup Kumar. "India Market Opportunities for Air Pollution Control and Air Quality Monitoring Technology." U.S. Commercial Service, Kokata/India. January 18th, 2017
[151] At the time of writing, the AQI website was not functioning. From *BBC News*. "India launches air quality index to give pollution information". April 6, 2015.
[152] U.S. Environmental Protection Agency, *Collaboration with India*, accessed May 28, 2013.
[153] U.S. Energy Information Administration, *International Energy Statistic 2010*.
[154] International Energy Agency. World Energy Outlook 2016: India Energy Outlook Special Report. p. 19
[155] "$14 Trillion to be sepnt on Power Plant Equipment and Repairs in the Next 25 Years." *Gold Dust*. June 2016.
[156] International Energy Agency. World Energy Outlook 2016: India Energy Outlook Special Report. p. 32
[157] International Energy Agency. World Energy Outlook 2016: India Energy Outlook Special Report. p. 28
[158] International Energy Agency. World Energy Outlook 2016: India Energy Outlook Special Report. p. 27
[159] Government of India's "Make in India" website. http://www.makeinindia.com/policy/national-manufacturing. Accessed 2/27/2016
[160] "Indian Market for Air Pollution Control Could Exceed $70 Billion Over the Next 7 Years." *Gold Dust*. September 2016.
[161] "India Waivers on Emissions as Power Plants Balk at Price Tag." *Gold Dust*. November 2016.
[162] Mitra, Arup Kumar. "India Market Opportunities for Air Pollution Control and Air Quality Monitoring Technology." U.S. Commercial Service, Kokata/India. January 18th, 2017
[163] "PacifiCorp Webinar 5 on Front End NOx Reduction." *Gold Dust*. September 2016.
[164] Mitra, Arup Kumar. *Waste Expo Market Opportunity Snapshot: India*. U.S. Commercial Service, Kolkata. April 6, 2016.
[165] Solid Waste Management Rules Revised After 16 Years; Rules Now Extend to Urban and Industrial Areas, Press Information Bureau, Government of India, Apr. 5, 2016
[166] "Financing India's Waste Management". *Waste Management World*. November 24, 2015. http://waste-management-world.com/a/financing-indias-waste-management. Accessed 2/27/16
[167] "E-waste management draft rules puts liability on producer: Government". *The Economic Times*. December 7, 2015. http://articles.economictimes.indiatimes.com/2015-12-07/news/68835774_1_e-waste-rules-extended-producer-responsibility-draft-rules. Accessed 2/28/2016
[168] U.S. Commercial Service, *India Commercial Guide*, 2012.
[169] Mitra, Arup Kumar. "Opportunities in Water Sector & Doing Business in India." India Water Market Briefing. U.S. Commercial Service. Water Webinar, March 1st 2017
[170] Bhat, Raveendra. "Water & Wastewater Opportunitites & Challenges in India." Water Technology Opportunities in India Webinar, Marcy 1st, 2017.
[171] Office of Energy and Environmental Industries (OEEI) estimates based on Global Water Intelligence Pipeline Data.
[172] Country Commercial Guide 2014.
[173] Global Water Intelligence. India Market Profile. 2016.
[174] Mitra, Arup Kumar. "Opportunities in Water Sector & Doing Business in India." India Water Market Briefing. U.S. Commercial Service. Water Webinar, March 1st 2017
[175] The World Bank. *World Development Indicators 2015*.
[176] Mitra, Arup Kumar. "Opportunities in Water Sector & Doing Business in India." India Water Market Briefing. U.S. Commercial Service. Water Webinar, March 1st 2017
[177] Global Water Intelligence. India Market Profile. 2016.
[178] Global Water Intelligence. India Market Profile. 2016.
[179] Country Commercial Guide 2014.
[180] ENVIS Centre on Hygiene, Sanitation, Sewage Treatment Systems and Technology, Aug. 12, 2016, http://www.sulabhenvis.nic.in/Database/STST_wastewater_2090.aspx
[181] Global Water Intelligence. India Market Profile. 2016.
[182] Global Water Intelligence. "Bihar Goes in Pursuit of Water PPPs." *Global Water Intelligence*, November 2012: Volume 13 Issue 11.
[183] Global Water Intelligence. *India reveals business model for Ganga PPPs.* January 7, 2016.
[184] Mitra, Arup Kumar. "Opportunities in Water Sector & Doing Business in India." India Water Market Briefing. U.S. Commercial Service. Water Webinar, March 1st 2017
[185] Global Water Intelligence. *India reveals business model for Ganga PPPs.* January 7, 2016.
[186] India's Ministry of Water Resources. River Development & Ganga Rejuvenation, National Mission for Clean Ganga, Sanctioned Projects. http://nmcg.nic.in/sanctioned_projects.aspx, Accessed March 8, 2017

[187] Global Water Intelligence. India Market Profile. 2016.
[188] Opportunities in Indian Water Market, Presentation, PwC.
[189] U.S. Commercial Service Kolkata. *Indian Water & Wastewater Sector - Opportunities for U.S. Companies*, 2014.
[190] Global Water Intelligence. India Market Profile. 2016.
[191] "Market for Water Used in Power Plants is Large and Fast Growing." *Gold Dust*. August 2016.
[192] Global Water Intelligence. "*Global Water Market 2017*". Volume 5. p.1608..
[193] Mitra, Arup Kumar. "Opportunities in Water Sector & Doing Business in India." India Water Market Briefing. U.S. Commercial Service. Water Webinar, March 1st 2017
[194] "Global Construction Market to Grow $8 Trillion by 2030: Driven by China, US and India". *PR Newswire*. November 9, 2015. http://www.prnewswire.com/news-releases/global-construction-market-to-grow-8-trillion-by-2030-driven-by-china-us-and-india-544142522.html. Accessed March 10, 2017.
[195] EBI Global Data Pack 2016
[196] Country Commercial Guide 2014.
[197] Country Commercial Guide 2014.
[198] Country Commercial Guide 2015.
[199] McCullough, D.G. "Saudi Arabia's Green Decree Brings Hopes of Sustainability". *The Guardian*. May 12, 2014
[200] U.S. Foreign Commercial Service – Jeddah, *Industry Sector Analysis: Pollution Control Equipment,* 2010.
[201] "Waste Management Key to Regaining Trust in the Arab World". The World Bank. March 14, 2016. http://www.worldbank.org/en/news/feature/2016/03/14/waste-management-key-to-regaining-public-trust-arab-world. Accessed March 15, 2017
[202] U.S. Foreign Commercial Service – Dharan, *Industry Sector Analysis: Waste Management*, 2010.
[203] Commercial Service Riyadh
[204] U.S. Foreign Commercial Service – Dharan, *Industry Sector Analysis: Waste Management*, 2010.
[205] Country Commercial Guide 2014.
[206] Country Commercial Guide 2014.
[207] Country Commercial Guide 2014.
[208] Country Commercial Guide 2014.
[209] Global Water Intelligence. "Middle East In Brief" Vol 16, Issue 11 (November 2015)
[210] Global Water Intelligence. "Saudi Arabia downplays water tariff restructuring" Vol 17, Issue 1 (January 2016)
[211] Global Water Intelligence, Global Water Market 2017. "Middle East and Africa" Vol 4, pg. 1384
[212] Bardisa, Maxime Serrano. *Saudi Water Sector: Ready, Steady, Privatise.* Research Note, New York: Bloomberg New Energy Finance, 2012.
[213] Country Commercial Guide 2014.
[214] Global Water Intelligence. "Saudis Line Up Riyadh Water Supply Blitz." *Global Water Intelligence*, July 2012: Vol 13, Issue 7.."
[215] Country Commercial Guide 2014.
[216] Global Water Intelligence. "Saudis Line Up Riyadh Water Supply Blitz." *Global Water Intelligence*, July 2012: Vol 13, Issue 7.
[217] Bardisa, Maxime Serrano. *Saudi Water Sector: Ready, Steady, Privatise.* Research Note, New York: Bloomberg New Energy Finance, 2012.
[218] Global Water Intelligence with OEEI estimates.
[219] Global Water Intelligence Project Tracker with OEEI estimates. 2016.
[220] Global Water Intelligence, Global Water Market 2017. "Middle East and Africa" Vol 4, pg. 1379
[221] Bardisa, Maxime Serrano. *Saudi Water Sector: Ready, Steady, Privatise.* Research Note, New York: Bloomberg New Energy Finance, 2012.
[222] Bardisa, Maxime Serrano. *Saudi Water Sector: Ready, Steady, Privatise.* Research Note, New York: Bloomberg New Energy Finance, 2012.
[223] Global Water Intelligence. "A Role For Designer Water." *Global Water Intelligence*, December 2011: Vol 12, Issue 12.
[224] Global Water Intelligence. "Powering Ahead with WWTPs." *Global Water Intelligence*, January 2012: Vol 13, Issue 1.
[225] Bardisa, Maxime Serrano. *Saudi Water Sector: Ready, Steady, Privatise.* Research Note, New York: Bloomberg New Energy Finance, 2012.
[226] Global Water Intelligence Project Pipeline with OEEI estimates.
[227] Global Water Intelligence, Global Water Market 2017. "Middle East and Africa" Vol 4, pg. 1384
[228] Country Commercial Guide 2014.
[229] Global Water Intelligence Project Tracker with OEEI estimates. 2016.
[230] Country Commercial Guide 2015.
[231] USTR. "New Opportunities for U.S. Exporters Under the U.S.-Korea Trade Agreement". https://ustr.gov/trade-agreements/free-trade-agreements/korus-fta. Accessed 2/4/2016.
[232] U.S. International Trade Administration. "The U.S.-Korea Trade Agreement: Opportunities for the U.S. Environmental Goods Sector". April 2011.
[233] USTR. 2015 National Trade Estimate. P. 239
[234] EPA Collaboration with South Korea, EPA International Cooperation, https://www.epa.gov/international-cooperation/epa-collaboration-south-korea
[235] See OECD Environmental Policy Stringency Index
[236] See OECD Environmental Policy Stringency Index

[237] Elise Hu, Korea's Air is Dirty, But it's Not All Close Neighbor China's Fault, NPR, http://www.npr.org/sections/parallels/2016/06/03/478796463/koreas-air-is-dirty-but-its-not-all-close-neighbor-chinas-fault
[238] South Korea Leads List of 2016 Climate Villains, Climate Change News, Apr. 11, 2016, http://www.climatechangenews.com/2016/11/04/south_korea_climate_villains/
[239] NRDC Issue Brief. "Paris Climate Conference: South Korea". November 2015. http://www.nrdc.org/globalwarming/files/paris-climate-conference-SouthKorea-IB.pdf. Accessed 1/30/2016
[240] South Korean Ministry of Environment. http://eng.me.go.kr/eng/web/index.do?menuId=238. Accessed 1/30/2016
[241] Ibid.
[242] Kwaak, Jeyup S. "In Pollution Battle, Seoul Targets BBQs, Spas". *WSJ Blog: Korea RealTime*. February 4, 2014.
[243] South Korean Ministry of Environment.
[244] U.S. Energy Information Agency (EIA). "South Korea Analysis". Updated October 5, 2015. https://www.eia.gov/beta/international/analysis.cfm?iso=KOR. Accessed 1/30/2016.
[245] Elise Hu, Korea's Air is Dirty, But it's Not All Close Neighbor China's Fault, NPR, http://www.npr.org/sections/parallels/2016/06/03/478796463/koreas-air-is-dirty-but-its-not-all-close-neighbor-chinas-fault; see also Jane Chung, "South Korea to shut 10 ageing coal-fired power plants by 2025". Reuters. July 5, 2016. http://www.reuters.com/article/us-southkorea-coal-idUSKCN0ZM06A. Accessed March 15, 2017.
[246] Lim, James. "South Korea Tightens Hazardous Waste Control". *Bloomberg BNA*. July 29, 2015.
[247] South Korean Ministry of Environment. http://www.korea.net/Government/Briefing-Room/Press-Releases/view?articleId=3124. Accessed 1/30/2016.
[248] Park T.; Choi J. (2012). Radioactive Waste Management in Korea (PDF) (Report). Haceteppe University, Korea Atomic Energy Research Institute.
[249] Meeyoung Cho, As Nuclear Waste Piles up, South Korea Faces Storage Crisis, Reuters, Oct. 12, 2014, http://www.reuters.com/article/us-southkorea-nuclear-storage-idUSKCN0I10WR20141012
[250] Editorial on South Korean Nuclear Waste Management, Know Nuclear Waste, May 26, 2016, https://knownuclearwaste.wordpress.com/2016/05/26/editorial-on-south-korean-nuclear-waste-management/
[251] "Global Water Intelligence 2017 Volume 5, P. 1755
[252] Alexander Danilenko, Korea, A Model for Development of the Water and Sanitation Sector, The World Bank Blog, Oct. 26, 2016, http://blogs.worldbank.org/water/korea-model-development-water-and-sanitation-sector
[253] Global Water Intelligence.
[254] Bodhi, C. P.5. Global Water Intelligence
[255] Ministry of the Environment. Major Policies; Waterworks Policy. 2016.
[256] "Water/Waste Water Treatment Market," *Asia Pacific Market Opportunity Profile*. http://www.bceia.com/media/17321/korea-water_wast_water_treatment_market.pdf
[257] "Sewage Management," *Ministry of Environment*. http://eng.me.go.kr/eng/web/index.do?menuId=294&findDepth=1
[258] Ibid.
[259] "POSCO E&C completes Korea's first commercial desalination plant," *PR Newswire*. http://www.prnewswire.co.uk/news-releases/posco-ec-completes-koreas-first-commercial-desalination-plant-281266201.html
[260] "Korea to develop new technology for water desalination: ministry," *The Korea Herald*. http://www.koreaherald.com/view.php?ud=20111004000851
[261] "Nuclear Desalination," *World Nuclear Association*. http://www.world-nuclear.org/info/Non-Power-Nuclear-Applications/Industry/Nuclear-Desalination/
[262] Korea Environment Institute 2012.
[263] The World Bank. (2014). World Bank and Environment in Indonesia. The World Bank. Retrieved 2 November 2015, from http://www.worldbank.org/en/country/indonesia/brief/world-bank-and-environment-in-indonesia
[264] Prakarsa January 2014
[265] Prakarsa January 2014
[266] As of September 2015. "Jokowi calls for acceleration of power plant and refinery projects". *Jakarta Post*. December 3, 2015
[267] U.S. Energy Information Administration (EIA). Indonesia Analysis. October 2015.
[268] U.S. Energy Information Administration: *Indonesia Country Analysis Brief*, 2013
[269] Ibid.
[270] *Gold Dust*. November 2015.
[271] "Jokowi to Launch 35,000 MW Electricity Program". *Tempo.co*. May 4, 2015. http://en.tempo.co/read/news/2015/05/04/056663309/Jokowi-to-Launch-35000-MW-Electricity-Program. Accessed 2/16/2016.
[272] Jensen, Fergus.. "Update 1 – Indonesia to review ambitious power plant programme." *Reuters*. May 13, 2016. http://www.reuters.com/article/indonesia-power-idUSL3N18A2OB (October 7, 2016).
[273] Ministry of Energy and Mineral Resources. "Coal Remains King in Indonesia: Rising Domestic Consumption of Coal." *Indonesia-Investments*. June 14, 2016. http://www.indonesia-investments.com/news/news-columns/coal-remains-king-in-indonesia-rising-domestic-consumption-of-coal/item6926 (October 7, 2016).
[274] "$10 Billion Annual Market for Precipitator Upgrade and Repair." Gold Dust. April 2016.
[275] http://www.epa.gov/international/regions/Asia/indonesiamain.html#learnmore
[276] Madsen, Michael Amdi. "IAEA Impact: Indonesia Works Towards Cleaner Air". May 26, 2015. https://www.iaea.org/newscenter/news/iaea-impact-indonesia-works-towards-cleaner-air. Accessed 2/17/2016.

[277] Madsen. "IAEA Impact".

[278] Madsen. "IAEA Impact".
[279] Ompusunggu, Moses, Regulation on Euro IV Adoption Signed, The Jakarta Post, March 28, 2017, http://www.thejakartapost.com/news/2017/03/28/regulation-on-euro-iv-adoption-signed.html
[280] Jong, Hans Nicholas. Indonesia set to phase out cheap, dirty, low-quality fuel"., *The Jakarta Post*. September 24, 2016
[281] ICCT Briefing.
[282] Jong, Hans Nicholas. "Indonesia in a State of Waste Emergency". *The Jakarta Post.* October 9, 2015.
[283] Jong, Hans Nicholas, Indonesia in State of Waste Emergency, The Jakarta Post, October 9, 2015.
[284] Vaessen, Step, Indonesia: Plastic Tax to Curb Rubbish Dumped in Rivers, Al Jazeera, September 15, 2016.
[285] Langenheim, Johnny, Indonesia Pledges $1bn a Year to Curb Ocean Waste, The Guardian, March 2, 2017.
[286] Ibid.
[287] Amindoni, Ayomi. "Waste-based power plants to be developed in seven cities". *The Jakarta Post*. February 6, 2016.
[288] Elyda, Corry. "Finnish Company to Operate City's First Waste-to-Energy Plant". *The Jakarta Post*. December 17, 2016.
[289] "Waste energy guidebook to be published." *The Jakarta Post*. June 8, 2015.
[290] Global Water Intelligence, Global Water Market 2017. "Asia Pacific" Vol 5. Pg 1626
[291] "World Development Indicators: Indonesia 2015." World DataBank. *The World Bank*. Accessed on October 11, 2016.
[292] Rastogi, Rama. "Indonesia's Innovation in Infrastructure." *Global Water Intelligence*, April 2011: Vol. 12, Issue 8.
[293] Global Water Intelligence, Global Water Market 2017. "Asia Pacific" Vol 5. Pg 1640 & 1649
[294] Global Water Intelligence, Global Water Market 2017. "Asia Pacific" Vol 5. Pg 1639
[295] Bloomberg New Energy Finance, Water Projects Database, 2013.
[296] Saragih, F. (2015). Indonesia Infrastructure Development. Presentation, Singapore. Retrieved from: http://www.iesingapore.gov.sg/~/media/IE%20Singapore/Files/Events/iAdvisory%20Series/Indonesia_29Apr15/420Opportunities20in20Indonesias20PPP20sector.pdf
[297] Global Water Intelligence, Global Water Market 2017. "Asia Pacific" Vol 5. Pg 1631
[298] Global Water Intelligence, Global Water Market 2017. "Asia Pacific" Vol 5. Pg 1631
[299] Global Water Intelligence, Global Water Market 2017. "Asia Pacific" Vol 5. Pg 1631
[300] BAPPENAS. *Pulbic Private Partnerships: Infrastructure Projects Plan in Indonesia.* Government, Jakarta: Ministry of National Development Planning, Republic of Indonesia, 2012.
[301] Commercial Service Jakarta. *Water Industry in Indonesia.* Yulie Tanuwidjaja, 2015.
[302] BAPPENAS. *Pulbic Private Partnerships: Infrastructure Projects Plan in Indonesia.* Government, Jakarta: Ministry of National Development Planning, Republic of Indonesia, 2012.
[303] Global Water Intelligence. Indonesia Country Report. 2016.
[304] Global Water Intelligence, Global Water Market 2017. "Asia Pacific" Vol 5. Pg 1626
[305] Global Water Intelligence, Global Water Market 2017. "Asia Pacific" Vol 5. Pg 1649
[306] The World Bank. "Current Challenges, Future Potential." *Indonesia Economic Quarterly*, 2011: 28 - 39.
[307] U.S. Energy Information Administration, *International Energy Statistic 2010.*
[308] Global Water Intelligence, Global Water Market 2017. "Asia Pacific" Vol 5. Pg 1630
[309] EBI Global Data Pack 2016
[310] European Commission. EU Accession Progress Report 2016.
[311] U.S. Energy Information Administration, *International Energy Statistic 2010.*
[312] Ministry of Environment and Forestry Air Quality Monitoring Stations Web Site. http://www.havaizleme.gov.tr/Default.ltr.aspx. Accessed 2/8/2016.
[313] PMR Project Implementation Status Report. May 2015.
[314] "Turkey". International Carbon Action Partnership. March 14, 2017.
[315] Ministry of Environment and Forestry, 2010 Ankara.
[316] European Commission. EU Accession Progress Report 2016.
[317] Global Water Intelligence, Global Water Market 2017. "Middle East and Africa." Vol.4 pg 1451
[318] U.S. Commercial Service Istanbul.
[319] Business Monitor International, Water Industry Forecast, 2015
[320] Business Monitor International, Water Industry Forecast, 2015
[321] Republic of Turkey. Action Plan on Climate Change 2011 – 2023.
[322] Eionet. Factsheet for Turkey. Accessed 2/20/2015.
[323] U.S. Commercial Service Istanbul
[324] European Commission. EU Accession Progress Report 2016.
[325] Turkish Statistical Institute. December 2015. http://www.turkstat.gov.tr/. Accessed 2/8/2016
[326] World Bank Vietnam GDP Data, latest available.
[327] Nguyen Nhan Hue and Truong Manh Tuan, Industrial Pollution Prevention and Control Policies and Laws – Vietnam's Country Report to the Asian Environmental Compliance and Enforcement Network, September 25, 2015, http://www.aecen.org/sites/default/files/country_report_vietnam.pdf
[328] Id.
[329] Environmental Business International Vietnam Environmental Industry 2011 Case Study, November 2011, Pg 7.
[330] Supra. Industrial Pollution Prevention and Control Policies and Laws – Vietnam's Country Report to the Asian Environmental Compliance and Enforcement Network

[331] See Resolution No. 142/2016/QH13 on Five-Year Social-Economic Development Plan from 2016-2020. http://www.chinhphu.vn/portal/page/portal/English/strategies/strategiesdetails?categoryId=30&articleId=10057712
[332] Viet Nam News, Environmental Protection Violations to Attract $89,000 Fine, Nov. 25, 2016, http://vietnamnews.vn/environment/346941/environmental-protection-violations-to-attract-89000-fine.html#LfDkJqW3VD4ZmLsm.97
[333] Dara O'Rourke, Motivating a Conflicted Environmental State: Community-Driven Regulation in Vietnam, Massachusetts Institute of Technology, P. 10-11
[334] Garber, Jonathan, Vietnam Could be Sowing the Seeds of the Next Crisis, Markets Insider, Dec. 27, 2016.
[335] Ngan Anh, Vietnam May be Better Off Without ODA Loans: Economists, Thanh Nien News, March 29, 2016.
[336] Ngan Anh, Vietnam May be Better Off Without ODA Loans: Economists, Thanh Nien News, March 29, 2016.
[337] Industrial Pollution Prevention and Control Policies and Laws – Vietnam's Country Report to the Asian Environmental Compliance and Enforcement Network
[338] Transparency International, Corruption Perceptions Index 2016, Jan 25, 2017. http://www.transparency.org/news/feature/corruption_perceptions_index_2016#table
[339] Asia News Monitor, Vietnam: Local Communities Weigh Cost of Vietnam's Economic Growth, Oct. 20, 2016.
[340] Asia News Monitor, Vietnam: Local Communities Weigh Cost of Vietnam's Economic Growth, Oct. 20, 2016.
[341] Pham Huong, Air Pollution in Vietnam Cities Hit Unhealthy levels: Government Study, Sep. 30, 2016, http://e.vnexpress.net/news/news/air-pollution-in-vietnam-cities-hit-unhealthy-levels-government-study-3476529.html
[342] Viet Phuong Nguyen, "Vietnam Doubles Down on Coal-fired Power Plants, Despite a Recent Study Warning of the High Environmental Costs," The Diplomat Jan. 25, 2017, http://thediplomat.com/2017/01/with-growth-of-coal-power-plants-vietnams-future-is-grim/
[343] Mai Ngyen and Ho Binh Minh, "Vietnam Abandons Plan for First Nuclear Power Plants", Reuters, Nov. 22, 2016, http://www.reuters.com/article/us-vietnam-politics-nuclearpower-idUSKBN13H0VO
[344] Viet Phuong Nguyen, "Vietnam Doubles Down on Coal-fired Power Plants, Despite a Recent Study Warning of the High Environmental Costs," The Diplomat Jan. 25, 2017, http://thediplomat.com/2017/01/with-growth-of-coal-power-plants-vietnams-future-is-grim/
[345] Viet Phuong Nguyen, "Vietnam Doubles Down on Coal-fired Power Plants, Despite a Recent Study Warning of the High Environmental Costs," The Diplomat Jan. 25, 2017, http://thediplomat.com/2017/01/with-growth-of-coal-power-plants-vietnams-future-is-grim/
[346] "increase Sales to Coal-fired Power Generators." *Gold Dust.* October 2016.
[347] Tuan, T. (2014). *Viet Namupdate on Urban air quality management*. Presentation, Vietnam Environment Administration. Retrieved from: http://cleanairasia.org/wp-content/uploads/portal/files/presentations/vietnam.pdf
[348] Asia News Monitor, Vietnam: Hanoi Air Pollution Hazardous, Mar. 9, 2016.
[349] "Can Hanoi tame its pollution nightmare, the motorbike?" *Asia Climate Journal*. October 9, 2014. http://climate-journal.asia/motorbikes-make-space-for-bicycles-in-hanoi-vietnam/. Accessed April 18, 2016.
[350] "Can Hanoi tame its pollution nightmare, the motorbike?" *Asia Climate Journal*. October 9, 2014. http://climate-journal.asia/motorbikes-make-space-for-bicycles-in-hanoi-vietnam/. Accessed April 18, 2016.
[351] "Euro 4 Emission Standard Vehicles May not Have Fuel in 2017" Vietnam Net Bridge, Mar. 11, 2016, http://english.vietnamnet.vn/fms/environment/166350/euro-4-emission-standard-vehicles-may-not-have-fuel-by-early-2017.html
[352] "Euro 4 Emission Standard Vehicles May not Have Fuel in 2017" Vietnam Net Bridge, Mar. 11, 2016, http://english.vietnamnet.vn/fms/environment/166350/euro-4-emission-standard-vehicles-may-not-have-fuel-by-early-2017.html
[353] Viet Nam News, Growth Not Worth Damaging Environment: PM, Aug. 25, 2016, http://vietnamnews.vn/society/301706/growth-not-worth-damaging-environment-pm.html#pbqGG4dC51liSUcM.97
[354] Global Water Intelligence, Global Water Market 2017, Vol. 5: Asia Pacific, P 1803
[355] See Law on Environmental Protection, No. 55/2014/QH13, June 23, 2014
[356] WHO/UNICEF 2015 Joint Monitoring Programme Estimates
[357] Water Supply and Sanitation in Vietnam, Water and Sanitation Program and World Bank Group, December 2014, P. 3-4.
[358] Tieng Viet, Vietnam: Urban Wastewater Review, The World Bank, https://www.worldbank.org/en/country/vietnam/publication/vietnam-urban-wastewater-review
[359] Global Water Intelligence Project Tracker 2016
[360] Vietnam: Water & Wastewater; Best Prospects and Opportunities, Presentation by U.S. Commercial Service, 2015.
[361] Doan Van. "Water Opportunities in Vietnam" U.S. Commercial Service, Ho Chi Min City, 2015.
[362] TUOI TRE NEWS,. (2015). *Over 5 million Vietnamese to benefit from WB sanitation, water supply financing. TUOI TRE NEWS*. Retrieved 19 November 2015, from http://tuoitrenews.vn/society/31610/over-5-million-vietnamese-to-benefit-from-wb-sanitation-water-supply-financing
[363] Global Water Intelligence Project Tracker 2016.
[364] BMI Research,. (2015). Energy And Utilities Infrastructure - Q1 2016. BMI Research. Retrieved 19 November 2015, from
[365] Global Water Intelligence, Global Water Market 2017, Vol. 5: Asia Pacific, P 1803
[366] Global Water Intelligence, Global Water Market 2017, Volume 5: Asia Pacific. Page 1526.
[367] Ngo Anh, Vietnam Country Commercial Guide 2016
[368] Asia News Monitor, Vietnam: Local Communities Weigh Cost of Vietnam's Economic Growth, Oct. 20, 2016.
[369] Duc Hung, Red Streaks of Sea Water Found Near Taiwanese Fish Killer's Plant in Vietnam, VN Express International, Feb. 20, 2017.

[370] Tra Mi, "Vietnam Bans Unsafe Seafood in Central Region", VOA, May 5, 2016, http://www.voanews.com/a/vietnam-bans-unsafe-seafood-in-central-provinces/3316289.html

[371] Asia News Monitor, Vietnam: Local Communities Weigh Cost of Vietnam's Economic Growth, Oct. 20, 2016.
[372] Nguyen Minh Quang, Vietnam's Next Environmental Hotspot, The Diplomat, Jan. 10, 2017, http://thediplomat.com/2017/01/vietnams-next-environmental-hotspot/
[373] Global Water Intelligence, Global Water Market 2017, Vol. 5: Asia Pacific, P 1820
[374] Vietnam Country Commercial Guide, Environmental and Pollution Control Equipment and Services, November 2, 2016, https://www.export.gov/article?id=Vietnam-Environmental-and-Pollution-Control-Equipment-and-Services
[375] WHO,. (2015). Viet Nam: Closer to bringing drinking water and sanitation to all. WHO. Retrieved 19 November 2015, from http://www.who.int/features/2015/viet-nam-water-sanitation/en/
[376] Global Water Intelligence, Global Water Market 2017, Vol. 5: Asia Pacific, P 1805
[377] See Resolution No. 142/2016/QH13 on Five-Year Socio-Economic Development Plan from 2016 – 2020, April 12, 2016. http://www.chinhphu.vn/portal/page/portal/English/strategies/strategiesdetails?categoryId=30&articleId=10057712
[378] Water Supply and Sanitation in Vietnam, Water and Sanitation Program and World Bank Group, December 2014, P. 5.
[379] Water Supply and Sanitation in Vietnam, Water and Sanitation Program and World Bank Group, December 2014, P. 5.
[380] Anh Quan, "Foreign Investment Permitted in Projects for Secure Water Pipes", The Saigon Times Daily, Oct. 25, 2016, https://www.vietnambreakingnews.com/2016/10/foreign-investment-permitted-in-projects-for-secure-water-pipes/
[381] Anh Quan, "Foreign Investment Permitted in Projects for Secure Water Pipes", The Saigon Times Daily, Oct. 25, 2016, https://www.vietnambreakingnews.com/2016/10/foreign-investment-permitted-in-projects-for-secure-water-pipes/
[382] "Ministry of Natural Resources and Environment: Launching Organization Activities World Water Day 2017, Feb. 3, 2017, http://monre.gov.vn/wps/portal/tintuc/!ut/p/c5/RclJDoIwFADQs3iC_wEBXQICBYGEthLohjROYZDBgIGeXnfmLR8I-Bnkp7nLVzMOsocShFV7oUO2doKIka9hlAfUlGGiY6hDBcL-_86iFkZkX_BY83REDTiUuK1Zi-M7YdNRsc_Cz_jcI5y2Kl_TzCfNJE7BzGe6zN4jHcwrKxyXuXFupMpbMnUr6OV8MOKw6s2r7Mw0yNakWtzV9Z3JnkuRbzYwddL5Aia6g7Q!/
[383] Viet Nam News, Growth Not Worth Damaging Environment: PM, Aug. 25, 2016, http://vietnamnews.vn/society/301706/growth-not-worth-damaging-environment-pm.html#pbqGG4dC51liSUcM.97
[384] Viet Nam News, Growth Not Worth Damaging Environment: PM, Aug. 25, 2016, http://vietnamnews.vn/society/301706/growth-not-worth-damaging-environment-pm.html#pbqGG4dC51liSUcM.97
[385] Decision Approving the National Strategy for Integrated Management of Solid Waste Up to 2025, with a Vision to 2050, No. 2149/QD-TTg, Dec. 17, 2009
[386] Decision Approving the National Strategy for Integrated Management of Solid Waste Up to 2025, with a Vision to 2050, No. 2149/QD-TTg, Dec. 17, 2009
[387] See Decision No. 798/QD-TTg of May 25, 2011, Approving the Program for Investment in Solid Waste Treatment During 2011-2020.
[388] See Decision No. 798/QD-TTg of May 25, 2011, Approving the Program for Investment in Solid Waste Treatment During 2011-2020.
[389] Huy, Luong Quang. (2015). *Vietnam solid waste management: Developing crediting NAMA and employing market-based instruments.* Presentation, the 15th Climate Technology Initiative (CTI) Workshop on Market Mechanisms for Climate Action at the Urban Level.
[390] EBI Vietnam Environmental Industry Case Study, 2011, p.3
[391] "VN faces great environmental problems: deputy PM". *Tuoitrenews*. June 6, 2013. http://tuoitrenews.vn/society/10390/vn-faces-great-environmental-problems-deputy-pm. Accessed April 17, 2016
[392] Viet Nam News, Barriers Said to Impede Waste Management, Dec. 2, 2016, http://vietnamnews.vn/environment/347276/barriers-said-to-impede-waste-management.html#eKczqMPLqVAUCeQG.97
[393] Viet Nam News, Barriers Said to Impede Waste Management, Dec. 2, 2016, http://vietnamnews.vn/environment/347276/barriers-said-to-impede-waste-management.html#eKczqMPLqVAUCeQG.97
[394] Viet Nam News, Barriers Said to Impede Waste Management, Dec. 2, 2016, http://vietnamnews.vn/environment/347276/barriers-said-to-impede-waste-management.html#eKczqMPLqVAUCeQG.97
[395] Viet Nam News, Woman fined nearly $300 for littering pavement, Mar. 1, 2017, http://vietnamnews.vn/society/372056/woman-fined-nearly-300-for-littering-pavement.html#wCVK9VqLZ64Mozg7.97
[396] Trung Son, Australia's Trisun Energy to Build $520 mln Waste Treatment Plant in Vietnam, VN Express, Feb. 22, 2017, http://e.vnexpress.net/news/news/australia-s-trisun-energy-to-build-520-mln-waste-treatment-plant-in-vietnam-3545202.html
[397] Waste Management World, Everbright to Build Vietnam's First Waste to Energy Project, Feb. 8, 2016, https://waste-management-world.com/a/everbright-to-build-vietnams-first-waste-to-energy-project
[398] Waste Management World, Everbright to Build Vietnam's First Waste to Energy Project, Feb. 8, 2016, https://waste-management-world.com/a/everbright-to-build-vietnams-first-waste-to-energy-project
[399] AmCham Vietnam. (2011). *Vietnam Solid Waste Market Analysis*. Retrieved 19 November 2015, from http://www.amchamvietnam.com/4730/vietnam-solid-waste-market-analysis/
[400] Viet Nam News, Growth Not Worth Damaging Environment: PM, Viet Nam News Aug. 25, 2016, http://vietnamnews.vn/society/301706/growth-not-worth-damaging-environment-pm.html#pbqGG4dC51liSUcM.97
[401] See Resolution No. 142/2016/QH13 on Five-Year Socio-Economic Development Plan from 2016 – 2020.
[402] Viet Nam News, Growth Not Worth Damaging Environment: PM, Aug. 25, 2016, http://vietnamnews.vn/society/301706/growth-not-worth-damaging-environment-pm.html#pbqGG4dC51liSUcM.97
[403] EBI Vietnam Environmental Industry Case Study, 2011, p.3

[404] Commercial Service Dubai. CS UAE Water/Environment Sector Plan FY 2016.
[405] UAE Ministry of Environment and Water. *UAE State of Green Economy 2014.*

[406] UAE Ministry of Environment and Water, *UAE State of Green Economy 2016*.
[407] UAE Ministry of Environment and Water. *UAE State of Green Economy 2014.*
[408] UAE Ministry of Environment and Water, *UAE Green Agenda 2015-2030*.
[409] UAE Ministry of Environment and Water. *UAE State of the Green Economy*. 2016
[410] UAE Vision 2021: Sustainable Environment and Infrastructure. Accesses 3/15/16 https://www.vision2021.ae/en/national-priority-areas/sustainable-environment-and-infrastructure
[411] Commercial Service Dubai. CS UAE Water/Environment Sector Plan FY 2016.
[412] Maya Najm, Commercial Service Dubai. Top Markets Study Field Survey 2016.
[413] Maya Najm, Commercial Service Dubai. Top Markets Study Field Survey 2016.
[414] UAE Vision 2021: Sustainable Environment and Infrastructure. Accesses 3/15/16 https://www.vision2021.ae/en/national-priority-areas/sustainable-environment-and-infrastructure
[415] "A dust-up over dust". *The Economist*. July 18, 2015. http://www.economist.com/news/middle-east-and-africa/21657805-does-united-arab-emirates-really-have-dirtiest-air-world-dust-up. Accessed 2/19/16
[416] U.S. Commercial Service Abu Dhabi. 2016
[417] See 2016 Little Green Data Book, World Bank
[418] Environment Agency – Abu Dhabi. Air Quality Quarterly Report, Jul-Sept 2015.
[419] U.S. Commercial Service Abu Dhabi. 2016
[420] Naser Al Wasmi. "UAE Ministry Continues to Campaign Against Claims Over Air Quality". *The National*. September 16, 2015
[421] UAE Ministry of Environment and Water. *State of Green Economy Report 2014.* p. 49
[422] "Carbon Abatement Committee holds first meeting". *WAM Emirates News Agency*. Oct 22, 2014. http://www.wam.ae/en/news/general/1395271270160.html. Accessed 2/23/16
[423] World Bank. The Little Green Data Book 2016. p. 217
[424] UAE Ministry of Environment and Water. *State of Green Economy Report 2014.* p. 99
[425] "Our History". *Dubai Electricity & Water Authority.* https://www.dewa.gov.ae/en/about-dewa/about-us/about-us/our-history (Accessed October 14, 2016).
[426] Business Monitor International (BMI). UAE Industry Forecast – Energy & Utilities Infrastructure – Q1 2016
[427] UAE Energy Plan for 2050 to Achieve Balance Between Energy Production and Consumption, Gulf News, Jan. 10, 2017, http://gulfnews.com/business/sectors/energy/uae-energy-plan-for-2050-to-achieve-balance-between-energy-production-and-consumption-1.1959893
[428] Id.
[429] Id.
[430] UAE Ministry of Environment and Water. *State of Green Economy Report 2014.* p. 64
[431] UAE Ministry of Climate Change and Environment. *State of Green Economy Report 2016.* p. 133
[432] UAE Ministry of Environment and Water. *State of Green Economy Report 2014.* p. 103
[433] Environment Agency - Abu Dhabi and Health Authority – Abu Dhabi. "Enhancing Air Quality in Abu Dhabi". Annual Policy Brief. 2014. p. 17
[434] Naser Al Wasmi, "Abu Dhabi waste chiefs reveal 'GCC first' master plan for sustainable recycling". *The National.* June 1, 2015.
[435] UAE Ministry of Environment and Water. *State of Green Economy Report 2014.* p. 67
[436] Masudi, Faisal. "Sharjah Waste-to-Energy plant to 'divert all waste from landfill'. *Gulf News*. January 20, 2016. http://gulfnews.com/news/uae/environment/sharjah-waste-to-energy-plant-to-divert-all-waste-from-landfill-1.1657165. Accessed 2/19/2016
[437] Masdar and Bee'ah to Build New 300,000 Tonne Waste-to-Energy Plant in Sharjah, Sharjah Update, Jan. 25, 2017, http://www.sharjahupdate.com/2017/01/masdar-and-beeah-to-build-new-300000-tonne-waste-to-energy-plant-in-sharjah/
[438] Graves, LeAnne. "Dubai building Dh2 billion facility for waste-to-energy generation". *The National*. June 21, 2016. http://www.thenational.ae/business/energy/dubai-building-dh2-billion-facility-for-waste-to-energy-generation (accessed on October 14, 2016).
[439] Todorova, Vesela. "Fears of rapid rise in hazardous wastes". *The National*. September 24, 2012.
[440] Todorova, Vesela. "Fears of rapid rise in hazardous wastes". *The National*. September 24, 2012.
[441] Veolia to Build Waste Treatment Plant in Dubai, Trade Arabia, Nov. 21, 2016, http://www.tradearabia.com/news/HEAL_316989.html
[442] Global Water Intelligence Project Database with OEEI Analysis.
[443] Sewerage Network Upgrade Project – Phase 5: Abu Dhabi Sewerage Services, The 4Teen, Jan. 24, 2017, https://www.the4teen.com/blog/sewerage-network-upgrade-project-phase-5-abu-dhabi-sewerage-services-company-adssc/
[444] Global Water Intelligence. *Oil prices raise desal PPP options. Vol 16, Issue 11 (November 2015).*
[445] UAE Ministry of Environment and Water. *UAE State of Green Economy 2014.*
[446] Maya Najm, Commercial Service Dubai. Top Markets Study Field Survey 2016.
[447] Freyberg, Tom. "Abu Dhabi to Reuse 100% Wastewater by 2019", *Water & Wastewater International*. January 18, 2017. http://www.waterworld.com/articles/wwi/2017/01/video-abu-dhabi-to-reuse-100-wastewater-by-2019.html (accessed March 15, 2017).
[448] Global Water Intelligence, Global Water Market 2017. "Middle East and Africa" Vol 4 pg. 1477
[449] Roscoe, Andrew, ILF Wins Abu Dhabi Sewerage Contract, Meed, Jan. 24, 2017, https://www.meed.com/sectors/water/wastewater/ilf-wins-abu-dhabi-sewerage-contract/5012063.article

[450] Roscoe, Andrew, Dubai Invites Interest in Planned Desalination Plant, Meed, Jan. 5, 2017, https://www.meed.com/sectors/power-and-water/water/dubai-invites-interest-in-planned-desalination-plant/5011493.article

[451] Id.
[452] Id.
[453] SEWA Evaluates Hamriyah Expansion Bids, Sharjah Update, May 18, 2016, http://www.sharjahupdate.com/2016/05/sewa-evaluates-hamriyah-expansion-bids/
[454] Commercial Service Dubai. CS UAE Water/Environment Sector Plan FY 2016.
[455] UAE Ministry of Environment and Water. *UAE State of Green Economy 2014.*
[456] UAE Ministry of Environment and Water. *UAE State of Green Economy 2014.*
[457] Global Water Intelligence. Switch to reverse osmosis to boost Abu Dhabi desal. Vol 17, Issue 1 (January 2016).
[458] Global Water Intelligence, Global Water Market 2017. "Middle East and Africa" Vol 4 pg. 1471
[459] Global Water Intelligence, Global Water Market 2017. "Middle East and Africa" Vol 4 pg. 1475
[460] UAE Ministry of Climinate Change and Environment, UAE State of Green Economy 2016, P. 111
[461] UAE Ministry of Climinate Change and Environment, UAE State of Green Economy 2016, P. 111
[462] Global Water Intelligence. Switch to reverse osmosis to boost Abu Dhabi desal. Vol 17, Issue 1 (January 2016).
[463] Commercial Service Dubai. CS UAE Water/Environment Sector Plan FY 2016.
[464] Global Water Intelligence Project Database with OEEI Analysis.
[465] Commercial Service Dubai. CS UAE Water/Environment Sector Plan FY 2016.
[466] Commercial Service Dubai. CS UAE Water/Environment Sector Plan FY 2016.
[467] UAE Ministry of Environment and Water. *UAE State of Green Economy 2014.*
[468] UAE Ministry of Environment and Water. *UAE State of Green Economy 2014.*
[469] See Federal Law No 24 for the Protection and Development of the Environment.
[470] See Federal Law No 24 for the Protection and Development of the Environment.