TopMarkets
A Market Assessment Tool for U.S. Exporters

2017 Top Markets Report
Smart Grid

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November 2017

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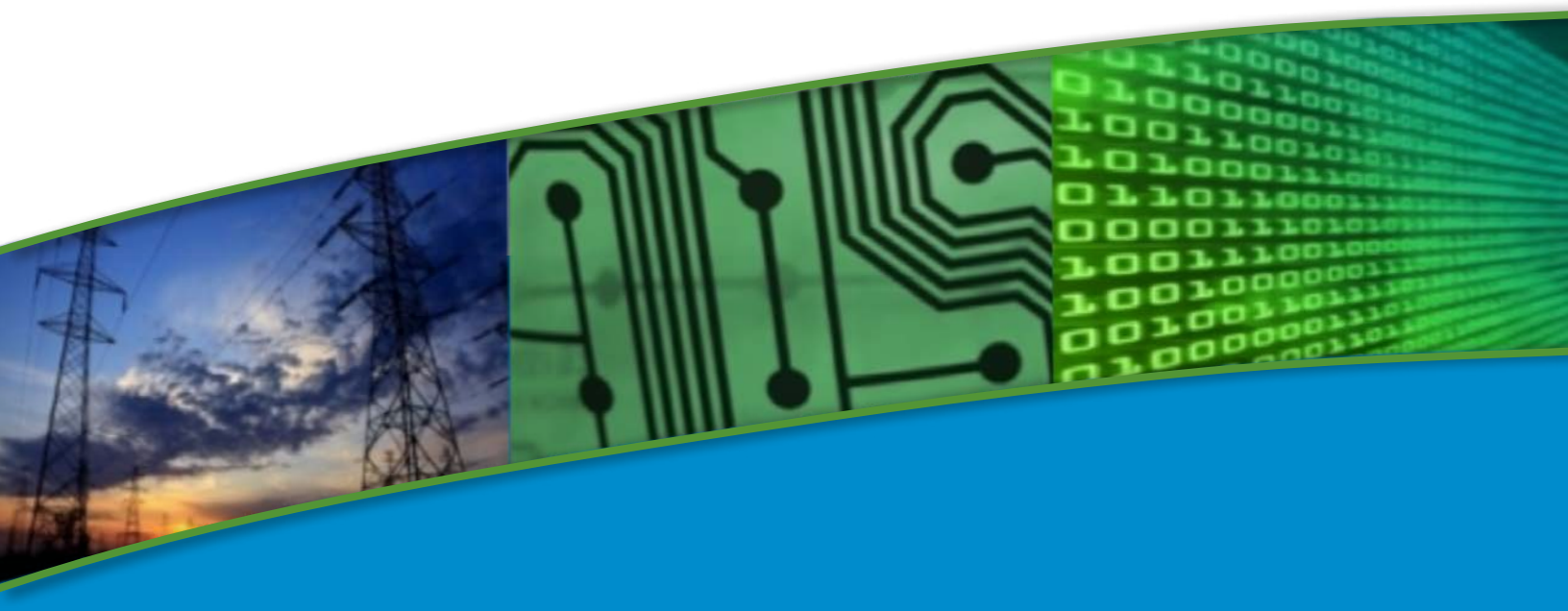

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Victoria Gunderson served as the lead author of this report. Special thanks to **Matt Goeppele-Parrish** who contributed to drafting and updating the country case studies. Additional thanks to **ITA Foreign Commercial Service**, **ITA Global Markets staff**, and **Philana Grant** for their respective contributions. Special thanks also to the Trade Promotion Coordinating Committee Working Group on Renewable Energy and Energy Efficiency and Renewable Energy and Energy Efficiency Advisory Committee for their counsel and input. Contributors to previous versions of this report include **Andrew Bennett** and **Lilian Lee**.

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Frequently Used Acronyms

ADMS	Advanced Distribution Management System
AMI	Advanced Metering Infrastructure
BMI	Business Monitor International
BNEF	Bloomberg New Energy Finance
CAGR	Compound Annual Growth Rate
DA	Distribution Automation
DER	Distributed Energy Resources
DERMS	Distributed Energy Resource Management System
DR	Demand Response
DSM	Demand Side Management
EMS	Emergency Management System
EPC	Engineering, Procurement, and Construction Company
EV	Electric Vehicle
ESCO	Energy Service Company
FERC	Federal Energy Regulatory Commission
FCS	Foreign Commercial Service
FDI	Foreign Direct Investment
GHG	Greenhouse Gas Emissions
GIS	Geospatial Information System
GTAP	Global Trade Analysis Project
GW	Gigawatts
HTS	Harmonized Tariff Schedule
HVAC	High-Voltage Alternating Current
HVDC	High-Voltage Direct Current
Hz	Hertz
ICT	Information Communication Technologies
IEA	International Energy Agency
INDC	Intended Nationally Determined Contribution
IPP	Independent Power Producer
IoT	Internet-of-Things
IP	Internet Protocol
ITA	International Trade Administration
kW	Kilowatt
MDB	Multilateral Development Bank
MW	Megawatt
NWA	Non-Wires Alternatives
OCED	Organization for Economic Cooperation and Development
PLC	Power-Line Communication
PPA	Power Purchase Agreement

Rf	Radio Frequency
SA	Substation Automation
SCADA	Supervisory Control and Data Acquisition
SG TMR	Smart Grid Top Market Report
SME	Small-to-Medium-Sized Enterprise
T&D	Transmission and Distribution
ToU	Time of Use
UHV	Ultra-High Voltage
UN	United Nations
USG	U.S. Government

Executive Summary

The global energy sector is undergoing transformation and the electricity grid is at the heart of the action. According to the International Energy Agency (IEA), approximately $8.9 trillion will be invested in electricity transmission and distribution (T&D) infrastructure globally from 2016-2040. [1] This amounts to approximately $354 billion annually with at least $33 billion invested through cross-border trade in T&D equipment. [2]

> ***What is smart grid?***
> The smart grid is a modernized electricity transmission and distribution network that includes two-way communication systems and enables the integration of technologies that will modernize the grid to improve its efficiency, reliability, sustainability, and security. In the context of this report, the term "smart grid industry" is used interchangeably with other industry nomenclature (e.g., grid modernization) to describe the ecosystem of goods, services, and technologies that support the transmission, distribution, and storage of electricity.

The United States serves as a key market for utilities to deploy smart grid technologies and pilot innovative business models and financing structures. This is driving U.S. firms to be global leaders in supplying advanced grid solutions both domestically and abroad. The United States is the third-largest exporter of T&D equipment and U.S smart grid software developers and technology service providers are widely viewed as leading global innovation. However, U.S. firms are facing increased competition domestically as well as internationally.

To inform both the strategic direction of U.S. Government (USG) trade policy activities and U.S. business development decisions, the U.S. Department of Commerce's International Trade Administration (ITA) developed the *Smart Grid Top Markets Report* (*SG TMR*). The *2017 SG TMR* is the third annual *SG TMR* and builds on an *Update* released in January 2017. [3] [4] [5] The *SG TMR* provides a comparative analysis of 50 global markets in terms of export growth potential for the U.S. smart grid industry in the near-term (2018-2022). The *SG TMR* approaches market analysis from the perspective of a stakeholder looking to understand the global landscape through the lens of a U.S.-based business exporting goods and services. This differs from other analytical reporting that projects, compares and quantifies global investment opportunities by country, as these analyses are agnostic to the origin of goods and services.

The *2017 SG TMR* integrates data and analyses on global markets and trade, including critical contributions of commercial specialists from U.S. Foreign Commercial Service (FCS) posts. The results are combined using a weighted scorecard methodology to produce relative rankings of the 50 subject markets. Markets are ranked both overall and for three sub-sectors: transmission and distribution (T&D) equipment; smart grid information communication technologies (ICT); and energy storage.

A summary of the top ten markets for each of the overall rankings and three sub-sector rankings is shown in Figure 1. North American trading partners – Canada and Mexico – provide the greatest opportunity for U.S. exporters. In the T&D Equipment Sub-Sector, emerging economies with high growth potential tend to rank higher due to the emphasis on future electricity consumption. Markets amid

Figure 1.

Top Ten SG TMR Ranked Markets, 2017				
RANK	Overall	T&D Equipment	Smart Grid ICT	Energy Storage
1	Canada	Mexico	UK	UK
2	Mexico	Canada	Canada	Denmark
3	Denmark	Ghana	Japan	Canada
4	UK	Ethiopia	Finland	Australia
5	Japan	Vietnam	Denmark	Japan
6	Ireland	Kenya	Mexico	Germany
7	Malaysia	Morocco	Australia	Finland
8	Chile	India	Sweden	Korea
9	India	Malaysia	Germany	Ireland
10	Australia	Philippines	Netherlands	China

transformation with aggressive renewable energy deployment targets tend to rank higher overall and in the Smart Grid ICT and Energy Storage Sub-Sectors.

Given the relatively slow timelines for electric utility procurement as well as timelines for formulation and implementation of policies and regulations, the outlook for U.S. exporters in 2018 remains similar to that presented in the *January 2017 Update*.

A complex set of global trends will shape the market for U.S. exporters in the near-term and will likely affect opportunities heading into 2018. Broadly, U.S. exporters will find opportunities due to increased digitalization, intersections at the energy-water nexus, coupling of demand-side management (DSM) with T&D projects, and deployment of microgrids for energy access. On the other hand, U.S. exporters will be challenged by the implementation of national protectionist policies in key markets, limited adoption of North American standards, lack of interoperability platforms, and the failure of regulations to keep up with technology advancements. Given that electricity is widely considered to be a public good, price sensitivity remains a noteworthy challenge even when considered on a lifecycle cost basis.

The *2017 SG TMR* is not intended to be read from start to finish. Rather, U.S. exporters and policymakers should approach each sub-sector snapshot and country case study as individual standalone documents. Country case studies are not confined to the highest-ranking markets. Five new case studies were added in 2017–for a total of 15 markets–to provide an in-depth analysis of the issues affecting markets across a range of development levels. These case studies highlight the diverse set of global opportunities and challenges facing U.S. smart grid exporters.

Overview and Key Findings

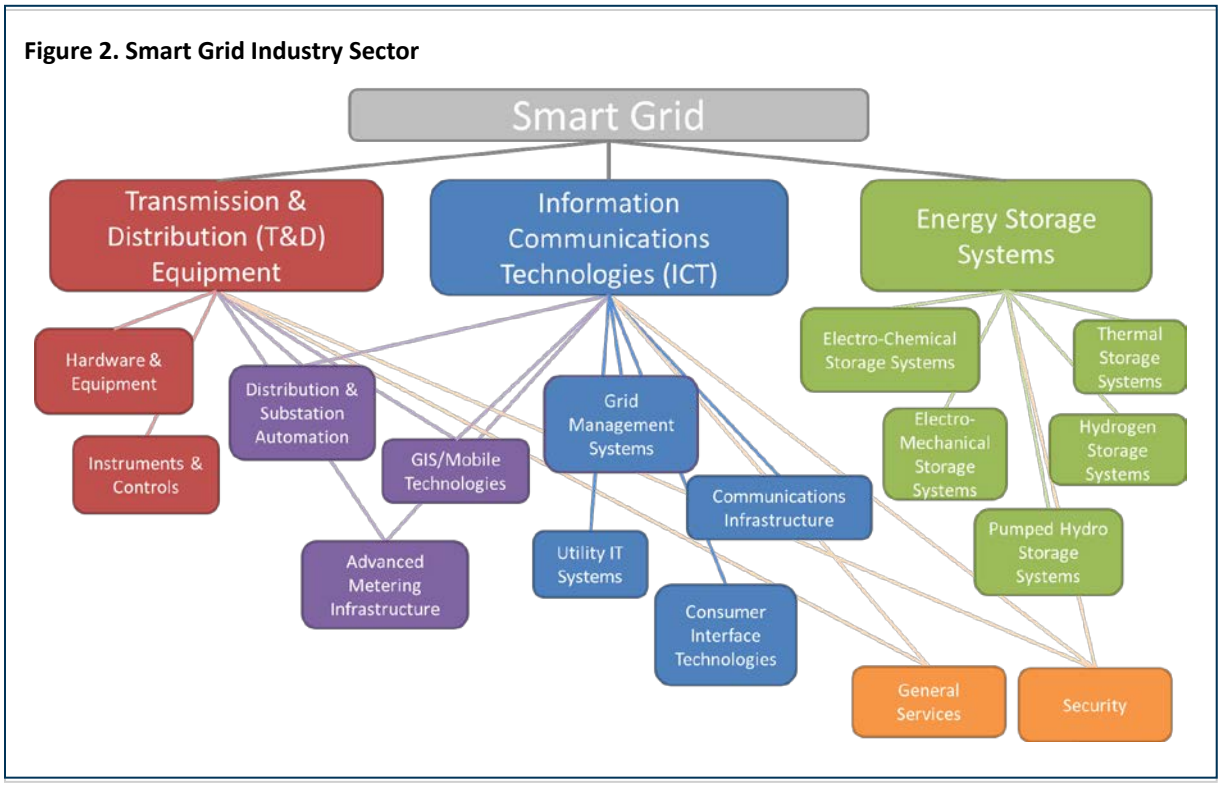
Introduction

The United States has made unprecedented investments in the modernization of its electricity grid and has become a world leader in the development and deployment of smart grid technologies. U.S.

companies of all sizes provide innovative technology solutions to some of the most pressing challenges facing the electricity industry, and investments by utilities and governments around the world drive consistent growth in the industry.

The subsequent pages of the International Trade Administration (ITA) *Smart Grid Top Markets Report* (*SG TMR*) include examinations of wider trends affecting the global development of smart grid technologies. These include investment, policy, and regulatory factors driving market development and competitiveness of U.S. exporters across the spectrum of smart grid technologies shown in Figure 2.

Figure 2. Smart Grid Industry Sector



The *2017 Smart Grid (SG) TMR* serves as the third annual report in the *SG TMR* series. [3] [4]

ITA evaluated 146 countries globally for data availability, current export market size, U.S. government strategic engagement, and U.S. Foreign Commercial Service (FCS) presence. Fifty global markets met all data availability criteria and are included in the *2017 SG TMR*. The absence of some markets from the *2017 SG TMR* is not necessarily indicative of a lack of opportunity for U.S. exporters.

Global utilities are purchasing an increasingly wider array of goods, technologies, and services. The *SG TMR* considers opportunities for both traditional suppliers of electrical equipment—such as cables, transformers, fuses, and switchgear—as well emerging segments and new market entrants supplying

communications networks, distributed energy resource (DER) aggregation software, energy efficiency services, and energy storage systems. U.S. exporters of related energy sector technologies, such as DER generation assets, home building energy management systems, and electricity trading services, may find this report to be an effective guide to the global electricity sector market and potential export gains.

The *2017 SG TMR* also includes in-depth country case studies discussing the electricity generation, transmission, distribution, and storage landscape in 15 markets. These country-specific case studies are intended to serve as stand-alone documents that highlight opportunities for U.S. exporters in the featured markets. The markets were chosen to represent geographical and economic diversity as well as to reflect markets historically active in U.S. Department of Commerce-sponsored activities.

Each subset of the smart grid sector faces different competitiveness challenges, and every global market possesses a set of characteristics that require nuanced and tailored trade policy and export promotion approaches. The *SG TMR* series is designed to provide market insights for U.S. companies as well as inform U.S. policymakers on global markets where U.S. Government (USG) resources can have the largest impact in support of U.S. competitiveness.

Top Markets and Methodology

Quantifying and ranking priority export markets for U.S. business—Top Markets—is rooted in understanding global trade flows. However, "smart grid" is an energy sector that experts struggle to define. In an era of technological convergence, many smart grid technologies are multi-use and include applications outside of the electric utility sector.

Existing global trade data based on the current Harmonized Tariff System (HTS) include product codes that capture accurate and relevant export revenues for a subset of T&D equipment rather than the entire smart grid market. For the most part, HTS product codes for the wide range of hardware, software, and networking technologies shown in Figure 2 are either non-existent or too broad to separate the smart grid applications for these technologies as opposed to other applications (e.g., broadband Internet, electric vehicles.) Furthermore, government or international institutions do not collect data on international trade in smart grid services, such as consulting, information technology (IT) system integration, and consumer energy efficiency programs.

Therefore, to quantify global smart grid opportunities and rank them by market, this report uses a variety of public and proprietary datasets to develop a system for comparative market sizing and quantifying relative opportunities for exporters of smart grid ICT, energy storage systems, and services. This includes available U.S. Census and United Nations (UN) trade data for T&D equipment; smart grid market and investment data; and renewable energy deployment trends. [6] [7] More than 10 qualitative and quantitative datasets are used to determine the presented rankings.

In January 2017, ITA released an interim *Update* to the *SG TMR Series* that expanded the global market assessment and ranked 50 global markets. [5] The *2017 SG TMR* markets were unchanged from the

January 2017 Update and the analysis discussed below is compared most immediately to this interim report. Figure 3 shows the overall *2017 SG TMR* rankings for these markets and is the result of weighting scores among five categories:

1. **Smart Grid Market Growth Potential (30 percent):** Industry data and information on policies, regulations, and other local drivers of the smart grid technologies and services market;
2. **Trade Factors and U.S. Competitiveness (30 percent):** Trade data and other information on exports of U.S. T&D equipment products and services in a given market;
3. **Energy Storage Growth Potential (10 percent):** Energy storage deployment and information on renewable energy deployment and other drivers for the energy storage system market;
4. **Key Economic and Energy Sector Investment Indicators (20 percent):** Broader economic data and power sector trends that affect investment in electricity infrastructure, and the development and growth of the smart grid in a given market; and
5. **Strength of Domestic Industry (10 percent):** Trade data and other information on the extent to which demand for smart grid technology and services will be met by the domestic industry – as opposed to international trade – in a given market.

Figure 3.

Overall Rankings									
1	Canada	11	Vietnam	21	Singapore	31	Spain	41	Thailand
2	Mexico	12	Korea	22	Germany	32	Morocco	42	Argentina
3	Denmark	13	Finland	23	Austria	33	Israel	43	Costa Rica
4	UK	14	Philippines	24	Egypt	34	Ethiopia	44	Bulgaria
5	Japan	15	China	25	Indonesia	35	Italy	45	Russia
6	Ireland	16	Saudi Arabia	26	Sweden	36	Portugal	46	New Zealand
7	Malaysia	17	Belgium	27	Kenya	37	Brazil	47	Kazakhstan
8	Chile	18	Turkey	28	Nigeria	38	South Africa	48	Peru
9	India	19	Netherlands	29	France	39	Colombia	49	Romania
10	Australia	20	Ghana	30	Poland	40	Czech Republic	50	Nicaragua

The *2017 SG TMR* deploys a weighted scorecard system and subsector rankings to better assess industry trends. The weighted scorecard methodology provides a platform for analysis of different technology sub-sectors depending on the weight assigned to the above five factors. Thus, in addition to the overall rankings, the *SG TMR* analysis also ranks markets for the potential growth of U.S. exports in the T&D Equipment, Smart Grid ICT, and Energy Storage Sub-Sectors. Essentially, these sub-sectors are representative of products, services, and technologies detailed in the ITA sector mapping shown in Figure 3. Sub-sector rankings are discussed in detail in their respective *Sub-Sector Snapshots*.

A detailed explanation of the methodology and key supporting data sets for each of the five categories can be found in Appendix 1. This also includes detailed information on the minor modifications to the methodology deployed in the *2017 SG TMR* relative to previous reports.

There are a variety of challenges to obtaining comprehensive and quantifiable information for each of these five categories. Small differences in ranking across markets or year-on-year are not statistically significant. Subsequent sections will provide qualitative analysis to highlight and explain large year-on-year shifts and events, trends, and other data to inform comparisons across markets. Full quantitative comparisons of *SG TMR* rankings across 2015, 2016, and January 2017 *Update* are shown in Appendix 2.

From the *January 2017 Update* to the *2017 SG TMR*, most markets remained relatively stable in the overall rankings. Significant increases in rankings were seen for Ghana (+23), Denmark (+18), Belgium (+13), and Morocco (+10). The largest year-to-year decreases occurred in Egypt (-16), France (-11), and Germany (-10). These ranking changes are linked to market signals in the five score areas.

Smart Grid Market Growth Potential (*Category #1*)
The development and deployment of smart grid technologies are affected by a significant number of enabling policy, regulatory, investment, and industrial drivers. The experiences of U.S. officials in diplomatic, technical, and commercial settings – coupled with additional market research – are used to quantify the competitiveness of the U.S. smart grid industry in global markets. In the *2017 SG TMR*, there were minimal year-on-year shifts in scores for *Category #1* relative to the *2017 Update*. Policy and regulatory changes take years, rather than months, to come to fruition. This category gives significant weight to the Smart Grid ICT Sub-Sector ranking, on which greater detail can be found in the sub-sector snapshot.

Trade Factors and U.S. Competitiveness (*Category #2*)
Category #2 scores are the result of equal weighting among three data indicators: U.S. exports of T&D equipment; the trend of U.S. exports over the last two years; and projected electricity consumption growth over the next five years. [8]

Figure 4. Highest Values among *Smart Grid Top Market Report* Markets [8]

Average Annual Electricity Consumption Projections, 2018-2022

	Market	Percentage
1	Kenya	8.74%
2	Ethiopia	8.60%
3	Vietnam	6.62%
4	Egypt	6.50%
5	Indonesia	6.48%
6	India	6.24%
7	Philippines	5.16%
8	Peru	5.02%
9	Malaysia	4.94%
10	Morocco	4.46%

In 2016, Canada and Mexico accounted for almost half of all U.S. T&D equipment global exports. Kazakhstan, Romania, and Sweden experienced the biggest percentage drops in T&D equipment exports from 2014 to 2016. U.S. exports to Ghana, Belgium, and Denmark increased by the largest percentage over the same period.

Turning to the five-year consumption projections for electricity, as shown in Figure 4, emerging economies such as Kenya and Ethiopia continue have the highest projections for anticipated annual growth rates (2018-2022) at 8.7 percent and 8.6 percent, respectively. Since the January 2017 *Update*, Italy, Portugal, and Russia saw the largest increases to their electricity consumption growth projections; projected growth increases have been scaled back for most significantly for Nicaragua, Mexico, and Nigeria.

Additional trends in this category are described in detail in Appendix 1 and the T&D Equipment sub-sector snapshot.

Energy Storage Growth Potential (*Category #3*)

Category #3 is a weighting across three normalized data sets: local assessment of energy storage market and U.S. export potential (50 percent); renewable energy as a share of the electricity mix from 2018-2022 (25 percent); and energy storage deployment score (25 percent).

Figure 5. Highest Values among *Smart Grid Top Market Report* Markets [8]

Projected Share of Non-Hydropower Renewable Energy in Electricity Mix, 2022

	Market	Percentage
1	Denmark	78.95%
2	Kenya	51.55%
3	New Zealand	45.83%
4	Poland	37.15%
5	Germany	35.49%
6	UK	29.26%
7	Spain	28.66%
8	Belgium	28.45%
9	Italy	25.48%
10	Finland	25.11%

ITA continues to improve the methodology for the *SG TMR*. This includes finding new data sets and honing processes for *Category #3* to reflect market trends and interest of U.S. exporters. For example, two key changes to the methodology are worth noting:

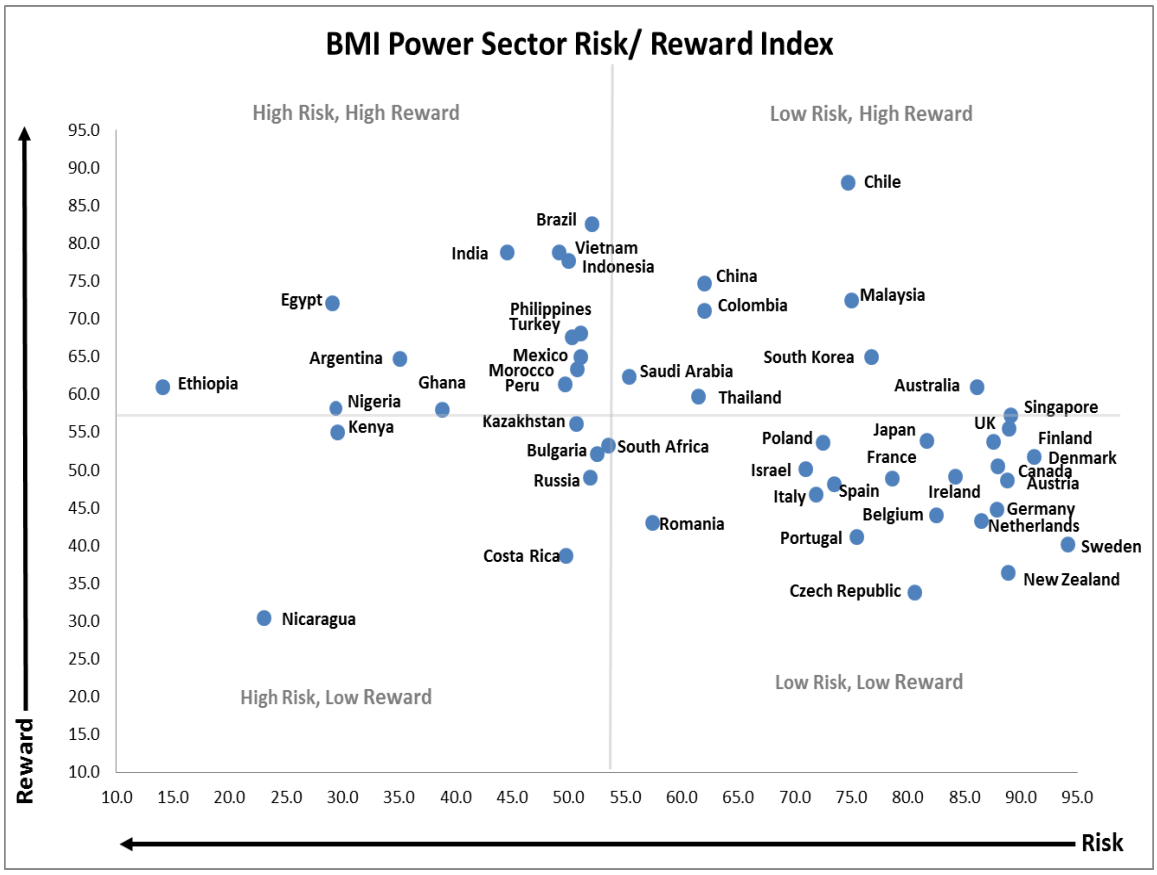
1. **Focus on battery energy storage**: In the *2017 Update*, all types of energy storage technologies (e.g., thermal, hydrogen, and pumped hydro storage) were considered in the first-ever *SG TMR* Energy Storage Sub-Sector rankings. ITA determined this analysis too broad to serve as an effective trade policy and promotion tool. Additionally, some energy storage technologies are covered by other *TMRs*. For example, pumped-hydro energy storage system exporters should see The *Renewable Energy Top Market Report* [9] for market opportunities under the assessments for U.S. hydropower exporters. Therefore, in the *2017 SG TMR*, the scope for energy storage was narrowed to global investment in battery-based (electrochemical) systems. This primarily manifests itself in the energy storage market growth score that provides a quantitative assessment of currently installed capacity of energy storage systems and the number of projects drawing from two sources and ranked on a 10-point scale. [10] [11] The narrowing of focus to battery-only systems had the greatest effect on markets with significant pump-hydro installations, where deployment numbers were scaled back.

2. **Focus on future renewable energy deployments:** The percentage of renewable energy used in the *January 2017 Update* was drawn from the World Bank and offered a historical and static glimpse at renewable energy deployment. In this report, the dataset was replaced with Business Monitor International's (BMI) projections for the percentage of non-hydropower and non-civil nuclear renewable energy of the electricity mix for 2018 to 2022. [8] This five-year projection window is consistent with timelines in other data sets used in *Category #2 (*Trade Factors and U.S. Competitiveness). Markets with ambitious renewable energy deployment targets – and with high expectations to meet those targets – saw increases in their scores. As shown in Figure 5, Denmark led all markets; in 2022 Denmark is predicted to derive 79 percent of its electricity from renewable energy.

Within *Category #3*, Kenya (+33), Malaysia (+25), Nigeria (+23), Saudi Arabia (+22), and Sweden (+22) saw the largest score increases; while Nicaragua (-24), Mexico (-23), Bulgaria (-21), and Thailand (-19) saw the largest drops year-on-year. This category places significant weight on the Energy Storage Sub-Sector ranking, on which greater details can be found in the sub-sector snapshot.

Key Economic and Energy Sector Investment Indicators (*Category #4*)
Macroeconomic market signals in the global economy and energy sector are factored into the rankings via *Category #4* – Key Economic and Energy Sector Investment Indicators. As outlined in Appendix 1 and highlighted in Figure 6, data in this category informs of the relative risk-to-reward ratio for investing in the power sector and is drawn from BMI Power Sector Risk/Reward Index. [12]

Figure 6. *Smart Grid Top Market Report* Markets Plot [12]



Largely, the BMI Risk/Reward Index methodology has an inherent bias toward larger emerging economies. This trend is evident in Figure 6, where generally, markets can be roughly segmented in four groups:

- **High risk, high reward:** Emerging economies with high projected electricity capacity and generation growth in the near-term. This predominately features low- and middle-income countries across Africa, Latin America, and South and Southeast Asia.
- **High risk, low reward:** Emerging economies with political and economic risks that limit reward potential including Russia, Nicaragua, and Kazakhstan.
- **Low risk, high reward:** Middle- and high-income countries with expectations for projected electricity capacity and generation growth in the near-term as well as stable economic and political environments – such as Chile, China, Colombia, and Malaysia.
- **Low risk, low reward:** Largely high-income European countries with low or minimal electricity demand growth.

From the *January 2017 Update* to the full *2017 SG TMR*, BMI revised its methodology for determining its Power Risk/Reward Index as described in detail in Appendix 1. The methodology changes resulted in significant changes to *Category #4* scores for a handful of markets.

Almost all markets saw increases to their Power Sector Risk/Reward Index. Twenty-one markets saw double-digit increases to their absolute values of the Power Sector Risk/Reward. The largest positive shifts are were in Denmark (+21), Singapore (+18), Austria (+18), Finland (+18), Morocco (+16), and Portugal (+16). The only markets that saw no shift or decreased values were Bulgaria (no change), India (no change), Egypt (-1), Costa Rica (-4), Kenya (-6), Ethiopia (-9), and Nicaragua (-14).

Since this data set is incorporated into all rankings (20 percent), its effect is seen in the overall rankings and at the sub-sector level. Interestingly, for some of these markets (e.g., Denmark), no major market changes (policy, regulatory, or political) occurred since the *Update* and data shifts are indicative of changes in methodology.

Strength of Domestic Industry (*Category #5*)
Data for this category remained consistent among all *SG TMRs* (2015, 2016, January 2017, and 2017) as the data set used for this category is updated infrequently. [13] As shown in Figure 7, markets least likely to meet their domestic demand from U.S. imports include New Zealand, Argentina, Brazil, China, and India.

Figure 7. Comparison of Smart Grid Top Market Report Markets [13]

Strength of Domestic Industry Rankings (*Category #5*)									
1	Nicaragua	11	Japan	21	Portugal	31	UK	41	Indonesia
2	Canada	12	Kenya	22	Netherlands	32	Morocco	42	Korea
3	Mexico	13	Saudi Arabia	23	Poland	33	Sweden	43	Peru
4	Vietnam	14	Colombia	24	Israel	34	Thailand	44	Italy
5	Singapore	15	Bulgaria	25	Kazakhstan	35	France	45	Russia
6	Nigeria	16	Austria	26	Czech Republic	36	Finland	46	India
7	Belgium	17	Egypt	27	Romania	37	Costa Rica	47	China
8	Chile	18	Ireland	28	Australia	38	Turkey	48	Brazil
9	Malaysia	19	Philippines	29	Ghana	39	Germany	49	Argentina
10	Ethiopia	20	Denmark	30	Spain	40	South Africa	50	New Zealand

Industry Overview

The smart grid is a modernized electricity T&D network that includes two-way communication systems and enables the integration of technologies that will modernize the grid to improve its efficiency, reliability, resiliency, sustainability, and security. Grid modernization includes the build-out and upgrade of T&D networks that extend electricity services to new populations and improve the grid's efficiency in delivering those services. In many markets, modernization goes beyond these initial T&D investments (e.g., poles and wires) to include a range of digital technologies and platforms, including the deployment and integration of Internet Protocol (IP) based communications, infrastructure ICT systems to better manage increasingly-complex utility networks and data, and online applications and consumer services that enable energy efficiency programs at the grid edge. Energy storage systems are increasingly being deployed across the electricity system for a wide range of utility use-cases – such as T&D deferral, frequency regulation, and peak load management – to enable better grid management.

The global smart grid industry involves all actors in the electric utility space: energy policymakers; regulators; generation, transmission, and distribution utilities; and vendors that supply the goods, services, and technologies. The industry is diverse and often segmented. Investment in the sector and the opening of new global markets are strongly influenced by the policy and regulatory environment. Utilities not only justify the internal business case for procurements but often are tasked with seeking regulatory approval to rate-base costs and pass them along to customers.

In the United States and around the world, electricity is widely considered to be a public good. [14] Price sensitivity of the ultimate customer – industrial, commercial, and residential electricity consumers – is significant regardless of a market's economic development status. Electricity prices often drive consumer behavior and economic decision making. For example, low energy prices have been shown to be a driver for manufacturing competitiveness and often inform the location selection of facilities. [15] In many emerging economies, overcoming social norms to successfully charge and collect payments is a challenge. Subsidies for electricity can further plague utilities as the full cost to deliver is not fully recouped.

These challenges are especially acute in emerging economies. More than 65 percent of global T&D network investments over the next two decades will be focused in non-OECD economies. [1] In these markets, utilities still struggle to collect payment for electricity delivered. Thus the industry needs new business and regulatory models, and new cost-effective, sustainable, innovative technology solutions to meet demand.

Large multinational firms are the predominant bidders for the buildout of large T&D projects. This includes manufacturing firms as well as infrastructure engineering, procurement, and construction (EPC) firms. Small- to medium-sized (SME) manufacturers and service providers often serve as sub-contractors to these larger firms. In smaller, or more discrete, utility procurements (e.g., smart metering deployment and system upgrading) partnerships can be formed among multiple SME hardware, software, and service providers to win a bid. This increasingly complex network of vendors and global

supply chains makes it difficult to provide a profile of the typical smart grid firm. Competitors are often partners. Firms can switch roles among subs and primes. New firms are regularly entering the market and disrupting the status quo, thus helping to transform the electric utility industry.

Grid Modernization in the United States

Energy, environmental, and security needs have accelerated both public and private sector investments in grid modernization and smart grid technologies across the United States. The federal government, state governments and private sector stakeholders have since made major investments in the development and deployment of smart grid technologies as well as in programs that are making the electric grid more efficient, reliable, resilient and secure.

There is strong regional variation in the electric utility industry in the United States, resulting from a bifurcated policy and regulatory regime between the Federal and state levels. A detailed analysis of the U.S. grid modernization efforts to date is outside the scope of the *SG TMR*. However, a diverse set of reporting exists to highlight the various U.S. policy, regulatory, and industry trends affecting domestic grid modernization. [16] [17] [14] [18]

Increased investment in U.S. grid modernization includes reliability enhancement, renewable resources integration, demand shifts, and market reforms that create more options for independent generators and require new connections to transmission systems. For example, U.S. investor-owned electric utilities invested over $20 billion in the U.S. transmission system in 2015, and are projected to invest $84 billion from 2016 to 2019. [19] In 2016, more than $10.6 billion was invested in ICT-enabled grid modernization in the United States. [20] This reflects a 14 percent CAGR over the last decade.

Coupled with growing global demand, sector investments drove an 18 percent year-on-year growth in U.S. jobs from 2015 to 2016. Today, more than 102,472 Americans are employed in the smart grid, grid modernization, and battery storage technologies sectors. [21] Based on estimates of available trade data revenues, at least 11,763 U.S. T&D equipment manufacturing jobs are supported by over $2 billion in T&D equipment exports in 2016. [22] In addition, there are more than half a million U.S. electric employees across over 3,000 U.S. utilities that are addressing the effects of new grid management challenges.

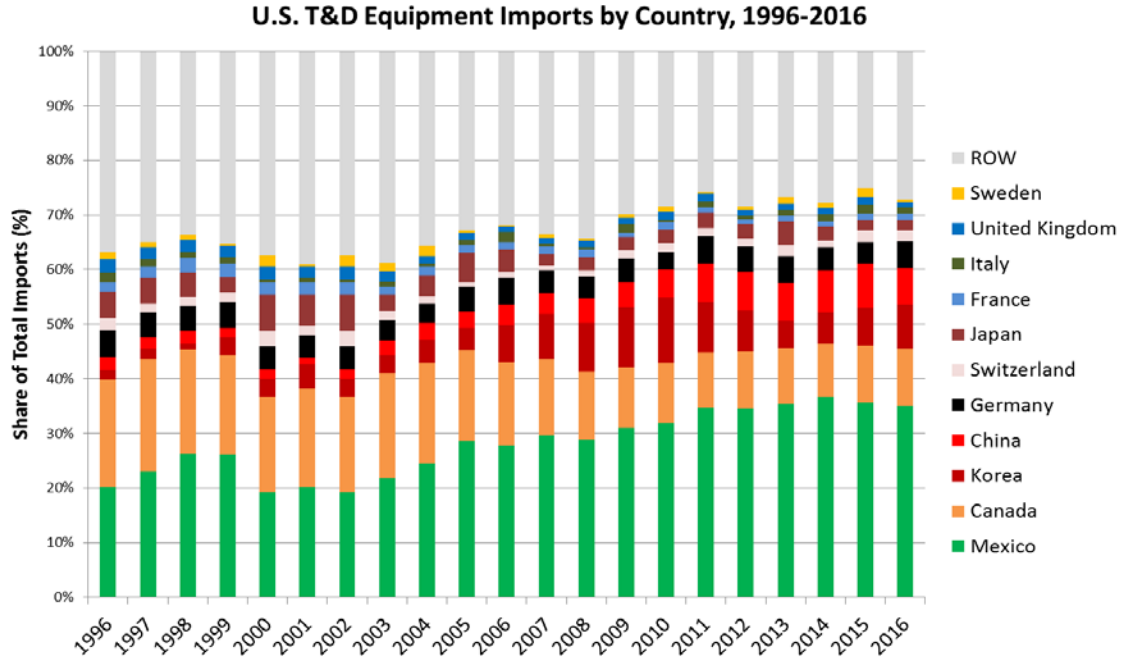
These utility experts often host international delegations of foreign utilities, regulators, and policymakers to share best practices and demonstrate the deployment of technologies (U.S. and foreign) onto the U.S. grid. These case studies serve as foundational evidence to support the deployment of U.S. products and services overseas. The link between U.S smart grid exports and domestic investments in technology deployment is robust: the U.S. electricity grid serves as both a test bed and showroom for U.S. exporters and their products and services.

It is rare to find a U.S.-based smart grid firm that does not supply goods or services to the domestic market. However, U.S. firms are facing increased competition domestically – both from foreign multinationals setting up U.S.-based operations as well as import competition. In 2016, foreign

companies invested more than $200 million in U.S. utilities and U.S. facilities to supply goods and services to the utility industry. [23] For example, major European multinational T&D equipment and lithium-ion battery manufacturers have established manufacturing facilities in the United States largely to supply the North American market and are employing thousands of Americans.

The ability of U.S. industry to meet domestic demand varies among smart grid sub-sectors. For T&D equipment, the United States is increasingly meeting its domestic needs through imports. U.S. imports of T&D equipment have increased with a 6 percent CAGR over the last decade totaling $4.12 billion in 2016 and leading to an approximate trade deficit of $2 billion in this sub-sector. As shown in Figure 8, Mexico supplies almost 40 percent of all U.S. T&D equipment imports and has grown at an 8 percent CAGR (2006-2016). If this trend continues for the T&D equipment subsector, it could have implications for global U.S. competitiveness in hardware manufacturing in the coming years.

Figure 8.



On the other hand, limited data is available to quantify imports to the United States for the smart grid ICT and energy storage sub-sectors. Broadly, the United States is the largest global market – accounting for more than 25 percent of all global investments in these more nascent sub-sectors – and firms based in the United States (U.S. or foreign owned) are the primary providers of these services and technologies. [20] ITA believes this results in a competitive advantage globally and a prime opportunity to grow future U.S. exports.

Global Landscape

While the United States is engaged in a robust and innovative electricity modernization effort, the global market is also actively investing. Global spending on grid modernization and smart grid technologies has emerged as a major growth segment for infrastructure investment, and it is expected to continue to grow. Predictions vary dramatically across sub-categories, but spending in all areas is expected to increase in both established and emerging markets. This is especially true for the more nascent Smart Grid ICT and Energy Storage Sub-Sectors. For example, according to a range of analysts:

- Smart grid spending will increase by more than 19 percent CAGR from 2017 to 2022 to $50.65 billion. [24]
- Smart grid IT – including supervisory and data acquisition (SCADA), emergency management systems (EMS), geospatial information systems (GIS), distributed energy resource management systems (DERMS), and advanced distribution management systems (ADMS) – will grow by more than 30 percent CAGR over the next decade to reach $21.4 billion in annual global investment by 2026. [25]
- Grid-connected energy storage will grow by a 16 CAGR from 2016 to 2025 to $7 billion. [26]

Drivers for the deployment and development of grid modernization equipment, technology, and services vary by region and by sub-sector. However, a consistent theme across the world is that utilities are concerned with revenue losses resulting from reduced loads driven by efficiency, increased distributed energy, and electricity theft. Global investment decisions are now focused on how to do more with less. This includes looking for ways to increase supply and demand-side energy management efficiencies. It further supports the increasing rise of “energy as a service” firms.

For emerging economies in Southeast Asia, India, Africa and Latin America, the focus is on reducing theft and T&D losses while building new infrastructure to meet increasing demand. Electricity access remains a priority as there are 1.1 billion people – 15 percent of the global population – who currently lack access. [27] Large service territories with low population density add complexity to the global market, but simultaneously provide opportunities for off-grid microgrid deployment.

Europe, North America, East Asia, and Australia have an increased focus on deploying advanced metering infrastructure (AMI) and big data analytics to better leverage the operational efficiencies resulting from advancements in cloud computing. Utilities in these countries are looking to improve systems management as revenues continue to decrease. Many European utilities have lost more than 50 percent of their market value since 2010 from the deployment of distributed energy resources and other efficiency gains that led to load loss. [28] This is challenging utilities in these markets to find new and creative business and financing models to meet their grid modernization needs.

The United States is globally competitive in supplying goods and services to these markets, and the U.S. domestic market serves as a key test bed for utilities to experiment with new business models. The United States is the third-largest exporter of T&D equipment, behind China and Germany. While limited HTS trade data cannot accurately capture global competitiveness in the smart grid ICT sub-sector, U.S. firms in information technology, networking technology, software and technology services are widely

viewed as ICT industry leaders. European firms serve as the biggest source of competition in the ICT sub-sector. In energy storage, Northeast Asian countries (Korea, Japan, and China) have identified the industry as strategic and governments are looking to bolster market opportunities for their firms. These firms serve as the primary competition for U.S. manufacturers of battery technologies, but also serve as strategic partners with U.S. software firms and as a source of foreign direct investment (FDI) for the United States.

Overall, the growth of the domestic smart grid investments and increased spending in international markets combine to provide expanded opportunities for U.S. innovators in international markets.

Opportunities

In addition to country and sub-sector specific market opportunities highlighted later in this report, the following offers a few key opportunities for the smart grid industry to engage in cross-sectoral initiatives and global trends:

- **Digitalization:** The smart grid industry includes evolving networking and information technologies that are driving the convergence between communication and infrastructure. It is estimated that more than $1.3 trillion of value is available to be captured from the digitalization in the electricity industry over the next decade. [29] Much of the near-term potential results from the deployment of sensors combined with = data generation to improve asset management performance. This is a global trend across industries that touch on the internet-of-things (IoT). Unique to the electricity sector is digitalization to enable the real-time balancing of supply and demand. This is estimated to contribute upwards of $191 billion directly to global utilities as well as an additional $623 billion in societal values (e.g., reduction in carbon emissions).
- **Smart Metering at the Energy-Water Nexus:** Much as been written about the intersection of energy and water – energy needed to move and purify water, and water used to generate electricity. As utilities look to implement "smart" systems, technologies can be applied to similar industries that manage resources and are looking to leverage ICT to increase efficiencies. For example, advanced metering infrastructure (AMI) is fundamentally the same for both the electric and water utility industries. Each need meters, communications infrastructure – radio frequency (Rf) mesh, power-line communications (PLC), or cellular – and analytical software to manage the big data. U.S. exporters who can leverage both markets will more rapidly achieve economies of scale.
- **Coupling T&D Projects with Demand Side Management (DSM):** In markets with limited excess generation capacity, utilities are searching for ways to use energy more efficiently to avoid brownouts and building costly new generation capacity. Financiers – including multilateral development banks (MDBs) – are increasingly coupling T&D build-outs and upgrades with energy efficiency projects to curb electricity demand. For example, on the DSM end, this may come in the form of smart lighting projects to reduce government costs and facilitate lower demand for electric utilities. U.S. smart grid exporters will benefit from forming strategic

partnerships with energy efficient (and in some cases "smart") lighting manufacturers and service providers.

- **Microgrids:** A microgrid is a local energy grid with control capabilities to disconnect from the traditional grid and operate autonomously. Microgrids will be increasingly deployed as critical infrastructure to provide backup for the grid in case of grid failure. These systems can also be used to avoid T&D buildouts or connect to a local generation source that is too small or unreliable for traditional grid use. A microgrid allows an energy consumer to be more energy independent and, in some cases, more environmentally friendly. Industrial energy users in locations with unreliable electricity access, remote and rural communities, island nations, and regions without established infrastructure are being evaluated as principal candidates for near-term microgrid deployment.

Challenges and Barriers

Over the last decade, investments in the smart grid have grown in every major economy. Increased export opportunities are anticipated for the wide range of U.S. suppliers and service providers marketing smart grid solutions to electric utilities around the world. However, the development of the smart grid will be unique across – and often within – export markets, and opportunities will vary depending on a nation's stage of smart grid development and specific market demands for various technology and services. Additionally, there are some key issues that could affect smart grid development, challenging the pace of deployment, and potentially hindering U.S. competitiveness in a given export market. These challenges include:

- **Protectionist National Policies:** Across the globe, governments recognize that the development and production of smart grid products and services sits at a unique intersection of national security and economic growth. The high potential of the sector to generate exports and thereby increase growth of domestic economies – as well as to meet domestic critical infrastructure needs –underscores why foreign governments are increasingly formulating policies and regulations to provide a competitive advantage to their domestic smart grid technology industries. This presents a challenge to U.S. exporters looking to tap into markets where national champions and strong, preferential policies – such as local content requirements – are ubiquitous, and access to financing is limited for foreign firms.
- **Standards and Interoperability:** The identification and adoption of international standards for smart grid technologies and the need to ensure their interoperability in order to help drive technology development, deployment and operations remain a hurdle to broad deployment. Standards and conformity assessment requirements serve as non-tariff trade barriers for U.S. smart grid firms looking to compete overseas. U.S. manufacturers face challenges as European governments and China seek to set standards that may not match those used by U.S. manufacturers. U.S. manufacturers also face additional financial burdens from the need to re-test products before they are allowed to sell them in foreign markets.
- **Electricity Price Sensitivity and the Regulatory Environment:** In both emerging and developed markets, there is a need for the development of a regulatory framework that will

sustain smart grid investment while enabling sufficient economic returns for the electricity industry. This is especially a challenge in emerging economies where price sensitivity presses utilities, regulators, and policymakers to develop creative solutions to investment and overcome cultural barriers to paying for electricity among new consumers of electricity. Furthermore, technology advancements that far outpace regulatory changes, deepen the challenges for exporters.

- **Cross-Border Data Flow Policies and Regulations:** Policies and regulations to restrict or prohibit cross-border data flows challenge American exporters. Even in cases where agreements are in place to address differences in privacy regulations (such as the EU-U.S. Privacy Shield agreement), buyers may not be aware of these agreements. In other markets, data localization policies challenge U.S. exporters to adjust business models to meet regulatory demands, which create additional costs and make U.S. firms uncompetitive in these markets.

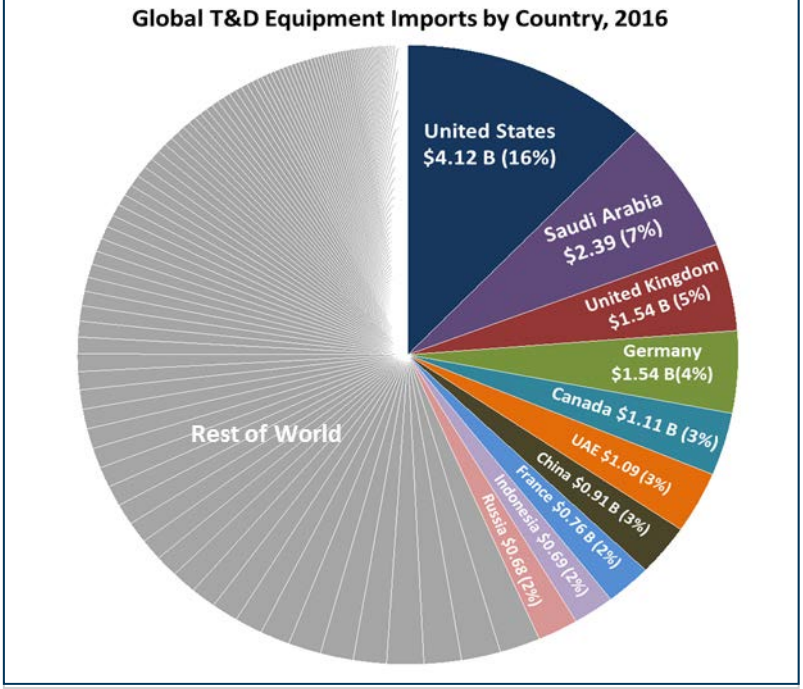
Despite the foreign challenges and barriers to the deployment of smart grid technologies, the United States remains a strong global competitor. Evolving technologies and policies are driving global investments that could translate into increased exports for U.S. companies.

Transmission & Distribution (T&D) Equipment Sub-Sector Snapshot

State of the Market

According to the International Energy Agency (IEA), approximately $8.9 trillion will be invested in T&D infrastructure globally from 2016 to 2040. [1] This translates to approximately $354 billion annually with at least $33 billion met through cross-border traded T&D equipment. [30]

Figure 9. [5]

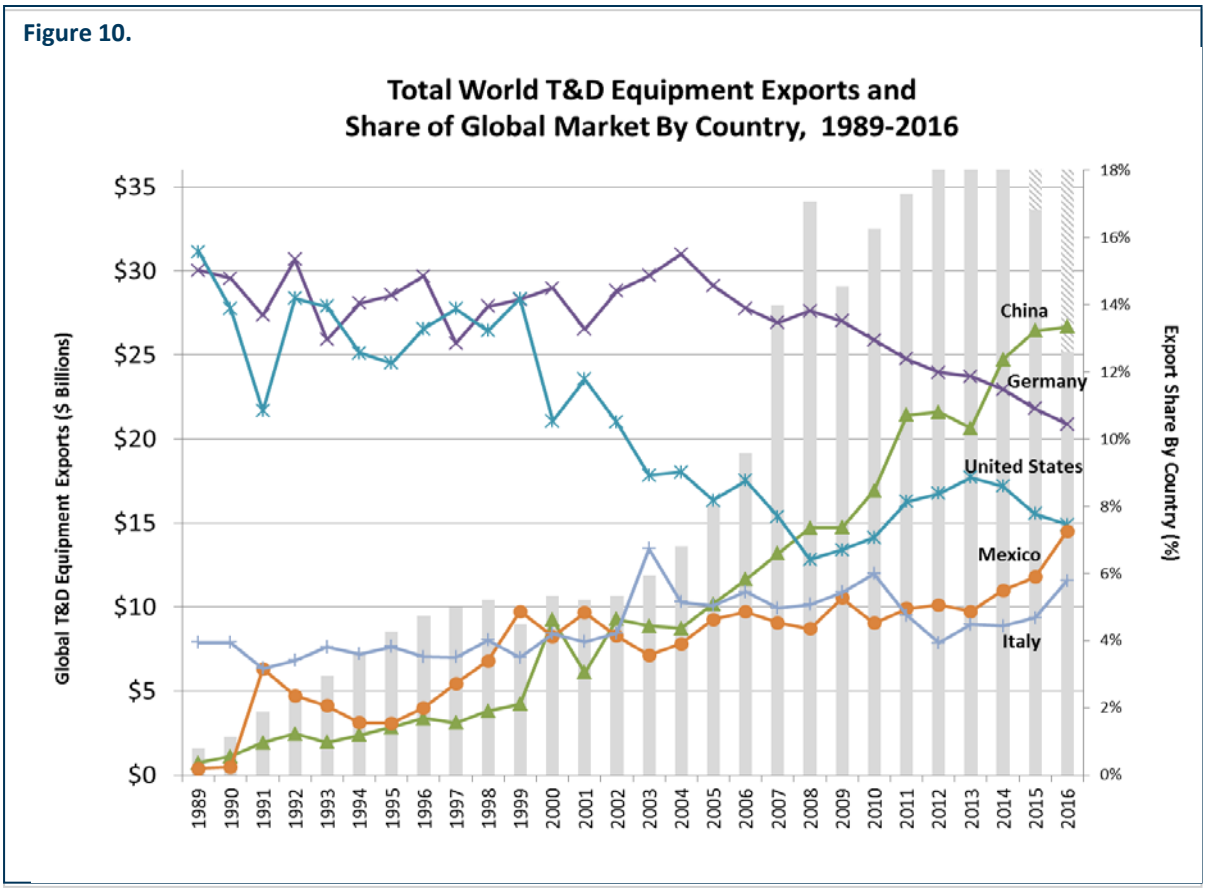


Over the last decade, global trade in T&D equipment has increased by at least a 3 percent CAGR. ITA analysis suggests that global trade in T&D equipment has plateaued in recent years. As shown in Figure 9, the United States was the largest global importer of T&D equipment and accounted for over 16 percent of the global import market ($4.12 billion in 2016). Other top import markets include Saudi Arabia ($2.39 billion), United Kingdom ($1.54 billion), Germany ($1.45 billion), Canada ($1.1 billion), and China ($0.91 billion). [31]

Over the last decade, most markets have seen an uptick in their total imports – including the United States, which experienced a 5 percent CAGR. Notable growing import markets include Egypt, Ethiopia, and Indonesia, each with CAGRs over 20 percent over the last ten years. Chile, Brazil, and the Philippines have also seen CAGRs over 15 percent over the same period.

However, not every market experienced increased imports in 2016. China has decreased its overall T&D equipment imports by more than $600 million over the last decade, which represents a 6 percent annual average decrease. Relative to other nations that saw a decrease in T&D equipment imports – such as Spain and Italy – China has been rapidly building out its electricity infrastructure.

Figure 10.



U.S. Competitiveness

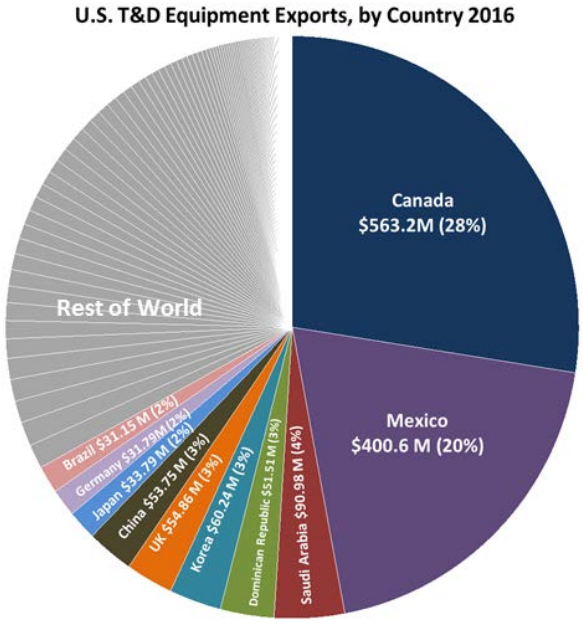
As Figure 10 illustrates, U.S. T&D equipment exports peaked in 2013 and have declined both by absolute numbers and as a share of the global market. The United States is currently the third largest global supplier of T&D equipment. In 2014, China overtook Germany as the global leader and has continued to grow its exports. Mexico and Italy complete the list of top five global suppliers.

Total U.S. T&D equipment export revenues reached $2 billion in 2016 (Figure 11). Canada and Mexico accounted for more than 47 percent of U.S. exports. Saudi Arabia, the United Kingdom, Korea, and Japan serve as the next largest markets. The top 10 U.S. export markets constitute more than two-thirds of the total revenue for U.S. T&D exporters; the top 50 markets included in this report cover almost 90 percent of total U.S. export sales.

Rankings

As shown in Figure 12, the T&D equipment sub-sector rankings focus on markets with high growth in the products and services necessary for the build-out, modernization, and automation of T&D networks. For example, trade in T&D equipment receives a higher weight in this ranking, as does electricity consumption growth, energy supply investment, and other factors driving the build-out of the grid.

Figure 11.



The top *SG TMR* T&D equipment markets are, therefore, more likely to be less-mature smart grid markets – such as Ghana, Ethiopia, Vietnam, and Kenya. Investments in these nations are focused on grid modernization that is essential to the development of a more advanced smart grid using information and communications technologies. Markets focused on connecting the 1.1 billion people (15 percent of the global population) who currently do not have access to electricity, also perform well in the T&D Equipment Sub-Sector. [27]

Figure 12.

T&D Equipment Sub-Sector Rankings									
1	Mexico	11	Turkey	21	Denmark	31	Japan	41	Italy
2	Canada	12	Chile	22	Poland	32	Thailand	42	France
3	Ghana	13	Belgium	23	Singapore	33	Costa Rica	43	South Africa
4	Ethiopia	14	Indonesia	24	China	34	Netherlands	44	Kazakhstan
5	Vietnam	15	Egypt	25	Israel	35	Nicaragua	45	Russia
6	Kenya	16	Nigeria	26	Australia	36	Spain	46	Portugal
7	Morocco	17	Peru	27	Colombia	37	UK	47	Germany
8	India	18	Korea	28	Austria	38	Brazil	48	Sweden
9	Malaysia	19	Saudi Arabia	29	Bulgaria	39	Finland	49	Romania
10	Philippines	20	Ireland	30	Argentina	40	Czech Republic	50	New Zealand

The T&D Equipment Sub-Sector rankings reflect a heavy weight on *Category #2 (*Trade Factors and U.S. Competitiveness), which is drawn: U.S. exports of T&D equipment; the trend of U.S. exports over last two years; and projected electricity consumption growth over next five years. The ranking methodology is described in more detail in Appendix 1.

In 2016, Canada and Mexico accounted for almost half of all U.S. T&D equipment global exports and lead the rankings for this sub-sector. But trends for U.S. exporters in North America are quite divergent. Canada experienced the largest drop in absolute export revenue from 2014 to 2016 – over $190 million, or 30 percent – while over the same period, absolute export revenue to Mexico saw the largest gain – $124 million, or 56 percent. Over the coming years, this trend will likely continue. Mexico will serve as a primary market for exporters of end products, and will remain a key global supply-chain partner for related manufactured goods.

Overall, 17 of the 50 markets covered in this report experienced increases in U.S. exports from 2014 to 2016. Major trading partners with decreasing T&D equipment exports since 2014 include China, Colombia, the United Kingdom and Brazil.

Electricity consumption trends serve as a strong indicator for potential electrical equipment opportunities. Kenya and Ethiopia are both expected to sustain year-on-year electricity growth above 8 percent over the next five years. [8] Since the issuance of the *January 2017 Update*, electricity consumption projections have been revised down for markets such as Nigeria, Saudi Arabia, Turkey, Vietnam and Indonesia.

Full year-on-year comparison of the T&D Equipment sub-sector rankings across all previous *SG TMRs* and related reports is included in Appendix 2.

Opportunities

ITA predicts that certain T&D Equipment Sub-Sector products and services will be increasingly important as governments and regulators look to implement policies that expand regional grids, especially in Europe and Africa, while at the same time increasing the resilience and integration of distributed energy resources.

- **New Transmission Lines for Renewable Energy Integration:** Co-location of energy resources and electricity load centers is an increasing challenge, especially as nations and regions look to transmit utility-scale, low-cost renewable energy. According to the IEA, 60 percent of all new power generation through 2040 will come from renewable sources. [1] Coupled with population shifts to urban regions and deregulation of electricity markets, electricity is increasingly being transmitted over longer distances from generation sites to end-users. High-voltage alternating current (HVAC) and high-voltage direct current (HVDC) transmission systems (lines, substations, and other equipment), as well as energy storage systems for transmission lines, will be a growing market, which has been predicted to grow at a 33 percent CAGR (2016-2025). [32] Deployment of ultra-high voltage transmission (UHV) could further enable larger amounts of

electricity to travel greater distances, up to three times farther than on traditional high-voltage transmission lines, with reduced losses and costs. China is currently the global leader in the deployment of UHV transmission. Brazil, Africa and Europe have all installed UHV lines manufactured in China.

- **Microgrids:** Microgrids will be increasingly deployed in developed countries to improve resiliency among customers willing to pay for increased reliability and higher power quality. Industrial energy users in locations with unreliable electricity access, along with remote and rural communities, island nations, and regions without established infrastructure, are also being evaluated as principal candidates for microgrid deployment. Microgrid opportunities exist across the globe, but regional variation is significant. Market opportunities will open further as cost reductions occur.
- **Regional Interconnections:** The physical linking of electrical systems allows the transfer of electricity across borders. As nations look to implement commitments to reduce emissions, increase energy security, and lower costs, there will be an increased global focus on cooperatively building infrastructure and developing policies and regulations to encourage the interconnection of grids. For example, new interconnections are being built in Poland and Lithuania to complete the synchronization of the electricity grid with the West as members of the European Union look to increase energy security and "transition" the energy sector.

Challenges and Barriers

Given the electricity grid plays a strong role in the economic and national security of a nation, the sector faces some unique trade challenges. Many nations view this sector as strategic and are focused on stimulating and nurturing their domestic industries. As a result, challenges have emerged for U.S. exporters:

- **Increased Number of Global Competitors:** As the global market for T&D equipment increased by 9 percent CAGR since 1990, the number of markets generating more than $10 million in T&D equipment revenues increased from 28 to 70. The result has been an increasing number of equipment producers in the global mix, thereby increasing the level of competition faced by U.S. firms.
- **Protectionist National Policies:** Foreign governments realize the potential for the sector to help grow domestic economies by manufacturing products for the domestic infrastructure and to supply global demand through exports. Foreign governments are increasingly formulating policies and regulations to provide a competitive advantage to their domestic industries. This presents a challenge for U.S. exporters looking to tap into markets where national champions are strong, preferential policies – such as local content requirements – are pervasive, and foreign firms' access to financing is limited.
- **Complex Global Supply Chains:** Globalization has increased the complexity of supply chains. T&D equipment parts and components are often sourced outside the assembly plant or final end-product manufacturing center. Foreign trade policies negatively impact U.S. manufacturers

and present potential supply chain choke points. Exporters are faced with difficult decisions as to how best to confront these foreign protectionist policies.

Smart Grid Information Communication Technologies (ICT)
Sub-Sector Snapshot

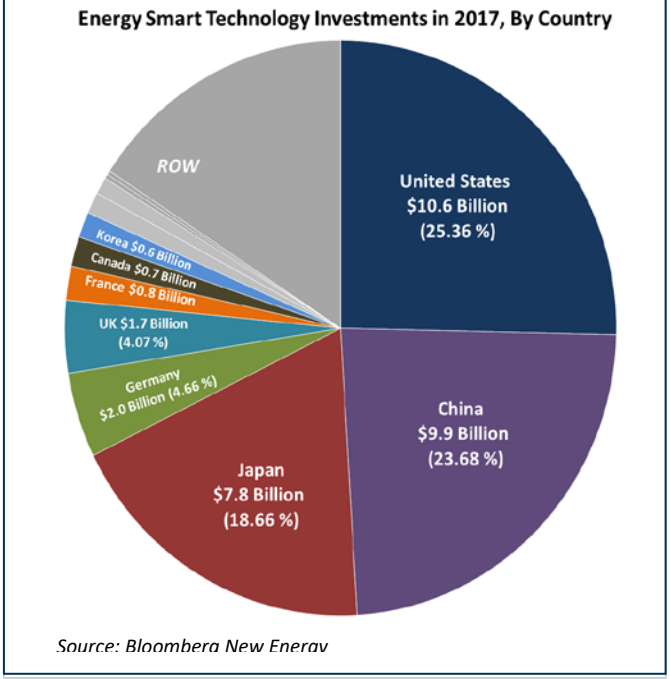
State of the Market

Global digitalization of the electricity sector is on the rise. From 2016-2025, it is estimated to provide over $1.3 trillion in value and up to 3.45 million new jobs globally. [29] Advanced metering infrastructure (AMI), distribution and substation automation (DA and SA), new analytical tools to promote energy efficiency, distributed energy resources (DER) aggregation, and developing connected smart grid networks are the focus of the Smart Grid ICT Sub-Sector rankings.

According to Bloomberg New Energy Finance (BNEF) in 2016, the United States led all global investors in so-called "energy smart technologies" with an investment totaling $10.6 billion (Figure 13). This represents over one quarter of all global investment. China ($9.9 billion) and Japan ($7.8 billion) followed closely behind, while a handful of European markets (Germany, United Kingdom, France, Italy, and Spain) joining Canada to round out the other large global markets.

As shown in Figure 2, there is a diverse array of products and services that comprise the Smart Grid ICT Sub-Sector. It is widely anticipated that investment in the suite of technologies, products, and services in the sub-sector will grow. For example, by one estimate the smart grid market will grow at an annual CAGR of 19.4 percent over the next five years with smart grid communications software expected to have the fastest growth rate among related technologies. [33]

Figure 13.



Source: Bloomberg New Energy

Smart metering is another important technology category. It is widely viewed as an enabler for other smart grid ICT solutions. Smart meter deployments can often serve as an indicator of market opportunities for related technologies and services, including analytical software for consumer engagement, demand response programs, and distribution equipment. From 2015 to 2016, global smart meter deployment grew by 61 percent. Growth

is expected to continue and subsequently peak in 2020 with $19.7 billion in global investment. [34] In 2016, Japan led global smart meter investments at $3.3 billion.

Broadly, global smart meter penetration is on the rise. As shown in Figure 14, developed nations largely dominate global smart meter deployments. [35] Rates of deployment (and associated investments) are expected to continue to increase in the near term, especially as European Union member states look to meet the 2020 target of an 80 percent penetration rate.

Figure 14.

Electric Smart Meter Penetration, 2017

Market	Percentage of Customers	Market	Percentage of Customers	Market	Percentage of Customers
Italy	100.00%	Australia	29.90%	Thailand	3.60%
Finland	97.60%	United Kingdom	29.80%	*Other Europe*	*1.10%*
China	96.50%	Poland	27.70%	Czech Republic	1.00%
Sweden	95.80%	*North Africa and Middle East*	*24.60%*	Belgium	0.80%
Spain	84.10%	France	23.80%	Ireland	0.80%
New Zealand	73.10%	Mexico	14.20%	Philippines	0.80%
Denmark	69.50%	Romania	10.10%	*Sub-Saharan Africa*	*0.50%*
Canada*	67%	Austria**	8.5%	India	0.50%
United States	51.80%	*Rest of Latin America & Caribbean*	*5.90%*	*Rest of Asia*	*0.40%*
Japan	47.60%	Singapore	4.90%	Indonesia	0.20%
Netherlands	46.50%	Malaysia	3.90%	Vietnam	0.00%
Portugal	39.40%	Germany	3.80%		
Korea	32.70%	Brazil	3.60%		

Data Sources: Bloomberg New Energy Finance [35]*; *Natural Resources Canada* [128]*; **Austrian E-Control* [129]

The specific drivers for future smart grid ICT investment are complicated, and they vary by market. Based on conversations with foreign utilities and foreign government officials, ITA's Foreign Commercial Service staff in the 50 *SG TMR* markets identified integration of renewable energy as the primary global driver for smart grid ICT deployments (Figure 15). This was followed by "meeting energy efficiency targets" and "aiding in addressing electricity demand trends" as the key reasons global utilities are pursuing deployment of advanced grid modernization technologies. Furthermore, the top three keys to successful deployment of smart grid ICT systems are the policy, regulatory, and standards environments.

Figure 15.

U.S. Foreign Commercial Service Survey Results		
	Top Smart Grid ICT Policy & Regulatory Drivers	Top Keys to Success for Smart Grid ICT Deployment
1	Integrating Renewables	Government Commitment
2	Meeting Efficiency Targets	National Regulations
3	Increasing Commercial & Industrial Energy Efficiency	Standards & Interoperability
4	Meeting Electricity Demand	Government Investment
5	Shifting Peak Demand	Consumer Demand
6	Meeting Climate Targets	Developing the Utility Business Case
7	Meeting Storage Targets	Provincial, State, Local Regulations
8	Reducing Non-technical Losses	Local Consumption
9	Deploying Electric Vehicles	Privacy Issues
10	Reducing Power Outages	

U.S. Competitiveness

As described in previous sections, there is a shortage of trade data for the Smart Grid ICT Sub-Sector, as HTS codes do not differentiate by end-use. Understanding U.S. competitiveness in this sub-sector is dependent on being able to analyze qualitative data. U.S. developers of smart grid analytical tools for demand response and other applications are widely recognized as global leaders and are partnering with smart meter manufacturers to deploy solutions. For example, by one account, over half of the 25 most important global smart grid providers highlighted in an annual market forecast are headquartered in the United States. [33] Largely, this is driven by the fact that the United States is a global leader in smart grid ICT investments. Domestic firms were initially established to serve the U.S. market, but are quickly looking global as investments increase overseas.

U.S. firms are completive globally. However, complex partnerships among hardware, software, and service providers are becoming the norm. This often results in local and international firms working together to bid on tenders aboard. This is especially true in emerging economies, where U.S. software and analytical services firms partner with local hardware manufacturers to bid more competitively in the market. This can present a challenge for the U.S. government in helping companies leverage a variety of U.S. trade promotion and financing tools that are dependent on the product's country of origin.

Rankings

Figure 16.

Smart Grid ICT Sub-Sector Rankings									
1	UK	**11**	Ireland	**21**	Belgium	**31**	South Africa	**41**	Morocco
2	Canada	**12**	France	**22**	Spain	**32**	Egypt	**42**	Costa Rica
3	Japan	**13**	Singapore	**23**	Vietnam	**33**	Indonesia	**43**	Bulgaria
4	Finland	**14**	China	**24**	India	**34**	Czech Republic	**44**	Russia
5	Denmark	**15**	Malaysia	**25**	Portugal	**35**	Thailand	**45**	Ghana
6	Mexico	**16**	Saudi Arabia	**26**	Brazil	**36**	Nigeria	**46**	Kazakhstan
7	Australia	**17**	Chile	**27**	Poland	**37**	Colombia	**47**	Kenya
8	Sweden	**18**	Turkey	**28**	Italy	**38**	Romania	**48**	Ethiopia
9	Germany	**19**	Austria	**29**	Philippines	**39**	Argentina	**49**	Peru
10	Netherlands	**20**	Korea	**30**	Israel	**40**	New Zealand	**50**	Nicaragua

The Smart Grid ICT Sub-Sector rankings focus on markets with high growth in the products and services necessary for the digitalization of the electricity grid. As shown in Figure 16 and Appendix 3, high-income countries present the greatest near-term export market potential. Among the top 25 ranked markets, only six markets are classified as upper-middle income (China, Malaysia, Mexico, and Turkey) and lower-middle income (India and Vietnam). All others are classified as high income. Regionally, European markets dominate the top rankings.

Only minor shifts were seen in the rankings from the *January 2017 Update* to the *2017 SG TMR*. This was largely because the Smart Grid ICT rankings are dominated by *Category #1* (Smart Grid Growth Potential). Policy, regulatory, and investment trends take time to implement. The short duration between the releases of the *January 2017 Update* and this full report, limits the potential for implementation and evaluation of new policies and regulations in most markets.

Those markets that moved year-on-year were largely the result of *Category #4* (Key Economic and Energy Sector Investment Indicators) score changes. This was the case for Singapore (+8) and Denmark (+7), and India (-10), which saw the biggest rankings shifts year-to-year. Largely, these shifts are noticeable but do not signal significant market shifts that should shift U.S. exporters' near-term strategies.

Full comparisons of year-to-year Smart Grid ICT sub-sector rankings are included in Appendix 2.

Opportunities

ITA expects that some Smart Grid ICT Sub-Sector solutions will be increasingly important as global governments, regulators, and utilities look to increase efficiencies, integrate renewable resources

effectively, gain market share amid increasing competition, engage consumers, and reduce revenue losses. A selected sub-set of these solutions are highlighted as follows:

- **Renewable Energy Integration Solutions:** In 2016 during a 17-hour period, Texas produced 40 percent of its electricity with wind energy. Denmark has set a goal of eliminating fossil fuels in its energy mix by 2050. Germany has deployed enough residential solar to generate 30 percent of its electricity from renewables. Increased penetration of intermittent, variable resources (solar and wind) are forcing grid operators to implement new ICT solutions to improve system planning and demand and supply forecasting.
- **Cybersecurity Software:** In December 2016, a fully automated cybersecurity attack caused a blackout across the Ukraine. This was the second nationwide blackout to hit the Ukraine in as many years and it elevated discourse on grid vulnerability to attacks and malware. U.S. smart grid firms with a focus on cybersecurity will find export opportunities among both developed and developing nations to tap an estimated $1.8 billion global market. [36] As the grid becomes increasingly digitized, the protection of consumer data and critical infrastructure will drive new markets for companies providing cybersecurity products and services to global utilities.
- **Distribution and Substation Automation (DA):** According to Navigant, global investment in distribution and substation automation products and services is expected to grow at a 49 percent CAGR over the next four years to reach $12.5 billion in 2021. [37] The robust U.S. technology track record of demonstrating that DA deployment ultimately results in fewer and shorter outages, lower outage costs, reduced equipment failure, and few inconveniences for customers provides a healthy and growing market opportunity in this segment in the near-term for U.S. exporters. [38]
- **Virtual Power Plants:** This is the grouping of multiple distributed electricity generators into one aggregated system by using advanced ICT solutions. Smart meters, advanced analytics, and demand response programs can be connected and coordinated to create a system of distributed energy generators (such as rooftop solar) that can bid their excess electricity production into local energy markets. By one estimate, the global virtual power plant market is expected to grow at a 30 percent CAGR from $191.5 million in 2016 to $1.2 billion in 2023. [39] U.S. exporters are expected to focus in the near term on commercial and industrial customers that have the most to gain in energy savings, can aggregate their generating capacity to bid into electricity markets, and must pay local utility demand charges.

Challenges and Barriers

The complex nature of the utility industry challenges vendors to engage with governments, regulators, and utilities in order to successfully sell products and services. There are numerous challenges and barriers that exist to opening foreign opportunities to U.S. exporters. These include, but are not limited to, the following:

- **Rapid Technology Evolution:** The electric utility industry is known as being risk-averse. Planning often takes decades rather than years or months. Given the speed that ICT systems evolve, U.S. exporters supplying these technologies will be challenged by slow decision-making and

hesitancy to procure products and systems if the "next generation" of those same products is expected to be updated and released in the near future.

- **Quest for an Industry-Wide Interoperable Platform:** Interoperability of hardware and software continues to plague utilities. Various vendor communities are working to develop coalitions of partners and competitors to develop common platform upon which various proprietary technologies can operate. Until a common platform is established, U.S. firms will be asked repeatedly to customize products to fit the unique need of each utility system. The time intensity of providing custom systems – especially when looking at the global market – will add costs which may price some suppliers out of particular markets. Unless the industry/market settles on an interoperable platform or widespread adoption of interoperability standards, economies of scale will be difficult to achieve and firms will continue to fight against each other for market share.
- **Lack of Utility Working Capital:** In many of the emerging economies ranked in the latter half of the Smart Grid ICT Sub-Sector rankings, T&D losses are upwards of 20 to 40 percent. Deployment of smart grid ICT solutions (e.g., smart metering) would help reduce these losses and improve payment collection. However, the utilities that could benefit the most are the least likely to have the resources to fund these upgrades. U.S. exporters need to be creative in determining new business models for the deployment of smart grid ICT if they want to sell into rapidly growing markets and encourage technological leapfrogging

Energy Storage Sub-Sector Snapshot

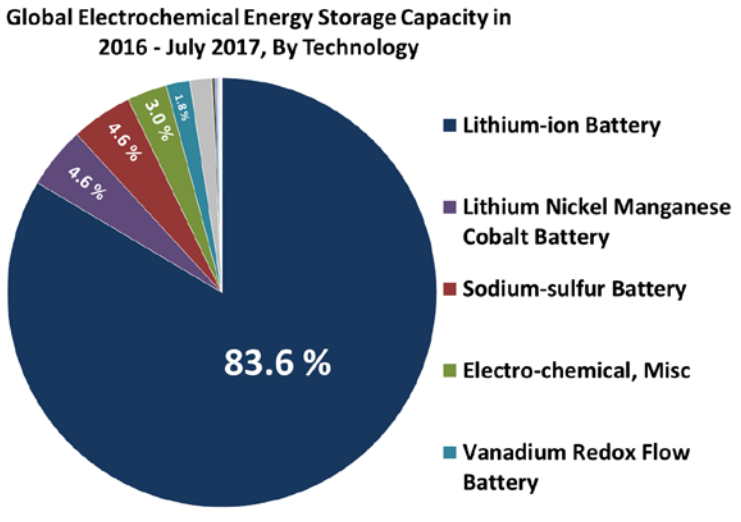
State of the Market

Utilities are piloting and deploying energy storage systems for a wide range of applications, so-called "use-cases." Energy storage systems are rapidly being deployed across the electricity system, in applications such as black start, arbitrage, frequency regulation and T&D deferral. According to the U.S. Department of Energy's (DOE) Global Energy Storage Database, as of July 2017, there were 1,587 energy storage projects either in operation, under construction, contracted or announced. [10] Together these projects total more than 192 GW of capacity.

Energy storage systems deploy diverse technologies to store energy. As shown in Figure 2, the five general classifications are electrochemical, electro-mechanical, thermal storage, hydrogen storage, and pumped hydro. Among projects included in the DOE database, 95 percent of global capacity was derived from 349 pumped hydropower projects (22 percent of total project number). Global energy storage deployment was further segmented among thermal (204 projects, 3.6 GW), electrochemical (952 projects, 3.1 GW), and electro-mechanical (70 projects, 2.6 GW).

Interestingly, almost 60 percent of all global projects leveraged electro-chemical systems. These projects reflect smaller capacities and are both reflective of inherent relative project size to hydropower and the maturity of the technology leading to more pilot-scale projects. Among projects commissioned in 2016 and the first half of 2017, over 83 percent – more than 13 percent – of new capacity was electrochemical (battery) based. As shown in Figure 17, more than 83 percent of new electrochemical energy storage capacity used lithium-ion technologies, or 71 projects totaling 0.9 GW. This is being driven by cost decreases and improved economies of scale. Between 2007 and 2017, lithium-ion battery pack costs declined by about 60 percent and are expected to drop by another 20 to 27 percent over the next two years for both utility and residential applications. [40] ITA believes that lithium-ion deployments will continue to be the near-term preference among buyers.

Figure 17.



The U.S. DOE Global Energy Storage Database links projects to use-cases. [10] Twenty-nine use-cases were identified in the database; a single project could leverage the energy storage system for multiple use-cases. As shown in Figure 18, among electrochemical projects, the leading use-case (by number of projects) is strongly related to renewable energy integration, where 27 percent of all global projects are deployed for "renewable energy firming." "Time shifting" was the second leading use-case among electrochemical projects (26 percent), and 75 percent of the time this relates to renewable energy generation shifts.

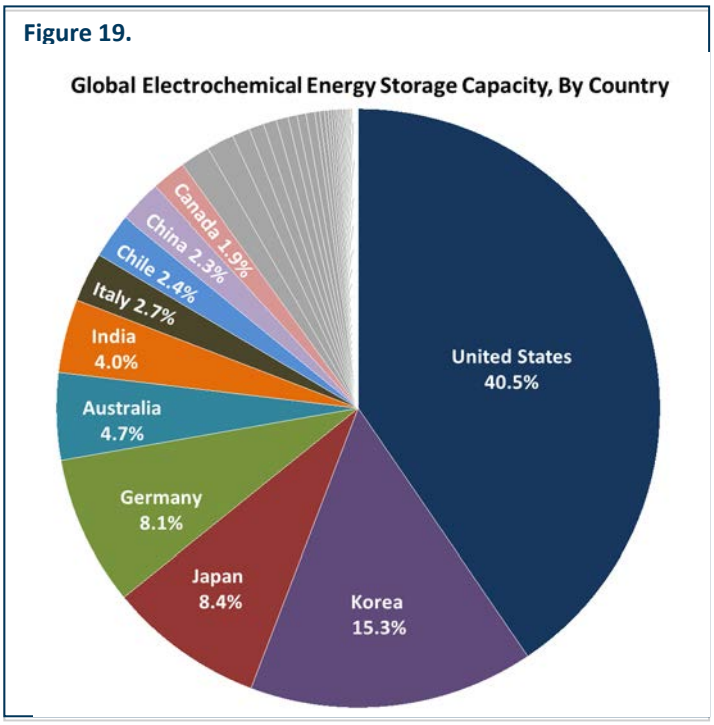
Figure 18. [10]

Global Electro-chemical Energy Storage Projects		
Use-Case	Number of Projects	% of Total Projects
Renewables Capacity Firming	255	27%
Electric Energy Time Shift	245	26%
Frequency Regulation	209	22%
Renewables Energy Time Shift	184	19%
Electric Bill Management	184	19%
Onsite Renewable Generation Shifting	170	18%
Microgrid Capability	157	16%
Voltage Support	144	15%
Resiliency	118	12%
On-Site Power	114	12%
Electric Bill Management with Renewables	104	11%
Electric Supply Capacity	94	10%
Grid-Connected Commercial (Reliability & Quality)	74	8%
Load Following (Tertiary Balancing)	56	6%
Electric Supply Reserve Capacity - Spinning	55	6%
Transportation Services	50	5%
Distribution upgrade due to solar	46	5%
Ramping	46	5%
Black Start	45	5%
Stationary Transmission/Distribution Upgrade Deferral	43	5%
Grid-Connected Residential (Reliability)	40	4%
Transmission Support	25	3%
Transmission Congestion Relief	23	2%
Demand Response	22	2%
Transportable Transmission/Distribution Upgrade	19	2%
Electric Supply Reserve Capacity - Non-Spinning	19	2%
Transmission upgrades due to wind	12	1%
Distribution upgrade due to wind	12	1%
Transmission upgrades due to solar	5	1%

As shown in Figure 19, the United States accounts for more than 40 percent of the total global capacity of electrochemical storage projects. The top 10 global markets account for 90 percent of installed capacity with Korea, Japan, Germany, Australia, and India being world leaders.

There is not yet one market – domestically or internationally – that has the comprehensive suite of policy, regulatory, business, and financing solutions for the rapid deployment of energy storage systems. There are discrete examples of policies, regulations, and business models that are fostering deployment across the globe, but finding the right combination remains a challenge. As a result, much of the near-term focus for opening global markets will be to build awareness, increase communication channels, and engage in discussions about best practices.

Figure 19.



In the medium-term, as the market matures, the deployment of energy storage systems will increase throughout the world. By one estimate, utility-scale and distributed energy storage will reach more than 30 GW (43 percent CAGR) and 19 GW (52 percent CAGR) in 2026, respectively. [41] [42] To realize these deployments, pilot and demonstration projects will likely be required in the near-term to build regional confidence among utilities for future deployments.

New policies and regulations that encourage development of energy storage projects will further fragment market opportunities. Long-term consideration of operational safety in different climates, project lifetimes, the need for recyclability of products (in the case of batteries), along with other factors, will impact how foreign utilities scope new projects.

U.S. Competitiveness

Many projects in the United States leverage domestic suppliers of batteries, integration software, associated electrical equipment, and other goods and services. For example, six of the world's top 10 energy storage system integrators are U.S.-headquartered firms and all 10 have healthy U.S. operations. [43] The U.S. vendors supplying goods and services to domestic customers have a competitive advantage globally based on experience and economies of scale across a range of technologies. However, over the coming decade, the market for new energy storage capacity is expected to shift outside U.S. borders. By 2025, forecasts suggest that the United States will be overtaken as the largest market for energy storage. [44] If U.S. firms do not begin to expand sales internationally now, the current U.S. competitive advantage may not be maintained as opportunities shift overseas.

U.S. export competitiveness varies by market location and segment y (e.g., battery manufacturer, software provider, and integrator). For example, Korean, Japanese, and Chinese firms maintain strong market share in lithium battery manufacturing and U.S. exporters of similar technologies face stiff competition globally – including bidding into projects that include other U.S. partners – especially in Asian markets. [45] Given the physical weight of lithium-ion batteries, the sourcing of products is often dependent on geographical distance to the demand center. Both U.S. and foreign firms have already explored, or are in the process of exploring, global manufacturing footprints. For example, U.S. domestic demand for lithium-ion batteries – primarily for electric vehicle usage – has been a driver for foreign vendors locating manufacturing facilities in the United States.

Rankings

As shown in Figure 20, the United Kingdom, Denmark, and Canada top the Energy Storage Sub-Sector rankings. Northeast Asian markets tend to rank well, but strong local competition and preferential policies in markets such as Japan, Korea, and China decrease opportunities for U.S. exporters. These markets still reflect large immediate markets (and therefore rank highly) as the number of projects (and project capacity) exceed those for other regions. The Nordics perform well given interest in advanced grid technologies, strong interest in carbon-neutrality, well-designed regional electricity markets, and fast-growing deployment of electric vehicles relative to other regions.

Figure 20.

Energy Storage Rankings									
1	UK	11	Chile	21	Saudi Arabia	31	Poland	41	Morocco
2	Denmark	12	Netherlands	22	Italy	32	Czech Republic	42	Costa Rica
3	Canada	13	India	23	Singapore	33	Brazil	43	Colombia
4	Australia	14	Sweden	24	Mexico	34	New Zealand	44	Argentina
5	Japan	15	Austria	25	Indonesia	35	South Africa	45	Thailand
6	Germany	16	Philippines	26	Kenya	36	Russia	46	Ethiopia
7	Finland	17	Malaysia	27	Egypt	37	Vietnam	47	Romania
8	Korea	18	Portugal	28	Nigeria	38	Turkey	48	Bulgaria
9	Ireland	19	France	29	Belgium	39	Kazakhstan	49	Peru
10	China	20	Spain	30	Israel	40	Ghana	50	Nicaragua

The *2017 SG TMR* Energy Storage Sub-Sector rankings included two key methodology changes: (1) focus exclusively on electrochemical (battery) storage technologies, and (2) incorporating five-year projections for renewable energy deployments. Interestingly, these shifts resulted in largely minimal changes relative to the inaugural *January 2017 Update* sub-sector rankings.

Nigeria (+13), Malaysia (+10), and Kazakhstan (+10) saw the largest increases, while Mexico (-15), Egypt (-11), and Thailand (-8) saw the largest year-on-year drops in relative rankings. Given that the energy

storage score is a composite of all five categories, relative shifts are not attributable to one particular factor. *Category #2* (Trade Factors and U.S. Competitiveness) scores for Egypt, Kazakhstan, and Thailand are reflected in their overall Energy Storage Sub-Sector score. For Malaysia, Mexico, and Nigeria, methodology changes to *Category #3* (Energy Storage Growth Potential), were the key drivers for changes in rankings. The transition from a static current renewable energy percentage of electricity to a five-year projection changed the outlook for both markets. Regarding Mexico, there was not one particular factor contributing to the decrease.

Full comparisons of year-to-year Energy Storage Sub-Sector rankings are included in Appendix 2.

Opportunities

Some Energy Storage Sub-Sector solutions will be increasingly important as foreign governments, regulators, and utilities look to integrate renewable resources effectively into their systems strategically deploy T&D assets, and increase grid management efficiencies. These solutions include:

- **Solar plus Storage:** As shown in Figure 18, renewable energy integration is the primary use-case for the deployment of global electrochemical energy storage systems. Although benefits can be derived by coupling any generation asset with an energy storage system, the combination of solar-energy generation and energy storage is likely to be the most immediate market opportunity. U.S. exporters that develop viable business models that couple behind-the-meter (especially C&I) solar and storage solutions will likely experience the most immediate success, especially in markets with TOU pricing. Navigant Research predicts that the behind-the-meter solar PV plus energy storage system market will grow to 27.4 GW of capacity and $49.1 billion in revenue by 2026. [46]
- **Non-Wires Alternatives (NWA):** Although only 5 percent of global energy storage projects target T&D deferral and a minor number of projects are aimed at T&D upgrades for renewable energy integration, deploying energy storage as NWA provides an interesting business proposition for electric utilities looking for quick solutions to T&D challenges. Broadly, investment in NWAs is expected to grow at a 30 percent CAGR over the next nine years. [47] However, solving the "ownership" question for the transmission or distribution utility will remain a challenge for deployment in some markets.
- **Diesel Generator Replacement:** For many emerging economy electricity consumers, unreliable access to electricity results in the deployment of fossil-fuel generators for backup power. In remote locations, these small behind-the-meter assets even serve as primary energy sources. Given price fluctuations (and the requirement for long-distance transmission, the price of electricity is very high in these locations. Energy storage solutions (often coupled with solar) can serve as an immediate cost-effective alternative. This is particularly true for many small island markets (and are therefore not be included in the *SG TMR* rankings), but offer lucrative export opportunities.

Challenges and Barriers

As previously noted, there is not yet one market – domestically or internationally – that has the comprehensive suite of policy, regulatory, and business solutions for the rapid deployment of energy storage systems. There are a policy, regulatory, and commercial challenges facing this emerging sub-sector. Examples include:

- **Accessing Clean Energy Subsidies:** A primary use-case for energy storage is to integrate renewable energy system into existing utility grids and operations. However, governments that offer subsidies to owners of clean energy generation assets such as solar or wind) do not often extend them to cover hybrid systems. U.S. exporters will face challenges in defining system components that are explicitly included in import tariff reductions or waivers, or are available for tax subsidies that have been created to encourage the deployment of energy storage systems.
- **Too Much Domestic Demand:** The rapid deployment of energy storage systems in the United States has overwhelmingly positive effects for U.S. suppliers. However, this success presents challenges because it limits their ability (and desire) s to expand international business opportunities. By waiting until the U.S. market is saturated before looking internationally U.S. firms may lose their current competitive advantage and concede global market share to foreign competitors.
- **Safety and Standards Development:** The complex chemistries of many battery technologies require proper handling, end-of-life care, and recycling to ensure safety and environmental sustainability. U.S. exporters may face delays as regulators adapt to emerging technologies. This is especially critical for lithium-ion batteries due to their potential as a fire hazard.

Australia Case Study

Australia has been taking measures to modernize its energy infrastructure, reduce coal usage, and increase renewable energy penetration. As in the United States, state and local governments play a strong role in the design, development, and operation of Australia's electrical system. As a result, commercial opportunities for U.S. firms will vary by region. Over the last year, blackouts across South Australia have become more common, while depressed global commodity prices have led to decreased electricity demand in Western Australia. Demand response programs in Western Australia that were implemented during high usage years have been hotly debated due to excess capacity in state-owned utilities.

Market Overview

Australia's overall electricity demand increased 0.7 percent per year from 2005 to 2015. In 2015, approximately 228 terawatt hours of electricity was generated. This low increase in demand was due to higher energy prices and more efficient energy use. Demand is expected to pick up in the coming years with an average increase of 2.1 percent over the next decade.

Generation

Coal dominates electricity generation in Australia: 63 percent of electricity is generated from coal; 21 percent from natural gas; and 14 percent from renewable energy sources. [48] Generation from renewable energy sources was 38 percent from hydropower, 32 percent from wind, 10 percent from bioenergy, and 17 percent from solar. Overall, the market is trending toward cleaner energy sources. According to the Australian Energy Market Operator (AEMO), there are an additional 20,000 MW of generation proposals throughout the country waiting to be developed: 62 percent for wind; 25 percent for natural gas; and 11 percent for solar. [49]

Privately-owned utilities dominate the southern and eastern regions, where AGL Energy, Energy Australia, and Origin Energy are the primary producers. AGL is the largest generator of renewable energy in the country. The majority of Australian hydro plants are located in Victoria, the majority of its wind farms are located in Victoria and South Australia and the majority of its solar farms are located in New South Wales. In 2016, the renewable energy generation mix of these regions was composed of 47.1 percent hydropower, 32.4 percent wind, 2.9 percent solar and 17.7 percent rooftop solar. [49] Southern and Eastern Australia have seen 15,200 MW of new capacity being added over the last 20 years. In the last few years, most of the new investment has gone towards wind and other forms of alternative energy instead of coal generation. [49]

In Western Australia, the state-owned company Synergy is the primary producer. Synergy, owns approximately 75 percent of the generation capacity, including contracts with third parties. [50] In 2015, the overall energy generation mix in Western Australia was composed of 93 percent non-renewable generation and 7 percent renewable generation. Among the renewable generation, 62 percent came from wind, 25 percent came from solar PV, 8 percent came from hydropower, and 5 percent came from biogas. [48]

In the Northern Territory, the state-owned company Territory Generation is the primary producer of electricity. The Northern Territory government created in Territory Generation in 2014 under the Power Generation Corporation Act (PGC) by to increase the efficiency of electricity generation throughout the state. Territory Generation has made investments in recent years, such as an AUD $101 million investment to upgrade the Owen Springs Gas Power station in Alice Springs and the Tennant Creek Gas Power station in Tennant Creek. [51] Upgrades at the Owen Springs Gas Power station included expanding the amount of power generation from solar and improving energy storage capability.

Transmission

Electricity utilities throughout Australia on average invest AUD $1.2 billion in transmission networks each year. AEMO, a state-owned company, owns most of the national transmission assets in Australia: AEMO owns three of the four main electricity grids in Australia [49] In 2017, AEMO appointed former Chair of the New York State Public Service Commission, Audrey Zibelman, as their new Chief Executive Officer. Zibelman previously oversaw the Reforming the Energy Vision process in New York. This appointment signals a strong likelihood that AEMO will promote the expansion of smart technology throughout its grids.

Wholesale electricity in the southern and eastern parts of Australia is traded through AEMO's National Electricity Market (NEM). NEM currently has over 40,000 kilometers of transmission lines to transport electricity. NEM's regional network is comprised of various state-based transmission networks such as Queensland's Powerlink and Southern Australia's ElectraNet that NEM links through cross-border interconnectors. The total value of the transmission assets in NEM is AUD 19 billion. The voltage at which the grid operates is between 49.85 to 50.15 Hertz (Hz). [49]

Wholesale electricity in Western Australia is primarily traded through AEMO's Wholesale Electricity Market (WEM). WEM includes over 7,800 kilometers of transmission wires and cables, covering three regional grids that include the major Southwest Interconnected System and Northwest Interconnected System as well as the smaller Regional Power system. The Southwest Interconnected System covers Perth and other prominent cities in the area and is the most used of the three systems.

Wholesale electricity in the Northern Territory is primarily traded through the state-owned Power and Water Corporation. The Power and Water Corporation is separate from AEMO and currently includes over 8,500 kilometers of transmission wires and cables. The Power and Water Corporation is connected to the fourth main Darwin-Katherine Electricity Network (NT) regional grid.

Distribution
Electricity networks throughout Australia on average invest AUD $5 billion in distribution networks each year. The distribution of electricity in Australia is primarily delivered by state-owned companies within each state. [49] For example, two of Queensland's most prominent distributors are state-owned Energex and Ergon Energy. NEM, Australia's largest electricity grid NEM, includes distribution networks worth AUD $68 billion.

Distribution voltage tends to vary by state. iIn South Australia, the high voltage in its distribution lines can be as high as 66 kilovolts while the low voltage that goes into residential homes is around 415 volts (V) with an end-user voltage of 240V. [52] In the Northern Territory, the Power and Water Corporation is in charge of distribution throughout the state.

Retail Sales & Pricing
To sell electricity under the National Energy Retail Law, a company must hold a retailer authorization. In order to obtain a retailer authorization, the three primary requirements are: the appropriate technical background to be an energy retailer, adequate access to financial resources, and suitability for a retailer authorization. [53] While some large customers buy electricity directly from the distributors, most customers buy through a retailer that determines electricity pricing at the state level and calculates prices based on the daily off-peak and peak average spot price. In the Southern and Eastern parts of Australia, AGL Energy, Origin Energy and EnergyAustralia are also the primary electricity retailers. Synergy is the primary energy retailer in Western Australia and the Power and Water Corporation is the primary retailer for the Northern Territory.

Storage
Battery storage deployment has started in Australian. Deployment will likely increase as system costs drop. ITA anticipates near-term deployment will be focused on the utility scale as well as on large commercial and industrial (C&I) customers with needs for high reliability of their systems. Australian households already show significant interest in and awareness of batteries: nearly three-quarters of customers with solar PV installations are interested in using battery storage. However, residential battery storage is unlikely to increase due to high price points. [49]

Policy & Regulatory Environment

The Department of the Environment and Energy serves as the lead for federal energy policymaking. It has set a Renewable Energy Target (RET) that would double the delivery of large-scale renewable energy from solar, wind, and hydropower to 33,000 gigawatts per hour (GWh) in 2020. The RET would increase the share of total generation from renewables to 23.5 percent. [54] The Department has initiated several projects focused on the deployment of smart technologies at the sub-national level. For example, "Smart Grid, Smart City" was designed to be Australia's first commercial-scale smart grid project. The trials, which concluded in 2014, were based in Newcastle and New South Wales. Results

suggested that the adoption of smart grid technologies across NEM would lower network prices and consumer expenses.

At the state level, each state in Australia has a department that focuses on energy policy and passes energy legislation. For example, the state of Queensland's Department of Energy and Water Supply is actively promoting the expansion of solar energy generation both on the rooftops of residential homes and through solar farms. For example, the Solar 150 initiative is meant to be Queensland's large-scale solar investment program and support up to 150 MW of solar power generation throughout the state.

The leading rule maker for the energy market in Australia is the Australian Energy Market Commission (AEMC). AEMC is tasked with making and amending the National Energy Rules, National Gas Rules and National Energy Retail Rules, while also providing advice to the government on how to further develop the Australian electricity market.

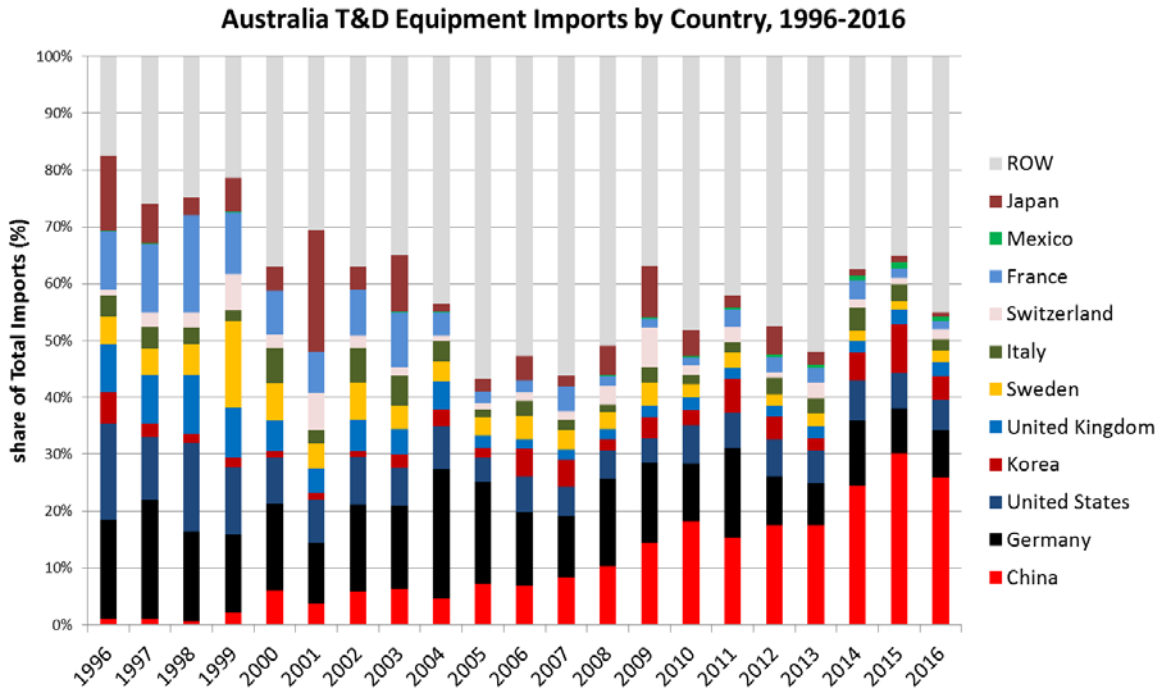
The main regulator for electricity in Australia is the Australian Energy Regulator (AER). While AER's primary focus is on NEM, it also advises AEMO as a whole. AER regulates both transmission and distribution at the central level. The electricity distribution businesses are required to submit an annual pricing proposal that outlines proposed prices for the following year. Tariffs included in a distributor's annual pricing proposal must match those approved by AER's tariff structure statement. The process and form in which customer's metering data is collected must be provided, including interval metering data and total metering data. Every state has its own regulatory body designed to enforce fair practices and pricing on a state level. State regulatory bodies also work with the Council of Australian Governments' (CoAG) Energy Council, a high-level intergovernmental dialogue between the different states of Australia on energy. In Western Australia, AER's presence is minimal, so the main energy regulator there is the Economic Regulation. As of July 2015, AER assumed the role as the main regulator of the Northern Territory's Power and Water Corporation from the Northern Territory's Department of Treasury and Finance and is now the main regulator for that region.

Market Analysis and Rankings

High scores in smart grid ICT and energy storage deployment propel Australia to *#10* in the overall *2017 SG TMR* rankings.

Over the last two decades, Australian T&D equipment imports have increased by a 9 percent CAGR. In 2016, the import market totaled $417 million. As shown in Figure 21, the United States is the third largest supplier of T&D equipment to Australia, behind China and Germany. Despite a reduction in overall market share from over 16 percent to 5 percent in 2016, absolute U.S. exports to Australia for T&D equipment grew at a 2 percent CAGR. In 2016, Australia imported $21.6 million in T&D equipment. Nevertheless, modest electricity consumption increases are anticipated for the market in the near-term (2 percent CAGR). Australia's T&D equipment score drops to *#26*, a ranking below its export revenue ranking for 2016.

Figure 21. [7]



Australia is often an early adopter of smart grid ICT solutions, investing routinely amounts among the top ten in the world. [34] ITA anticipates that recent blackouts in South Australia will increase near-term investment in the Smart Grid ICT and Energy Storage Sub-Sectors – areas where U.S. firms have already been successful in the market. Australia is ranked *#4* for the Energy Storage Sub-Sector *SG TMR* rankings due to high-profile deployments of energy storage – particularly in South Australia – coupled with more than 117 MW of existing storage on the system.

Opportunities and Challenges for U.S. Companies

U.S. firms have found success in the Australian market to date. Regional diversity will continue to determine which sub-sectors represent opportunities in different states. Near-term market considerations include:

Opportunities

- Energy storage solutions in South Australia for grid stability
- Smart metering and associated analytics
- Behind-the-meter solar plus storage solutions
- Products and services to improve the Western Australia (WEM) and the Northern Territory (Power and Water Corporation) grids

- Renewable integration smart grid ICT solutions

Challenges

- Reduced revenues from grid defection, affecting working capital of utilities
- Powerful lobbying against renewable energy, which could affect the overall regulatory framework
- Decreasing government renewable energy subsidies

Know Your Buyer

Australian purchasers of U.S. smart grid goods and services include generation, transmission and distribution companies.

Summary of Resources

- U.S. Department of Commerce, Australia Country Commercial Guide: https://www.export.gov/ccg
- Australian Government, Department of the Environment and Energy: http://www.environment.gov.au/
- Australian Government, Office of the Chief Economist: https://industry.gov.au/Office-of-the-Chief-Economist/Pages/default.aspx
- Australian Energy Market Operator: https://www.aemo.com.au/
- Economic Regulation Authority: https://www.erawa.com.au/
- Territory Generation: http://territorygeneration.com.au/
- Australian Energy Regulator: https://www.aer.gov.au/

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Brazil Case Study

Brazil's ranking is affected by economic and electricity demand growth, as well as by a policy and regulatory environment that may constrain investment and export opportunities in the energy sector. Brazil is currently the largest electricity market in Latin America. Smart grid deployments have been slowed by regulatory and technical hurdles, resulting in lower *SG TMR* rankings. The business environment is also challenging for new-to-market U.S. smart grid exporters, because participation often requires strong local partnerships and longer timelines for investment.

Market Overview

Brazil's overall electricity demand has increased by an average of 2.5 percent per year for the last ten years. While energy demand has trended upward over the last ten years, demand decreased in 2016 by 1.2 percent in response to Brazil's most recent economic recession. Demand is expected to continue to increase 2.4 percent per year over the next ten years.

Generation

Brazil's electricity market is heavily dependent on hydroelectric power, with approximately 80 percent of its electricity generated by the source in an average year. Droughts, however, have recently restricted the country's electricity generation. For example, southeastern Brazil experienced a long drought from 2013 – 2016 that was exacerbated by the strong 2015–16 El Niño event. This resulted in the worst water shortage event in the region in 35 years. As hydroelectric output fell during this period, generation increased from other fuels, such as natural gas and liquid fuels. This has stimulated interest in the deployment of solar and wind power.

Privatization and competition have been limited in Brazil's power supply and services markets. However, in 2017, Brazil's Minister of Mines and Energy (MME) Fernando Bezerra Coelho Filho proposed the privatization of Brazilian electric utility Centrais Elétricas Brasileiras (Eletrobrás). With more than 24,000 employees, Eletrobrás is the largest power company in Latin America and controls approximately one-third of total installed capacity.

Wilson Ferreira Junior, Eletrobrás's CEO, stated that the privatization of the utility would eliminate hurdles that state companies face in Brazil, and will allow the utility to compete on equal terms with private utilities. At a news conference in Brasilia with Energy Minister Fernando Coelho Filho, Mr. Ferreira stated that current power sector regulations in Brazil block the firm's growth and lead to inefficiencies.

MME Minister Coelho Filho disclosed that his agency might issue new shares to raise $6 billion, which would dilute the government's stake to 47 percent. However, no individual private shareholder would be allowed to take a controlling interest in the company. Additionally, the government would remain a shareholder and would reserve the right to veto some strategic decisions.

The Brazilian government currently holds a 51 percent voting stake in Eletrobrás. The Brazilian Development Bank (BNDES) owns about 20 percent of common shares and 14 percent of preferred shares. The proposal to sell control of Eletrobrás was formally presented to the council of the government's Investment Partnership Program in late 2017 and additional announcements on the privatization expected in 2018.

With the potential privatization, Eletrobrás would be required and able to compete with other local private utilities and would be looking at improving efficiency and output by sourcing newer technology. This could pose as a good opportunity for U.S. suppliers of power generation and distribution products and services.

Transmission

Transmission lines in Brazil have become increasingly privately owned and operated, but are overseen at a national level by the state-owned Operador Nacional do Sistema Elétrico (ONS). Equatorial Energia SA, which is in the process of building seven new transmission projects, reflects Brazil's need for private investment in its 60 Hz transmission infrastructure, which has been inadequate and delayed some projects. Brazil requires that projects involved in energy auctions prove that the transmission lines are secured before participating in the auctions. This practice reduces delays associated with insufficient transmission infrastructure while helping to drive the market for T&D equipment.

Distribution

Privatization and competition have gone much further in the distribution segment, where there are more than 60 providers across the country. While state governments are allowed monopolies over their electricity markets, many have been privatized. For example, CELG, a distribution company from the state of Goiás, was successfully privatized and acquired by Italian Group ENEL in 2016. Approximately 70 percent of distribution companies acquire some of their financing from private capital. Poor energy efficiency and nationwide average T&D losses more than 15 percent are also pressing issues affecting Brazilian distribution firms. The need to upgrade infrastructure is a common refrain in Brazil, but meeting the need has proved difficult. The end user voltage varies by state in Brazil: 110 V, 127 V, or 220 V.

Storage

Deployment of energy storage technologies is not growing quickly in Brazil due to the absence of a strong regulatory framework governing its adoption, use, and overall management. However, Brazil's energy regulator, the National Electrical Energy Agency (ANEEL), has become increasingly motivated to improve energy storage investments. In 2016, ANEEL developed a three-year roadmap requiring utility

companies to invest 0.4 percent of their annual revenue towards the research and development of energy storage technology. The framework includes plans to improve research and development of battery energy technologies by local firms. The framework also features plans for utility firms to partner with universities and smart grid solution providers in researching, developing and testing energy storage technology. ANEEL also launched a Strategic Public Call for R&D energy storage projects this year. ANEEL has approved 23 projects; and each project has four years to be completed.

Regional Integration

South American markets continue to pursue regional integration. Brazil has implemented (or is considering) interconnections between its system and Argentina, Bolivia, Guyana, Peru, Suriname, and Uruguay. The Brazil – Argentina HVDC Interconnection consists of a transmission system 490km long between the Rincón de Santa Maria substation in northern Argentina, Itá in southern Brazil, and an HVDC converter station at Garabi in Brazil, near the border.

Policy & Regulatory Environment

The primary government agency that oversees energy policymaking is Brazil's Ministry of Mines and Energy (MME). While MME is the primary crafter of national energy policy, each state in Brazil has its own state-level MME equivalents that engage in their own energy policymaking.

In 2011, Brazil released its "Ten Year Energy Plan" and set a goal of adding 18 GW of renewable resource capacity by 2020. The expanded renewable supply is intended to diversify the energy supply mix and help Brazil reduce greenhouse gases by 37 percent by 2025 and 43 percent by 2030, compared to 2005 levels. Renewable energy projects in Brazil – particularly locally sourced projects – receive favorable financing in Brazil, and electricity produced from renewable sources with capacity less than or equal to 30 megawatts (MW) receives a 50 percent reduction in T&D tariffs.

In December 2015, Minister of Mines and Energy Eduardo Braga launched a multi-agency distributed generation initiative (Pro-GD) seeking attract $25 billion in investment by 2030. This launch included installation of 2.7 million solar units to increase Brazil's non-hydropower renewable resources share from 13 percent to 23 percent. The initiative is also expected to lower CO2 emissions by 29 million tons to contribute to Brazil's goals of cutting greenhouse gas emissions.

ANEEL is the primary regulator of the Brazilian energy sector for both transmission and distribution. ANEEL regulates public tenders for electricity sold to distribution utilities, sets tariffs for residential consumers in the regulated market, and is responsible for maintaining an economic balance that enables distributors to cover operating costs and recover an adequate return on investment. Meanwhile, electricity trading between independent energy suppliers is unregulated; industrial consumers have the option of purchasing from the unregulated market.

ANEEL predicts that revisions to net-metering policies in 2016 will increase opportunities for aggregation of sources and increase the number of small customer units installed to 1.2 million by 2024. This increase would amount to 4.5 GW of installed capacity. This policy change also enables "shared generation," where interested parties are allowed to create a consortium or cooperative to install a micro (up to 75 kilowatts) or mini-distributed (up to 5 megawatts) generation unit to reduce the electric bill for the parties.

Despite the long-standing goal of nationwide deployment, Brazil's smart meter market has not grown due to an unfavorable regulatory environment. In 2012, ANEEL approved a long-awaited resolution establishing requirements for smart meters, but limited the classes of consumers eligible for the roll-out from ANEEL and the National Institute of Metrology, Quality, and Technology (INMETRO) need to provide additional technical regulations to enable deployment.

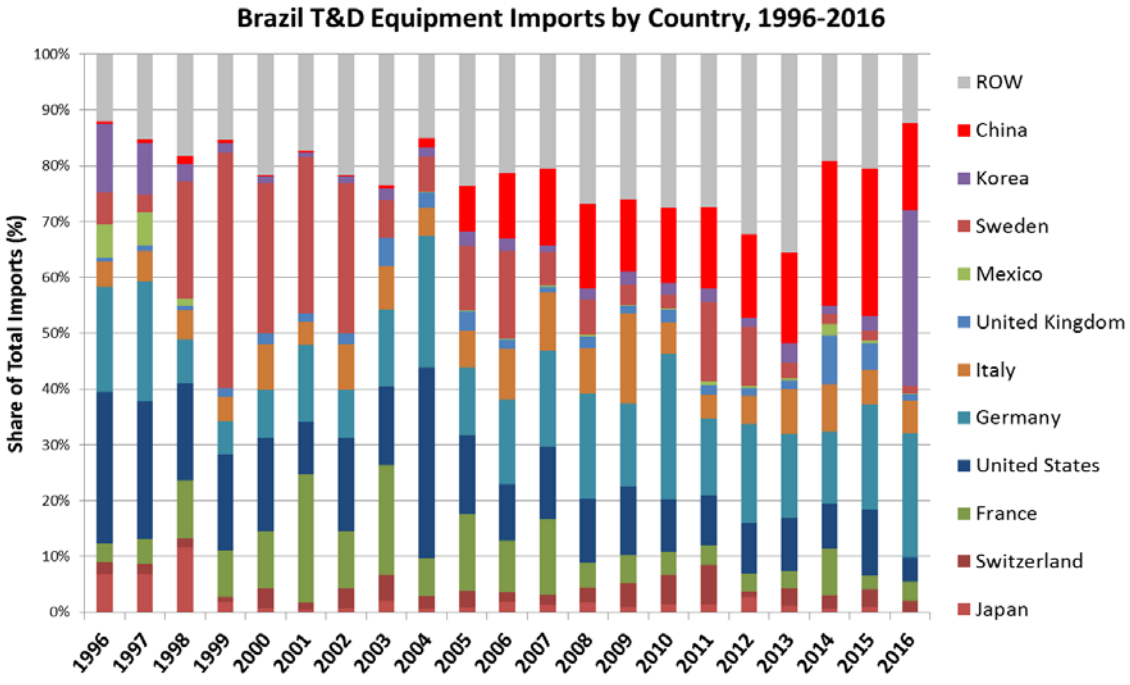
Market Analysis and Rankings

Despite low overall and sub-sector *SG TMR* rankings, Brazil remains the largest market in Latin America and a priority for many U.S. exporters.

Brazil's electricity needs and investment in large infrastructure projects through the 2013 period of economic growth have been important growth drivers for U.S. suppliers of grid modernization equipment and services. In 2013, U.S. T&D equipment exports to Brazil more than doubled. However, in 2016, U.S. exports returned to pre-2007 levels – $25 million per year – representing a decrease of more than 40 percent since 2013. These patterns contribute to the *#38 SG TMR* ranking for the T&D Equipment Sub-Sector in Brazil.

From2013 to 2016, Brazilian T&D equipment imports increased by 22 percent to $544 million. As shown in Figure 22, eleven global markets accounted for almost all Brazilian T&D equipment imports in 2016. Korean T&D equipment imports to Brazil skyrocketed in 2016 to comprise over 30 percent of imports ($171 million). Year-on-year variation is significant. There has been a recent increase in Chinese T&D equipment imports to Brazil, representing increased competition in the market. This may be the result of greater involvement by State Grid Corporation of China and China Three Gorges Corp to manage and own Brazilian utility assets.

Figure 22. [7]



Beginning with the Lula administration (2003 – 2011), Brazil set ambitious goals for its national smart grid ICT deployment, but the market has been slow to develop due to challenges in the regulatory and business environment. Once these hurdles are resolved, ITA expects significant investment in smart distribution solutions that can solve the problem of electricity theft. While smart meter penetration has only reached 4 percent in the overall market, some of the larger urban utilities with higher-income consumer footprints will require advanced smart grid solutions to a range of power management challenges, resulting in a *#26* ranking for the Smart Grid ICT Sub-Sector. [35]

Energy storage system deployment in Brazil has been limited, but ITA anticipates that increasing grid management challenges resulting from transmission system buildout delays and increasing draughts limiting capacity will open up market opportunities – especially for hybrid wind or solar plus battery systems. U.S. equipment and control system suppliers have won bids to supply projects under the government's pilot project program; if these pilots move forward and result in increased system deployment, U.S. industry will likely see increased opportunities in the medium-term.

Opportunities and Challenges for U.S. Companies

U.S. suppliers continue to find export success in Brazil's T&D sector, where projects are continuing to grow despite economic and political issues that pose a threat to future growth. However, Brazil

continues to be a challenging market for U.S. firms to do business. Technology firms need a great deal of upfront work to overcome cultural and technical issues.

Opportunities

- Coupling of smart grid ICT projects with renewable energy deployments
- Transmission buildouts to connect renewable energy generation to load centers
- Energy efficiency products and services to address limited excess capacity issues resulting from draughts
- Smart metering to reduce non-technical losses at the distribution level
- Microgrids for remote communities

Challenges

- Challenging geography and environmental permitting of transmission projects
- High import tariffs, rigidity in the labor market, and a complicated customs system increase costs and operational risk
- Policies to stimulate and attract manufacturing to Brazil

Know Your Buyer

Brazilian purchasers of U.S. smart grid goods and services include generation, transmission and distribution companies. For example, according to the Brazilian Electric Power Utility Association (ABRADEE), there are 64 electric power utilities in Brazil, with 74.1 million consumers and 2 million new connections every year.

Summary of Resources

- U.S. Department of Commerce, Brazil Country Commercial Guide: https://www.export.gov/ccg
- Brazilian Ministry of Mines and Energy (MME): www.mme.gov.br
- Brazilian National Electrical Energy Agency (ANEEL): www.aneel.gov.br
- Brazilian Electrical and Electronics Industry Association: www.abinee.org.br
- Eletrobrás: www.eletrobras.com.br
- Empresa de Pesquisas Energéticas (EPE): www.epe.gov.br

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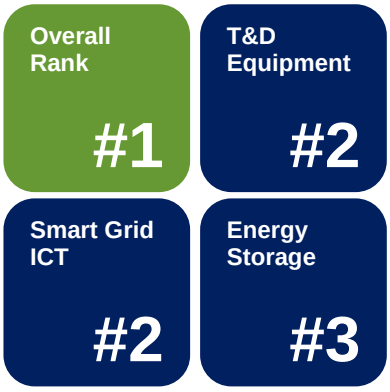
Canada Case Study

Canada ranks first overall in the *2017 Smart Grid Top Market Report*. Canada is the United States' top smart grid trading partner and a world leader in advanced smart grid deployment. U.S. exporters are highly competitive in Canada and face few barriers to doing business. There is still potential for growth in this market. Canada needs to invest in its aging electricity infrastructure, and some provinces are planning large build-outs and upgrades to transmission lines. Regional integration with the United States further provides opportunities for cross-border electricity trade and the potential for Canadian generators to serve as a balance to U.S. renewable energy generation.



Market Overview

Canada's overall electricity demand has steadily increased by an average of 0.3 percent per year for the last ten years. In 2015, Canada generated approximately 634.5 terawatt hours of electricity. Demand is expected to increase by 0.8 percent annually over the next decade.

Generation

Hydro Quebec, OPG, BC Hydro, TransAlta and Bruce are Canada's largest national producers of electricity. Canada's electricity generation is dominated by hydropower, which supplies 59.3 percent of the market, followed by nuclear (16 percent), coal (9.5 percent), natural gas (8.5 percent), non-hydropower renewable energy (5.2 percent), and oil (1.3 percent). Canada has an estimated 142 GW of total installed electricity generation capacity. [55] Energy mix varies by region and will persist even as coal-based generation is eliminated across the country.

Transmission

Transmission assets in Canada are operated and owned by provincial-owned companies and not-for-profit companies such as BC Hydro and Alberta Electric System Operator. As the Canadian grid is synchronous with its respective U.S. interconnections, it operates at a frequency of 60 hertz (Hz).

Distribution

Distribution assets are owned and operated by local companies with regional monopolies, with variation in regional policy and investment approach. For example, Toronto Hydro is heavily investing in smart grid technology to improve distribution plans to invest CAD $4 billion between 2015-2019 for increased maintenance and operational support of the current grid system. In Edmonton, Alberta, the utility company EPCOR plans to expand its grid to reduce outages and improve overall reliability. End-user voltage varies by region but is typically 110V for residential and 247V and higher for industrial/commercial.

Retail Sales, Metering, & Pricing

The distribution utilities also handle retail sales. Electricity prices vary by region as a result of market structure and generation resource mix. For example, Alberta has a deregulated electricity market where prices are market-based, while Ontario has partially restructured its electricity market. In other provinces and territories, electricity prices are set by the electricity regulator. Electricity prices in Canada have traditionally been among the lowest in the world due to Canada's large hydropower endowment. Anticipated investment in an aging electric power infrastructure and the shift towards non-hydro renewable and low-carbon sources will likely affect prices in the future.

Almost all Canadian households have "smart" or "advanced" meters installed. Ontario is by far the largest market and the nation's leader in terms of smart grid applications, including the utilization of time-of-use (ToU) pricing. Other cities and provinces appear to be following Ontario's lead. Montreal has embarked on a new round of smart meter deployment and is moving toward ToU pricing. While Alberta and British Columbia are not planning to switch to ToU pricing in the near-term, both provinces continue to invest in energy efficiency programs to send demand signals. Overall, annual deployments of smart meters nationwide slowed in 2013 as the deployment was near completion. Bloomberg New Energy Finance predicts deployments to remain at approximately 700 million units per year through 2021. [56]

Storage

Canada is actively investing in energy storage initiatives to increase deployments throughout the country. Energy Storage Canada (ESC) is the primary advocate of energy storage research and works with provincial initiatives such as the Alberta Storage Alliance identify opportunities to incorporate energy storage technology into energy projects. In 2014, Ontario's Independent Electricity System Operator (IESO) awarded 34 MW of energy storage projects to five companies.

Regional Integration

Canada's transmission system is interconnected with other provinces in Canada and with the United States. The Quebec Interconnection, Western Interconnection, and Alaska Interconnection all connect parts of the Canadian electricity market to the U.S. electricity market. Canada is the leading foreign supplier of electricity to the United States; the United States imported 59 terawatt-hours of electricity from Canada in 2014. [57]

Progress in the development of multiple power transmission lines between U.S. and Canadian provinces creates the potential for electricity trade between the two countries to register sizeable growth over the coming years. Projects for new interconnections between the two countries include the $1.4 billion Northern Pass transmission line, proposed by U.S.-based Eversource Energy, the $1.2 billion New England Clean Power Link, proposed by TDI-New England, and the Lake Erie Connector transmission line, proposed by ITC Holdings' subsidiary ITC Lake Erie Connector.

Policy & Regulatory Environment

Natural Resources Canada is the ministry within the Canadian national government that implements energy policies nationwide. Canada's ten provinces and three territories each govern their natural resources, and each province has developed an electricity grid and market that is largely independent, though border provinces are well-integrated with the U.S. grid to facilitate North-South trade. The North American Electric Reliability Corporation (NERC) oversees electricity trade and reliability in Canada – which is similar to its role in the United States – including in the development of standards for most provinces.

At the national level, Canada's energy policy is increasingly driven by climate change targets. Canada has committed to reducing its greenhouse gas (GHG) emissions by 2030 to 30 percent below 2005 levels. Federal regulations require that plants reduce GHG emissions to an average no greater than 420 metric tons of CO2 per gigawatt hour of electricity produced. Most provinces are accelerating the transition away from coal in their jurisdictions, with Ontario being the first to eliminate coal-based generation in 2015. Canadian Prime Minister Justin Trudeau has pledged his commitment to prioritizing renewable energy policies, which should have positive effects on smart grid deployment. In 2016 Canada launched a national framework for pricing GHG emissions, and by 2018 all jurisdictions are required to implement a carbon pricing strategy (e.g., cap-and-trade or fixed price) related to all fossil fuel combustion. [58]

Canada and the provinces have taken important steps to help finance investment in the clean energy sector. Private and public stakeholders are cooperating on research and development and other projects, which are open to international suppliers and partners.

The National Energy Board is the national regulator and regulates the cross-border trade of electricity. Each province has its provincial regulator (e.g., Ontario Energy Board and Alberta Energy Regulator). These regulators set the rules for energy companies operating in their province, establish energy rates, license energy companies, develop new energy policies and provide unbiased advice to the Canadian government and provide tools to energy consumers to increase transparency in the energy sector.

Market Analysis and Rankings

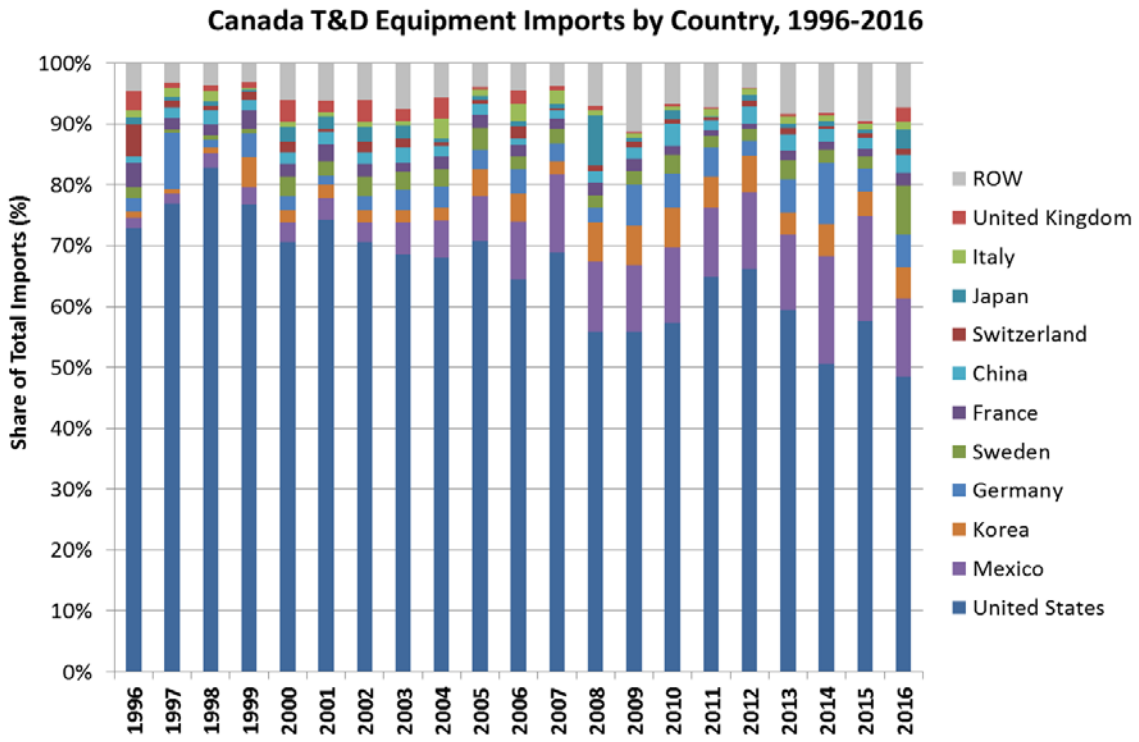
Canada is one of the most advanced countries in the world in smart grid development. As a neighbor and free trade agreement partner, Canada remains a top destination for U.S. goods and services across all *SG TMR* sub-sectors and tops the *SG TMR* overall rankings (*#1*).

Canada is the fifth largest global T&D equipment market, although overall imports have declined since 2012. In 2016, 28 percent of all U.S. global exports of T&D equipment were destined Canada. As shown in Figure 23, the United States is the leading supplier of T&D equipment in Canada with a 56 percent market share in 2016. In 2016, U.S. manufacturers supplied $539 million in T&D equipment revenue out of the $1.11 billion market. However, after peaking in 2012, U.S exports have slowly declined in absolute revenue and percentage of market share in Canada, which peaked at 82 percent in 2005. Mexico has emerged to be the largest U.S. competitor in the market. Mexican imports to Canada have grown at a 15

percent CAGR over the last decade and now reflect more than 11 percent of the overall market share. Other major competitors include Korea, Germany, and Sweden.

Over the next five years, Canada's electricity consumption is projected to grow at less than 1 percent per year. [8] Due to slow growth and declining U.S. market share, Canada ranks *#2* in the T&D Equipment Sub-Sector, with Mexico ranking #1.

Figure 23. [7]



In 2017, Canada invested more than $700 million in energy smart technologies, making it the seventh-largest global investment market. [20] Furthermore, Canada has been a global leader in areas like smart meter deployment, with rollouts across all provinces near completion leading and 59.4 percent penetration throughout the country. [35]

Electricity sector regulations throughout Canada continue to facilitate smart grid deployments and support energy efficiency as a tool to meet climate and energy policy goals for the country. Ontario has been a world-leader in smart grid deployment and is helping to drive developments in the rest of Canada. Opportunities for highly competitive U.S smart grid ICT firms are strong due to Canada's advanced stage of smart grid deployment. There will be few issues of interoperability for U.S. smart grid exporters to Canada due to the shared transmission network and a history of U.S.-Canada cooperation

on standards. For example, over 2.6 million customers in Ontario can now access their smart metering data through a "Green Button" format – a U.S. led initiative – that enables energy monitoring and opens the market to a variety of consumer energy efficiency applications. As a result, Canada ranks *#2* in the Smart Grid ICT Sub-Sector.

Canada has deployed over 57 MW of electrochemical energy storage systems, which is roughly 2 percent of the global total. Ontario hosts 75 percent of these storage systems. [59] More than 40 percent of the projects have been deployed for renewable energy firming; frequency regulation, voltage support, and resiliency continue to be leading use-cases in the market. U.S. firms are very active in the market across all project segments (e.g., manufactured good suppliers, integrators, and developers) and ITA anticipates this will continue. Canada ranks *#3* in the Energy Storage Sub-Sector rankings.

Opportunities and Challenges for U.S. Companies

Investment and export opportunities for U.S. firms will be driven by the need to upgrade and extend Canada's aging electricity infrastructure to meet household, commercial and industrial demands.

Opportunities

- Technologies, software, and services to effectively integrate solar and wind into the grid
- Energy efficiency programs
- Reactive Power Control Systems
- Advanced metering infrastructure and microgrids in Quebec
- Transmission infrastructure for cross-border projects
- Vehicle-to-grid applications in Quebec, Ontario, and British Columbia

Challenges

- Competitive landscape lacks diversity and is dominated by a handful of utilities
- Regional variation enhances market complications

Know Your Buyer

Canadian purchasers of U.S. smart grid goods and services include generation, transmission and distribution companies.

Summary of Resources

- U.S. Department of Commerce, Canada Country Commercial Guide: https://www.export.gov/ccg
- Canadian National Energy Board: http://www.neb-one.gc.ca/index-eng.html
- Innovation, Science and Economic Development Canada: https://www.canada.ca/en/innovation-science-economic-development.html
- Statistics Canada: http://www.statcan.gc.ca/start-debut-eng.html

- Energy Storage Canada: http://energystoragecanada.org/
- Natural Resources Canada: https://www.nrcan.gc.ca/home
- Alberta Energy Regulator (AER): https://www.aer.ca/
- Ontario Energy Board: https://www.oeb.ca/

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China Case Study

China is the world's largest market for electricity infrastructure development, which presents an enticing opportunity for U.S. exporters. While Chinese suppliers will provide the bulk of smart grid technologies for China's distribution network, opportunities exist to provide solutions to increase operational and network efficiency, address renewable integration and management, and implement demand side management programs. However, U.S. exporters face challenges in entering the market because state-owned enterprises (SOEs) have almost complete control over the energy sector and China an overall difficulty for foreign companies to directly invest in Chinese projects, U.S. exporters face robust challenges to entering the market.

Market Overview

China's overall electricity demand has increased by an average of 8 percent per year for the last decade. In 2016, China generated approximately 5,702 terawatt hours of electricity.

Generation

In 2016, 65.2 percent of China's energy was generated from coal, 19.7 percent from hydropower, 4 percent from wind, 3.6 percent from nuclear, 3.3 percent from other forms of thermal power (e.g., biomass and oil), 3.1 percent from natural gas, and 1.1 percent from solar. [60]

China's electricity market is dominated by coal, although this has been dropping in share over the last two years as China seeks to improve urban air quality. China is actively investing in its renewable energy sector, and plans to invest an additional $387.1 billion in renewable power generation from 2016 – 2020. [61] With demand anticipated to grow by 4 percent per year over the next five years, expanding the electricity supply will be necessary. To contribute to this expansion, China has made increased its investment in renewable resources and nuclear energy.

Electricity generation is dominated by four state-owned utilities that control nearly half of total capacity: China Datang Corporation, China Huaneng Group, China Power Investment Corporation, and China Energy Investment Group. China also has a number of secondary state-owned utilities that operate locally.

Transmission

China's transmission assets are entirely owned and operated by the state-owned State Grid Corporation of China (SGCC) and the China Southern Power Grid Company (CSG). China's transmission lines operate

at a frequency of 50 hertz (Hz). China has actively increased the amount of high voltage electricity transmission used to transport electricity to coastal load centers.

The government has merged the 12 regional grids (formerly controlled by the State Power Corporation) into three large power grid networks: northern and north-western grids operated by SGCC, and a southern grid operated by the CSG. SGCC has largely kept pace with goals outlined in the country's 12th Five Year Plan (2011 through 2015) to boost grid investment by 68 percent over the period, particularly in ultra-high-voltage transmission lines. SGCC tapped to invest an additional $243.2 billion (CNY 1.6 trillion) in the 13th Five Year Plan (2016 through 2020). The challenge of connecting major hydro and wind resources to distant population centers will continue to drive growth in China's T&D market.

Distribution

SGCC and CSG also own and operate the distribution of electricity with an end-user voltage of 220V. Both companies are investing in upgrades to distribution systems to better reach rural communities. SGCC and CSG hope to improve overall distribution infrastructure and thereby to lower the frequency and length of power cuts for the average inner-city household. [62]

China is also seeking to massively expand its use of smart meters. Beginning in 2010, SGCC earmarked over $40 billion for smart grid technologies. Although SGCC has delayed its deployment goals, SCCC and CSG expect to install an additional 280 million smart meters over the next five years. Additionally, SGCC has updated its grid connection policies to enable the expanded installation of distributed energy resources. To better integrate and manage these resources, the utilities are expected to invest almost $7 billion in distributed automation technologies over the next five years.

Retail Sales & Pricing

SGCC and CSG are the primary sellers of electricity. Power prices at both the generation and consumption levels are set by the government. Electricity prices are currently separated into residential, agricultural, and commercial & industrial (C&I) tiers, with additional levels of detail – including peak and trough pricing – offered to C&I customers. The National Development and Reform Commission (NDRC) determines the profit margins of generators and sets prices and incentives according to supply type.

Storage

China has more than 50 energy storage demonstration projects in the planning and operating stages. The country is already using batteries to smooth wind and solar outputs, and is expected to introduce other large-scale energy storage technologies to meet growing energy and flexibility needs. In 2016, China announced plans to add an additional 400 MW of energy storage capacity through various project construction plans that include participation of companies such as Samsung SDI-Sungrow, Dalian Rongke, and Narada Battery. [63] Like the United States, China is evaluating how to classify, use and regulate energy storage as part of generation, load management, and T&D deferral.

Despite recent clean energy investments, China lags behind the United States in energy storage technology. China's 13th Five Year Plan, released in early 2016, has a renewed commitment to clean energy, including a focus on energy storage (e.g., advanced batteries) as a strategic emerging industry.

Regional Integration

In September 2015, President Xi Jinping called for talks on establishing a global grid, based on input from leading research organizations like Argonne National Laboratory and Edison Electrical Institute. [64] In March 2016, the Global Energy Interconnection Development and Cooperation Organization (GEIDCO) was formed in Beijing with the goal of promoting interconnections to meet growing global demand with clean energy deployments. GEIDCO has initially focused on developing additional interconnections among Asian nations, but has a long-term goal of linking all global electricity trade.

Policy & Regulatory Environment

The NDRC is the central policymaker in China's electricity market. The NDRC is the primary price-setter and regulator and also develops and implements major policies that affect the wider economy and energy sector. Energy policy planning primarily falls to the National Energy Administration (NEA), a sub-agency within NDRC. The NDRC currently dictates the pace of privatization and liberalization of China's energy markets, including the involvement of foreign companies.

China's government has made statements about its intent to reduce carbon emissions, including through bans on new coal-fired power plants in certain regions and the creation of a national carbon trading system. These measures will likely accelerate the market for non-coal-fired generation, as well as for smart grid and energy efficiency technologies and services.

To balance electricity supply and demand, China is increasingly focused on energy efficiency opportunities, including the implementation of demand side management (DSM) programs. Beginning in 2011, NDRC mandated peak load reductions for grid companies of 0.3 percent annually. DSM programs are being piloted in Suzhou, Beijing, Foshan and Tangshan; Energy Service Companies (ESCOs) and technology solution providers work with end-users and utilities in these cities to achieve energy savings through Direct Load Control technologies, interruptible tariff programs, smart metering solutions, and time-of-use (ToU) pricing options. ToU pricing is available to roughly 66 percent of commercial and industrial consumers in China.

China fell short of its goal to reduce energy consumption per unit of GDP, or "energy intensity," by 16 percent from 2010 to 2015 and has since scaled this back to 15 percent – along with a total energy consumption cap of 5 billion tons of coal equivalent – by 2020.

As part of China's goal of opening up the electricity sector, the NDRC allows limited foreign investment in the construction and operation of the power grid. China also has others goal for reforming the energy market, which include the creation of an open wholesale electricity market as well as the unbundling and separation of owners, operators and various business units across the electricity supply chain.

Progress on these reforms been slow, as China has only succeeded in separating some of the power grid operators from generation companies.

Market Analysis and Rankings

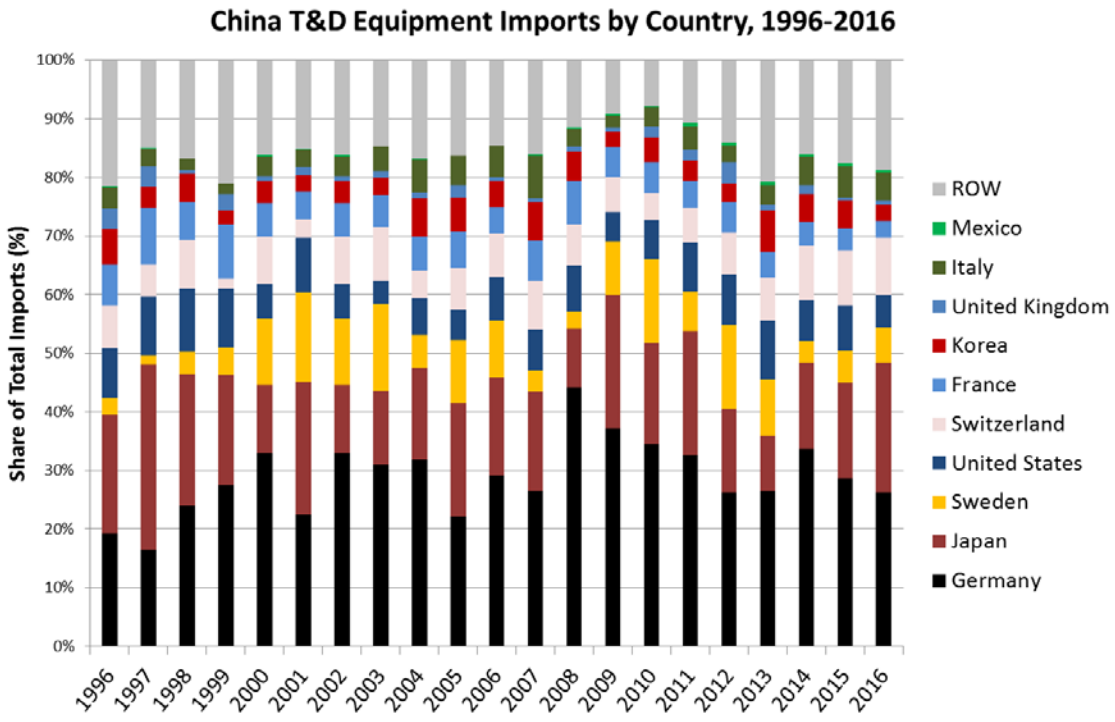
China is one of the largest global smart grid investors in support of its local electricity grid, and is a key global competitor in the sector. China's reliance on domestic suppliers creates a poor competitive environment for U.S. firms, dropping China's ranking to *#15* overall.

China's overall *2017 SG TMR* ranking dropped four places relative to the *2017 January Update*. This was largely driven by decreases in *Category #2* (Trade Factors and U.S. Competitiveness). China's slowing economy coupled with energy efficiency and climate change programs are slowing growth expectations for electricity demand. Projections suggest that China's electricity consumption will grow at an annual rate of 3.28 percent from 2018-2022. [8]

China has decreased its overall T&D equipment imports by more than $600 million over the last decade, representing an average decrease of 6 percent per year. China is one of only a handful of markets to see decreases over the last decade, thus suggesting that China's electricity infrastructure demands are being met by domestic suppliers. This is supported by China low *Category #5* (Strength of Domestic Industry Score), one of the lowest among *SG TMR* markets and is further underscored by China's rise to become the world's leading T&D equipment exporter.

China ranks *#24* in the T&D Equipment Sub-Sector. Exports of U.S.-manufactured T&D equipment to China were $51 million in 2016, making China is the seventh-largest destination for U.S. T&D exports. Domestic firms, as well as German and Japanese firms, are strongly competitive in the market. As shown in Figure 24, German firms hold the greatest market share of Chinese imports. The United States is the fourth-largest supplier.

Figure 24. [7]



China invested $9.9 billion in 2016 in energy smart technologies reflecting a 54.3 percent 10-year CAGR, including a 182.9 percent increase from 2015 to 2016. [20] Smart meter procurements are almost complete, with a market penetration of 96.5 percent. [35] This underscores the government's commitment to diversifying its energy mix, reducing carbon emissions, and increasing energy efficiency.

China ranks *#14* in the Smart Grid ICT Sub-Sector. Data localization policies, cybersecurity regulations, intellectual property concerns, and a preference for domestic suppliers decrease tangible market opportunity for U.S. exporters. ITA believes that the best prospects for U.S. firms are narrowly focused in areas where Chinese firms do not yet have capability. U.S. exporters may find opportunities to supply software and services for demand response and renewable energy integration.

The market size for the energy storage in China is estimated to be somewhere between 72 – 406 MW of capacity. [10] [11] China is expected to be a leader in energy storage systems and has identified advanced batteries systems as a domestic priority industry under its Made in China 2025 program. As a result, U.S. exporters will face tough domestic competition in the market. Nevertheless, given the large market size potential, China is ranked *#10* in the Energy Storage Sub-Sector.

Opportunities and Challenges for U.S. Companies

Despite the huge investments in grid modernization and smart metering, the market for U.S. firms in China is significantly limited by China's reliance on domestic supply chains as well as technical interoperability issues, particularly in the distribution network. New-to-export U.S. firms should approach the market cautiously.

Opportunities

- Opportunities in T&D infrastructure, particularly high voltage transmission (though these are declining)
- Equipment and services for live power line maintenance and training
- Network management technologies and applications following modernization of China's substations
- Energy efficiency programs (e.g., demand response) and projects with industrial and municipal partners, particularly green data centers
- Microgrids

Challenges

- Opaque market
- Favored incumbent suppliers and fierce domestic competition
- Government intervention to support local firms and production (e.g., Made in China 2025 campaign)
- Data localization and cybersecurity policies

Know Your Buyer

SGCC and CSG remain the primary purchasers of smart grid technologies. However, U.S. firms should anticipate forming local partnerships to be successful in the market.

Summary of Resources

- U.S. Department of Commerce, China Country Commercial Guide: https://www.export.gov/ccg
- People's Republic of China, National Development and Reform Commission: http://en.ndrc.gov.cn/
- The State Grid Corporation of China: http://www.sgcc.com.cn/ywlm/index.shtml
- Southern China Power Grid Company: http://eng.csg.cn/h5.html

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www.export.gov/China

Egypt Case Study

Egypt's power supply is under strain from a growing industrial sector, aging infrastructure, and a rising population Blackouts occur regularly. As a result, the government of Egypt has sought to increase its generation capacity, which drives a need for expansion of T&D networks. However, political and financial instability – coupled with rising protectionism – create risks for power infrastructure projects and will dampen near-term opportunities for U.S. exporters.

Market Overview

Electricity demand in Egypt has grown an average 6.3 percent per year over the last decade and is expected to grow at a 6.5 percent annually over the next five years.

Generation
In 2016, Egypt's electricity mix was sourced from natural gas (72.8 percent), oil (15 percent), hydropower (7.2 percent), coal (3.5 percent), and non-hydro renewables (1.3 percent).

Egypt's state-owned Egyptian Electricity Holding Company (EEHC) dominates power generation in the market. The EEHC owns six generation companies: Cairo Generation Company, East Delta Electricity Production Company, West Delta Electricity Production Company, Upper Egypt Generation Company, Middle Delta Electricity Production Company, and Hydro Plants Generation Company (HPPEA).

Transmission
Transmission infrastructure is owned and operated by the Egyptian Electricity Transmission Company (EETC). In 2015, EETC was removed from the EEHC's portfolio and became an independent state agency. It is now the market operator with a formalized monopoly over state transmission assets.

The EETC anticipates investing $1.62 billion in modernizing and building out new transmission infrastructure. [65] The Ministry of Finance will not provide a sovereign guarantee for EETC deals signed by because the EETC is now operating as an independent state agency.

Distribution and Pricing
EEHC owns Egypt's nine regionally-focused distribution companies: North Cairo, South Cairo, Alexandria, North Delta, South Delta, Behaira, Canal, Middle Egypt, and Upper Egypt. The companies deliver end-user voltage at 220 V.

In 2016, the EEHC allocated $21 million to invest in distribution lines, transformers, and cables of medium and low voltage. The expansion plan will include 3,540 km of lines and 2,271 km of cables. The EEHC will also contract to provide 1,036 distribution transformers and 6,347 low voltage transformers.

In accordance with terms set by Egypt's International Monetary Fund loan agreement, Egypt agreed to reform its long-standing energy subsidies, including phasing out electricity subsidies by the end of 2018-2019. In June 2017, however, Ministry of Electricity and Renewable Energy (MOEE) Minister Mohamed Shaker announced that Egypt would both increase electricity prices and keep subsidies in place until the end of 2021-2022, due to inflationary concerns. Current pricing for residential electricity consumption falls into seven tiers based on consumption levels.

Storage

Deployment of energy storage in Egypt is limited. The Japanese government is backing a loan for JPY ¥10 billion to develop a 20 MW solar plant that will accommodate a 30 MW energy storage facility. [66] The government of Egypt is in the process of developing its first pumped storage power plant at Ataqa (Suez) with a capacity of 2100 MW. [67]

Regional Integration

Egypt's electricity infrastructure has strong regional connections. Minister Shaker announced in December 2017 that Egypt would begin construction in 2018 on the interconnection of its power grid with Saudi Arabia's grid, which will enable the exchange of 3,000 MW during peak hours. [68]

Egypt's grid is already part of a five-country interconnection with Jordan, Syria, Iraq, and Turkey, and also has a link to Libya's electricity grid. Egypt is in talks with neighboring countries in Sub-Saharan Africa to build connections under the Nile Basin Initiative, which includes Burundi, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda. Upon completion, Egypt and Uganda would be linked by one electricity grid. Geopolitical concerns and inter-country rivalries have dampened investor confidence in these types of large-scale infrastructure projects.

Policy & Regulatory Environment

The Supreme Council for Energy is the highest forum in Egypt for developments and monitoring of Egypt's energy policies. In February 2008, the Supreme Council of Energy set a target for renewables energy generation (including hydropower) to reach 20 percent of Egypt's energy mix by 2020. The New and Renewable Energy Authority (NREA) has been instrumental in promoting wind and energy projects throughout Egypt, and is charged with ensuring that Egypt meets its renewables targets. However, projections suggest that Egypt will fall short of its renewables goal.

The MOEE is the primary body responsible for policy creation. Among its policy goals, MOEE has set a goal to install 20 million smart meters over the next ten years. [69] In March 2017, the EEHC and the Armed Forces awarded 5 foreign companies a tender to supply 250,000 smart electricity meters.

The Egyptian Electric Utility and Consumer Protection Regulatory Agency (EgyptERA) oversees the newly deregulated market. It regulates power generation, transmission, distribution, and the sale of electricity at the state-level. EgyptERA's oversight includes licensing, design, tariff approval, and operation of a dispute resolution mechanism.

In February 2015, the government approved a draft law to privatize electricity production, distribution and transmission; to allow free competition in the production, transfer, distribution and sale of electricity; and to separate the transport, production, and distribution of electricity. Additionally, in 2015, a new investment law was passed granting non-tax incentives for projects, including those in the energy sector. Project incentives include payment facilities about the price of the power required to operate a project or allocating government land at reduced prices. The law also reduces customs duties on imported equipment and machinery required for the establishment of a project to 5 percent. In addition, the law increases flexibility of land allocation to investors by allowing sale even if while payment is not made until the project is fully operational.

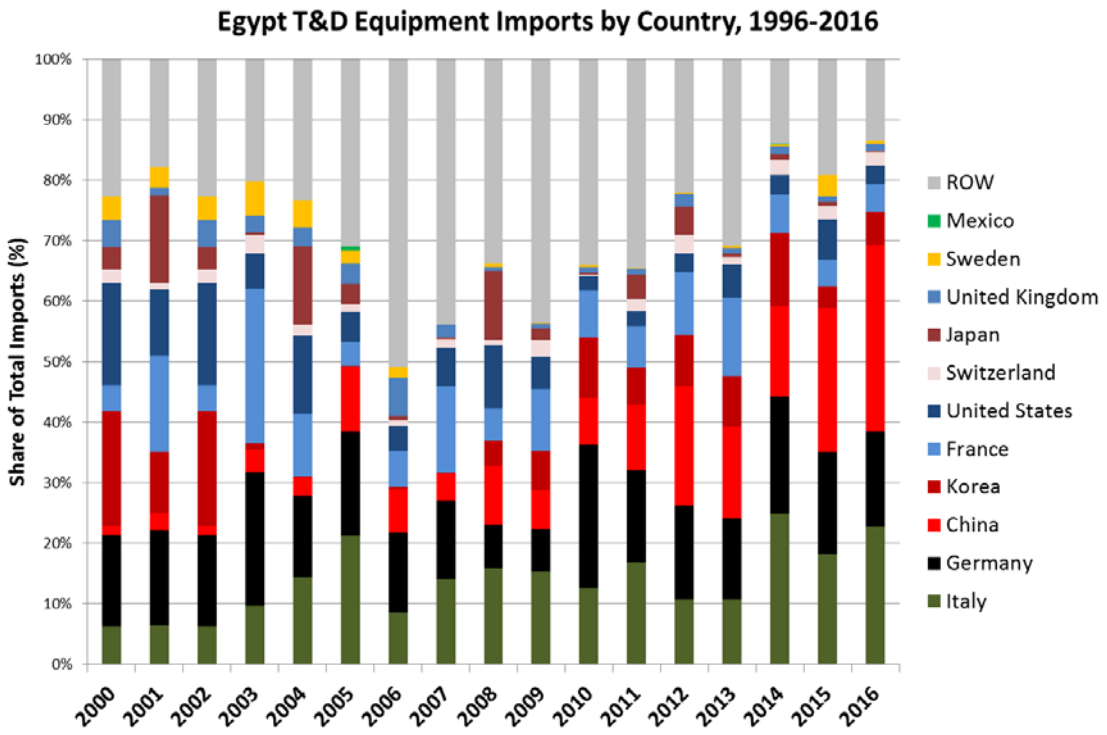
Market Analysis and Rankings

Egypt was ranked #8 in the *January 2017 Update,* but has dropped to *#24* overall in the *2017 SG TMR*. Decreased scores in *Category #4* (Key Economic and Energy Sector Investment Indicators) affected Egypt's ranking both overall and at the sub-sector level.

Over 2018-2022, Egypt's electricity consumption is expected to average annual growth of 6.5 percent, representing a slight downward revision since the *January 2017 Update* [8] Egypt is still expected to be the fourth fastest growing *SG TMR* electricity consuming market after Kenya, Ethiopia, and Vietnam.

In 2016, Egypt imported $177 million in T&D Equipment, representing the lowest import levels since 2012. Definitive yearly trends, however, are difficult to determine given the annual fluctuations in imports that are dependent on progress of individual projects. As shown in Figure 25, China was the largest exporter to the Egyptian market 2016 with over 30 percent of the market share. The United States (3 percent) was the sixth largest supplier into the market behind Italy (23 percent), Germany (16 percent), Korea (6 percent), Turkey (5 percent), and France (4 percent).

Figure 25. [7]



Egypt ranked *#15* in the T&D Equipment Sub-Sector *2017 SG TMR*, representing a 10-spot decrease from the *January 2017 Update*. This decrease was driven by lower projections for electricity consumption as well as a 50 percent drop in U.S. exports to the market from 2015 to 2016. In 2016, U.S. T&D equipment exports to Egypt totaled $56 million.

Egypt ranked in the bottom half in the Smart Grid ICT (*#32*) and Energy Storage (*#27*) Sub-Sectors. Opportunities exist to supply these advanced grid technologies exist, but financing for projects may be difficult.

Opportunities and Challenges for U.S. Companies

Opportunities

- Ambitious power supply program that will drive T&D equipment sales
- Recognized need for international investment to meet goals
- Prepaid electricity meters to curb non-technical T&D losses

Challenges

- Limited private sector participation
- Rising introduction of trade protectionist policies
- Higher inflation resulting from Egypt's floating of its currency
- Political instability and ongoing security concerns

Know Your Buyer

Egyptian purchasers of U.S. smart grid goods and services include generation, transmission, and distribution companies.

Summary of Resources

- U.S. Department of Commerce, Egypt Country Commercial Guide: https://www.export.gov/ccg
- Ministry of Electricity and Energy: http://www.moee.gov.eg/english_new/home.aspx
- Egyptian Electric Holding Company: http://www.eehc.gov.eg/eehcportal/Eng/
- Egyptian Electricity Transmission Company: http://www.eetc.net.eg/

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Ethiopia Case Study

Ethiopia has one of the world's fastest growing electricity markets. This growth will likely create a need to build out transmission and distribution (T&D) infrastructure. Under the Universal Electricity Access Plan, the Government of Ethiopia hopes to extend universal electricity access by 2025. As a result, near-term market opportunities for U.S. exporters will be concentrated in the T&D Equipment Sub-Sector. However, U.S. exporters will likely face project delays and political uncertainty resulting in high risks for investments.

Market Overview

Only 26.6 percent of the Ethiopian population is connected to the electricity grid. However, in seven years the government has a goal to reach universal access to electricity. Over the next five years, electricity consumption is expected to grow at an annual average rate of 8.6 percent. [8]

Generation
Ethiopia's electricity mix is dominated by hydropower, accounting for approximately 92 percent of generation. The remaining electricity is generated from non-hydro renewables (7.5 percent) and the oil (0.5 percent). Oil usage is primarily for small-scale, diesel-fired electricity generation off of the grid.

The state-owned Ethiopian Electric Power (EEP) controls almost all electricity generation, although the Ethiopian government is interested in expanding investment in generation to the private sector. Despite these intentions, the regulatory and policy environment is not adequate to create a strong independent power producer (IPP) ecosystem.

Transmission
The EEP is also the state owner and operator of Ethiopia's transmission system. It supplies bulk electricity to the distribution-level off-taker and can sell electricity to large domestic consumers via power purchase agreements (PPAs).

Distribution
In 2013, the Ethiopian Electric Power Company was split from a fully vertically-integrated utility into EEP and the Ethiopian Electric Utility (EEU). The EEU was tasked with managing the distribution and sales of electricity to end users. Since the split, a consortium of Indian companies – Power Grid Corporation, Bombay Suburban Electric Supply (BSES), and National Hydroelectric Power Corporation (NHPC) – has managed the firm on a contract basis.

The EEU plans to leverage financing from the World Bank's International Development Association to invest $1.7 billion in the coming years to update six distribution networks in Adigrat, Debre Marqos, Gondor, Shashamane, Wolaita Sodo and Harar. The project will also include deployment of 150,000 electricity meters. In 2016, China Electric Power Equipment & Technology Co. Ltd. carried out a similar project for deployment of automated control systems and other distribution upgrades.

Regional Integration

In addition to addressing rising domestic demand for electricity, Ethiopia wants to become a regional energy hub. Ethiopia plans to build out more transmission to serve domestic needs as well as those of neighboring countries. To support this, 30 percent of current power infrastructure projects are focused on regional T&D interconnections. For example, the Ethiopian government invested $1.26 billion on a 1,045km voltage line as part of the Ethiopia-Kenya Power Interconnection project, which began in August 2016. [70] When completed in 2019, the resulting new transmission line will allow Ethiopia to increase its capacity for domestic consumption while exporting a surplus of 2 GW to Kenya. [70]

Currently, Ethiopia exports 100MW to the South Sudan and 50MW to Djibouti. [71] Exporting is likely to remain controversial for Ethiopia's domestic population because Addis Ababa and other urban population centers are suffering from electricity shortages. In addition, conflict over water resources between Ethiopia and other regional neighbors – most notably Egypt – will remain a major risk to project completion.

Policy & Regulatory Environment

The Ministry of Water, Irrigation, and Energy (MOWIE) is responsible for the development, planning, and management of the broader Ethiopian energy sector. It implements regulations and laws and signs international agreements. It also supervises the three main institutions in the power sector: the EEP, the EEU, and the Ethiopian Energy Authority (EEA). MOWIE is seeking additional investments in Ethiopia's energy sector to meet rapidly growing domestic needs as well as plans to export electricity to neighboring countries.

Since 2000, the EEA has been the state regulator of energy efficiency, conservation, safety, and quality. The EEA sets prices for the private and state power distributors and determines tariffs for consumers. Retail electricity tariffs are subsidized and do not cover the cost of generation. Therefore, if the Ethiopian government wants to attract greater private investment over the long-term; rates will need to increase to reflect the cost to of electricity delivery.

Market Analysis and Rankings

Ethiopia remains an emerging market for global smart grid suppliers, and is the only lower income nation to be included in the *SG TMR* rankings. ITA anticipates that near-term growth opportunities will

focus on building out new T&D networks, while long-term market opportunities may arise in smart grid ICT and energy storage.

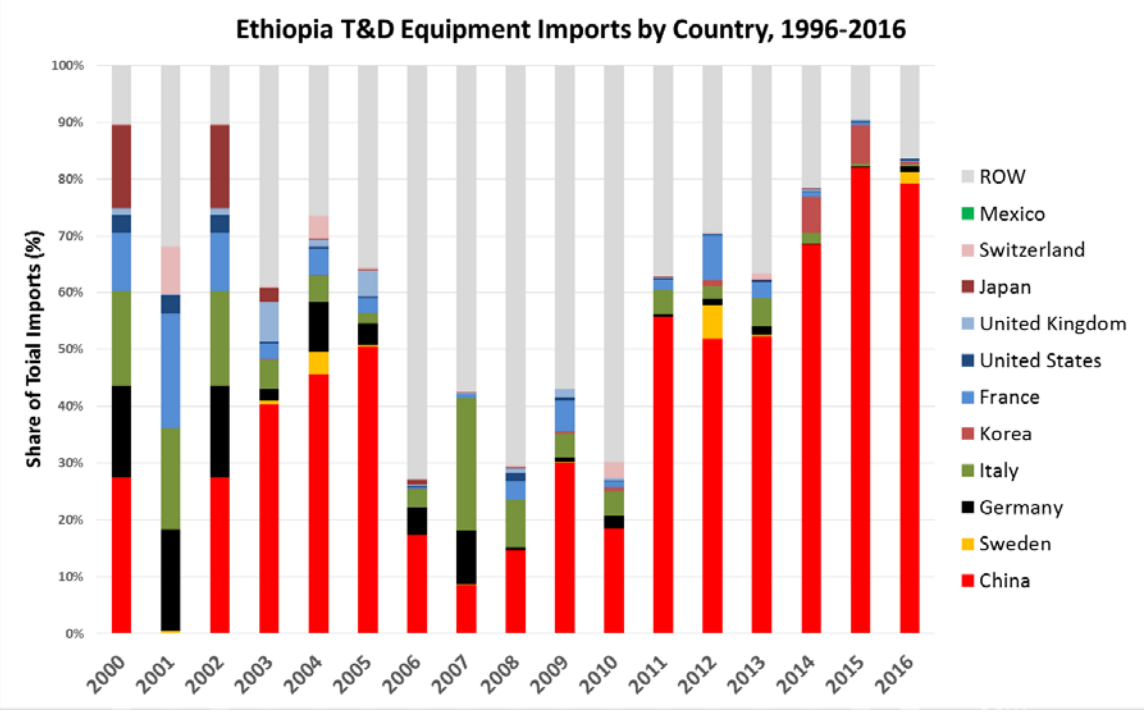
In 2016, Ethiopia imported $259 million in T&D equipment from global suppliers, representing an 18 percent CAGR over the last decade. China is the dominant supplier to the market with just under 80 percent of the market share (Figure 26). The U.S. market share is just under 1 percent of the total, with only $500,000 in T&D equipment supplied by U.S. exporters in 2016.

U.S. SG exports to Ethiopia have grown at a 13 percent CAGR over the last decade. This rate is just shy of the overall import growth rates for the market and suggests substantial room for further growth if U.S. exporters are able to capture market from Chinese exporters, whose exports have grown at a 38 percent CAGR over last decade.

Among *SG TMR* markets, Ethiopia's anticipated near-term electricity consumption growth rates are second only to Kenya. These growth rates are the primary driver for Ethiopia's high T&D Equipment Sub-Sector ranking (*#4*).

Ethiopia is a challenging place to do business, as shown by the country's low rank – 159th out of 190 markets – in the annual World Bank Doing Business rankings. [72] U.S. exporters will face challenges in the market due to limited access to financing, low utility working capital, and poor adherence to global best practices. [73]

Figure 26. [7]



Opportunities and Challenges for U.S. Companies

The U.S. government has been actively engaged in the Ethiopian energy sector. The U.S. Agency for International Development funded a feasibility study to study off-grid solutions to hybridize existing diesel mini-grids. For U.S. exporters looking to get involved in the Ethiopian SG market should consider the following trends:

Opportunities

- Distribution system upgrades and meter deployment in Adigrat, Debre Marqos, Gondor, Shashamane, Wolaita Sodo and Harar (with help from World Bank financing)
- Products and services to supply the second phase of the Growth and Transformation Plan (GTP II)
- Supporting regional transmission projects
- Off-grid solutions for diesel generation replacement and hybridization

Challenges

- Low electricity tariffs that not allow for full-cost recovery for investments
- Dominance of Chinese firms in the market

- Regional insecurity that could cause interstate conflict
- Foreign exchange constraints

Know Your Buyer

Ethiopian purchasers of U.S. smart grid goods and services include generation, transmission and distribution companies: EEP and EEU.

Summary of Resources

- U.S. Department of Commerce, Ethiopia Country Commercial Guide: https://www.export.gov/ccg
- Power Africa Ethiopia Fact Sheet: https://www.usaid.gov/powerafrica/ethiopia
- Ethiopian Electric Utility: http://www.eeu.gov.et/index.php?lang=en

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Germany Case Study

Germany's electricity sector is undergoing a significant transformation away from the use of coal, natural gas, and nuclear and toward renewable energy sources such as solar and wind. To achieve this "Energy Transition" (Energiewende), Germany will need to deploy advanced grid technologies to effectively manage generation intermittency and will need to increase grid planning that efficiently transmit electricity from resource rich regions to load centers. Germany's continued expansion of renewable energy has also increased the demand for battery storage. Price sensitivity remains a challenge: Germany already has high electricity prices and utility working capital is limited by the effectiveness of net metering policies that stimulate self-generation. As a result, utilities remain hesitant to transition away from coal despite government efforts.

Market Overview

Germany's overall electricity demand has steadily decreased over the last ten years. This decrease was the result of energy efficiency programs, policy changes to reduce consumption, and higher prices. Electricity demand is projected to continue to decrease over the next decade from 563 TWh in 2017 to 545 TWh in 2026.

Generation

In 2016, Germany generated approximately 646 terawatt hours (TWh) of electricity. Coal is the primary source of power generation, accounting for 40.3 percent of the total. The rest of the electricity generation is composed of renewables (29.0 percent), nuclear (13.1 percent), natural gas (12.4 percent), and oil (0.9 percent). The remaining 4.3 percent of generated electricity is provided by miscellaneous sources. [74] Among renewable energy generation, 41.0 percent came from wind, 24.1 percent from biomass, 20.3 percent from solar, 10.3 percent from hydropower, and 3.1 percent from waste. [74]

Privately-owned Rheinisch-Westfälisches Elektrizitätswerk (RWE), E.ON, EnBW, and Sweden's Vattenfall dominate the electricity sector. These firms plan to invest more than $79 billion by 2020 in new and modernized power plants. According to the German Association of Energy and Water Industries (Bundesverband der Energie- und Wasserwirtschaft, BDEW), 84 large power projects are planned, each of which will add at least 20 MW of generating capacity. These facilities will include 23 offshore wind farms, 29 gas-fired plants, 17 coal-fired plants, and 10 pumped storage power plants – all of which will have a combined capacity of 42,000 MW. Of these projects, 69 are in the permitting stage, while 15 are at the planning stage under the management of various public utilities, large energy companies, associations, and private investors.

Transmission

German transmission assets are owned by four regionally-specific privately-owned companies: Amprion Inc. (western Germany), TransnetBW GmbH (southwestern), TenneT (central), and 50Hertz (eastern). While these companies own their transmission assets, operations are contracted out and overseen by E.ON, EnBW, Vattenfall, and RWE Innogy because Germany lacks a unified transmission operator.

On June 8, 2016, German Chancellor Angela Merkel emphasized the importance of expanding Germany's electricity network following reforms to curb the costs associated with the EEG. She stated that efforts to constrain the cost of the Energiewende would have to move forward in conjunction with new grid infrastructure. This encouraged transmission asset owners Amprion and TransnetBW to push ahead with the development of Germany's 'Ultranet': plans to develop four high-voltage power lines to deliver critical offshore wind power to the Southern industrial base as a replacement for lost nuclear capacity. The companies plan to develop the first of these power lines by 2022, which would expand upon Germany's current 35,000 kilometers of transmission wires and cables that operate at a frequency of 50 hertz. [75]

Distribution

German distribution assets are owned by E.ON, EnBW, Vattenfall and RWE and various smaller, local, publicly-owned municipal utilities (Stadtwerke) like Stadtwerke Munich and Stadtwerke Köln. Around 80 percent of the distribution grid runs below ground. There are 1,679,000 kilometers of distribution grid in Germany at three different voltages. The high voltage grid (approximately 77,000 km) transmits power at 60 kV to 220 kV and is used for the primary distribution of the electricity to transformer substations in population centers or large, energy-intensive companies in the industrial sector. The medium voltage (approximately 479,000 km) transmits power at 6 kV to 60 kV to smaller regional substations and larger consumers such as factories or hospitals. The low voltage grid (approximately 1,123,000 km) transmits power at 230 V or 400 V to private households and other smaller private consumers. [75]

Grid management challenges resulting from the Germany's increased renewables deployment have been blamed for an increasing number of blackouts and brownouts in 2017. Because of rolling brownouts, many commercial and industrial consumers are installing their own distributed energy resources and microgrid infrastructure to enable off-grid capabilities that will maintain their operations (either as a backup or a primary power source). As a result, utilities are losing critical revenue streams. The German Government is exploring how to incentive investment into the expansion of Germany's distribution network through new tariff policies.

Retail Sales & Pricing

E.ON, EnBW, Vattenfall and RWE control around half of Germany's electricity retail market, alongside numerous local distribution companies, many of which are owned by state or municipal governments. Government policy determines more than half of the power price for households and small businesses in Germany. Fifty-five percent of German household's power bills consist of charges for using power

grids, 33 percent consists of charges for other services (e.g., distribution and financing investment in renewable energy), and 25 percent goes to the sales tax and electricity tax. [76]

Storage

Germany is one of the world's leading energy storage markets. Battery-makers have benefitted from Germany's rebates for solar-plus-battery household systems. The rebate program covered 30 percent of the cost of the system (an average of $4,000 returned per household), and was combined with low-interest loans for other various renewable energy storage systems. When the subsidies expired in November 2015, Germany announced that the goal of encouraging more solar-plus-battery systems had been met, with 67 MW of energy storage (128 MWh) deployed – valued at $169 million. The subsidies, however, were subsequently extended through 2018. [77]

Reginal Landscape

Germany's transmission companies are a part of the European Network of Transmission System Operators for Electricity that helps interconnect 36 transmission systems across Europe. Amprion Inc's assets are interconnected with Creos (Luxemburg), Elia (Belgium), RTE (France), Swissgrid (Switzerland), TenneT – Germany, TenneT – Netherlands, Transnet BW, and VUEN (Austria). Transnet BW's transmission assets are interconnected with Amprion Inc, APG (Austria), RTE, Swissgrid, and TenneT – Germany. TenneT – Germany's assets are interconnected with Transnet BW, 50Hertz, Amprion Inc, APG, CEPS, Energinet and SVK. 50Hertz is interconnected with CEPS (Czech Republic), Energinet (Denmark), PSE (Poland), and TenneT – Germany.

More interconnections between Germany and other countries are being built with a particular focus on eastern European countries. The interconnections between Austria and Germany are being planned to be removed by October 2018 to allow for greater traffic at a lower cost with fewer technical risks. Wind power transmitted south from northern Germany often gets rerouted through Poland and the Czech Republic, overwhelming their grids and risking blackouts.

Policy & Regulatory Environment

The Federal Ministry of Economic Affairs and Energy is the primary federal government agency overseeing energy policymaking, with departments in each German state overseeing sub-federal energy policymaking. For example, Baden-Württemberg has the Ministry of the Environment, Climate Protection, and the Energy Sector, which is actively engaged in facilitating cooperation with other countries for investment opportunities in Europe and around the world. The federal government emphasizes Energiewende to move toward renewable sources and away from non-renewable sources, and is phasing out nuclear energy. According to the federal government, the Energiewende will cost an estimated €550 billion ($646 billion) through 2050, including investments in renewable energy technology, new power plants, storage technology, and more efficient power grids. As part of Energiewende, the Renewable Energy Law (Erneuerbare Energien Gesetz, EEG) regulates the expansion of renewable energy through feed-in-tariffs (FiT) and feed-in priority which has enabled electricity producers using renewables to feed their power into the German grid at fixed prices.

Bundesnetzagentur is the main regulator for electricity in Germany. It oversees regional transmission monopolies and strives to foster energy generation, trade, and retail competition. Bundesnetzagentur approves network charges for gas and electricity transit; preventing or removing obstacles in access to energy supply networks for suppliers and consumers; standardizing processes for switching suppliers; and improving the conditions for connecting new power plants to the grid.

Since 2011, Bundesnetzagentur has sought to expand Germany's electricity grid infrastructure. Germany is trying to increase the number of extra-high voltage lines to more efficiently transport large volumes of renewable energy. Bundesnetzagentur is seeking to ensure more efficient licensing procedures to accelerate the expansion of the grid.

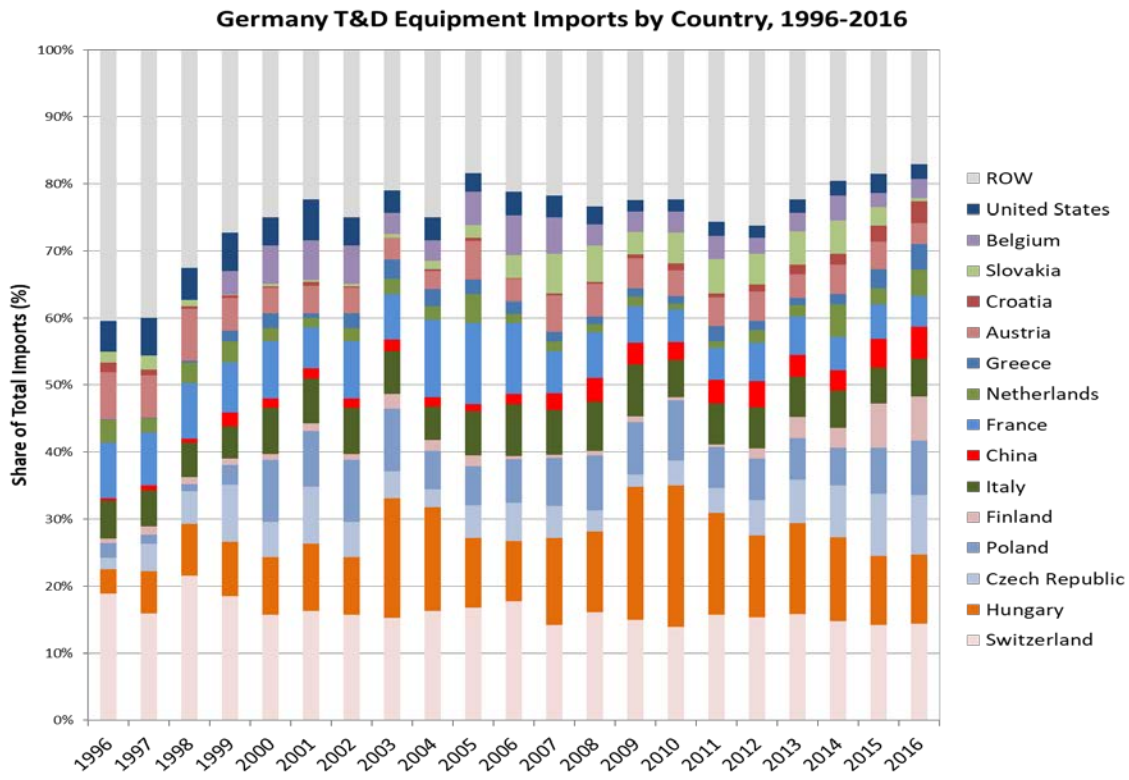
The Energiewende and the growth in European electricity trading present major challenges for Germany's electricity grid and gas supply networks. The electricity grid and gas networks must be able to fulfil their transport tasks, and must be protected against any third-party intervention.
Sufficient generating capacity is necessary to meet the predicted future energy consumption. In addition, reliable control mechanisms must ensure that network integrity is maintained even if the network input and output volumes are not balanced. Bundesnetzagentur works on the security of electricity and gas supply.

Market Analysis and Rankings

Renewable energy deployments continue to be the main driver for advanced grid modernization technologies and smart grid growth in Germany. Despite strong competition from domestic companies, Germany is in the top ten for the Smart Grid ICT (*#9*) and Energy Storage (*#6*) Sub-Sector rankings.

Germany is the 11th largest export market for U.S. T&D equipment. In 2016, U.S. manufacturers supplied over $31 million in T&D equipment to Germany, representing 2 percent of the overall market. As shown in Figure 27, Germany leverages a diverse set of global suppliers. Only Switzerland (14 percent) and Hungary (10 percent) have been able to capture significant market share. All other suppliers have less than 10 percent of the market. Over the last decade, total German imports of T&D equipment have increased at a 5 percent CAGR over the last decade, but imports from the United States have largely remain stagnant, resulting in declining U.S. market share.

Figure 27. [7]



Germany is being ranked *#47* for T&D Equipment Sub-Sector due to strong competition from European companies, stagnant U.S. exports, differing electrical standards, and declining energy consumption rates. However, Germany's overall *SG TMR* ranking is pulled up to *#22* by opportunities for U.S. exporters in the Smart Grid ICT (*#9*) and Energy Storage *(#6*) Sub-Sectors.

ITA anticipates that U.S. smart grid ICT firms will find opportunities as a direct result of the Energiewende despite strong competition German companies and other European suppliers. In 2017, smart meter penetration in Germany was limited to 3.80 percent; [35] Germany's push to reach 80 percent penetration by 2022 will lead to new opportunities for software and service providers.

Renewable energy penetration is expected to reach 35 percent by 2022. Managing the system with increased solar PV penetration will further drive interest in electrochemical energy storage systems. Roughly 253 MW of electrochemical energy storage has been announced or commissioned, or is under construction, in Germany. [10] More than half of these projects focus on frequency regulation and another third focus on renewable energy capacity firming. Behind-the-meter storage is expected to be the largest growth segment in Germany.

German firms with energy storage offerings (e.g., Sonnenbatterie and Siemens) offer both competition and potential partnership for U.S. firms. In July 2017, Siemens and AES Energy Storage announced it would form a new energy storage joint venture, Fluence, to sell worldwide the platforms previously offered by both firms.

Opportunities and Challenges for U.S. Companies

U.S. companies looking to participate in the German smart grid market should consider a few key trends:

Opportunities

- Effects of "Electricity Market 2.0" (Strommarkt 2.0) and new price signals
- Need for new HV transmission to bring generation to load centers
- Energy storage solutions to balance renewable energy deployments
- AMI to support better grid management and meet EU smart meter deployment targets
- Demand management programs for commercial and industrial customers

Challenges

- Fierce competition from German firms (and other European firms) to supply T&D equipment
- Reliance on European standards
- Limited utility working capital

Know Your Buyer

German purchasers of U.S. smart grid goods and services include generation, transmission and distribution companies as well as an emerging buyer community of commercial and industrial energy consumers. U.S. exporters will likely need a local partner who has local contacts and a good understanding of procurement practices.

In Germany, trade fairs play a major role in product marketing; U.S. companies wishing to enter the German market often make their first approach at major trade fairs, which can be an inexpensive way to test the market. Exhibiting at fairs can establish key contacts and facilitate direct sales. From trade show contacts, U.S. companies can gather a great deal of valuable information about marketing in Germany and Europe. In addition, trade fairs can allow U.S. exporters to evaluate competitors.

Summary of Resources

- U.S. Department of Commerce, Germany Country Commercial Guide: https://www.export.gov/ccg
- Federal Ministry of Economic Affairs and Energy: http://www.bmwi.de/Navigation/EN/Home/home.html

- Ministry of the Environment, Climate Protection, and the Energy Sector Baden-Wurttemberg
- Bundesnetzagentur: https://www.bundesnetzagentur.de/EN/Areas/Energy/AboutUs/aboutus-node.html
- E.ON: https://www.eon.com/en.html
- Amprion: https://www.amprion.net/index-2.html
- Transnet BW: https://www.transnetbw.com/en
- European Network of Transmission System Operators for Electricity: https://www.entsoe.eu/Pages/default.aspx
- RWE Group: https://www.rwe.com/web/cms/en/8/rwe/
- EnBW: https://www.enbw.com/index_en.html
- Vattenfall: https://corporate.vattenfall.com/
- Stadtwerke Muniche: https://www.swm.de/english.html

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India Case Study

India needs to further develop its power infrastructure. Ambitious government policies for energy access, renewable energy deployment, and development of "smart cities" send positive signals that the Indian smart grid market presents opportunities for U.S. exporters. Nevertheless, the Indian market features notable challenges, including access to financing and policies preferring domestic manufactured goods (outlined in the Make in India campaign). Electricity theft continues to run rampant, as rural and urban Indians struggle to pay for power. Indian utilities struggle to gather adequate capital to invest in grid modernization and expansion. Despite these challenges, the Indian market is expected to grow extensively, and thus remains attractive to U.S. exporters. India's *Smart Grid Top Market* (*SG TMR*) rankings are bolstered by these high growth trends as well as large population size and market size.

Market Overview

India's overall electricity demand has increased steadily at 7 percent per year for the last decade. In 2016, India generated approximately 1,348 terawatt hours (TWh) of electricity. Demand is expected to continue to increase by 6.2 percent per year over the next five years.

Generation

India's electricity market will remain dominated by coal over the coming decade despite significant growth in nuclear, non-hydro renewables, and natural gas. Coal dominates electricity generation (59 percent of total generation), followed by renewables (31 percent), natural gas (8 percent), and nuclear (2 percent). Hydropower accounts for 44 percent of the renewable energy sources used, with the rest coming from a combination of wind, solar, and biomass. [78]

The Indian electricity sector is dominated by government-owned companies, and private sector involvement is limited. Most major power plants are owned and operated by federal government-owned public-sector corporations such as National Thermal Power Corporation (NTPC) and various state-level corporations.

Nevertheless, global investors are highly interested in the country's rapidly expanding solar sector due to supportive government policies for renewable energy. Prime Minister Modi has prioritized energy sector reform and expanding the domestic renewables sector. To support these goals, the government has increased the availability of funding to the renewables sector and allocated concentrated zones of development for solar power facilities (e.g., Ultra Mega Solar Power Projects - UMSPP). This is intended to de-risk project development by driving down implementation time and cost. The resulting reduction

in costs for developers has led to increased competition and reduced tariff prices. The falling cost of solar technology has further encouraged tariff reductions. Beyond the solar sector, India has also been looking at the possibility of developing joint hydropower projects with neighboring countries.

Transmission

Transmission and distribution (T&D) remain dominated by the Indian government, with the private sector limited to 1 percent of transmission and 5 percent of distribution. T&D losses in India are very high – a national average of 8 percent less at transmission level and 26 percent loss at the distribution level. Several large states report distribution losses of more than 40 percent.

The Power Grid Corporation is the owner and operator of the national interstate power grid – under its subsidiary the Power System Operator Corporation Limited – as well as the grid developer. In 2009, the National Load Dispatch Center began monitoring operations of the national grid, supervising regional load dispatch centers, and scheduling and dispatching electricity. The national grid runs at 50 hertz (Hz). In 2013, five regional grids were combined in one synchronous national system, but interconnections are seen as inadequate due to outdated control technologies. The Power Grid Corporation anticipates spending $18 billion in the next five years to extend and upgrade the Indian power grid to include smart technology, but this would fall short of the $50 billion that the Ministry of Power estimates would be necessary to modernize the grid over the next decade.

Distribution

The power distribution companies (DISCOMs) handle electricity sales and retail to commercial and residential customers. Industrial customers can buy directly from the generators and wholesale market. In a majority of Indian states, the distribution, sale, and retail of electricity is largely handled by the regional governments. There are some private companies also engaged in the distribution of electricity, including those with service territories in the city of Delhi, Mumbai, Kolkata, Ahmedabad, and Surat.

India's DISCOMs are largely not profitable. The government continues to direct cash to the DISCOMs to bail them out of debt under the Ujwal DISCOM Assurance Yojana (UDAY) program, while still exploring policy and regulatory reforms to find permanent solutions. State-owned utilities with significant rural populations face the particularly difficult challenges to profitability, as they are charged with electrifying new customers in remote locations with limited social acceptance of paying for the commodity.

Pricing

Electricity pricing in India is politically sensitive, with large industrial customers paying higher prices to subsidize residential customers. In June 2017, Niti Aayog, the Indian federal policy think tank, released the new draft energy policy calling for using "direct benefit transfer" to residential customers to address the subsidies. The draft suggests that DISCOMs should pay full-market price to generation companies and receive the full cost to deliver service from customers.

Storage

The use of energy storage technology is beginning to grow in India. In January 2017, India implemented its first grid-scale battery storage project, which is operated by Tata Power Delhi Distribution. Other grid-scale and pilot projects have been subsequently announced.

The energy storage sector is expected to grow rapidly due to India's ambitious plan for universal adoption of electric vehicles by 2030. India's transport Minister, Nitin Gadkari, has made the Government's intention clear for moving towards alternative fuels. The underlying factors for this decision include:

(i) Meeting obligations to bring down India's share of global carbon dioxide emissions by 2030 as outlined under the Paris Agreement on climate;
(ii) Improving air quality, as many of the Indian cities are among the world's most polluted cities due principally to vehicular emissions; and
(iii) Reducing India's dependence on oil imports.

The Government of India has launched several projects to meet this target. For example, the Energy Efficiency Services Limited (EESL) – a public service utility under Ministry of Power that facilitates implementation of energy efficiency projects – published a global tender for procurement of 10,000 electric vehicles. The state of Karnataka has made it mandatory to have charging points and pods in all high-rise buildings. Maharashtra has become the first state to establish electric mass mobility systems – with an electric fleet of 200 electric vehicles, including taxis, buses, e-rickshaw and autos now operating in the Nagpur city.

The government of India plans to roll out its national policy for electric vehicles in 2018. This will include standards and specifications for the vehicles and provide guidelines to incentivize their use. However, the transition to electric vehicles will only succeed if technology improvements and cost reductions continue, along with charging infrastructure and a smart electricity grid to take additional load. Currently, there are around 100 charging stations across India.

Regional Integration

India has been working on developing power grid interconnections with several neighboring countries. India currently has interconnections to Bhutan, Bangladesh, Myanmar, and Nepal. New proposals are underway, including an undersea interconnection between India and Sri Lanka. As India's energy demand continues to increase, India is prioritizing electricity trading to ensure that it can meet its domestic demand.

Policy & Regulatory Environment

India's energy policy is overseen by its Ministry of Power (MOP). Tariffs are regulated by the Central Electricity Regulatory Commission (CERC) and its state-level counterparts.

The Modi administration flagship power sector initiative has been a pledge to ensure continuous power access – 24 hours a day, seven days a week – for all Indians. This will require substantially improving

electricity access to the 250 million people whose electricity access may be limited to 3-4 hours a day, as well as bringing electricity to 300+ million people who have no electricity access. For India to meet these targets, Bloomberg New Energy Finance estimates that generation capacity will need to increase four-fold, and $750 billion in new investment will be required by 2030.

In 2014, MOP initiated the Integrated Power Development Scheme to support a more efficient grid through transmission and distribution systems updates and steady funding for sub-transmission, distribution and metering. MOP issued a Smart Grid Vision and Roadmap for India with the vision of a nationwide smart grid that features efficient, reliable distribution. To achieve the targets in the roadmap, the government approved a National Smart Grid Mission (NSGM) with an outlay of approximately $155 million in the 12th Five Year Plan, including $72 million in allocated funds in 2015. The NSGM serves as an institutional mechanism for planning, monitoring and implementing policies and programs related to the smart grid. MOP announced that grants covering up to 30 percent of the project cost would be available from the NSGM budget; grants are also available to cover 100 percent of costs for selected components, such as training and capacity building.

The NSGM is also charged with overseeing state-specific policy efforts; some regions have already begun to implement smart grid-enabling policies on their own. Net metering policies have been adopted in locations such as Andhra Pradesh, Maharashtra and Punjab. Tata Power Delhi has begun to bundle other services and institute a series of social programs driving customers to pay for power instead of stealing it.

Additionally, the National Telecom Machine-to-Machine (M2M) Roadmap, a reference document for deployment of devices at the intersection of physical and digital worlds, incorporates efforts related to the smart grid ICT sub-sector. The M2M Roadmap is the world's first national strategy for the "internet of things" (IoT), and it highlights the Smart Grid Pilot Program that will provide $60 million for 14 pilot projects, each with at least 20,000 customers. Most of the projects are focused on deploying smart meters and increasing meter readings to address theft issues, support reliability, support dynamic tariff structures and renewable resources integration. Four of the projects are underway, and 6 are in the contracting phase.

The India Smart Grid Forum (ISGF), the public-private partnership initiative of MOP, contributes to smart grid development. ISGF performs research, organizes conferences, engages in standards development, performs training and provides recommendations to policymakers and regulators.

The Modi government has proposed a dramatic nationwide program to build 100 "smart cities", which offer another opportunity for smart grid policy and regulation development. India's cities account for approximately 60 percent of the country's gross domestic product (GDP), which is expected to reach 75 percent by 2030. The Atal Mission for Rejuvenation and Urban Transformation (AMRUT) was launched with the smart cities project and is focused on providing basic services like electricity to households in 500 cities.

Market Analysis and Rankings

India makes up 18 percent of the global population, but only accounted for 5.7 percent of the global energy demand in 2013. India runs at an average energy deficit of 5 percent – with values as high as 25 percent in some regions – leading to daily rolling brownouts that hamper economic growth and limit foreign investment in the country. For example, a blackout in July 2012 affected 620 million people.

India continues to be a difficult market for U.S. exporters. Nevertheless, India ranks *#9* overall in the *2017 SG TMR* due to the country's India's growing electricity consumption, ambitious government policies, and growing economy. This reflects a relatively minor drop in rankings from the *January 2017 Update*, resulting largely from methodology changes in BMI's Risk/Reward Index – one of the indicators used in *Category #3* (Key Economic and Energy Sector Investment Indicator). Although India's absolute BMI Risk/Reward Index score did not change, other markets saw rises in their scores. Previously, India had the highest risk/reward index score among *SG TMR* markets, but had only the 12th-highest score in 2017. [12] This change may better reflect the relative risks of an investment in the Indian market, given that India ranks 130th of 189 in the World Bank's Doing Business rankings. [72]. U.S. firms have had some success in India through broader partnership efforts, but challenges remain.

Despite India's lower ranking in the Smart Grid ICT (*#24*) and Energy Storage (*#13*) Sub-Sectors, ITA anticipates that opportunities to supply advanced grid technologies (e.g., software, analytics, and integration services for AMI, DA, SA, microgrids, energy storage, and DER) are significantly more attractive to U.S. exporters – and are only expected to increase over time. For example, according to Navigant, the Indian market for Smart Grid ICT and Energy Storage will grow at a 45 percent CAGR to reach $32.3 billion in 2026. [79]

Smart meter penetration in the market is less than one percent, but recent mandates by Government of India suggest a near-term opportunity for U.S. smart grid ICT exporters to partner with domestic hardware providers to meet this demand. [35] However, exporters will be challenged by Indian price sensitivity and limited capital for procurement.

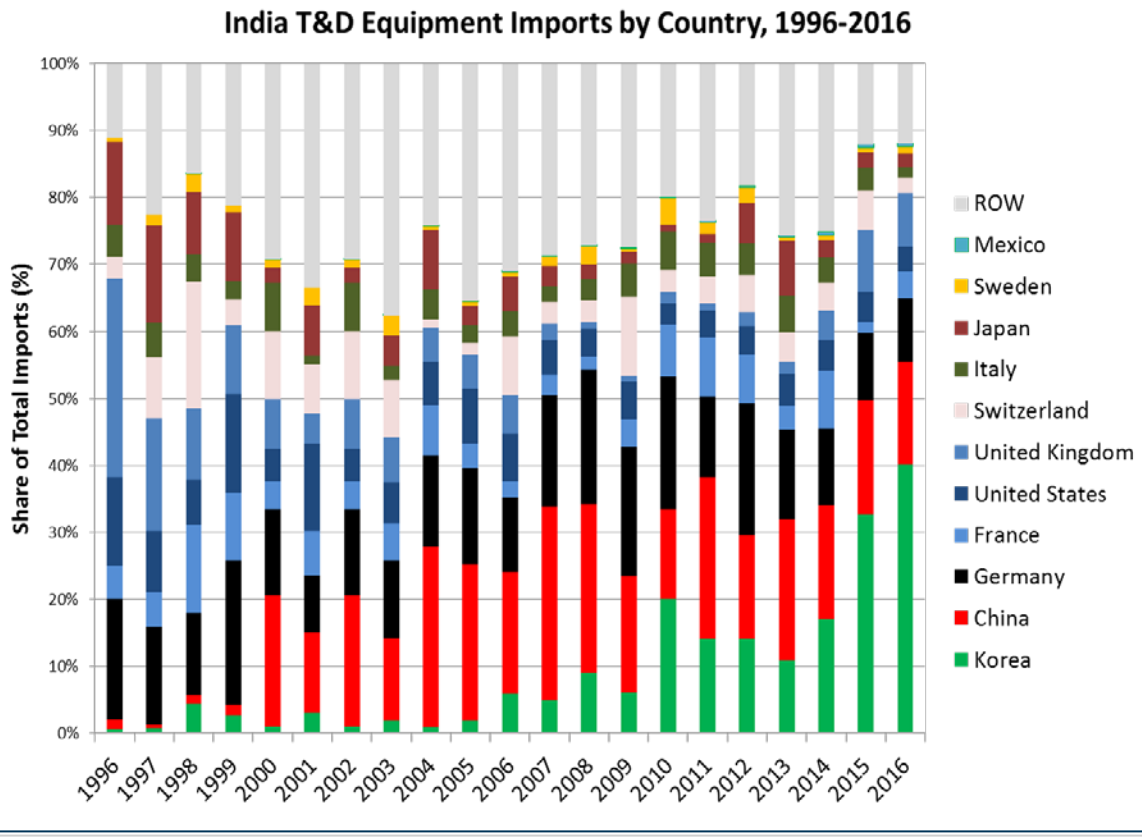
Ambitious renewable energy deployment goals drive expectations for greater energy storage deployment in the market. Although renewable energy is only expected to account for 9 percent of electricity generation in 2022, India has limited hydropower availability for load balancing, which leaves Indian utilities interested in electrochemical energy storage solutions. According to the U.S. Department of Energy Global Energy Storage Database, seven electrochemical pilot projects – with a total capacity of 125 MW – have been announced or are operational in the market.

In 2016, India imported $462 million in T&D equipment. As shown in Figure 28, Korea was the leading supplier to the Indian market with 40 percent of the market share ($185 million). Korea's exports of T&D equipment to India have grown at a 35 percent CAGR over the last decade, significantly outpacing the market's growth rate of 11 percent over the same period.

The United States was the sixth largest supplier behind China (15 percent), Germany (9 percent), the United Kingdom (7 percent), and France (4 percent). U.S. exports to India grew at a 4 percent CAGR over the last decade.

Despite being the only 21st largest export destination for global U.S. T&D equipment exports, India ranks *#8* in the T&D Equipment Sub-Sector. India's ranking is driven by increasing U.S. exports to the market, India's large market size, and expectations of growing electricity consumption. [8] Nevertheless, much of India's electricity hardware needs are met by domestic firms, and foreign firms have had limited success in unlocking the T&D equipment sub-sector.

Figure 28. [7]



Opportunities and Challenges for U.S. Companies

U.S. companies interested in entering the Indian market should consider the following trends:

Opportunities

- Smart meter rollouts proposed under the UDAY program
- Grid-scale energy storage solutions to balance renewable energy deployments
- Outage management systems
- Solar and wind forecasting software
- Electric vehicle to grid planning services

Challenges

- Slow and bureaucratic regulatory system
- Highly regulated electricity prices and insufficient cost recovery
- Limited access to financing
- Strong competition from local T&D equipment suppliers
- Lowest-cost procurement preferences over lifecycle cost recovery
- Poor contract enforcement

Know Your Buyer

The primary buyers of smart grid technologies in India are the transmission and distribution companies. Commercial and industrial energy consumers, however, represent an emerging community of buyers. Due to rolling brownouts, these consumers are installing their own distributed energy resources and microgrid infrastructure to enable off-grid capabilities and maintain their operations.

Central and local government authorities continue to be active players in securing deals in-country as the electricity sector is not completely privatized. As in other large markets, exporters should think of distinct regions or states as different opportunities. Exporters to India should be prepared to face varied political and economic conditions across India's 29 states and 7 union territories.

Summary of Resources

- U.S. Department of Commerce, India Country Commercial Guide: http://www.export.gov/ccg/india090814.asp
- Indian Ministry of Power: www.powermin.gov.in
- Indian Ministry of New and Renewable Energy: www.mnre.gov.in
- Central Electricity Authority: http://www.cea.nic.in/
- Indian Renewable Energy Development Agency - www.ireda.gov.in
- India Smart Grid Forum: http://indiasmartgrid.org
- Confederation of Indian Industry: http://www.cii.in/
- Federation of Indian Chambers of Commerce and Industry: http://www.ficci.com/
- India Energy Storage Alliance: http://indiaesa.info/

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U.S. Commercial Specialist
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www.export.gov/India

Japan Case Study

Japan ranks fifth among Smart Grid Top Market Report (*SG TMR*) markets for near-term smart grid export growth, due largely to electricity sector reforms, energy efficiency objectives and active technology procurements by utilities. While U.S. suppliers face robust competition in Japan, they have increased their presence in the past few years. The market will be attractive for innovators and new entrants due to major overhauls, including the break-up of vertically-integrated utilities, the creation of a nationwide grid operator, incentives for distributed generation and demand response. Sustained reforms will drive the pace and scope of new opportunities for U.S. suppliers. Strong relationships with Japanese partners will continue to be a requirement in this market.

Market Overview

Japan's energy demand has decreased over the last decade on average by 1.3 percent annually. In 2016, Japan generated 961.6 TWh of electricity.

Generation

Since 1995, Japan has gradually liberalized its electricity sector, beginning with power generation. In July 2012, the Japanese government installed the feed-in tariff (FIT) mechanism under the Act on Special Measures Concerning Procurement of Renewable Energy Sourced Electricity by Electric Utilities (the Renewable Energy Act). The government started electricity system reform to open up the electricity market and encourage more private sector participation.

Japan's electricity market is divided into ten geographical areas. Each area is dominated by a regional utility that controls generation, transmission, distribution and retail. Other major players in the generation market are Electric Power Development (also known as "J-power") and the Japan Atomic Power Company. Some registered retailers (including ex-power producer and supplier companies) have their power generation plants and supply their own generated electricity to their customers. Some private companies with large factories (e.g. steel, chemical and railway companies) and many municipal governments have also their own power plants and sell surplus electricity on a wholesale basis to utility companies and registered retailers.

Across the market, liquefied natural gas (38.8 percent of generation) and coal (30.8 percent) dominate the market, followed by renewable (14.9 percent), other forms of thermal (7.5 percent), oil (6.2 percent), and nuclear (1.7 percent). [80] Among the renewable energy generation used, 51 percent

came from hydropower, 29.5 percent came from solar, 12.8 percent came from biomass, 5.4 percent from wind, and 1.3 percent from geothermal. [80]

Transmission & Distribution

Most transmission and distribution (T&D) assets are owned by the ten regional utility companies. J-Power also has some major transmission lines. Eastern Japan (including Tokyo, Kawasaki, Sapporo, Yokohama, and Sendai) operates at a frequency of 50 hertz (Hz), while western Japan (including Okinawa, Osaka, Kyoto, Kobe, Nagoya, Hiroshima) operates at a frequency of 60 Hz. [81] The voltage delivered for consumption is consistent throughout Japan at 100 volts (V). The final phase of Japan's electricity system reform will require the regional utility companies to unbundle their power generation and retail functions from their transmission and distribution functions. Starting in April 2020, utility companies conducting T&D will be prohibited from power generation and retail operations.

Retail Sales & Metering

Although regional utility companies remain major retailers, Japan has liberalized retail of electricity since 1999, with full liberalization since April 2016. Over 400 private companies have registered to become retailers under the Electricity Business Act.

Compared to other mature markets, electricity prices in Japan are high and consumption levels are low. Following the Fukushima disaster and energy crisis, household rates rose as much as 40 percent in some regions. Despite the reactivation of nuclear power generation, rate hikes are expected to continue to fund continued upgrades to the system and provide relief to debt-laden utilities.

Utilities have present plans for the installation of smart meters to all of Japan's 80 million households by 2025. As utilities have started the procurement process, Japan surpassed China as the largest smart meter investor in 2015.

Storage

Japan has been actively looking to expand the use of energy storage to boost solar generation in the country. For example, the Yamanashi Prefectural Government encouraged the incorporation of energy storage systems into some of its solar power plants. [82] Yamanashi's expansion of energy storage was supported by a behind-the-meter storage subsidy program that boosted sales of lithium-ion batteries. Although the subsidies were not renewed in 2016, the prefectural government is hoping to attract large companies to further invest in these initiatives.

Policy & Regulatory Environment

Japan's energy market is overseen by the Ministry of Economy, Trade, and Industry (METI), which is responsible for policy planning and the stable supply of electricity. METI conducts rule-making through the Agency for Natural Resources and Energy. The Japan Fair Trade Commission monitors the state of competition and has been increasingly active in the electricity market since reforms began in the 1990s.

Roughly 60 percent of the electricity market was deregulated by 2011, including sales to large industrial and commercial customers.

The approval of the 2014 Basic Energy Plan represented a complete overhaul of Japan's energy policy, utility industry and electricity markets. Natural gas, coal and renewable resources will make up a greater share of the nation's energy supply mix. The plan did not set specific targets but did state that the share of renewable resources would exceed the previous policy objective (20 percent by 2030). Nevertheless, the plan will likely ease emissions restrictions as it aims to cut emissions by just 3.8 percent by 2020, a lower goal than those set by previous policies.

The Japanese government has also announced the establishment of a national grid and the liberalization of retail power markets. The Basic Energy Plan and related regulatory changes will break-up the regional utilities' monopolies, allowing for competition in the $67 billion market for retail electricity for households and small shops. Japan has awarded over 150 retail licenses since 2016. Many of the new retailers are small firms, including non-electricity companies. This suggests potential for the future bundling of electricity with gas, communications or other services.

In 2015, METI established two regulatory bodies: he Organization for Cross-Regional Coordination of Transmission Operators (OCCTO) and Electricity Market Surveillance Committee (EMSC). OCCTO, established in April 2015, oversees the construction of cross-regional transmission lines, reviews utility power supply and demand plans, and directs utilities to increase power generation and interchange as necessary.

The EMSC, was established in September 2015, consists of 5 members that make recommendations to the METI Minister on the electricity market and ensuring neutrality.

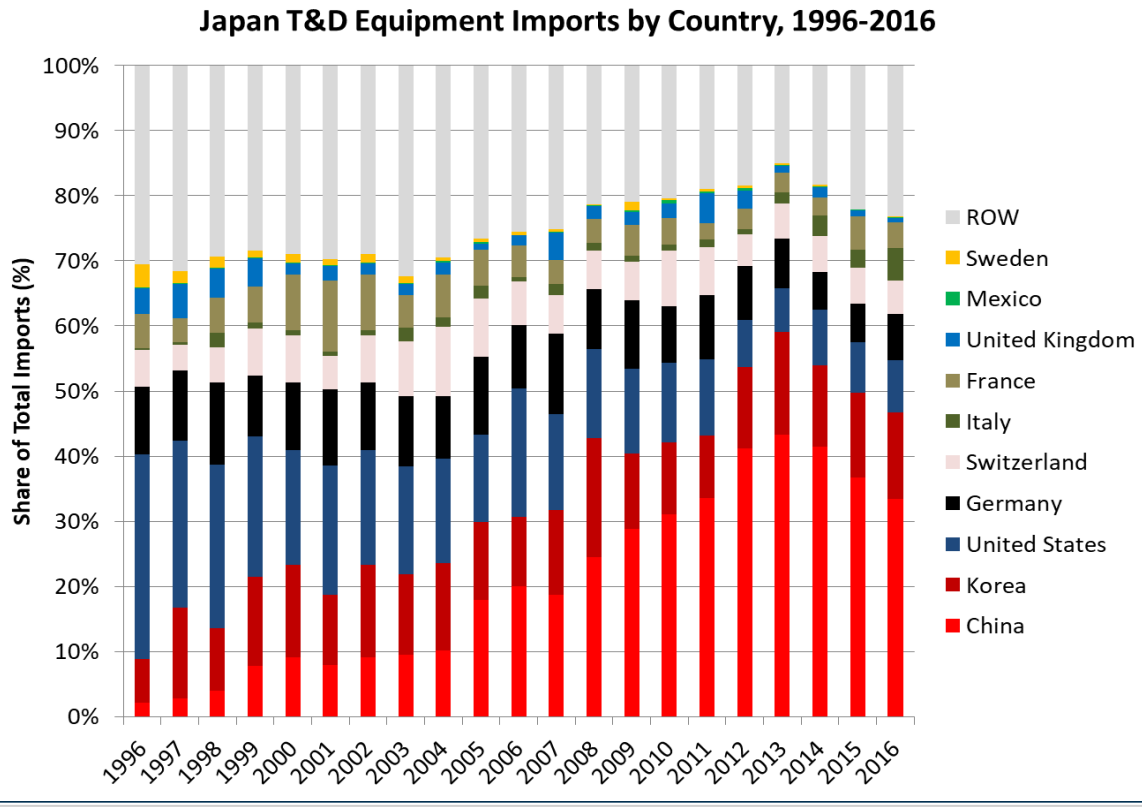
Market Analysis and Rankings

Japan is one of the largest global smart grid markets, making it an attractive market for U.S. exporters. Japan ranks *#5* in the overall *SG TMR* ranking. This is the third year that it has been in the top 5 overall in the *SG TMR* series. Although Japan's electricity consumption is expected to grow by less than one percent per year over the next five years, [8] Japan remains attractive due to investments in advanced grid modernization technologies in the Smart Grid ICT and Energy Storage Sub-Sectors. Japan has also invested in new energy supply technologies, enhanced T&D infrastructure, and energy efficiency services. Japan is also funding the integration of clean energy technologies and helping drive the development of the market for smart grid applications.

Japan ranked *#31* in the T&D Equipment Sub-Sector. Japan meets much of its domestic need by local firms, and import growth – 4 percent CAGR over the last decade – has been slow. In 2016, Japan imported $311 million in T&D equipment. As shown in Figure 29, China's imports to the market have outpaced overall import growth by increasing at a 9 percent CAGR over the last decade. In 2016, Japan

imported $104 million in T&D equipment from China, which accounted for 33 percent of the total market.
The United States is the third largest supplier to the market behind China and Korea. However, U.S. market share has declined because U.S. export levels have not grown over the last decade. In 2016 the United States exported $25 million in T&D equipment to Japan (8 percent of import share).

Figure 29. [7]



Japan ranked *#3* for opportunities for U.S. exporters in the Smart Grid ICT Sub-Sector. In 2016, Japan invested $7.8 billion in energy smart technologies, the third-largest investment after the United States ($10.6 billion) and China ($9.9 billion). [20] Smart meter deployments ramped-up in 2015, with smart meter penetration reaching 47.6 percent. BNEF predicts 6 to 10 million additional installations per year through 2022. [35] As Japan's utilities deploy AMI, they will also likely make investments in data management software, consumer interface technologies, and additional smart grid applications and services.

Electricity retail deregulation has come into effect, and most Japanese consumers will have access to live pricing and the choice to select ToU-based tariffs. New pricing regimes – along with expectations of increased use of renewable energy – are driving more energy storage deployments. [8] Among fifty reported projects, approximately 260 MW of electrochemical energy storage have been deployed (or will be deployed) in the market. [10]

However, despite being ranked *#5* in the Energy Storage Sub-Sector, U.S. exporters will face strong domestic competition in Japan. Opportunities for U.S. firms will be significantly segmented by technology function. For example, U.S. battery manufacturers may struggle to succeed in the Japanese market due shipping distance and domestic manufacturing competition. On the other hand, systems integrators and software providers may be able to partner with local equipment manufacturers and form strategic global partnerships.

Opportunities and Challenges for U.S. Companies

ITA anticipates additional opportunities as Japan's electricity market reform takes shape and its smart grid develops. As Japan's electricity sector moves to a more customer-oriented and competitive structure, energy efficiency service providers and smart grid innovators with experience in mature markets will be highly competitive.

Opportunities

- Distributed energy resource management systems
- Consumer engagement software and analytics
- Outage management systems
- Commercial and industrial demand management systems
- Energy storage system integration software

Challenges

- Strong competition from large domestic firms (e.g., Toshiba, Hitachi, and Mitsubishi)
- Long approval process for projects (greater than two years)
- Burdensome project and technology certification process

Know Your Buyer

Smart grid procurers in Japan include the established regional utilities. New retailers may be promising partners as market liberalization comes into effect.

Summary of Resources

- U.S. Department of Commerce, Japan Country Commercial Guide: http://www.export.gov/ccg/japan090820.asp
- Japan Ministry of Economy, Trade, and Industry: http://www.meti.go.jp/english/

- Japan External Trade Organization: https://www.jetro.go.jp/en/
- Institute for Sustainable Energy Policies (ISEP): http://www.isep.or.jp/en/

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Mexico Case Study

Mexico's 2014 energy reforms have significantly improved the outlook for the Mexican smart grid market. These reforms are designed to liberalize the electricity generation market, open future development to private firms and create competition between energy producers and among electricity retailers. Opportunities for U.S. exporters to Mexico are strong given the interconnection of the Mexican and U.S. electrical grids along the border, longstanding relationship between U. S. and Mexican firms, intergovernmental collaboration between both countries on energy issues, and the business potential brought about by the market's liberalization. Mexico's overall *Smart Grid Top Market Report* (*SG TMR*) ranking is second only to Canada.

Market Overview

Mexico's overall electricity demand has increased on average by 3.1 percent per year for the last 10 years. In 2016, approximately 313.7 terawatt hours (TWh) of electricity was generated. Demand is expected to continue to increase at an annual average rate of 3.6 percent over the 10 years ending in 2018.

Generation

Mexico's vertically integrated, state-owned electric utility, the Federal Electric Commission (CFE), previously owned and operated nearly 100 percent of the country's national electric transmission and distribution grid and generated most of the country's electricity. However, as a result of the 2014 reforms, the utility is undergoing an unbundling process across its vertical segments of generation, transmission, distribution, and retail. Each market segment will have new subsidiaries owning the assets and managing the system. To date, at least six discrete competitive, for-profit generation subsidiaries have been formed. Each will have the ability to partner with private-sector firms. In addition to the six CFE subsidiaries, electricity generation will become a competitive market that will include independent power producers (contracted via CFE), and private generators.

Natural gas was the primary source of electricity generation, accounting for 55.3 percent of the generation mix in 2016. This was followed by renewable energy at 19.3 percent, crude oil at 11.7 percent, coal at 11.2 percent, and nuclear at 2.5 percent. Among the renewable generation sources, 63.5 percent was from hydropower, while 36.5 percent came from non-hydro renewables.

Transmission

The reforms created a new independent system operator, the National Center for Energy Control (CENACE) in November 2014. CFE will continue to own the country's transmission infrastructure, which

runs at a frequency of 60 Hz, through its transmission subsidiary. Planning and access to the transmission system are now overseen by the Mexican government and independent regulatory agencies. CENACE controls the new wholesale market which enables customers to purchase power directly from producers and includes overseeing a spot power market, capacity market, clean energy certificate trading, and financial transmission rights auctions.

Although full implementation of the reforms is not expected to be completed until after 2018, significant progress has been made to date. In 2016, CENACE held the country's first wholesale electric power auctions. The resulting long-term contracts, targeted at renewable energy projects, attracted commitments of an estimated cumulative investment of $4 billion over the next three years, which may help further the government of Mexico's plans to generate 35 percent of its electricity from renewable sources by 2024.

As a result of this split between private and public, two key trends in the Mexican electricity sector are emerging. The first is an increased investment in the T&D sector to facilitate the integration of more renewable energy, transmit electricity from resource-rich regions to load centers, and address high grid losses. The second major trend is that projects are opening to private investment. It is anticipated that CFE, along with the government of Mexico will issue "public-private" transmission line tenders on a regular basis. At the end of 2018, more than five transmission lines are expected to be tendered, at a value of more than $6.6 billion. [83] A recent high-profile example is the proposed HVDC line to connect Oaxaca and Yautpec.

Distribution & Metering

CFE will continue to own much of the electricity distribution infrastructure (end-user voltage of 220V). CFE has been further instructed to further separate its distribution business into additional subsidiaries to drive horizontal competition. The Ministry of Energy proposed a corporate structure that includes 16 regional distribution utilities that CFE will set up.

The Mexican government will be responsible for overseeing planning of the distribution system. Largely, private-sector participation in the transmission and distribution system will be limited. However, CFE can form joint ventures and bilateral agreements with private entities to finance, build, operate, and modernize distribution assets. CFE's smart grid vision is now viewed under the changes produced by the energy reforms. Grid modernization efforts during the last five years have been focused on smart metering pilots, control and automation systems, and grid monitoring solutions, such as phasor measurement units (PMU).

Some recent projects include the installation of 700,000 smart meters, with a total of 2 million meters tendered, through an eight-phase distribution loss-reduction metering program and a new energy management system (EMS) procured by CENACE. U.S. smart metering and communications companies have already been awarded several contracts within this set of projects. ITA anticipates that international suppliers, including U.S. firms, will continue to capitalize on these tenders for so-called "smart technologies."

Retail Sales
Under the reforms, retail sales will be segmented into two CFE subsidiaries: basic services and qualified users. Largely, this reflects a division for residential sales and for large customers. Competition is being encouraged.

Storage
Energy storage deployments in Mexico have been limited to date, but interest in the market is growing, especially as renewable energy deployments grow and the new wholesale market takes form. For example, AES Energy Storage and Mexico's Grupo Bal created a partnership in August 2015 to invest up to $2.5 billion over the next five years in Mexico's electricity sector, which would include improving its energy storage technologies. [84] Tesla has also worked to increase its presence in energy storage in Mexico through its purchasing of ILIOSS, a solar installer in Mexico, as a way to encourage the expansion of energy storage through solar installations. [85]

Regional Integration
CFE has several high-voltage interconnections with the transmission systems of various utilities along the U.S.-Mexico border with the most substantive interconnections being between Southern California Edison (SCE) and CFE's Baja California region. Some of these interconnections are used for permanent interchanges of energy, while others are used only for emergency purposes. Mexico also has interconnections with other countries in Central America, including a Mexico-Guatemala interconnection that consists of a single transmission line that mostly runs through Guatemala. Looking forward, CENACE and CFE are expected to pursue expansions of regional integrations with North and Central America.

Policy & Regulatory Environment

The Energy Regulatory Commission (CRE) is the primary power sector regulator, while the Energy Secretariat (SENER) plays a policy and planning role. CENACE leads the expansion plan for the National Transmission System in addition to overseeing the new wholesale market discussed above.

In May 2016, SENER published its Development Program of the National Electric System (known as PRODESEN) for 2016-2030. It estimates that over $114 billion will be invested in Mexico's electricity system over the next 15 years, including $89.6 billion for generation, $13.9 billion for transmission, and $16 billion for distribution. Other investments are targeted to expand and modernize T&D networks to reduce grid losses, install smart meters and gradually deploy additional smart meter technologies. [86] In August 2017, SENER published its 2017-2019 Smart Grid Program, which aims to reduce losses, optimize costs, and incorporates distributed generation, energy storage, and demand response into its systems. The plan establishes three priorities: development of both enterprise architecture and a telecommunications strategy for CFE, and establishing a cybersecurity framework for the Mexican electrical grid.

Smart grid implementation is specifically mentioned in the Constitutional Energy Reform as a means to reduce power losses, increase quality and reliability, and enable the integration of energy generated from intermittent renewable sources. CRE received a grant from the U.S. Trade and Development Agency to develop a smart grid deployment plan and renewable energy integration regulatory roadmap, which was published in February 2015.

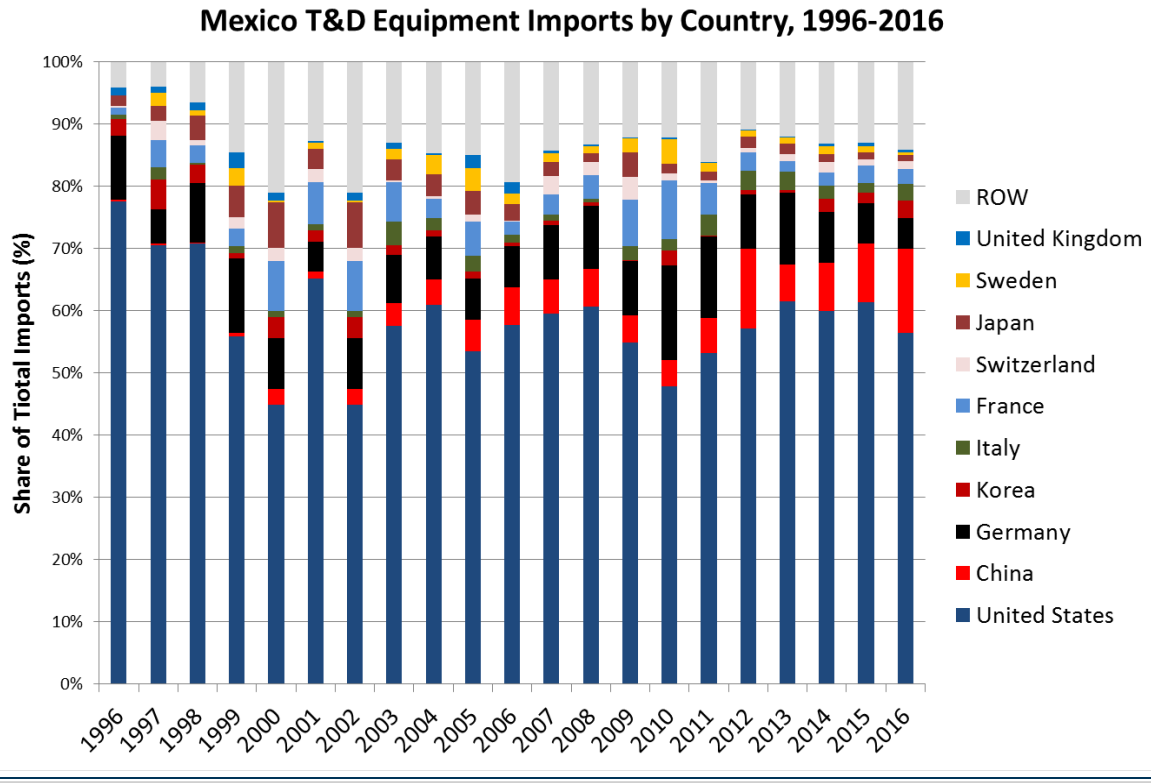
Market Analysis and Rankings

In 2017, energy-sector reforms continue to shape the Mexican energy market and provide increased opportunities for foreign firms. Investments in the Mexican power transmission and distribution systems will likely increase with the launch of tenders for new power transmission lines and continued public spending on expanding and raising the efficiency of the electricity network. However, the T&D network is still subject to theft and technical losses. For U.S. exporters, Mexico ranks *#2* overall, *#1* in the T&D equipment, *#6* in Smart Grid ICT, and *#24* for energy storage systems.

Mexico is the 13th largest global import market for T&D equipment, with imports totaling $619 million in 2016. As shown in Figure 30, the United States continues to be the leading supplier to the Mexican market. Over the past decade, Mexico's overall imports have grown at a 5 percent CAGR and U.S. exports to the market have kept pace, retaining an approximately 60 percent market share. Other primary suppliers include China (13.5 percent market share at $84 million) and Germany (5 percent market share at $31 million). Over the next five years, electricity demand is expected to grow at 2.84 percent annually. [8]

Bilateral T&D equipment trade with Mexico is complex. Integrated supply chains entangle the two markets, and Mexico is increasingly supplying more T&D equipment to the United States. In2016, Mexico exported $1.6 billion in T&D equipment to the United States, an 8 percent CAGR from 2006-2016.

Figure 30. [7]



Liberalization of the Mexican market and the creation of a new market operator are creating additional opportunities for smart grid ICT firms. Opportunities for exports of smart grid products will increase along with Mexico's growing deployment of renewable energy. By 2022, projections suggest that 15 percent of Mexico's electricity will be generated by renewables. [8] Smart meter rollouts continue, and the market penetration rate in 2017 reached 14.2 percent. [35]

Expansion of energy storage technology remains more modest in comparison to the Mexican government's efforts to promote investment in other parts of the energy sector. Mexico dropped 15 rankings in the Energy Storage Sub-Sector to *#24*. This is largely the result of methodology changes that focus exclusively on electrochemical systems, where no electrochemical energy storage projects were reported in the U.S. Department of Energy Global Energy Storage Database or the Bloomberg New Energy Finance project database. [10] [11] Mexico's ranking is largely driven by expectations that as Mexican utilities pursue electrochemical energy storage projects the United States will likely be the supplier of batteries and associated electrical equipment based on geographical proximity to the United States and a history of strong T&D equipment exports.

Opportunities and Challenges for U.S. Companies

As U.S. firms look to engage in the Mexican market, the following opportunities for smart grid solutions and underlying market challenges will be important:

Opportunities

- Advanced metering infrastructure
- SCADA Systems
- Products and services to reduce of technical and non-technical T&D losses
- Enterprise IT and communications architecture
- Consumer engagement software and billing management
- GIS asset mapping tools
- Cross-border electricity trade
- Cybersecurity technologies, software, and services

Challenges

- Lack of smart grid standards
- Access to capital, particularly for SMEs
- Uncertainty in market reforms

Know Your Buyer

In order to do business in Mexico, it is crucial to develop and maintain close relationships with clients and partners. Mexicans prefer direct communication, such as telephone calls or face-to-face meetings. U.S. companies should engage utilities early to promote the inclusion of their products or services in the utility's specifications. The tendering and awarding of contracts can be a lengthy process. Companies should be patient and make sure they have sufficient resources to dedicate to these efforts or engage with Mexican partners that have experience working with the CFE.

In its new, post-reform role as a competitive state company, CFE's procurement process has been modified to facilitate direct purchases, less cumbersome tender processes, and partnerships with the private sector. The company is open to new technologies and welcomes commercial presentations, which may lead to invitations or specific technology recommendations in tenders.

Mexico's size and diversity are often under-appreciated by U.S. exporters. It can be difficult to find a single distributor or agent to cover this large market. A local distributor or partner is recommended to track tender announcements and complete bids. Foreign companies often form consortiums with Mexican vendors to compete in CFE tenders, benefitting from their partners' local expertise.

Summary of Resources

- U.S. Department of Commerce, Mexico Country Commercial Guide: http://www.export.gov/ccg/mexico090857.asp

- Mexico Secretariat of Energy (SENER): http://www.energia.gob.mx
- Federal Electricity Commission (CFE): http://www.cfe.gob.mx
- Energy Regulatory Commission (CRE): http://www.cre.gob.mx

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Nigeria Case Study

The decline in global crude oil prices caused Nigeria to slip into an economic recession in 2017, since crude oil is Nigeria's primary export commodity. However, active U.S. government programs such as the Power Africa Initiative are helping to drive opportunities for T&D suppliers in Africa's most populous nation. ITA anticipates that the country will need to overhaul its deteriorating T&D infrastructure to drive economic growth and provide electricity to 50 percent of the population that is living without it.

Market Overview

The structural transformation of Nigeria's power sector began in 2004 with the National Integrated Power Plan (NIPP), a government-funded initiative to boost and stabilize electricity supplies, followed by the Electric Power Sector Reform Act (EPSRA) of 2005. EPSRA has thus far led to the unbundling of state-owned Power Holding Company of Nigeria (PHCN), a process that officially ended in late 2013 and resulted in 11 electricity distribution companies (DisCos), six generating companies (GenCos), and a transmission company. The generation and distribution companies have been privatized, while transmission remains government owned. It is estimated that up to $4 billion in funding will be required to upgrade and expand assets in the newly privatized generation and distributions sectors.

Nigeria's overall electricity demand has increased on average by 2.9 percent per year over the 10 years ending in 2016 2016 when 27.0 terawatt hours (TWh) was generated. Demand is expected to continue to increase over the next decade by an average of 3.47 percent per year.

Generation

Natural gas dominates electricity generation and accounts for 65.8 percent of the market. Other generation sources include hydropower at 19.9 percent, oil at 13.7 percent, and non-hydro renewables at 0.5 percent. In December of 2016, Ogbonnaya Onu, the Minister for Science and Technology, stated that the Nigerian government has plans to begin using nuclear energy and it has started making arrangements with the Russian State Nuclear Corporation, Rosatom, for guidance and supports. [87]

Transmission

Transmission Company of Nigeria (TCN) manages the electricity transmission network in the country and is presently fully owned and operated by the government. TCN's licensed activities include electricity transmission, system operation and electricity trading. Nigeria's transmission network consists of high

voltage substations with a total (theoretical) transmission wheeling capacity of 7,500 MW over 20,000km of transmission lines operating at a frequency of 50 hertz (Hz). [88]

A major pillar of Nigeria's efforts to improve the transmission network was the government's three-year, $23.7 million management contract with Manitoba Hydro International Limited (MHI), a Canadian electric utility company. Under MHI's management, the Transmission Company of Nigeria (TCN) was expected to effectively and reliably transport power from generation companies to distribution companies and eligible customers connected to the national grid. The contract also has the goal to establish local capacity to avoid stranded generation assets and reduce system collapses and transmission losses. The contract with MHI expired in 2016. TCN has resumed management of the network.

The Federal Government of Nigeria (FGN) plans to pool $2.6 billion in institutional funding for near-term investment in transmission infrastructure with annual capital expenditures set at $370 million in the distribution sector. In 2017, TCN secured $1.55 billion from the World Bank, African Development Bank, the Islamic Development Bank, and the European Union [89] that will be used to achieve its ambitious goals of adding 20,000 MW of transmission capacity. FGN must ensure that the newly privatized electricity sector can generate adequate returns on the investment.

Distribution & Metering

There are 11 Electricity Distribution Companies (DisCos) operating in Nigeria. Each of these companies oversees and operates a regional distribution system that spans from three to five of Nigeria's 36 states. [88]

Theft from distribution lines is a problem in Nigeria. Utilities have instituted various metering initiatives over the years to address the issue. Most recently, the Nigerian Ministry of Power indicated it would serve as the lead for prepaid meter deployment in the country after the utilities failed to effectively deploy meters in the country. [90]The government has introduced a new mechanism for licensing "Meter Service Providers" to finance, procure, install, and manage prepaid meters. [91]

Storage

There is increasing interest in energy storage coupled with rooftop solar. The Nigerian company Greenicles Solar has installed 30 MWh of batteries into homes throughout Nigeria. [92]

Regional Integration

Nigeria has cross border interconnections with Benin and Niger. More recently, the West Africa Power Pool (WAPP), a "specialized institution" of the Economic Community of West African States (ECOWAS), and the African Development Bank signed a grant in 2016 to support the Nigeria-Benin Interconnector Reinforcement Project meant to build more transmission lines between the countries. [93] WAPP is focused on creating a regional power market to enhance grid reliability and improve access to electricity across its member nations: Benin, Burkina Faso, Cote D'Ivoire, Gambia, Ghana, Guinee, Guinee Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo.

Policy & Regulatory Environment

The Energy Commission of Nigeria (ECN) is the primary government energy policymaking body. It has made the expansion of the power supply and upgrades to T&D infrastructure policy priorities, but the country has many challenges to overcome on the regulatory and finance fronts to ensure stronger investment growth in the sector.

In 2006, the Nigerian Rural Electrification Agency (REA) was established to increase access to electricity from 35 percent to 75 percent of Nigeria's population by 2020. Under the Energizing Education Project and Energizing Economics Program, REA aims to stimulate microgrid projects at 37 federal universities and seven university teaching hospitals as well as provide support for broader deployment of microgrid renewable technologies. Other goals under the effort include deployment of street lighting and the development of off-grid and renewable energy training centers.

Amid the electricity sector reforms that began in 2005, the Nigerian Electricity Regulatory Commission (NERC) was established as an independent regulator including licensing and compliance for market participants. In recent years, NERC has worked to expand gas-fired electricity supplies and has issued power generation licenses to independent power producers.

In 2012, NERC implemented a new Multi-Year Tariff Structure (MYTO) intended to increase electricity rates and help attract further investment to the sector. The MYTO has corrected some policies that resulted in severely underpriced electricity that came at a high cost to the government and was detrimental to investment in the power network. Today, the agency is focused on establishing a regulatory framework for the development of renewable resources and for the improvement of the efficiency of the grid, including energy efficiency and demand-side management programs.

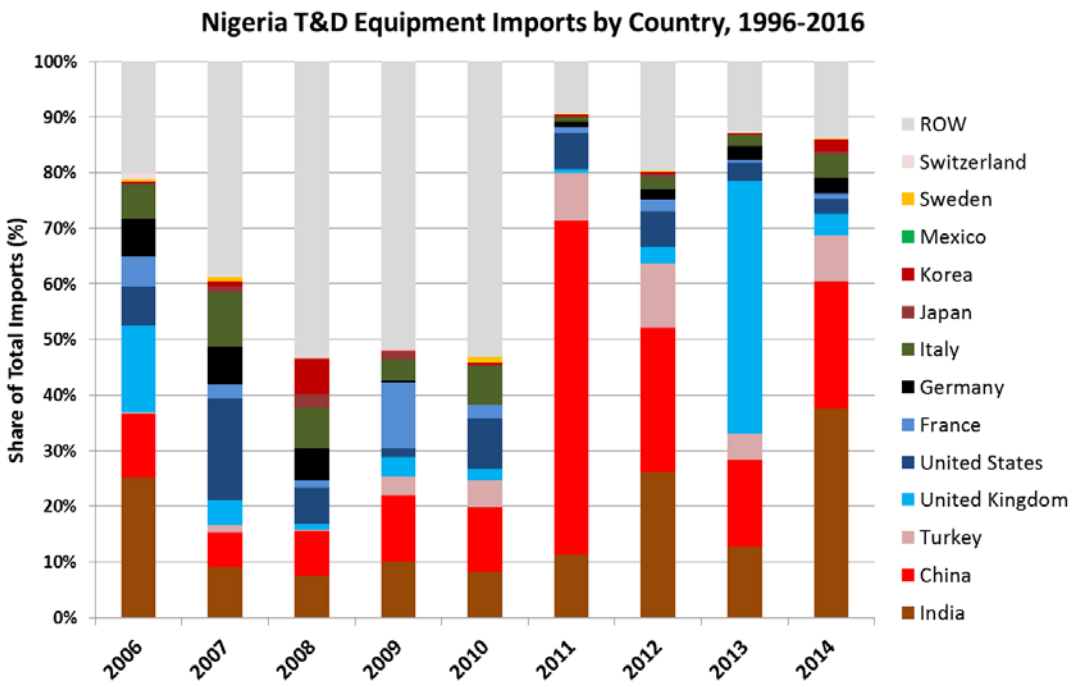
Government efforts have been effective in stimulating more renewable energy development as more than 9.5 GW of solar energy PPAs have been signed. This is driving the most recent "Vision 30:30:30" that was issued under the National Renewable Energy and Energy Efficiency Policy. The effort looks to add 30 GW of electricity by 2030 with renewable energy comprising 30 percent of the mix.

Market Analysis and Rankings

The country's privatized distribution companies are under pressure to modernize their infrastructure and quickly expand power supplies. Financing these projects is a challenge, but efforts, such as the Power Africa Initiative, have already helped to catalyze international investment in power and grid modernization projects. After a drop in rankings from *2016 SG TMR* to *the January 2017 Update,* Nigeria's ranking in the *2017 SG TMR* has remained stable overall (*#28*) and in the T&D Equipment (*#16*) and Smart Grid ICT (*#36*) Sub-Sectors. Nigeria saw a significant rise in the Energy Storage Sub-Sector rankings (*#28*), an increase of 15 rankings.

Nigeria imported more than $300 million in T&D equipment in 2014, its last year of reported import statistics to the United Nations. From 2006 to 2014, imports rose at a 9 percent CAGR. As shown in Figure 31, India is the top supplier to Nigeria. It captured 38 percent of the market and was followed by China (24 percent), Turkey (9 percent), and Italy (4 percent). In 2014, U.S. manufacturers captured 3 percent of the market ($8.3 million).

Figure 31. [7]



Nigeria's rise in energy storage rankings is driven by limited electricity generation (that has led to rolling blackouts) and an increasing demand for backup generation solutions. Diesel generators are common among wealthy residential, commercial, and industrial customers. Off-grid solar plus storage solutions is a growing market. There is only one reported large-scale electrochemical energy storage project being tracked by the DOE Global Energy Storage Database. [10] The 1.1 MW project is deploying a lithium-ion battery system at a food-processing facility for on-site power.

Opportunities and Challenges for U.S. Companies

Thus far, investor interest in Nigeria's transformed power sector has been positive, including the U.S.-supported Power Africa Initiative. The initiative aims to expand access to power across Sub-Saharan

Africa by 2030 through the addition of 60 million new electricity connections and 30,000 MWs of new and cleaner power generation. In Nigeria, the initiative provides technical assistance, credit enhancement, financing for independent power producers and other forms of transaction facilitation to support 14,000 MWs of additional capacity.

Opportunities

- T&D network upgrades and new buildouts
- Prepaid meters, billing and collection software, and other related products and services
- Global Information System (GIS) software and platforms, Supervisory Control and Data Acquisition (SCADA) systems, and network monitoring and control systems
- Outage management and emergency response solutions
- Smart grid road mapping and strategy services

Challenges

- High costs of capital and pressure from local investors to provide immediate returns
- Tariff structures that do not reflect the true cost of service
- Local content requirements and other emerging protectionist policies
- Access to customer data to inform grid management and investment decisions

Know Your Buyer

Nigerian purchasers of U.S. smart grid goods and services include generation, transmission and distribution companies. For example, there are 11 distribution companies in Nigeria that maintain a monopoly status within each of their geographical areas.

Summary of Resources

- U.S. Department of Commerce, Nigeria Country Commercial Guide: http://www.export.gov/ccg/nigeria091342.asp
- Power Africa Portal: https://www.usaid.gov/powerafrica
- Power Africa Nigeria: https://www.usaid.gov/powerafrica/nigeria
- Nigerian Electricity Regulatory Commission: http://www.nercng.org/index.php/contact/discos
- Nigerian Rural Electrification Agency: http://rea.gov.ng/
- Transmission Company of Nigeria: http://www.tcnorg.com/
- West Africa Power Pool: http://www.ecowapp.org/

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Philippines Case Study

The Philippines continues to experience rapid growth in its energy sector in response to increasing demand driven by significant domestic economic growth. The government is currently exploring how to expand the use of renewable energy coupled with electricity storage to diversify the country's energy generation. Furthermore, the government has already committed to making the Philippine electricity grid fully interconnected by 2020 through various domestic grid-connected projects. U.S. smart grid exporters will face significant competition in the market given that the primary operator of the Philippines' transmission system is 40 percent owned by the State Grid Corporation of China.

Market Overview

In 2016, approximately 74.15 terawatt hours of electricity was generated in the Philippines from an installed capacity base of just over 16 GW. Overall electricity demand has grown by an average of 5 percent per year for the decade ending in 2016. Looking forward, electricity demand is expected to continue to increase at a similar rate with an average annual increase of 5.3 percent over the 10 years ending in 2026

Generation

The three major island groups in the Philippines – Luzon, Visayas, and Mindanao – will require a substantial increase in installed electricity generation capacity to meet increasing demand. It is anticipated that an additional 13,800 MW of capacity will be needed by 2040. However, only 2,300 MW has been committed.

The country's conventional energy sources – oil, gas, and coal – remain central to meeting the country's energy demand in the short term, even as the country pursues alternative energy sources. Across the market, coal dominates electricity generation. Forty-seven percent of electricity is generated from coal, 24.2 percent from renewable energy, 21.9 percent from natural gas, and 6.2 percent from oil. Among the renewable energy sources, just over half is generated from geothermal, followed by 37 percent from hydropower, 5 percent from solar, 5 percent from wind, and 3 percent from biomass. [94]

The role of state-owned companies in the generation and distribution of electricity has rapidly declined since the enactment of the Electric Power Industry Reform Act (EPIRA) of 2001. EPIRA was designed to increase competition through privatization. This resulted in the creation of the Power Sector Assets and Liabilities Management Corp. (PSALM), which took ownership of all existing generation assets as well as assuming all of the liabilities and obligations of the state-owned National Power Corporation (NPC). PSALM's primary responsibility is to work on privatizing NPC's assets through a bidding process open to

national and international firms. As a result, most of electricity generation capacity in the country is now privately owned.

First Gen is the largest Philippine-owned and controlled independent power-generation company, with an installed capacity of over 2.9 GW and accounting for approximately 23 percent of gross generation in the country. Aboitiz Power (AP) is one of the largest power produces in the Philippines with 44 generating facilities with a combined capacity of 2.5 GW. AP invested ₱100 billion (USD $2.3 billion) between 2011 and 2013 in new generation assets. As of 2013, AP announced plans to invest ₱85 billion (USD $2.06 billion) from several loan agreements with half of the investments going towards new coal-fired power plants.

Transmission

The transmission infrastructure for the Philippines spans three primary regions: Luzon, Visayas, and Mindanao. Each region's grid operates at a frequency of 60 hertz (Hz) and a voltage that can exceed 230kV.

Philippines' transmission assets are owned by the state-owned National Transmission Corporation (TransCo) which was also created with passage of EPIRA. While TransCo initially oversaw its operations, TransCo was auctioned successfully in December 2008 with the winning bid of $3.95 billion coming from a consortium of firms (the National Grid Corporation of the Philippines), which includes a 40 percent stake from the State Grid Corporation of China. This auction resulted in the creation of the privately-owned National Grid Corporation of the Philippines (NGCP) that now oversees transmission operations.

Distribution

Electricity distribution and retails sales are handled by private distribution utilities and local government companies (electric cooperatives) in each of the three regions. In Luzon, which is the largest service territory in the country, privately-owned Meralco is the largest electricity distribution utility and the largest utility in the country. It serves more than 6 million customers in 36 cities and 75 municipalities including metro Manila. Meralco announced plans to invest $5.9 billion in distribution projects over the decade ending in 2026. As for the other two regions, AP owns various regional subsidiaries that operate in Visayas (Visayan Electric Company) and Mindanao (Cotabato Light & Power Company and Davao Light & Power Company).

Operating voltages vary throughout the country, ranging between 69 to 138 kV, with an end-user voltage of 230V.

Retail Sales and Pricing

The price of electricity depends heavily on prices of fossil fuel imports. Fluctuations in global energy prices cause the country's electricity prices to vary. The market is becoming increasingly more price-sensitive. There is a growing preference among electrical equipment buyers for lower priced yet technically compliant options. U.S. firms will face intense competition from low-cost electricity generating equipment supplied by firms based in China, Japan, Singapore, and Germany.

Storage
The Philippines is exploring energy storage systems and is actively trying to find ways to use storage to increase the efficiency of renewable energy. For example, there is a solar power project in Concepcion, Tarlac that will incorporate energy storage for load shifting. [95]

Regional Landscape
Due to the Philippines' geographical location, its electrical system is not connected to other countries. However, it is currently working on various projects to better interconnect the electricity grid between the Luzon, Visayas, and Mindanao regions. These regions together comprise more than 7,500 islands with the largest of the islands being Luzon, which spans an area of 42,458 square miles, followed by Mindanao with an area of 37,657 square miles.

While the Luzon and Visayas electricity grids are connected through NGCP's Naga-Ormoc High Voltage Direct Current (HVDC) line, a proposed Visayas-Mindanao connection project is planned to be completed by 2020. The project will help ensure that electricity can be distributed and shared among the country's three island groups. The interconnected grid will help mitigate electricity shortages caused by power plants shutting down in certain areas.

Outages are particularly frequent in smaller, less-developed islands and remote rural communities that lack the adequate energy infrastructure to meet demand. Microgrids have begun to penetrate these markets. For example, in 2016 the Shell Foundation worked with Philippine-based renewable energy consultant Silver Navarro to install a microgrid system into a community to increase reliability. [96]

Policy & Regulatory Environment

The main energy policymaking government agencies are the Philippines' Department of Energy (DOE) and the Department of Environment and Natural Resources (DENR).

The Philippines' DOE is promoting the use of clean energy through the National Renewable Energy Program (NREP). This program has resulted in more than 724 Renewable Energy Service contracts being awarded to companies for the construction of new generating facilities with a potential capacity of 14,498 MW. Among the renewable energy resources, hydropower dominates with 398 awarded projects and a potential capacity of 8,037 MW, followed by solar with 160 awarded projects, of which 144 are on-grid and 16 are off-grid. [97]

Various policy mechanisms have been developed to incentivize the expansion of renewable energy including a feed-in tariff (FIT) and a net metering. The FIT has stimulated the deployment of new renewable energy projects including 400 MW of wind and 527 MW of solar. [97]

The Energy Regulatory Commission (ERC) is the electricity industry's regulator. In 2005, the ERC established the Distribution Management Committee (DMC) that is responsible for monitoring

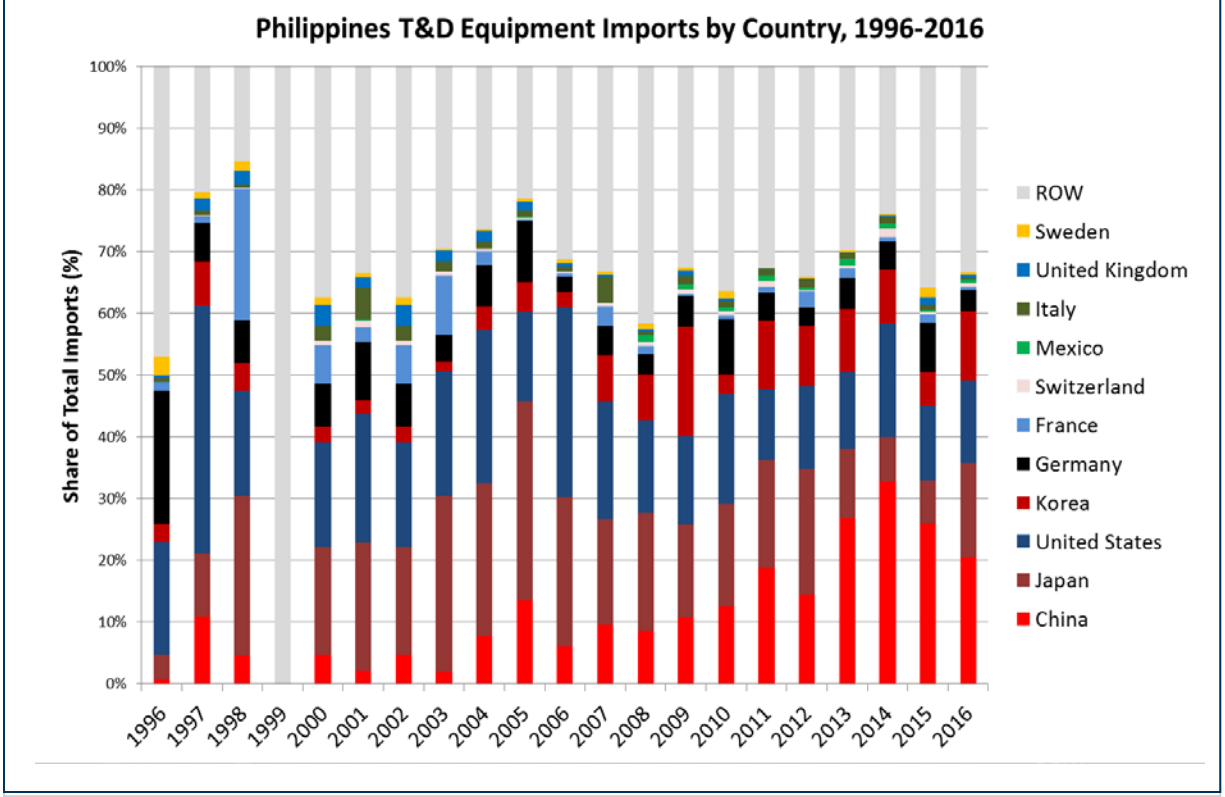
compliance with the Distribution Code at the operations level. The DMC also ensures that all distribution users are represented in reviewing and making recommendations for the maintenance and development of the distribution system as well as specifying the processes for dispute settlements. The DMC is divided into five subcommittees that oversee specific parts of their operations: Distribution Planning, Distribution Reliability & Protection, Distribution Operations, Rules Review, and Compliance.

Market Analysis and Rankings

Electricity consumption in the Philippines is projected to grow at 5.16 percent annually over the five years ending in 2022. [8] Coupled with the deployment of energy storage systems and plans to roll out smart meters and install SCADA systems, the market lands at *#14* overall in the 2017 *SG TMR* rankings. At the sub-sector level, the market ranks *#10* for T&D Equipment, *#29* for Smart Grid ICT, and *#16* for Energy Storage.

In 2016, the Philippines imported more than $362 million in T&D equipment, a 10-year CAGR of 14 percent. As shown in Figure 32, China is the leading supplier to the Philippines, capturing over 20 percent of the market in 2016, followed by Japan (15 percent), the United States (13 percent), and Korea (11 percent). U.S. exports to the Philippines have experienced year-to-year fluctuations, but since 2010 have accounted for between 11 to 13 percent of the market.

Figure 32. [7]



Opportunities and Challenges for U.S. Companies

As U.S. firms explore the Philippine market, ITA believes the following areas will be of near-term importance:

Opportunities

- Software and hardware to integrate renewable energy into the system
- Smart metering
- Consumer interface technologies fostered by greater retail market competition
- SCADA systems to improve system automation
- Microgrids for remote islands

Challenges

- Price sensitivity of consumers
- Technical assistance needed to increase utility technical capacity and foster sales
- Strong competition from Chinese and Korean firms

Know Your Buyer

Philippine purchasers of U.S. smart grid goods and services include generation, transmission and distribution companies. Agents and distributors are commonly used in the Philippines and are essential for success for most U.S. companies. It is recommended that U.S. companies visit their agents and distributors to strengthen these relationships and assess the local companies' abilities. U.S. companies should be patient yet diligent in pursuing contracts, particularly projects with the Philippine government.

Summary of Resources

- U.S. Department of Commerce, Philippines Country Commercial Guide https://www.export.gov/ccg
- Arangkada Philippines (a joint USAID-American Chamber of Commerce project) www.investphilippines.info
- Department of Energy (DOE) - http://www.doe.gov.ph
- Department of Environment and Natural Resources - http://www.denr.gov.ph/
- National Transmission Corporation (TransCo) - http://www.transco.ph/
- Energy Regulatory Commission (ERC) - http://www.erc.gov.ph
- National Electrification Administration (NEA) - http://www.nea.gov.ph
- National Grid Corporation of the Philippines (NGCP) - http://www.ngcp.ph
- National Power Corporation (NPC) - http://www.napocor.gov.ph
- Power Sector Assets & Liabilities Management (PSALM) Corp. - http://www.psalm.gov.ph

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Saudi Arabia Case Study

An understanding of Saudi Arabia's electricity policies starts and ends largely by focusing on trends in global oil prices. Proven crude oil and natural gas reserves, as well as generous subsidies, have driven energy demand growth over the last several decades. Over the two years ending in 2016, global oil prices hit decade lows, creating uncertainty in the electricity market and impacting investment, policy, and regulatory decisions. ITA expects that as regional interconnections and renewable energy deployment plans move forward, there will be growing interest in implementing smart grid information communications technology (ICT) solutions.

Overall Rank	T&D Equipment
#16	#10
Smart Grid ICT	**Energy Storage**
#16	#21

Market Overview

Generation

The electricity market in Saudi Arabia has grown rapidly for over the decade ending in 2016, doubling in size since 2000. Electricity generation is expected to grow at just over 5 percent annually in the near-term. Additional generating capacity of 2 to 4 GW needs to come online each year to meet growing demand.

In 2016, 41 percent of Saudi Arabia's electricity generation was from oil, 59 percent was from natural gas, and less than 1 percent was derived from non-hydro renewables. Over the coming decade, the electricity generation mix in Saudi Arabia is expected to change. In 2026, oil is expected to decrease to 34 percent of the total electricity share, while natural gas will increase to 66 percent and non-hydro renewables will double, but remain under 1 percent of the generation mix.

Saudi Arabia remains the largest power market in the Gulf Cooperation Council (GCC) and spending on infrastructure is expected to continue. Opportunities for private-sector investment will likely increase as the Saudi government is unable to fund infrastructure projects at the rate it once did.

The electricity market is dominated by one firm, Saudi Electricity Company (SEC), with the Saudi Government maintaining a majority stake in the firm. SEC generates almost 75 percent of the country's power, while other producers include the Saline Water Conversion Corporation (SWCC) and Saudi Aramco. SWCC operates 32 plants that desalinate water and supply electricity, with total annual output of approximately 2.5 GWh of power.

Overall, SEC plans to invest $40 billion through 2020 to expand generating capacity and upgrade transmission and distributions lines. The expansion will increase power generation by 37 percent to 71 GW. In 2016, 4,737 MW of capacity were added, while future investment plans include the addition of

700 MW from wind and solar in 2018, and an additional 8.8 GW of renewable energy between 2019 and 2023.

Transmission and Distribution

Downstream, SEC maintains a virtual monopoly through its National Grid subsidiary in the transmission, distribution and sale of electricity. SEC has launched a series of projects to overhaul outdated segments of the power grid and lay the groundwork for a modern transmission and distribution system. Indeed, there are plans to spend nearly $14.7 billion for the transmission and $13.7 billion for distribution of electric power over the ten years ending in 2016.

SEC has expanded its transmission network by more than 50 percent since 2000. It expects investments in transmission to reach $80 billion through 2020. Much of its longer-term investment is expected to focus on interconnecting the Kingdom's transmission network both internally -- between the western, central, and southern provinces -- and internationally.

Experts estimate that power losses along the distribution system are approximately 9 percent of total output and will slowly drop over the next decade as grid modernization moves forward. SEC is planning significant investments, including the addition of 161,807 km of distribution lines between 2017-2021. SEC plans to accelerate its investments in the smart grid, including a significant smart meter roll out across the country. One component of the Kingdom's smart grid and energy efficiency program was put into place in 2010 when electricity tariffs for industrial and large commercial customers were increased and variable tariffs were introduced to encourage conservation during peak demand hours. To implement the new tariff system in the private consumer sector, SEC sees smart meters as a necessary tool for its customers. With some pilot projects completed in Riyadh, SEC is looking to roll out smart meters to the rest of the country. Investment in the distribution system in Saudi Arabia, including smart grid systems, is predicted to reach $24 billion over the next decade.

Storage

There is no specific guidance on energy storage. However, as of the drafting of this report, the Saudi government is in the process of qualifying energy storage bids for the 300 MW Sakaka Solar PV independent power plant project in Al Jouf province and the 400 MW wind power project in Tabuk province as part of its National Renewable Energy Program (NREP).

Regional Integration

SEC has plans to increase regional integration. It is undertaking a feasibility study to build a 3 GW underwater connection with Egypt to balance daily and seasonal peak loads. There are plans to eventually expand the connection to Europe to better utilize existing generation capacity during non-peak operating seasons.

In addition, the Gulf Cooperation Council Interconnection Authority's (GCCIA) Interconnection Project includes three phases to connect Saudi Arabia, Bahrain, Kuwait and Qatar via overhead and submarine lines to help provide improved aggregate demand and supply over a wider area and meet peak loads in

the summer. The project was funded by several sources, with SEC providing nearly half the total to connect the GCC states.

Policy & Regulatory Environment

Saudi Arabia's electricity market is overseen by three major government entities: Ministry of Energy, Industry and Mineral Resources (MEIM; King Abdullah City for Atomic and Renewable Energy (KACARE); and the Electricity and Co-Generation Regulatory Agency (ECRA).

KACARE drives the integration of clean energy sources in Saudi Arabia and the development of energy efficiency programs and directives. MEIM is responsible for setting long-term energy plans and policies for the electricity sector and overseeing private investment in the energy, industry, and minerals sectors.

Saudi Arabia's National Renewable Energy Program (NREP) is a long-term, multifaceted renewable energy strategy designed to balance the domestic power mix to deliver long-term economic stability and prosperity to the Kingdom, while working towards carbon reduction commitments. The NREP is led by MEIM, directly supporting Saudi Arabia's National Transformation Program (NTP) and Vision 2030. The office that is responsible for the delivery of the NREP is the MEIM's REPDO.

The Program is being rolled out in a phased process to ensure that the Kingdom benefits from a greater diversity of generation inputs that would lower opportunity costs of renewable energy over time. The NREP aims to substantially increase the share of renewable energy in the total energy mix, targeting the generation of 3.45 GW of renewable energy by 2020 – approximately 4 percent of generation capacity – and 9.5 GW by 2023.

However, delays in projects and market uncertainty have caused the Saudi Government to push back this target to 2040, as part of its INDC submission to the UNFCCC negotiations in late 2015. This announcement came from MEIM, which released a new power sector strategy white paper that forecasted its needs and requirements through 2040. The plan focuses heavily on sustainability, conservation, and planning to reduce energy use, as Saudi Arabia has one of the world's highest levels of energy intensity. Its energy consumption per capita is twice as high as Western Europe and the United States. The country wants to reduce energy intensity between 2005 and 2030 by 30 percent.

ECRA is the independent regulator of the Kingdom's electricity industry. ECRA assesses tariffs, issues licenses, monitors service providers, investigates complaints, establishes quality of service standards, sets standards, and promotes fair competition among providers and suppliers.

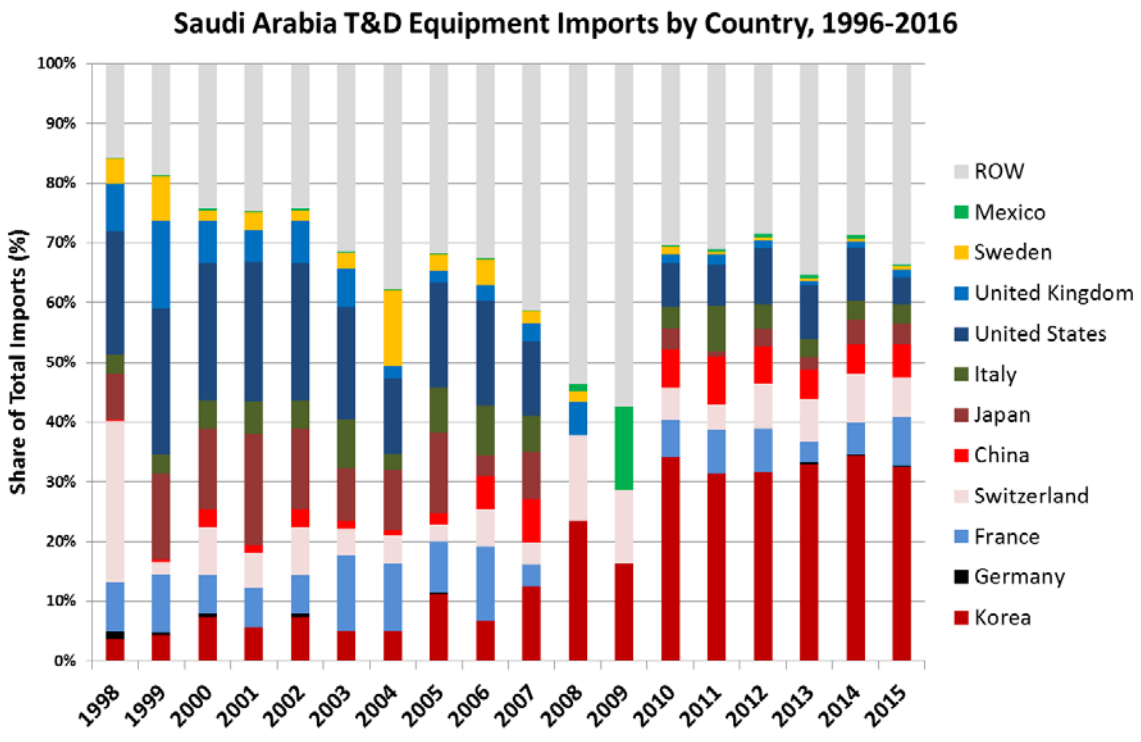
ECRA is in the midst of a comprehensive long-term plan to privatize and deregulate the electricity market, starting with the structural separation of the vertically-integrated electricity supplier monopoly, SEC. ECRA intends to separate and introduce private competition to SEC's generation, transmission, and distribution business segments and increase competition in distribution and retail sales. Currently,

however, competition exists only in the form of Independent Water and Power Plants (IWPP) that compete with SEC in the generation market and are integrated with its grid.

Market Analysis and Rankings

Saudi Arabia is the second largest global import market for T&D equipment, only trailing the United States. In 2015, Saudi Arabia imported more than $2.5 billion in T&D equipment. As shown in Figure 33, Korea is the leading supplier to the market with just under 30 percent market share. The United States is the seventh largest supplier with 4 percent market share behind German (10 percent), Turkey (8 percent), France (7 percent), Switzerland (6 percent), the United Arab Emirates (5 percent), and China (4 percent). This reflects a negative CAGR of 15 percent from 2005-2015 for U.S. exports to the region, which stands in contrast to the positive 18 percent CAGR for overall exports to Saudi Arabia.

Figure 33. [7]



Saudi Arabia's aggressive infrastructure expansion program to increase electricity generation, efficient distribution, fuel diversification, and energy conservation will be restrained as oil prices remain low. For example, Saudi Arabia's electricity growth consumption projections have been scaled back to 2.6 percent growth annually. This is down from previous projections and, coupled with decreased trade in

manufactured goods, has resulted in a slow drop in Saudi Arabia's *SG TMR* T&D Equipment Sub-Sector Rankings from *#1* in 2015 to *#19* in 2017.

The country's T&D infrastructure is modernized, but commercial and industrial scale consumers will seek to capitalize on potential energy efficiency gains through investments in smart grid ICT and smart building technologies and services. The market potential for residential and industrial energy efficiency products and services is projected to grow rapidly as a result, and a wide range of opportunities for U.S. companies in the green building and energy efficiency subsectors are expected to broaden. As a result, Saudi Arabia ranks highly among markets in the Smart Grid ICT Sub-Sector (*#16*).

Opportunities and Challenges for U.S. Companies

U.S. firms interested in the Saudi Arabian market should keep in mind the following:

Opportunities

- Outage management systems
- Distribution and substation automation
- Synchrophasor technologies and wide-area monitoring
- Energy efficiency programs for commercial and industrial customers
- High-voltage transmission systems and related equipment
- Products and services to effectively integrate renewable energy into the grid

Challenges

- Reduced loss of capital for purchases resulting from a sustained period of low oil prices
- Artificially low tariffs (for some sectors) that can result in wasting electricity and challenges recouping costs
- Increasing reliance on European standards

Know Your Buyer

Although U.S. exporters are not required to appoint a local Saudi agent or distributor to sell to Saudi companies, ITA recommends that all new-to-market U.S. companies consider partnering with a local company for monitoring business opportunities, navigating import and testing requirements, and identifying public-sector sales opportunities.

Summary of Resources

- U.S. Department of Commerce, Saudi Arabia Country Commercial Guide: http://www.export.gov/ccg
- Ministry of Water and Electricity: www.mowe.gov.sa
- Saudi Electric Company (SEC): www.se.com.sa
- Saline Water Conversion Corporation: www.swcc.gov.sa

- Water and Electricity Company (WEC): www.wec.com.sa
- Power and Water Utility Company for Jubail and Yanbu: www.marafiq.com.sa
- Electricity and Cogeneration Regulatory Authority: www.ecra.gov.sa

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Turkey Case Study

Select utilities in Turkey are investing heavily in smart grid technologies. A major challenge for Turkey's electricity distribution companies, however, is raising revenue to support new investment, since low electricity prices are strictly controlled by government regulatory body. As a result, maintaining and upgrading the grid, rather than digitalization, remains the priority. Turkey's *SG TMR* ranking is bolstered by strong electricity demand growth, public- and private-sector investment in grid modernization, and steady progress in electricity market reforms.

Market Overview

Average electricity demand in Turkey has exceeded 5 percent per year over the decade ending in 2016 when consumption reached 279 terawatt hours (TWh). Demand is expected to continue to increase over the next decade by 3.4 percent annually.

Generation

Natural gas and coal are the primary sources of electricity generation in Turkey, accounting for 32.5 percent and 32.6 percent, respectively. This is followed by hydropower at 25 percent, wind at 6 percent, and other sources for the remainder of the generation. [98] Turkey is in the process of constructing its first nuclear power facility, the Russian-made Akkuyu Nuclear Power Plant, which is scheduled to be online by the end of 2023. [99]

In March 2001, the Turkish government implemented a new Electricity Market Law, which set the stage for the liberalization of power generation and distribution activities. Under the law, state-owned Turkish Electricity Generation and Transmission Corporation (TEAS) was split into separate generation, distribution and trade companies -- Turkish Electricity Generation Company (Elektrik Uretim AS, EUAS), Turkish Electricity Transmission Company (TEIAS), Turkish Electricity Distribution Company (TEDAS), and the Electricity Trading and Contracting Corporation (TETAS), with the goal of eventual privatization of the generation and trade companies. Currently, all 21 electric distribution service companies (DSOs) of TEDAS are privatized, while power plants operated by EUAS continue to be privatized.

The Turkish power sector is a mix of both public and private entities. A majority of its electricity generation – approximately 83 percent – is provided by independent power producers (IPPs) and other privately-owned companies. State-owned EUAS operates thermal and large hydroelectric plants and provides the remaining 17 percent of power generation.

Investment is expected to continue to focus on electricity supply growth, particularly coal, nuclear, solar, wind, and geothermal power. Non-hydro renewable resources currently account for approximately 9 percent of generation. To date, Turkey's Energy Market Regulatory Authority (EMRA) awarded licenses for 1,600 MW of solar power and plans to open bids for another 3,000 MW.

Transmission
Transmission system operations and maintenance are controlled by TEIAS, a wholly state-owned company. Turkey's transmission grid operates at a frequency of 50 hertz (Hz) and reported a transmission loss rate of 2.2 percent in 2016. [98] In 2016, TEIAS invested $1.9 billion in its transmission system and it announced plans to invest a total of $3.5 billion from 2016 to 2019, including the construction of 14 new transmission lines located across the country. [100] This will add to the current 61,269 km of lines already in place. TEIAS is considering contracting with the private sector to survey, maintain, and repair its transmission lines. TEIAS plans to carry out tenders and receive proposals for these services in the near- to medium-term.

Distribution
Distribution assets in Turkey are owned by the government, but are operated by private-sector distribution utilities. In 2013, the Turkish government privatized all 21 electricity distribution service operators (DSOs) that serve more than 41 million customers.

Turkish utilities have been exploring live-wire maintenance and repair (LWMR). TEIAS has begun LWMR on a pilot basis, though none of the DSOs have experience using LWMR. As a result, the majority of the transmission and distribution lines are not regularly maintained, which has contributed to recent power loses and brown outs.

Storage
Currently, there is no energy storage capacity online. As T&D deferral use-case and renewable energy capacity grows, and as the cost of storage technology decreases, market opportunities are expected to grow significantly.

Regional Integration
Turkey has regional interconnections with Azerbaijan, Armenia, Bulgaria, Georgia, Greece, Iran, Iraq, and Syria and is seeking to build interconnections with other European countries. [101] In 2016, Turkey became an observing member of the European Network of Transmission System Operators for Electricity.

Policy & Regulatory Environment

The Ministry of Energy and Natural Resources (MENR) is responsible for Turkey's energy policy. Its "2015 to 2019 Strategic Plan" set policy objectives for the sector, including a goal of having 30 percent renewable resources by 2023 (including hydropower). Feed-in tariffs have been in place in Turkey since

2011 and were established to improve the incentives for renewable resources. Turkey's electricity prices, however, remain low in comparison to many European nations.

Established in 2007, The Energy Efficiency Co-ordination Board (EECB) is responsible for preparing national energy efficiency strategies, plans and programs, monitoring implementation, and assessing effectiveness. The EECB has sought to align Turkey's energy efficiency policies with those of the European Union's and has set legally-binding goals to reduce energy intensity by 15 percent by 2020. Efforts are focused on energy-intensive sectors such as manufacturing, transport, and power generation. While these energy efficiency programs are being financially supported by the International Finance Corporation (IFC), World Bank, and European Bank for Reconstruction and Development (ERBD), there is concern by organizations such as the World Bank that institutional and functional gaps will limit Turkey's ability to improve efficiency and meet its targets. [102]

Turkey's electricity market regulator is the Turkish Energy Market Regulatory Authority (EMRA). EMRA's main decision-making body is a board composed of seven members appointed by the Council of Ministers each for a six-year term. [103] Its primary duties include: issuing licenses; drafting, amending, and enforcing performance standards; setting tariff rates; and ensuring the development of infrastructure. [104]

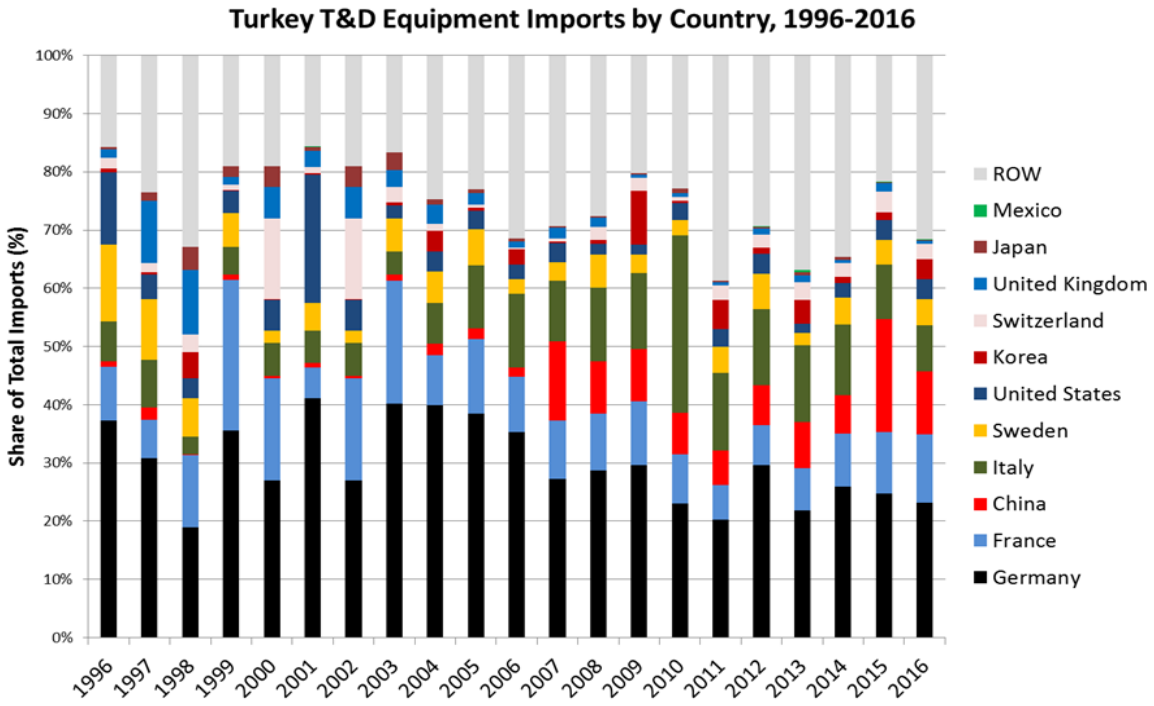
EMRA approves five-year investment plans of DSOs to improve grid infrastructure and introduce smart systems to decrease technical and non-technical losses and blackouts. Nationwide, distribution losses average 17 percent. While a majority of utilities have losses that are less than 8 percent, two utilities in eastern and southeastern Turkey have losses of greater than 60 percent. [98] To reduce losses, the DSOs are planning to invest around $6.4 billion in their distribution systems between 2016 and 2020. [100]

Market Analysis and Rankings

Despite the current economic slowdown in Turkey, electricity demand has continued to grow steadily at 5 percent CAGR, and is expected to continue growing over the next decade at above 4 percent per year. [8] ITA expects that smart grid and energy efficiency technologies will likely be important solutions to curbing demand and reducing the need for T&D buildouts.

In 2016, Turkey imported $294 million in T&D equipment, down by 3 percent from 2015, and far less than the $563 million in equipment imports in the peak year of 2013. As shown in Figure 34, Germany is the leading supplier to the market with over 23 percent market share (2016). The United States is the ninth largest supplier to the market. U.S. exports to Turkey have grown at a CAGR of almost 8 percent over the decade ending in 2016, leading to a slight increase in overall market share (3.5 percent in 2016) with sales of $10 million.

Figure 34. [7]



The demand for smart grid ICT among utilities in Turkey is driven largely by the need to decrease electricity distribution losses, increase power quality and reliability, and solve problems encountered in forecasting and balancing markets. Even among emerging economies, the market ranks in the top 20 for the Smart Grid ICT Sub-Sector (*#18*).

Turkish utilities are currently exploring energy storage as a solution to addressing their growing renewable energy deployments. It is expected that by 2022, 13 percent of electricity will be generated by non-hydropower renewable sources. However, no energy storage deployments to date have been reported.

Opportunities and Challenges for U.S. Companies

U.S. firms exploring the Turkish market should consider the following in the near-term:

Opportunities

- Automated meter reading systems
- Renewable resources integration and monitoring systems
- Demand management and reactive power control systems
- Utility IT and communication system upgrades

- Cybersecurity solutions for transmission and distribution systems
- Live-wire maintenance and repair systems
- Air surveillance and maintenance repair systems

Challenges

- Limited budget allowed by EMRA
- Lack of standards
- Ownership of meters belongs to customers

Summary of Resources

- U.S. Department of Commerce, Turkey Country Commercial Guide: http://www.export.gov/ccg
- Turkish Energy Market Regulatory Authority (EMRA): http://www.emra.org.tr/
- Turkish Electricity Transmission Company: https://www.teias.gov.tr/
- Turkish Electricity Generation Company (EUAS): http://www.euas.gov.tr/
- Electricity Trading and Contracting Corporation (TETAS): http://www.tetas.gov.tr/

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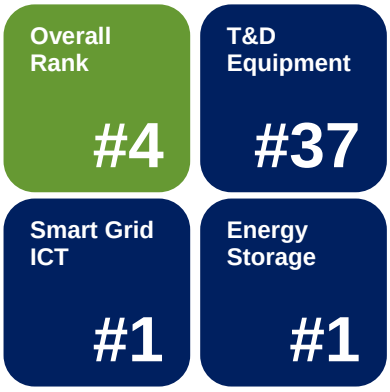
United Kingdom Case Study

The United Kingdom is one of the most attractive markets in the world for advanced smart grid technologies and applications. The UK market offers immense opportunities for innovators in the Smart Grid ICT and Energy Storage Sub-Sectors due to a highly competitive electricity sector and recent efforts by the government and its regulators.



Market Overview

Electricity demand in the UK has steadily decreased by an average of 1.0 percent annually over the last decade. This decrease was largely the result of increased efficiency energy practices. Over the next decade, electricity consumption is expected to increase by an average of 0.3 percent per year.

Generation

The primary source of electricity generation is natural gas (35.6 percent of total generation), followed by non-hydro renewables (25.4 percent), nuclear (19.7 percent), coal (17.0 percent), hydropower (2.0 percent), and oil (0.6 percent).

The UK electricity sector is dominated by the "Big Six" privately-owned energy companies: E.ON, RWE npower, Centrica, Scottish and Southern Energy, Scottish Power, and EDF Energy. These firms generate two-thirds of the total electricity produced in the United Kingdom. EDF Energy is the UK's biggest producer of electricity: it generates about 20 percent of the UK's electricity and has 8 million residential, industrial, and commercial customers.

Transmission

The UK's transmission network is owned and maintained by multiple regional transmission companies, but is operated by the National Grid Electricity Transmission PLC (NGET). The system operates at 50 Hz. Three Onshore Transmission Operators (TOs) and 12 Off-Shore Transmission Operators (OTOs) are permitted to develop, operate, and maintain the high voltage system within their own distinct geographic transmission areas. The three TOs are NGET in England and Wales, Scottish Power Transmission Limited in southern Scotland, and Scottish Hydro Electric Transmission PLC in Northern Scotland and the Scottish islands.

The transmission system in England and Wales consists of 4,500 miles of overhead lines, 410 miles of underground cables, and 341 substations. To encourage transmission projects for renewable generation, the UK government created the Transmission Investment for Renewable Generation (TIRG) in 2004 to help fund projects outside of the main price control process. [105]

Distribution

Electricity is distributed with an end user voltage of 230 volts (V). Great Britain has 14 licensed distribution network operators (DNOs), each with a monopoly in its regional distribution services area. There are also independent network operators (IDNOs) that own and operate small distribution networks in the market; IDNOs must be licensed by the regulator to operate. [106] The UK holds an annual Electricity Network Innovation Competition for electricity network companies to compete for funding of up to £70 million for the development and demonstration of new technologies, operating arrangements and commercial arrangements. [107]

Retail, Pricing, & Metering

The "Big Six" energy companies control 95 percent of the retail market. Electricity prices in the UK are market-based.Retail competition used to drive down electricity prices, but prices have generally increased over the last ten years. Nevertheless, electricity prices remain lower in the UK than in other European markets.

Storage

Energy storage technology is becoming popular in the UK as the country seeks to expand the role of renewable energy generation and improve energy efficiency. In December 2016, the T4 Capacity Market Auction awarded contracts that will result in 21 new-built battery storage projects with a combined capacity of over 501MW. These projects include EDF Energy Renewables' 49MW West Burton project and E.ON's 10 NW Blackburn Meadows project in Sheffield. In July 2017, UK Business Secretary Greg Clark announced a four-year investment of £246 million ($319.35 million) towards the Faraday Challenge, which is designed to boost expertise in battery technology in the UK. [108]

Regional Integration

The UK currently has interconnections with the Netherlands, France and Ireland resulting in 4 GW of potential transmission capacity. [109] The UK currently has a low level of interconnection capacity compared with other European countries, but the UK plans to add 12 new interconnectors with other countries such as Norway, Denmark, Belgium, and France by creating more sub-sea cables. These new interconnections would add 14GW of additional capacity.

Policy & Regulatory Environment

The UK smart grid program is the most well-publicized and transparent project of its kind in any market. The Department of Business, Energy and Industrial Strategy (BEIS) is the primary energy governmental agency in the UK. Before July 2016, BEIS was known as the Department of Energy & Climate Change (DECC).

The UK Energy Bill was signed into law in August 2014, after which the UK made a series of legislative changes to facilitate implementation. The key objectives for the electricity sector include were:

1. Implementation of Energy Market Reform (EMR) to attract GBP $110 billion investment in generation and grid upgrades by 2020;
2. Safety and security regulations for the nuclear sector (implemented by the Office of Nuclear Regulation);
3. Consumer protections, including limits on energy tariffs, improved transparency of electricity bills, and expansion of third-party consumer electricity services; and
4. Increased coordination and strategic alignment between the Office of Gas and Electricity Markets (Ofgem)—the electricity regulator— and the UK Government.

Depending on implementation, the Energy Bill should help create new opportunities for energy technologies and services. Although the government has stated its intention to nearly triple the funding available for low-carbon sources of power, subsidies were cut amid regulatory uncertainty in 2015, thus worsening the outlook for additional deployment of onshore wind and solar. New provisions for capacity markets in the UK are intended to facilitate the development of demand response programs and may stimulate increased investment in interconnections as regional neighbors with excess capacity seek to bid into the UK system.

The Data Communications Company (DCC) is an independent agency responsible for linking all smart electricity and gas meters in homes and small businesses with the systems of energy suppliers, network operators and energy service companies. The DCC was created by the DECC in 2013 and began operating in 2016. The UK government has also created the Central Delivery Body, which contracts with media companies, consultants and electricity sector experts to support the "brand identity" of the smart metering program and ensure consumer engagement during smart grid roll-out and operations.

Ofgem is the regulator of electricity transmission, distribution, and retail sales in the UK. Ofgem has allowed utilities to include smart meters, renewable integration, and consumer energy efficiency program costs in electric bills. Ofgem's new performance-based RIIO framework (Revenue = Incentives + Innovation + Outputs) will involve setting eight-year price controls, offering incentives to encourage the growth of smart grids.

Regulations in the UK provide healthy support for the smart grid and energy efficiency markets. The DECC set a deployment goal for smart meters at more than 50 million devices (30 million for electric), with regulated roll-out beginning in 2016 with a goal of 80 percent of homes with a smart meter by 2020. In 2017, smart meter penetration was only 29.8 percent of the market, suggesting more investment is needed to achieve the stated goal. [35]

The DECC and Ofgem created the public-private Smart Grid Forum to develop a roadmap and vision for the nation's smart grid.

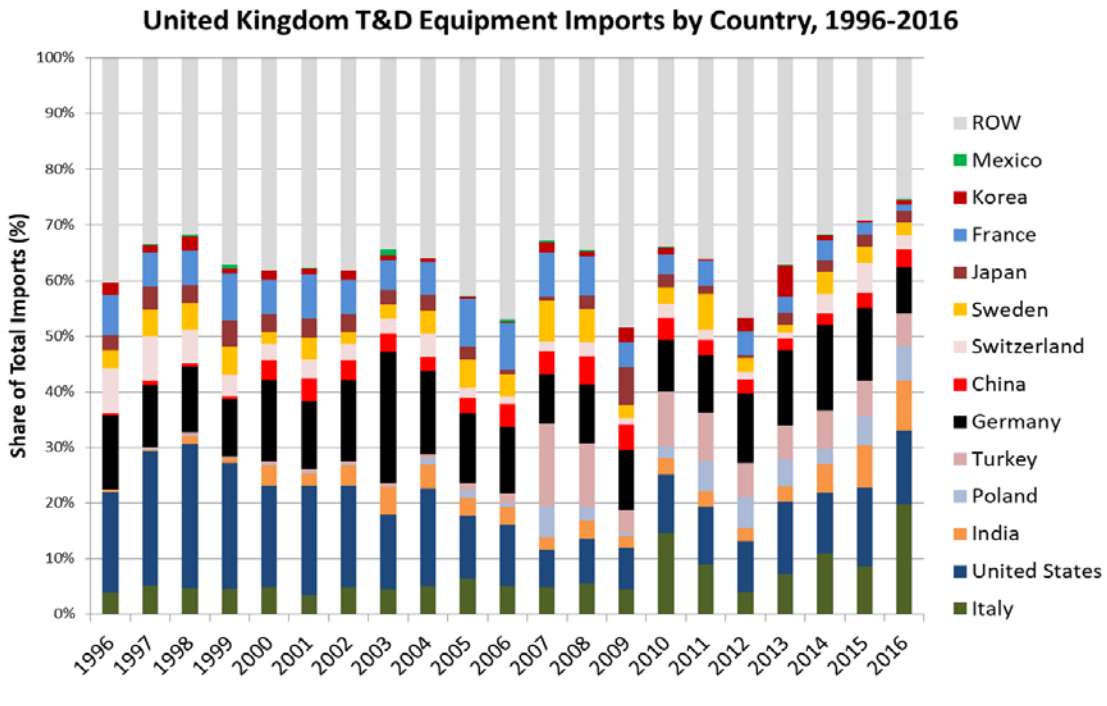
Market Analysis and Rankings

The United Kingdom remains one of the most attractive markets for U.S. firms looking to deploy advanced grid modernization technologies. The UK is ranked as the *#4* overall market for U.S. exporters in the *2017 SG TMR*, and features top rankings for Smart Grid ICT (*#1*) and Energy Storage (*#1*) Sub-Sectors. According to Ofgem, Great Britain will need to invest around £100 billion to meet its electricity infrastructure needs over the next decade. [110]

In 2016, the United Kingdom imported more than $1.5 billion in T&D equipment, following an11 percent CAGR over the past 10 years. The UK is the third largest global import market and the sixth largest export market for the United States. As shown in Figure 35, Italy was the leading supplier to the UK market in 2016 with almost 20 percent market share. The United States is the second largest supplier to the UK market (13 percent market share), with a 13 percent CAGR from 2006-2016. Other key competitors in the market include India and Germany; India has been steadily growing its presence in the market (23 percent CAGR over the past decade).

Despite being a key T&D equipment market for U.S. exporters, the UK is ranked *#28* in the T&D Equipment Sub-Sector for the 2017 SG TMR. The lower ranking is due to slow anticipated electricity consumption projections relative to other economies.

Figure 35. [7]



The UK is ranked *#1* in the Smart Grid ICT sub-sector due to near-term export opportunities related to government efforts to deploy smart grid technologies. In 2016, the United Kingdom invested $1.7 billion in energy smart technologies – representing a 15 percent 10-year CAGR and a 70 percent year-on-year growth from 2015 to 2016. [20]

The UK Government has committed to a nationwide smart meter roll-out by 2020. In 2017, smart meter penetration was only 29.8 percent of the market, indicating continued near-term opportunities for U.S. exporters. [35]

The UK also features a regulatory framework capable of funding smart grid deployments, and a highly competitive market for retail electricity and consumer energy efficiency services. With the forthcoming electricity market reforms, the UK may also become a strong market for demand response and other smart grid solutions at the distribution and consumer levels.

Complex electricity market design – including a frequency regulation market – has opened up opportunities for U.S. energy storage suppliers. Estimates of market size range significantly, with 46-502 MW of electrochemical energy storage capacity that could be delivered to the market in the near-term. [10] [11] [108] The storage projects satisfy a variety of use-cases, including frequency regulation, electric load time shifting, onsite renewable energy generation, voltage support and renewable energy firming.

Opportunities and Challenges for U.S. Companies

The UK is increasingly focusing on energy security, as existing generation capacity depletes, electricity imports rise, and energy sector investments slow amid political and regulatory uncertainty. The UK Government is faced with the challenge of facilitating investment in the electricity sector and achieving carbon reduction goals—while also containing the rising consumer electricity prices that have become a hot-button political issue. ITA anticipates that interconnections will play an increasing role in the UK energy market in the near-term.

Opportunities

- AMI to meet climate change, energy efficiency, and smart meter targets
- Energy storage systems for enhancing grid management, including frequency regulation and voltage support
- Consumer interface technologies and services for billing
- Consumer and industrial demand management systems

Challenges

- Market uncertainty related to Brexit's potential to shift relationships with the European Union
- Robust market competition with European firms
- Potential "doubling charges" on energy storage systems that are leveled when the electricity is charged and then discharged

Know Your Buyer

United Kingdom purchasers of U.S. smart grid goods and services include generation, transmission, and distribution companies. This includes transmission networks operators such as National Grid, Scottish Power Transmission, Scottish Hydro Electric Transmission and Northern Ireland Electricity, as well as distribution networks operators such as Electricity North West, Northern Ireland Electricity, Northern PowerGrid, SP Energy Networks, SSE Power Distribution, UK Power Networks and Western Power Distribution.

There are currently many opportunities for U.S. exporters of smart grid technology in the UK to improve transmission and distribution. However, capturing these opportunities is not easy amid strong competition. To succeed in the UK, U.S. solutions providers need to develop a compelling business model:

- Deep understanding of value provided. Utilities are demanding more clearly articulated value propositions (e.g., reduced operating costs, increased grid efficiency, improved customer engagement);
- Sound grasp of government and regulatory incentives and impact of legislation;
- Appreciation of long sales cycles that characterize the utility procurement processes;
- Provision of interoperable, secure, flexible solutions, as utility customers increasingly seek flexibility to incorporate future smart grid elements (e.g., distributed generation, electric vehicles, distributed storage); and
- The ability to identify and manage partnerships to provide multi-disciplinary solutions to satisfy utilities that engage with dozens of providers to implement a single smart grid project.

Technology providers must customize their solutions and be prepared to partner with UK partner companies.

Summary of Resources

- U.S. Department of Commerce, United Kingdom Country Commercial Guide: http://www.export.gov/ccg
- U.K. Department of Energy and Climate Change: https://www.gov.uk/government/organisations/department-of-energy-climate-change
- U.K. Office of Gas and Electricity Markets: https://www.ofgem.gov.uk/
- U.K. Parliament: http://www.parliament.uk/
- U.K. Office of Gas and Electricity Markets: https://www.ofgem.gov.uk/
- Data Communications Company: https://www.smartdcc.co.uk/

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Addendum: Resources for U.S. Exporters

The U.S. Government has numerous resources available to help U.S. exporters: from additional market research to guides to export financing, to overseas trade missions, to staff around the country and the world. For additional information about services from the International Trade Administration (ITA), please visit www.export.gov.

Smart Grid Exporter Portal
https://www.export.gov/industries/smart-grid
This online portal for the U.S. smart grid industry to connect to news, events, and market intelligence resources from the U.S. Department of Commerce and other U.S. Government agencies under the Trade Promotion Coordinating Committee on Renewable Energy and Energy Efficiency (TPCC-REEE). The portal also includes the latest information from the Department of Commerce's Renewable Energy and Energy Efficiency Advisory Committee, a Federal Advisory Committee that advises the Secretary regarding the development and administration of programs and policies to expand the competitiveness of U.S. exports of related goods and services.

Country Commercial Guides
http://export.gov/ccg/
Written by U.S. Embassy trade experts worldwide, the Country Commercial Guides provide an excellent starting point for what you need to know about exporting and doing business in a foreign market. The reports include sections addressing market overview, challenges, opportunities and entry strategies; political environment; selling U.S. products and services; trade regulations, customs, and standards; and much more.

Basic Guide to Exporting
https://www.export.gov/export-education*A Basic Guide to Exporting* addresses virtually every issue a company looking to export might face. Numerous sections, charts, lists and definitions throughout the book's 19 chapters provide in-depth information and solid advice about the key activities and issues relevant to any prospective exporter.

Trade Finance Guide: A Quick Reference for U.S. Exporters
http://www.export.gov/tradefinanceguide/index.asp
Trade Finance Guide: A Quick Reference for U.S. Exporters is designed to help U.S. companies, especially small and medium-sized enterprises, learn the basics of trade finance so that they can turn their export opportunities into actual sales and achieve the ultimate goal of getting paid on time for those sales. Concise, two-page chapters offer the basics of numerous financing techniques, from open accounts to forfeiting and government assisted foreign-buyer financing.

Trade Missions
http://www.export.gov/trademissions/
Department of Commerce sponsors foreign trade missions for U.S. firms that wish to explore and pursue export opportunities by meeting directly with potential clients in local markets. Trade missions include pre-screened, one-on-one meetings with foreign industry executives and government officials that match specific business objectives.

Certified Trade Fairs
https://www.export.gov/Events
The Department of Commerce's trade fair certification program endorses overseas trade shows that are reliable venues and good markets for U.S. firms to sell their products and services abroad. These shows are paramount for U.S. firms to enter and expand into foreign markets. The certified show/U.S. pavilion ensures a high-quality, multi-faceted opportunity for American companies to successfully market overseas. Among other benefits, certified trade fairs help U.S. exhibitors facilitate contacts, gain market information, engage in business counseling and other services to enhance their marketing efforts.

International Buyer Program
https://www.export.gov/Events
The International Buyer Program (IBP) brings thousands of international buyers to the United States for business-to-business matchmaking with U.S. firms exhibiting at major industry trade shows. Every year, the IBP results in millions of dollars in new business for U.S. companies by bringing pre-screened international buyers, representatives and distributors to selected shows. U.S. country and industry experts are on site at IBP shows to provide hands-on export counseling, market analysis, and matchmaking services. Each IBP show also has an International Business Center where U.S. companies can meet privately with prospective international buyers, prospective sales representatives, and business partners and obtain assistance from experienced ITA staff.

The Advocacy Center
http://www.export.gov/advocacy/
The Advocacy Center coordinates U.S. government interagency advocacy efforts on behalf of U.S. exporters that are bidding on public-sector contracts with overseas governments and government agencies. The Advocacy Center helps to ensure that sales of U.S. products and services have the best possible chance competing abroad. Advocacy assistance is varied but often involves companies that want the U.S. Government to communicate a message to foreign governments or government-owned corporations on behalf of their commercial interest, typically in a competitive-bid contest.

Global Energy Team
http://www.export.gov/industry/energy/index.asp
The Global Energy Team is a network of global energy specialists that draws on experiences across the U.S. Commercial Service, Foreign Commercial Services, and ITA industry analysts. The team provides updates on upcoming events, trade leads, and market research.

U.S. Commercial Service
http://www.export.gov/usoffices/index.asp
With offices throughout the United States and in U.S. Embassies and consulates in nearly 80 countries, the U.S. Commercial Service utilizes its global network of trade professionals to connect U.S. companies with international buyers worldwide. Whether looking to make their first export sale or expand to additional international markets, companies will find the expertise they need to tap into lucrative opportunities and increase their bottom line. This includes trade counseling, actionable market intelligence, business matchmaking, and commercial diplomacy.

U.S. Trade and Development Agency
https://www.ustda.gov

The U.S. Trade and Development Agency (USTDA) connects U.S. manufacturers and service providers with foreign project sponsors to open new export markets and identify commercial opportunities for U.S. companies through programs such as reverse trade missions. For example, reverse trade missions bring foreign decision-makers from the public and private sectors to the United States to observe the design, manufacture and operation of U.S. products and services that can help them achieve their development goals. These strategically planned visits present excellent opportunities for U.S. businesses to establish or enhance relationships with prospective overseas customers.

Appendix 1: Methodology

Score Categories and Weighting

The *Smart Grid Top Market Report* (*SG TMR*) rankings integrate data and information on global markets and trade, including the critical contributions of commercial specialists from U.S. Foreign Commercial Service posts in every country ranked in the report. The data to evaluate 146 markets are combined using a weighted scorecard methodology to produce relative rankings of the 50 subject markets.

Each scorecard is based on quantitative and qualitative analysis that integrates data and information on key smart grid export market drivers, based on five categories:

1. Smart Grid Market Growth Potential Score
2. Trade Factors and U.S. Competitiveness Score
3. Energy Storage Growth Potential Score
4. Key Economic and Energy Sector Investment Indicators Score
5. Strength of Domestic Industry Score

Weighing of *Categories #1*, *#2*, and *#3* varied for the sector and sub-sector rankings. No modifications to the weighing were made in the *January 2017 Update.* The weighing was as follows:

OVERALL RANKING

1. Smart Grid Market Growth Potential Score: 30%
2. Trade Factors and U.S. Competitiveness Score: 30%
3. Energy Storage Growth Potential Score 10%
4. Key Economic and Energy Sector Investment Indicators Score: 20%
5. Strength of Domestic Industry Score: 10%

T&D EQUIPMENT SUB-SECTOR RANKING

1. Smart Grid Market Growth Potential Score: 0%
2. Trade Factors and U.S. Competitiveness Score: 70%
3. Energy Storage Growth Potential Score 0%
4. Key Economic and Energy Sector Investment Indicators Score: 20%
5. Strength of Domestic Industry Score: 10%

SMART GRID ICT SUB-SECTOR RANKING

1. Smart Grid Market Growth Potential Score: 70%
2. Trade Factors and U.S. Competitiveness Score: 0%
3. Energy Storage Growth Potential Score 0%
4. Key Economic and Energy Sector Investment Indicators Score: 20%
5. Strength of Domestic Industry Score: 10%

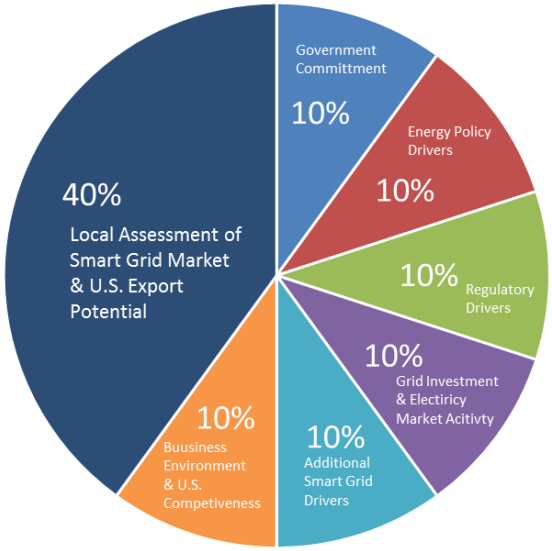
ENERGY STORAGE SUB-SECTOR RANKING

1. Smart Grid Market Growth Potential Score: 20%
2. Trade Factors and U.S. Competitiveness Score: 10%
3. Energy Storage Growth Potential Score 40%
4. Key Economic and Energy Sector Investment Indicators Score: 20%
5. Strength of Domestic Industry Score: 10%

The following sections provide in-depth detail and reference data for each of the 5 components of the scorecard.

1. Smart Grid Market Growth Potential Score (*Category #1*)

Figure A1. Smart Grid Growth Potential Score, By Input Factor Percentage



The development of the smart grid in a given market is dependent on a range of factors that can be impacted by policy, regulations, investment, electricity industry, consumers, and the wider economic and business environment. To estimate potential for export growth in each market, ITA developed a scoring system to evaluate smart grid market drivers and factors impacting the U.S. smart grid industry competitiveness (Figure A1). This part of the *SG TMR* analysis focuses on the market potential for exporters of integrated ICT and services, and is based on contributions of smart grid commercial specialists from the U.S. Foreign Commercial Service posts in every country ranked in the report. No modifications to the criteria were made for the *2017 SG TMR*, but the data set was updated based on new information.

2. Trade Factors & U.S. Competitiveness Score (*Category #2*)

The *SG TMR* also quantifies opportunities for U.S. manufacturers of T&D equipment. In order to estimate U.S. export growth potential, this category score incorporates existing trade data, along with an analysis of additional market factors that impact growth potential.

In the *2017 SG TMR*, the methodology for *Category #2* was modified slightly from the *January 2017 Update* to an equal weighting among the following normalized values:

- total absolute export value from the previous year (2016),
- recent percentage change in total U.S. exports (2014-2016), and

- BMI's projected electricity consumption annual growth percentage (2018-2022).

UN and U.S. Census data were accessed on July 7, 2017. [7] [6] Trade data were drawn from 16 product codes from the international Harmonized System: 850421; 850422; 850423; 850432; 850433; 850434; 853210; 853510; 853521; 853529; 853530; 853540; 853590; 853720; 854460; and 902830.

The trade data trend analysis is supplemented by an electricity consumption trend score drawing on BMI electricity consumption predictions for the next five years (2018-2022). This score quantifies potential growth in T&D infrastructure investment driven by a recent electricity consumption trends while also considering market factors—including national policy, financing, and other economic factors—that could potentially impact the build-out of T&D infrastructure.

The resulting category score and ranking is a relative measure of a market's potential for near-term growth in U.S. exports of T&D equipment.

3. Energy Storage Growth Potential Score (*Category #3*)

The Energy Storage Growth Potential score is the sum of three normalized, weighted data sets.

1. **Local Assessment of Energy Storage Market and U.S. Export Potential (25 percent):** Qualitative local assessment by on-the-ground U.S. Commercial Service Specialists of feedback received from local utilities, policymakers, and regulators involved with deployment of energy storage.
2. **Renewable Energy Electricity Deployment Score (25 percent):** The share of electricity generated by renewable energy (i.e., non-hydro) projected over 2018-2022.
3. **Energy Storage Deployment Score (50 percent):** Quantitative assessment of the current installed capacity of battery (electrochemical) energy storage systems and a number of projects drawing from the U.S. Department of Energy's Energy Storage Database and BNEF. Countries were ranked on a 10-point scale. [10] [11]

4. Key Economic and Energy Sector Investment Indicators Score (*Category #4*)

To incorporate broader economic and investment data that could impact the growth of smart grid markets, this score uses BMI's Power Risk/Reward Index of major international electricity markets. [12] BMI's score "considers a thorough and all-encompassing range of factors that affect the investment climate in the electricity sector." Because smart grid development and deployment depends on these wider factors – including the health of the electricity sector, the overall investment climate, and the national economy – BMI's score is a valuable addition to ITA's analysis. Scores were accessed on July 11, 2017.

BMI revised its methodology it's the Power Risk/Reward Index between the *January 2017 Update* and the full *2017 SG TMR*. The modifications are highlighted in Figure A2, which compares factors side by side.

Figure A2.

Weighting Of Power R/R Index Indicators & Year-on-Year Methodology		
	pre-2017	2017
Component	Weighting & Factors	
Rewards	65% of R/R Index	60% of R/R Index
Industry Rewards	60% of Rewards	60% of Rewards
	Electricity capacity, MW, 5-year average	Electricity capacity, MW
	Electricity generation, GWh, 5-year average	Electricity capacity growth, %
	Electricity generation, %	Electricity generation, TWh
	Electricity consumption, GWh	Electricity generation growth, %
	Electricity consumption, %	
	Access to electricity, % of population	
Country Rewards	40% of Rewards	40% of Rewards
	Real GDP growth, %, 5-year average	Real GDP growth, % change, 5-year average
	GDP per capita, %, 5-year average	Labour market risk,
	Population, % change	Population, % change 5-year average
	Imported raw material dependence	Electricity import dependence
	Electricity import dependence	
	Inflation, 5-year average	
Risks	35% of R/R Index	40% of R/R Index
Industry Risks	60% of Risks	50% of Risks
	Liberalisation level	Competitve landscape
	Financing	Financial barriers
	Renewables outlook	Energy policy
	Transparency of tendering process	Legal risks
		T&D loses
Country Risks	40% of Risks	50% of Risks
	Short-term political stability	Long-term economic risk
	Policy continuity	Short-term economic risk
	External risk	Long-term political risk
	Institutions	Short-term political risk
	Corruption	Operational risk

5. Strength of Domestic Industry Score (*Category #5*)

The fifth component of the *SG TMR* analysis integrates data on the share of the market for electricity sector technologies that will be met by imports. This score is based on the analysis produced by Purdue University's Global Trade Analysis Project (GTAP), which estimates the share of commodities that various industries procure from foreign markets and domestic markets. GTAP's "import share" analysis includes an estimate for each country of the electronic equipment and machinery that the electricity sector procures for its operations. This category includes a range of equipment in the electricity sector, so it representations a useful proxy for utility reliance on imports to meet a country's technology needs.

The Import Potential Score supplements ITA's trade data analysis and provides a proxy data point for the potential demand in a market's electric utility sector for a range of technologies, including some smart

grid technologies. The Import Potential Score positively impacts Top Markets scores for countries that are more likely to import growing and evolving smart grid technologies.

GTAP data did not change for the *2017 SG TMR*. [13]

Appendix 2: Year-on-Year Comparisons

RANK	2015 SG TMR Overall	2016 SG TMR Overall	2017 Update SG TMR Overall	2017 SG TMR Overall	2017 Rankings Comparison
1	Canada	Canada	Mexico	Canada	*(+1)*
2	Japan	Mexico	Canada	Mexico	*(-1)*
3	Saudi Arabia	Japan	UK	Denmark	*(+18)*
4	Australia	Saudi Arabia	India	UK	*(-1)*
5	UK	Australia	Australia	Japan	*(+2)*
6	Singapore	UK	Korea	Ireland	*(+7)*
7	China	China	Japan	Malaysia	*(+8)*
8	Chile	India	Egypt	Chile	*(+2)*
9	Philippines	Vietnam	Saudi Arabia	India	*(-5)*
10	Vietnam	France	Chile	Australia	*(-5)*
11	Mexico	Chile	China	Vietnam	*(+3)*
12	Turkey	Turkey	Germany	Korea	*(-6)*
13	France	Korea	Ireland	Finland	*(+6)*
14	Malaysia	Malaysia	Vietnam	Philippines	*(+2)*
15	Netherlands	Spain	Malaysia	China	*(-4)*
16	Germany	Netherlands	Philippines	Saudi Arabia	*(-7)*
17	Korea	Philippines	Indonesia	Belgium	*(+13)*
18	Austria	Germany	France	Turkey	*(-4)*
19	Brazil	New Zealand	Finland	Netherlands	*(+1)*
20	Colombia	Singapore	Netherlands	Ghana	*(+23)*
21	India	Nigeria	Denmark	Singapore	*(+1)*
22	Nigeria	Austria	Singapore	Germany	*(-10)*
23	Denmark	Israel	Turkey	Austria	*(+6)*
24	Sweden	Denmark	Sweden	Egypt	*(-16)*
25	Indonesia	Sweden	Kenya	Indonesia	*(-8)*
26	Thailand	Indonesia	Spain	Sweden	*(-2)*
27	Portugal	Italy	Ethiopia	Kenya	*(-2)*
28	Poland	Thailand	Poland	Nigeria	*(+3)*
29	South Africa	South Africa	Austria	France	*(-11)*
30	Italy	Colombia	Belgium	Poland	*(-2)*
31	Spain	Poland	Nigeria	Spain	*(-5)*
32	Russia	Brazil	Italy	Morocco	*(+10)*
33	*Israel (unranked)*	Portugal	Israel	Israel	---
34	*New Zealand (unranked)*	Russia	Thailand	Ethiopia	*(-7)*
35	*Argentina(unranked)*	*Argentina(unranked)*	Brazil	Italy	*(-3)*
36	*Belgium (unranked)*	*Belgium (unranked)*	Argentina	Portugal	*(+3)*
37	*Bulgaria(unranked)*	*Bulgaria(unranked)*	Colombia	Brazil	*(-2)*
38	*Costa Rica (unranked)*	*Costa Rica (unranked)*	South Africa	South Africa	---
39	*Czech Republic (unranked)*	*Czech Republic (unranked)*	Portugal	Colombia	*(-2)*
40	*Egypt(unranked)*	*Egypt(unranked)*	Czech Republic	Czech Republic	---
41	*Ethiopia(unranked)*	*Ethiopia(unranked)*	Costa Rica	Thailand	*(-7)*
42	*Finland(unranked)*	*Finland(unranked)*	Morocco	Argentina	*(-6)*
43	*Ghana (unranked)*	*Ghana (unranked)*	Ghana	Costa Rica	*(-2)*
44	*Ireland (unranked)*	*Ireland (unranked)*	Romania	Bulgaria	*(+2)*
45	*Kazakhstan(unranked)*	*Kazakhstan(unranked)*	Peru	Russia	*(+4)*
46	*Kenya (unranked)*	*Kenya (unranked)*	Bulgaria	New Zealand	*(+2)*
47	*Morocco (unranked)*	*Morocco (unranked)*	Nicaragua	Kazakhstan	*(+3)*
48	*Nicaragua (unranked)*	*Nicaragua (unranked)*	New Zealand	Peru	*(-3)*
49	*Peru (unranked)*	*Peru (unranked)*	Russia	Romania	*(-5)*
50	*Romania (unranked)*	*Romania (unranked)*	Kazakhstan	Nicaragua	*(-3)*

RANK	2015 SG TMR T&D Rankings	2016 SG TMR T&D Rankings	2017 Update SG TMR T&D Rankings	2017 SG TMR T&D Rankings	2017 Rankings Comparison
1	Saudi Arabia	Mexico	Mexico	Mexico	---
2	Canada	Vietnam	Ethiopia	Canada	*(+6)*
3	Colombia	India	Kenya	Ghana	*(+23)*
4	China	Nigeria	Vietnam	Ethiopia	*(-2)*
5	Singapore	Saudi Arabia	Egypt	Vietnam	*(-1)*
6	Chile	Malaysia	India	Kenya	*(-3)*
7	Vietnam	Chile	Indonesia	Morocco	*(+15)*
8	Nigeria	Indonesia	Canada	India	*(-2)*
9	Malaysia	Canada	Malaysia	Malaysia	---
10	Japan	Philippines	Saudi Arabia	Philippines	*(+1)*
11	Indonesia	Turkey	Philippines	Turkey	*(+5)*
12	Mexico	Korea	Korea	Chile	*(+2)*
13	Turkey	China	Nicaragua	Belgium	*(+22)*
14	Australia	Singapore	Chile	Indonesia	*(-7)*
15	Philippines	Australia	Peru	Egypt	*(-10)*
16	Brazil	Colombia	Turkey	Nigeria	*(+2)*
17	Korea	Thailand	China	Peru	*(-2)*
18	India	Israel	Nigeria	Korea	*(-6)*
19	Thailand	Poland	Australia	Saudi Arabia	*(-9)*
20	Germany	UK	Singapore	Ireland	*(+1)*
21	Netherlands	Netherlands	Ireland	Denmark	*(+22)*
22	Austria	Spain	Morocco	Poland	*(+7)*
23	Poland	Japan	Colombia	Singapore	*(-2)*
24	Sweden	France	Thailand	China	*(-7)*
25	UK	Austria	Costa Rica	Israel	*(+13)*
26	France	Germany	Ghana	Australia	*(-7)*
27	South Africa	South Africa	Argentina	Colombia	*(-4)*
28	Denmark	Denmark	UK	Austria	*(+9)*
29	Portugal	Portugal	Poland	Bulgaria	*(+15)*
30	Italy	Sweden	Japan	Argentina	*(-3)*
31	Russia	Italy	France	Japan	*(-1)*
32	Spain	New Zealand	Kazakhstan	Thailand	*(-8)*
33	*Israel (unranked)*	Brazil	Netherlands	Costa Rica	*(-8)*
34	*New Zealand (unranked)*	Russia	Germany	Netherlands	*(-1)*
35	*Argentina(unranked)*	*Argentina(unranked)*	Czech Republic	Nicaragua	*(-22)*
36	*Belgium (unranked)*	*Belgium (unranked)*	Belgium	Spain	*(+3)*
37	*Bulgaria(unranked)*	*Bulgaria(unranked)*	Austria	UK	*(-9)*
38	*Costa Rica (unranked)*	*Costa Rica (unranked)*	Israel	Brazil	*(+2)*
39	*Czech Republic (unranked)*	*Czech Republic (unranked)*	Spain	Finland	*(+3)*
40	*Egypt(unranked)*	*Egypt(unranked)*	Brazil	Czech Republic	*(+5)*
41	*Ethiopia(unranked)*	*Ethiopia(unranked)*	South Africa	Italy	*(+7)*
42	*Finland(unranked)*	*Finland(unranked)*	Finland	France	*(-11)*
43	*Ghana (unranked)*	*Ghana (unranked)*	Denmark	South Africa	*(-2)*
44	*Ireland (unranked)*	*Ireland (unranked)*	Bulgaria	Kazakhstan	*(-12)*
45	*Kazakhstan(unranked)*	*Kazakhstan(unranked)*	Romania	Russia	*(-5)*
46	*Kenya (unranked)*	*Kenya (unranked)*	Portugal	Portugal	---
47	*Morocco (unranked)*	*Morocco (unranked)*	Sweden	Germany	*(-12)*
48	*Nicaragua (unranked)*	*Nicaragua (unranked)*	Italy	Sweden	*(-1)*
49	*Peru (unranked)*	*Peru (unranked)*	New Zealand	Romania	*(-4)*
50	*Romania (unranked)*	*Romania (unranked)*	Russia	New Zealand	*(-1)*

RANK	2015 SG TMR Smart Grid ICT	2016 SG TMR Smart Grid ICT	2017 Update SG TMR Smart Grid ICT	2017 SG TMR Smart Grid ICT	2017 Rankings Comparison
1	Canada	Canada	Canada	UK	*(+1)*
2	UK	Japan	UK	Canada	*(-1)*
3	Japan	UK	Mexico	Japan	*(+1)*
4	France	Australia	Japan	Finland	*(+1)*
5	Australia	France	Finland	Denmark	*(+7)*
6	Saudi Arabia	China	Australia	Mexico	*(-3)*
7	Philippines	Mexico	Sweden	Australia	*(-1)*
8	Netherlands	New Zealand	Germany	Sweden	*(-1)*
9	Denmark	Spain	France	Germany	*(-1)*
10	Turkey	Saudi Arabia	Ireland	Netherlands	*(+1)*
11	Mexico	Netherlands	Netherlands	Ireland	*(-1)*
12	Germany	Germany	Denmark	France	*(-3)*
13	Austria	Turkey	Saudi Arabia	Singapore	*(+8)*
14	Singapore	Korea	India	China	*(+1)*
15	Chile	India	China	Malaysia	*(+2)*
16	Sweden	Sweden	Korea	Saudi Arabia	*(-3)*
17	China	Denmark	Malaysia	Chile	*(+2)*
18	Vietnam	Chile	Spain	Turkey	*(+2)*
19	Korea	Austria	Chile	Austria	*(+5)*
20	Malaysia	Italy	Turkey	Korea	*(-4)*
21	India	Malaysia	Singapore	Belgium	*(+1)*
22	Brazil	Vietnam	Belgium	Spain	*(-4)*
23	Portugal	Singapore	Vietnam	Vietnam	---
24	South Africa	Philippines	Austria	India	*(-10)*
25	Nigeria	Israel	Brazil	Portugal	*(+8)*
26	Spain	Brazil	Egypt	Brazil	*(-1)*
27	Poland	South Africa	Italy	Poland	*(+1)*
28	Italy	Thailand	Poland	Italy	*(-1)*
29	Colombia	Poland	Israel	Philippines	*(+1)*
30	Thailand	Nigeria	Philippines	Israel	*(-1)*
31	Russia	Colombia	South Africa	South Africa	---
32	Indonesia	Indonesia	Indonesia	Egypt	*(-6)*
33	*Israel (unranked)*	Portugal	Portugal	Indonesia	*(-1)*
34	*New Zealand (unranked)*	Russia	Czech Republic	Czech Republic	---
35	*Argentina(unranked)*	*Argentina(unranked)*	Thailand	Thailand	---
36	*Belgium (unranked)*	*Belgium (unranked)*	Argentina	Nigeria	*(+2)*
37	*Bulgaria(unranked)*	*Bulgaria(unranked)*	Colombia	Colombia	---
38	*Costa Rica (unranked)*	*Costa Rica (unranked)*	Nigeria	Romania	*(+1)*
39	*Czech Republic (unranked)*	*Czech Republic (unranked)*	Romania	Argentina	*(-3)*
40	*Egypt(unranked)*	*Egypt(unranked)*	Costa Rica	New Zealand	*(+3)*
41	*Ethiopia(unranked)*	*Ethiopia(unranked)*	Bulgaria	Morocco	*(+3)*
42	*Finland(unranked)*	*Finland(unranked)*	Russia	Costa Rica	*(-2)*
43	*Ghana (unranked)*	*Ghana (unranked)*	New Zealand	Bulgaria	*(-2)*
44	*Ireland (unranked)*	*Ireland (unranked)*	Morocco	Russia	*(-2)*
45	*Kazakhstan(unranked)*	*Kazakhstan(unranked)*	Kenya	Ghana	*(+1)*
46	*Kenya (unranked)*	*Kenya (unranked)*	Ghana	Kazakhstan	*(+3)*
47	*Morocco (unranked)*	*Morocco (unranked)*	Ethiopia	Kenya	*(-2)*
48	*Nicaragua (unranked)*	*Nicaragua (unranked)*	Peru	Ethiopia	*(-1)*
49	*Peru (unranked)*	*Peru (unranked)*	Kazakhstan	Peru	*(-1)*
50	*Romania (unranked)*	*Romania (unranked)*	Nicaragua	Nicaragua	---

RANK	2017 Update SG TMR Energy Storage	2017 SG TMR Energy Storage	2017 Rankings Comparison
1	UK	UK	---
2	Canada	Denmark	*(+4)*
3	Germany	Canada	*(-1)*
4	Japan	Australia	*(+1)*
5	Australia	Japan	*(-1)*
6	Denmark	Germany	*(-3)*
7	Korea	Finland	*(+6)*
8	China	Korea	*(-1)*
9	Mexico	Ireland	*(+2)*
10	India	China	*(-2)*
11	Ireland	Chile	*(+1)*
12	Chile	Netherlands	*(+2)*
13	Finland	India	*(-3)*
14	Netherlands	Sweden	*(+3)*
15	France	Austria	*(+7)*
16	Egypt	Philippines	*(+3)*
17	Sweden	Malaysia	*(+10)*
18	Spain	Portugal	*(+5)*
19	Philippines	France	*(-4)*
20	Italy	Spain	*(-2)*
21	Singapore	Saudi Arabia	*(+3)*
22	Austria	Italy	*(-2)*
23	Portugal	Singapore	*(-2)*
24	Saudi Arabia	Mexico	*(-15)*
25	Indonesia	Indonesia	---
26	Poland	Kenya	*(+3)*
27	Malaysia	Egypt	*(-11)*
28	Belgium	Nigeria	*(+13)*
29	Kenya	Belgium	*(-1)*
30	South Africa	Israel	*(+3)*
31	Czech Republic	Poland	*(+5)*
32	Vietnam	Czech Republic	*(-1)*
33	Israel	Brazil	*(+1)*
34	Brazil	New Zealand	*(+2)*
35	Turkey	South Africa	*(-5)*
36	New Zealand	Russia	*(+2)*
37	Thailand	Vietnam	*(-5)*
38	Russia	Turkey	*(-3)*
39	Argentina	Kazakhstan	*(+10)*
40	Ethiopia	Ghana	*(+7)*
41	Nigeria	Morocco	*(+4)*
42	Costa Rica	Costa Rica	---
43	Bulgaria	Colombia	*(+3)*
44	Romania	Argentina	*(-5)*
45	Morocco	Thailand	*(-8)*
46	Colombia	Ethiopia	*(-6)*
47	Ghana	Romania	*(-3)*
48	Nicaragua	Bulgaria	*(-5)*
49	Kazakhstan	Peru	*(+1)*
50	Peru	Nicaragua	*(-2)*

Appendix 3: Regional & Income-Level Rankings Comparison

Market	World Bank Classifciations		*2017 SG TMR* Rankings			
	Region	Income Level	Overall	T&D Equipment	Smart Grid ICT	Energy Storage
Argentina	Latin American and the Caribbean	Upper-Middle	42	30	39	44
Australia	East Asia and Pacific	High	10	26	7	4
Austria	Europe and Central Asia	High	23	28	19	15
Belgium	Europe and Central Asia	High	17	13	21	29
Brazil	Latin American and the Caribbean	Upper-Middle	37	38	26	33
Bulgaria	Europe and Central Asia	Upper-Middle	44	29	43	48
Canada	North America	High	1	2	2	3
Chile	Latin American and the Caribbean	High	8	12	17	11
China	East Asia and Pacific	Upper-Middle	15	24	14	10
Colombia	Latin American and the Caribbean	Upper-Middle	39	27	37	43
Costa Rica	Latin American and the Caribbean	Upper-Middle	43	33	42	42
Czech Republic	Europe and Central Asia	High	40	40	34	32
Denmark	Europe and Central Asia	High	3	21	5	2
Egypt	Middle East and North Africa	Lower Middle	24	15	32	27
Ethiopia	Sub-Saharan Africa	Low	34	4	48	46
Finland	Europe and Central Asia	High	13	39	4	7
France	Europe and Central Asia	High	29	42	12	19
Germany	Europe and Central Asia	High	22	47	9	6
Ghana	Sub-Saharan Africa	Lower Middle	20	3	45	40
India	South Asia	Lower Middle	9	8	24	13
Indonesia	East Asia and Pacific	Lower Middle	25	14	33	25
Ireland	Europe and Central Asia	High	6	20	11	9
Israel	Middle East and North Africa	High	33	25	30	30
Italy	Europe and Central Asia	High	35	41	28	22
Japan	East Asia and Pacific	High	5	31	3	5
Kazakhstan	Europe and Central Asia	Upper-Middle	47	44	46	39
Kenya	Sub-Saharan Africa	Lower Middle	27	6	47	26
Korea	East Asia and Pacific	High	12	18	20	8
Malaysia	East Asia and Pacific	Upper-Middle	7	9	15	17
Mexico	North America	Upper-Middle	2	1	6	24
Morocco	Middle East and North Africa	Lower Middle	32	7	41	41
Netherlands	Europe and Central Asia	High	19	34	10	12
New Zealand	East Asia and Pacific	High	46	50	40	34
Nicaragua	Latin American and the Caribbean	Lower Middle	50	35	50	50
Nigeria	Sub-Saharan Africa	Lower Middle	28	16	36	28
Peru	Latin American and the Caribbean	Upper-Middle	48	17	49	49
Philippines	East Asia and Pacific	Lower Middle	14	10	29	16
Poland	Europe and Central Asia	High	30	22	27	31
Portugal	Europe and Central Asia	High	36	46	25	18
Romania	Europe and Central Asia	Upper-Middle	49	49	38	47
Russia	Europe and Central Asia	Upper-Middle	45	45	44	36
Saudi Arabia	Middle East and North Africa	High	16	19	16	21
Singapore	East Asia and Pacific	High	21	23	13	23
South Africa	Sub-Saharan Africa	Upper-Middle	38	43	31	35
Spain	Europe and Central Asia	High	31	36	22	20
Sweden	Europe and Central Asia	High	26	48	8	14
Thailand	East Asia and Pacific	Upper-Middle	41	32	35	45
Turkey	Europe and Central Asia	Upper-Middle	18	11	18	38
United Kingdom	Europe and Central Asia	High	4	37	1	1
Vietnam	East Asia and Pacific	Lower Middle	11	5	23	37

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