WHITE PAPER

Investing in Mexico's Energy Infrastructure Series: Power Generation and Cross-Border Prospects

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Executive Summary

The extensive reform under way in Mexico across all energy sectors has created a wave of anticipation and speculation about the future shape of the market and new opportunities for private investment. By opening their markets and modernizing their regulatory regime, Mexico's leaders hope to invigorate hydrocarbon reserve additions and production while stimulating the country's economic growth. This process is expected to create significant potential opportunities for investment across all sectors. However, maximizing these opportunities while mitigating some of the risks and regulatory uncertainties will require close monitoring of the coming developments in rulemaking and market design.

In light of these developments, ICF International has developed a series of papers that highlight emerging issues in different aspects of the energy opening. In the first paper, we reviewed the reform efforts under way in Mexico, looked at current production of renewable energy on both sides of the border in the context of overall generation, and explored potential growth of cross-border renewable energy trade, especially into the California market.

In this paper, we examine the current opportunities and risks in cross-border power markets in the context of the Mexican regulatory reform, especially along the Arizona-Sonora and Texas-Tamaulipas/Coahulia/Chihuahua areas of the border.

The reasons to be optimistic about prospects in both markets and flows between them are many. Gas trade already is substantial and likely to grow in the near term due to rapidly expanding Mexican energy demand that will be met through the buildout of further combined cycle generation. This buildout will cause Mexican gas demand to grow almost 30 percent between 2015 and 2020. This demand will be met by burgeoning U.S. exports. On the northern side of the border, the supply from rapidly growing shale gas production is more than ample—the supply rose 4 Bcf/d by last year in Eagle Ford alone. Significant new pipeline Mexican capacity of more than 5,000 km is planned or already online.

The question is how markets will develop after these pipeline additions are complete, especially on the Texas end of the border. Reasonable scenarios show that the demands of exploration and production for hydrocarbons (E&P) and pipeline operations from international operators moving south across the border drive the development of distributed generation and transmission. The additions have the potential to lead to a broader linkage with already existing industrial infrastructure north and south of the border and new transmission capacity to create more robust cross-border trade. Additionally, existing regulatory advantages in the near term may incentivize building generation in Texas with high-capacity transmission to Mexican industrial areas and with the opportunity for the direction to reverse as Mexican reserves are developed and fuel costs drop.

Further west, cross-border working groups have previously documented savings that could arise from more robust transmission linkages between Arizona and Sonora. Differences in time of day and seasonal peak demand as well as in wholesale and retail prices between regions also may encourage these developments and could lead to more efficient use of existing generation.

Whether and to what degree these scenarios play out will depend on the ability of Mexican regulators to put in place new permitting and market rules with a focus on harmonizing different regulatory constructs and mitigating physical security and geologic risks.

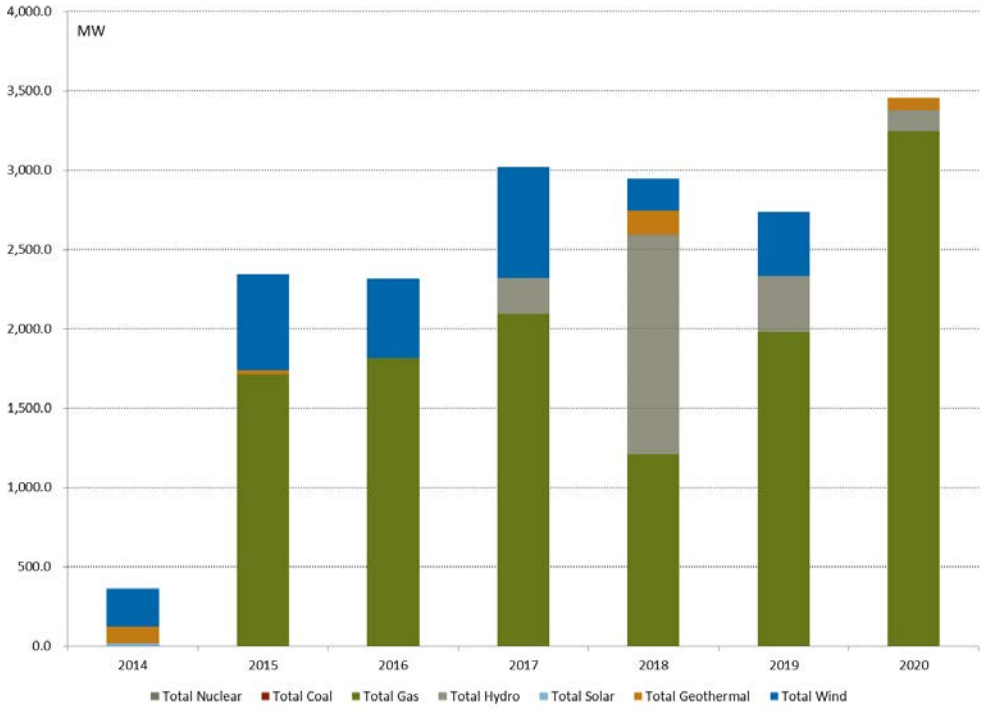
Current State and Near-Term Prospects of Power Generation and Trade

Mexico's Growing Gas-Fired Generation

Fossil-fueled plants provide most of Mexico's current capacity and generation today. In 2013, Mexico had 53.5 GW of generation capacity and generated 258 billion kWh, an increase of nearly 25 percent in 10 years, although most of that growth occurred prior to 2008. As of 2012, independent generators accounted for 12.2 GW of this generation capacity, consisting mostly of gas-fired combined-cycle generation. During the past 15 years, combined cycle generation has been a growing proportion of total generation.

Between 2009 and 2014, the Mexican gas sector has experienced substantial growth. In the next five years, nationwide energy demand is expected to increase on the order of 2.7 percent annually, rising to perhaps 4.5 percent annually beginning around 2020. Much of this demand is expected to be met by the buildout of further combined cycle generation that will continue to provide a lower marginal (operating) cost than existing fuel–oil-fired mid-merit plants with better reliability and lower emissions.

Figure 1. Mexico Power Plant Additions 2014–2020



Between 2009 and 2014, the Mexican gas and renewable sectors have experienced substantial growth and this is expected to continue into the 2015–2020 timeframe. Early in the period, nationwide demand is expected to increase perhaps 2.7 percent annually and rise to perhaps 4.5 percent annually by 2020. Much of this increase is expected to result from the buildout of combined cycle generation driving total daily Mexican gas demand up 29% from 9.3 Bcf/d in 2015 to 12.0 Bcf/D in 2020. Mexican gas production fell from 5.4 Bcf/d to 5.1 Bcf/d from 2010 to 2013. ICF estimates that a third of total 2020 demand will be met through the supply of natural gas from the U.S

In recent years, the United States has become a major net exporter of natural gas to Mexico. In 2012, Mexico imported a total of 779 Bcf (2.1 Bcf/D) of natural gas; around 80 percent came from the United

States. U.S. natural gas exports to Mexico accounted for more than 35 percent of total U.S. natural gas exports.[1] These flows have been steadily increasing in the past three years.[2]

As Mexico looks to develop its own shale reserve and tap into the growth of U.S. supply to feed its new combined cycle plants, the country has undertaken a significant expansion of pipeline capacity to manage these flows, including more than 5,000 km of new pipelines at a cost of about $10 billion. The network changes announced in 2013 will bring supply to four previously unserved states: Zacatecas, Colima, Sinaloa, and Morelos. In April 2014, more additions were announced that may bring additional incremental supplies and improve overall system performance.[3]

Current Mexico and U.S. Electricity Trade

Overall, Mexico has been a net exporter of electricity to the United States since 2003.

Figure 2. Current Cross-Border Transmission Ties: Limited but Indications of Growth

Arizona

- 20 MW (34.5 kV) AC tie between San Luis, Arizona, and San Luis, Sonora
- 8 MW tie serving customers in San Luis, Sonora
- A recent investigation by an Arizona and Sonora governmental Cross-Border Transmission Task Force identified a shared desire for a double-circuit 400 kV line with an AC-DC-AC tie to enter the United States between Nogales and Douglas, Arizona.

Texas

- Railroad DC tie: 150 MW back-to-back high voltage direct current (HVDC) converter connecting Sharyland Utilities Railroad substation to Cumbres station in Mexico.
- Sharyland has been constructing an additional 150 MW HVDC converter, resulting in a total transfer capacity of 300 MW, to be fully operational in 2014.
- Laredo DC-tie:100 MW variable frequency transformer
- Eagle Pass DC-Tie: 36 MW back-to-back HVDC converter connecting American Electric Power (AEP) Eagle Pass substation with the Comisión Federal de Electricidad (CFE) system.

California

- Two 230 kV AC ties that together account for 800 MW of transmission
- Recent Presidential permit for Sempra International for construction, operation, maintenance, and connection of a 230-kilovolt (kV) transmission line across the U.S.-Mexico border to supply electricity from its Mexican wind farm to the California market

In Arizona, the existing infrastructure connecting Arizona and Sonora is not used routinely for wholesale trade. By contrast, wholesale trade between Texas (Electric Reliability Council of Texas [ERCOT] counter-parties) and Mexico (CFE) has been more substantive and frequent. The table below summarizes the major purchases and sales between the two regions in recent years.

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[1] EIA Country Profiles - Mexico, April 24, 2014, http://www.eia.gov/countries/cab.cfm?fips=MX

[2] EIA Country Profiles - Mexico, April 24, 2014, http://www.eia.gov/countries/cab.cfm?fips=MX

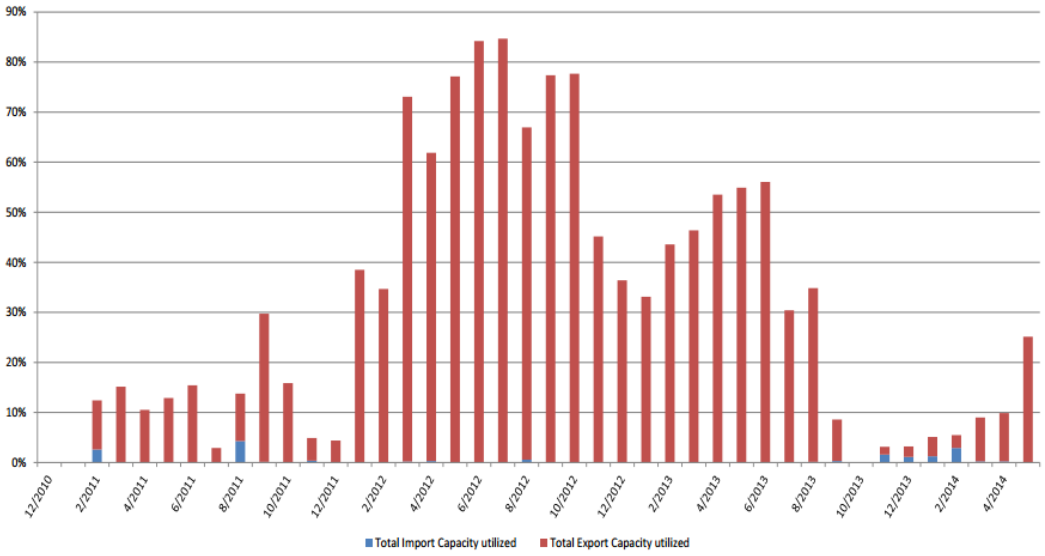
[3] These are summarized in several public forums. See for example Slide 24 from the presentation of Katya Somohano of CFE at the XXIII 2014 La Jolla Energy Conference, Institute of the Americas.

Figure 3. ERCOT–Mexico Annual Electricity Trade (MWh)[4]

	2011	2012	2013	2014 (YTD)	Grand Total
Sold	305,119	1,435,521	543,585	6,690	2,290,916
Purchased	39,620	6,438	32,170	127,574	205,802
Grand Total	344,739	1,441,959	575,755	134,264	2,496,717

Analysis shows day-part differences in this trade and consumption and seasonal differences as well, suggesting recurring patterns that may drive future investment.[6] The chart below shows that exports from ERCOT are highest during the spring during on-peak hours, while most sales into ERCOT from Mexico take place on-peak in winter months. Although the overall flows are relatively modest compared with transactions on either side of the border, they are tangible proof of the benefits and incentives for cross-border trade.

Figure 4. ***Volume of ERCOT–Mexico Electricity Trade, 2011–2014***[5]



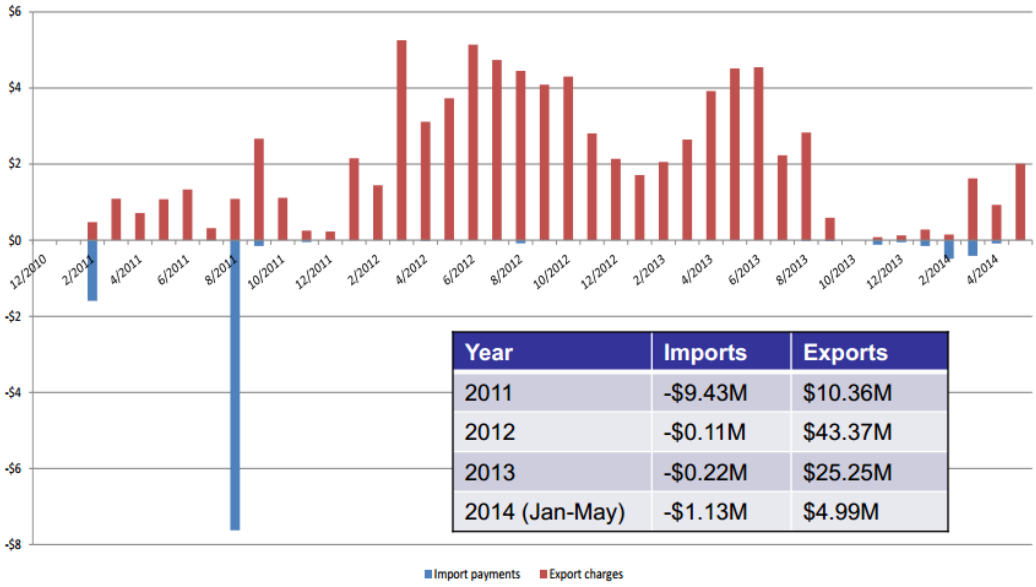
In addition to examining the volume of trade, it is also productive to consider the relative price and value of that trade. This is made more difficult by the fact that pricing in Mexico from Comisión Federal de Electricidad (CFE) varies as does pricing within ERCOT. Further, pricing within ERCOT varies based on its location (by node) while locational pricing within Mexico is not fully transparent.

Thus, to estimate the value trade, we have adopted pricing from the ERCOT perspective. Note that the relatively high level of exports from ERCOT to Mexico (CFE) is across many day-parts (not shown), months and seasons likely due in large part to lower fuel costs and more efficient heat rates. Imports have, however, also been important during certain day-parts (not shown) and months especially during times of system stress (for example August, 2011).

[4] This type of trade is most easily tracked in ERCOT because interties are DC rather than AC infrastructure—consequently, the direction and size of trade can be examined directly.

[5] ERCOT, Presentation by Joel Mickey to the NARUC Summer Meeting, Dallas, TX, July, 2014, http://www.narucmeetings.org/Presentations/mickey%20-%20US-Mexico%20Cross-border%20Trade.pdf

Figure 5. Export/Import Payments Related to ERCOT–Mexico Electricity Trade, 2011–2014[6]



Year	Imports	Exports
2011	-$9.43M	$10.36M
2012	-$0.11M	$43.37M
2013	-$0.22M	$25.25M
2014 (Jan-May)	-$1.13M	$4.99M

Future Opportunities in Cross Border Trade

Potential for Cross-Border Wholesale Power Transactions

The Arizona-Mexico Commission's 2013 report[7] submitted to the governors of both states identified value from an energy, reliability, and economic point of view in having greatly expanded transmission capacity through a bidirectional transmission link between Arizona and Sonora. The report found that investment in cross-border transmission could increase Sonoran access to the Palo Verde wholesale trading hub in Arizona, provide options for supplying the diversity of system peaks during periods of high demand (2 to 4 p.m. and 7 to 9 p.m. in Sonora; 4 to 6 p.m. in Arizona), and serve as a mechanism for taking advantage of seasonal differences in demand. Additionally, at times, access to low-cost hydro generation in Sonora could be useful to the thermal systems north of the border. All of these factors could play some role in encouraging cross-border trade and infrastructure investment.

Moreover, in Sonora, CFE has 11 central station plants that are insufficient during summer peak periods. During times of high demand, the states of Durango and Nayarit are primary exporters to Sonora. These imports are slightly under 700 MW and can represent up to 33 percent of the total demand in Sonora in spite of substantive transmission constraints. An opportunity definitely exists here, as the bilateral commission identified; however, additional in region generation is another and potentially more likely solution.

In Texas, recent production successes in the Eagle Ford shale—now more than one (1) million barrels of oil per day and more than 4.0 Bcf/d—have increased optimism about the size and low cost of oil, gas, and condensate reserves north of the border. The economic conditions and current infrastructure buildout clearly support significant expansions in gas flows for power generation in the coming years. Also as a result of these exploration activities, infrastructure buildout has grown to support native Texas power demand.

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[6] ERCOT, Presentation by Joel Mickey to the NARUC Summer Meeting, Dallas, TX, July, 2014, http://www.narucmeetings.org/Presentations/mickey%20-%20US-Mexico%20Cross-border%20Trade.pdf

[7] Arizona-Mexico Commission Energy Committee, "Bi-National Electricity Transmission Opportunities for Arizona and Sonora", June 14, 2013, http://www.azenergy.gov/doclib/6-14-13_Bi-NatlTF-Eng-WEB.pdf

In fact, an underappreciated factor is the rapid and repeatable tract-by-tract nature of shale development has led to innovation in supporting infrastructure above ground. During early E&P development phases, electricity additions and infrastructure were some of the factors limiting the scale up of drilling. During this period, E&P companies established new operating protocols with power providers, and modularized generation additions were early successes. In some areas of the State, these additions have been spread out across a geologic play, with multiple smaller, modular generation and transmission/delivery equipment installations. Although each individual installation is not sufficient to impact the overall need for power, taken together, they have the potential to shift the preexisting supply and demand balances.

Significant excitement has grown about further developing the hydrocarbon potential extension of the Eagle Ford shale on the Mexican side of the border for power generators and electricity providers. Such excitement will likely support a straightforward strategy of following existing international operators from Texas as they move across the border. With appropriate regional planning, some of these international power operators may seek to expand their base of operations across the border, perhaps as early as 2016. If the same pattern of modularized generation to support drilling plays out, a separate source of robust demand growth for power generation and delivery could develop.

Growing Pipeline Capacity

As discussed previously, especially for the initial 2014–2018 period, ICF has developed a base view of growth in Mexican electricity demand and savings from substituting lower priced U.S. gas for mid-merit fuel oil consumption to generate electricity and stable domestic gas production in Mexico. We believe the growth and the savings will drive increases in natural gas flows from north to south to support existing and planned generation additions. This pattern should continue to play out for the foreseeable future. The Secretaria de Energia (SENER) foresees the need for an incremental 47GW of new capacity through 2027.[8]

Given current and planned capacity increases, gas transportation should not be a limiting factor in supply—substantial pipeline capacity is on line or coming on line. The Los Ramones projects from the City of Rio Grande, Texas, are slated to go on line between December 2014 and December 2015 and will have a capacity of 2,100 MMcf/D. The Northwest Pipeline projects connect near the Arizona and California borders and will add more than 1,000 MMcf/D capacity between 2014 and 2016. The Chihuahua Pipeline addition that connects to a point near El Paso, Texas, was completed in mid-2013 and added 850 MMcf/D of capacity. If shale additions can be completed as expected, a substantial increase in exports seems reasonable. Part of this future build already is being talked about and recognized with the additions announced in April 2014.[9]

Risks and Uncertainties to Resolve

Initially, Mexico's substantial new combined cycle generation and pipeline capacity may offset some of the need for large transmission infrastructure investment. Furthermore, to effectively expand operations and "follow their customers," power providers must navigate geologic and security uncertainty, and understand a new and different regulatory program.

Geologic Uncertainty

Uncertainty remains about the extent of geologic risk in these promising areas in Mexico where a relative shortage of well control exists. The Burgos Basin extension of the Eagle Ford shale formation remains extraordinarily underexplored: since 2008, more than 5,400 wells have been sunk on the Texas side of the

[8] SENER, Prospectiva del Sector Eléctrico 2012-2026, published 2012, http://sener.gob.mx/res/PE_y_DT/pub/2012/PSE_2012_2026.pdf

[9] These are summarized in several public forums. See for example Slide 24 from the presentation of Katya Somohano of CFE at the XXIII 2014 La Jolla Energy Conference, Institute of the Americas.

border, while Mexico has attempted fewer than 25.[10] Some of the results have been outlined by PEMEX in the past.[11]

The location of this resource raises other geologic issues. Hydraulic fracturing is water intensive, requiring several million gallons of water per well. Yet, 55 percent of the Mexican population receives water only intermittently, creating potential frictions and competition for resources. Although Mexican experts believe accessing water through a pipeline from the sea or coastal areas is possible, that option has not yet been fully addressed.[12]

Physical Security

Some of the Burgos Basin shale overlaps with regions prone to violence and smuggling. Theft from existing pipelines in the region by organized crime groups and armed gangs (some believed to have ties to drug cartels) also has been a continuing problem. Mexican officials estimated that from 2012 and 2013 more than 1,500 illegal fuel taps caused about $1.1 billion in losses.[13] The security expertise gleaned from exploration and production operations in other parts of the globe may provide important lessons to mitigate safety issues along the Mexican border as new investors look to develop the geologic play. However, the new Mexican regulator still will face the challenge of putting new procedures and security measures in place. Under the sub-laws, the new National Agency of Industrial Security and Environmental Protection of the Hydrocarbon Sector will oversee both physical security and environmental permitting in an interesting intersection of responsibilities. This intersection may create certain efficiencies or complexity with respect to implementation of new regulations.

How Regulations Will Develop

Significant details remain unclear in the Mexican regulatory reform, including some changes that will be completely new. Mexican lawmakers envision an independent system operator (ISO) (CENACE) that considers international perspectives and experience as well as a wholesale electricity market. However, some major design elements have yet to be decided, including the role of capacity, energy, and ancillary service market components and governing structure.

Another major area to follow will be the role of planning for the system and how those protocols may unfold. Many observers and participants cite existing transmission studies and permitting as candidates for streamlining. Although generation interconnection agreements and transmission siting are standardized in ERCOT, these processes are not as well understood in Mexico. As a consequence, transmission and interconnect agreements can take more than one to two years in Mexico and substantially less in Texas. (On the other hand, environmental regulatory and permitting processes can take considerably longer in the United States, depending on the location.)

Other major regulatory uncertainties include the market design and bidding rules in Mexico with respect to energy, ancillary service, and capacity markets. Also uncertain is the role of nodal (locational) pricing. Finally, harmonizing markets operated by ISOs in Texas and California compared with those to be established by El Centro Nacional de Control de Energía (CENACE) and Mexican stakeholders remains to be accomplished.

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[10] Washington Post, "The Fracking Divide: Mexico's oil frontier beckons U.S. drillers in wake of new law", April 19, 2014 http://www.washingtonpost.com/world/the_americas/the-fracking-divide-mexicos-oil-frontier-beckons-us-drillers-in-wake-of-new-law/2014/04/19/1951ba0c-e8ff-452d-84bd-d488f730991c_story.html

[11] PEMEX Investor Meeting, Slide 22, December, 2013, http://www.ri.pemex.com/files/content/Pemex_Outlook_i_131204.pdf

[12] Washington Post, "The Fracking Divide: Mexico's oil frontier beckons U.S. drillers in wake of new law", April 19, 2014 http://www.washingtonpost.com/world/the_americas/the-fracking-divide-mexicos-oil-frontier-beckons-us-drillers-in-wake-of-new-law/2014/04/19/1951ba0c-e8ff-452d-84bd-d488f730991c_story.html

[13] EIA Country Profiles - Mexico, April 24, 2014, http://www.eia.gov/countries/cab.cfm?fips=MX

Getting these regulations streamlined and consistent in a manner that supports cross-border permitting and regulation will be important, as will the ability of investors to understand and navigate the evolving cross-border regimes.

Conclusion—Possibilities Looking Ahead

The possibilities for further development of robust trade in the medium to long term are strong.

The Arizona-Mexico Commission Energy Committee found that a 400 kV transmission line and AC-DC-AC intertie holds promise to increase cross-border wholesale transactions. Such a facility could provide access for new combined cycle and temporary hydro surpluses to be sold into the Palo Verde trading hub in Arizona, one of the largest transaction hubs in the West. Also, the stage could be set for additional wheeling into California. In the medium term, these initial transmission investments could lead to a rational regional development framework in Sonora and Arizona as well as a thoughtful approach to future regional combined cycle generation and solar buildout. Moreover, the substantial cross-border resource base is a tantalizing prospect for investors as they consider fast-growing demand needs in southern California.

The Texas experience with the development of distributed generation through modular additions to support E&P and pipeline operations seems likely to be successful on the Mexico side of the border. If this infrastructure were to grow in size and scope as it has north of the border, an incentive would be in place for additional infrastructure to link larger blocks to existing assets in Mexico and Texas. Compatible transmission and interconnection regimes then could assist in a broader linkage into already existing industrial infrastructure north and south of the border. The culmination would be a dedicated AC-DC-AC line or potentially even an HVDC facility of much larger size that could provide regional reliability and access to a wider set of fuel and power sources. A dedicated high-capacity line at 1000 MW would represent about a 150 percent addition to existing ties. Depending on the terminus, the line would allow multiple fuel sources to contribute. Major industrial load centers and cities could be linked together to better balance supply and demand growth regionally.

Similarly, the continuing expansion of gas pipeline capacity is initially expected to continue north to south gas flows. However, if Mexico supplies were to grow substantially in size and deliverability with the development of the Burgos Basin play, over-time flows might possibly be reversed from south to north. This type of integration and evolving market dynamic already has been in seen in the large buildout and shifts in operation for assets in Canada near the U.S. border.

Power developments between Norte/Noreste Mexico and ERCOT may have similar potential. In the medium term, taking advantage of lower cost fuel on the northern side of the border and relatively predictable and rapidly processed regulatory requirements for interconnection and build generation in Texas may make sense. As Mexican oil and gas reserves are developed, fuel costs drop, and additional capacity is brought on line in Mexico, the power flow direction could reverse.

The degree to which these developments occur will depend on the ability of Mexican regulators, state regulators, and U.S. authorities to put in place permitting and market rules with a focus on harmonizing different regulatory constructs. Early attention and focus also will be needed to mitigate physical security and geologic risks.

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Peter K. Nance is a principal in ICF International's Energy and Aviation Markets Division. He has extensive experience with institutional reform, examining major trends in the energy sector, and helping clients develop new business offerings that use strategic planning and market analysis to effectively leverage their real competitive advantages. He has directed more than 200 consulting projects in strategic planning, commodity trading and marketing, risk management, and financial strategy. He has experience in business and project development; market design; market supply and demand assessment; business and integrated resource planning; and financial and economic evaluation in the oil, natural gas, and power sectors.

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