U.S. shale gas trends – economic and global implications

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Abstract. Natural gas from shale has moved the U.S., and North America more broadly, to become one of the largest producers of the commodity worldwide. Large technological gains have allowed reservoirs of unconventional hydrocarbons to become commercially viable to extract and market. The addition of this growing supply into the global marketplace, has upended longstanding trading patterns, and created new economic outcomes worth noting. This paper will discuss the recent trends of shale energy development in the U.S., the impact it is having on domestic and international markets, and the implications as the world shifts to a new low carbon energy paradigm. It will cover changes in workforce, midstream build out, power generation trends, petrochemicals, and emerging LNG export capacities.

1. Introduction
The advent of shale energy development in the U.S. and its rapid evolution and emergence across the continent has significantly impacted the energy paradigm that has been in place for decades of time. This paradigm has a foundation in coal-based power generation, declining domestic production of conventional oil and gas resources, increasing imports of oil to meet expanding demand, mainly for transportation, and additional imports of natural gas via pipeline links to western Canada, along with limited LNG imports. With trends in natural gas usage expected to continue, a large number of LNG import facilities were planned, and many built, to accommodate in part the increasing need for energy of all types.

Starting in the mid-1990’s and rapidly expanding into many regions of the U.S., new shale resources were assessed for their reservoir qualities at the same time the technology and techniques for producing these unconventional resources was rapidly advancing. And in late 2004, Range Resources made public that they had drilled a well into the Marcellus shale that showed signs of being commercially viable. That success created even larger interest in these black shales as a key onshore gas resource and the process has rapidly moved forward. Currently in the U.S., unconventional gas resources, mainly shale gas, now make up 65% of the dry gas supply in the U.S. Pennsylvania is now the number one producer of shale gas in the U.S. and is only behind Texas in total volumes of all natural gas produced.

In approximately 10 years, the oil and gas production dynamics in North America have been upended. Along with large new supplies of natural gas, production of shale oil from onshore resources advanced and moved the U.S. to being one of the 3 top producers globally. Western Canada became the world’s second largest producer of shale gas with many exploration and production (E&P) firms easily moving back and forth across the border with technology, manpower, capital, and equipment. Other countries quickly looked to match this successful trend and potentially produce their own shale
gas resources. Argentina, after a slow start and needing to overcome political and capital constraints, has now quickly advanced the output of the Vaca Muerta in the western part of the country, and China is poised to deliver similar results, although not at the same speed for a number of technical reasons. Countries with shale gas resources in Africa, South America, Europe, Asia, and Australia/New Zealand all have made attempts to replicate the experiences of North America with limited successes.

This newfound abundance has created distortions in the previous energy marketplace as additional supply is now entering the market from countries that were energy consumers in the recent past. New LNG exports from the U.S. are adding to a now oversupplied spot market and in combination with large initial CSG-based LNG exports from Australia. And new conventional sources of gas are also coming online in many regions of the world. For the first time a “global” market for gas is now taking shape with calls for an increased number of trading hubs, more contemporary pricing models, and a greater worldwide equalization of natural gas pricing than was unexpected only a few years ago.

Increasing supply has led to large new investment of capital in energy intensive industries in locations with a now predictable and ample low cost supply, easy access to demand markets, and a trained workforce. This is rapidly changing the petrochemical industry in the U.S and Canada, the power generation model in Japan, and the geopolitical energy equation in most regions of the world. There are additional current and pending implications for manufacturing and investment outcomes in China, India, and Europe. On top of that, as the world changes its energy diversity to a lower carbon portfolio as an outcome of the COP 21 Agreement in Paris, natural gas is planned to participate with higher demand leading to increasingly higher prices.

2. Advancement of Shale Energy in the U.S. and Globally
For decades of time, E&P companies have realized the quantities of gas which were available in many organic rich black shales spread around the world due to prior reservoir analysis and drilling. Starting in the mid 1990’s there was a more in-depth effort to extract this resource from the source rock versus the more conventional practices of producing it from geological “traps” as had been common for decades. Successfully developing the “unconventional” resource necessitated the combined use of the evolving technologies such as hydraulic fracturing to stimulate the shale resource and allow commercial volumes of natural gas to flow to the surface. And then in a brief period of time, this was paired with horizontal drilling that permitted the drill bit to intersect more of the shale and release increasing volumes of shale gas.

![Figure 1. U.S. Shale Plays.](image)

Although this process was developed in the black shales of Texas and surrounding states, it quickly found opportunity in previously undeveloped shales like the Marcellus and Utica that underlie the mature Appalachian conventional resources of the eastern U.S. (Figure 1) Parallel efforts occurred in a number of other North American locations with western Canada finding considerable opportunity in the Montney and Duverney shales of Alberta and the Horn River shale in British Columbia. And in a similar manner, robust efforts by energy companies emerged in numerous European countries, including the UK and Poland, several South American jurisdictions (particularly Argentina), and China. To date, significant commercial quantities of natural gas from shale are being
produced in the U.S., Canada, Argentina, and China respectively [1]. Several other countries are on the cusp of producing commercially and will add to the global supply within the next decade.

A number of key factors contributed to the rapid advancement of shale gas in the U.S. and to some degree, Canada. These included a mature and predictable regulatory environment, easy access to large amounts of working capital, availability of drilling equipment and trained crews, legacy of oil and gas development, and private ownership of the mineral resource (U.S. only). There was also relatively strong political will for this resource to be developed, a modern transmission infrastructure largely in place, and a market that was strong and looking to expand. And in less than 15 years, the U.S. went from essentially no natural gas from shale to currently 65% of its 79 bcf/d national production, originating from this unconventional resource. But a number of the factors that allowed North American shale gas to flourish, have held back exploration in other global jurisdictions, namely the lack of transparent regulatory protocols, fears of water contamination, limited local incentive or social license, governments unfamiliar with the development process, and poor in-country educational efforts for the various impacted stakeholders. And the advent of social media, with the easy ability to spread misinformation or cast doubt, stalled shale exploration in many global locations.

In countries moving forward with shale, advanced exploration and production technologies, aligned with an increasing global appetite of natural gas, and public demands for a worldwide energy paradigm shift to lower carbon fuels, have driven the production efforts on an industrywide basis. In the Marcellus and Utica for instance, companies are now routinely designing longer laterals with increasing number of “frack stages” and with more wells on a single well pad. This heightens the geographical reach of companies from individual well pads, greatly reducing development and production costs, and allows for increasing larger quantities of gas to find a market.

The infrastructure to develop and transport these quantities of gas has changed considerably throughout North America with $100B expected to be spent on pipeline buildout to move gas to domestic and export markets. Along with these typically macro investments, more regional efforts to remediate waste water, recycle drilling waste, transport water by pipe vs. truck, and convert drilling fleets from diesel to natural gas fuels, have advanced a process that is substantially less environmentally impactful.

3. U.S. Shale Gas Production Trends

U.S. shale gas production has been on a steady upward slope since the year 2000. In that time frame, production has shifted between different shale basins driven largely by a specific play’s profitability, which has often been tied to NGLs in a region’s production stream, and overall volume. Proximity to end markets has been a key factor in production, as is takeaway capacity. With the eastern U.S. being its largest gas market, and with a previous positive basis over Henry Hub market pricing [2], the Marcellus and Utica shales have had significant market penetration and pushed historical supplies from the Gulf Coast states and western Canada out of this premium market in a broad fashion. Transmission lines supplying gas from those locations are now at reduced capacity or have been reversed. Much of the previous and now growing demand in New England and eastern Canada, is increasingly being met by supply originating in the Appalachian basin. While this has created new markets for eastern U.S. producers, it is severely limiting western Canadian companies as they previously marketed most of their supply to U.S. customers. Attempts to move more of their gas to overseas customers through LNG shipments has become constrained by market forces and pushback from local indigenous communities.

From 2012 to 2015, approximately 85% of new U.S. natural gas production was sourced from the Marcellus and Utica shales (Figure 2) [3].
With over 14,000 shale wells now drilled in this basin (Figure 3), mostly in the Marcellus, it is leading the direction of shale production in the U.S. Initial well volumes in the Marcellus were typically in the range of 3 to 5 Mmcf/d but have now been replaced with production rates of 10+ Mmcf/d, flatter production decline curves, and expected overall production rates of 4+ bcf over the life of the well (20+ years). Horizontal well bores are trending longer, now commonly in the 7,000+ ft range, with a recent Utica well lateral reaching over 18,000 ft long and stimulated utilizing 128 frack stages.

As the production of shale gas has progressed and the technology refined, estimates of expected overall volumes to be produced from the reservoirs have changed considerably. Early estimates of the Marcellus for instance were for a total of approximately 4 Tcf of gas to be produced over a predicted 50-75 year lifespan. In the last two years, over 4 Tcf has been produced in each of the respective years and it is projected that 2016 will end cresting a similar level of production (Figure 4).
As these new drilling and well stimulation techniques and technologies are being deployed, increasing shale gas volume, coupled with the global downturn in oil and gas price which has led to lower service contractor pricing, have combined to make eastern U.S. shale gas some of the cheapest in North America to produce and bring to market. This has created an expanding interest in shale gas for new gas-fired baseload power generation capacity, new North American and European petrochemical manufacturing, and a growing demand for the initial wave of LNG shipments now finding their way to the Atlantic basin market and likely beyond, particularly Europe, India, and some Asian markets.

4. Global Interest in Shale
As the shift in sourcing natural gas in North America has moved from traditional supplies of conventionally produced gas, to larger volumes of shale gas, matched with a larger pool of expertise to propel a similar trend elsewhere, a worldwide assessment of how to grow this phenomenon has taken place for a number of reasons. The most compelling case has been a greater understanding of the wide distribution of shale energy reservoirs globally, with many of them in countries that have traditionally been importing energy and have a balance of payments skewed in that direction. For example, Argentina has been importing large volumes of natural gas by pipe from Bolivia at high contracted prices which has impacted their overall economy significantly. At the same time, they have some of the world’s largest shale gas reservoirs that have only recently started to be developed. Uniquely, they also have a petrochemical industry of some scale that has been importing feedstock, a transportation system that has CNG distribution already widely in place, and automobiles in large numbers modified to use this fuel if available at or below gasoline prices.

Along with the potential for more favourable economic outcomes, there has also been a strong geopolitical argument, specifically in Europe which has been heavily dependent on Russia for supplies via traditional long distance pipelines. European interest has formed in two parallel tracks. First, an early assessment by companies awarded agreements to explore for shale energy within their borders. Countries with programs worth noting include Lithuania, Ukraine, Romania, Poland, and the UK (Figure 5). All have had efforts on the ground to physically explore and assess the potential to find and commercially produce this resource. Poland, the most aggressive in this regard, had the highest level of initial drilling, and conducted the most significant change to their regulatory protocols and related legislation. Due to geology, most companies have now slowed their exploration programs and/or mothballed their efforts.
The UK has more recently rallied in the direction of shale energy, with the country awarding a number of significant exploration blocks to a range of domestic and international companies. There have been delays in their forward motion on the issue ranging from induced seismicity, to political reviews, and more recently strong community resistance. Many in the decision making process have aligned around the idea that North Sea natural gas supplies are diminishing, coal for power generation will end in 2025, and the need for gas will continue to increase as part of the UK’s commitment to the COP21 agreement. On May 23, 2016, the North Yorkshire County Council approved the first permit to hydraulically fracture a shale gas well in the UK since 2011. There is strong political will at the national level to develop shale energy but this interest is facing substantial challenges in local jurisdictions.

The second track Europe has taken is to identify new sources of gas that can meet their needs and diversify their suppliers. This path has led to new imports of LNG from Norway via a FSRU in Lithuania with similar import terminal and pipeline initiatives in Poland supplied mainly by Qatari LNG [4]. This new wave of LNG focused construction has added to a robust network of LNG import and regasification facilities throughout the EU that has been expanding for the past three decades. From this has been a continual interconnection of gas transmission lines between countries allowing for more options based on rapidly evolving market and political realities.

With the option of new supplies of shale gas-derived LNG from North America reaching the continent, the creation of new import and trading hubs is viewed as a strategic realignment of how gas is sourced and ultimately transits Europe. Similar to Ukraine in some ways, Poland is finding itself in the midst of this quickly evolving natural gas policy discussion, impacting not just consumers inside its national borders, but also those throughout neighbouring countries. Creating a “hub” would allow it to diversify its suppliers, particularly with LNG imports, increase market advantaged pricing, and potentially add to energy security in Poland and beyond.

5. Power Generation Trends in U.S. Impacted by Shale Gas
Due to more recent trends of shale gas production in the U.S., leading to lower prices predicted into the near term, there is a pronounced transition towards more gas-fired power generation. In a parallel fashion, there has been a strong trend to retire the older segment of the coal-fired fleet. Utilities facing new governmental emission regulations, increasing market penetration of renewables, international commitments to the COP21 Agreement, and some level of expectation of the Clean Power Plan (CPP) being implemented, are driving U.S. power generation away from its historical reliance on coal [5]. For the first time, natural gas has overtaken coal and is providing 31% of baseload capacity. In the PJM region of mid-Atlantic and Midwest, 5,000 MW of new installed capacity is now generated from gas-fired plants built in the past three years, most of which are in the shale gas footprint, and a parallel 1,600 MW drop in demand, largely accounted for in decommissioning of coal plants too old to justify emission reduction technology.
Currently lower LNG prices, due to an oversupplied world market expected to last until 2025, are leaving large amounts of the commodity in North America looking for buyers. In January 2016, power generation in the U.S. utilized 26 bcf/d of the country’s 79 bcf/d of natural gas consumption and is trending to higher levels with the retirement of older coal-fired plants (14,400MW in 2015), and now 2-3 older, smaller nuclear plants. It reached 31.2 bcf/d in May. January’s use represented a 24% increase over the five year average. There are also substantial numbers of coal plants that can be fired on natural gas in the U.S., although not at the operating efficiencies of newer combined heat and power units more commonly being constructed now. Fuel switching in those cases is largely a dynamic of coal versus natural gas price and is influenced by the export market of coal, largely to Europe, India, and China. The market is attempting to balance but production of shale gas continues to put increasing amounts of new supply on the domestic market, creating favourable fuel price for utility generators, and drive new capacity builds skewed heavily towards gas paired to renewables. March saw the first drop in overall natural gas production in the U.S. but mostly in “associated” gas that is produced in conjunction with oil. Shale gas during the same timeframe had further volume increases.

This new gas demand for power generation has caused supply constraints in limited locations in the U.S., particularly parts of the New England market, specifically Massachusetts, and some of the south eastern states. This is being influenced by increases in gas-fired plant construction, older regional nuclear going offline, and public resistance in some communities to allow new pipeline construction. A similar situation is occurring in parts of the urban California market and is amplified due to a recent loss of subterranean gas storage capacity related to equipment failure.

Implementation of CPP is still questionable with over 100 entities now suing EPA to prevent it from moving forward. CPP foes had early success with the U.S. Supreme Court which placed a stay in effect and sent the case back down to a lower court to be heard. That will take place in September 2016. Pending that result, the losing party is expected to further challenge the outcome back at the Supreme Court, reaching the court docket in either 2017 or 2018. In the interim, a number of states and several large utilities continue to replace older deployed technology with renewables and gas-fired units, lowering carbon emissions based on market forces, and to some degree in response to evolving societal demands. Compared to 2005, CO2 emissions were 23% lower at the end of 2015.

6. Petrochemical Investment Based on New Shale Gas Supplies

Due to expanding supplies of natural gas liquids, mainly ethane, butane, and propane derived largely from new sources in U.S. shale production, there is increasing interest in building additional petrochemical capacity to utilize the larger volumes now reaching the market. The American Chemical Council indicated in April 2016, that shale-driven chemical projects had reached $164B in investments currently made or committed to in the near term. Most of these are greenfield projects along with some manufacturing units being brought back on line. Their projections indicate this could generate nearly 730K new jobs, either directly in the industry or the supply chain it would feed. Further indications show a $105B/year contribution to the larger regional and national economy.

Relatively low cost ethane is the main driver in this facilities investment, as it is the source of most U.S. polyethylene production versus naphtha that is more commonly used for the same purpose in Europe and Asia. Naphtha being derived from crude oil, has seen its previously less favourable price spread when crude was over $100/bbl, lessen compared to U.S. ethane, as Brent prices have dropped to under $50. Investment in new U.S. petrochemicals increasingly cites growing volumes of natural gas liquids that will likely maintain a favourable price spread compared to most other global locations, other that some Middle East facilities. This was quoted as the reason for Shell’s recent announcement to build a new $5B petrochemical complex in Marcellus/Utica region of western Pennsylvania. This plant will covert local ethane to 1.6 million tonnes of polyethylene annually. They further cite that 70% of North American polyethylene customers are within a 700 mile of that new plant. Price of
shale-derived ethane in that region has dropped to 25% of its original price when Shell initiated their investment decision making process.

Additional petrochemical manufacturing related to new shale based ethane is also ramping up in Norway and Scotland with the ethane purchase agreements put in place by INEOS in 2012. The first shipment left Philadelphia in early March on newly built “Dragon” class ships designed to move ethane sourced from the same regions of the Marcellus and Utica shale development that Shell is utilizing for their newly announced “cracker” plant. INEOS’s Grangemouth ethane cracker in Scotland had been previous mothballed due to supply issues that new favourably priced imported ethane is anticipated to resolve.

New production worldwide adds to overall supply which in the near term is expected to exceed domestic demand in most markets, creating the need for enhanced exports. This is projected to place downward price pressure on polyethylene. IHS estimates that 24 million metric tonnes of new polyethylene production will come online by 2020, 8 million of which will come from mainly the Gulf Coast of the U.S. and Pennsylvania. With traditional feedstock price advantage held by Middle Eastern producers, proximity to end markets and operating efficiencies is deemed critical to capturing and holding market share by new polyethylene capacity.

7. Workforce Implications
Direct and indirect workforce growth associated with shale energy development in North America has been significant. In Pennsylvania’s Marcellus/Utica before the market induced downturn in 2014, it was estimated that between 45,000 and 100,000 new jobs were added to the State’s economy at a higher than average wage scale. Several workforce assessments were jointly conducted by Penn State entities that investigated the specific skill sets needed and the number of workers required to complete a gas well from inception to commercial production [6]. For a single shale well in the Appalachian basin, 420 people representing 150 occupations were needed during development and eventual production, with over 13.09 FTEs created per well annually. Approximately 75% of the new workforce was blue collar and came from the trades sector. The research further established a workforce multiplier of 1.52 to gauge the indirect and induced outcomes of workforce impacts.

Cleveland State University conducted a workforce study in 2015/16 for the Utica shale in the core of the basin, modelled on a similar methodology, and discovered a parallel trend seven years after the earlier Marcellus studies [7]. One main difference was the efficiencies employed by upstream energy production firms and the associated service industry, had reduced the need for truck drivers, a sizable percentage of employees, due to advances in transporting water by pipelines regionally versus by truck. There was also noted a lessening need for rig workers of many types due to single wells being drilled in 12 days or less compared to the earlier assessments where a single well normally was drilled in 3 to 4 weeks.

Early shale development placed a heavy burden on companies and communities in attempts to source this skilled workforce locally. Companies and post-secondary institutions put in place training programs funded internally and through government grants during the transition in many of the key shale energy regions of the U.S. The ShaleNET program, funding with $20M by Dept. of Labor, trained over 14,000 people since its inception in 2010.

A similar situation has occurred in other regions of the world where interest in developing the shale resource has been high but unique skill sets needed in the labor pool have not matched so well. Often this is resolved with the recruitment of expats but that has been problematic due to high labor costs, limited housing options, and political conflict associated with not employing local workers from areas that often have elevated unemployment rates. Many of the global jurisdictions negotiating development agreements with energy companies have resorted to local content requirements that
provide for a higher percentage of local goods and services (including workforce) to be sourced from the nearby region. This has also generated the development of localized training programs, increasing the pool of available expertise. Some political leaders have seen this as a way to train an indigenous workforce to work both domestically and internationally, expanding local and more distant revenue generation.

8. LNG Market and Price Trends
The trend of the past five years has shown an increasing demand for natural gas delivered to countries with the capacity to import more of the commodity. The reasons vary, ranging from the shuttering of the nuclear industry in Japan, the growing overall need for energy of all types in China, the shortage of gas for power generation in countries such as South Africa as it slowly moves from coal, and the realignment of the complete North American gas market, to illustrate several examples.

Some of this demand is being matched to new pipeline capacity being installed. This includes 4 bcf/d projected as exports from the U.S. to both Mexico and eastern Canada respectively by 2017. Similar current gas transmission projects from Mozambique to South Africa and between Central Asian and Russian suppliers to China. Constraints, political and/or financial, are increasingly challenging these projects, and in some cases, combining with a resistive public, particularly in the U.S. ($32B in related projects cancelled or postponed since 2012), slowing the ability to complete the project in a commercially predictable manner. This is contributing to the increasing demand and flexibility of LNG imports, particularly with newer offshore FSRU technologies.

Qatar has more recently been the world’s leading LNG exporter, with 77Mmt/a (2015). In the same year, the U.S. and Canada exported almost no LNG. By 2020, Australia [8] is expected to reach over 85Mmt/a, claiming the number one spot globally, with the U.S. moving to 62Mmt/a and becoming the world’s third largest producer in that five year window.

At the same time, there are large world class natural gas developments that are emerging and will shortly be chasing the market. These include large scale offshore discoveries in Israel and Egypt, new east coast Africa supplies, western Canadian shales, Argentine and Columbian onshore unconventionals, and Iranian conventional fields potentially going online with the lifting of sanctions. This has contributed to a precipitous drop in the price of LNG in the past 18 months. Landed price of LNG in Japan was over $16 USD in November ‘14 compared to $4.10 in April 2016. And with the conversion of significant power generation in the U.S. to gas-fired capacity paired with renewables, there is a growing volume of thermal coal available to the world market at the lower end of a 5 year price range, further contributing downward pressure in LNG price due to additional fuel competition in the power sector.

Although there are a number of Canadian and U.S. export facilities permitted by the respective government agencies, final investment decisions have in many cases been delayed or cancelled due to the very difficult market dynamics predicted for the next 5 to 10 years. Canadian exports will be the hardest to justify as they are predominately greenfield projects with strong community pushback, high labor costs, and the need for extensive supply pipeline construction. There is now a growing concern by Canadian energy producers that they will effectively be shut out of the export market at the same time they are losing much of the current market in the U.S. due to its own shale gas development. This has led to a growing dialogue that Canada’s abundant gas resources may be exploited in the more distant future by another generation of consumers. With the Canadian government’s more recent moves to now review new energy projects with an added analysis of their climate contributions, the path forward on these projects is even more challenged.
The U.S. has five new LNG export projects under construction for a combined capacity of just under 11 Bcf/d, representing over $44 B in planned investment (Table 1). Several of these projects have now been permitted to expand, adding additional capacity or “trains” and accomplishing greater economy of scale. Although there are many new applications in the approval queue in the U.S., many industry consultants are now predicting that these five locations will be the only ones constructed in the foreseeable future due to global LNG market that appears oversupplied through 2025. Some projects originally fast tracked by their investors have been slowed, anticipating they can better match the future demand and in a more favourable price environment. With U.S. upstream producers originally expecting a greater opportunity for exports to provide price support, this is viewed negatively. One bright spot is now seen in the recent widening of the Panama Canal which will allow 80% of LNG carriers to make the passage, permitting increasing amounts of Gulf Coast U.S. LNG less costly access to Asian markets compared to the 20% able to transit the original waterway.

| Project                        | Committed Investment | Capacity   |
|--------------------------------|----------------------|------------|
| Sabine Pass (Cheniere)         | US $12B+             | 3.76 Bcf/d |
| Cameron LNG (Sempra)           | US $10B              | 1.7 Bcf/d  |
| Freeport LNG (Freeport LNG)    | US $11B              | 1.8 Bcf/d  |
| Cove Point (Dominion)          | US $3.5B             | 0.82 Bcf/d |
| Corpus Christi LNG             | US $7.5B             | 2.14 Bcf/d |
| total                          | US $44 B             | 10.22 Bcf/d|

Price trends for natural gas have changed considerably in the past 5 years, with the availability of new domestic sources and increased LNG shipments being a substantial influence. There is a 40% increase in LNG supplies entering the global market by 2020 contributing to short term oversupply. Combined with that is more widespread interest in the “tolling” model that U.S. LNG exporters are using to price cargoes versus the more traditional, oil-linked, 20+ year contracts [9]. Although there can be strategic market advantages to both models for buyers, additional inroads globally have been made with this new model, with some Asian buyers creating a supply portfolio of cargoes priced in both methods to spread risk.
9. Summary

Natural gas from shale development in North America is having transformative impacts on the domestic energy markets of those respective countries. It is changing the power generation market most noticeably with more power burn in the U.S. attributed to natural gas than coal. This has led to more utilities making market-based decisions to retire older coal plants which will further lock in more gas-fired generation and renewables capacity. Overlaying that is the regulatory emphasis coming from the new CPP initiative at the federal level in the U.S. Together they form the heart of the U.S. commitment made to the COP 21 Agreement in December 2015 in Paris. With a 23% CO2 emission reduction coming from the U.S. since 2005, deployment of renewables due to state and federal level subsidies, and anticipated mid-term low price for natural gas, market forces and political/societal pressures are expected to carry this trend forward for the next decade if not longer. Some large utility providers are already predicting that the emission limits imposed by CPP (if implemented) may not be necessary in some regions until 2026 or later due to low cost gas and a further buildout of subsidized renewables.

Along with the conversion of the power generation industry is a similar trend in petrochemicals as the volume of natural gas liquids becomes predictably larger, increasing lower cost, and in close proximity to one of the largest demand markets in the world. Capital and technology investments are pacing higher with more international producers moving capacity or investing in new plants closer to this relatively inexpensive feedstock.

LNG production and export is also seen as being the next large step North American shale gas production is trending towards. Five new plants are currently under construction in the U.S. with over 30 in the permitting or final investment decision queue in the U.S. and Canada. Market pricing for LNG has changed considerably from oil-linked pricing to a newer “tolling” model developed around expected U.S. exports. This is moving the world from traditional 20+year fixed destination designated LNG cargoes and towards a more fluid spot market price. There is a large increase in LNG carrier capacity and a new option in the expansion of the Panama Canal, both allowing more flexibility to reach markets at a reduced cost. But along with the reduced purchases from large Asian buyers, substantial supply increases from Australia and now the U.S., landed LNG prices have dropped precipitously since 2014 and are at 5+ year lows and are predicted to be oversupplied through at least 2020, with some analysts expecting it to last through 2025.

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