Energy Economics and Technology Committee 2019 Report
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Principal Theme: Unease at the Top

The string of industry accomplishments since the shale era became a tangible and disruptive force about ten years ago has been marked by one record after another. 2018 (to mid-2019 at the time of this review) continues this tradition with the exception that developments have picked up even greater speed. The breadth and pace of changes boggles the mind of even the most seasoned observers. In recording the changes over the past ten years, the reports of the Energy Economics and Technology Committee have principally focused on the "shock and awe" of various milestones, punctuated at times with attention to the "fracking backlash" or the wave of industry bankruptcies from collapsing prices. But unlike the past ten years, the industry has now entered into a realm of true vertigo which goes well beyond the misunderstandings that have typically informed backlash about the arguably-still-new processes of geosteering/horizontal drilling and high-volume hydraulic fracturing. This moment is captured in the report's theme of "unease at the top".

A confluence of forces with uncertain prospects weigh upon the outlook. Four principal elements describe this state of affairs:

(1) ***Astonishing industry accomplishments***, as noted, which comprise record oil, natural gas, natural gas liquids (NGLs), and liquefied natural gas (LNG) production, use and export.

(2) ***A magnifying social agenda***, touched off in part by the United Nations Intergovernmental Panel on Climate Change (UN-IPCC) report on the severity of climate change, and represented by expansion of state Renewable Portfolio Standards (principally targeting sources of electricity generation) and by pronounced policy aspirations, including the longer-standing "Keep It in the Ground" and fossil fuel divestiture movements but also, and most prominently in the ramp-up to the U.S. 2020 elections, the "Green New Deal" and several other proposals such as Washington State Governor Jay Inslee's "Evergreen Economy Plan", proposals from other announced candidates on the Democratic side, a Republican R&D proposal, and a resurfacing of interest in the Schultz-Baker plan for a carbon tax.

(3) ***Growing financial wariness***, evidenced principally by a new-found reluctance on the part of "Wall Street", namely investors of various types, to continue to extend debt to finance industry operations. The shale era has been characterized by a combination anomalously low costs of money and anomalously low reliance on free cash flow to sustain activities. This has been accompanied by growing attention to so-called "parent-child" well conflicts, in a sense displacing the attention that has formerly been given to "break-even" economics of drilling, although the economic questions are basically the same.

(4) ***Political wild cards***. Since OPEC's earliest days, oil and geopolitics have been inseparable (truthfully, this intertwining goes back much farther). But the unexpected has taken on a new course over 2018-2019 with United States policies entering the fray as a source of instability rather than stability, through such things as iron and aluminum tariffs, trade war with China, and sanctions imposed on former major producers Iran and Venezuela. The U.S.-Iran relationship as of mid-July, 2019, is contributing to a "growing sense of foreboding and unpredictability" ("Iran and U.S. on a Collision Course", editorial, *New York Times* June 17th).

This review addresses the first two developments, as these take up virtually all the oxygen in the room. We see an industry at the top of its game, and a society about to do something tangible about climate change. The global context for whatever might be achieved in the U.S. is conveyed in a global context in several charts in the Appendix (e.g., historical emissions in the U.S. and Europe, China and India, and the Russian Federation).

Financial conditions in the industry, which have become increasingly precarious, and political uncertainties also deserve attention. They are slated for Committee examination in subsequent contributions. Considering all these developments together, the ability to look forward with any clarity is severely hampered – thus, "unease". It is impossible to draw conclusions, or define narrow paths, which is why so much attention is now being given to "scenarios". This type of thinking and planning was pioneered in the oil industry of all places, at Shell, in the tumultuous 1970s, and it applies again today to a variety of economic analysis and forecasting tasks when the ability to frame probabilities is a fruitless task. (The seminal references on scenario planning are the writings of Pierre Wack about this early period: "Scenarios: Uncharted Waters Ahead" and "Scenarios: Shooting the Rapids," *Harvard Business Review*, September and November, 1985. An economist in the planning department at Royal Dutch/Shell Group, Wack headed its "business environment" division. For all their relevance, the piece could have been written yesterday.)

Also omitted at present are a number of other notable, recent developments. Among these:

(a) Continued "consumer savings" from fracking (a topic quantified in depth for the year 2015 in the Committee's 2016 report; total was $755 billion);

(b) The relative stability of natural gas prices in the face of extreme cold periods, along with such notable, generally local, aberrations as spikes in the Pacific Northwest and Southern California, and extreme low-to-negative prices out the Permian Basin. Not coincidentally, flaring has reached new heights, over one billion cubic feet per day across the Bakken and the Permian.

c) LNG export pricing, particularly for spot shipments, which in the Spring 2019 reached new lows, squeezing revenues from that traffic and perhaps causing pause in the race toward the next wave of LNG export mega-projects; and

(d) Tracking oil/natural gas prices (the latter at extreme lows for the current era) and their "price ratios", which provide a cue to liquids profitability.

A further development of note is:

(e) The International Maritime Organization's imposition of a global 0.5% sulfur limit on bunker fuel, which comes into effect on January 1, 2020. This reverberates across a refining industry awash in U.S. light, low-sulfur crude and also affects demand/pricing of many other crude grades as well.

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Astonishing Industry Accomplishments

Crude and Tight Oil. Ballooning crude oil production, tight oil's contribution, and consequences for imports of oil and petroleum products are shown in the first three figures.

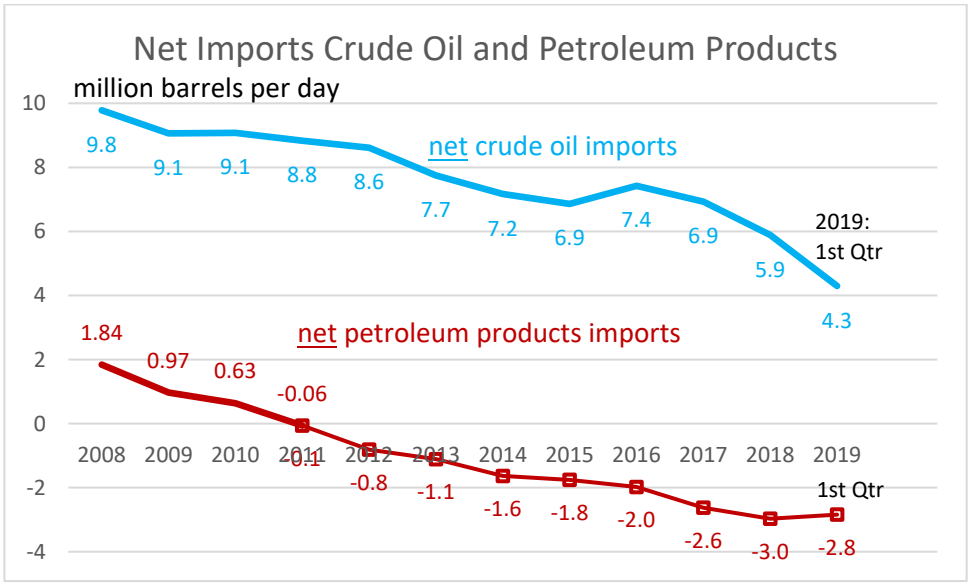

Figure 2. Net Liquids Imports – incl. Seven Years Net Exports of Products

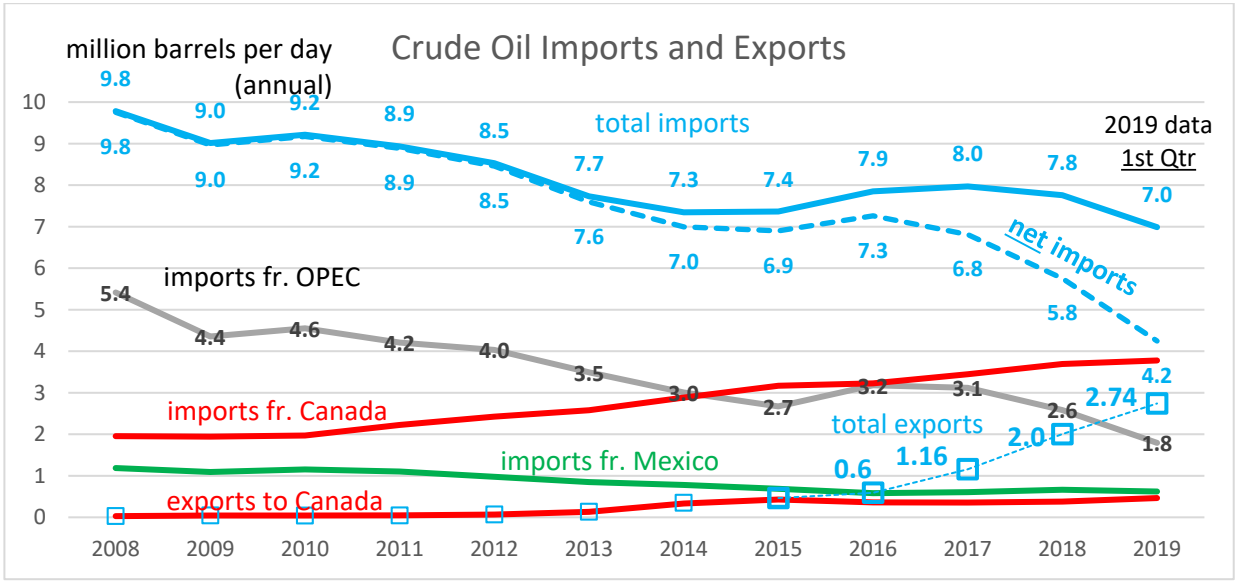

Figure 3. Oil Imports/Exports Detail – OPEC, Canada, Mexico, and the New Exports

To be technically correct, the industry broke its teeth on horizontal drilling/geosteering with massive high-volume hydraulic fracturing well before 2008 when first going for natural gas from Texas' Barnett Shale, and the record is longer than ten years, but meaningful impacts of shale era production, i.e. impacts at a national/international scale, post-date 2008.

Tight crude production grew from 1 million barrels per day (1 M b/d) to 2 ½ M b/d in the three years Dec. 2010 to Dec. 2013. This is not just ancient history, it takes us to the doorstep of the 2014 oil price collapse. Tight oil's share of production grew from 18% to 44% over this time. In the next nine months, tight production grew by another, full 1 million barrels per day, and its share grew to 50%. Due to its importance, this period is cross-hatched on the curves in Figure 1. High prices of over $100 per barrel (West Texas Intermediate average monthly spot, not shown) reigned for six months in 2014 from February through July, descending to $84.40 by October and $75.70 in November. This was the month Saudi Arabia announced it would aim to maintain market share rather than cut back its own production to fend off the onslaught of U.S. production, yet it is apparent that global prices had already begun their descent. The Saudi policy gave the price collapse quite a boost, with prices falling below $50 per barrel by January 2015. Momentum carried production (total crude and the tight oil share) higher into the spring/summer of 2015. For the next 24 months it veered lower and did not regain its former peak until October 2017.

Since July/August 2017, oil production has been on a remarkable upward tear. In the twelve months December 2017-2018, tight oil production grew 1.6 M b/d and total crude 1.9 M b/d (to 7.2 and 12 M b/d respectively). This is the largest oil production increase in any year of the shale era. Going back just a few more months to July-August 2017, the growth in production by yearend 2018 was 2.7 M b/d. For perspective, growth of oil production during the entire shale era, e.g. from the 5.2-5.6 M b/d levels during the 2008 to mid-2011 flat period through December 2018, was 6.2-6.7 M b/d. The latest 2.7 M b/d surge represents 40% (or more) of the growth during this entire era, all crammed into the 16 months to December 2018. The tight oil share of total crude production has exceeded 60% every month since May 2018.

The U.S. impacts global prices through imports and exports. Petroleum products have been traded freely but crude exports were restricted and minimal until December 2015. The big picture -- net imports of both crude and petroleum products -- is Figure 2. The combined impact was a decline in net imports of 4.1 million barrels per day between 2010 to 2014. Imports of OPEC crude over that time declined 1.6 M b/d. The next big downward "leap" resulted primarily from escalating U.S. crude exports. In the past two years, 2016-2018, net combined (pet. products and crude) imports declined 2.5 M b/d, of which 1 M b/d was due to trade in petroleum products and 1.4 M b/d due to increasing crude exports. The latter rose from 2.0 (2018 ave.) to 2.74 M b/d during the first quarter of 2019. It is evident that the U.S. shale-based role as a global price "softening agent" continued into 2018-2019, even though most recent political developments have an opposite effect (e.g., Iran sanctions and Venezuela turmoil). Regarding OPEC, U.S. imports reached a new low in 2018 (2.6 M b/d), far short of gradually increasing trade with Canada (3.7 M b/d in 2018), and the OPEC portion fell even further during the first quarter of 2019 (to only 1.8 M b/d).

Natural Gas and LNG. The astonishing story of natural gas and liquefied natural gas (LNG) is shown in the next three figures, addressing burgeoning supplies and exports. Attention shifts in some of the later slides, addressing major sources of natural gas demand. Before getting

into those facets, it is necessary to recognize the parallel boom in natural gas liquids production and the historic records being set in oil and natural gas "proven" reserves, i.e. reserves booked annually by companies according to financial and other criteria. These have been subjected to punishing price swings over the past ten years, yet given loft by the shale phenomenon. Reserves, as all the other principal data presented in this section, are reported by EIA.

Looking back to 2008, natural gas production (dry) grew over 60% or 34 Bcf/d by yearend 2018. It hit 80 Bcf/d in March 2018 and rose even further to 89 Bcf/d by December. This surge actually started after July-August 2017 where it held at the 75 Bcf/d. That mini-plateau and the 2018 data are cross-hatched on Figure 4. The remarkable thing is the subsequent, and recent, 16-month climb accounts for 14 Bcf/d or over 40% of the growth in production rates seen over the entire ten-year period. Even with explanations, this is a lot for so late in the game.

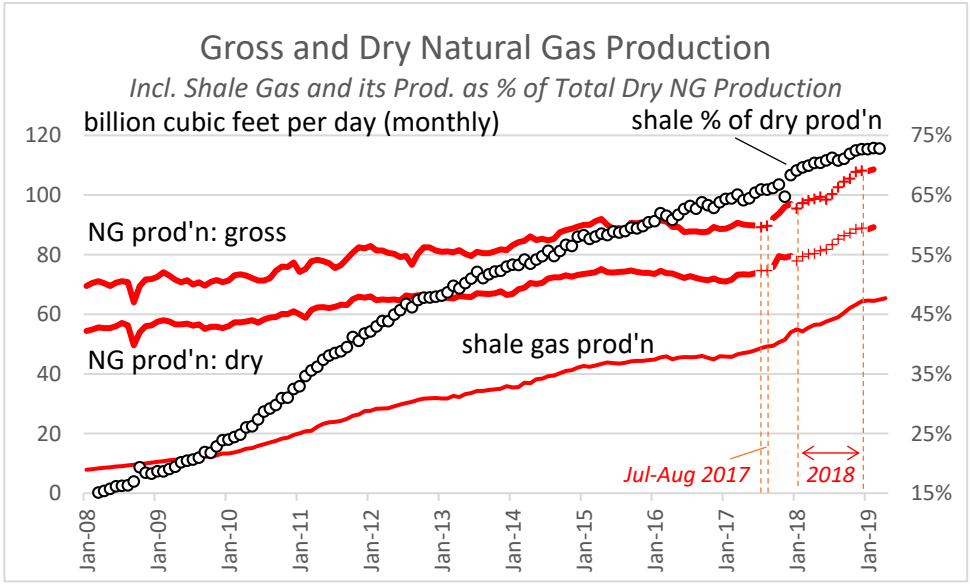

Figure 4. Natural Gas Production Statistics

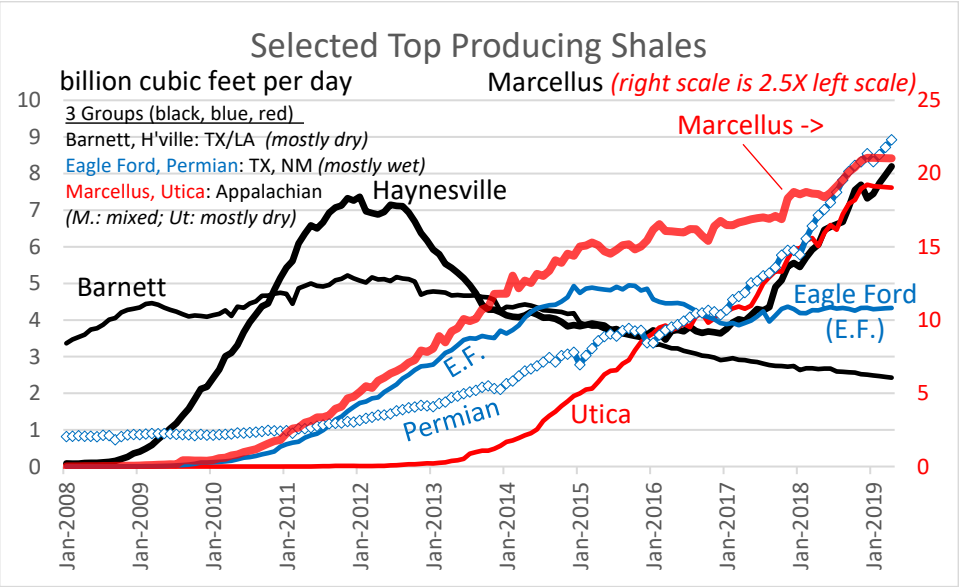

Figure 5. Marcellus, Permian, Haynesville and Utica Lead the Shales

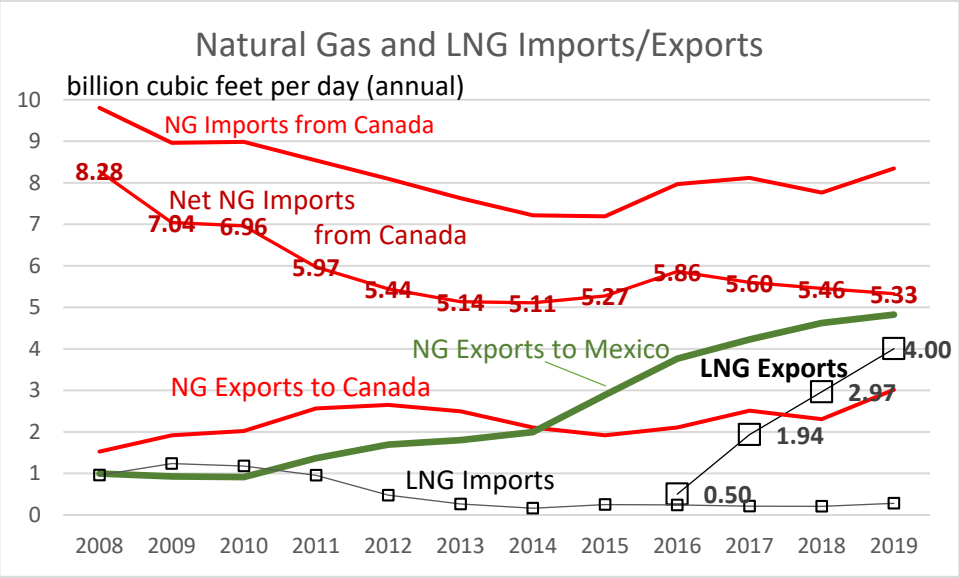

Figure 6. The Three Vital Elements of Gas Trade: Canada, Mexico and LNG Exports

The share of total natural gas production attributed to shales, i.e., fracking, has been phenomenal. While tight oil reached a 60% share of oil production by June-July 2018, and is still hovering there, shale gas reached a 60% share of gas production in December 2015 and 73% by December 2018. While production from the Marcellus is massive, growth in the two years since December 2016 has been dominated by the Permian (+4.8 Bcf/d to April 2019), the Haynesville (+ 4.6 Bcf/d, due to its notable, early 2019 advance), and the Marcellus (+4.3 Bcf/d), with the Utica in fourth place (+3.4 Bcf/d). The Permian has received the most attention, but for natural gas, the historic turnaround of the Haynesville is the biggest surprise.

The U.S. has been a net exporter of natural gas since 2017. The U.S. has long been a net importer of natural gas from Canada, with the numbers falling in a narrow band of 5 to 6 Bcf/d since 2011. In 2017, pipeline exports to Mexico reached 4.2 Bcf/d. The new era of LNG exports, marked by shipments from Cheniere's Sabine Pass facility beginning May 2016, moved to a higher level in 2017, averaging almost 2 Bcf/d. These exports then exceeded the balance with Canada. In 2018 and into early 2019, exports to Mexico climbed by another ~0.5 Bcfd/d, and LNG exports continued their rapid climb, averaging 3 Bcf/d over the year and hitting 1 Bcf/d above that in the first months of 2019. Cheniere was joined by Dominion's smaller Cove Point facility in 2018. Cheniere's four operational trains at Sabine Pass had DOE authorization to ship a combined 20 million metric tons of LNG per year (mtpa), equivalent to 1,006 Bcf/yr (2.75 Bcf/d). The company refers to single train, nominal "run rates" of 4.5 mtpa increasing, in practice, to a recently heightened range of 4.7 to a full 5.0 mtpa. Cheniere's capability increased by 50% in February, 2019 with a fifth train at Sabine Pass and a first at its new Corpus Christi location. The pace of U.S. exports is expected to expand sharply, hitting 6 Bcf/d in the summer and 7 Bcf/d by the end of 2019, based on further expansions from Cheniere and opening the Cameron and Freeport projects. LNG exports will exceed those to Mexico for the first time, even though the latter will expand to 5.5 Bcf/d by summer. These near-term projections are from the Natural Gas Supply Association's *2019 Summer Outlook*, prepared by Energy Ventures Analysis. Exports, particularly of LNG, are being closely watched for their effects on what has been an oversupplied domestic market.

How Big is 2018's Growth in Natural Gas Production from a Consumer's Perspective? One way to appreciate the extraordinary growth in natural gas production is to compare it to different measures of gas use. This is done in Table 1, ranking sates by total gas consumption and their residential sector gas use. The thresholds are consumption of 1 trillion cubic feet (total) and 100 billion cubic feet (residential). Rankings are based on 2017 data due to some gaps in the 2018 record at the time of writing. Texas is the greatest overall gas consumer. 2018's 3+ Tcf production growth would meet 92% of Texas' needs; it is 54% higher than the next largest state, California; and is as great as 45% of all the gas used in the remaining six top states.

Understanding Scale of Growth of U.S. Natural Gas Production in 2018

Dry Gas Production	Bcf	Bcf/d
2017	27,291	74.8
2018	30,440	83.4
Growth	3,149	8.6

Total Gas Consumption, Top States "Trillion Foot Club"
(2017 Data, 2018 if available)

	Rank (per 2017 consumption)	2017, Bcf	Bcf/d	2018 Bcf	Bcf/d
1	Texas	3,399	9.3		
2	California	2,048	5.6		
3	Louisiana	1,426	3.9		
4	Florida	1,377	3.8	1,471	4.0
5	New York	1,230	3.4		
6	Pennsylvania	1,025	2.8	1,197	3.3
7	Illinois	970	2.7	1,101	3.0
8	Ohio	900	2.5	1,060	2.9

Residential Gas Consumption, Top States "100 Bcf Club"

	Rank (per 2017 consumption)	2017, Bcf	Bcf/d	2018 Bcf	Bcf/d
1	New York	432	1.2	476	1.3
2	California	431	1.2		
3	Illinois	378	1.0	435	1.2
4	Michigan	299	0.8	336	0.9
5	Ohio	259	0.7	294	0.8
6	New Jersey	222	0.6	239	0.7
7	Pennsylvania	219	0.6	253	0.7
8	Wisconsin	131	0.4	143	0.4
9	Minnesota	124	0.3		
10	Indiana	124	0.3	144	0.4
11	Massachusetts	121	0.3	130	0.4
12	Colorado	119	0.3	133	0.4
13	Georgia	111	0.3	133	0.4
14	Missouri	87	0.2	114	0.3
	Total	3,056			

Table 1. Top States Gas Consumption Rankings – Total and Residential Sector

With respect to residential use, fourteen states used more than 100 billion cubic feet. The 3+ Tcf production growth is as large as 97% of residential use in all these 14 states combined. The politics of fossil fuel use are addressed later, but it is notable that California and New York

rank second and fifth in total use and have the two largest residential sectors. (The rankings may change somewhat when EIA issues more complete data for 2018.)

Natural Gas Liquids. In addition to these record-breaking developments, natural gas liquids production (principally propane, and smaller amounts of ethane and butane) has grown at an increased pace, tracking supplies in the "Texas Inland" region and lesser growth out of the Appalachian region. Levels averaged nearly 4.5 million barrels per day in 2018 and reached 4.7 Mb/d in March, 1 Mb/d higher than the 2017 level. Exports of propane and butane averaged about 1.1 Bcf/d in 2018, per RBN Energy *NGL Voyager* summary of May 17, 2019.

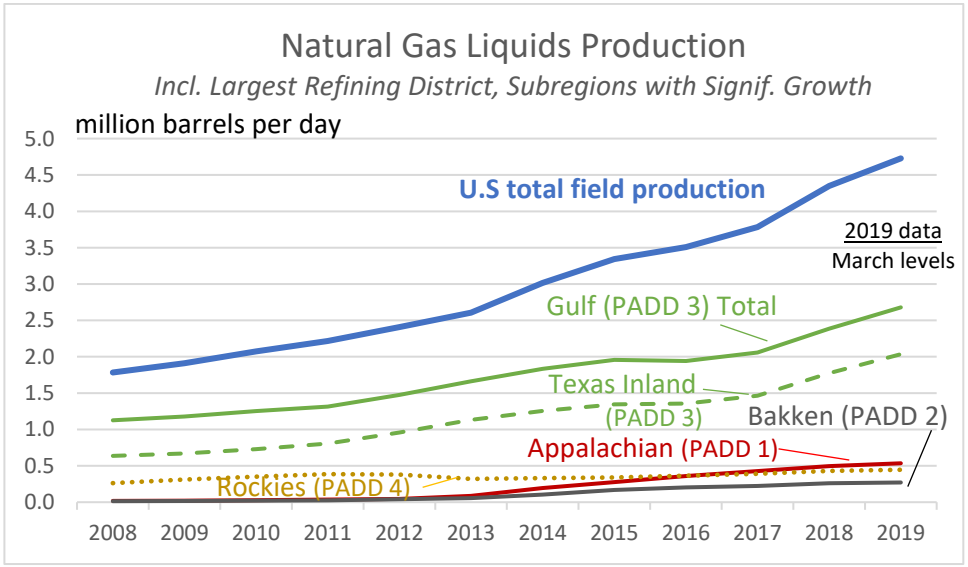

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Figure 7. NGL Supply Growth

Oil and Natural Gas Reserves. The combined technical and financial fortunes of the oil and gas industry are recorded in their reported proven reserves, which like everything discussed so far have reached record highs. By 2017, oil reserves had doubled since 2008, yet they dipped sharply after the oil price collapse (2015), principally due to financially driven revisions in that year (-4.9 billion barrels crude) without a significant boost from extension/discoveries (+2.9 billion barrels crude). 2017 reflects a major turnaround in adapting to lower prices, with positive revisions (+2.6 billion barrels crude) coupled with sharply higher growth in extensions/new discoveries (+5.1 billion barrels crude), the highest in a decade or more. The tight oil share of crude reserves was ~20 billion barrels or 51% of total crude reserves. The next estimate may increase due to higher 2018 prices, but this may not hold due to declines in 2019 (EIA's June 2019 *Short Term Energy Outlook* projects $59.29 per barrel).

Weak natural gas prices hit natural gas reserves twice, causing (negative) -45 trillion cubic feet (Tcf) revisions in 2012 and -81 Tcf in 2015. The 2017 improvement was caused by both substantial positive revisions (+41 Tcf) and a major increase in extension/new discoveries (+71 Tcf), the highest since 2001, maybe ever. The shale gas share, like shale's share of production, reached new highs – 308 Tcf or 70% of reserves measured on a dry basis. The next report will likely hold steady due to higher 2018 prices, but 2019's may decline with the *STEO* at $2.77.

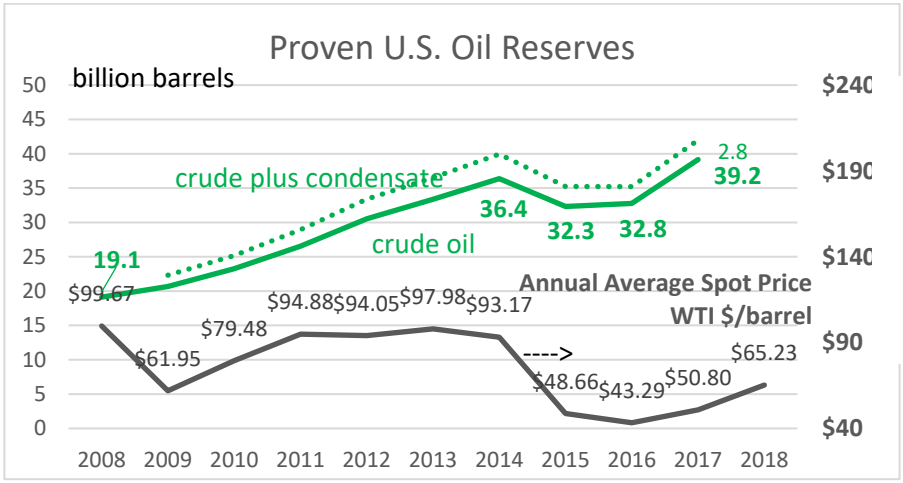


Figure 8. Oil Reserves

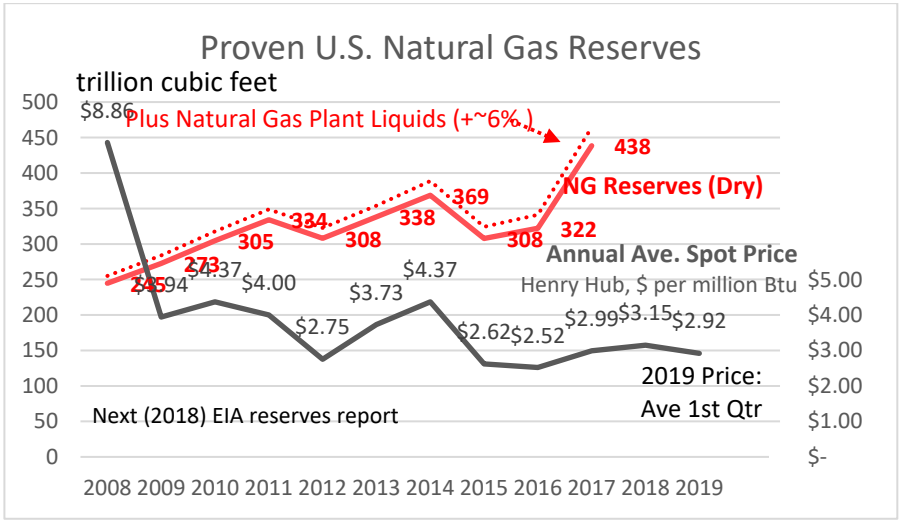


Figure 9. Natural Gas Reserves

Top Growth Sectors of Domestic Natural Gas Demand. A longer history is instructive when looking at the industrial sector because high prices prevailed 2000-2008 (the pre-shale era), which buttressed the move to import LNG and spurred a pronounced period of what became known as "demand destruction". The industrial sector's loss was the power sector's gain, as their opposite fortunes are almost perfectly matched: a 4 Tcf decline in the industrial sector by 2005, a 4 Tcf gain in the power sector by 2007. In the ten years 2008-2018, industrial demand gradually regained lost ground, surpassing 2000 use for the first time last year (2018), by an extra 0.5 Bcf/d. Much of this has been driven by post-2015 renaissance in petrochemicals and related industries. Per the aforementioned NGSA *2019 Summer Outlook*, based on tracking some 80 major projects, about have their anticipated impact on new gas demand had been achieved by 2018, and about half or another 2 Bcf/d remains to come to into effect between 2019 and 2023. These numbers are important to understand the overall scale of changes expected in the important industrial sector. The power sector's growth has been more continuous but rocky, ultimately growing 60 per cent or 10.9 Bcf/d over the last ten years (i.e. from 18.2 Bcf/d in 2008 to 29.1 Bcf/d in 2018).

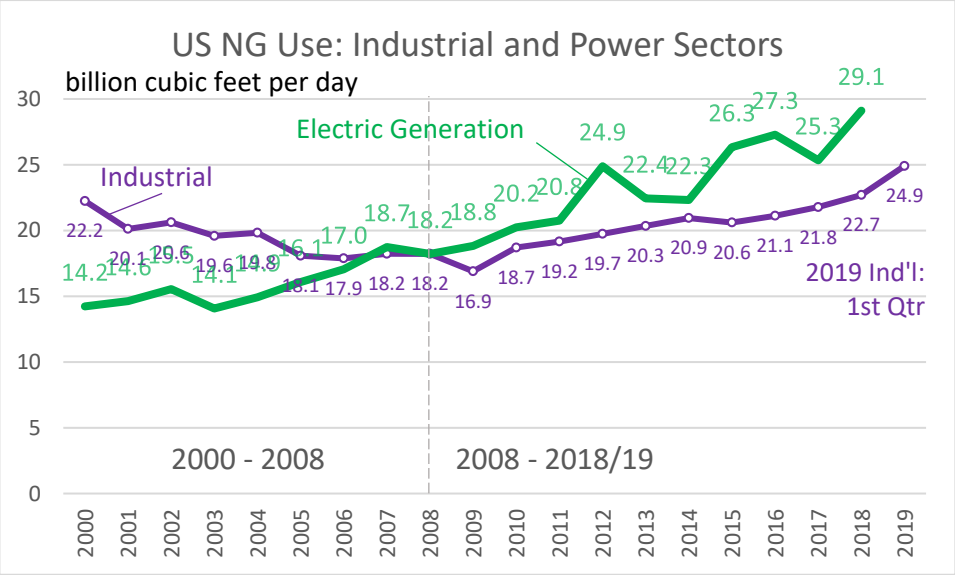


Figure 10. Long-Term History, Industrial and Power

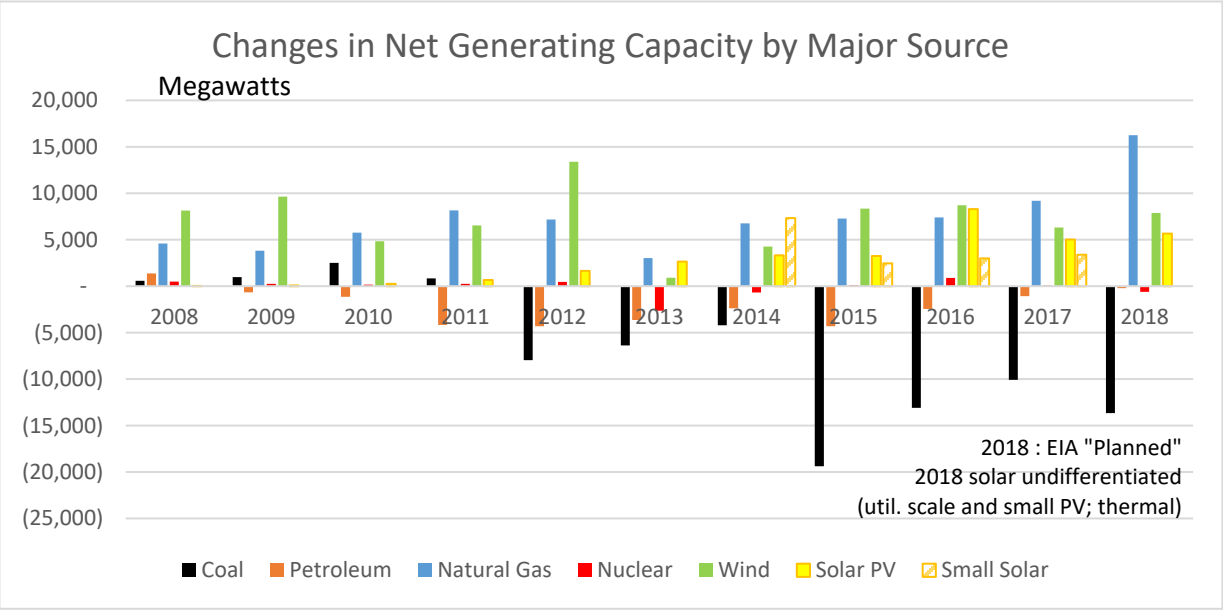


Figure 11. Net Capacity Additions and Retirements

The swings in gas use for power generation have been principally driven by its price, thus the step-ups associated with the price collapse in 2012 (an anomalously mild 2011-2012 winter) and 2015-2016 – and average prices have remained mainly below $3.00/mmBtu ever since. Structural changes, however, are adding to the upward trend in power sector use, namely progressive gas-fired capacity additions and coal power plant retirements. Year-to-year net capacity changes are summarized in the second chart above (Figure 11). In the NGSA *2019 Summer Outlook*, about half the jump in 2018 gas use was attributed to favorable prices and half to capacity additions. The report projected new capacity would account for even more, or 70%, of the growth in the power sector's "gas burn" in 2019, even with continuing soft prices.

As for the coal retirements over this period, coal plants have been subjected to a host of environmental regulations related to emissions of SO_2, NOx, ozone, fine particulates, emissions of mercury and non-mercury hazardous air pollutants, regional haze, and visibility. Waves of retirements across this entire period have been affected by the timelines and extensions for the different rules. The rules do not mandate specific retirements, but rather emissions limits, for which the installation of emissions control technologies such as baghouses for particulates or flue gas desulfurization technologies of various types simply would not be profitable. In these decisions, plant age has certainly been a significant consideration. Nearly all the coal plants retiring in 2015 were 45 to 65 years old.[1] Low-cost natural gas and thus

[1] "What is Killing the US Coal Industry?", Charles D. Kolstad, Policy Brief, Stanford Institute for Economic Policy Research , March 2017. https://siepr.stanford.edu/research/publications/what-killing-us-coal-industry accessed June 12, 2019. See Figure 3.

low power prices have been a factor, and locally, individual plants have accelerated retirement as part of plans to adopt other sources of generation, e.g. as part of Renewables Portfolio Standards processes (more below). It would be difficult to tease apart the role of all these different influences.

Power Sector Detail. Gas-fired generation began to exceed coal during most of 2015 and thereafter, the gap widening since early 2018. The exception was the frigid 2016-2017 winter.

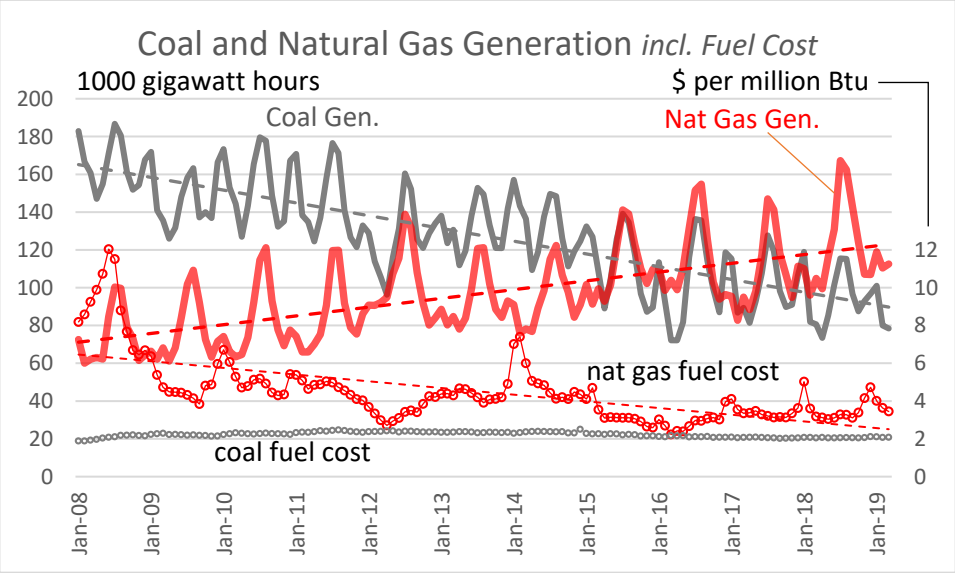


Figure 11. Trajectories of Coal and Natural Gas Generation

The states with largest growth in gas use for power generation are Florida, Pennsylvania and Virginia, reflecting changes in their generation mix. All benefited from the cheap prices stemming from the mild 2011-2012 winter. No trend appears to be dominant in Texas. The gradual rise of its wind generation has eroded natural gas growth, evident in the moderating of the increase in the state's winter/spring minimums, which rose sharply in 2015. A clear anomaly is the degree to which gas generation was greatly curtailed during the frigid 2016-2017 winter.

The trend of gas-fired generation in California, looked at annually, is also not very distinct, but the more recent years of lower gas-fired generation reflect one force that has been rising inexorably, renewables, aggravated by three years in a row of normal to above-normal hydroelectric generation.

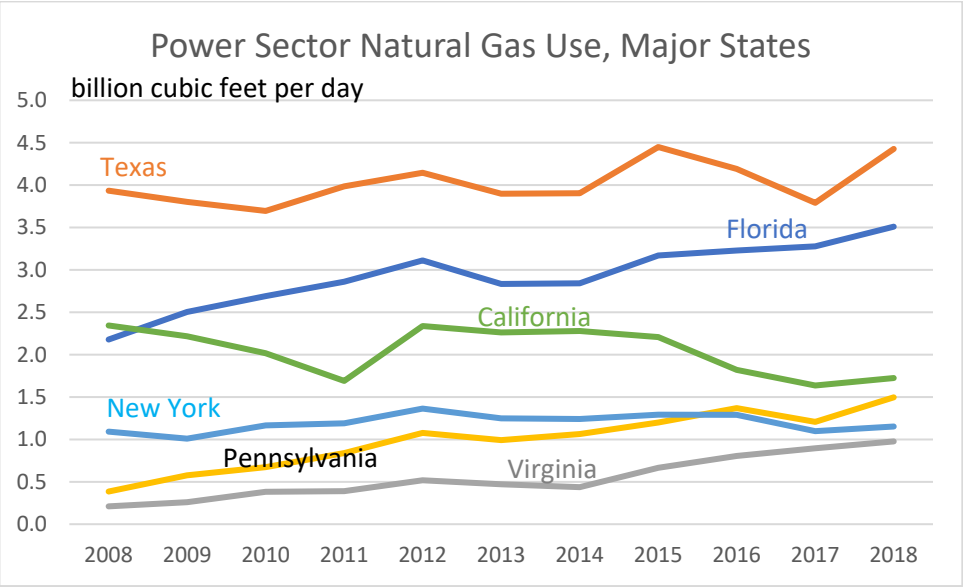


Figure 12. Gas Use for Power, Major States

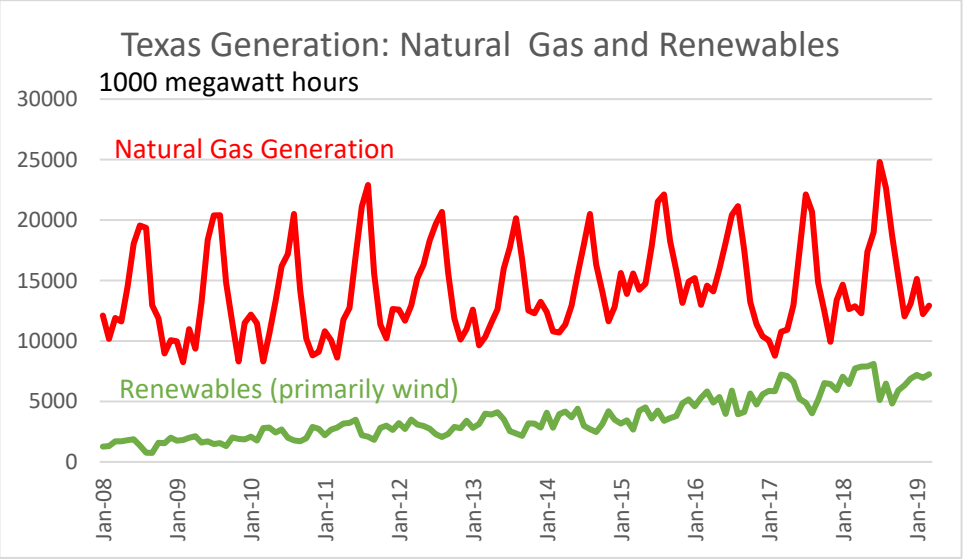


Figure 13. Texas Generation Detail

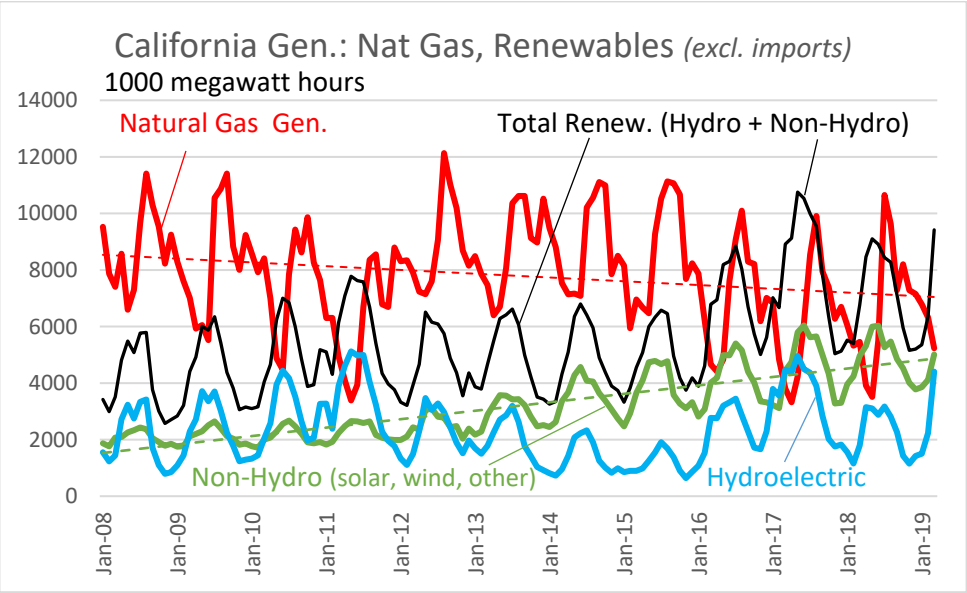


Figure 14. California Generation Detail

This review returns to the states of Texas and California, also addressed in the annual summary a year ago, due to the bellwether role these high-renewables states may play for understanding implications of greater renewables penetration on the use of natural gas for power.

Industrial Sector Detail. This summary concludes with geography of the industrial sector. The top states and those with the greatest recent increases in gas use in this sector are two, Texas and Louisiana. California and Illinois are essentially flat. The growth in Indiana has been gradual, post-Great Recession. Iowa's 2017 jump of 1+ Bcf/d occurs all months, hinged to the start-up of Iowa Fertilizer Co.'s plant, the first such greenfield plant producing nitrogenous fertilizers in 25 years (see EIA *Natural Gas Weekly Update*, May 4, 2017).

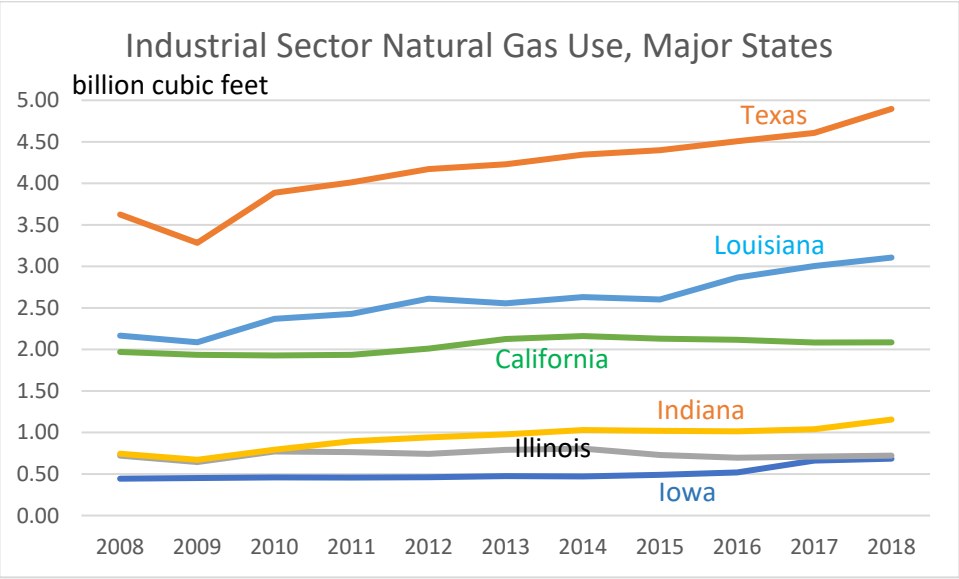


Figure 15. Gas Use by Industry, Major States

A Magnifying Social Agenda

Culminating 30 Years of Climate Science. A formalized mechanism to address looming problems of climate change can be dated to 1988 with the founding of the Intergovernmental Panel on Climate Change (IPCC) under the auspices of the United Nations Environmental Programme (UNEP) and the World Meteorological Organization. UNEP is the organization which led, only a year before, to the signing of the Montreal Protocol on Substances that Deplete the Ozone Layer, widely heralded for its success and contrasted with the failure to address climate change.[2] The IPCC has therefore been around for a long time. It counts such milestones as the Kyoto Protocol, signed December 11, 2007, and the Paris Agreement, signed December 12, 2015. The former set in motion a "first commitment" period of hoped-for "binding targets" through 2012, albeit without U.S. ratification. The latter, also known as the Paris Accord, notably steered clear of setting unpopular or unrealistic binding targets, substituting modifiable/updatable "intended nationally determined contributions". The U.S. contribution envisioned, by 2025, a 26-28% reduction in greenhouse gases from 2005 levels, considered to be on track with a much steeper 80% reduction by 2050. 4 ½ months into his term, U.S. President Trump pledged June 1, 2016 to withdraw from the Agreement, an event which could occur November 4, 2020, four years after the agreement went into effect.

While the flexibility in the new approach is indeed a lessening of stringency, the science of climate change has been moving in the opposite direction. This is apparent from major reports released in 2017 and 2018. Sticking with the IPCC, it is developing a series of additional reports leading up to its Sixth Assessment Report, scheduled for June 22, 2022. On October 7, 2018, it released its *1.5 C Special Report*. This study describes just how bad things will be if global temperatures increase only +1.5° C 9 (2.7°F) above pre-industrial levels, compared to +2° C (3.6°F), and how steep reductions would have to be to level out at those levels. The 1.5C° task is daunting, namely to reduce global anthropogenic emissions of CO_2 by 45% from 2010 levels in just twelve years and needing to reach net zero by 2050. A 2°C goal would lighten that near-term task to a reduction of 25% instead of 45% and extend the net zero point by 20 years.[3]

U.S.-centered impacts and challenges of climate change are the chief focus of the U.S. Global Change Research Program, established by Congress at essentially the same time that the IPCC started, following from a 1989 Presidential Initiative and Congress' Global Change Research Act of 1990. It involves the efforts of 13 federal agencies and recent financial commitments across these agencies of about $2.5 billion per year. The Fourth National Climate Assessment (NCA4) was issued in October, 2017, followed by a second volume in November 2018. From the first report, a figure lays out the general correlation between the scale of emissions and temperature impacts (Figure 16; Figure 14.2 in document). CO_2 emissions from energy and industry are indicated on one scale, a proxy for a variety of contributors to

[2] Cass R. Sunstein, "Of Montreal and Kyoto: A Tale of Two Protocols", Environmental Law Reporter ELR ® 10566, August 2008. Available from Environmental Law Institute (fee) https://elr.info/news-analysis/38/10566/montreal-and-kyoto-tale-two-protocols and Vanderbilt Law School (reprinted with permission) https://law.vanderbilt.edu/files/archive/Sunstein-2008.pdf.

[3] IPCC references: https://www.ipcc.ch . *Global Warming of 1.5°C*: https://www.ipcc.ch/sr15/ News reporting upon the release of the IPCC's October 7, 2018 report: https://www.washingtonpost.com/energy-environment/2018/10/08/world-has-only-years-get-climate-change-under-control-un-scientists-say/?utm_term=.d5941aeb2bbc

temperature changes across the "full set of human activities and physical Earth systems", including other greenhouse gases, short-lived emissions such as methane, and aerosols. The flat line on the left side (A), branching off at "INDCs", tracks the path of emissions if no improvements are made beyond all the parties to the Paris Agreement complying with their intended nationally determined contributions (INDCs). The associate warming impact at the end of the century is shown on the right side (B). At a 50:50 probability level, it bridges 2-3°C and 3-4°C, far above the desired 1.5-2°C, beyond which already-bad outcomes become increasingly dire. This underscores why all these studies recognize that much greater reductions are needed than the first intentions made at the Paris Agreement.

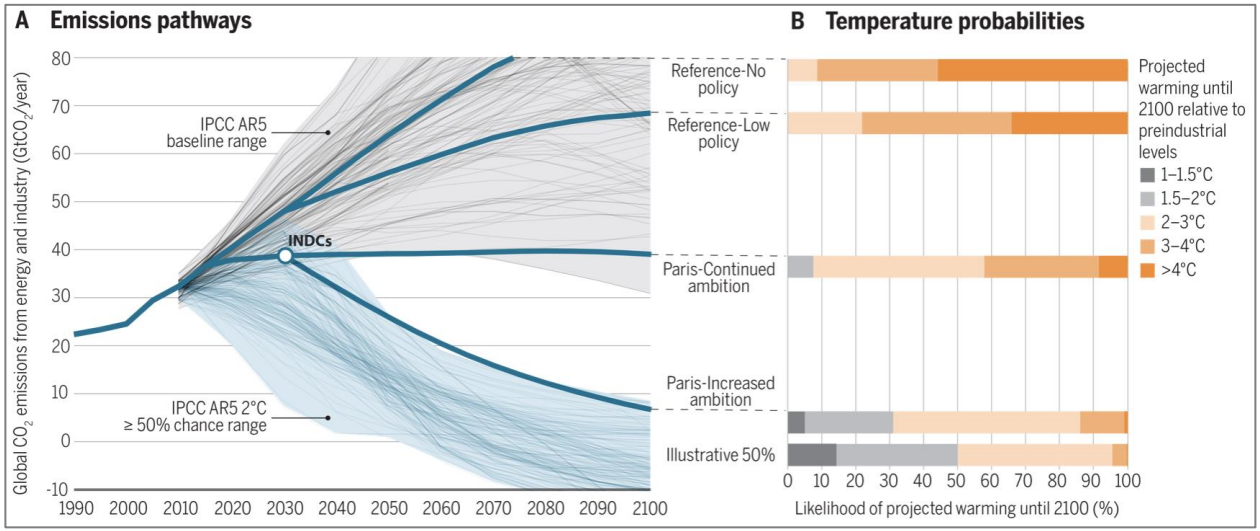


Figure 16. US National Climate Assessment: Emissions and Temperatures[4]

Whether societies can mobilize to meet any of the more stringent goals, even aware of consequences of not doing so, goes into aspects of psychology, politics and socioeconomics that are not within the scope of the assessments.

The Center for Climate and Energy Solutions (C2ES) is somewhat of an outlier in this regard, with a recent initiative tapping a number of prominent energy industry stakeholders. The organization's stance can be described as "informative" rather than "persuasive", acting as a hub to various studies and offering perspective on the host of official documents issued by the U.S. Global Change Research Program, the UN IPCC, and others.[5] While there may be no such thing as a practical response to climate issues, my reading of the C2ES materials leads me to

[4]Fourth National Climate Assessment (NCA4) Volume 1, Climate Science Special Report: Chapter 14: Perspectives on Climate Change Mitigation. 2017 https://science2017.globalchange.gov/chapter/14/

[5] Center for Climate and Energy Solutions: https://www.c2es.org; *Pathways to 2050: Alternative Scenarios for Decarbonizing the U.S. Economy,* May 2019: https://www.c2es.org/document/pathways-to-2050-scenarios-for-decarbonizing-the-u-s-economy

characterize the organization as not wanting the perfect to become the enemy of the good. Over the course of 2018, C2ES convened a host of company representatives to help develop and guide serious discussion and analysis on how the U.S. might bridge the gap between insufficient measures and achieving an 80% CO_2 reduction by mid-century, consistent with 2°C or better goals. Participants included such stakeholders as ABB, Arizona Public Service, Berkshire Hathaway Energy, BHP, BP, Dow, Duke Energy, Entergy, Exelon, National Grid, Pacific Gas and Electric, and others.

A question of certain concern to the oil and gas industry is what happens, or seemingly must happen, to the use of natural gas and oil? The study foresees oil use (gasoline and other fuels in transportation) dropping about 10% by 2030 and by a stark two-thirds by 2050. This is based on quantifying a group of quite different reduction scenarios ("pathways") all moving in the same direction. Major inroads are made by efficiency, electric vehicles, biomass-derived fuels and possibly hydrogen. Likewise, near-term changes in natural gas-fired electric generation are modest, possibly with some carbon sequestration entering the picture. By 2050, though, natural gas reductions (compared to the 2030 reference case) are also extensive, approaching 50%. Two-thirds of this gas-fired generation employs carbon capture and sequestration. Massive increases take place in solar and wind. Several of the scenarios specify significant to massive multipliers in nuclear power. Against this, even with the participation of industry representatives, the cost implications are surprisingly obscure and the over-arching 80% reduction goal by 2050 may appear unattainably ambitious. Nevertheless, the direction and scale of possible change deserve scrutiny as an 80% reduction is becoming a kind of "baseline".

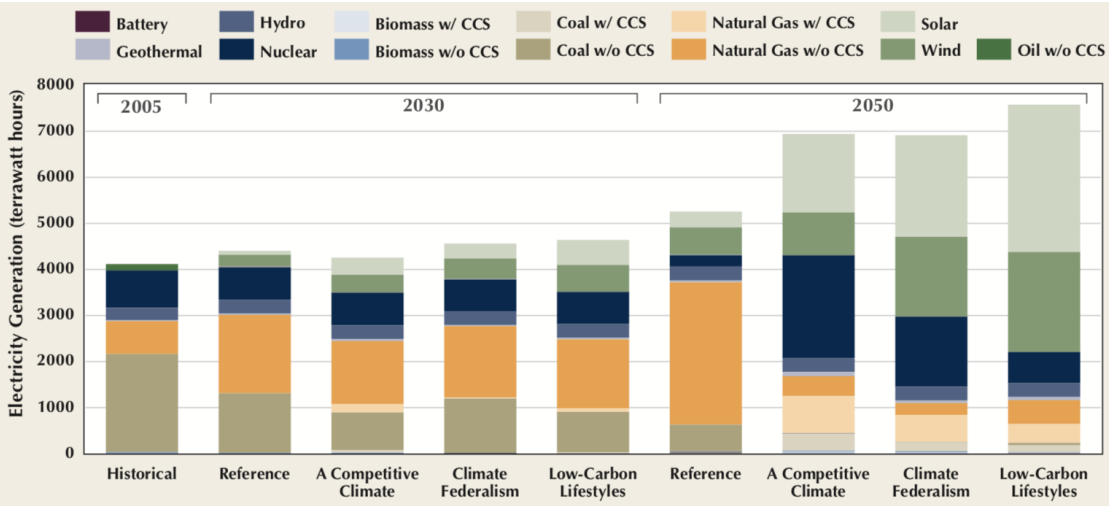


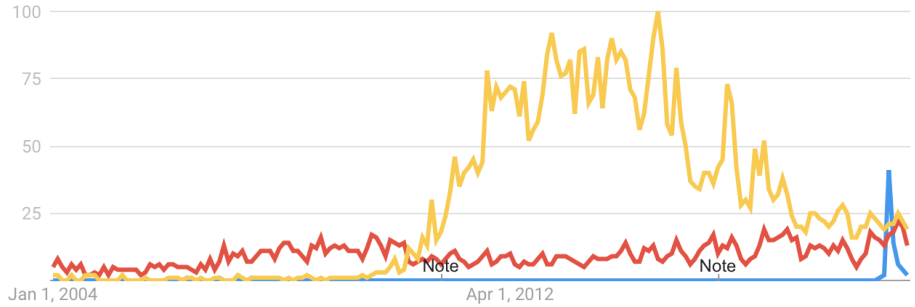
Figure 17. C2ES "Pathways" for Climate-Driven Change in Electricity Generation

Calculations such as these describe how climate challenges present truly existential risks to the oil and gas sector, should societies address them as rapidly and deeply as defined or unless alternative pathways present themselves. They also have transformative implications for any kind of long-term economic planning and forecasting.

As disturbing as these voices are to the citizen or to the oil/gas professional, it is curious that they have hardly risen above the level of a persistent background hum until so very recently. This owes in part to the fact that climate change or "global change" have been visible parts of the energy-environment landscape for 30 years, in part because the problem has always appeared so intractable along so many dimensions, and in part to other aspects of human nature (aspects of which are addressed in a recent book on the early history of climate awareness highlighted below). So, what's different now?

The Crescendo of Rising Aspirations – Green New Deal and New Urgencies. The last months of 2018, and the period since, stand out as a time when the ripples of concern over climate change reached a new level. This jumps out, not just from the handful of resonating scientific reports, but also from the newspapers, both the traditional and alternative press, political news, energy-economic seminars, and the like. The period also coincides with the takeover of the U.S. House of Representatives in the November, 2018 midterm elections by a wave of progressive and other Democrats. Beyond one's anecdotal experience, one way to capture what's different now is to track internet topic searches over time using the Google Trends tool. This is done in Figure 18.

A 01 Jan 2004 – 18 June 2019



B 24 June 2018 – 18 June 2019

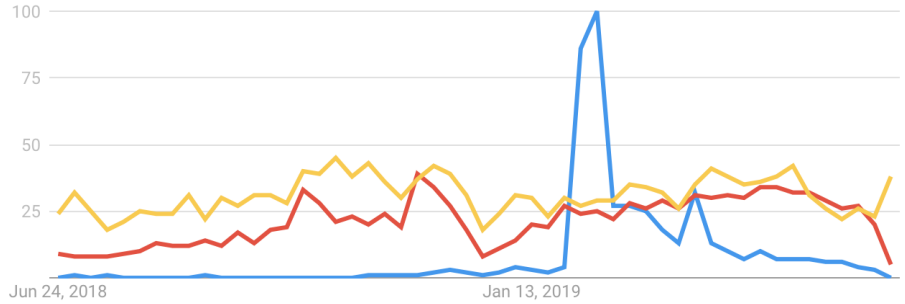


Figure 18. Internet Search Frequencies using Google Trends

The Green New Deal is a resolution introduced on February 7, 2019 to the House of Representatives by Alexandria Ocasio-Cortez (D-NY) and to the Senate by Edward Markety (D-MA). The House version, H. Res. 109, has 93 cosponsors and went to 11 committees and 10 subcommittees.[6] The Senate version, S. Res. 59, went to one committee and has 12 cosponsors.[7] The resolution is "It is the duty of the Federal Government to create a Green New Deal", which focuses in part on climate and in part on many other social and economic ills.

The first words refer to the October 2018 IPCC Special Report on Global Warming of 1.5°C and the November 2018 Fourth National Climate Assessment, discussed above. It proceeds to summarize key findings from those reports, underscoring the importance to hold warming to +1.5°C. Current impacts cited from these studies include rising sea levels, wildfires, severe storms and drought. Unabated impacts cited include global mass migrations, $0.5 trillion lower U.S. economic output by 2100, a doubling of wildfires in the western U.S., loss of 99% of coral reefs globally, exposure of 350 million people to deadly heat stress by 2050 (globally), and $1 trillion damage to U.S. public infrastructure and coastal real estate.

The resolution recognizes the global nature of the problem, citing the United States' disproportionate historic responsibility for greenhouse gas emissions ("20% of global greenhouse gas emissions through 2014"), its "high technological capacity", and therefore its need to "take a leading role in reducing emissions through economic transformation". It calls for a "10-year national mobilization" to both eliminate "pollution and greenhouse gas emissions *as much as technologically possible*" and to meet "*100 percent* of the power demand in the United States through clean, *renewable*, and zero-emission energy sources" (italics added). The time frame is shockingly short and even the two goals of technological feasibility and 100 percent renewables appear to be in conflict. Further, there is no explicit mention of nuclear power. But there is certainly a sense of urgency.

[6] https://www.congress.gov/bill/116th-congress/house-resolution/109
[7] https://www.congress.gov/bill/116th-congress/senate-resolution/59?q=%7B%22search%22%3A%5B%22green+new+deal%22%5D%7D&r=3&s=2

Affordability comes up in some parts of the resolution, which refers to "systemic racial, regional, social, environmental, and economic injustices". The resolution writes that, beyond the direct climate-related goals, the goals are "to create millions of good, high-wage jobs", "to ensure economic security for all people", "to secure clean air and water…, healthy food, access to nature…", and "to stop current, prevent future and repair historic oppression" of a wide array of disadvantaged people and communities. Affordability is mentioned directly regarding access to electricity and affordability of buildings, public transit, housing and food.

Because of the broad scope and almost limitless aspirations of the Green New Deal, it might be easy to dismiss it or label it as a kind of socialist propaganda. It is therefore noteworthy that the government's National Climate Assessment describes U.S. communities particularly vulnerable to climate-related risks explicitly and in detail, as follows:[8]

> …children, older adults, low-income communities, some communities of color, and those experiencing discrimination are disproportionately affected by extreme weather and climate events.

The report embellishes further:

> … poor people in high-income regions, minority groups, women, pregnant women, those experiencing discrimination, children under five, persons with physical and mental illness, persons with physical and cognitive disabilities, the homeless, those living alone, Indigenous people, people displaced because of weather and climate, the socially isolated, poorly planned communities, the disenfranchised, those with less access to healthcare, the uninsured and underinsured, those living in inadequate housing, and those with limited financial resources to rebound from disasters.

The efforts of the IPCC are similarly interconnected across a broad spectrum of impacts, in that the U.N. has set forth a number of Sustainable Development Goals which intertwine with climate impacts and affect people and their livelihoods in many circumstances. Its activities extend to poverty, hunger, health, "decent" work/economic growth, and others, in addition to goals of "affordable clean energy" and "climate action".[9] The latter is where the IPCC activities most closely fit.[10] When the scope of the IPCC and the National Climate Assessment is seen more fully, the breadth of aspirations expressed in the Green New Deal looks less out of step.

Cauldron of Choices. From its first day, the Green New Deal rose above what might be called a cauldron of choices, some long-simmering, some recently added. A major driver heating up the cauldron is the prospect of the U.S. 2020 elections, bringing forth a number of new climate proposals, heightening the attention given to some new entities such as the Sunrise Movement[11], and reminding us of pre-existing

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[8] Fourth National Climate Assessment, Chapter 14: Human Health. https://nca2018.globalchange.gov/chapter/14/

[9] The UN's "2030 Agenda for Sustainable Development" was adopted at the UN's Sustainable Development Summit in New York on September, 2015, about three months before the Paris Agreement. https://sustainabledevelopment.un.org/post2015/transformingourworld

[10] UN Sustainable Development Goals. 13: Climate Action. https://www.un.org/sustainabledevelopment/climate-change/

[11] The Sunrise Movement, representing a self-described youth perspective, encouraged candidates in the 2018 election to not accept support from the fossil fuel industry. The week after the election, it staged a protest before then House Minority Leader Nancy Pelosi's office calling for an aggressive plan on climate change, supported by newly-elected Alexandria Ocasio-Cortez who by that time had already drafted a measure to establish a "Select Committee for a Green New Deal". Background: https://www.vox.com/energy-and-environment/2018/11/14/18094452/alexandria-ocasio-cortez-nancy-pelosi-protest-climate-change-2020 Organization: https://www.sunrisemovement.org/

activities which have been long been around, such as "Keep it in the Ground" campaigns[12] and fossil fuel divestiture initiatives[13]. The legacy includes protests over the Dakota Access Pipeline tapping the Bakken tight oil region, ostensibly related to water and sacred grounds[14], and the still-progressing battles over the Keystone XL Pipeline tapping Alberta oil sands.[15]
Climate effects due to oil use became a highly politicized flashpoint confronting the XL Pipeline, whose history shows just how persistent and lingering these concerns can be. The Obama Administration's rejection dates to 2015. That decision occurred shortly before the Paris Agreement, motivated in part by how its approval could undermine the appearance ("tone" and "attitude") of U.S. climate leadership.[16]
There is an object lesson in this that applies to the mix of politics and giant things, such as U.S. fossil fuel use, when we see how much politics can embroil so much smaller things, a single pipeline among many.

What else is in the cauldron? A systematic review of proposals is impractical at this time, but it is important to understand the tenor of ideas, to appreciate that the ambitious Green New Deal is not the only deal in town, that pressures are building from a number of directions.

The Governor of Washington Jay Inslee is promoting a "Climate Mission Agenda" comprised of two plans announced in May: a "100% Clean Energy for America Plan" and an "Evergreen Economy Plan".[17] The vision is to "defeat climate change", thus every bit as aspirational – and apparently more so with this phrasing – than the Green New Deal. It carries a price tag of $300 billion per year of federal spending over ten years, expected to leverage an additional $600 billion per year in other spending. The effort is described as a "mobilization", set forth a Clean Energy Standard in power generation to be carbon-neutral by 2030 and 100% clean, renewable and zero-emission five years later, along with zero emissions in categories of new vehicles and buildings by 2030. Provisions extend to clean water, worker protections, education, a quintupling of energy R&D to $35 billion per year and other initiatives.

Massachusetts Senator Elizabeth Warren's proposals are addressing specific segments of the climate challenge, e.g. a moratorium on federal leasing, stricter standards on methane leakage, net zero emissions from non-combat military bases, a $1.5 trillion plan for procurement of

[12] http://keepitintheground.org
[13] These initiatives, not exclusively based on college campuses (only 15% of the total being tracked), as of June 2019 number over 1,000 and credit total divestment as worth $8.77 trillion. https://gofossilfree.org/divestment/commitments/
[14] The Standing Rock Sioux tribe protested to halt Energy Transfer Partners' DAPL during most of 2016. The project stalled over various Agency requests and eventually halted under the Obama Administration by order of the Army Corps of Engineers, only to be authorized in Jan/Feb 2017 under the Trump Administration. The line went into servicer June 1, 2017. Current status per ETP website: https://daplpipelinefacts.com
[15] TransCanada's Keystone XL Pipeline, first proposed in Canada in 2008, became embroiled in disputes between the US EPA, the State Department, and two Administrations. Like DAPL, it was given new life under the Trump Administration only to confront further legal challenges with the latest response to provide a new presidential permit (March 29, 2019). Wall Street Journal: "Trump Moves Again to Clear Path for Keystone XL Pipeline" https://www.wsj.com/articles/trump-issues-new-permit-for-keystone-xl-pipeline-11553894429
[16] Keystone XL timeline: https://ballotpedia.org/Keystone_XL_Pipeline_political_timeline
[17] Inslee overview: https://www.cleantechalliance.org/2019/05/16/jay-inslee-announces-climate-mission-agenda-part-ii/ . Plans: https://jayinslee.com/issues/100clean and https://www.jayinslee.com/issues/evergreen-economy/text/Inslee_EvergreenEconomyPlan_2.pdf

US-made low-carbon technology ($150 billion per year over ten years), substantial foreign assistance ($100 billion), and jacked-up energy R&D ($400 billion over ten years).[18]

Beto O'Rourke, former House Representative from Texas, proposes a $5 trillion effort over ten years, leveraged by $1.5 trillion federal dollars, to achieve net zero emissions by 2050, half of that to be achieved by 2030. The standard would be issued by executive order. R&D would receive $250 billion. The bulk of expenditures are directed to infrastructure and communities.[19] Use of a carbon tax is unclear. A fact sheet indicates the stardard will "send a clear price signal to the market."[20]

As this handful of examples indicate, a lot of money is needed. Public monies are expected to leverage very significant amounts of private capital. A net zero target by 2050, maybe earlier, is becoming the de facto goal, which would imply the drastic declines in coal, oil and gas use mapped out earlier would be necessary. The notion of a carbon tax, per se, appears to be unpopular, although it is quite likely this aversion will melt away over time as financial challenges become more evident.[21] Nuclear power and waste handling are barely mentioned, although the need for advanced nuclear power has been raised. And virtually no attention is given to the international dimensions of the climate challenge, without which all efforts would be naught (the single exception being Warren's "Marshall Plan". Ending oil and gas industry subsidies and tackling methane leakage are priorities, as is, especially, providing a strong boost to R&D.

In contrast to these Democrat-led proposals, most centered on meeting the IPCC threshold targets (basically net zero CO_2 and related emissions by mid-century, with Warren not yet tackling the scope in those terms), the singular proposal to date on the Republican side, from Senator Lamar Alexander, is centered on ten R&D "grand challenges". It directly criticizes the Green New Deal in colorful language as being "so far out in left field that that not many are going to take it seriously" and, to silence on nuclear power, "With nuclear power available, the [Green New Deal's] strategy for fighting climate change with windmills and solar makes as much sense as going to war in sailboats". His proposal is a five-year "Manhattan Project for Clean Energy"[22]. That image echoes the kind of "mobilization" seen in all the other proposals, although the dollars are not comparable.[23] Its emphasis is squarely on R&D, not on the U.S. achieving anything like "net zero", a strategy

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[18] Overview of Sen.Warren initiatives to date: https://www.vox.com/policy-and-politics/2019/6/22/18691902/elizabeth-warren-2020-climate-change-policy-proposal-corruption and "Elizabeth Warren Adds $2 Trillion And A Green Marshall Plan To Climate Vision" https://www.huffpost.com/entry/elizabeth-warren-climate-plan_n_5cf5b117e4b0a1997b6f86e3

[19] O'Rourke campaign overview https://betoorourke.com/climate-change/

[20] O'Rourke factsheet: https://gallery.mailchimp.com/26e7511e243b1abdc9f1a6130/files/e6ceb790-0b5c-4968-b65a-3530b0db324b/ORourke_Climate_Plan.pdf

[21] Philip Sharp, former Indiana congressman and president emeritus of Resources for the Future: "Keynote: Federal politics on the cusp of major climate policy". Silicon Valley Energy Summit 2019, Stanford University, June 21, 2019. J. Platt notes. Sharp observed that political bargaining might take the form of trading actual tax hikes for carbon taxes.

[22] Sen. Alexander's outline: https://www.alexander.senate.gov/public/index.cfm/2019/3/one-republican-s-response-to-climate-change-a-new-manhattan-project-for-clean-energy-10-grand-challenges-for-the-next-five-years

[23] Sharp, ref. previous footnote, offered cautions about such top-down analogies as the space program or over-proscribing technology winners (such as through Renewable Portfolio Standards, as these underestimate the role of technological dynamism and overestimate the powers of forecasting.

which it justifies in the context of the global nature of the problem: "…reducing carbon emissions in the United States may be a good thing to do, but it doesn't do much to address climate change because most of the increase in greenhouse gases is in developing countries" (v. footnote 22). Among the Project's "grand challenges" are advanced nuclear, carbon capture, batteries, solar, buildings (these receive a lot of attention in the other proposals), and even fusion. A doubling of R&D funding is recommended, to a level of $6 billion per year.

The preceding sets forth the different ends of the spectrum of the social agenda on climate change. On one end, bold, expensive and politically-daunting steps ("mobilization"), possibly suitable to the task in an international equity or symbolic sense, and on the other end, non-controversial, essential programs of strengthened research but little else. It is impossible to know where across this spectrum the nation will ultimately wind up, or when. An example of what could lie in the middle is an approach like the Baker-Shultz "Climate Dividends Plan" supported by the Climate Leadership Council. It has garnered support from the oil industry. Considered more stringent that the Paris Agreement intended reductions, it is estimated to drive U.S. CO_2 emission reductions to 41- 47% below 2005 levels by 2035.[24] It is based on a gradually escalating carbon tax of about $40/ton from 2021 onwards. Its attractions to the oil industry are based on several features (pointed out in the 2019 spring commentary, Footnote 24). The stringency falls short of sending dramatic shocks to the transportation sector (e.g., $50/ton translates to 44 cents per gallon) – a leniency which comes at the expense of a flatter emissions profile after the 2030s. But perhaps more important to the fossil fuel industry, the plan would preclude lawsuits related to damages from historic contributions to emissions. This is not just a theoretical risk, as confirmed by existing lawsuits and public attitudes surveyed by Yale's Program on Climate Change Communication on June 19, 2019 (54% in favor of fossil fuel companies paying for all or most of damages ascribed to climate change).[25]

Renewable Portfolio Standards – The Future is Now. Twenty-nine states have enacted Renewable Portfolio Standards (RPS), with some moving toward economy-wide "net zero" standards (e.g. Washington). Figure 19[26] provides an update into June, 2019 drawing principally on the DSIRE® maps, with updates based on consulting C2ES data (Climate Change and Energy Solutions, cited earlier) and recent announcement coming from New York's Assembly's actions (pending governor signature). Four states, noticing how cheap electricity costs have imperiled their nuclear reactors, have enacted Zero Emission Credits. There are some nuances in the state programs, such as whether natural gas can be counted as clean and whether the states have enacted measures beyond the electric sector, for which the C2ES provides additional details (Footnote 25).

The most notable recent developments are the swings on the deep environmental side. Hawaii was first to claim a 100% renewable standard, by 2045. It has now been matched by California, Washington, and New Mexico. The measure approved by the New York Assembly in June,

[24] Baker-Shultz plan: https://www.clcouncil.org/our-plan/ Climate Leadership Council endorsement and analysis of plan's impacts – "Exceeding Paris": https://www.clcouncil.org/media/Exceeding-Paris.pdf Context, attraction to oil industry and commentary as of spring 2019: https://insideclimatenews.org/news/07032019/carbon-tax-proposals-compare-baker-shultz-exxon-conocophillips-ccl-congress

[25] Yale surveys: https://climatecommunication.yale.edu/publications/majority-of-americans-think-fossil-fuel-companies-are-responsible-for-the-damages-caused-by-global-warming/

[26] The principal reference for Figure 19 is DSIRE®: http://ncsolarcen-prod.s3.amazonaws.com/wp-content/uploads/2018/10/Renewable-Portfolio-Standards-2018.pdf Further tracking: https://www.c2es.org/document/renewable-and-alternate-energy-portfolio-standards/

2019 would advance the date for similar stringency to 2040, now awaiting the Governor's signature. On the far left, there has been a leapfrogging among several states to achieve environmental leadership and, while coal is not a major share of these states' generation, the implications for natural gas are considerable. The enabling factor is Democratic lead the legislative bodies in these states, coupled with a Democratic governor.

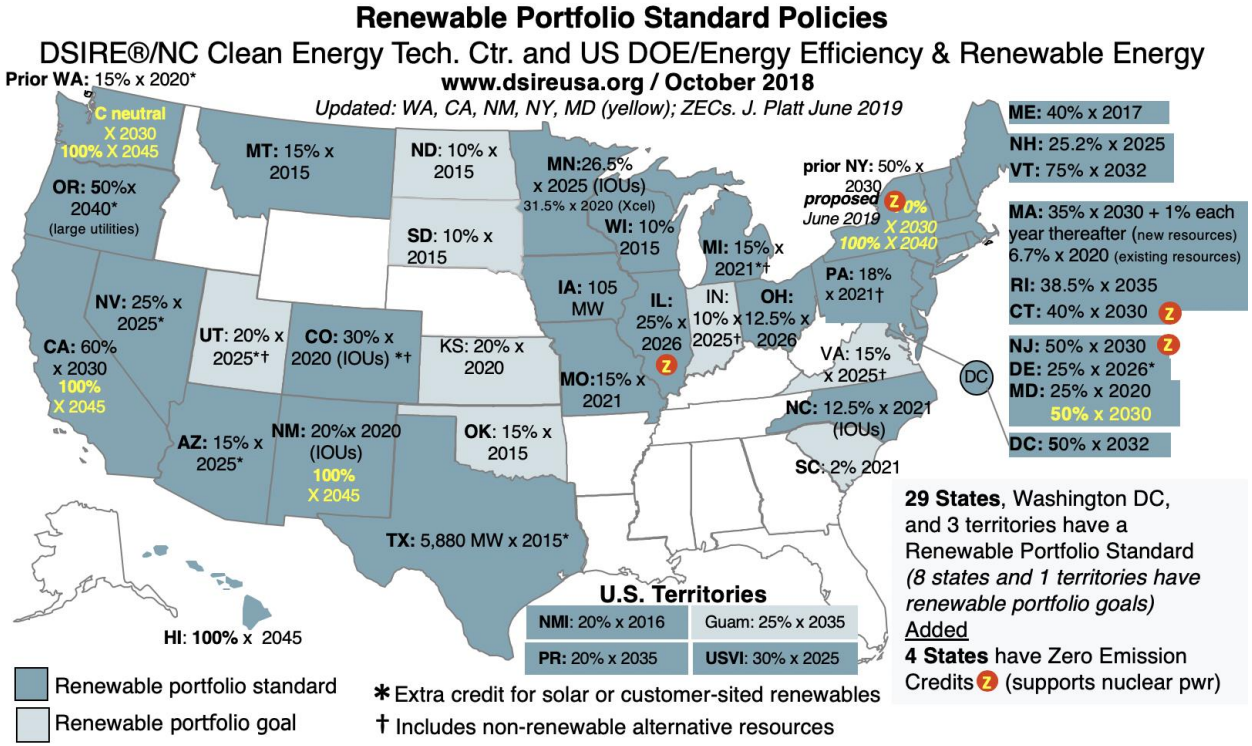

Figure 19. State Actions to Decarbonize Electric Power

What Else is Different About Now? Similar to setting standards such as these, although not as impactful, is the bubbling up of additional support for climate measures from states and cities. And there is a new stridency, with the carrying of protests into the streets. A 24-state subset of those with RPS has joined then United States Climate Alliance, represented by their governors.[27] Membership is mapped in Figure 20 (also Footnote 26). While the geography is not greater than the RPS, the principal goal is to achieve the aims of the Paris Agreement, i.e. to reduce greenhouse gas emissions 26-28% below 2005 levels by 2025. For a number of the states, those reductions could not be achieved by their existing Portfolio Standards alone.

[27] US Climate Alliance (state governors): https://www.usclimatealliance.org

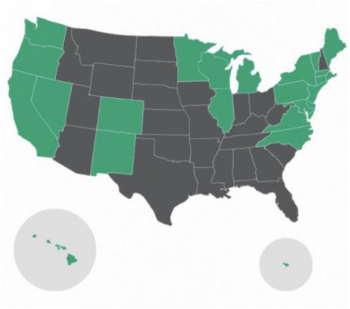

Figure 20. States Whose Governors Have Joined the US Climate Alliance

Also spurred by the US announcement to pull out of Paris Agreement is the non-partisan Alliance for a Sustainable Future.[28] Formed by the United States Conference of Mayors and the Center for Climate and Energy Solutions, the number of cities involved grew from 102 to 159 between 2017 and 2018. With cities such as Buffalo, Dallas, Dayton, Houston, Las Vegas and Orlando involved, the initiative goes beyond hotspots of environmental activism. The mayors have supported a resolution to meet 100% of their electricity needs with "clean, renewable" power by 2035. Additional programs span electric vehicles, charging stations, buildings, and transportation infrastructure.

Apocalyptic and Other Noteworthy Literature. One of the most heavily cited and recent books of the climate apocalypse genre was published in early 2019. The official climate reports cited at the beginning of this section represent some of driest, cryptic, abbreviation-ridden and cautious writing imaginable. They are the essential writings, the bible so-to-speak, on climate matters, their credibility boosted in no small part by the financial commitment they represent. A further selling point in their favor is that they digest what is surely an even more inscrutable, inaccessible and voluminous body of literature, the thousands of documents comprising the underlying science. David Wallace-Wells' book *The Uninhabitable Earth* swims against this tide, bringing color, touch and feel to lethal heat strokes, Jurassic Park-like release of diseases once captive in permafrost, heat-linked cognitive decline, mass migrations, war and the like. While it could be viewed as an argument for mass mobilization like no other, it could also be viewed as an argument for "every little bit helps", i.e. for the "good" not the {"perfect" because it is so much better than the "worse". A handy read is the original 2017 *New York Magazine* article upon which the book was expanded.[29]

A second read, not an apocalyptic scenario but, in retrospect, an historic might-have-been (which is, too, a kind of horror story), is Nathaniel Rich's deep dive into the decade of climate-related research between 1979 and 1989: *Losing Earth – A Climate History*.[30] As mentioned, in the

[28] Alliance for a Sustainable Future (city mayors): https://www.usmayors.org/programs/alliance-for-a-sustainable-future/

[29] *New York* magazine, "The Uninhabitable Earth", David Wallace-Wells. July 2017. http://nymag.com/intelligencer/2017/07/climate-change-earth-too-hot-for-humans.html ; *The Uninhabitable Earth – Life After Warming*, Tim Duggan Books, 2019.

[30] Nathaniel Rich, Article: "Losing Earth: The Decade We Almost Stopped Climate Change", *New York Times Magazine*, August 1, 2018. Entire issue. https://www.nytimes.com/interactive/2018/08/01/magazine/climate-change-losing-earth.html; Book: *Losing Earth – A Recent History*, Farrar, Strauss and Giroux, 2019.

time since then about as much carbon has been released as in the entire industrial era. One thing that may make this book worth reading is precisely what has garnered it criticism from some quarters, mainly that it is not a 100% condemnation of, say, Exxon as master-mind of climate denial. That decade was a time, it should be pointed out, when society's top concern was having too little oil, or natural gas, and second, enormous attention was being given to the "squeaky wheel", which was acid rain, the science behind it, how to reduce SO_2 from power plants, which power plants, how much, and what that might cost. Speaking personally as one directly involved in those matters, the notion of global warming seemed like a distraction, something relegated to a column in *Science* magazine perhaps but not a matter of pressing business concern. This then is a second reason to consider this book – to dig into what was going on during those years that those of us not directly involved had totally overlooked.

While these books could have appeared at almost any time over the past decade, their appearance now is different because the audience is different. Climate change has moved from snore to front-page news. Ex-Congressman Philip Sharp captured the tenor of the times with his observation that the nation is "on the cusp" of major legislation (Footnote 21). The fact that readers actually want to read books like these, now, is itself a data point in the magnifying social agenda addressed in this section.

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As a contributor to NYT Mag., Rich also wrote "The Invisible Catastrophe", addressing the Aliso Canyon natural gas storage field leak of 2015-2016. March 31, 2016. https://www.nytimes.com/2016/04/03/magazine/the-invisible-catastrophe.html

Appendix

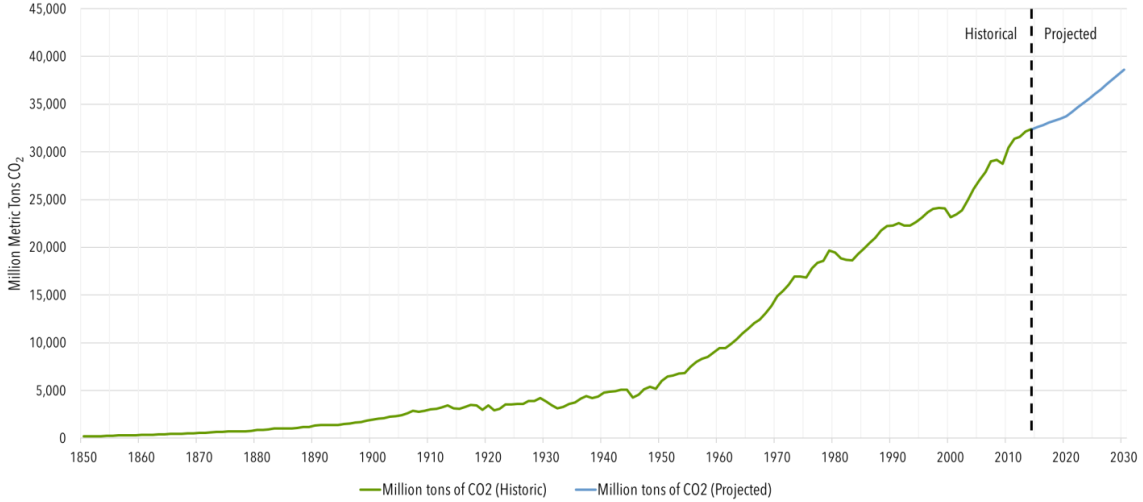

Figure A-1. Global CO_2 Emissions, 1850-2030(est.)
Source: C2ES, citing Oak Ridge National Laboratory: Carbon Dioxide Information Analysis Center, and International Energy Agency: World Energy Outlook. https://www.c2es.org/content/international-emissions/

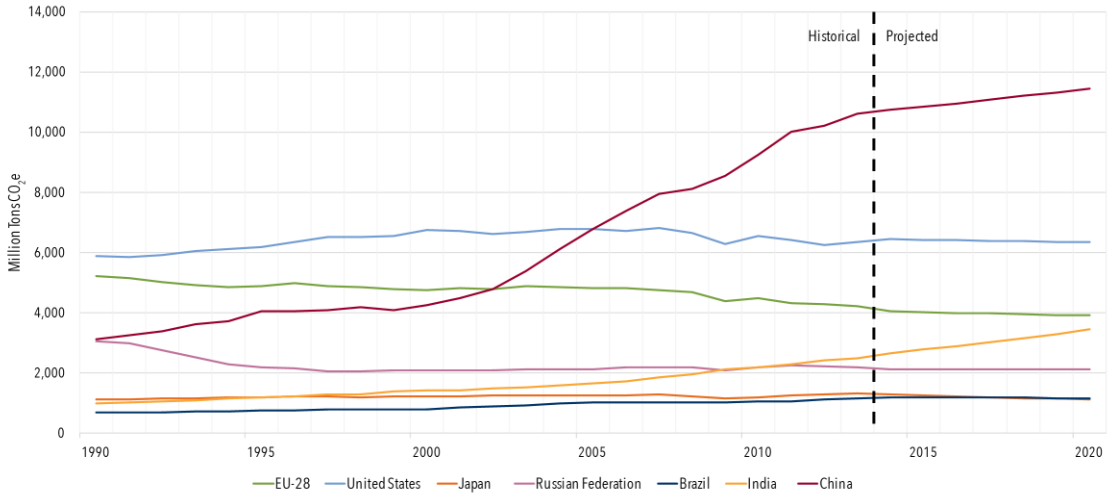

Figure A-2. Greenhouse Gas Emissions, Selected Economies, 1990-2020
Source: C2ES, citing International Energy Agency: World Energy Outlook and CO_2 Highlights, and US. Environmental Protection Agency: International Non-CO_2 Projections. https://www.c2es.org/content/international-emissions/