Pace Environmental Law Review

Volume 38
Issue 2 *Spring 2021*

Article 2

May 2021

An Instrumental Perspective on Power-to-Gas, Hydrogen, and a Spotlight on New York's Emerging Climate and Energy Policy

Tade Oyewunmi
Vermont Law School, toyewunmi@vermontlaw.edu

Recommended Citation
Tade Oyewunmi, *An Instrumental Perspective on Power-to-Gas, Hydrogen, and a Spotlight on New York's Emerging Climate and Energy Policy*, 38 Pace Envtl. L. Rev. (2021)
DOI: https://doi.org/10.58948/0738-6206.1848
Available at: https://digitalcommons.pace.edu/pelr/vol38/iss2/2

An Instrumental Perspective on Power-to-Gas, Hydrogen, and a Spotlight on New York's Emerging Climate and Energy Policy

TADE OYEWUNMI*

* Dr. Tade Oyewunmi is an Assistant Professor and Senior Energy Research Fellow, Institute for Energy and the Environment (IEE), Vermont Law School. This paper is part of the 'Renewable Energy Integration, Decarbonization, and Power-To-Gas' Research Project at the IEE. It adopts and develops on findings and working papers under the project, particularly, 'Decarbonization and the Integration of Renewables in Transitional Energy Markets: Examining the Power to Gas Option in the United States', *Oil, Gas and Energy Law Intelligence* (OGEL) 4 2020 (co-authored with Heather D. Dziedzic); and 'Decarbonization Options for Gas and Electricity Systems: Power-to-Gas (P2G) and Carbon Capture Utilization and Storage (CCUS)' presented at the University of Houston Law Center's 1st Annual Conference on Global Energy Transition Law and Policy, April 17th, 2020. Thanks to participants of the Maryland Law School/Pace Law School Climate Change Seminar, October 12, 2020 for their comments on an initial draft of this paper. I also appreciate Zach Berger (JD/Master of Energy Regulation and Law Candidate, 2021) and Antonia Douglas (JD/Master of Energy Regulation and Law Candidate, 2021) for their research assistance relating to the IEE Research Project.

I. INTRODUCTION

Ideally, law and regulation implemented by organizational institutions aim at defined policy objectives. Thus, from an instrumental perspective, they can be viewed as "tools" or serving as a "means to an end" that comprises the said objectives.[1] Regulation can be broadly depicted as "part of" or "an adjunct to law" or a legal framework that is instrumentalist in orientation.[2] It encompasses the mass of technical statutes, judicial and quasi-judicial decisions, statutory instruments, and other secondary and tertiary rules and guidelines containing prescriptive and descriptive standards of social or economic conduct for a particular context or regulated industry

1. BRIAN Z. TAMANAHA, LAW AS A MEANS TO AN END: THREAT TO THE RULE OF LAW 6–7, 43 (2006). Tamanaha agreeably opines that most of the legal instrumentalists' view of law and regulation indicate an underdeveloped notion of how to identify the social or economic goals that regulation should achieve. He argues that an instrumental understanding of the law is incomplete without resolving the question of "ends." Thus, when sharp disagreements occur between stakeholders regarding what the common social "good" is and the law is consequently perceived as merely an instrument, individuals and groups in society will endeavor to seize or co-opt the law in every way possible in order to fill in, interpret, manipulate, and utilize the law to serve their own subjective ends, rather than function to effectively maintain order and resolve disputes or achieve what is the true common good. *Id.* at 1. Generally, the legal, regulatory and policy framework governing energy supply systems involve: a) ensuring suppliers and operators earn just and reasonable returns on investments and affordable prices for consumers; b) reliability and security of supply; and c) protection from environmental harm and sustainability. *See* Tade Oyewunmi, *Natural Gas in a Carbon-Constrained World: Examining the Role of Institutions in Curbing Methane and Other Fugitive Emissions*, 9 LSU J. ENERGY L. & RES. 87, 88 (2021). For instance, in JOSEPH TOMAIN & RICHARD CUDAHY, ENERGY LAW IN A NUTSHELL 63–64 (3d ed. 2016) it was noted that, over the last 100 years, the US government consistently implemented energy policies that support private ordering by markets to correct market defects through industry-specific government regulation. The underlying aim was *inter alia* to curtail growing monopoly powers of utilities, promote fair open access and viable energy markets, reasonable pricing and returns on investments. From the 1970s, more there has been increasing attention to energy-related pollution control especially from coal-fired plants following the enactment of the Clean Air Act and other environmental protection measures.

2. Julia Black, *Critical Reflections on Regulation*, 27 AUSTL. J. LEGAL PHIL., 2002, at 1, 30.

like energy.[3] Considered from such purview, regulation becomes the functional aspect of implementing legal rules and facilitating the realization of defined "ends" or "policy" objectives, which in a carbon-constrained energy context typically comprise: a) ensuring operators and consumers bear only fair and reasonable costs; (b) reliability and security of supply; and (c) preventing or curtailing environmental harm and externalities. Such a perspective *inter alia* presupposes a thorough understanding of the context and balanced engagement with the intended regulated activity on the part of specialized governance institutions. The activity here could be a utility-scale solar project in need of integrated storage solutions that could utilize nearby existing energy infrastructure. In such a context, both the regulator and the regulated utilities would need to reasonably facilitate the deployment of innovative solutions to meeting such underlying energy policy objectives.

Given the above premises, this paper aims to examine the role of law and regulation in advancing technology-based energy decarbonization options such as hydrogen-compatible networks and power-to-gas (P2G) in the context of New York's energy and climate change mitigation goals. Hydrogen is an *energy carrier* with a significant potential to deliver zero and low-carbon energy depending on how it is produced. Also, when combined with oxygen in a fuel cell, hydrogen produces heat and electricity with only water vapor as a by-product. The aeronautics, industrial, and transportation sectors have used hydrogen for several years in bespoke applications.[4] The United States (U.S.) produces about ten million metric tons of hydrogen every year, 95% of which is via centralized reforming of natural gas (i.e., steam methane reformation (SMR) and known as "Blue Hydrogen") used mostly in petroleum refining and ammonia industries.[5] Other modes of utilization include fuel cell vehicles,

---

3. *Id.* at 3–4. *See* BRONWEN MORGAN & KAREN YEUNG, AN INTRODUCTION TO LAW AND REGULATION: TEXT AND MATERIALS 79–129 (2007) (discussing regulatory instruments and techniques); Tade Oyewunmi, *Examining the Role of Regulation in Restructuring and Development of Gas Supply Markets in the United States and the European Union*, 40 HOUS. J. INT'L L. 191, 213 (2017).

4. *See* U.S. Dep't of Energy, *About the Hydrogen Program*, ENERGY.GOV, https://www.hydrogen.energy.gov/about.html [https://perma.cc/5APU-LJMD]; *see also The Future of Hydrogen*, IEA (June 2019), www.iea.org/reports/the-future-of-hydrogen [https://perma.cc/2BXQ-ESDN].

5. Off. of Energy Efficiency & Renewable Energy, *Things You Might Not Know About Hydrogen and Fuel Cells*, ENERGY.GOV (Oct. 8, 2019)

metals refining, and synthetic natural gas production.[6] Notably, the P2G process leads to the production of "green hydrogen" by using electricity that would otherwise be curtailed or lost from variable renewable energy (VRE) sources, such as solar and wind, to split water into its hydrogen and oxygen components. The "green hydrogen" process is becoming increasingly relevant to the issues of (i) decarbonization of gas and electricity networks; and (ii) solving the "curtailment," "intermittency," and "storage" challenge in an energy system where renewables are gradually playing a larger role.[7] It may also be key to facilitating the integration of a growing share of VREs in existing networks and in the same vein avoiding the "stranded assets" dilemma energy utilities with significant natural gas pipeline and storage networks that can be made compatible with hydrogen or synthetic methane produced as a result.[8] Natural gas supply is supported by a vast array of pipelines and storage networks. It accounts for about 34% of total U.S. electricity generation (as of 2019) and VREs like solar and wind are equally scaling up rapidly across power markets in the U.S. and poised to grow from 19% in 2019 to over 38% by 2050. Thus, it is essential to take a keen look at how these developments and systems interconnect and could be more efficiently integrated.[9]

https://www.energy.gov/eere/articles/10-things-you-might-not-know-about-hydrogen-and-fuel-cells [https://perma.cc/6UGK-HMCP].

6. *Id.* (currently, the two largest users of "blue hydrogen" are the petroleum refining and fertilizer production industries, and there are about 1,600 miles of hydrogen pipeline in the U.S. including hydrogen production facilities in almost every state). Ruven Fleming & Joshua P. Fershee, *The 'Hydrogen Economy' in the United States and the European Union: Regulating Innovation to Combat Climate Change*, *in* INNOVATION IN ENERGY LAW AND TECHNOLOGY: DYNAMIC SOLUTIONS FOR ENERGY TRANSITIONS 137, 137 (Donald Zillman et al. eds., 2018).

7. Heather D. Dziedzic & Tade Oyewunmi, *Decarbonization and the Integration of Renewables in Transitional Energy Markets: Examining the Power to Gas Option in the United States*, OIL, GAS & ENERGY L., August 2020, at 1, 13–14.

8. *See* MARTIN LAMBERT, POWER-TO-GAS: LINKING ELECTRICITY AND GAS IN A DECARBONIZING WORLD? 1, 4–5 (Oct. 2018), https://www.oxfordenergy.org/wpcms/wp-content/uploads/2018/10/Power-to-Gas-Linking-Electricity-and-Gas-in-a-Decarbonising-World-Insight-39.pdf [https://perma.cc/FFP7-ZKXJ]; Christopher J. Quarton & Sheila Samsatli, *Power-to-Gas for Injection into the Gas Grid: What Can We Learn from Real-Life Projects, Economic Assessments and Systems Modelling?*, 98 RENEWABLE & SUSTAINABLE ENERGY REV., Dec. 2018, at 302, 303.

9. *EIA Expects U.S. Electricity Generation from Renewables to Soon Surpass Nuclear and Coal*, EIA (Jan. 30, 2020), https://www.eia.gov/todayinenergy/detail.php?id=42655 [https://perma.cc/SDN9-3EW6].

Law and regulation can play an instrumental role in the context of energy and decarbonization as policymakers ponder leveraging existing networks and emerging technologies. Such considerations are even more relevant for a state such as New York where—even though the state's Clean Energy Standard revised in 2019 requires 100% carbon-free electricity by 2040—29% of New York's in-state generation came from renewable sources in 2018, one-third of its utility-scale net generation came from in-state nuclear power plants that may be decommissioned soon,[10] it was the sixth-largest natural gas consumer in the U.S., and three in five households used natural gas for home heating.[11] As with most other states and jurisdictions with similar approaches, such energy decarbonization objectives are clear and laudable. However, it is instructive to recall statements such as the Intergovernmental Panel on Climate Change's (IPCC) AR5 chapter on "Energy Systems," which states that "reducing GHG emissions from the electric power sector will require infrastructure investments and changes in the operations of power systems - these will both depend on the mitigation technologies employed."[12]

---

10. *New York State Profile and Energy Estimates: Profile Analysis*, EIA, https://www.eia.gov/state/analysis.php?sid=NY#31 [https://perma.cc/2NFQ-ZH4W] (Sept. 17, 2020) ("One of the state's four nuclear power plants—Indian Point—accounted for two-fifths of the state's nuclear generating capacity that year. However, one of Indian Point's two reactors ceased operations at the end of April 2020, and the second reactor is scheduled for retirement by 2021. Indian Point's reactors provided 13% of the state's power in 2019.").

11. *New York State Profile and Energy Estimates: Profile Overview*, EIA, https://www.eia.gov/state/?sid=NY#tabs-4 [https://perma.cc/RW2L-QBS6] (Sept. 17, 2020).

12. Thomas Bruckner et al., *Energy Systems*, *in* CLIMATE CHANGE 2014: MITIGATION OF CLIMATE CHANGE 511, 534–35 (Ottmar Edenhofer et al. eds., 2014). The report further states that:

> The fundamental reliability constraints that underpin this process are the requirements that power supply and electricity demand remain in balance at all times (system balancing), that adequate generation capacity is installed to meet (peak) residual demand (capacity adequacy), and that transmission and distribution network infrastructure is sufficient to deliver generation to end users (transmission and distribution). Studies of high variable RE penetration and the broader literature suggest that integrating significant RE generation technology is technically feasible, though economic and institutional barriers may hinder uptake. Integrating high penetrations of RE resources, particularly those that are intrinsically time variable, alongside operationally inflexible generation is expected to result in higher system-balancing costs. Compared to other mitigation options variable renewable generation will contribute less to capacity adequacy, and, if remote from loads, will also increase transmission costs. The

Given the functional approach to law and regulation,[13] a holistic understanding of the energy system's context is essential to realizing the objective of preventing environmental implications arising from the process of supplying reliable and reasonably priced energy in a carbon-constrained world. As part of the same institutional framework, such laws and regulations are only as effective as the extent to which the underlying objectives are realized. A key challenge to the effectiveness of energy law and regulation is the peculiar and sometimes-counteracting nature of the various underlying energy policy objectives. For instance, the incoming U.S. government already has laudable energy and climate objectives which include leveraging existing infrastructure and building new systems.[14]

The 2018 IPCC Special Report provides a useful outlook on the various options and strategic pathways towards effective decarbonization.[15] Concerning energy systems, the report notably finds that modeled global pathways for limiting global warming to

---

> determination of least-cost portfolios of those options that facilitate the integration of fluctuating power sources is a field of active and ongoing research . . . .
>
> Energy storage might play an increasing role in the field of system balancing. Today pumped hydro storage is the only widely deployed storage technology. Other storage technologies including compressed air energy storage (CAES) and batteries may be deployed at greater scale within centralized power systems in the future . . . . These short-term storage resources can be used to compensate the day-night cycle of solar and short-term fluctuation of wind power. With the exception of pumped hydro storage, full (levelized) storage costs are still high, but storage costs are expected to decline with technology development. 'Power to heat' and 'power to gas' (H_2 or methane) technologies might allow for translating surplus renewable electricity into other useful final energy forms.

Id. (footnotes and citations omitted).

13. TAMANAHA, *supra* note 1, at 34; Black, *supra* note 2, at 22–23. *See e.g.*, Todd S. Aagaard, *A Functional Approach to Risks and Uncertainties Under NEPA*, 1 MICH. J. ENV'T & ADMIN. L. 87, 90–91 (2012) (discussing a functional approach as applied to NEPA); TADE OYEWUNMI, REGULATING GAS SUPPLY TO POWER MARKETS: TRANSNATIONAL APPROACHES TO COMPETITIVENESS AND SECURITY OF SUPPLY 6–9 (2018). *See also* Pami Aalto, *Institutions in European and Asian Energy Markets: A Methodological Overview*, 74 ENERGY POL'Y 4, 4–5 (2014).

14. *See The Biden Plan to Build a Modern, Sustainable Infrastructure and an Equitable Clean Energy Future*, BIDEN HARRIS, https://joebiden.com/clean-energy/ [https://perma.cc/DB26-9P4Y].

15. Joeri Rogelj et al., *Mitigation Pathways Compatible with 1.5° C in the Context of Sustainable Development*, *in* GLOBAL WARMING OF 1.5° C 93, 129–47 (Valeria Masson-Delmotte et al. eds., 2018).

1.5°C generally require, among other things, meeting energy service demands with enhanced energy efficiency measures and electrification of key sectors of the economy.[16] In this pathway, low-emission energy sources are projected to have a higher share (compared with 2°C pathways), particularly before 2050, and renewables are expected to supply 70–85% of electricity in 2050.[17] The IPCC report equally recognizes the challenges and differences between the options and national circumstances and agreeably underscores the need for a comprehensive policy-driven systemic change in the pathways to decarbonization. It highlights a suite of technologies and innovative solutions recommended in this regard such as energy efficiency, electrification of energy end-use sectors like transportation, renewable energy utilization, Carbon Dioxide Removal (CDR) options, Carbon Capture and Storage (CCS), and deployment of low to net-zero carbon fuels, which (as mentioned earlier) includes hydrogen.[18] All these options and tools have their unique features and would require a significant degree of pragmatism by policymakers and stakeholders to be implemented at the right time and scale for them to have any meaningful decarbonization effect in reality.

The inherent paradoxical issues in the evolving energy transitions and decarbonization scenario has been highlighted and examined by several energy law and policy scholars.[19] This paper builds on the premise that regulatory institutions and policymakers in states such as New York cannot afford to approach the three aspects of energy policy as mutually exclusive. Rather, it is becoming more important to leverage all existing technologies and innovative means of reaching climate and energy policy goals and not just one

16. Intergovernmental Panel on Climate Change [IPCC], *Summary for Policy Makers*, *in* GLOBAL WARMING OF 1.5° C, *supra* note 15, at 15.

17. *Id.*

18. *Id.* at 14.

19. David B. Spence, *Paradoxes of "Decarbonization,"* 82 BROOK. L. REV. 447, 459 (2017); Amy L. Stein, *Distributed Reliability*, 87 U. COLO. L. REV. 887 (2016) (discussing the implications of changing market dynamics relating to roles played by utilities, grid operators, consumers and distributed energy resources); William Boyd, *Public Utility and the Low-Carbon Future*, 61 UCLA L. REV. 1614 (2014) (discussing the role of public utility law in energy transitions and integrating low-carbon systems). *see also* TADE OYEWUNMI ET AL., DECARBONISATION AND THE ENERGY INDUSTRY: LAW, POLICY AND REGULATION IN LOW-CARBON ENERGY MARKETS (Tade Oyewunmi et al., eds., 2020) [hereinafter DECARBONISATION AND THE ENERGY INDUSTRY].

at the expense of the other. From the issuance of New York's Clean Energy Standard in 2016, the passage of Accelerated Renewable Energy Growth and Community Benefits Act (AREGCBA), the Climate Leadership and Community Protection Act (Climate Act), and the 2018 New York Public Service Commission's (PSC) adopting 1,500-megawatt (MW) energy storage targets and incentive scheme, a lot of ground has arguably been covered. However, there are still questions about what role emerging technologies such as P2G and hydrogen compatible networks could play in the decarbonization and VRE integration context for New York in particular and the U.S. generally.

This paper will consider these highlighted issues. Part II discusses the growth and challenges with VREs in the U.S. energy mix while highlighting the hydrogen and P2G options' potential role. Part III will examine the issues in regulating gas and electricity systems in a carbon-constrained world and the challenges and potential for decarbonization by deploying hydrogen and P2G. Part IV examines New York's emerging climate and energy regulation framework and points out the possible issues with deploying P2G and hydrogen in the state. The paper concludes by highlighting that, in the pathways to decarbonization, the overarching objective when choosing what and how to regulate should be to curb greenhouse gas (GHG) emissions and ensure that the necessary provisions to foster the required technologies and networks are clearly defined.

II. DECARBONIZING GAS NETWORKS AND GREEN HYDROGEN

Over the years, the U.S. electricity supply has relied on carbon-intensive sources such as coal, which contributes significantly to GHG emissions. In 2019 alone, the carbon dioxide (CO_2) emissions from the sector accounted for 1,618 million metric tons (MMmt) of CO_2 or about 31% of total U.S. energy-related CO_2 emissions, arising from coal (60%), gas (38%), petroleum (1%) and others.[20] A logical

20. *Frequently Asked Questions: How Much of U.S. Carbon Dioxide Emissions Are Associated with Electricity Generation?*, EIA, https://www.eia.gov/tools/faqs/faq.php?id=77&t=11#:~:text=How%20much%20of%20U.S.%20carbon,emissions%20of%205%2C146%20(MMmt) [https://perma.cc/U5VA-JYFK] (Dec. 1, 2020); *see Sources of Greenhouse Gas Emissions,* EPA, https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions [https://perma.cc/SF6U-DXU5] (Dec. 4, 2020) (the electricity sector

means to reduce energy-related GHG emissions is to incentivize the generation of power from net-zero carbon sources, renewables, or less-carbon-intensive and more efficient systems such as gas-to-power. While there are methane and other fugitive emissions attributable to the upstream gas production and midstream gas transmission segments of the gas-to-power value chain in different degrees and contexts, there are plausible carbon-reduction benefits attributable to switching from coal and oil to gas-fired generators in the electricity market.[21] Natural gas suppliers and utilities would need to reduce, capture, or innovatively deal with emissions attributable to that value chain in a low-carbon, net-zero carbon, or carbon-neutral future energy mix.[22]

---

accounted for 27% of GHG emissions by sector in 2018); *U.S. Energy-Related CO2 Emissions Increased in 2018 but will Likely Fall in 2019 and 2020*, EIA (Jan. 28, 2019), https://www.eia.gov/todayinenergy/detail.php?id=38133# [https://perma.cc/EGU9-D2AY]. "[E]nergy-related CO2 emissions increased by 2.8% in 2018 but will decrease in 2019 and 2020." *Id.* Despite the growing switch from coal-fired EGUs to gas-fired EGUs, "the 2018 increase is the largest in energy-related CO2 emissions since 2010," perhaps due to weakening regulations, greater economic activities and growing demand and consumption patterns. *Id.*

21. Oyewunmi, *supra* note 1, at 100, 106–07; *see* U.K. DEP'T FOR BUS., ENERGY & INDUS. STRATEGY, 2018 U.K. GREENHOUSE GAS EMISSIONS, PROVISIONAL FIGURES 7 (Mar. 2019), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/790626/2018-provisional-emissions-statistics-report.pdf [https://perma.cc/HF7P-HZ6Q]. In the U.K. for instance, even though electricity consumption was 8% higher in 2018 compared to consumption levels in 1990, the overall emissions from power stations were 68% lower in 2018 than in 1990. *Id.* at 8. The decline in emissions was inter alia attributed to the growing switch from coal to natural gas, and the rising use of renewable energy sources such as offshore wind. *Id.* Further, "[c]arbon dioxide emissions in the energy supply sector decreased by 7.2 per cent (7.7 Mt), between 2017 and 2018 driven by a change in the fuel mix for electricity generation." *Id.* at 7. "Since 1990, UK carbon dioxide emissions have decreased by 39 per cent. This decrease has resulted mainly from changes in the mix of fuels being used for electricity generation, with a shift away from coal and growth in the use of renewable energy sources. This was combined with lower electricity demand, owing to greater efficiency resulting from improvements in technology and a decline in the relative importance of energy intensive industries." *Id.*

22. There has been a lot of debate pertaining to emerging technologies such as Carbon Capture Utilization and Storage (CCUS), commercial acceptance of regulations pertaining to methane emissions midstream, and prevention of waste and emissions through flaring in the upstream gas sector. *See* Bradley N. Kershaw, Note, *Flames, Fixes, and the Road Forward: The Waste Prevention Rule and BLM Authority to Regulate Natural Gas Flaring and Venting*, 29 COLO NAT. RES., ENERGY & ENV'T L. REV., 115, 125, 132 (2018). *See also Inventory of U.S. Greenhouse Gas Emissions and Sinks*, EPA, https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks [https://perma.cc/S7PW-47CB] (Sept. 11, 2020); Ryan Collins, *Texas Oil Regulator Shifts Stance as Gas Flaring Hits Record*,

Renewable energy utilization and projects have increased over the past twenty-five years in the US mostly due to favorable economics and a wave of laws and policies providing the needed incentives. For instance, twenty-nine states and the District of Columbia have reportedly introduced Renewable Portfolio Standards (RPS) since 1994, setting both voluntary and mandatory targets for renewable electric generation.[23] These targets have helped increase demand for renewable electric generation, primarily from wind and solar,[24] by requiring the overall portfolio of electricity supply from utilities to include minimum percentages of renewable energy capacity. It is noted that about half of all growth in U.S. renewable electricity generation and capacity since 2000 is associated with state RPS requirements, though not all of that is strictly attributable to RPS policies.[25]

Under a typical RPS program, utilities must obtain renewable energy certificates or credits (RECs) for the required percentage of their power generation from sources such as wind, solar, geothermal, biomass, and some types of hydroelectricity.[26] Other sources may include landfill gas, municipal solid waste, and ocean energy.[27] A REC is created for each megawatt-hour of electricity (or equivalent energy) generated from a qualifying energy source, with some programs also giving credits for various types of renewable space heating and water heating, fuel cells, energy efficiency measures,

---

BLOOMBERG MARKETS (Aug. 9, 2019, 7:36 AM), https://www.bloombergquint.com/business/texas-oil-regulator-shifts-stance-as-gas-flaring-hits-record [https://perma.cc/K5X5-PJ6B].

23. *See Renewable Energy Explained: Portfolio Standards*, EIA, https://www.eia.gov/energyexplained/renewable-sources/portfolio-standards.php (November 18, 2019); GALEN BARBOSE, U.S. RENEWABLE PORTFOLIO STANDARDS: 2018 ANNUAL STATUS REPORT 8 (Nov. 2018), https://eta-publications.lbl.gov/sites/default/files/2018_annual_rps_summary_report.pdf [https://perma.cc/F6RA-YL6K].

24. *Id.* at 9.

25. Laura Shields, *State Renewable Portfolio Standards and Goals*, NCSL (Apr. 7, 2021), https://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx [https://perma.cc/ND2L-26BL]; GALEN BARBOSE, U.S. RENEWABLE STANDARDS: 2019 ANNUAL STATUS UPDATE 4 (July 2019), https://eta-publications.lbl.gov/sites/default/files/rps_annual_status_update-2019_edition.pdf [https://perma.cc/PWG4-73JS] (Only about 30% of renewable energy generation developments in 2018 is attributable to RPS. The framework continues to play a significant role in particular regions such as the Northeast and Mid-Atlantic regions of the U.S.).

26. Shields, *supra* note 25.

27. *Id.*

and advanced emissions curtailing fossil-fueled technologies.[28] It is noted that some states have clean energy targets or goals rather than 'renewable' energy standards.[29] As such, they focus more on systems that qualify as carbon-free, carbon-neutral, or clean energy.[30] Such clean energy programs may permit technologies such as nuclear energy, or natural gas with carbon capture and storage, to count toward clean energy policy targets.[31] These state-level packages for RPS and clean energy programs, coupled with local supportive policies, and federal production and investment incentives has significantly led to cost reductions and competitiveness of VRE technologies such as wind and solar.

From an environmental benefits standpoint, RPS and clean energy policies are designed to indirectly reduce energy-related GHG emissions, by displacing traditional, carbon-intensive fuels like coal and oil. In New York, for instance, the state's Public Service Commission (NYPSC) issued the "Order Approving Renewable Portfolio Standard on September 24, 2004, adopting the RPS" to "increase the proportion of renewable energy New Yorkers used from 19.3% (using 2004 as the baseline year) to at least 25% by the end of 2013."[32] The latest revision to the state's RPS framework was done as part of the 2015 New York State Energy Plan, by setting out the Clean Energy Standard (CES) highlighting the goal of 70% of New York's electricity coming from renewable energy by 2030.[33] The CES is effective from August 1, 2016, and is currently set to expire on December 31, 2030, and applies to the following eligible RES technologies: Solar Photovoltaics, Wind (All), Biomass, Fuel Cells using Non-Renewable Fuels, Tidal, Hydroelectric (Small), Anaerobic

28. *Id.*

29. *Id.* (listing California, Colorado, and Indiana).

30. *Id.*

31. *Id.* For example, section 8-1-37 of Indiana's Code provides that 30% of its clean energy portfolio goal may be met with clean coal technology, nuclear energy, or natural gas that displaces electricity from coal. *Id.*

32. NYSERDA, *Renewable Portfolio Standard*, N.Y. STATE, https://www.nyserda.ny.gov/All-Programs/Programs/Clean-Energy-Standard/Renewable-Portfolio-Standard [https://perma.cc/HXA8-3JP2]. On January 1, 2010, after a review of the RPS, the PSC issued another increasing the RPS goal from 25 percent by 2013 to 30 percent by 2015, using the same 2004 baseline. *Clean Energy Standard*, DSIRE (Sept. 9, 2020), https://programs.dsireusa.org/system/program/detail/5883 [https://perma.cc/UQ6U-VGNY].

33. NYSERDA, *supra* note 32.

Digestion, Fuel Cells using Renewable Fuels, while the applicable sectors include Investor-Owned Utilities, Municipal Utilities, Cooperative Utilities, Retail Suppliers

At the federal level, the Obama-era Clean Power Plan (CPP),[34] issued in 2015, sought to tackle the issue of energy decarbonization head-on by limiting the emissions from electric generators.[35] The Environmental Protection Agency (EPA) issued the CPP pursuant to section 111(b) of the U.S. Clean Air Act (CAA). It comprised a framework of performance-based standards upon which emissions of CO_2 from affected newly constructed, modified, and reconstructed fossil fuel-fired electric utility generating units (EGUs) could be curtailed. The Obama EPA also issued guidelines for states to use in developing plans to limit CO_2 emissions from existing fossil fuel fired EGUs under section 111(d) of the CAA. The highlighted regulatory steps aimed at curtailing carbon emissions from the EGUs sector were intended to drive innovation by operating utilities via more cost-efficient or sustainable emission controls. Arguably, utilities that failed to innovate or achieve the standards, would have become less competitive when compared to other less carbon-intensive or net-zero carbon sources. Such prospects were essentially terminated following the Trump administration's repeal of the CPP. In 2019, following prior stays by the courts[36] and the issuance of the Affordable Clean Energy rule, the CPP stands repealed.[37]

To some, this was a setback in climate policy; others recognize that economics and state-level policies have already driven the electric industry to a projected 33% reduction in GHG emissions by 2030.[38] This surpasses the 32% reduction sought by the CPP by 2030.

34. *See* Clean Power Plan, 80 Fed. Reg. 64,661 (Oct. 23, 2015) (to be codified at 40 C.F.R. pt. 60).

35. *See State-by-State Resources to Better Understand EPA's Carbon Pollution Rule*, GEORGETOWN CLIMATE CTR. (June 2, 2014), https://www.georgetownclimate.org/articles/state-by-state-resources-to-better-understand-epas-carbon-pollution-rule.html#summary [https://perma.cc/U77P-VVEK].

36. Rob Jordon, *Goodbye, Clean Power Plan: Stanford Researchers Discuss the New Energy Rule*, STAN. NEWS SERV. (June 21, 2019), https://news.stanford.edu/press-releases/2019/06/21/goodbye-clean-power-plan-understanding-new-energy-rule/ [https://perma.cc/JF6Y-MF3A].

37. Repeal of the Clean Power Plan, 84 Fed. Reg. 32,520 (July 8, 2019) (to be codified at 40 C.F.R. pt. 60).

38. Maggie Shober, *Should We Mourn the Clean Power Plan?*, S. ALL. FOR CLEAN ENERGY (June 18, 2019), https://cleanenergy.org/blog/trump-replacing-clean-power-plan/ [https://perma.cc/Q4RM-SZKC].

It also exceeds the initial commitment of the United States to the Paris Climate Agreement, which was a 28% reduction by 2025.[39] These achievements, however opportune they may be, demonstrate the ability of corporate sustainability, energy markets, state and regional policy, and economic incentives to drive meaningful change in the energy sector and its carbon footprint.

A. Scaling-up VREs and Energy Supply Networks

One of the key operational rules for electricity markets and regulation is the need to balance demand and supply in real-time. This is even more complex if firstly we understand that energy is the capacity to do work or carry out a task such as transportation or lightning a dark room. Such capacity is generated from different sources and transformed into types such as "electric" carried by electricity and "thermal" resulting from heat. Despite the successful lowering of costs for VREs and the growing projected role of these sources of energy, it is worth pointing out that most of the preferred "clean" energy sources are intermittent and variable, and subject to geophysical constraints.[40] Delivery and securing electrical energy from the sun and wind depend significantly on when the sun shines and the wind blows; or geographical location that could impact on energy production intensity and scale of the relevant technology.[41] Considering the intermittency issues and the variability concerns of the fastest-growing renewables, i.e., solar and wind, plus the structural or organizational impact of an increasing array of distributed energy resources,[42] several issues arise from a coherent energy regulation and policy standpoint.

39. Memorandum from the United States to the United Nations, Intended Nationally Determined Contribution 2 (Mar. 9, 2016) (on file with the United Nations).

40. Matthew R. Shaner et al., *Geophysical Constraints on the Reliability of Solar and Wind Power in the United States*, 11 ENERGY & ENV'T SCI. 914, 915 (2018); Jesse Jenkins, *Getting to Zero: Pathways to Zero Carbon Electricity Systems*, KLEINMAN CTR. FOR ENERGY POL'Y (Feb. 1, 2018), https://kleinmanenergy.upenn.edu/events/getting-to-zero-pathways-to-zero-carbon-electricity-systems/ [https://perma.cc/VF8S-UZUB].

41. Shaner et al., *supra* note 40, at 915.

42. *See* BRYAN PALMINTIER ET AL., ON THE PATH TO SUNSHOT: EMERGING ISSUES AND CHALLENGES IN INTEGRATING SOLAR WITH THE DISTRIBUTION SYSTEM 57 (May 2016), https://www.nrel.gov/docs/fy16osti/65331.pdf [https://perma.cc/4VTG-UVEG].

One such challenge is illustrated in the duck curve issue, which arises because utilities and transmission operators must balance electricity supply and demand across a typical day of renewable energy production and consumption. The dilemma is created when solar energy, generated when the sun is shining, exceeds typical demand or when demand increases just as real-time generation drops in the evening.[43] Other issues also include long-term planning and risk mitigation,[44] network congestion management and load balancing, the need to curtail energy generation from an increasing number of renewable systems due to inadequate storage or network connection options, the "missing money" problem, and shirking by investors in traditional energy utilities leading to potential capacity inadequacies.[45] These issues underscore the need for ensuring efficient integration of the growing array of intermittent and decentralized renewable systems with existing networks as well as developing advanced storage and network coupling solutions. Some of the pragmatic ways of facilitating a proper integration of net-zero carbon and renewable energy in conventional gas and electricity markets include the deployment of advanced energy storage solutions to enhance reliability.[46]

Following the apparent success of RPS implementation and other economic incentives,[47] renewables-based electric generation has doubled in the U.S. within the last decade, and now provides

---

43. Off. of Energy Efficiency & Renewable Energy, *Confronting the Duck Curve: How to Address Over-Generation of Solar Energy*, ENERGY.GOV (Oct. 12, 2017), https://www.energy.gov/eere/articles/confronting-duck-curve-how-address-over-generation-solar-energy [https://perma.cc/R49Z-ZHU8].

44. LeRoy Paddock & Karyan San Martano, *Energy Supply Planning in a Distributed Energy Resources World*, *in* INNOVATION IN ENERGY LAW AND TECHNOLOGY: DYNAMIC SOLUTIONS FOR ENERGY TRANSITIONS 371, 372–80 (Donald Zillman et al. eds., 2018).

45. *See* Amy L. Stein, *Distributed Reliability*, 87 U. COLO. L. REV. 887, 936, 946 (2016); William Boyd, *Public Utility and the Low-Carbon Future*, 61 UCLA L. REV. 1614, 1699–700 (2014).

46. Amy L. Stein, *Regulating Reliability*, 54 HOUS. L. REV. 1191, 1235 (2017); Francisco Castellano Ruz & Michael G. Pollitt, *Overcoming Barriers to Electrical Energy Storage: Comparing California and Europe*, 17 COMPETITION & REGUL. NETWORK INDUS. 123, 124, 128 (2016); Michael J. Allen, *Energy Storage: The Emerging Legal Framework (and Why It Makes a Difference)*, 30 NAT. RES. & ENV'T 20, 20, 22 (2016).

47. *U.S. Renewable Electricity Generation Has Doubled Since 2008*, EIA (Mar. 19, 2019), https://www.eia.gov/todayinenergy/detail.php?id=38752 [https://perma.cc/5HQM-29R4].

17.6% of the country's electricity.[48] Paired with the reduction in GHG emissions, there is strong evidence that the energy system is headed in the right direction. But, if the system has already surpassed previous national and international targets for decarbonization, then where is the next signpost? Industry experts have different visions of the future system, some seeking an electric system powered 100% by wind, solar, and hydro.[49] Others have cautioned that this approach, while technically feasible, ignores the political, technical, and financial hurdles to achieve such an aggressive target.[50] Instead, analysis of future electric generation seems to have coalesced around a lower target of an 80% penetration rate for renewables-based electricity, at least as a starting point for meaningful modeling.[51] Even at 80%, this target comes with significant challenges considering the nearly five-fold increase of renewables' contribution to the grid. It also confirms the current reliance on the electric grid to do the heavy lifting of decarbonizing our society.

Renewable energy sources such as wind and solar are inherently intermittent because they depend largely on weather or seasonal patterns. Thus, energy from renewable-based facilities such as solar PV systems and wind turbines is only available at a specific scale and time, when the sun shines and the wind blows, unless the capacity to adequately store that energy exists. Such solutions must also compete with other existing forms of storage, such as pumped hydroelectric systems, while also meeting the required scale and duration to guarantee reliability, affordability, and security of a fully renewable energy supply. Unpredictability creates a plausible risk to long-term and real-time capacity and is not a desirable trait in either electric supply or grid management. A fundamental feature of electricity supply networks is that reliability requires an instantaneous balancing of both supply and demand, which is

48. *Id.*

49. Mark Z. Jacobson et al., *Low-Cost Solution to the Grid Reliability Problem with 100% Penetration of Intermittent Wind, Water, and Solar for All Purposes*, 112 PNAS 15060, 15060 (2015).

50. Christopher T. M. Clack et al., *Evaluation of a Proposal for Reliable Low-Cost Grid Power with 100% Wind, Water, and Solar*, 114 PNAS 6722, 6723 (2017).

51. TRIEU MAI ET AL., RENEWABLE ENERGY FUTURES STUDY: EXPLORATION OF HIGH-PENETRATION RENEWABLE ELECTRICITY FUTURES 3-3 to 3-10 (2012), https://www.law.berkeley.edu/php-programs/courses/fileDL.php?fID=7308 [https://perma.cc/HK5X-P9MB].

something that wind and solar especially struggle to achieve, depending on the time of the day, season, and location.

For grid managers, like Regional Transmission Operators (RTOs) and Independent System Operators (ISOs) (collectively, "grid operators"), these distributed and variable resources challenge their ability to maintain the grid's stability and reliability. Without examining the detailed engineering principles involved in the electric grid, it is sufficient to note here that balancing supply and demand, while maintaining frequency and voltage, are key components of a secure and reliable electricity network.[52] These characteristics are captured in the Ancillary Service markets throughout the country, via the RTOs and ISOs. For the purpose of this evaluation, it must be assumed that as the penetration of intermittent renewable-based energy increases from 17% to 80%, there will be a growing need for system resources to contribute such ancillary services, which seek to level fluctuations of intermittent supply. Of interest here is the ability of non-traditional, non-electric resources to aid load leveling and energy storage.[53]

Because traditional renewables-based electricity is generated when the fuel (e.g., wind, water, or sunshine) is available, its contribution to electric supply is naturally independent of demand. During times of overproduction, when renewable supply exceeds demand, grid operators must eliminate this imbalance to, *inter alia*, (i) preserve the integrity of the electric system; (iii) prevent network congestion; and (iii) regulate supply's potential impact on market prices and cost-recovery projections. These issues lead to curtailment, which in essence limits the generation, or output of renewable energy to the grid, thus, decreasing the overall contribution of renewables-based electricity to energy consumption below what is achievable without curtailment.[54] Without significant changes in demand, expansion of transmission resources, or the development of adequate, cost-efficient storage solutions, increasing

52. REISHUS CONSULTING LLC., ELECTRICITY ANCILLARY SERVICES PRIMER 7 (Aug. 2017), http://nescoe.com/wp-content/uploads/2017/11/AnxSvcPrimer_Sep2017.pdf [https://perma.cc/KHV7-5GVN].

53. Andrea Mazza et al., *Applications of Power to Gas Technologies in Emerging Electrical Systems*, RENEWABLE & SUSTAINABLE ENERGY REVS., Sept. 2018, at 794, 800.

54. LORI BIRD ET AL., NAT'L RENEWABLE ENERGY LAB., WIND AND SOLAR ENERGY CURTAILMENT: EXPERIENCE AND PRACTICES IN THE UNITED STATES 16–20 (Mar. 2014), https://www.nrel.gov/docs/fy14osti/60983.pdf [https://perma.cc/4ZLG-9TH5].

renewables on the grid will only increase curtailment. Curtailment is generally low in terms of percentage of total generation: roughly 4% of wind supply annually, for example.[55] Nevertheless, this curtailment equates to significant energy waste, equaling roughly hundreds of thousands of megawatt-hours (MWh) in each regional market.[56] In 2013, the MidContinent Independent System Operator (MISO) curtailed over 1 million MWh of wind energy.[57] That is enough energy to power nearly 100,000 homes in that region alone, for an entire year.[58] Curtailment and the duck curve challenge are also essential issues in the California-ISO market with a very high share of VREs.[59]

55. LORI BIRD ET AL., WIND AND SOLAR ENERGY CURTAILMENT PRACTICES 5, 19 (Oct. 2014), https://www.nrel.gov/docs/fy15osti/63054.pdf [https://perma.cc/U9KU-VMG7].

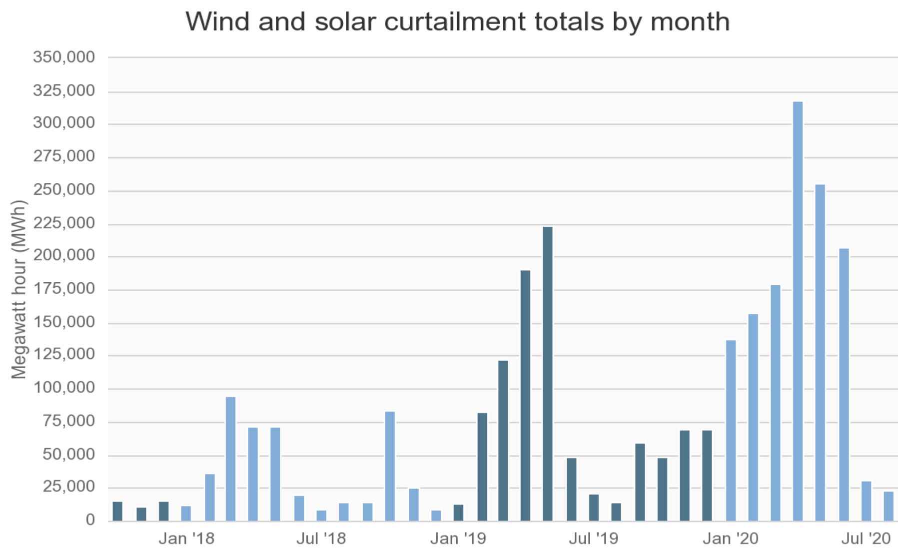
56. *See id.* at 5, 7–13.

57. *Id.* at 11.

58. 1,000,000 MWh= 1e+9 kwh. Calculated using 2017 average U.S. household electric consumption of 10,399 kwh/year. *How Much Electricity Does an American Home Use?*, EIA, https://web.archive.org/web/20190228082306/https://www.eia.gov/tools/faqs/faq.php?id=97&t=3 [https://perma.cc/797B-KVQF?type=image] (Oct. 26, 2018).

59. *See Managing Oversupply*, CAL. ISO, http://www.caiso.com/informed/Pages/ManagingOversupply.aspx [https://perma.cc/KGZ8-EDAP] (Jan. 11, 2020).

Figure 1: CAISO Oversupply and Curtailment: January 2018–July 2020[60]



In addition to curtailment issues, renewable energy faces a continued barrier when trying to move electricity from the point of generation to areas of demand, due to the lack, or inadequacy, of necessary transmission and distribution infrastructure. With large-scale wind and solar projects sited for optimal production and not necessarily for proximity to transmission, this disparity manifests as a stranded supply. These conditions are known as transmission constraints and result from the infrastructure's physical limitations, system design, or reliability rules, any or all limiting cost-efficient and optimized power flow.[61] This limitation of power transmission below levels of market demand leads to grid congestion. Again, using MISO as an example, there were $1.2 billion of costs associated with grid congestion in 2011, a figure that is increasing.[62] While not the sole indicator of congestion, the U.S. Department of Energy has

60. *Id.*

61. U.S. DEP'T OF ENERGY, NATIONAL ELECTRIC TRANSMISSION CONGESTION STUDY, at viii (Sept. 2015), https://www.energy.gov/sites/prod/files/2015/09/f26/2015%20National%20Electric%20Transmission%20Congestion%20Study_0.pdf [https://perma.cc/8XA5-TH5D].

62. *Id.* at xviii.

looked to interconnection queues as a gauge. Midwest interconnection requests totaled over thirty-three gigawatts (GW), with wind dominating the queue in 2012.[63] Correcting this issue at the transmission level is not as simple as building new infrastructure and high voltage wires. Transmission lines are both expensive and generally unpopular. "Often it may be easier, cheaper, and environmentally preferable to eliminate or shift demand, or to locate generation strategically than it is to build new lines."[64] This solution is revisited throughout this paper.

Solutions that help avoid the challenges of building new transmission networks include providing more on-site, location-specific energy conversion or storage options, like P2G technology. Rather than curtailment, excess energy from renewables can be converted into gaseous forms, such as hydrogen or synthetic methane, and stored in existing gas networks and storage facilities.[65] To the extent that the P2G option utilizes surplus renewable energy results in pipeline quality hydrogen gas or synthetic methane and the utilization of existing gas supply network or storage facilities, then it arguably exemplifies a pathway towards (a) preventing the stranded assets question faced by existing gas industry suppliers in a carbon-constrained world and (b) supporting the growing net-zero-carbon energy industry by creating options to store excess renewable energy in usable and safe forms within existing supply systems. Figure 2 below shows the potential uses in which hydrogen or synthetic methane produced from a P2G facility could be deployed (e.g., in transportation, power generation on-demand, and residential uses).[66]

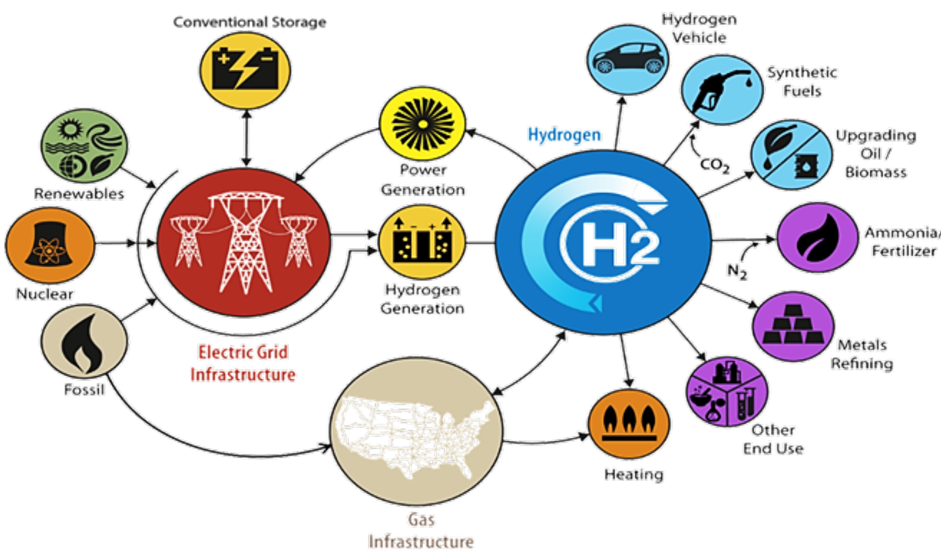
63. *Id.* at xiv fig.ES-3.

64. Shelley Welton, *Non-Transmission Alternatives*, 39 HARV. ENV'T L. R. 457, 460 (2015).

65. Azadeh Maroufmashat & Michael Fowler, *Transition of Future Energy System Infrastructure; Through Power-to-Gas Pathways*, ENERGIES, Aug. 2017, at 6–7.

66. *See also* LAMBERT, *supra* note 8, at 5. Some identifiable challenges to the deployment of P2G technologies include scalability and finding the demand centers for by-productions such as hydrogen in different economic sectors such as transportation where, for instance, hydrogen gas may have to compete with traditional gasoline or traditional battery-powered EVs. Hydrogen refueling standards, station permitting process limitations, and unclear or inadequate guidelines for ensuring safe blends with natural gas networks are some of the other considerable challenges. *See*. Fleming & Fershee, *supra* note 6, at 140–45; Off. of Energy Efficiency & Renewable Energy, *Hydrogen Storage Challenges*, ENERGY.GOV, https://www.energy.gov/eere/fuelcells/hydrogen-storage-challenges

Figure 2: Schematic on the U.S. H2@Scale Concept and Integration of Energy Supply Systems[67]



In the U.S., natural gas accounts for about 31% of total primary energy consumption, and 35% of that consumption went into electricity generation.[68] Thus, gas supply networks play a major role in electricity supply, and, when considering national energy reliability, security, and competitiveness objectives, one should consider the natural gas transmission and distribution system, as well as the electric transmission system. The nation's electric network is comprised of roughly 240,000 miles of high-voltage

[https://perma.cc/22PK-6XTA]; U.S. DEP'T OF ENERGY, HYDROGEN STRATEGY: ENABLING A LOW-CARBON ECONOMY 17–18 (July 2020), https://www.energy.gov/sites/prod/files/2020/07/f76/USDOE_FE_Hydrogen_Strategy_July2020.pdf [https://perma.cc/U8SZ-57KE].

67. Off. of Energy Efficiency & Renewable Energy, *H2@Scale*, ENERGY.GOV, https://www.energy.gov/eere/fuelcells/h2scale [https://perma.cc/6TF8-PHVA].

68. U.S. ENERGY INFO. ADMIN., ANNUAL ENERGY OUTLOOK 2019 at 21 (Jan. 2019), https://www.eia.gov/outlooks/archive/aeo19/pdf/aeo2019.pdf [https://perma.cc/Y3WA-Y6JY]. In its 2050 projections for electricity generation by fuel sources, the U.S. EIA reports that, by 2050, 39% of electric generation capacity will be fuelled by natural gas (up from 34% in 2018), while renewables will grow from 18% in 2018 to 31% by 2050. *Id.* at 22. Nuclear is expected to decline from 19% in 2018 to 12% by 2050 while coal continues to decline from 28% in 2018 to 17% by 2050. *Id.*

transmission lines.[69] Interestingly, there are over 1.6 million miles of natural gas transmission pipelines nationwide.[70]

One advantage that the natural gas value chain has, which is unmatched by the electric sector, is energy storage capacity. As also depicted in Figure 3 below, there are around 400 active storage facilities spread across thirty states with the capacity to store roughly four trillion cubic feet (Tcf) of natural gas for consumer use in the U.S.[71] This is enough storage to accommodate 20% of all-natural gas consumed in the U.S. By comparison, storing 20% of the electricity consumed would require 85 GW of advanced battery storage,[72] more than triple the available electrical energy storage installed in the U.S. to date.[73]

69. *Transmission*, EDISON ELEC. INST., https://www.eei.org/issuesandpolicy/transmission/Pages/default.aspx [https://perma.cc/GA5B-RURH].

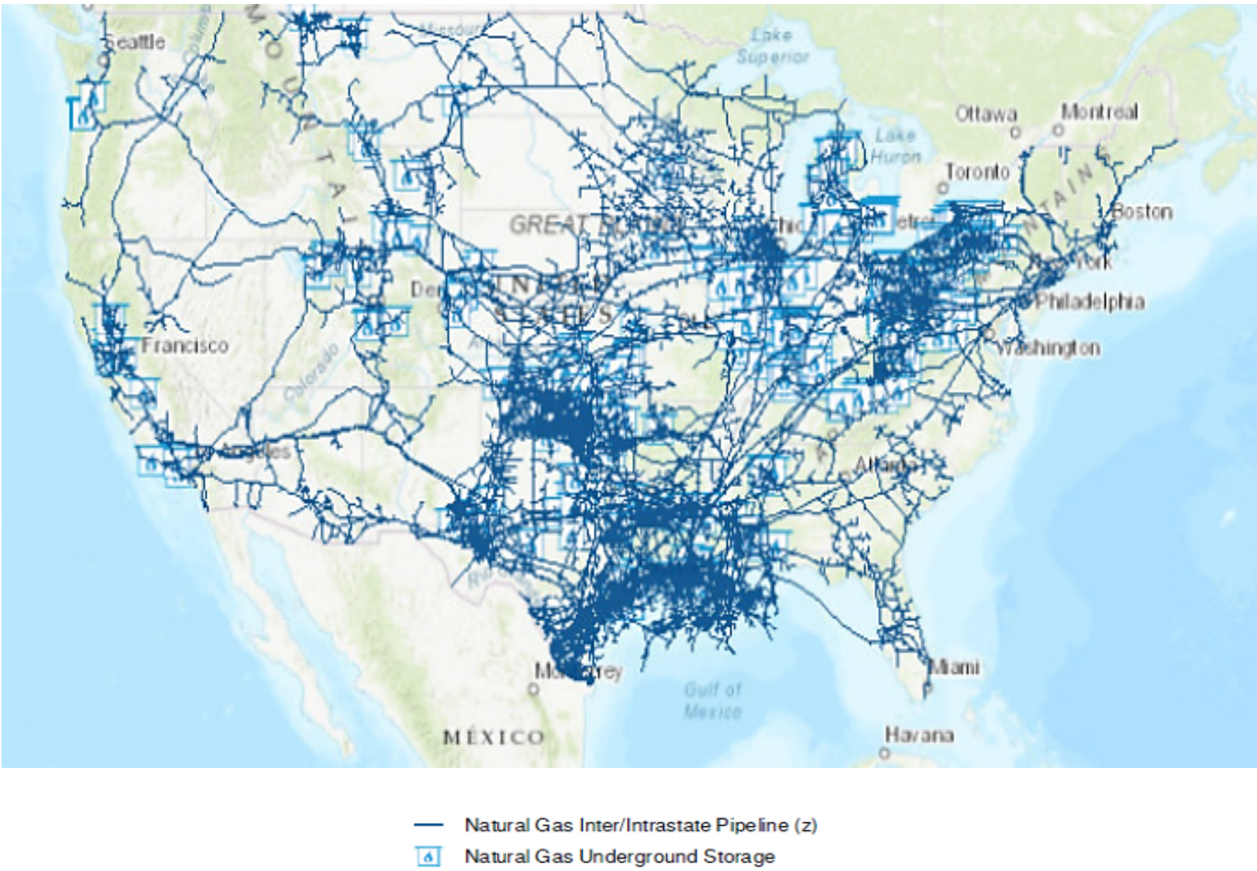
70. AM. GAS ASSOC., ANNUAL DISTRIBUTION AND TRANSMISSION MILES OF PIPELINE 27 (Dec. 2020), https://www.aga.org/contentassets/71fe352cf6fa4291a29be724ab0622b8/table5-3.pdf [https://perma.cc/Q5DP-BG2R].

71. *Reliable Natural Gas*, AM. GAS ASSOC., https://www.aga.org/natural-gas/reliable [https://perma.cc/L88A-NZTX].

72. Calculated using 2017 consumer energy sales of 3,723,356 thousand megawatt hours. *Summary Statistics for the United States, 2009-2019*, EIA, https://www.eia.gov/electricity/annual/html/epa_01_02.html [https://perma.cc/BH84-5J7P].

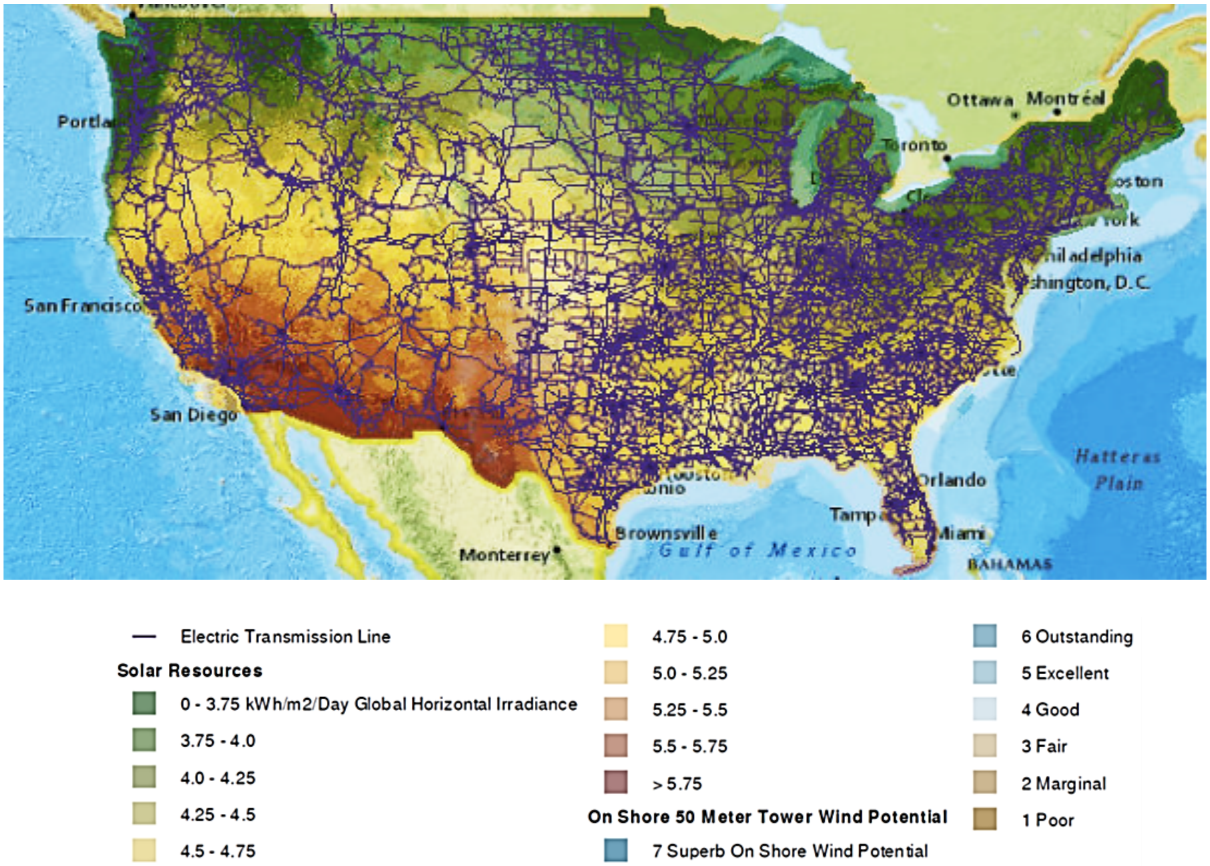
73. In 2020, given 23.2 GW of installed storage, 96% was provided by pumped hydro systems. CTR. FOR SUSTAINABLE SYS., UNIV. OF MICH., U.S. GRID ENERGY STORAGE 1 (Sept. 2020), http://css.umich.edu/sites/default/files/US%20Grid%20Energy%20Storage_CSS15-17_e2020.pdf [https://perma.cc/RY6F-F4KG].

Figure 3: U.S. Natural Gas Pipeline Transmission Network and Storage Facilities[74]



74. *U.S. Energy Mapping System*, EIA, https://www.eia.gov/state/maps.php [https://perma.cc/TMS2-TKDY]. For more about the U.S. natural gas pipeline network and storage, see *Natural gas explained: Natural gas pipelines*, EIA, https://www.eia.gov/energyexplained/natural-gas/natural-gas-pipelines.php [https://perma.cc/ZD3J-YXKW] (Dec. 3, 2020).

Figure 4: The U.S. Electricity Transmission Network and Geographic Spread of Onshore Wind and Solar Resources[75]



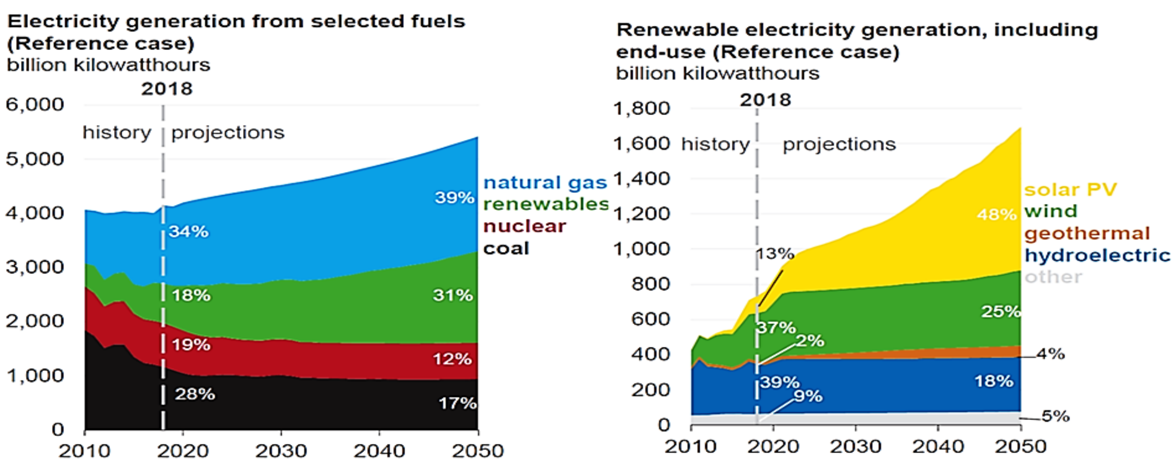
In particular regard to New York, the state has twenty-six natural gas underground storage facilities that, along with storage in nearby states, are key to meeting northeastern winter heating demand.[76] "Virtually all major interstate pipelines from the Gulf

75. *U.S. Energy Mapping System*, *supra* note 74. The bulk of existing transmission assets is concentrated in the Northwest and Eastern areas that have comparatively less solar and wind energy intensities or resources.

76. *New York State Energy Profile*, EIA, https://www.eia.gov/state/print.php?sid=NY [https://perma.cc/BX7N-ZPPJ] (Sept. 17, 2020).

Coast, Appalachia, and Canada reach New York, both to supply in-state customers and to ship supplies onward to New England."[77] The question for future energy policymakers will be whether the vast gas supply networks can efficiently decarbonize and play a key role in the unfolding energy transition and low-carbon future. Over the past two decades, gas supply networks have become increasingly interconnected with the electricity market,[78] while electricity generated from renewables such as solar and wind is expected to gain more market share onwards to 2050 as shown in figure 5 below.[79]

Figure 5: U.S. Electricity Generation by Source Outlook to 2050[80]



77. *Id.*

78. *See* OYEWUNMI, *supra* note 13, at 85–96. As the markets and organization of natural gas supply to power developed in the U.S., the role of gas and network infrastructure also grew. *Id.* From the 1990s till present day, this growth was driven largely by the policy-led restructuring of the interstate gas market, independent economic regulation initiatives, competitiveness and security of supply edge compared to coal and other base load sources, technological advancements and efficiency improvements in gas-to-power facilities, abundance of gas supply from local shale gas production boom and the attendant effects on reducing the price and costs of gas-to-power, growing fuel-switching patterns from coal to gas for environmental, and commercial reasons. *Id.*

79. U.S. ENERGY INFO. ADMIN., *supra* note 68, at 21.

80. *Id.*

Despite the energy storage, reliability, capacity adequacy, and intermittency challenges, the utilization of renewable energy sources such as solar and wind continue to grow due to factors such as falling costs of installation and project development, concerns relating to decarbonization and climate change mitigation, demand for new, domestic energy supplies, and direct policies such as renewable portfolio standards and federal tax incentives.[81] The remainder of this paper explores the evolving and future scenario, the technologies and assets that are positioned to support the effort, the regulatory bodies that may govern, and the role of law and regulation in its success.

1. Understanding the Energy Supply System and Operators

The network of electric transmission lines, most of which is depicted in Figure 4 above, comprises the main part of the complex power supply grid in the U.S., which is often categorized into three interconnected network systems (i.e., the eastern interconnection,[82] the western interconnection,[83] and the Electric Reliability Council of Texas (ERCOT)).[84] Power generation, supply, and consumption within these interconnected network systems could be entirely within a State's territory (i.e., intrastate) or from one state to consumers in another state (i.e., interstate). Operators in the value chain include an extensive collection of (i) public, private, and cooperative utilities; (ii) over 1,000 independent power generators; (iii) seven ISOs and four RTOs;[85] and (iii) an increasing number of

81. Troy A. Rule, *Still Growing: How America's Renewable Energy Industry is Surviving in the Trump Era*, OIL, GAS & ENERGY L., Nov. 2018, at 10.

82. Including the region east of the Rockies, excluding most of Texas, but including adjacent Canadian provinces except Québec. U.S. DEP'T OF ENERGY, DOE/OE-0017, UNITED STATES ELECTRICITY INDUSTRY PRIMER 11 (2015).

83. Extending from the Rockies to the Pacific Coast, again including adjacent Canadian provinces. *Id.*

84. Covering most of Texas. *Id.*

85. *Id.* at 26–28. There are currently seven ISOs within North America, comprising: CAISO—California ISO, NYISO—New York ISO, ERCOT—Electric Reliability Council of Texas; also, a Regional Reliability Council, MISO—Midcontinent Independent System Operator, ISO-NE—ISO New England, AESO—Alberta Electric System Operator, IESO—Independent Electricity System Operator, additionally, there are currently 4 RTOs within North America: PJM—PJM Interconnection, MISO, SPP—Southwest Power Pool; also a Regional Reliability Council, ISONE—ISO New England; also an RTO. *Id.* at 26.

distributed homes and businesses with onsite generating systems. The NYISO covers the entire state of New York and is responsible for operating the state's wholesale power markets that trade electricity, capacity, transmission congestion contracts, and related products, in addition to administering auctions for the sale of capacity.[86] NYISO operates New York's high-voltage transmission network and performs long-term planning.[87]

At the national level, the respective U.S. wholesale electricity markets formed after the enactment of the Public Utilities Regulation Act 1978 (PURPA)[88] prompted the growth of qualified non-utility generators, including small scale renewables, while the Energy Policy Act 1992 ("EPAct 1992")[89] facilitated the emergence of wholesale electricity generators in the U.S.[90] The Federal Energy Regulatory Commission (FERC) also initiated several regulatory actions to introduce competition and a market-based approach to supply, pricing, and access to interstate transmission networks.[91] Among other things, the EPAct 1992 was implemented pursuant to FERC's Order No. 888, 18 C.F.R. pts. 35, 385, and Order 889, 18 C.F.R. pt. 37.[92] In addition, FERC's Order 888 provides that public utilities that own or operate interstate transmission facilities are to file non-discriminatory open access tariffs outlining the "minimum terms and conditions for non-discriminatory service."[93] Order 888 also requires utilities to "'functionally unbundle' their transmission service from their generation and power marketing functions, and to

86. New York State Energy Profile, supra note 76.

87. *What We Do: Reliably Managing NY's Power Grid & Energy Markets*, N.Y. ISO, https://www.nyiso.com/what-we-do [https://perma.cc/NP6V-VPTL]. The most severe transmission constraints in NYISO area are in the southeastern portion of the state, leading into New York City and Long Island. *See Market Assessments: Electric Power Markets*, FERC, https://www.ferc.gov/industries-data/market-assessments/electric-power-markets [https://perma.cc/R46Y-G7TA] (Oct. 23, 2020) ("As a result of their dense populations, New York City and Long Island are the largest consumers of electricity. Consequently, energy flows from the west and the north toward these two large markets, pushing transmission facilities near their operational limits. This results in transmission constraints in several key areas, often resulting in higher prices in the New York City and Long Island markets.").

88. Public Utility Regulatory Policies Act of 1978, Pub. L. No. 95-617, 92 Stat. 3117.

89. Energy Policy Act of 1992, Pub. L. No. 102-486, 106 Stat. 2776.

90. *See* TOMAIN & CUDAHY, *supra* note 1, at 394–402.

91. *Id.* at 403.

92. *Id.* at 402.

93. *Id.*

provide unbundled ancillary transmission services."[94] Currently, the traditional wholesale electricity markets exist in the Southeast, Southwest, and Northwest where utilities are responsible for system operations and management while providing power to retail consumers. Such utilities are vertically integrated to the extent that they own the generation, transmission, and distribution systems used to serve electricity consumers.[95]

As a result of Order 888, several transmission network operators and owners formed ISOs from existing power pools, helping to facilitate open access to supply networks. Going a step further, in FERC's Order No. 2000, the Commission encouraged utilities to join RTOs which, like an ISO, would operate the transmission systems and develop innovative procedures to manage transmission equitably.[96] Each of the ISOs and RTOs has energy and ancillary services markets in which buyers and sellers could bid for or offer generation, capacity, and other valuable services. The ISOs and RTOs use bid-based markets to determine economic dispatch. While major sections of the country operate under more traditional market structures, two-thirds of the nation's electricity load is served in RTO regions. Notably, FERC's Order 1000, issued in 2011, had the effect of requiring transmission operators to cooperate with neighboring systems and to consider a state-level policy on such matters as renewable energy, energy efficiency, environmental, and land-use regulatory authorities, so far as decisions by those regulatory bodies impact the ability of the transmission operators to accurately assess system reliability.[97]

B. Cleaner Gas Sources

Renewable Natural Gas is "derived from biomass or other renewable resources and is a pipeline-quality gas that is fully

94. *Id.*

95. Wholesale physical power trade typically occurs through bilateral transactions, and while the industry had historically traded electricity through bilateral transactions and power pool agreements, Order No. 888 promoted the concept of ISOs. Promoting Wholesale Competition Through Open Access Non-Discriminatory Transmission Services by Public Utilities; Recovery of Stranded Costs by Public Utilities and Transmitting Utilities, 61 Fed. Reg. 21,540, 21,551 (May 10, 1996) (to be codified at 18 C.F.R pts. 35, 385).

96. Order No. 2000, 18 C.F.R. § 35 (1999).

97. Order No. 1000, 18 C.F.R. § 35 (2011).

interchangeable with conventional natural gas."[98] Two important categories of RNG are worth distinguishing. The first category includes gaseous fuels that are created by processes not directly associated with energy production. These include waste gases that are collected from a variety of feedstocks, such as wastewater treatment digesters, manure, and other agricultural wastes or landfill gases to form biogas and biomethane. These waste gases are captured and either used locally for heat or electricity or conditioned further for injection into an existing natural gas pipeline. Most often associated with methane, a potent GHG, these waste gases have a large carbon footprint, and their capture results in carbon-negative fuel supply. This is because methane is about twenty-five times more potent in terms of global warming impact than carbon dioxide, which is the resulting emission from natural gas combustion.[99]

A simple way to visualize this positive environmental attribute is a methane capture equal to -25 plus a combustion emission of +1 is equal to a total GHG impact of -24.[100] The number of RNG facilities in this category has nearly doubled in the last five years.[101] These facilities have the potential to displace up to 10% of natural gas supplied from traditional, fossil-based sources.[102] However, their positive impact on decarbonization, by reducing GHGs, far exceeds their impact on natural gas supply, due to the global warming potential of methane mentioned earlier. One study of a southern California gas utility found that replacing 16% of the gas system's throughout, for that single utility, could achieve the same GHG

98. AM. GAS FOUND., RENEWABLE SOURCES OF NATURAL GAS: SUPPLY & EMISSIONS REDUCTION ASSESSMENT 5 (Dec. 2019), https://gasfoundation.org/wp-content/uploads/2019/12/AGF-2019-RNG-Study-Full-Report-FINAL-12-18-19.pdf [https://perma.cc/YZ2F-TNSR].

99. *Understanding Global Warming Potentials*, EPA, https://www.epa.gov/ghgemissions/understanding-global-warming-potentials [perma.cc/6F3J-MEF2] (Sept. 9, 2020).

100. This example does not include upstream impacts associated with potential land use changes.

101. Alyssa Danigelis, *Renewable Natural Gas Production Facilities Grow by 85% in Four Years*, ENV'T & ENERGY LEADER (Apr. 20, 2018), https://www.environmentalleader.com/2018/04/renewable-natural-gas-production-growth/ [https://perma.cc/GMP2-UK9M].

102. AM. GAS FOUND., THE POTENTIAL FOR RENEWABLE GAS: BIOGAS DERIVED FROM BIOMASS FEEDSTOCKS AND UPGRADED TO PIPELINE QUALITY 1 (Sept. 2011) https://gasfoundation.org/wp-content/uploads/2019/11/agf-renewable-gas-assessment-report-110901.pdf [https://perma.cc/Y557-FN8D].

reduction as electrifying *all* buildings in California.[103] These environmental benefits have been noted by both regulators and utilities nationwide, and both are moving forward with investments, laws, and policies that support further development of these resources.[104]

Some states have required RNG potential studies and voluntary procurement targets for utilities to further motivate the expansion of this industry.[105] Because these RNG facilities are finding a supportive policy, at least in some states, and because these renewable energy supplies remain isolated within the gas system, this paper does not evaluate the details of capture-based RNG any further than noted above. There are many opportunities for further study associated with these fuels, their end-uses, regulatory support, and the need for incentives.

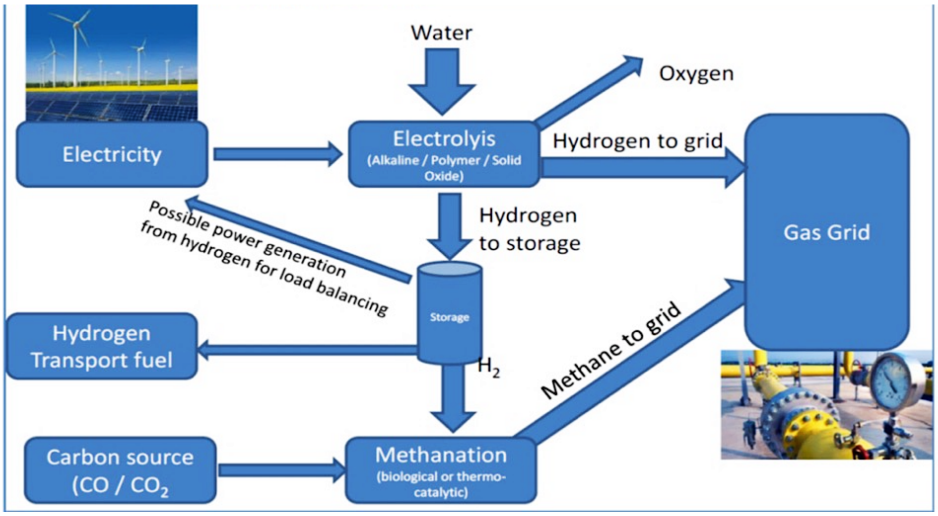
103. SOCALGAS, GETTING THE FACTS ON RENEWABLE NATURAL GAS: MAKING CALIFORNIA'S FUTURE RENEWABLE 16 (2018), https://www.epa.gov/sites/production/files/2018-11/documents/7._deanna_haines-508.pdf [https://perma.cc/2E6T-G5XQ].

104. *See* 2019 Or. Laws Ch. 541; S. 154, 2019 Leg., 80th Sess. (Nev. 2019); S. 605, 2014 Leg., Reg. Sess. (Cal. 2014).

105. In Oregon, a Renewable Natural Gas Bill was recently signed into law which outlines the objectives of adding as much as 30% RNG into the state's pipeline system. The new law sets voluntary RNG goals for Oregon's natural gas utilities. S. 98, 80th Leg., Reg. Sess. (Or. 2019). Additionally, it (i) allows utility investment in the interconnection of RNG production; (ii) supports targets of 15% by 2030, 20% by 2035 and 30% by 2050; and (iii) provides local communities a potential revenue source to turn their waste into energy. *Id.*

C. The Green Hydrogen and Methanation Option

Figure 6: The Power-To-Gas and Methanation Process[106]



Unlike the more common "Blue Hydrogen" produced from SMR, "green hydrogen," which is hydrogen produced from renewable electricity via electrolysis, is gaining considerable attention, especially in Europe, and more so in the U.S. Electrolysis is an electrochemical reaction that uses electricity to split molecules into their constituent atoms. To obtain "green" hydrogen, electrolysis occurs in a device called an electrolyzer, which splits water into hydrogen and oxygen.[107] Understandably, the costs of the "electrical

106. LAMBERT, *supra* note 8, at 3.

107. WOOD MACKENZIE, GREEN HYDROGEN PRODUCTION: LANDSCAPE, PROJECTS AND COSTS 5 (Oct. 2019), https://cafcp.org/sites/default/files/Executive_summary___Wood_Mackenzie_Green_Hydrogen.pdf [https://perma.cc/GUY4-BDMC]. The starting point for P2G is to use excess electrical energy to produce hydrogen (with oxygen as a by-product). LAMBERT, *supra* note 8, at 3. Further, the three ways to carry out the process:

> [1] Alkaline Electrolysis (AEL). This is the most well-established technology, using an aqueous alkaline solution as the electrolyte. It is available commercially at a price of about €1000/kW, but it can take 30 to 60 minutes to restart the system following a shutdown, making it less suitable for handling intermittent power supply with frequent starts and stops: a considerable drawback for the envisaged use of balancing supply from intermittent renewables; [2] Polymer Electrolyte Membrane (PEM)

energy" used in the process, as well as the electrolyzer and water of essential components, impact the scalability and utilization of this process compared to the blue hydrogen process of SMR. As shown in Figure 6 above, these systems can produce two gaseous fuels: hydrogen and/or synthetic methane. Hydrogen results from the first of two potential processes: electrolysis. By completing a second step in the process, methanation, a P2G system can also produce methane. This second step involves the added benefit of carbon capture, as the chemical conversion of hydrogen to methane requires the addition of a carbon source. In both cases, these systems are categorized as carbon neutral. Hydrogen production and use neither require nor emit GHGs. Methane production requires carbon as an input, which creates a carbon sink. Methane's end-use, however, involves combustion and release of carbon dioxide, thus the synthetic methane produced by P2G is carbon neutral.[108] These fuels can then be used on-site for heat or electricity or injected into the natural gas pipeline system.

Because P2G systems rely on electricity as the primary input, this energy must come from low-carbon or carbon-neutral renewable sources to make any compelling argument for its GHG benefits. The most interesting quality of P2G systems though is not necessarily their direct impact on GHG reductions. Rather, it is their interaction with the electric system and their role in overall energy management. The system's ability to utilize electricity in novel ways creates opportunities that do not exist with other, more traditional

---

> Electrolysis. This technology is newer than AEL and is also available commercially. It has better start-stop characteristics than AEL membranes, but currently costs around €2000/kW and is predicted to have a shorter equipment lifetime than AEL. [3] Solid Oxide Electrolysis (SOEC) has been developed more recently and is still at the laboratory stage. While these are still to be commercialised, they are expected to have a higher electrical efficiency, lower material cost, and the ability to operate in reverse as a fuel cell. A life cycle analysis of water consumption required for hydrogen production16 shows that around 10 US gallons (38 kgs) water is required per kilogram hydrogen production from electrolysis. This is comparable to the water requirement for hydrogen production from Steam Methane Reforming (SMR).

Id. at 4 (citations omitted).

108. Tade Oyewunmi, *Decarbonising Gas and Electricity Systems: An Outlook on Power-to-Gas and other Technology-Based Solutions*, *in* DECARBONISATION AND THE ENERGY INDUSTRY, *supra* note 19, at 69, 88 (evaluation of carbon footprint for P2G systems does not include lifecycle emissions associated with renewable energy production, land use changes, or other potential contributors to greenhouse gas emissions such as material or equipment fabrication).

loads. There is now a growing class of energy consumers in an increasingly decentralized electricity value chain because of the distributed nature of renewable energy generation and energy storage systems. With the adoption of ancillary technologies such as net metering and smart meters, electricity supply stakeholders that were previously primarily consumers can sell excess energy they produce to the conventional grid and also provide essential grid services such as storage, efficiency, and demand response. This growing class of electricity sector stakeholders is widely known as 'prosumers.'[109]

The P2G option and concept align well with the evolving paradigm in which consumers and suppliers of distributed renewable-based electricity are increasingly involved in grid reliability issues, demand response, and energy storage.[110] Conversely, it could also be argued that scaling up P2G adds additional regulatory complexity to the natural gas and electricity regulatory framework from a legal and institutional perspective.[111] For instance, policymakers would have to consider issues such as (i) what is/are the most effective approach(es) and rules to govern access and pricing for shipping or storing hydrogen produced via P2G in existing natural gas systems; (ii) is hydrogen from P2G a "storage" medium or energy transmission medium?; and (iii) which institutions (state or federal) will oversee the development of P2G projects and transactions involving interstate or intrastate supply or supplies for bulk "storage" purposes.

109. Sharon B. Jacobs, *The Energy Prosumer*, 43 ECOLOGY L.Q. 519, 521 (2016). *Cf.* Stein, *supra* note 45, at 889, 896 (customers also contribute to two resources that assist with maintaining the reliability of the grid: (1) energy storage and (2) demand response (DR), referred to as "reliability resources" that are an essential component of supporting intermittent, renewable energy).

110. Power-to-Gas-to-Power systems add a third step to the process, where synthetic methane is combusted in a standard gas-fired turbine to produce electricity. PAULA SCHULZE ET AL., POWER-TO-GAS IN A DECARBONIZED EUROPEAN ENERGY SYSTEM BASED ON RENEWABLE ENERGY SOURCES 12 (2017), http://www.afhypac.org/documents/European%20Power%20to%20Gas_White%20Paper.pdf [https://perma.cc/WMM8-S3L8].

111. *See* Jacobs, *supra* note 109, at 571–72; *see also* OYEWUNMI, *supra* note 13, at 86–100.

III. REGULATING P2G IN THE GAS AND ELECTRICITY CONTEXT

To address the regulatory complexity of P2G systems, it is helpful to evaluate each segment of the process (i.e., electricity from VREs and gas networks) in the context of the markets from which those segments relate separately before we can understand the interplay between the two. P2G's electric supply can be reasonably procured from a variety of sources and by a diverse number of buyers as shown earlier in Figure 2 above. The electrical energy can be sourced from three basic categories: interstate transmission, intrastate transmission, and distribution, or local generation. The first two are traditional "grid" supplies, while the third is most commonly associated with isolated systems such as co-generation or self-generation facilities, where no connection to external grids exists and, thus, is mostly independent of distribution networks. Another example of this isolated generation could include local microgrids, where energy is physically isolated to local infrastructure.[112] The locational aspect of the sourced energy is key in identifying whether power is purchased in wholesale or retail markets, or outside of existing market structures.

In addition to the physical location of energy offtake, power purchasers range from private firms and power marketers to traditional investor-owned electric utilities. Because the ultimate product in most power-to-gas systems is gaseous fuel (i.e., hydrogen or synthetic gas), there is a high likelihood that gas producers and gas utilities also become power purchasers. Additionally, on the issue of energy purchases, there are notable differences in regulatory oversight when traditionally regulated firms are involved. Gas utilities are typically associated with local distribution networks and are regulated by state Public Utility Commissions and institutions. Such gas utilities could also own and operate interstate pipelines, thus subjecting them to the jurisdiction of the Federal Energy Regulatory Commission.[113] This distinction is significant as we look to identify the regulatory framework affecting P2G systems, their energy supply, and their gas production.

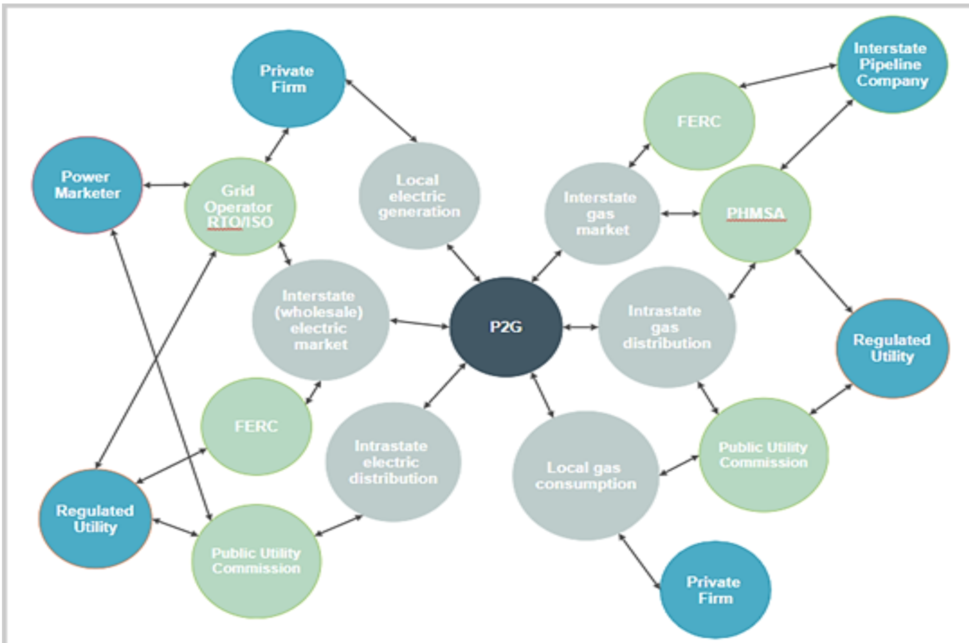
---

112. Dan T. Ton & Merrill A. Smith, *The U.S. Department of Energy's Microgrid Initiative*, ELECTRICITY J., Oct. 2012 at 84, 84–85.

113. *NGPA Section 311 Pipelines*, FERC (May 7, 2020), https://www.ferc.gov/industries-data/natural-gas/intrastate-transportation/ngpa-section-311-pipelines [https://perma.cc/A3E5-NW8J].

The final group of variables that must be considered is the ultimate disposition of the gas from the P2G system. Here too, we see a wide array of options available to P2G facilities. The first, and by far most simplistic in terms of regulatory obligations, would be consumption. In this case, gas is combusted locally, eliminating the interaction with pipelines or other existing infrastructure. This consumptive use can be expanded to include the broader category of power-to-gas-to-power, where the resulting renewable gas is combusted in a steam turbine system, for electric generation. While arguably the least efficient use of the P2G system, it is a route worth exploring. The more likely scenarios involve existing pipelines and underground storage systems. P2G products could be transported through interstate pipelines, distribution systems, and/or retained in underground storage fields for future use or transport. From the above, the energy source, the identity of the P2G developer, and the means disposition and buyer of the hydrogen or synthetic methane can each play a pivotal role in the ultimate framework affecting these systems. Figure 7 below shows this intricate relationship.

Figure 7: Power-to-Gas Regulatory Interactions by Power Source and Gas Disposition[114]



A. Energy Procurement

To understand the policies and regulations affecting P2G facilities, each of the potential sources outlined above is further discussed throughout this section, categorized at the federal, state, and local levels of jurisdiction. For purposes of this discussion, it is generally assumed that these categories are synonymous with each of the potential energy sources: interstate transmission, distribution, and on-site generation, respectively, unless specifically noted. Additionally, it is assumed that any firm type has open access to each category of energy supply.

1. Federal Level

Interstate energy supplies require electric transmission systems and are primarily managed by RTOs and ISOs in the United States.

114. Dziedzic & Oyewunmi, *supra* note 7, at 17.

Many of these grid operators have also developed and now manage robust energy markets as a means of understanding risk associated with the system, and the supply more generally. These energy markets are commonly referred to as wholesale markets, as they are the primary resource for traditional utilities, power producers, and power marketers to secure or sell energy that is not covered by other supply contracts, such as power purchase agreements (PPAs). Because the majority of transactions in these markets occur as a means to serve a consumer that is *not* the buyer, these activities are "sale for resale."[115] These transactions are regulated by the Federal Energy Regulatory Commission (FERC).[116] However, in a typical P2G system, the electrical energy purchased in wholesale power markets is no longer a "sale for resale" because it is consumed via the electrolyzer to produce hydrogen which may then be stored or utilized in hydrogen-compatible systems.[117] Therefore, in the case of P2G, the purchase of energy from the wholesale market does not ordinarily trigger FERC jurisdiction as a typical wholesale 'sale-for-resale' transaction.

The next question to consider focuses on the delivery of electricity to the purchaser or P2G facility owner. If electricity is purchased directly from a generator on the wholesale market and transmitted via the interstate transmission lines, such activity will ordinarily be within the FERC's jurisdiction.[118] For many large industrial customers with access to transmission lines, FERC rates are part of the total cost of energy, meaning a P2G facility would pay FERC-regulated rates for moving electricity to the point of consumption. However, the P2G facility is unlikely to be directly regulated by FERC, as it is simply a consumer. Recently, as private firms have shown an increased demand for renewable energy and/or lower-cost energy, this scenario is becoming more prevalent.[119] While a direct, physical connection is possible for a P2G system to directly access the transmission system, it is not necessary to take advantage of wholesale energy supplies. Facilities can connect to the

115. *See* Federal Power Act § 201, 16 U.S.C. § 824(b)(1), (d).

116. *See id.* § 824(b)(1).

117. With the exception of Power-to-Gas-to-Power applications, energy is used, not resold.

118. 16 U.S.C. § 824(b)(1).

119. *See* Sarah Penndorf, *Renewable Energy Power Purchase Agreements*, 3DEGREES (Feb. 5, 2018), https://3degreesinc.com/resources/ppas-power-purchase-agreements/ [https://perma.cc/ZG89-HSCP].

grid wherever it may be convenient, including through lower-voltage distribution lines, while still benefitting from wholesale market access. Systems designed to purchase energy wholesale but be physically connected to low voltage distribution would require additional coordination with the local utility and fees for the use of the system.

By purchasing energy from the wholesale market, P2G systems maximize potential income-earning opportunities. Facilities also have the option of bilateral contracts, or Power Purchase Agreements (PPAs), between a renewable energy supplier and the P2G facility. To date, however, PPAs offer far less flexibility, remaining insulated from day-ahead and spot market pricing. While PPAs are ideal for investors and developers looking for price stability, P2G's benefits stem most directly from its ability to perform under volatile market conditions. The buyer (the P2G facility) would provide more grid services if they were to bid demand into the wholesale market, based on specific price signals, minimum load requirements, or curtailment orders. These conditions are variable and restricting a P2G system's response to these market signals limits the benefit to the facility, by limiting access to the lowest cost energy, increasing the likelihood that excess electric supply goes unutilized.

Wholesale markets are regulated by FERC but managed by RTOs and ISOs in most regions. These organizations are given considerable latitude under FERC's oversight to develop rules and markets to suit the needs of their regional energy supply, including interconnection approvals. For instance, the NYISO, which was launched in 1999 following FERC approval, manages wholesale power and capacity markets for New York and ensures the system is balanced, etc.[120] Likewise, the PJM Interconnection is the RTO that "operates a competitive wholesale electricity market and manages the reliability of its transmission grid" in all or part of thirteen states in the U.S.[121] Ultimately, an RTO must have commission-approved

120. *See Market Assessments: Electric Power Markets*, supra note 87.

121. *See id.* The 13 states covered by OJM include Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia. *Id.* "PJM's markets include energy (day-ahead and real-time)" and it also "provides open access to the transmission and performs long-term planning." *Id.* In managing the grid, PJM "centrally dispatches generation and coordinates the movement of wholesale electricity" capacity and ancillary services. *Id.*

tariffs that outline how the market rules will impact transmission costs, reliability, and wholesale markets.[122] Rules which may incentivize power-to-gas systems would impact both system reliability and payments to P2G facilities from ancillary service markets. These ancillary service payments are part of market-based rates, requiring FERC approval when initially developed by the RTOs.[123]

For many purchasers, such as utilities or existing power marketers, purchasing energy for P2G systems would not spur any unique oversight from FERC. Because the markets and their rules are managed by FERC, market participants are bound more closely to the rules of the RTOs. For purchasers that are not already market participants, such as private firms or gas producers, there is a requirement that these firms register as Market Participants in the appropriate regional market. This activity is often regulated by state utility commissions, in terms of who may register and/or participate in wholesale markets as discussed later. P2G facilities are likely to behave similarly to other distributed energy resources (DERs) and energy storage systems. Both DERs and storage systems have recently been evaluated by FERC, but these decisions have not included, nor specifically addressed P2G and hydrogen produced as a way of storing energy from VREs that would otherwise be curtailed or lost as a player in such markets. This is an area of future policy development and expansion.

2. State Level

Electric purchases within each state may originate in wholesale energy markets, as described above. Alternatively, P2G facilities can simply interconnect with existing distribution systems and purchase energy through their local electric utility. This arrangement is familiar to consumers, regulators, and utilities and would function similarly to other commercial or industrial energy use. Energy purchases in this system are regulated by each state's public utility commission (such as the NYPSC in New York) and any relevant tariffs of the utility. Here too, overarching policies from FERC and

122. *See* 18 C.F.R. § 35.1 (2020).
123. *See* 18 C.F.R. § 35.36–35.42 (2020).

the RTOs dictate activities within the markets by non-utility firms, even when purchasing at the retail level.[124]

Arguably more important than access to markets, at the state level, is the presence or absence of supportive policy. As noted earlier, state RPS laws have fostered a significant acceleration of renewable electricity, primarily from wind and solar. However, few of these include innovative technologies, like renewable natural gas and P2G produced hydrogen, as qualified producers at the moment.[125] Those that do require that renewable gas be used for electric generation. Therefore, only power-to-gas-to-power facilities would have the potential to benefit and meet such standards. A secondary question arises for P2G systems, concerning certifying the power generated from their system: Would power purchased from the grid have to be from renewable sources to qualify under RPS programs? By design, the P2G systems would be taking excess renewable energy from the grid, and only that energy, because it is the most economical option for P2G systems. However, it could be argued that the secondary generation, in power-to-gas-to-power systems, is produced via renewable natural gas, a gas that can be produced endlessly, so long as electricity is available. However, this argument is unlikely to resonate with the spirit of the RPS regulations and policy. Therefore, a power-to-gas-to-power facility is expected to purchase verifiable renewable energy to participate in RPS programs.

Lastly, energy purchases made by regulated utilities must undergo additional evaluation by State utility commissions, where they will be scrutinized against "prudent" and "used-and-useful" standards.[126] While seemingly familiar, P2G facilities are due to proper consideration under this assessment. If an electric utility is the owner-operator of a P2G facility, the initial investment would undergo rigorous approval processes to determine its usefulness and the appropriate rate of return. However, the ongoing operation may trigger a broader discussion on whether the subject P2G system is utilized in a sufficient capacity to qualify as "used" by commissioners.

124. An example of overlapping market rules is evidenced in FERC Order 745, where market access is dictated by state utility commissions, but compensation and market rules are constructed by FERC for the RTOs. Order No. 745, 18 C.F.R. § 35.28(v) (2020).

125. *See* Shields, *supra* note 25.

126. *Electric Alternative Regulation*, VT. PUB. UTIL. COMM'N, https://puc.vermont.gov/electric/electric-alternative-regulation [https://perma.cc/7YB3-9PMT].

Additionally, electric utilities' purchases of energy for the P2G facilities will be judged against the least-cost and prudency benchmarks. In the ideal P2G system, power purchases would only be made in times of surplus, thus eliminating the competition between utility customers and its P2G operations.

3. Local Level

Considering the option for on-site local P2G facilities, there are few regulatory triggers related to the necessary electricity. For private firms, locally generated electricity is analogous to the now-familiar rooftop solar or off-grid movement.[127] The driver behind such movements is the absence of regulatory oversight and independence from grid infrastructure. P2G systems could exist today, without connections to the electric grid, and have no regulatory requirements other than those associated with siting and local operations. For these systems, the more tangible oversight occurs at the point of production of the gaseous fuel, be it hydrogen or methane. While this option can reasonably produce gas, without interacting with electric regulations, this is not necessarily true for power-to-gas-to-power systems. Generating power on the back end of these systems triggers many of the federal and state regulations discussed earlier, potentially including net metering policies.

While not specifically Power-to-Gas, one illustration of this local option is the landfill gas system. Through methane capture systems, landfills serve as RNG producers. In most cases, the RNG is combusted on-site to produce energy. As with other renewable fuels, landfill gas production is variable, and thus not perfectly matched to on-site energy demand. Net-metering, also known as net-billing or net-generation, can apply to landfill gas generation in the same way it applies to residential rooftop solar, for any excess electricity produced at the landfill, assuming it is connected to the grid.[128] However, if these systems are not conveying electricity to the grid (i.e., locally isolated) then excess gas, not utilized for electric

127. *See* Cadie Thompson, *Why Living off the Grid Will get a lot Easier in 25 years*, CNBC (Nov. 27, 2014, 3:58 PM), https://www.cnbc.com/2014/11/27/why-living-off-the-grid-will-get-a-lot-easier-in-25-years.html [https://perma.cc/SLQ7-PMT9].

128. *See* Database of State Incentives for Renewables & Efficiency, *State and Utility Net Metering Rules for Distributed Generation*, IREC, https://irecusa.org/wp-content/themes/IREC/includes/dsire-xml-feed/fs-net-metering-table.php [https://perma.cc/8QVJ-YB5Y] (Apr. 27, 2012).

generations could be transported to the gas grid. The structure of these systems and the current RNG markets have created alternative opportunities for landfills to redirect captured and conditioned RNG to pipelines. This flexibility means that these systems may interact with regulatory structures in a similar fashion to power-to-gas systems, in that they have touchpoints with both electric and gas market rules, laws, and regulations.

B. Gas Supply Arrangements

P2G systems, as previously noted, have the capability of converting electric energy to gaseous fuel, typically hydrogen or methane. Methane, in this regard, is in the form of synthetic natural gas, and thus similar to conventional, fossil-based natural gas for purposes of this discussion. The technical and physical features of hydrogen bring up issues on its compatibility with existing gas networks which calls for a critical consideration of things like blending limits, effects on pipeline integrity, and the compatibility with a variety of end-use infrastructure.[129] Further consideration of the technical and physical concerns is beyond the scope of this paper. Rather, the aim is to highlight the potential roles of P2G in the integration of renewables in existing electricity supply structures from a policy and regulatory perspective.

The transmission of methane or hydrogen produced via P2G is analogous, in many ways, to the procurement of energy already discussed. Compared to electricity, the gas system has one key distinction that should be noted, even if apparent to most readers. Natural gas supply does not need to be instantaneously matched to demand. Natural gas can be stored (e.g. in empty aquifers, depleted reservoirs, and/or underutilized pipelines) and, therefore, does not rely solely on the transmission and distribution pipelines that make up the gas "grid." Applicable laws and regulations are dependent upon the disposition of the gas, specifically whether the gas is injected into pipelines, where along the system gas is introduced, and whether it is fully or partially combusted on-site. The following sections follow the same structures, with federal, state, and local regulatory oversight detailed throughout. Here, we also expand on the storage potential of natural gas and energy in a gaseous form.

129. LAMBERT, *supra* note 8, at 5; Fleming & Fershee, *supra* note 6, at 139, 147–53.

The gas industry in the U.S. was largely restructured between the 1980s to 2000s, resulting in the unbundling and deregulation of competitive segments such as upstream production and downstream sales and marketing, as well as the development of economic regulation and an open-access regime to midstream transmission networks.[130] Regulation for interstate supplies is through FERC, while local distribution is regulated at the state level.[131] Although wholesale prices are generally set by competitive markets in various hubs, state public utility commissions can exercise regulatory authority over retail gas prices and are responsible for consumer protection, natural gas facility construction, and environmental issues that are not covered by FERC or the Department of Transportation (DOT).[132] Importantly, numerous natural gas marketers serve as middlemen to connect producers and end-users by offering both bundled and unbundled services.[133]

1. Federal Level

As noted above, the management of pipeline infrastructure, for reliability purposes is slightly less onerous than the equivalent electric system. Whether driven by key technical differences or a dissimilar industry history, the natural gas grid is not managed by RTOs like the electric transmission system. The electric grid operators' role ensures the physical stability of the system, but also the key balancing of supply and demand. The equivalent manager on the gas system is the transmission pipeline owner. Interstate pipeline owners manage their available capacity and balance supply and demand via transportation contracts. FERC regulates these natural gas pipelines through cost-of-service tariffs, which would affect the rates for P2G facilities transporting gas through interstate assets.[134] Unlike electric RTOs, pipeline operators align gas quality

130. *See* Richard Pierce, *Reconstituting the Natural Gas Industry from Wellhead to Burnertip*, 25 ENERGY L.J. 57, 77–99 (2004); Oyewunmi, *supra*, note 3, at 194, 244–48.

131. INT'L ENERGY AGENCY, ENERGY POLICIES OF IEA COUNTRIES: UNITED STATES 2019 REVIEW 163 (2019); TOMAIN & CUDAHY, *supra* note 1, at 288.

132. *See* TOMAIN & CUDAHY, *supra* note 1, at 284.

133. *Id.*

134. *Cost-of-Service Rate Filings*, FERC (Aug. 14, 2020), https://www.ferc.gov/industries-data/natural-gas/overview/general-information/cost-service-rate-filings [https://perma.cc/9Q68-ZJWX].

requirements and other rules across the national system.[135] Electric RTO rules and wholesale markets are regional and do not necessarily align from region to region. Natural gas markets are therefore much more streamlined, with less variational across the system.[136]

For P2G systems, the most likely point of interaction with federal regulations is the physical connection (i.e., the interconnect) to an interstate pipeline, should the location or technical requirements require it. Connecting to this interstate system pulls the subject P2G pipeline under FERC's jurisdiction and would require the same Certificate of Public Convenience and Necessity that is required of any new interstate pipeline.[137] If the P2G facility retains ownership of the pipeline, additional operational regulations begin to apply. The Pipeline and Hazardous Materials Administration (PHMSA) under the federal Department of Transportation (DOT) manages the construction, operation, and maintenance of interstate pipelines and natural gas storage to ensure public safety.[138] PHMSA also regulates the transportation of hydrogen but recognizes the need for further research and development if new infrastructure is necessary for expanded production.[139] Assuming most early P2G systems would utilize existing natural gas pipelines and blend hydrogen with natural gas, then the existing rules would apply.

By converting renewable electricity to natural gas, significant storage capacity can also be realized. Natural gas storage offers medium to long-term seasonal storage options, which are familiar to gas operators, as opposed to the hourly or daily capacities offered

135. For gas to be transported on the interstate natural gas transmission system it must meet pipeline quality natural gas standards. *See* INTERSTATE NAT. GAS ASS'N OF AM., THE INTERSTATE NATURAL GAS TRANSMISSION SYSTEM: SCALE, PHYSICAL COMPLEXITY AND BUSINESS MODEL 3–4 (2010), https://www.ingaa.org/file.aspx?id=10751 [https://perma.cc/CQ88-VK8E].

136. *See* STEVEN LEVINE ET AL., UNDERSTANDING NATURAL GAS MARKETS 16 (2014), https://www.api.org/~/media/Files/Oil-and-Natural-Gas/Natural-Gas/API-Understanding-Natural-Gas-Markets.pdf [https://perma.cc/GS7D-V77B].

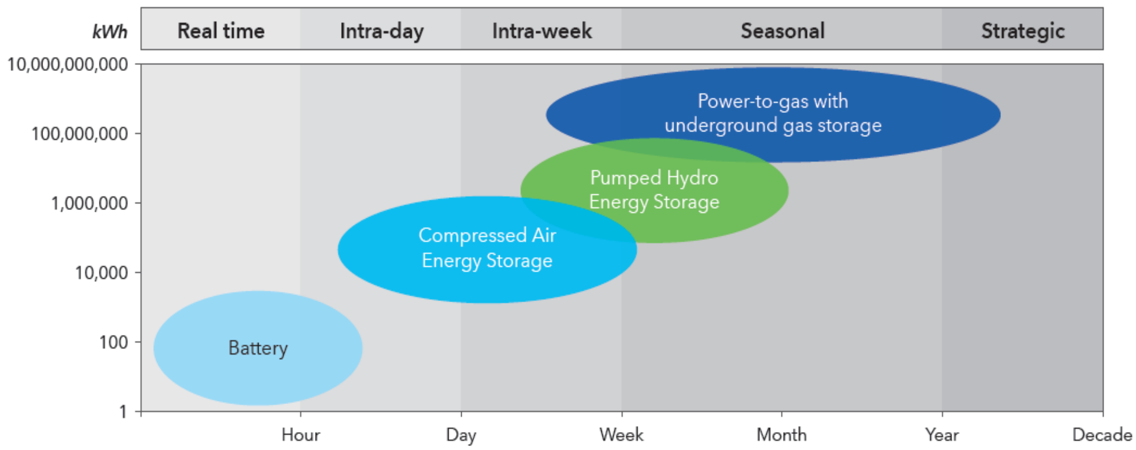
137. 15 U.S.C. § 717f(c).

138. *PHMSA Regulations*, U.S. DEP'T OF TRANSP., https://www.phmsa.dot.gov/phmsa-regulations [https://perma.cc/FMP8-VSKR] (Feb. 27, 2020).

139. *Hydrogen,* U.S. DEP'T OF TRANSP., https://primis.phmsa.dot.gov/comm/Hydrogen.htm?nocache=5671 [https://perma.cc/P8F8-QMGA].

through current battery technologies, a comparison depicted in Figure 8 below. Over-reliance on battery technologies also comes with risks of vulnerability to the few supply sources for the inputs of building batteries themselves such as cobalt and lithium which are only available in a few countries globally.[140]

Figure 8: Storage Capabilities Over Time, By Storage Resource Type[141]



PHMSA retains federal oversight of natural gas storage operations in both pipelines and underground storage reservoirs. Currently, electric RTOs do not consider P2G as storage, and thus only view these systems as consumptive. If P2G systems can pull gas out of storage, either from pipelines or from underground reservoirs, and convert that back to electricity, those systems would align more directly with FERC and RTO rules being developed around energy storage and DERs.[142] Few projects are developed beyond the pilot stages; therefore, it is too early to determine whether this flexibility will be economically viable.

140. KEVIN B. JONES ET AL., THE ELECTRIC BATTERY: CHARGING FORWARD TO A LOW-CARBON FUTURE 39–42 (2017).

141. SCHULZE ET AL., *supra* note 110, at 8.

142. Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators, 84 Fed. Reg. 23,902, 23,927 (May 23, 2019) (to be codified at 18 C.F.R. pt. 25).

2. State Level

P2G systems can be co-located with storage and remain within the confines of the local distribution system. Intrastate gas storage companies could utilize P2G as a supplemental supply for peak demand, with gas injected directly into the distribution pipeline or local reservoirs. If the P2G operator is also the owner of the distribution pipeline, then the regulatory oversight would be limited to the public utility commission. For non-utility firms needing to connect to the distribution system, an interconnection agreement with the local utility would be required. Unlike interstate pipelines, the safety of intrastate pipelines is managed by the public utility commissions. In some states, underground storage is also managed by state agencies overseeing oil and gas operations, distinctly separated from pipeline transportation. For example, in Michigan, the Department of the Environment, Great Lakes, and Energy oversee surface facilities, like P2G, connected to gas storage reservoirs.[143] In Texas, however, the Railroad Commission would regulate all facets of P2G gas production, with and without storage.[144] Unique to state energy policy, and also unique to oil and gas production, is the concept of waste prevention.[145] These conservation regulations do not necessarily apply to P2G facilities, but such waste prevention policies could be expanded to incentivize P2G and renewable gas production facilities, a recommendation further explored below.

Another unique point of regulation for local P2G systems may be the disposition of hydrogen into fuel cells. While this research did not investigate the ultimate disposition of produced fuels (i.e., end-user), the storage of hydrogen for local fueling stations is expected to be regulated at the local and state level. To date, California is the only state with publicly accessible hydrogen fueling stations,[146]

143. *See Oil, Gas, and Minerals Division*, MICH. DEP'T OF ENV'T, GREAT LAKES, & ENERGY, https://www.michigan.gov/egle/0,9429,7-135-3306_57064---,00.html [https://perma.cc/8PYD-HP4P].

144. *See RRC's Authority and Jurisdiction,* RRC, https://rrc.state.tx.us/about-us/faqs/rrc-authority-and-jurisdiction/ [https://perma.cc/FJP3-ZVFE].

145. JOEL B. EISEN ET AL., ENERGY, ECONOMICS AND THE ENVIRONMENT: CASES AND MATERIALS 181–88 (5th ed. 2019).

146. *Hydrogen Fueling Stations*, U.S. DEP'T OF ENERGY, https://afdc.energy.gov/fuels/hydrogen_stations.html [https://perma.cc/MUQ5-5P3U].

which are regulated by the California Air Resources Board and Department of Transportation.[147]

3. Local Level

Like electricity procurement and generation, producing gas for local combustion triggers few if any additional laws and/or regulations. Examples of P2G systems that may utilize this local model include co-generation facilities that may combust produced gas on-site for local heating systems or industrial processes. Because the gas is not being placed in a pipeline for transport off-site, the federal and state regulations governing the transport and sale of gas do not apply. Combusting gas for on-site electric generation may involve net-metering rules of the local utility if excess electricity is exported to the grid.

C. Decarbonized Gas and Integrated Electricity Policy Approach

The novelty of P2G is the fact that the whole is greater than the sum of its parts. Electric consumption is not created equal, nor is renewable gas production interchangeable with fossil gas development. Power to gas systems, as described throughout this paper, offer opportunities to flatten supply curves, reduce curtailment, alleviate grid congestion, and store energy. These benefits allow the electric system to take on greater percentages of intermittent energy resources, like wind and solar, and defer or eliminate costly investments in electric transmission expansions.

P2G systems also can sequester carbon and decarbonize heat and transportation fuels. While not discussed in detail in this paper, many other studies and policy initiatives have outlined the importance of the latter, in terms of meeting larger GHG reduction goals.[148] Seeking significant reductions in GHG emissions, or carbon-

147. *Hydrogen Laws and Incentives in California*, U.S. DEP'T OF ENERGY, https://afdc.energy.gov/fuels/laws/HY?state=CA [https://perma.cc/PLZ6-8XTH].

148. *See, e.g.*, Audrey Partridge, *Decarbonizing Natural Gas End Uses in Minnesota*, E21 INITIATIVE (June 11, 2019), https://e21initiative.org/decarbonizing-natural-gas-end-uses-in-minnesota/ [https://perma.cc/3FZW-Z5AP]; TIMME VAN MELLE ET AL., GAS FOR CLIMATE: HOW GAS CAN HELP TO ACHIEVE THE PARIS AGREEMENT TARGET IN AN AFFORDABLE WAY (Feb. 2018), https://www.itm-power.com/images/NewsAndMedia/Reports/ECOFYS_-_Gas_for_Climate_Feb_2018.pdf [https://perma.cc/DD4K-48AY].

neutral societies will require a significant shift in energy system design. The current question among industry analysts and policymakers is whether the electric system alone can supply enough renewable energy, at a swift enough pace, to meet decarbonization targets, while maintaining energy reliability, the security of supply, and environmental sustainability. Recent studies suggest that aggressive electrification models achieve end-use penetration of only 52% by 2050 while continuing to rely on natural gas for electric generation.[149] Such aggressive electrification is expected to double the demand for electric supply by 2050,[150] further stressing current grid infrastructure. To accommodate this level of electrification, considerable costs are anticipated to complete necessary upgrades to transportation systems and bolster generation supplies.[151] A 2018 study modeled an aggressive electrification profile, assuming 100% electrification of residential and commercial buildings, in addition to significant electrification of several industrial processes. That study concluded that electrification alone could achieve only a 20% reduction in GHG emissions.[152]

To achieve notable reductions, closer to 70%, significant grid decarbonization must occur in the form of increased low-carbon supply. The same study assumed 33% of electric supply would come from wind and solar, with an additional 22% from other low-carbon sources like nuclear.[153] Yet, "these combined measures . . . are insufficient to achieve the 2050 emission levels indicated by climate scientists to reduce the most-severe impacts of climate change."[154] In that model, 28% of the electric supply is still sourced from natural gas. Therefore, looking at electric supply alone, decarbonization of gas supply has considerable value. When the end-use of natural gas is added to this system-wide emission profile, we see that low-carbon and carbon-neutral renewable natural gas has a significant role to

149. ELEC. POWER RSCH. INST., U.S. NATIONAL ELECTRIFICATION ASSESSMENT 7–8, 38 (Apr. 2018), https://ipu.msu.edu/wp-content/uploads/2018/04/EPRI-Electrification-Report-2018.pdf [https://perma.cc/GD2Y-KJMX].

150. Trieu Mai et al., *An Electrified Future*, IEEE POWER & ENERGY MAGAZINE, July/Aug. 2018, at 34, 35.

151. *See* Patrick Plas, *Expediting a Renewable Energy Future with High-Voltage DC Transmission*, GREENTECH MEDIA (July 6, 2017), https://www.greentechmedia.com/articles/read/expediting-a-renewable-energy-future-with-high-voltage-dc-transmission#gs.wflqpm [https://perma.cc/B279-P8YP].

152. Mai, *supra* note 150, at 44.

153. *Id.* at 42.

154. *Id.* at 45.

play in decarbonizing energy supplies. European studies have shown that minimizing gas use, often as part of larger, policy-driven electrification, increases the costs of decarbonization. Alternatively, by utilizing existing gas infrastructure to supply renewable natural gas and hydrogen, one study estimated that across all sectors, the European Union (EU) can save 138 billion Euros per year, when compared to the "minimal gas" scenario studied.[155] This detailed analysis of the European energy system is a reasonable proxy for the U.S., with the exception of Europe's early adoption and implementation of hydrogen fuels across multiple sectors. It is also interesting to note that the EU is keen on an integrated approach to its decarbonization plans.[156]

As in the U.S., one of the greatest drawbacks for the large-scale deployment of PRG and green hydrogen has been the costs of the technology, even though the recent plummeting of the price/costs or renewable electricity may serve as a boost. Also, there is the challenge of requiring much more electricity to produce roughly the same amount of hydrogen and methane as would the other alternatives and traditional sources. Other constraints will include clarifying the nitty-gritty of the applicable rules and standards to ensure safety and retrofitting non-compatible supply infrastructure. The recent NASEM report however points to the technological and cost-saving potential of repurposing existing gas supply networks and systems to be compatible with hydrogen or blends of hydrogen and net-zero synthetic fuels.[157] The potential of a fully integrated approach in this regard is also worth pointing out to the extent that hydrogen production facilities can be located close to industrial

155. VAN MELLE ET AL., *supra* note 148, at 48.

156. The European Commission recently published its EU Hydrogen Strategy and its EU Energy System Integration Strategy to which its Hydrogen Strategy is complementary to and supportive of. It is also complementary to the EU Industrial Strategy which was published in March 2020. All of the strategies are part of the overall EU Green Deal aiming at climate neutrality by 2050. ALEX BARNES & KATJA YAFIMAVA, EU HYDROGEN VISION: REGULATORY OPPORTUNITIES AND CHALLENGES 1–2 (Sept. 2020), https://www.oxfordenergy.org/wpcms/wp-content/uploads/2020/09/Insight-73-EU-Hydrogen-Vision-regulatory-opportunities-and-challenges.pdf [https://perma.cc/RXE9-6X2E]; MARTIN LAMBERT, HYDROGEN AND DECARBONISATION OF GAS: FALSE DAWN OR SILVER BULLET? (Mar. 2020), https://www.oxfordenergy.org/wpcms/wp-content/uploads/2020/03/Insight-66-Hydrogen-and-Decarbonisation-of-Gas.pdf [https://perma.cc/YL2N-9MPM].

157. NAT'L ACADEMIES OF SCI., ENG'G, & MED., ACCELERATING DECARBONIZATION OF THE U.S. ENERGY SYSTEM. 47–50 (2021).

hydrogen consumers, while the energy carrier can also be blended in compatible gas networks.

1. Proactive Energy Decarbonization

The U.S. electric energy landscape, as it exists today, is a complex web of regulated, semi-open, and fully open markets.[158] This variability is typically created from the absence of a national renewable energy standard and the general flexibility granted to the states in recent court decisions.[159] While natural gas markets are generally more streamlined, a patchwork of renewable natural gas laws and regulations has been developed.[160] On the whole, however, the regulation of renewable natural gas has, thus far, mirrored its fossil-based counterpart.

As demonstrated from this preliminary research into P2G, the legal construct that exists today is capable of regulating P2G facilities. P2G is unique when viewed as a holistic energy system. But, when viewed through the lens of jurisdiction, the system functions as two separate points of regulation: electric consumption and gas production. Power-to-gas-to-power systems add a third: electric generation. Undoubtedly, the latter creates another layer of complexity, yet does not stray from the existing framework for such generators.[161] As already outlined above, these systems provide added value above their contribution to their respective, segregated markets, and future regulation must recognize and incentivize these multi-industry benefits to achieve maximum decarbonization potential.

Existing laws and regulations are agnostic to the benefits P2G systems provide. This approach is by design, where RTO/ISOs are concerned. While neutrality may be appropriate for system operators, it does not satisfy, nor align with the greater policy goals

158. To access compare these complex energy markets, see *State-By-State,* RETAIL ENERGY SUPPLY ASS'N, https://www.resausa.org/states [https://perma.cc/UFX2-PZXY].

159. Brannon P. Denning, *Environmental Federalism and State Renewable Portfolio Standards*, 64 CASE W. RSRV. L. REV. 1519, 1547 (2014) (discussing Rocky Mountain Farmers Union v. Corey, 730 F.3d 1070 (9th Cir. 2013)).

160. S. 154, 80th Leg., Reg. Sess. (Nev. 2019).

161. Public Utility Regulatory Policies Act of 1978, 16 U.S.C. § 2611–2627 (outlining the retail regulatory policies and standards for electric utilities).

of state and federal lawmakers seeking to decarbonize energy supplies.

From the RTO/ISO Council (IRC) report on Emerging Technologies, several key positions were identified in the pursuit of increased renewable penetration.[162] Two of these positions are especially relevant.

> 1. [The IRC] [g]enerally supports policies and positions that recognize the electricity system's ability to reliably and efficiently accommodate large-scale amounts of renewables and realize their growing technological potential.
> 2. [The IRC] [i]s agnostic to specific technologies that may be applied to the renewable integration problem while simultaneously ensuring that policies include the greatest possible optionality for new and emerging technologies to be applied to renewable integration.[163]

If the goal of system operators is to integrate as much renewable electricity as possible, while balancing the grid reliability, then P2G is at least an equal competitor with battery storage. Yet, a recent 2019 FERC ruling relating to energy storage makes no mention of gas as an energy storage medium, nor does it discuss the potential for existing storage assets to play a role in a seasonal capacity.[164] The final rule instead creates a split definition of energy storage that prioritizes a storage resource's ability to "inject electric energy back onto the grid" while remaining neutral on the storage medium. The Commission stated that "this definition is intended to cover electric storage resources capable of receiving electric energy from the grid and storing it for later injection of electric energy back to the grid, regardless of their storage medium (e.g., batteries, flywheels, compressed air, and pumped-hydro)."[165] This definition is supportive

162. ISO/RTO COUNCIL, EMERGING TECHNOLOGIES: HOW ISOS AND TROS CAN CREATE A MORE NIMBLE, ROBUST BULK ELECTRICITY SYSTEM 16 (Mar. 2017), https://isorto.org/wp-content/uploads/2018/05/PUBLIC_IRC_Emerging_Technologies_Report.pdf [https://perma.cc/5WWX-D2Q6].

163. *Id.*

164. *See* Order No. 841, 18 C.F.R. § 35 (2019). (discussing electric storage participation in markets operated by RTOs and ISOs, but not explicitly discussing gas as an energy storage vehicle).

165. *Id.* at 5.

of Power-to-Gas-to-Power systems, as these facilities would be "[p]hysically designed and configured to inject electric energy back onto the grid."[166] However, FERC Orders 841 and 841a do not address energy conversion systems, like P2G, despite the ability to provide analogous grid services, while achieving improved storage capacity.

Furthermore, Order 841 requires RTOs/ISOs to revise tariffs to establish a participation model for electric storage resources. One of the requirements of the participation model is that the RTOs "ensure that a resource using the participation model . . . can be dispatched and can set the wholesale market clearing price as *both* a wholesale seller and wholesale buyer consistent with existing market rules."[167] This obligation further limits the participation of P2G in storage markets by requiring facilities to be wholesale sellers to the electric market. To take full advantage of P2G, it is preferable to move produced gas across interstate lines into other markets in need of decarbonization, such as heat and transportation. Additionally, hydrogen can be redirected to energy storage via hydrogen fuel cells. None of these pathways currently qualifies under FERC's rules for electric storage resources. FERC's interpretation of storage resources is decidedly focused on electricity storage, rather than energy storage. The resulting framework, therefore, excludes P2G and any benefits it may bring to the grid. FERC could consider segregating the buyer-side participation from the seller-based obligation, by lifting the dual requirement in Order 841. This would allow P2G facilities to participate as a storage resource without the responsibility of returning power to the grid.

Alternatively, because the most significant benefits of P2G occur on the demand-side of the electric market, FERC could also consider P2G as a distributed energy resource (DER). Though traditionally defined as a generation resource on the distribution system, the interpretation has evolved to include a wide variety of resources and interactions with the energy system, depending upon the jurisdiction. Currently, FERC's proposed definition is

> A source or sink of power that is located on the distribution system, any subsystem thereof, or behind a customer meter. These resources may include but are not limited to, electric storage resources,

166. *Id.* at 7.
167. *Id.* at 3, 57 (emphasis added).

> distributed generation, thermal storage, and electric vehicles and their supply equipment.[168]

This approach was adopted by FERC in its recent September 17, 2020 issuance of Order 2222 on the Participation of Distributed Energy Resource Aggregations in Markets Operated by Regional Transmission Organizations and Independent System Operators.[169] The Order enables DER aggregators to participate in all regional organized wholesale electric markets and defines DERs to participate in RTO/ISO wholesale markets as "any resource located on the distribution system, any subsystem thereof or behind a customer meter. These resources may *include, but are not limited to, electric storage resources, distributed generation, demand response, energy efficiency, thermal storage, and electric vehicles and their supply equipment*."[170] As a result, the class of DERs can "participate in the regional organized wholesale capacity, energy, and ancillary services markets alongside traditional resources . . . [and also] aggregate to satisfy minimum size and performance requirements that they might not meet individually."[171]

168. FED. ENERGY REGUL. COMM'N, NO. AD18-10-000, DISTRIBUTED ENERGY RESOURCES TECHNICAL CONSIDERATIONS FOR THE BULK POWER SYSTEM 8 (2018).

169. Order No. 2222, 18 C.F.R. § 35 (2020).

170. *Id.* (emphasis added).

171. *FERC Opens Wholesale Markets to Distributed Resources: Landmark Action Breaks Down Barriers to Emerging Technologies, Boosts Competition*, FED. ENERGY REGUL. COMM'N (Sept. 28, 2020), https://www.ferc.gov/news-events/news/ferc-opens-wholesale-markets-distributed-resources-landmark-action-breaks-down [https://perma.cc/HS3A-FAAT].

> Under the new rule, regional grid operators must revise their tariffs to establish DER aggregators as a type of market participant, which would allow them to register their resources under one or more participation models that accommodate the physical and operational characteristics of those resources. The new rule builds off the DC Circuit Court's recent ruling on Order 841, in which the court affirmed FERC's exclusive jurisdiction over wholesale markets and the criteria for participation in them. Order 2222 prohibits retail regulatory authorities from broadly excluding DERs from participating in regional markets. However, the new rule prohibits regional grid operators from accepting bids from the aggregation of customers of a small utility unless the relevant retail regulatory authority for that utility allows such participation. The final rule also respects retail regulators' current ability to prohibit retail customers' demand response from being bid into regional markets by aggregators.

Id.

Arguably, Order 2222's DER classification continues to exclude "non-generation" and "non-electric" resources, such as green hydrogen produced from the electricity, that would otherwise be curtailed or lost from VREs.[172] A preferred definition and one that is likely to suit power-to-gas applications are from the National Association of Regulated Utility Commissioners (NARUC):

> [A] resource sited close to customers that can provide all or some of their immediate electric and power needs and can also be used by the system to either reduce demand (such as energy efficiency) or provide supply to satisfy the energy, capacity, or ancillary service needs of the distribution grid. The resources, if providing electricity or thermal energy, are small in scale, connected to the distribution system, and close to load.[173]

By including ancillary services, demand reduction, and thermal energy in their definition, NARUC leaves the door open for novel DERs like power-to-gas systems. If FERC were to adopt a similarly broad definition, then P2G may have access to wholesale markets as DERs as an alternative pathway to storage. As of the writing of the paper, FERC has not yet issued the long-awaited order on DERs; therefore, a definitive interpretation of what constitutes a DER does not yet exist.

What these two examples demonstrate is a clear focus by FERC on electric energy resources. While not surprising, the scope of FERC's oversight does not preclude them from taking a broader view. In 2012, the Commission issued an Order directing further conferences and reports on the interaction of natural gas and electric industries.[174] While this order was focused on improving the knowledge and coordination of the sectors as it related to natural gas generation, the same coordination need can be identified for power-to-gas applications. FERC is in a unique position, with authority over both electric and gas transmission assets. By taking an integrated view of both systems, the agency could leverage the assets and capabilities of both to foster a more efficient system, with a higher

172. *See* Order No. 2222, *supra* note 169.

173. NAT'L ASS'N OF REGUL. UTIL. COMM'N, DISTRIBUTED ENERGY RESOURCES RATE DESIGN AND COMPENSATION 45 (Nov. 2016), https://pubs.naruc.org/pub/19FDF48B-AA57-5160-DBA1-BE2E9C2F7EA0 [https://perma.cc/U4KA-WRDQ].

174. *Coordination Between Natural Gas and Electricity Markets*, 141 F.E.R.C. ¶ 61,125 (2012).

percentage of renewable energy resources. The regulated States also have this advantage, with Public Utility Commissions retaining authority over both electric and gas distribution systems. Here too, the Commissions can regulate both sectors to maximize the overall efficiency and decarbonization pathways.

Some preliminary framework already exists in State policy. As mentioned earlier, State regulation of oil and gas development is based in significant part on the concept of waste avoidance, and these policies are generally known as conservation regulations.[175] This regulation is meant, traditionally, to prevent the physical waste of valuable oil and gas resources, prevent economic waste, and protect correlative rights.[176] While drafted during the last century, and ever-evolving, these conservation regulations establish a valuable history of regulating for efficiency and waste reduction. In the systems discussed throughout this paper, it is evident that, across multiple sectors, there are ample opportunities to reduce or avoid waste energy.

Specifically, as already outlined, curtailed renewable energy and vented methane are two readily identifiable sources of waste that could be prevented. In 2018, the Federal Bureau of Land Management (BLM) drafted a rule designed to minimize waste associated with oil and gas development on Federal public lands under BLM jurisdiction, thus aiming to limit waste via venting and flaring of methane.[177] This rule is an expansion of traditional conservation regulation by including vented gas, a byproduct, or waste of development on Federal land. State Conservation Commissions, or other agencies with authority for such regulations,[178] could reasonably amend conservation regulation to

175. The primary purpose of state-level oil and gas conservation laws is to avoid physical and economic waste of oil and gas resources. These legal instruments aimed at ensuring production efficiency and rational development of oil and gas resources. *See* EISEN ET AL., *supra* note 145; JOHN S. LOWE, OIL AND GAS LAW IN A NUTSHELL 21–35 (7th ed. 2019).

176. Owen Anderson, *Foreword: The Evolution of Oil and Gas Conservation Law and the Rise of Unconventional Hydrocarbon Production*, 68 ARK. L. REV. 231, 241 (2015).

177. Waste Prevention, Production Subject to Royalties, and Resource Conservation; Rescission or Revision of Certain Requirements, 83 Fed. Reg. 49,184 (Sept. 28, 2018) (to be codified at 43 C.F.R. pts. 3160, 3170).

178. Many States have retained specific agencies to oversee Oil and Gas operations and Conservation regulations, including but not limited to Idaho, Wyoming, West Virginia, Colorado, and Arizona. *See e.g.*, Oil and Gas Conservation

address similar economic and energy waste, depending upon the authority granted each agency under state law. Alternatively, the responsibility for these conservation rules could be shifted to utility commissions, with the intent of managing all energy resources under a single entity. Where this model fails is in deregulated states, where many functions of the utility commissions are no longer relevant, and where energy systems are managed primarily by market design. In these states, and as an option in regulated states, new agencies could be created to address energy management in all its forms, regulated and unregulated, gas and electric, to create the most efficient, lowest carbon system possible, at a reasonable cost. A drastic shift from business as usual, expanding conservation regulation beyond conventional oil and gas development could provide a route for cross-industry synergies that today are unrealized, such as the power to gas and renewable natural gas.

With this mindset, States also have the opportunity, via legislative action, to expand Renewable Portfolio Standards to gas utilities. To date, no state has taken this step and no equivalent RPS laws are governing natural gas. Similar in function to an RPS, some states have set voluntary targets or study requirements around renewable natural gas, but none have set strict limits. For the regulated gas utility, an RPS would provide the same benefit as demonstrated in the electric utility. It would serve to drive demand for renewable natural gas and lower technology costs while providing a mechanism for utilities to invest in these systems. Without this definitive and clarifying legislative solution, regulated utilities are

Act, COLO. REV. STAT. §§ 34-60-101 to 131 (2019); Oil and Gas Conservation Act, WYO. STAT. ANN. §§ 30-5-101 to 128 (2020). Other states, however, have delegated conservation regulation to other agencies. For instance, Michigan's conservation rules are managed by the Department of the Environment, Great Lakes, and Energy. *See supra* note 143 and accompanying text. Another example is Texas's conservation regulation, managed by the Railroad Commission of Texas (RCT). The RCT has primary regulatory jurisdiction over the oil and gas production, pipeline transporters, natural gas and hazardous liquid pipeline industry, natural gas utilities, and the LP-gas industry, among others. The RCT's role is established under provisions of the Texas Constitution and exercises its statutory responsibilities under relevant state and federal laws. *See RRC's Authority and Jurisdiction*, *supra* note 144; *About Us*, RRC, https://www.rrc.state.tx.us/about-us/ [https://perma.cc/NJJ6-PVT5]. Notably, the Texas Natural Resources Code was enacted for the purpose of conserving oil and gas. TEX. NAT. RES. CODE ANN. §§ 85.045, 85.046(a) (West 2021) (prohibiting waste of oil and gas, including "physical or economic waste," "production of oil in excess of transportation . . . or reasonable market demand," and wasteful burning).

typically unable to pursue such innovative solutions, even if those solutions offer low-carbon options for customers or provide reliability benefits via storage. These are generally not the least-cost options and are therefore unlikely to pass the scrutiny of some regulators. However, some progressive states, including North Carolina and California have recognized the benefits of renewable natural gas, primarily biogas, and have begun building frameworks to capture waste from agricultural operations. But, even in states fostering waste reduction, most renewable gas is still routed to electric generation or vented to the atmosphere. A gas RPS would ensure RNG has value as an end-use fuel, without conversion to electricity.

IV. NEW YORK'S ENERGY AND CLIMATE DRIVE

New York has 26 underground natural gas storage facilities that, along with storage in nearby states, are key to meeting northeastern winter energy and heating demand. Virtually all major interstate pipelines from the Gulf Coast, Appalachia, and Canada reach New York, both to supply intrastate customers and to ship supplies onward to New England interstate.[179] The state is also reported to be the sixth-largest natural gas consumer in the U.S. as of 2018, with the residential sector, the electric power sector, and the commercial sector has taken up most of the gas supplies. In the electricity context, utility-scale renewable energy sources such as hydro, and increasingly wind energy are playing significant roles, although natural gas-fired systems have a bigger share of the energy mix currently. In what is arguably traceable to the laid down RPS regime, a CES framework as well as strong political support, the level of wind energy has almost doubled in the past decade. Since 2009, wind energy is the state's second-largest renewable source of generation after hydropower. It is worth highlighting that the state's nuclear facility—Indian Point—which provided about 13% of the state's power in 2019 was shut down by the operator and permanently stopped generating electricity on April 30, 2021. Meanwhile, the state is ramping up VREs, especially Wind Energy, and in "the process of soliciting bids for the development of 9,000 megawatts of offshore wind energy by 2035."[180] The potential

179. *See New York State Energy Profile*, supra note 76.

180. *Id. See New York's Indian Point Nuclear Power Plant Closes After 59 Years of Operation*, EIA (Apr. 30, 2021),

intermittency challenges that such loss of conventional 'baseload' in nuclear and scaling up of VERs and DERs may create is obvious to a keen observer. There are also network congestions and transmission constraints between upstate and southern New York. These may be part of the rationale behind the state's recent drive to incentivize energy storage resources.[181] The EIA reports that three natural gas-fired power plants have been introduced over the past three years to help support the electric supply needed by New York City that Indian Point had been providing: Bayonne Energy Center II (120 MW), CPV Valley Energy Center (678 MW), and Cricket Valley Energy Center (1,020 MW). It is worth considering whether these gas-fired systems (and future ones) should be designed to be able to utilize utilized hydrogen or synthetic methane produced from P2G system as solar and wind energy increases in the medium to long term. Such investment decisions will be ultimately made by the relevant utilities operating these systems as part of an integrated systems planning, in coordination with institutions such as the NYISO.

In December 2018, NYPSC issued an order adopting an energy storage deployment target of 3,000 MW by 2030, with an interim goal of 1,500 MW by 2025. This order followed recommendations from the Energy Storage Roadmap. Senate Bill 6599, enacted in July 2019, also requires the NYPSC to consider policy measures to achieve 3 MW of statewide energy storage capacity by 2030. Like the other DERs and 'storage' definitions and regulations discussed above, NYSERDA's bulk and retail energy storage incentive programs focus on "electricity storage" and defines eligible technologies as including "chemical, thermal, or mechanical systems."

Following the recent decision by FERC directing RTOs/ISOs to remove barriers to energy storage from participating in energy, capacity, and ancillary service markets, the NYISO announced recently that it would allow full participation of energy storage

---

https://www.eia.gov/todayinenergy/detail.php?id=47776 [https://perma.cc/RZB9-26TE].

181. NYISO allows full participation for energy storage in wholesale power markets. *Press Release: NYISO Implements Industry-Leading Rules for Energy Storage Resources*, N.Y. INDEP. SYS. OPERATOR (Sept. 8, 2020), https://www.nyiso.com/-/press-release-7c-nyiso-implements-industry-leading-rules-for-energy-storage-resources [https://perma.cc/PU7K-TGVQ] ("NYISO's actions are an important first step to allow energy storage resources to participate in the wholesale markets.").

resources in its wholesale energy markets. Although, as discussed earlier, the potential for a P2G system and the green hydrogen produced from the energy that would otherwise be curtailed from the increasing array of wind and solar in the state to fully participate in such a market is still in question.

New York adopted its first renewable portfolio standard (RPS) in 2004. In 2015, when the RPS expired, the state had reached its target of obtaining 29% of electricity sales from renewable sources. The RPS was replaced by the state's Clean Energy Standard (CES), which required utilities and other retail electricity suppliers in the state to acquire 50% of the electricity they sold from clean energy resources by 2030. In July 2019, the CES was revised to require 100% carbon-free electricity by 2040 and economy-wide net-zero carbon emissions by 2050. It was updated to require 70% renewable energy generation by 2030[182] and 100% zero-emission statewide electric demand by 2040.[183] This includes 9GW of offshore wind by 2035, 6GW of distributed solar by 2025, and 3GW of energy storage by 2030.[184] Additionally, New York has set GHG reduction goals at 40% of 1990 levels by 2030 and 85% of 1990 levels by 2050.[185] Meeting these goals will require a massive buildout of renewable energy and decarbonization of the heating and transportation sectors.

In addition to renewable resources, the CES identifies qualifying nuclear power plants in the state as zero-emission resources that will contribute to the state goal of carbon-free electricity. Facilities that are not technically capable of eliminating all carbon emissions can purchase offsets. The offsets must be from nearby sources that reduce carbon, like forests and agriculture. The CES is divided into three tiers. Tier 1 and Tier 2 constitute the Renewable Energy Standard (RES) component of CES, which totals to 50% renewable energy goal by 2030. Tier 3 is an additional component of CES designed to support the state's existing nuclear facilities as a bridge to 50% renewables. The emission credits from nuclear sources cannot be used for compliance with the state's RES

182. N.Y. PUB. SERV. LAW § 66-P*2(2)(a) (McKinney 2021).

183. *Id.* § 66-P*2(2)(b).

184. *Id.* § 66-P*2(5).

185. *Reducing Greenhouse Gas Emissions: Limiting Future Impacts of Climate Change*, N.Y. DEP'T OF ENV'T CONSERVATION, https://www.dec.ny.gov/energy/99223.html [https://perma.cc/CV3X-PKUB].

goals. The eligible technologies for the RES component include biogas (including anaerobic digestion and landfill gas), biomass, fuel cells, hydro (without new storage impoundment), solar, tidal/ocean, and wind. Biomass generators that are co-fired with fossil fuels are eligible, but they receive credits only for electricity generated from the biomass portion of the fuel.[186]

A. Testing the P2G and Green Hydrogen Option

The state of New York could be a very good testing ground for P2G and decarbonization of an existing extensive network of gas and electricity networks via the production and supply of green hydrogen from P2G systems. First, New York has implemented the most aggressive clean energy and climate goals in the country.[187] Besides, it has a single state ISO regulation via NYISO, and an extensive network of intrastate gas supply and storage networks as well as connections to neighboring interstate markets. However, New York would arguably need to enact a more comprehensive "energy" decarbonization framework that would explicitly help facilitate the successful commercialization and buildout of P2G systems, hydrogen, or similar innovative solutions with a focus on effectively realizing the three main dimensions of well-rounded energy policy and regulatory framework in a carbon-constrained world highlighted above. Its ambitious climate-centered goals "have already prompted the state to promote transmission build-out and explore setting a price on carbon emissions, among other actions."[188]

186. "The incremental production associated with the upgrade of an existing facility is eligible for the RES if it meets certain requirements," and "the requirements vary based on whether the project utilizes an intermittent resource (i.e., hydro, wind or solar) or a non-intermittent resource (i.e., biomass, fuel cells) to produce energy." *Clean Energy Standard, Program Overview*, DSIRE, https://programs.dsireusa.org/system/program/detail/5883 [https://perma.cc/XB8C-RK5D?type=image] (Sept. 9, 2020). Only the production resulting from the incremental upgrade will be considered eligible for the RES program. *Id.*

187. David Roberts, *New York Just Passed the Most Ambitious Climate Target in the Country*, VOX, https://www.vox.com/energy-and-environment/2019/6/20/18691058/new-york-green-new-deal-climate-change-cuomo [https://perma.cc/Z5ZK-HW7G] (July 22, 2019, 8:56 AM); *see* S. 6599, 2019 S. Assemb., Reg. Sess. (N.Y. 2019) (enacting the New York State Climate Leadership and Community Protection Act by amending various laws).

188. Jeremy Dillon, *FERC Blocks N.Y. Grid Operator's Bid to Support Clean Energy*, GOVERNORS' WIND & SOLAR ENERGY COAL. (Sept. 8, 2020), https://governorswindenergycoalition.org/ferc-blocks-n-y-grid-operators-bid-to-support-clean-energy/ [https://perma.cc/P2PQ-JS77].

An integrated energy law and policy approach with a clear provision for incentivizing systems like P2G and hydrogen compatible networks can help New York meet its climate goals, while also solving the energy trilemma issues of curtailment and energy waste, stranded assets for its utilities, and protecting New Yorkers from the implications of a potentially unreliable and expensive energy systems overhaul. Regarding renewable energy integration, New York already faces congestion and curtailment issues.[189] These issues will only become more pronounced as more renewable energy comes online. P2G can alleviate curtailment and congestion issues to help facilitate the integration of more renewable energy generation. Additionally, New York defines energy storage as a "commercially available technology that is capable of absorbing energy, storing it for some time, and thereafter dispatching the energy using mechanical, chemical, or thermal processes to store energy that was generated at one time for use at a later time."[190] Because electrolysis is a chemical reaction,[191] power-to-gas-to-power could qualify under this definition and can help meet New York's storage goals. Although, as discussed above, adding another layer or re-conversion of green hydrogen to power for these benefits could add more costs and regulatory issues to the package. A roll-out of hydrogen and methane networks could still serve as a means of decarbonizing the sectors that are hard and expensive to electrify such as industry and mass transit. As of 2016, 66% of New York's GHG emissions came from transportation and heating.[192] Only 15% of GHG emissions came from electric generation.[193] In addition to electrification, the integration of decarbonized gases such as blue and green hydrogen, biogas, and RNG will be useful to decarbonize these sectors and help meet the GHG emission reduction goals.

189. *See* N.Y. INDEP. SYS. OPERATOR, 2019 CONGESTION ASSESSMENT AND RESOURCE INTEGRATION STUDY (July 2020), https://www.nyiso.com/documents/20142/2226108/2019-CARIS-Phase1-Report-Final.pdf/bcf0ab1a-eac2-0cc3-a2d6-6f374309e961?t=1595616909286 [https://perma.cc/9GSK-MH3E] (taking into account public policy concerns into transmission congestion modeling).

190. N.Y. PUB. SERV. L. § 74(1) (McKinney 2021).

191. Hydrogen & Fuel Cell Techs. Off., *Hydrogen Production: Electrolysis*, ENERGY.GOV, https://www.energy.gov/eere/fuelcells/hydrogen-production-electrolysis [https://perma.cc/GF54-J4U9].

192. NYSERDA, NEW YORK GREENHOUSE GAS INVENTORY FACT SHEET (2019), [https://perma.cc/5VDT-MR3E].

193. *Id.*

1. The Network System Operator

As discussed in the regulatory section, federal electric regulation through the FERC-approved ISO/RTO tariffs significantly impacts P2G systems where they can be most effective: wholesale capacity and ancillary service markets. NYISO is unique because it is a single state ISO.[194] Additionally, FERC Order 1000 requires system operators to consider public policy matters during the transmission planning process.[195] Because NYISO is a single state ISO, NYISO is expected to give significant consideration to New York's climate change goals and the resulting impacts on energy transmission infrastructure.[196] Planning for the aggressive increase in renewables will require the consideration of policy to facilitate the integration of technologies, like P2G, which can reduce transmission congestion and load balancing problems. This may influence the structure of NYISO's other tariffs dictating how P2G technology can access capacity and ancillary service markets.

2. Existing Natural Gas System

New York has a substantial natural gas system in place, which will need to transition to primarily zero carbon emissions per the state's climate goals.[197] Currently, natural gas is the largest source of New York electricity production and the largest overall source of energy within New York.[198] New York has eighty-seven natural gas power plants,[199] twenty-one natural gas local distribution companies, fifteen intrastate natural gas transmission line

194. For more information on New York ISO, see *What We Do*, N.Y. INDEP. SYS. OPERATOR, https://www.nyiso.com/what-we-do [https://perma.cc/99RN-H9Z6].

195. Order No. 1000, 18 C.F.R. § 35 (2011).

196. *See id.*

197. N.Y. PUB. SERV. L. § 66-P*(2)(b) (McKinney 2021) ("That by the year two thousand forty (collectively, the 'targets') statewide electrical demand system will be zero emissions.").

198. *New York State Profile and Energy Estimates: Profile Analysis*, *supra* note 10. "In 2019, the residential sector, where three out of every five households heat with natural gas, accounted for almost two-fifths of the natural gas delivered to New York consumers." *Id.* "The electric power sector consumes natural gas to fuel nearly two-fifths of the state's electricity generation, and three-tenths of the natural gas delivered to consumers in New York in 2019 went to that sector." *Id.*

199. U.S. DEP'T OF ENERGY, STATE OF NEW YORK ENERGY SECTOR RISK PROFILE 2, https://www.energy.gov/sites/prod/files/2016/09/f33/NY_Energy%20Sector%20Risk%20Profile_0.pdf [https://perma.cc/7SQL-Q73Y].

companies, eleven interstate natural gas transmission line companies, and two hydrogen gas transmission line companies.[200] In total, New York contains 4,550 miles of natural gas transmission lines, 48,680 miles of natural gas distribution mains, and over three million natural gas service lines.[201] Additionally, New York has twenty-six natural gas underground storage facilities.[202] Besides the significant infrastructure, New York natural gas utilities have been forecasting capacity shortages due to the inability to import sufficient supply from out of state.[203] New York has the infrastructure to accommodate widespread RNG integration and the mandate to decarbonize its gas system. P2G RNG can help solve the problem.

Given the foregoing discussions and highlighted issues, it is posited that the state could make certain changes to its regulatory framework to maximize the positive role innovative technologies such as P2G and RNG can play. First, New York must incorporate RNG into its clean energy standard. New York's climate renewable energy goals will be met through Tier 1 RECs and Zero Emission Credits (ZEC).[204] Under their current definitions, neither includes RNG,[205] although certain forms of biogas are included within the REC definition.[206] The New York Public Service Commission should amend the definition of a Tier 1 REC to include RNG, green hydrogen, synthetic methane. This would allow the natural gas power plants to participate in the clean energy revolution by fostering the scaling up of the integration and decarbonized

200. *See NYS Pipeline Safety Program*, N.Y. STATE DEP'T OF PUB. SERV., https://www3.dps.ny.gov/W/PSCWeb.nsf/All/4606B847387FBCB6852580A700678AD0?OpenDocument [https://perma.cc/2ZRP-D8CP].

201. *Id.*

202. *New York State Profile and Energy Estimates: Profile Analysis*, *supra* note 10.

203. NAT'L GRID, NATURAL GAS LONG-TERM CAPACITY SUPPLEMENTAL REPORT 10 fig 3 (May 2020), https://millawesome.s3.amazonaws.com/Downstate_NY_Long-Term_Natural_Gas_Capacity_Supplemental_Report_May_8_2020.pdf [https://perma.cc/FR3K-HRDT].

204. *See* N.Y. DEP'T OF PUB. SERV., STAFF WHITE PAPER ON CLEAN ENERGY STANDARD, Case 15-E-0302, 10th Sess., at 13–14 (2016); *see also LSE Obligations*, N.Y. STATE ENERGY RSCH. & DEV. AUTH., https://www.nyserda.ny.gov/All-Programs/Programs/Clean-Energy-Standard/LSE-Obligations [https://perma.cc/6GYC-5ZBE].

205. *See* N.Y. DEP'T. OF PUB. SERV., *supra* note 204, at app. A 1-3, app. E 1.

206. *See id.* at app. D 2.

hydrogen and biomethane options. This could then help integrate RNG into the heating and transportation sectors as well.

Regarding electricity regulation, NYSO tariffs can play an important role. Namely, they can broaden the requirements surrounding participation in wholesale capacity and ancillary service markets. FERC order 841 requires grid operators to allow storage to bid into these markets and requires that tariffs "ensure that a resource using the participation model can be dispatched *and* can set the wholesale market clearing price as both a wholesale seller and wholesale buyer consistent with existing market rules."[207] This wording would allow a P2G to power facility, but not a facility purchasing power from the wholesale capacity market and producing green hydrogen without selling electricity back into the wholesale markets. NYISO can petition FERC for a change to the working of Order 841 to eliminate the dual participation requirement. Additionally, NYISO can explicitly allow P2G facilities to purchase energy in the wholesale capacity and ancillary service markets, even if not classified as storage under FERC Order 841.

V. CONCLUSION

Progress to address climate change is underway within the U.S. Renewable energy is becoming integrated into the electric power markets at a fast and steady rate. However, the associated transmission and grid balancing problems require technology and innovative solutions to address the intermittent nature of renewable energy generation and integration issues. Notably, the incoming federal government plans to "[l]everage existing infrastructure and assets."[208] It also proposes "[t]o build the next generation of electric grid transmission and distribution," which includes investing in technology-based solutions and facilitating market access for resources such as green hydrogen.[209] There is a potential to develop an efficiently integrated system that leverages the technological and cost-saving potential of repurposing existing gas supply networks and systems to be compatible with hydrogen or blends of hydrogen and net-zero synthetic fuels. Likewise, there is also the potential

207. Order No. 841, 18 C.F.R. § 35 (2019).

208. *The Biden Plan to Build a Modern, Sustainable Infrastructure and an Equitable Clean Energy Future*, *supra* note 14.

209. *Id.*

pathway for decarbonizing industrial applications since hydrogen production facilities can be located close to industrial hydrogen consumers, while the energy carrier can also be blended incompatible gas networks.

Several pathways are being developed for decarbonization outside of the electricity sector, including for heating and transportation. The P2G option considered in this paper exemplifies the potentials and the need for an integrated approach to law and regulation for the objective of energy and decarbonization. It also exemplifies and technology-based solutions and the peculiar challenges such solutions have such as costs and maturity or the need for scalability. Hydrogen is now gaining considerable attention globally as a key resource in the path towards decarbonization and the P2G option provides an interesting suite of solutions to the challenges that over-reliance in intermittent VREs create. In the New York context and the U.S., law, and regulation can play the instrumental role of guiding operators and institutions towards the underlying objectives of energy supply and decarbonization. New York will need to address these issues head-on given their aggressive climate change goals. The regulatory framework for integrating P2G exists, it is a matter of fine-tuning those systems to efficiently facilitate the buildout of P2G. New York and NYISO can amend certain policies, like the definition of RECs, and the energy market tariffs to help incentivize P2G investment. New York must capitalize on this opportunity to meet its climate goals and demonstrate the benefits of P2G for the rest of the country to follow.