HARRIS BEACH PLLC
ATTORNEYS AT LAW

677 BROADWAY, SUITE 1101
ALBANY, NEW YORK 12207
518.427.9700

GENE KELLY
MEMBER
DIRECT: 518.701.2775
FAX: 518.427.0235
JAFZALI@HARRISBEACH.COM

March 8, 2020

Via US and Electronic Mail (chris.hogan@dec.ny.gov)

Mr. Christopher M. Hogan
Chief, Major Project Management Unit
Department of Environmental Conservation
Division of Environmental Permits
625 Broadway, 4th Floor
Albany, NY 12233-1750

Re: CPV Valley, LLC – CPV Valley Energy Center
Title V and IV Permit Applications
DEC ID 3-3356-00136/000010 & 00009

Response to November 29, 2020 Notice of Revocation of Complete Application and Notice of Incomplete Application

Dear Mr. Hogan:

Harris Beach PLLC represents CPV Valley, LLC ("Valley" or "Applicant") with respect to its applications for a Title V and IV (Phase II Acid Rain) permit (collectively, the "Application") under the Clean Air Act and Article 19 of the New York Environmental Conservation Law ("ECL").

As you know, the New York State Department of Environmental Conservation ("NYSDEC" or "Department") issued a Notice of Revocation of Complete Application and Notice of Incomplete Application dated November 29, 2020 ("NOIA") regarding Valley's Application. The Department's stated basis was that Valley was required to provide an assessment of how NYSDEC's issuance of a Title V permit be would be consistent with the Statewide greenhouse gas ("GHG") emissions limits established in the Climate Leadership and Community Protection Act Section 7 [2] (Chapter 106 of the Laws of 2019) (the "CLCPA"), ECL Article 75, and recently promulgated at 6 NYCRR Part 496 (eff. December 30, 2020).[1] On behalf of Valley, this letter and the attached ICF Report dated March 8, 2021 ("ICF Report") constitutes Valley's response to the Department's NOIA.[2]

[1] The Part 496 regulations were still in the rulemaking process when NYSDEC revoked its application completeness determination and issued the NOIA.
[2] Valley reserves all rights to challenge NYSDEC's revocation of its May 2019 application completeness determination in any administrative or judicial action or proceeding.

Brief Background

Valley owns and operates the Valley Energy Center ("Facility"), a nominal net 680-megawatt ("MW") combined cycle gas turbine ("CCGT") electric generating facility located in Orange County, in the Lower Hudson Valley Region. The Facility started operations in January 2018 under a combined Air State Facility ("ASF") and a pre-construction Prevention of Significant Deterioration ("PSD") permit (ASF Permit ID: 3-3356-00136/00001, issued August 1, 2013) ("ASF Permit"), among other permits and approvals. The August 1, 2013 ASF Permit had a five-year term and was due to expire July 31, 2018. As such, Valley submitted an application to renew its ASF Permit to DEC on or about January 23, 2018 as required.[3]

NYSDEC rejected Valley's ASF renewal application on or about August 1, 2018 on the grounds that Valley should have applied for a Title V permit rather than an ASF permit renewal, notwithstanding that Valley's ASF permit did not require a Title V application until January 2019. Ultimately, Valley filed its Title V Application on August 24, 2018 and continued operations under the automatic permit extension provision in the State Administrative Procedure Act ("SAPA") § 401 (2). After reviewing the Application for completeness, NYSDEC published a Notice of Complete Application in the New York State Environmental Notice Bulletin ("ENB") on May 29, 2019. NYSDEC then prepared a draft permit and established a 60-day public comment period, including two public legislative hearings on July 17, 2019.[4]

Under the applicable law and implementing regulations, NYSDEC must "[t]ake final action on a [Title V] permit application within eighteen months after the date of receipt of a complete application" (ECL § 19-0311 [2] [i]; 42 USC §§ 7661a [b] [7] and 766lb [c]). Rather than taking a final action, NYSDEC revoked its prior application completeness determination and issued the November 29, 2020 NOIA seeking additional information under the CLCPA. As a result, Valley representatives engaged in discussions with NYSDEC Staff on several occasions to identify the scope of the information the Department seeks under the CLCPA.

NYSDEC's November 29, 2020 NOIA

As set forth in the NOIA, NYSDEC requires Valley to provide the following CLCPA information as part of its Title V application: (1) an assessment of how the Facility's operations would be consistent with GHG emissions limits established under ECL Article 75 and 6 NYCRR

---

[3] The State Administrative Procedures Act ("SAPA"), DEC regulations and the ASF Permit require Valley to submit a permit renewal application at least 180 days prior to the Permit's July 31, 2018 expiration. The ASF Permit was also conditioned on Valley submitting a Title V permit application within one year of starting operations at the Facility (January 2018). Thus, when Valley filed its ASF renewal application in January of 2018, Valley still had one year before it was required to apply for a Title V application under the terms of its ASF Permit.

[4] During this period, the CLCPA was enacted in July 2019 (eff. January 2020).

Part 496;[5] (2) an assessment of how the Facility's operations would be consistent with the electric sector targets of the CLCPA that mandate 70% renewable generation by 2030, and zero emissions from the statewide electric system by 2040;[6] and (3) an assessment of how future physical climate risk has been considered in accordance with the Community Risk and Resiliency Act ("CRRA").[7] As detailed below and in the ICF Report, Valley's Title V Application is consistent with the CLCPA.

The Facility's Operations are Consistent with Statewide GHG Emission Limits

ICF's assessment demonstrates that Valley's Application, if approved, would not interfere with the attainment of the CLCPA GHG emission limits established under ECL Article 75 and the Part 496 regulations.

ICF analyzed the impact on both direct and indirect (upstream)[8] GHG emissions associated with the operation of the Facility. ICF's analysis shows that between 2025 and 2040, operation of the Facility results in a reduction of ninety thousand (90,000) short tons per year of direct and upstream GHG emissions in NYS, mostly driven by direct emission reductions (ICF Report § 2.3). ICF attributes these net annual reductions in GHG emissions to the fact that the Facility is one of the most efficient thermal generators in NYS, displacing less efficient (and higher emitting) generation sources, without any negative impact to renewable generation (ICF Report § 2.2).

ICF's analysis of the Facility's impact of GHG emissions is fully set forth in section 4.2. This section shows the GHG Emissions from less efficient NYS generators anticipated to be displaced (ICF Report § 4.2, Table 4-8), impact of the Facility on GHG emissions (ICF Report § 4.2, Table 4-2), and net reduction on statewide GHG emissions from the Facility's operation (ICF Report § 4.2, Table 4-9).

The Facility's Operations are Consistent with Statewide Electric System Emission Goals

ICF's analysis also demonstrates that the Facility will not interfere with the state's long-term energy targets of a zero-emissions statewide electric system by 2040. This conclusion is based on projections that assume the Facility will be zero-emitting by converting to burning Renewable Natural Gas ("RNG") or green hydrogen, and that the PSC will consider those as CLCPA-compliant fuel sources.

---

[5] CLCPA § 7 [2] stating "In considering and issuing permits . . . all state agencies . . . shall consider whether such decisions are inconsistent with or will interfere with the attainment of the statewide greenhouse gas emissions limits established in article 75 of the environmental conservation law."
[6] CLCPA § 4 amends the Public Service Law ("PSL") by adding a new Section 66-p to require the New York State Public Service Commission ("PSC") to implement a program to achieve a 70% of statewide electric generation from renewable energy systems by 2030 and zero GHG emissions from the statewide electric system by 2040.
[7] See CLCPA § 9.
[8] Upstream emission impacts were calculated using emissions factors developed by the NYSDEC (ICF Report § 2.2, Appendix A-5).

The ICF Report analyzes and sets forth its assumptions that RNG combustion would result in zero on-site GHG emissions. The ICF report suggests that thermal resources running on RNG may in fact lead to net negative emissions (ICF Report § 2.2, Appendix A-3), however, ICF assumes RNG to be zero-emissions and CLCPA complaint based on discussions with NYSDEC Staff (ICF Report § 2.2 fn. 7, § 3.2, § 4.1). While use of RNG is assumed to result in net zero GHG emissions, ICF's analysis still considers combustion emissions from RNG for informational purposes (ICF Report § 2.3). The ICF Report additionally considers and provides an evaluation of the anticipated adequacy of RNG and hydrogen supply and cost (ICF Report § 2.3, § 2.4, Appendices A-3 [RNG] and A-4 [hydrogen]).

The Facility's Siting and Design Meets CRRA Requirements

As originally enacted, the CRRA[9] required applicants for certain permits or funding for specified permits to demonstrate that future physical climate risk due to sea-level rise, storm surge, and flooding had been considered in project design, and that DEC consider incorporating these factors into certain facility-siting regulations. As a result, NYSDEC developed sea-level rise projections for New York State under 6 NYCRR Part 490. CLCPA § 9 extends applicability of the CRRA to all "major permits" defined under ECL 70-0107 [3], including applications for Title V permits.

While Climate Act § 9 amended the CRRA to now include all major permits, it did not expand the CRRA's narrow scope, which is to consider climate risk *in project design and facility siting*. Valley's Title V Application here is necessary to continue operations at an existing facility that does not require any design or siting modifications. Thus, a CRRA assessment as extended to Title V Applications by the CLCPA is not required under the circumstances here.

Even if a CRRA assessment was required, project design and facility siting issues were thoroughly considered during the pre-construction project review and approval that started in March 2008 and was subject to a full review under the State Environmental Quality Review Act ("SEQRA"), including public scoping, the preparation of a draft environmental impact statement ("DEIS") and final environmental impact statement ("FEIS"). NYSDEC completed its SEQRA review of the Facility in connection with the issuance of the ASF Permit in 2013 and issued a SEQR Findings Statement on July 25, 2013. With respect to the instant Application, the Department has already determined that the Facility has not changed in any material way since 2013 and that the findings and determinations in the original DEIS and FEIS are still applicable. As such, the permit record already contains the necessary information to assess future physical climate risk.

[9] (L.2014 Ch. 355)

The Facility, in relation to FEMA mapping, as well as surface elevations, potential for flooding, and floodplain impacts are addressed in the DEIS[10] and FEIS.[11] Surface elevations across the 122 acre parcel range from approximately 452 feet above mean sea level ("MSL") to 498 feet above MSL[12] and the Facility is outside any floodplain areas.[13] When compared to the state-established sea-level rise projections, the Facility's location ensures that future physical climate risk due to sea-level rise, storm surge, and flooding is low. The Part 490 regulations, which are applicable to consideration of sea-level rise by NYSDEC and applicants for relevant permits subject to the CRRA, show projected sea-level for the New York City/Lower Hudson Region relative to the baseline levels[14] as:

Time Interval	**Low Projection**	**Low-Medium Projection**	**Medium Projection**	**High- Medium Projection**	**High Projection**
2020s	2 inches	4 inches	6 inches	8 inches	10 inches
2050s	8 inches	11 inches	16 inches	21 inches	30 inches
2080s	13 inches	18 inches	29 inches	39 inches	58 inches
2100	15 inches	22 inches	36 inches	50 inches	75 inches

6 NYCRR § 490.4.

As such, because the projected sea-level rise for the geographic area where the Facility is located is well below the elevation level of the Facility, the existing permit record is sufficient to show that there is little to no additional climate risk under a CRRA assessment.

Conclusion

Valley requests that you accept this letter and attached ICF Report in response to the November 29, 2020 NOIA, make a determination that the Application is complete, perform technical review limited to issues identified in the NOIA, and take final action on the Application by granting approval and issue the Title V permit.

Thank you for your continuing attention in this matter.

---

[10] See DEIS, on file with NYSDEC and available at https://www.cpv.com/our-projects/cpv-valley/deis/.
[11] FEIS, on file with NYSDEC and available at https://www.cpv.com/our-projects/cpv-valley/feis/.
[12] DEIS § 2.1 [Site Description], § 4.4.1.2 [Field Investigation], § 9.1.1 [Topography].
[13] DEIS § 3.4.1.2 [Potential Impacts], § 3.5.2.1 [Consistency with Flood Damage Prevention Code], § 13.3.5 [Operational Impacts], § 14.2.2 [Wetlands], Appendix 14-B, Appendix 14-C; FEIS § 3.2.6 [Wetland Hydroperiod], Response to Comment PB4-10, PB4-38.
[14] See 6 NYCRR § 490.3 [d] (defining baseline level as "[t]he average level of the surface of marine or tidal water over the years 2000 through 2004").

HARRIS BEACH PLLC
ATTORNEYS AT LAW

Very truly yours,

HARRIS BEACH PLLC

Gene Kelly

Encl.

Greenhouse Gas Analysis for CPV Valley Energy Center Title V Permit Application

March 8, 2021

Prepared for:
Competitive Power Ventures

Prepared by:
ICF

Table of Contents

1 EXECUTIVE SUMMARY

ICF submits this report in connection with CPV Valley, LLC's (Valley) application to the New York State Department of Environmental Conservation (NYSDEC) for a Clean Air Act (CAA) Title V (Air) permit for its Valley Energy Center generating facility (the Facility) and in response to NYSDEC's November 29, 2020 Notice of Incomplete Application.

This report analyzes whether Valley's draft Title V permit, if approved, would be consistent with the attainment of New York State's (NYS) greenhouse gas (GHG) emission limits established in Climate Leadership and Community Protection Act (CLCPA), Article 75 of the Environmental Conservation Law (ECL), and regulations under 6 NYCRR Part 496.

ICF finds that issuance of the Title V permit to Valley would be consistent with the long-term statewide greenhouse gas reduction goals of NYS for the following reasons:

- The Facility is among the most efficient electric generating facilities in NYS and will reduce statewide GHG emissions by 90 thousand short tons per year between 2025 and 2040 through the displacement of less efficient and higher emitting generating facilities in NYS. In 2040 and beyond, the Facility and other NYS thermal resources are assumed to be zero-emitting by converting to burning RNG or hydrogen.
- The Facility complements existing and anticipated intermittent renewable energy resources added to the NYS electric grid by providing a flexible resource to the electric system due to its controllable power output level and quick ramp rate.
- As thermal resources will continue to be an important part of the NYS electric grid beyond 2040, the Facility, if converted to use renewable natural gas (RNG) or hydrogen, will be integral to grid reliability while still meeting the state's goal of 100% of statewide electric generation from zero emissions energy systems.[1]

2 INTRODUCTION

2.1 Background

Valley owns and operates the Valley Energy Center, a nominal net 680-megawatt (MW) combined cycle gas turbine (CCGT) facility located in NYISO Load Zone G in Lower Hudson

[1] To meet CLCPA goals and statewide GHG limit regulations, electricity demand is anticipated to significantly increase (65% to 80% relative to current load), which may lead to challenges in meeting demand reliably. Periods of low renewable generation availability could place added stress on the system without the availability of flexible and efficient thermal RNG or hydrogen-capable resources such as the Facility. See Energy+Environmental Economics, New York State Decarbonization Pathways Analysis, June 24, 2020, § 4.4 [Source: https://climate.ny.gov/-/media/CLCPA/Files/2020-06-24-NYS-Decarbonization-Pathways-Report.pdf].

Valley. The Facility started operations in January 2018 under an Air State Facility (ASF) permit. Valley filed its Clean Air Act Title V operating permit on August 24, 2018. NYSDEC's Notice of Complete Application was published on May 29, 2019. NYSDEC revoked its prior application completeness determination and issued a Notice of Incomplete Application on November 29, 2020 seeking additional information under the CLCPA.

CLCPA Section 7(2) requires all state agencies to consider whether their permit approval decisions are inconsistent with or will interfere with the attainment of the statewide GHG emission limits established in ECL section 75-0107 and promulgated at 6 NYCRR Part 496 (eff. December 30, 2020). Part 496 requires reductions of statewide GHG emissions to 60% of 1990 levels by 2030 and to 15% of 1990 levels by 2050, but the rule does not impose compliance obligations on individual sources. Further, the CLCPA amends the Public Service Law (PSL) to require the New York State Public Service Commission (PSC) to implement a program to achieve the following targets: 1) 70% of statewide electric generation from renewable energy systems by 2030; and 2) zero emissions from the statewide electric system by 2040.

NYSDEC has required Valley to provide the following as part of its Title V application:

- An assessment of how the Facility's operations would be consistent with the greenhouse gas emissions limits established under ECL Article 75 and 6 NYCRR Part 496.
- An assessment of how the Facility's operations would be consistent with the electric sector targets of the CLCPA that mandate 70% renewable generation by 2030, and zero emissions from the statewide electric system by 2040.

This report provides the analysis in response to the NYSDEC's requests and assesses the impact of the Facility on GHG emissions.

2.2 Scope of Analysis and Modeling Approach

ICF's analysis addresses the following two key questions:

- Whether the Facility's operation is consistent with CLCPA GHG reduction requirements, and
- Whether the Facility will interfere with NYS long-term energy targets of a zero-emissions statewide electric system by 2040?

To evaluate the Facility's consistency with the CLCPA, ICF first developed a forward-looking resource mix for NYS using its proprietary Integrated Planning Model (IPM). This resource mix was optimized to meet all clean energy and zero-emissions targets while meeting reserve margin requirements. The optimization also accounted for transmission capabilities, capital costs and other assumptions. After determining the most economic resource mix, ICF followed the typical approach to assessing the impacts of a proposed facility on the electricity system, which is to first model the system without the facility (the Base Case), and then to model it with the facility (the Change Case). ICF used ABB's PROMOD production cost modeling software to assess the impacts of the Facility based on the resource mix determined using IPM. The Facility's impact was estimated for the 2025-2050 forecast period, with 2025, 2030, 2040 and 2050 being the model run years.

This analysis does not address all potential future scenarios impacting Facility operations. Specifically, the Facility could retire if declining market prices or competition with other resources compel it to. Alternatively, the Facility could add carbon capture and sequestration technology to eliminate carbon emissions. The financial risk of closure or capital investment to comply would be borne entirely by Valley since the Facility was built without any financial assistance from NYS or its ratepayers. Additionally, the Facility could be required by NYS to continue to operate using natural gas in 2040 in order to meet NERC and other reliability requirements.[2] This analysis does not address this scenario due largely to the extreme complexity involved and uncertainty regarding future conditions.

ICF calculated the impact on both direct and indirect (upstream) GHG emissions associated with the operation of the Facility. It compared the Facility's projected emissions with the weighted average emission rates of NYS's displaced fossil generators and corresponding upstream emission impacts based on projected electric generation and corresponding fuel consumption of the Facility. Since the Facility is one of the most efficient thermal generators in NYS, displacement of less efficient (and higher emitting) generation leads to a net reduction in GHG emissions. The net impact of the Facility on statewide greenhouse gas emissions is calculated by the following equation:

$$\begin{aligned} &Net\ Impact\ of\ the\ Project\ on\ Statewide\ GHG\ Emissions \\ &\quad = Increase\ in\ emissions\ from\ the\ Project\ in\ tons \\ &\quad - \Big[displacement\ of\ other\ NYS\ thermal\ generation\ in\ MWh \\ &\quad * average\ emissions\ rate\ in\ \frac{tons}{MWh}\Big] \end{aligned}$$

The total amount of other NYS thermal generation displaced by the Facility is equal to the projected generation of the Facility itself and is summarized in the tables below.[3] The average emissions rate of displaced NYS thermal generation was calculated based on the heat rate of displaced generation and estimated to be 0.46 ton CO_2e/MWh. This includes emissions of N_2O which were calculated using a weighted average historical emission rate of NYS fossil

---

[2] The CLCPA added a new Section 66-p to the Public Service Law entitled "Establishment of a Renewable Energy Program," which, among other things, specifically provides in subsection (2): "In establishing such program, the [Public Service Commission] shall consider and where applicable formulate the program to address impacts of the program on safe and adequate electric service in the state under reasonably foreseeable conditions. The [Public Service Commission] may, in designing the program, modify the obligations of jurisdictional load serving entities and/or the targets upon consideration of the factors described in this subdivision." Further, in Section 66-p(4) further states that the Public Service Commission "may temporarily suspend or modify the obligations under such program provided that the commission, after conducting a hearing as provided in section twenty of this chapter, makes a finding that the program impedes the provision of safe and adequate electric service; the program is likely to impair existing obligations and agreements; and/or that there is a significant increase in arrears or service disconnections that the commission determines is related to the program."

[3] ICF models renewable resources as "must-run" in PROMOD. As such, generation from the Facility does not impact renewable generation and only displaces other less efficient NYS resources.

generators from EPA's most recently available eGRID data.[4,5] In comparison, the Facility's emission rate is 0.43 ton CO_2e/MWh. Upstream emission impacts were calculated using emissions factors developed by the NYSDEC, associated with the change in fuel consumption for electric generation in NYS.

Table 2-1: Projected Generation and Fuel Consumption of the Facility using RNG in 2040 and 2050

Impact		2025	2030	2040	2050
Projected Generation of the Facility (GWh)		4,395	2,365	1,142	1,661
Projected Fuel Consumption of the Facility (Thousand MMBtu)	Natural Gas	32,592	17,850	-	-
	RNG	-	-	8,862	12,695

Table 2-2: Projected Generation and Fuel Consumption of the Facility using Hydrogen in 2040 and 2050

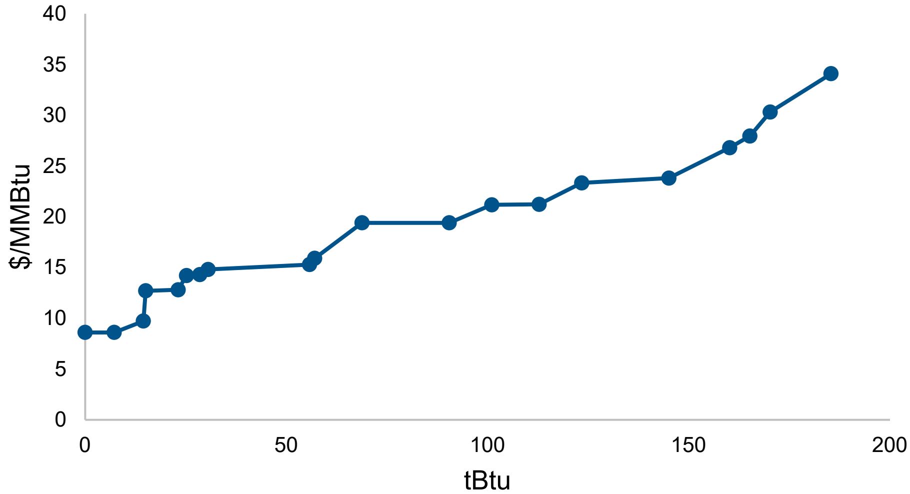
Impact		2025	2030	2040	2050
Projected Generation of the Facility (GWh)		4,395	2,365	797	1,100
Projected Fuel Consumption of the Facility (Thousand MMBtu)	Natural Gas	32,592	17,850	-	-
	Hydrogen	-	-	6,253	8,423

ICF developed cost and volume estimates for two zero-emissions fuels, RNG and hydrogen, to inform its analysis of the Facility's consistency with the CLCPA electric system targets. To estimate RNG potential for NYS in 2040, ICF drew upon a previous assessment of RNG potential it had developed for the American Gas Foundation (AGF).[6] The estimate was based on an inventory of RNG feedstocks and production volumes accessible to NYS. ICF then developed cost estimates for RNG production from various feedstocks such as landfill gas, municipal solid waste, animal manure, food waste, etc. The cost estimates were further refined by region to arrive at a cost versus availability estimate. The figures below present the RNG cost curve used in this study. ICF's detailed methodology to develop the cost curve is provided in Appendix A-3.

---

[4] N_2O is a by-product of combustion and has a 20-year Global Warming Potential (GWP) of 264.
[5] EPA eGrid 2018. Weighted average historical emission rate in NYS was 0.00039 lb/MMBtu. [Source: https://www.epa.gov/egrid]
[6] ICF, Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment, December 2019 [Source: https://gasfoundation.org/2019/12/18/renewable-sources-of-natural-gas/].

Figure 2-1: RNG Cost Curve in 2040 and beyond



It is important to note that ICF assumed that RNG would be considered a CLCPA-compliant fuel source in 2040 and beyond.[7] As a biogenic fuel, the CO_2 emissions from combustion are assumed not to add to the atmospheric loading. A complete accounting of the sources of RNG may result in net negative methane emissions, as capturing RNG prevents methane emissions at source. However, in accordance with Part 496, Statewide GHG Emission Limits, combustion emissions from RNG must be included in the statewide greenhouse gas emissions.[8] Thus, notwithstanding ICF's assumption that RNG may be considered a CLCPA-consistent fuel source, this report includes direct combustion emissions from RNG in 2040 and 2050, for informational purposes.

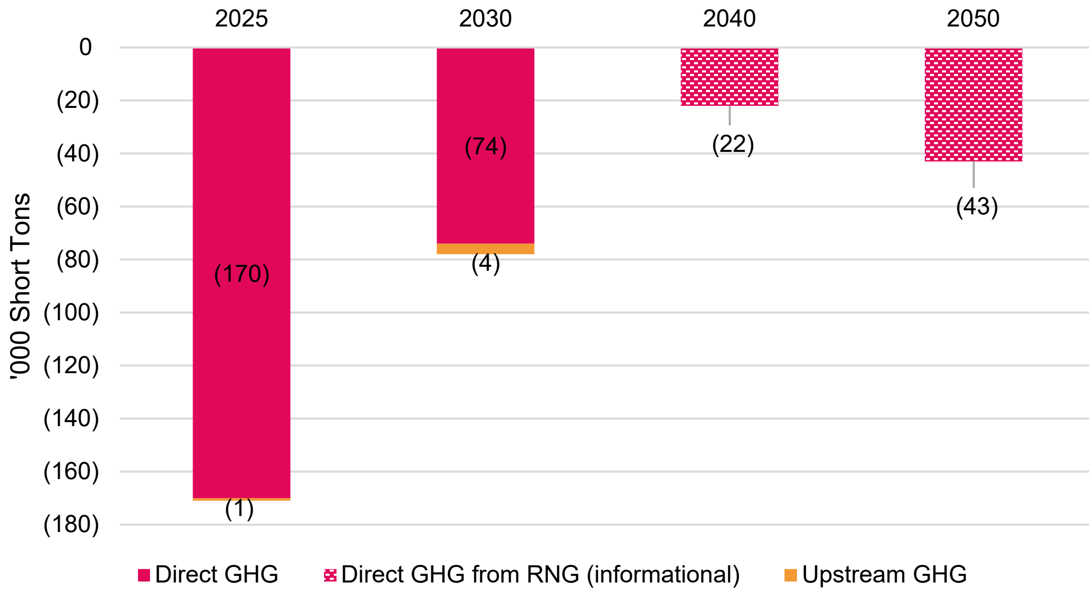
2.3 Key Findings

Reduction in GHG emissions: Between 2025 and 2040, operation of the Facility results in a reduction of 90 thousand short tons per year of direct and upstream GHG emissions in NYS. Much of the reduction is driven by direct emission reductions (see Figure 2-2). In 2040 and 2050, all NYS thermal resources running on RNG and Hydrogen are assumed to be zero-emissions. However, as mentioned above, combustion emissions from RNG are included in this analysis for informational purposes.

[7] NY DEC staff suggested that ICF may include an assumption that RNG will be considered zero emissions by the NY PSC. [Source: Binder, Jonathan A. "RE: ICF CPV Valley Title V Analysis Assumptions Documents." E-mail message to ICF, Valley and Harris Beach, LLC. February 10, 2021]

[8] 6 NYCRR Part 496, Statewide Greenhouse Gas Emission Limits, NY DEC. [Source: https://www.dec.ny.gov/regulations/121052.html]

Figure 2-2: GHG Impacts of the Facility in NYS



Efficient, RNG or hydrogen-capable thermal resources such as the Facility play an important role in NYS's resource mix: ICF's analysis found that the most cost-effective solution for a future resource mix that is consistent with the CLCPA targets involves retaining some existing thermal resources, combined with large amounts of new renewable and energy storage resources. The thermal resources that are retained post-2040 would be retrofitted to burn RNG or hydrogen. Figure 2-3, Figure 2-4 and Figure 2-5 show NYS's capacity and generation mix (including the Facility) in 2040. Post-2040, only offshore wind and battery storage capacity is added to the resource mix.

Figure 2-3: CLCPA-Consistent Resource Mix (in GW) in 2040 in NYS

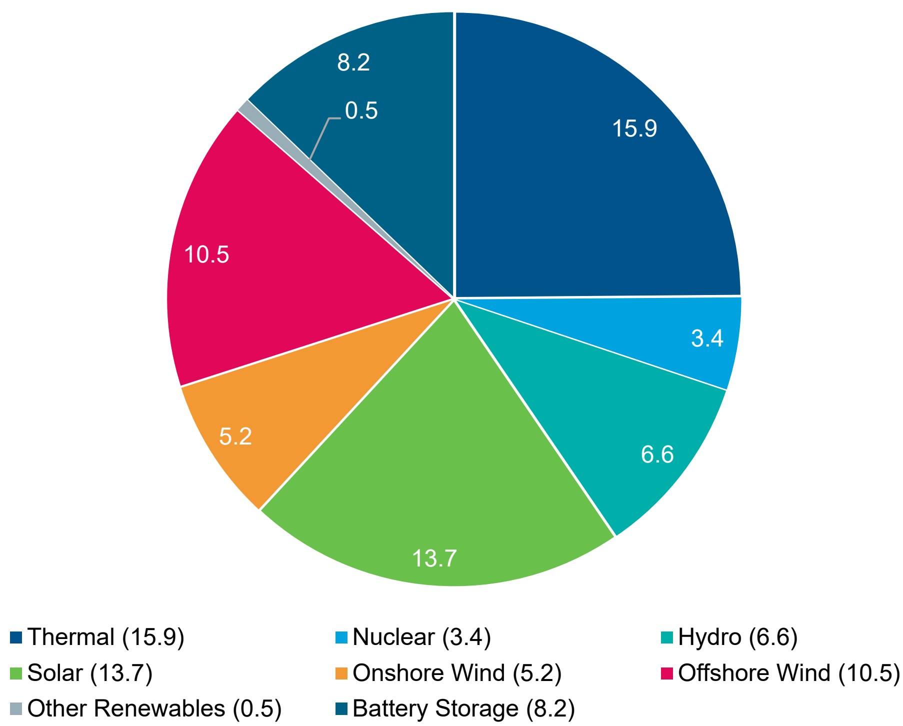


Figure 2-4: CLCPA-Consistent Generation Mix (in TWh) using RNG in 2040 in NYS

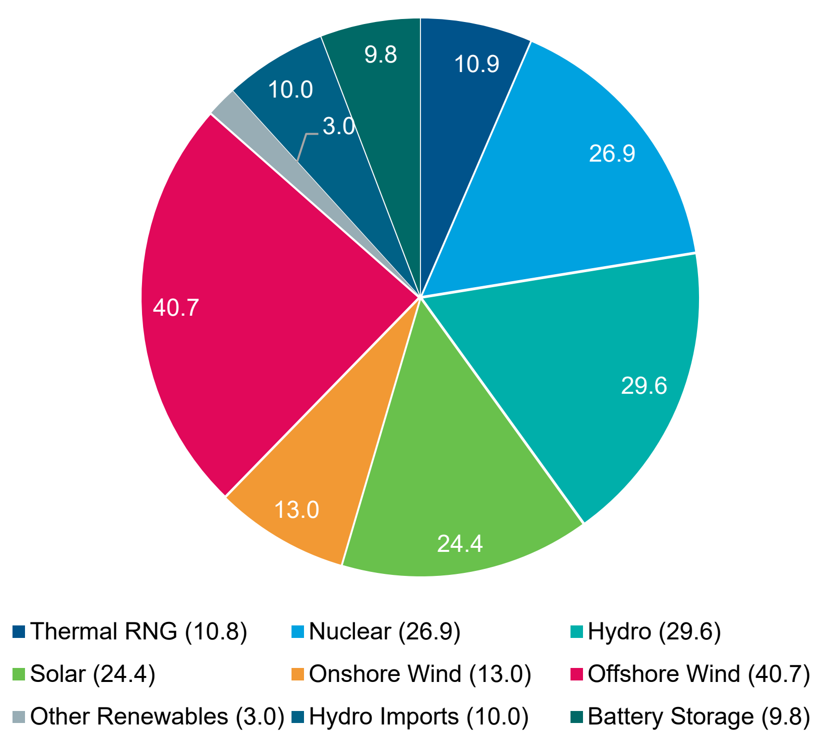
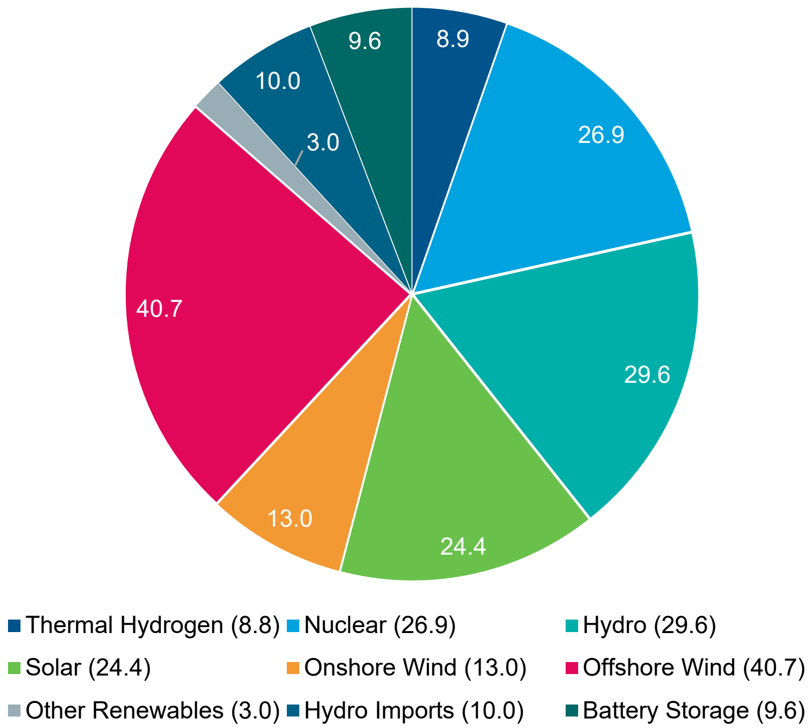


Figure 2-5: CLCPA-Consistent Generation Mix (in TWh) using Hydrogen in 2040 in NYS



The least-cost resource mix is driven by two primary requirements 1) to maintain adequate reserve margin, and 2) to meet the CLCPA targets of 70% renewable energy by 2030 and a 100% zero-emission electric system by 2040. Due to the rapidly falling capital costs and minimal variable costs of renewable resources, ICF finds it optimal to utilize these resources to meet the CLCPA targets. Thus, renewable and battery storage resources make up most of the generation capacity. However, since renewable resources do not provide much reserve margin contribution (solar PV only provides 2% in the winter), it is more cost effective and supportive of reliability objectives to retain some thermal resources to meet resource adequacy requirements. Thus, in 2040, ICF's projected capacity resource mix comprises 15.9 GW of thermal RNG or hydrogen resources, 10.5 GW of offshore wind, 5.2 GW of onshore wind, 13.7 GW of utility-scale solar PV, and 8.2 GW of 4 and 8-hour battery storage. In 2050, only incremental offshore wind and battery storage additions are required, and they reach a total of 17.8 GW and 12.8 GW, respectively. The thermal capacity retained in 2040 comprises the most efficient and flexible combined cycle gas turbines (CCGT) and combustion turbines (CT). These resources play an important role as capacity and load-following resources to help meet reserve margin and reliability requirements. Given the relatively high costs of RNG (see Appendix A-3), the average capacity factor of thermal RNG generators in 2040 is only about 8%, and they are projected to provide only 6% of the state's zero-emissions electricity. Given the even higher costs of hydrogen (see Appendix A-4), the average capacity factor of thermal hydrogen generators in 2040 is only 6%, and they are projected to provide only 5% of the state's zero-emissions electricity.

The Facility provides for flexible, on-demand dispatchable capacity: By 2040, as renewable resources become dominant, the need for flexible, on-demand dispatchable capacity rises in order to supplement the intermittent nature of renewable generation. Due to its quick start-up and ramp times, the Facility will provide key load-following services to address any shortfalls in renewable generation due to resource unavailability. Due to its high efficiency and fast ramp times, the Facility operates at a capacity factor of 18.3% on RNG in 2040, which is higher than the 8% average of all converted thermal RNG resources.

Hydrogen interacts with renewable output: The quantity of available hydrogen is infinite (as long as water is available), but its cost is a function of the cost of power. At current estimates, the cost of hydrogen in 2040 is $45/MMBtu (in nominal terms). However, the greater the reliance on renewables, the lower the hydrogen price to the extent excess renewable production is used to produce hydrogen.

2.4 Consistency with Other Long-Term Studies in New York and California

ICF's findings are consistent with recent deep decarbonization studies for New York and California. These studies have shown that some level of thermal generation in the form of advanced quick-start, dispatchable combined cycle plants like the Facility will likely be required in power systems pursuing deep decarbonization. A study conducted for New York State Energy Research and Development Authority (NYSERDA) found that in a high electrification scenario, meeting heating loads during winter months would be challenging due to low renewable energy production, which can stretch over several days.[9] The study concluded that this long-duration reliability challenge can be solved through a combination of large-scale hydro, RNG, hydrogen, carbon capture and storage (CCS), and nuclear power.[10] Separately, the NYISO commissioned the Brattle Group to simulate resources that can meet state policy objectives and energy needs through 2040.[11] The study similarly concluded that dispatchable zero-emission sources such as RNG-fired thermal units would grow in capacity in order to meet the 2040 zero-emission energy and resource adequacy needs.[12] In the Brattle Group report, the generation from these plants decreases but capacity needed increases, showing a falling capacity factor.[13]

Studies for California have yielded similar conclusions. A study sponsored by the California Energy Commission (CEC) concluded that "by 2050, 85% to 95% zero-carbon electricity is expected to be required; however, 100% zero-carbon electricity is likely to be cost prohibitive

---

[9] Energy+Environmental Economics, New York State Decarbonization Pathways Analysis, June 24, 2020
[10] Ibid, pg. 21
[11] New York's Evolution to a Zero Emission Power System, Modeling Operations and Investment Through 2040, May 18, 2020, prepared for New York Stakeholders, Prepared by the Brattle Group.
[12] Ibid. pg. 22
[13] Ibid, pg. 23

compared to alternative GHG mitigation strategies."[14] In a California Public Utilities Commission (CPUC) November 2019 study,[15] the CPUC forecasts for 2045 concluded:

- "Almost all gas fired capacity retained past 2030 due to high peak demand" under all 2045 scenarios examined[16]
- "Gas capacity necessary to maintain reliability, even with significant buildout of out of state transmission or offshore wind"[17]
- "Electricity sector generation will result in CO_2 emissions in all scenarios"[18]

California also expects to rely on biofuels and hydrogen as additional options for the continued use of gas-fired power plants. For example, in the CPUC study, the Commission identifies three 2045 decarbonization scenarios – high electrification, high biofuels and high hydrogen. The high biofuels and high hydrogen scenarios focus on alternative types of gaseous fuels whose combustion would not increase CO_2 emissions.[19] Gas power plants can use these fuels, creating the option to extend the reliance on existing gas power plants. The CPUC study concludes that almost all existing gas power plants will be retained in these cases.[20]

In both the cases of California and New York, the growing reliance on electrification will increase the importance of reliability and resiliency because energy delivery will increasingly rely on one delivery system – power – rather than multiple systems such as natural gas, power and oil. Therefore, there will be an even greater need for flexible thermal generation. Similar to the conclusion of the NYSERDA study, the CPUC study finds that higher electrification increases electricity demand and leads to challenges in meeting demand reliably.[21] As such, if electricity demand is high in winter months in California, periods of low solar generation could place added stress on the system, and further diminish the likelihood that California will eschew the critical reliability contribution of its existing gas fleet.

3 MODELING TOOLS AND ASSUMPTIONS

3.1 Modeling Tools

ICF's proprietary modeling tool, IPM, was used to analyze the power sector outlook. IPM was developed by ICF to be the primary modeling tool for the US Environmental Protection Agency to analyze the impact of emission regulations on the power and fuel industries at national and regional levels. ICF has utilized IPM for a variety of clients such as Regional Greenhouse Gas

[14] California Energy Commission, Deep Decarbonization in a High Renewables Future, June 2018
[15] California Public Utilities Commission (CPUC), 2019-2020 Proposed Reference System Plan, CPUC Energy Division, November 6, 2019
[16] Ibid, Page 158
[17] Ibid, Page 161
[18] Ibid, Page 152,
[19] Ibid, page 150. Combustion of hydrogen produced via electrolysis using renewable power during excess generation periods results in emission of water. Biofuels such as renewable natural gas is sourced in a manner which prevents the release of methane into the atmosphere.
[20] Ibid, page 158.
[21] Ibid, pages 150 -165

Initiative (RGGI), NYSERDA, and utilities to assess the impacts of alternative policy and market assumptions on New York CO_2 emissions and NYISO markets.

ICF used ABB PROMOD IV, an industry-standard and NY DPS-approved software, for production cost modeling. PROMOD considers generating unit characteristics, forced outages, transmission topology and constraints, and market system operations to simulate security-constrained economic dispatch of generating units.

3.2 Modeling Assumptions

Table 3-1 below summarizes ICF's modeling assumptions for this analysis.

Table 3-1: Summary of Modeling Assumptions

Parameter	Modeling Assumption
Modeling Years	2025, 2030, 2040, 2050
Environmental Regulations	Full CLCPA Compliance
Peak Load Forecast	2020 NYISO Gold Book Baseline Forecast adjusted for high BTM Solar and high energy efficiency from Low Load Scenario
Energy Use Forecast	2020 NYISO Gold Book Baseline Forecast adjusted for high BTM Solar and high energy efficiency from Low Load Scenario
DERs and Energy Storage	2020 NYISO Gold Book Baseline Forecast of Energy Storage; High BTM Solar from Low Load Scenario
Energy Efficiency	High Energy Efficiency from 2020 NYISO Gold Book Low Load Scenario
Firm Builds	Updated as per 2020 Gold Book, and 2018 CARIS Phase 2 Base Case Assumptions and Preliminary Results. Includes Cricket Valley, Copenhagen Wind, Arkwright Summit, Cassadaga Wind, Baron Wind, 8 Point Wind, Number 3 Wind, Bluestone Wind, Roaring Brook Wind, Ball Hill Wind, Canisteo Wind, Alle Cat Wind, Deer River Wind
Firm Retirements	Updated as per 2020 Gold Book, and 2018 CARIS Phase 2 Base Case Assumptions and Preliminary Results. Includes Indian Point units 2 and 3. Also includes Cayuga and Somerset.
Renewable Build Costs	Costs based on NREL 2019 ATB with EPA regionalization factors for NY

Parameter	Modeling Assumption
Thermal Build Costs (excluding CCGT with CCS)	NREL 2019 ATB with EPA regionalization factors for NY
CCGT with CCS Capital Cost	EPA v6
RNG and Hydrogen Fuel Availability and Price Forecast	Based on several feedstocks (landfill gas, animal manure, etc.) from the eastern seaboard, weighted by New York's share of natural gas consumption
Natural Gas Fuel Price Forecast	2018 CARIS Phase 2 fuel forecasts, applied on a monthly basis
Emissions Price Forecast	Updated as per 2018 CARIS Phase 2 Base Case Assumptions and Preliminary Results

ICF used a combination of the Baseline Forecast and the Low Load Forecast from the NYISO's 2020 Gold Book to model a conservative demand scenario. This scenario uses the Baseline Forecast modified to include high energy efficiency and high BTM solar PV from the low load forecast (Table 3-1). Thus, the peak and energy demand used are lower than the Gold Book's baseline forecast. This is a very conservative scenario since it does not assume completion of many of the other economy-wide CLCPA targets such as electrification of space heating and transportation. Appendix A-1 contains detailed peak and energy assumptions.

ICF's capital cost assumptions for renewable energy and storage technologies were derived from the 2019 NREL Annual Technology Baseline (ATB). Assumptions for non-renewable technologies were sourced from EPA's Power Sector Modeling Platform v6 and EIA's Annual Energy Outlook (AEO 2019). Additionally, the capital costs were scaled according to region based on EPA's cost regionalization factors from its Power Sector Modeling Platform v6. Detailed capital cost assumptions are provided in Appendix A-2.

Table 3-2 below shows the Facility's plant parameters.

Table 3-2: Plant Parameters for the Facility

Parameter	Modeling Assumption
Fuel Type	Natural Gas/RNG/Hydrogen (with minor modifications)
Prime Mover	Combined Cycle Gas Turbine
Primary Gas Hub(s)	F-I Blend, 2018 CARIS Phase 2 fuel forecast
Online Year	2018
Summer DMNC[22] UCAP (MW)	658

[22] Dependable Maximum Net Capability

Parameter	Modeling Assumption
Winter DMNC UCAP (MW)	726
Base Block Full Load Average Output (MW)	622
Duct Block Average Incremental Output (MW)	84
Annual Average Full Load Base Heat Rate (Btu/kWh)	6,844
Annual Average Base + Duct Heat Rate (Btu/kWh)	7,133
Emissions	
CO_2 (lb/MMBtu)	117
N_2O (lb/MMBtu)	0.00022

4 MODELING RESULTS

This section presents and discusses the results of ICF's analysis of the Base Case and Change Case for four discrete run years – 2025, 2030, 2040 and 2050. The first sub-section discusses New York's resource and generation mix as the CLCPA requirements and targets are implemented, and the subsequent sub-section discusses the impact of the Facility on direct and upstream greenhouse gas emissions in NYS.

4.1 CLCPA Consistent Resource Mix

ICF's assessment of New York's future resource mix was driven by the concurrent need to maintain adequate reserve margin in the NYISO electric system and meet the CLCPA's electricity supply targets. Thus, the optimal solution incorporates a mix of capacity resources required to maintain reliability, and energy resources required to fulfill the CLCPA targets. The most cost-effective resource mix relies on new offshore wind, onshore wind and solar PV capacity to produce non-emitting generation sufficient to meet the 70x30 and the 100x40 targets, while relying on existing thermal capacity reconfigured to burn RNG or hydrogen and new energy storage for reserve margin requirements. Thus, flexible, efficient, and biofuel-capable thermal resources such as the Facility play an important role in the projected resource mix to provide key load-following and reliability services.

Table 4-1 presents ICF's projected resource mix with the Facility online for 2025, 2030, 2040 and 2050. Between 2025 and 2050, a significant increase in offshore wind, solar PV and battery storage is expected to meet the resource-specific requirements of the CLCPA.

Table 4-1: Projected Resource Mix (in MW) in the Change Case

Capacity Type	2025	2030	2040	2050
Thermal	23,678	19,987	15,925	15,675
Nuclear	3,361	3,361	3,361	3,361
Hydro	6,624	6,624	6,624	6,624
Solar	5,448	9,503	13,672	13,672
Onshore Wind	5,250	5,250	5,250	5,250
Offshore Wind	1,696	6,098	10,471	17,839
Other Renewables	481	481	481	481
Battery Storage	1,500	3,000	8,211	12,740

Between 2025 and 2050, ICF projects the renewable capacity to increase to 17.8 GW of offshore wind, 5.2 GW of onshore wind, 13.7 GW of solar PV and 12.7 GW of battery storage in NYS. Prior to 2040, the renewable additions are driven by New York State mandates such as the 9 GW offshore wind target by 2035 as well as the 3 GW energy storage requirement by 2030. In addition, the requirement to meet 70% of the energy demand from renewable sources in 2030 drives incremental renewable builds in 2030.

In 2040, as NYS transitions to a 100% zero-emission electricity system, additional offshore wind and solar capacity is added between 2030 and 2040 to supply non-emitting generation. ICF projects offshore wind to reach over 10 GW and solar to reach almost 14 GW by 2040. However, ICF does not project new onshore wind additions as higher installed costs (see Appendix A-2) and a lack of sites with high wind resource potential make it less competitive relative to offshore wind and solar. An incremental 5.2 GW of battery storage is also projected beyond the firmly planned 3 GW, reaching a total installed capacity of 8.2 GW. The incremental storage capacity is added to maintain resource adequacy as thermal units, especially old, large and inflexible oil/gas steam units, are projected to retire. These retirements prior to 2040 are balanced through additions of offshore wind capacity in particular, and, as additional thermal facilities retire in 2040, 8-hour battery storage. While thermal generating capacity is projected to retire prior to 2040, substantial amounts of capacity are also projected to retrofit to burn RNG or hydrogen, maintaining over 15 GW of capacity in the system in 2040.

Post-2040, ICF projects additions of offshore wind and battery storage to be the most cost-effective solution to help meet demand growth and reliability requirements. New solar capacity is not projected after 2040 as additions of offshore wind, that provide greater reliability value than solar, are more cost-effective.

The need to retain existing natural gas capacity by converting it to burn RNG or hydrogen in 2040 is three-fold. First, there is a need for overall capacity levels (or resource adequacy) that can be reliably committed to satisfy demand at any time, including in periods of low renewable generation. According to the NYISO, "as intermittent resources like wind and solar expand across the bulk power system, the Installed Reserve Margin (IRM) percentage will increase because intermittent resources do not contribute an equivalent amount of capacity to reliably meet peak demand as dispatchable resources. Policymakers will need to be cognizant that the intermittency of renewable resources requires that flexible and controllable capacity be available to meet load in the absence of sufficient energy production."[23] Further, it is noted that since individual wind and solar may be simultaneously affected by regional weather conditions, such as extended periods of low wind, maintaining resource adequacy would pose a challenge in the absence of dispatchable generation.[24] Indeed, a study prepared for the NYISO stakeholders found that the marginal capacity value of offshore wind, solar PV and 8-hour battery storage declines as penetration increases.[25] Thus, for every incremental MW of thermal capacity retirement, more than one MW of renewable and storage capacity would be required to maintain the same IRM. ICF's analysis suggests that it is more economical to retain some gas-fired generation by converting it to use RNG than to continue building renewable and battery capacity.

Second, there is a need for resources that are flexible enough to perform load-following of more variable net load (total load less renewable generation) patterns, respond to short-term fluctuations, insure against forecast uncertainty associated with renewables, and provide grid services such as voltage support. The Facility is a quick-start, fast-ramping, and efficient CCGT, that, along with other efficient CCGTs and CTs, provides more flexible load-following capability and grid services such as frequency regulation and voltage support.

Finally, RNG or hydrogen-fired thermal generation is projected to provide zero-emission electricity supply to New York's grid in 2040 and beyond. In both the Base and Change cases, gas-fired capacity running on RNG generates approximately 11 TWh in 2040 and 17 TWh in 2050, or 7% and 10% respectively of the state's annual energy use (see Table 4-2 and Table 4-3). Due to the higher costs of hydrogen versus RNG, thermal resources running on hydrogen generate 9 TWh in 2040 and 11 TWh in 2050 (see Table 4-4 and Table 4-5).

[23] NYISO 2019 Power Trends, pg. 23.
[24] NYISO 2020 Power Trends, pg. 26
[25] *NYISO Grid in Transition Study,* The Brattle Group. March 30, 2020.

Table 4-2: Generation Mix (in GWh) in the Base Case using RNG in 2040 and 2050

Capacity Type	2025	2030	2040	2050
Thermal	39,073	20,502	10,824	16,993
Nuclear	27,757	26,376	26,872	28,129
Hydro	27,626	27,626	27,627	27,626
Solar	10,058	17,712	24,394	23,212
Onshore Wind	13,407	13,266	13,008	12,311
Offshore Wind	6,981	24,742	40,768	62,226
Other Renewables (biomass, etc.)	2,948	2,948	2,956	2,948
Scheduled Hydro Imports	9,993	9,993	9,993	9,993
Energy Storage	2,165	3,760	11,931	21,361
Total (excl. energy storage)	137,843	143,166	156,442	183,438

Table 4-3: Generation Mix (in GWh) in the Change Case using RNG in 2040 and 2050

Capacity Type	2025	2030	2040	2050
Thermal	40,348	20,957	10,893	17,324
Nuclear	27,757	26,376	26,872	28,129
Hydro	27,626	27,626	27,627	27,626
Solar	10,058	17,720	24,423	23,269
Onshore Wind	13,405	13,258	13,002	12,311
Offshore Wind	6,981	24,742	40,733	62,299
Other Renewables	2,948	2,948	2,956	2,948
Scheduled Hydro Imports	9993	9993	9993	9993
Energy Storage	2,021	3,702	11,770	21,103
Total (excl. energy storage)	139,116	143,621	156,499	183,899

Table 4-4: Generation Mix (in GWh) in the Base Case using Hydrogen in 2040 and 2050

Capacity Type	2025	2030	2040	2050
Thermal	39,073	20,502	8,921	11,204
Nuclear	27,757	26,376	26,872	28,129
Hydro	27,626	27,626	27,627	27,626
Solar	10,058	17,712	24,426	23,236
Onshore Wind	13,407	13,266	13,024	12,340
Offshore Wind	6,981	24,742	40,759	62,333
Other Renewables (biomass, etc.)	2,948	2,948	2,956	2,948
Scheduled Hydro Imports	9993	9993	9993	9993
Energy Storage	2,165	3,760	11,719	20,878
Total (excl. energy storage)	137,843	143,166	154,577	177,810

Table 4-5: Generation Mix (in GWh) in the Change Case using Hydrogen in 2040 and 2050

Capacity Type	2025	2030	2040	2050
Thermal	40,348	20,957	8,889	11,555
Nuclear	27,757	26,376	26,872	28,129
Hydro	27,626	27,626	27,627	27,626
Solar	10,058	17,720	24,448	23,275
Onshore Wind	13,405	13,258	13,019	12,340
Offshore Wind	6,981	24,742	40,722	62,384
Other Renewables	2,948	2,948	2,956	2,948
Scheduled Hydro Imports	9993	9993	9993	9993
Energy Storage	2,021	3,702	11,626	20,656
Total (excl. energy storage)	139,116	143,621	154,527	178,250

It is important to emphasize that this analysis does not examine the full extent to which electrification of New York's energy system may impact electricity demand. The load forecast utilized in this analysis assumes achievement of the energy efficiency mandates as well as the full resource targets of the CLCPA, such as the six GW distributed generation solar PV target in 2025. However, impacts of electric vehicles (EVs) and non-EV electrification are consistent with NYISO's 2020 Gold Book Baseline scenario, which assumes only moderate levels of electrification and EV proliferation. Given the load forecast assumptions of this analysis, ICF's findings regarding the Facility's benefits are likely conservative. If the broader economy-wide CLCPA greenhouse gas reduction targets are to be realized, electricity demand will rise significantly as space heating, transportation, and other end-use energy needs transition to electricity. As a result, more zero-emissions generation and capacity will be required in NYS. This increase is also shown in other studies published by NYISO, such as the Climate Change Report published in December of 2019 and the Gold Book High Load case, both of which predict substantial demand increases compared to demand assumptions in this analysis.[26,27] With the potential for significant increases in electric load, efficient and flexible RNG or hydrogen-fired thermal units will be even more important to maintaining reliability in the grid.

4.2 Impact on Greenhouse Gas Emissions

ICF's assessment of the impact of the Facility on GHG emissions in NYS comprises impacts on both direct GHG emissions from the Facility and upstream emissions associated with the operation of the Facility. As mentioned earlier (see Section 2.2), the net impact of the Facility on statewide greenhouse gas emissions is calculated by the following equation:

$$\begin{aligned} &Net\ Impact\ of\ the\ Project\ on\ Statewide\ GHG\ Emissions \\ &= Increase\ in\ emissions\ from\ the\ Project\ in\ tons \\ &- \Big[displacement\ of\ other\ NYS\ thermal\ generation\ in\ MWh \\ &* average\ emissions\ rate\ in \frac{tons}{MWh}\Big] \end{aligned}$$

The total amount of other NYS thermal generation displaced by the Project is equal to the projected generation of the Facility itself and is summarized below.

Table 4-6: Projected Generation and Fuel Consumption of the Facility using RNG in 2040 and 2050

Impact	2025	2030	2040	2050
Projected Generation of the Facility (GWh)	4,395	2,365	1,142	1,661
Projected Fuel Consumption of the Facility (Thousand MMBtu)	32,592	17,850	8,862	12,695

[26] Itron Inc., New York ISO Climate Change Impact Study Phase 1: Long-Term Load Impact, December 2019

[27] NYISO 2020 Load & Capacity Data, April 2020

Table 4-7: Projected Generation and Fuel Consumption of the Facility using Hydrogen in 2040 and 2050

Impact	2025	2030	2040	2050
Projected Generation of the Facility (GWh)	4,395	2,365	797	1,100
Projected Fuel Consumption of the Facility (Thousand MMBtu)	32,592	17,850	6,253	8,423

The tables below present the impact of the Facility on Statewide GHG (CO_2, CH_4, N_2O) emissions. In 2040 and 2050, combustion emissions from RNG are shown for informational purposes even though this analysis assumes that RNG would be considered a CLCPA-compliant fuel by the NY PSC.[28] Direct and upstream emissions from hydrogen are zero.

Table 4-8: Amount of GHG Emissions from other NYS generators displaced by the Facility

Impact (thousand short tons)	2025	2030	2040 (RNG)	2050 (RNG)	2040 and 2050 (Hydrogen)
Reduction in direct GHG emissions through displacement of other generators	2,010	1,082	522	760	-
Reduction in upstream emissions due to reduced fuel consumption of displaced generators	1,589	874	-	-	-
Total [B]	**3,599**	**1,956**	**522**	**760**	**-**

Table 4-9: Impact of the Facility on GHG Emissions in NYS

Impact (thousand short tons)	2025	2030	2040 (RNG)	2050 (RNG)	2040 and 2050 (Hydrogen)
Increase in direct GHG emissions in NYS from generation by the Facility	1,840	1,008	500	717	-
Increase in upstream GHG emissions from operation of the Facility	1,588	870	-	-	-
Total [A]	**3,428**	**1,877**	**500**	**717**	**-**

[28] NY DEC staff suggested that ICF may include an assumption that RNG will be considered zero emissions by the NY PSC. [Source: Binder, Jonathan A. "RE: ICF CPV Valley Title V Analysis Assumptions Documents." E-mail message to ICF, Valley and Harris Beach, LLC. February 10, 2021]

Table 4-10: Net Impact on Statewide GHG Emissions from operation of the Facility

Impact (thousand short tons)	2025	2030	2040 (RNG)	2050 (RNG)	2040 and 2050 (Hydrogen)
Net reduction in GHG emissions [C] = [A] - [B]	**(172)**	**(79)**	**(22)**	**(43)**	**-**

APPENDICES

A-1 Peak and Energy Use Assumptions

The tables below present the peak and energy demand assumptions used in this study.[29]

Net Coincident Summer Peak Demand (MW)												
Year	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**NYCA**
2020	2,649	1,937	2,712	582	1,338	2,321	2,133	645	1,427	11,299	5,037	32,080
2021	2,614	1,919	2,686	611	1,310	2,272	2,097	642	1,422	11,269	4,963	31,805
2022	2,583	1,903	2,660	637	1,282	2,230	2,069	641	1,428	11,356	4,852	31,641
2023	2,547	1,882	2,630	657	1,249	2,181	2,039	638	1,419	11,298	4,699	31,239
2024	2,512	1,860	2,596	674	1,217	2,136	2,013	636	1,412	11,253	4,560	30,869
2025	2,478	1,838	2,562	684	1,185	2,091	1,986	631	1,399	11,163	4,450	30,467
2026	2,453	1,817	2,534	688	1,158	2,056	1,966	628	1,395	11,132	4,357	30,184
2027	2,435	1,806	2,514	688	1,138	2,031	1,948	625	1,397	11,134	4,305	30,021
2028	2,430	1,801	2,507	688	1,129	2,020	1,945	626	1,402	11,187	4,282	30,017
2029	2,436	1,802	2,508	684	1,128	2,019	1,946	627	1,413	11,269	4,269	30,101
2030	2,442	1,805	2,512	683	1,132	2,022	1,955	629	1,426	11,375	4,282	30,263
2031	2,454	1,812	2,520	679	1,139	2,029	1,964	631	1,439	11,497	4,312	30,476
2032	2,466	1,814	2,524	679	1,145	2,035	1,976	633	1,455	11,624	4,358	30,709
2033	2,476	1,819	2,528	678	1,149	2,042	1,990	634	1,465	11,716	4,395	30,892
2034	2,487	1,827	2,529	677	1,154	2,047	2,006	635	1,477	11,808	4,436	31,083
2035	2,500	1,831	2,532	677	1,160	2,059	2,021	637	1,488	11,909	4,483	31,297
2036	2,510	1,838	2,537	677	1,165	2,066	2,036	638	1,499	12,001	4,551	31,518
2037	2,519	1,846	2,540	676	1,172	2,076	2,053	638	1,508	12,082	4,608	31,718
2038	2,530	1,852	2,543	678	1,179	2,087	2,070	638	1,517	12,151	4,669	31,914
2039	2,541	1,860	2,546	676	1,185	2,097	2,087	638	1,524	12,212	4,738	32,104
2040	2,551	1,867	2,549	678	1,191	2,108	2,104	638	1,527	12,238	4,759	32,210
2041	2,558	1,870	2,550	678	1,197	2,118	2,120	636	1,530	12,264	4,785	32,306
2042	2,566	1,877	2,552	677	1,202	2,124	2,134	635	1,534	12,287	4,793	32,381
2043	2,571	1,878	2,553	677	1,204	2,128	2,147	633	1,536	12,307	4,807	32,441
2044	2,575	1,880	2,551	676	1,209	2,132	2,159	631	1,538	12,323	4,818	32,492
2045	2,579	1,883	2,549	675	1,210	2,135	2,170	628	1,540	12,336	4,822	32,527
2046	2,582	1,885	2,544	675	1,213	2,137	2,180	627	1,542	12,340	4,836	32,561
2047	2,585	1,884	2,544	675	1,215	2,137	2,191	624	1,541	12,338	4,840	32,574
2048	2,586	1,884	2,540	674	1,217	2,138	2,202	623	1,540	12,329	4,859	32,592
2049	2,589	1,885	2,538	675	1,219	2,136	2,212	620	1,539	12,316	4,878	32,607
2050	2,591	1,884	2,534	675	1,221	2,135	2,222	619	1,536	12,295	4,890	32,602

[29] 2020 Load & Capacity Data Report (Gold Book), NYISO, April 10, 2020.

Net Coincident Winter Peak Demand (MW)												
Year	A	B	C	D	E	F	G	H	I	J	K	NYCA
2020	2,213	1,551	2,513	750	1,323	1,887	1,551	492	857	7,540	3,271	23,948
2021	2,201	1,542	2,507	780	1,317	1,874	1,535	492	864	7,609	3,220	23,941
2022	2,196	1,534	2,509	807	1,314	1,868	1,520	495	884	7,817	3,133	24,077
2023	2,187	1,524	2,502	831	1,310	1,858	1,504	495	894	7,927	3,058	24,090
2024	2,179	1,515	2,495	851	1,305	1,851	1,489	495	905	8,055	2,958	24,098
2025	2,172	1,508	2,485	865	1,301	1,844	1,474	494	919	8,185	2,900	24,147
2026	2,171	1,504	2,478	873	1,298	1,843	1,464	495	940	8,374	2,869	24,309
2027	2,173	1,506	2,474	878	1,298	1,845	1,462	496	962	8,557	2,872	24,523
2028	2,186	1,511	2,479	881	1,303	1,853	1,466	500	990	8,815	2,891	24,875
2029	2,206	1,523	2,490	886	1,312	1,868	1,481	506	1,026	9,142	2,918	25,358
2030	2,226	1,535	2,504	891	1,321	1,885	1,500	513	1,068	9,507	2,934	25,884
2031	2,256	1,553	2,523	897	1,335	1,906	1,524	521	1,107	9,869	2,992	26,483
2032	2,289	1,570	2,549	904	1,350	1,931	1,554	530	1,150	10,244	3,061	27,132
2033	2,325	1,591	2,576	914	1,367	1,959	1,588	538	1,193	10,628	3,154	27,833
2034	2,368	1,615	2,607	925	1,387	1,990	1,627	548	1,234	11,007	3,260	28,568
2035	2,417	1,643	2,644	937	1,411	2,026	1,666	558	1,277	11,382	3,393	29,354
2036	2,467	1,672	2,682	951	1,433	2,061	1,710	569	1,305	11,746	3,539	30,135
2037	2,517	1,705	2,724	965	1,458	2,100	1,757	581	1,331	12,096	3,683	30,917
2038	2,572	1,738	2,769	981	1,485	2,140	1,805	594	1,354	12,427	3,847	31,712
2039	2,631	1,772	2,817	996	1,513	2,180	1,854	605	1,371	12,731	3,963	32,433
2040	2,689	1,809	2,864	1,012	1,541	2,222	1,903	615	1,386	13,009	4,083	33,133
2041	2,747	1,845	2,915	1,028	1,569	2,263	1,954	625	1,400	13,271	4,221	33,838
2042	2,803	1,881	2,963	1,044	1,595	2,300	2,000	634	1,410	13,506	4,337	34,473
2043	2,855	1,913	3,009	1,059	1,621	2,335	2,045	642	1,417	13,711	4,438	35,045
2044	2,905	1,946	3,050	1,075	1,643	2,369	2,088	648	1,423	13,885	4,522	35,554
2045	2,950	1,976	3,090	1,089	1,665	2,396	2,129	653	1,426	14,028	4,608	36,010
2046	2,990	2,002	3,127	1,102	1,684	2,418	2,166	658	1,427	14,127	4,686	36,387
2047	3,027	2,028	3,158	1,115	1,699	2,440	2,199	662	1,428	14,187	4,770	36,713
2048	3,061	2,052	3,189	1,129	1,714	2,458	2,230	665	1,428	14,216	4,846	36,988
2049	3,094	2,077	3,220	1,140	1,731	2,475	2,260	667	1,427	14,224	4,917	37,232
2050	3,122	2,098	3,245	1,151	1,742	2,489	2,287	669	1,427	14,216	4,968	37,414

Net Energy Projections (GWh)												
Year	A	B	C	D	E	F	G	H	I	J	K	NYCA
2020	14,182	9,396	15,078	4,810	7,462	11,272	8,994	2,657	5,589	48,857	19,584	147,881
2021	14,247	9,456	15,187	5,139	7,458	11,214	8,942	2,754	5,560	49,049	19,524	148,530
2022	14,233	9,460	15,236	5,407	7,404	11,117	8,837	2,819	5,564	49,455	19,336	148,868
2023	13,993	9,311	15,049	5,586	7,226	10,837	8,601	2,835	5,443	48,400	18,625	145,906
2024	13,764	9,161	14,865	5,728	7,042	10,572	8,380	2,831	5,352	47,602	17,931	143,228
2025	13,522	8,999	14,650	5,813	6,847	10,296	8,159	2,823	5,262	46,758	17,326	140,455
2026	13,322	8,863	14,466	5,858	6,680	10,065	7,981	2,812	5,191	46,123	16,861	138,222
2027	13,159	8,756	14,325	5,872	6,544	9,882	7,851	2,807	5,155	45,809	16,644	136,804
2028	13,064	8,698	14,249	5,868	6,455	9,773	7,794	2,817	5,159	45,813	16,694	136,384
2029	13,024	8,686	14,225	5,851	6,413	9,720	7,795	2,836	5,196	46,124	16,761	136,631
2030	12,997	8,688	14,218	5,843	6,387	9,690	7,837	2,861	5,250	46,602	17,004	137,377
2031	13,010	8,724	14,244	5,838	6,380	9,689	7,890	2,890	5,315	47,201	17,337	138,518
2032	13,040	8,750	14,283	5,840	6,383	9,698	7,965	2,923	5,394	47,889	17,806	139,971
2033	13,074	8,790	14,313	5,841	6,389	9,713	8,055	2,952	5,476	48,629	18,219	141,451
2034	13,122	8,846	14,357	5,852	6,402	9,735	8,158	2,985	5,562	49,399	18,769	143,187
2035	13,185	8,904	14,410	5,865	6,422	9,771	8,254	3,017	5,653	50,198	19,383	145,062
2036	13,236	8,973	14,472	5,884	6,444	9,805	8,368	3,049	5,745	51,014	20,122	147,112
2037	13,294	9,040	14,533	5,902	6,469	9,845	8,484	3,081	5,836	51,829	20,806	149,119
2038	13,361	9,117	14,601	5,924	6,502	9,892	8,605	3,111	5,929	52,660	21,473	151,175
2039	13,443	9,194	14,678	5,942	6,537	9,947	8,736	3,141	6,023	53,477	22,265	153,383
2040	13,528	9,281	14,759	5,963	6,580	10,006	8,875	3,170	6,113	54,276	22,644	155,195
2041	13,620	9,367	14,844	5,982	6,623	10,071	9,013	3,193	6,200	55,045	22,948	156,906
2042	13,718	9,453	14,933	6,000	6,669	10,135	9,157	3,216	6,281	55,764	23,238	158,564
2043	13,818	9,539	15,017	6,017	6,716	10,204	9,298	3,234	6,357	56,425	23,522	160,147
2044	13,919	9,624	15,101	6,036	6,766	10,267	9,440	3,250	6,424	57,020	23,821	161,668
2045	14,017	9,704	15,178	6,052	6,812	10,328	9,577	3,260	6,482	57,542	24,013	162,965
2046	14,115	9,780	15,254	6,068	6,860	10,386	9,713	3,269	6,532	57,977	24,272	164,226
2047	14,213	9,858	15,327	6,083	6,906	10,442	9,849	3,277	6,572	58,321	24,504	165,352
2048	14,308	9,927	15,392	6,097	6,951	10,493	9,979	3,284	6,602	58,587	24,799	166,419
2049	14,401	10,000	15,458	6,110	6,996	10,545	10,108	3,287	6,627	58,802	24,984	167,318
2050	14,488	10,062	15,510	6,121	7,036	10,587	10,230	3,291	6,645	58,947	25,175	168,092

A-2 Capital Cost Assumptions

The tables below provide ICF's capital cost assumptions for new renewable and CCGT with CCS resources. The values below represent the base numbers and do not show regionalization factors.

NREL ATB 2019 Build Costs (2018$)			
Utility Solar PV	Overnight Capital Cost ($/kW)	FOM ($/kW-yr)	
2020	$1,407	$17	
2025	$1,268	$15	
2030	$1,128	$14	
2035	$1,066	$13	
2040	$1,003	$12	
Onshore Wind	Overnight Capital Cost ($/kW)	FOM ($/kW-yr)	
2020	$1,526	$43	
2025	$1,388	$42	
2030	$1,251	$40	
2035	$1,190	$38	
2040	$1,129	$37	
Offshore Wind	Overnight Capital Cost ($/kW)	FOM ($/kW-yr)	
2020	$2,927	$113	
2025	$2,487	$96	
2030	$2,112	$81	
2035	$1,795	$69	
2040	$1,525	$58	
Battery Storage	4-Hour Capex ($/kW)	8-Hour Capex ($/kW)	FOM ($/kW-yr)
2020	$1,186	$1,990	$30
2025	$733	$1,500	$18
2030	$496	$1,256	$12
2035	$448	$1,178	$11
2040	$399	$1,099	$10

Combined Cycle with CCS	EPA v6 Reference Case Assumptions (2018$)			
	Overnight Capital Cost ($/kW)	FOM ($/kW-yr)	VOM ($/MWh)	Heat Rate (MMBtu/MWh)
2020	$2,201	$34.73	$7	7.514
2025	$2,096	$34.73	$7	7.493
2030	$1,918	$34.73	$7	7.493
2035	$1,776	$34.73	$7	7.493
2040	$1,672	$34.73	$7	7.493

A-3 RNG Cost Curve Development

To model RNG as a potential future fuel source for power plants, ICF analyzed resource availability and developed a cost curve. The objective of the RNG resource assessment was to characterize the technical and economic potential of RNG as a greenhouse gas emission reduction strategy, with a focus on local and regional resources deliverable to New York State. The assessment was based on an inventory of RNG feedstocks and production volumes accessible to NYS on existing transmission pipeline infrastructure. Biomass-based feedstocks were grouped into eight categories:

- Agricultural residues
- Animal manure
- Energy crops
- Food waste
- Forestry and forest product residues
- Landfill gas (LFG)
- Municipal solid waste (MSW)
- Wastewater treatment gas (WWT) from water resource recovery facilities (WWRFs)

ICF relied on existing studies, government data and industry resources to estimate the current and future supply of the feedstocks. The table below summarizes the resources that ICF drew from in its RNG resource assessment, broken down by RNG feedstock. The data sources and assessment approach were consistent with other RNG assessments ICF has conducted, notably its national assessment of RNG potential for the American Gas Foundation (AGF).[30]

Feedstock for RNG	Resources for assessment	
Agricultural residue	• US DOE 2016 Billion Ton Report	• Bioenergy Knowledge Discovery Framework
Animal manure	• AgStar Project Database	• USDA Livestock Inventory (Cattle, Swine, etc)
Energy crops	• US DOE 2016 Billion Ton Report	• Bioenergy Knowledge Discovery Framework
Food waste	• US DOE 2016 Billion Ton Report	• Bioenergy Knowledge Discovery Framework
Forestry and forest product residue	• US DOE 2016 Billion Ton Report	• Bioenergy Knowledge Discovery Framework
LFG	• US EPA Landfill Methane Outreach Program	
MSW	• US EPA	• Waste Business Journal
WRRF	• US EPA	• Water Environment Federation

[30] ICF, Renewable Sources of Natural Gas, December 2019. [Source:https://gasfoundation.org/2019/12/18/renewable-sources-of-natural-gas/]

Based on these sources, ICF then developed RNG production potential estimates incorporating constraints on accessibility to feedstocks, the time it would take to deploy projects, the development of technology to achieve higher levels of RNG production, and the consideration of likely Facility economics—with the assumption that the most economic projects will come online first. The RNG production estimates differentiate between the two biomass-based RNG production technologies currently available: anaerobic digestion and thermal gasification.

RNG Feedstock	Supply Assumptions
Agricultural residue	50% of the agricultural residue biomass available at $50/dry ton.[31]
Animal manure	60% of technically available animal manure.
Energy crops	50% of the energy crop biomass available at $70/dry ton.
Food waste	70% of the food waste available at $10/dry ton.
Forestry and forest product residue	60% of the forest and forestry product residue biomass available at $460/dry ton.
Landfill gas[32]	RNG production at 65% of the LFG facilities that have collection systems in place; 60% of the LFG facilities that do not have collections systems in place; and 80% of EPA's candidate landfills.
MSW	60% of the non-biogenic fraction of MSW available at $100/dry ton.
WRRF	50% of WRRFs with a capacity greater than 3.3 million gallons per day.

The RNG resource scenario also includes constraints based on geography and further limited by the current share of regional natural gas consumption. The scenario includes only RNG feedstocks from the U.S. eastern seaboard region, based on the EIA's census regions of New England, Mid-Atlantic, South Atlantic, East North Central and East South Central. Available RNG resources are further limited by NYS's share of regional non-electric generation natural gas consumption, which is equivalent to roughly 10% of the region.

The potential availability of biomass in the region far exceeds the usage for power generation in ICF's RNG scenario. ICF's RNG scenario assumes up to 185 TBtu of available RNG in 2040, which represents roughly 2% of the total biomass available in the U.S. eastern seaboard region.

Infrastructure build out and technology development are constrained, and these constraints are reflected temporally. In the near term, RNG is sourced from feedstocks that use commercially

---

[31] Feedstock availability for agricultural residue, energy crops, forestry and forest product residue, and MSW are based on specified-price simulations for biomass used in the DOE Billion Ton Report. These price simulations introduce markets for biomass at specific farmgate or tipping fee prices, with the price driving the available volume of biomass. The higher the price, the greater the volume of economically viable biomass is available.

[32] ICF considered only landfills that are either open or were closed post-2000. This constraint was imposed to account for the fact that the phase during which the decomposition of waste in a landfill produces sufficient methane concentrations lasts about 20-25 years, and this is the period during which waste-to-energy projects are most viable.

available anaerobic digestion technology (landfill gas, WRRFs and animal manure). To allow time for technology and infrastructure development, RNG feedstocks that use thermal gasification do not make a significant contribution until post-2030, including agricultural residues, forestry residues and energy crops.

RNG production will require new interconnections to pipelines, but RNG supply does not necessarily require additional natural gas system infrastructure, such as transmission and distribution pipes. The assumptions that limit the potential for each feedstock are designed to reflect that not all of the feedstocks that could technically produce RNG are viable or feasible. For some feedstocks this lack of viability could be due to geography or other physical restrictions. For example, only 60% of the technically available animal manure feedstock is considered for RNG production, reflecting that the animal manure feedstock is located in rural or regional areas, and some of these locations are a long distance from existing pipelines.

Overall natural gas infrastructure is not explicitly addressed in the RNG resource assessment. ICF's general assumption is that with a steady decline in natural gas consumption over the long term, RNG coming into the pipeline system (particularly at larger volumes post-2035) will not constrain pipeline capacity or be impactful to the gas system.

ICF developed assumptions for the capital expenditures and operational costs for RNG production from the various feedstock and technology pairings. ICF characterizes costs based on a series of assumptions regarding feedstock type, production facility size, gas upgrading and conditioning costs (depending on the type of technology used, the contaminant loadings, etc.), compression, and interconnection for pipeline injection. ICF also includes operational costs for each technology type.

In relation to pipeline interconnection, ICF understands developers have experienced a wide range of costs. Costs will vary for individual projects, including particularly for those that use anaerobic digestion and thermal gasification technologies. ICF's supply-cost curves are meant to be estimates of the potential costs that may occur in the future, rather than exact values. This is especially true in the long term, because ICF does not include significant cost reductions that might occur from RNG utilization scaling in time. The table below outlines ICF's baseline assumptions employed in its RNG costing model.

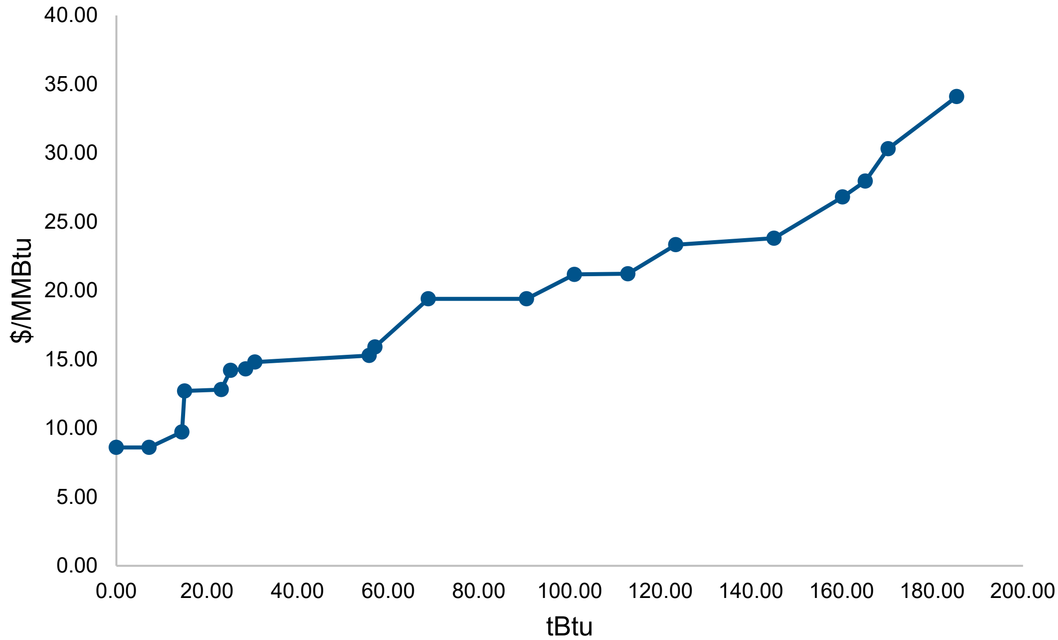
Cost Parameter	ICF Cost Assumptions
Facility Sizing	▪ Differentiate by feedstock and technology type: anaerobic digestion and thermal gasification. ▪ Prioritize larger facilities to the extent feasible, but driven by resource estimate.
Gas Conditioning and Upgradation	▪ Vary by feedstock type and technology required.
Compression	▪ Capital costs for compressing the conditioned/upgraded gas for pipeline injection.

Cost Parameter	ICF Cost Assumptions
Operational Costs	▪ Costs for each equipment type—digesters, conditioning equipment, collection equipment, and compressors—as well as utility charges for estimated electricity consumption.
Feedstock	▪ Feedstock costs (for thermal gasification), ranging from $30 to $100 per dry ton.
Financing	▪ Financing costs, including carrying costs of capital (assuming a 60/40 debt/equity ratio and an interest rate of 7%), an expected rate of return on investment (set at 10%), and a 15-year repayment period.
Delivery	▪ Cost of delivering the biogas in line with financing, constructing, and maintaining a pipeline of about 1 mile in length. The costs of delivering the same volumes of biogas that require pipeline construction greater than 1 mile will increase, depending on feedstock/technology type, with a typical range of $1-$5/MMBtu.
Facility Lifetimes	▪ 20 years. The levelized cost of gas was calculated based on the initial capital costs in Year 1, annual operational costs discounted at an annual rate of 5% over 20 years, and biogas production discounted at an annual rate of 5% for 20 years.

These cost assumptions are further refined by region, including average utility costs for the electricity and natural gas used in RNG production. However, the variation of costs between regions is modest. Tipping fees are based on state-level data, and relevant for estimating costs associated with LFG and WRRFs. The table below provides a summary of the different cost ranges for each RNG feedstock and technology.

	Feedstock	Cost Range ($/MMBtu)
Anaerobic Digestion	Landfill Gas	$7.10 – $19.00
	Animal Manure	$18.40 – $32.60
	Water Resource Recovery Facilities	$7.40 – $26.10
	Food Waste	$19.40 – $28.30
Thermal Gasification	Agricultural Residues	$18.30 – $27.40
	Forestry and Forest Residues	$17.30 – $29.20
	Energy Crops	$18.30 – $31.20
	Municipal Solid Waste	$17.30 – $44.20

The chart below shows ICF's price versus quantity curve for RNG in 2040 and beyond.



A-4 Hydrogen Cost Curve Development

Power-to-gas (P2G) is a form of energy technology that converts electricity to a gaseous fuel, such as hydrogen. Electricity is used to split water molecules into hydrogen and oxygen, and the hydrogen can be further processed to produce methane when combined with a source of carbon dioxide. If the electricity is sourced from renewable resources, such as wind and solar, then the resulting fuels are carbon neutral.

The key process in P2G is the production of hydrogen from renewable sources of electricity by means of electrolysis. This hydrogen conversion method is not new, and there are three electrolysis technologies with different efficiencies and in different stages of development and implementation:

- Alkaline electrolysis,
- Proton exchange membrane electrolysis, and
- Solid oxide electrolysis.

The hydrogen produced from P2G is a highly flexible energy product that can be used in multiple ways. It can be:

- Stored as hydrogen and used to generate electricity at a later time using fuel cells or conventional combustion turbine generating technologies.
- Injected as hydrogen into the natural gas system, where it augments the natural gas supply.
- Converted to methane and injected into the natural gas system.

The flexibility of hydrogen provides advantages beyond as an input to methanation for RNG. Hydrogen can be used in place of natural gas in many industrial applications, and hydrogen can be mixed directly with natural gas in pipeline systems, although there are physical limits to the level of hydrogen blending in natural gas pipeline systems. In addition, currently most commercially produced hydrogen is derived from conventional natural gas and does not have the environmental benefits of carbon neutral hydrogen produced from P2G.

Whether hydrogen or methane is the final product, P2G offers the potential to produce carbon neutral fuels from sustainable resources and leverage existing natural gas infrastructure for long-term and large-scale storage. Competing electric energy storage options, including batteries and pumped hydro storage, are expensive as a long-term energy storage option, and can be more expensive than hydrogen storage.

The quantity of carbon-neutral hydrogen available from P2G is technically unlimited as long as enough water and renewable electricity is available. ICF estimates that hydrogen would be available at an expected cost of $30/MMBtu in 2019 dollars, which equates to $45/MMBtu in nominal 2040 dollars. However, as the amount of renewable electricity increases, the cost to produce hydrogen will decline.

A-5 Upstream Emissions Factors

Consistent with the suggestion of NY DEC staff, ICF excluded upstream emissions from RNG and used upstream emission factors shown in the table below.[33]

GHG Emission Rate (g/MMBtu)				
Fuel Type	CO_2	CH_4	N_2O	CO_2e (20-year GWP)
Natural Gas	11,913	384	0.136	44,205
Coal	3,279	397	0.103	36,650
Distillate Fuel/Oil	15,164	121	0.258	25,375

[33] Leddy, Maureen A. "RE: ICF CPV Valley Title V Analysis Assumptions Documents." Email message to ICF, Valley and Harris Beach. February 4, 2021.