Power Forecast Study

2021 Update

Prepared for
North Dakota Transmission Authority

January 2022

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1 Study Background

The North Dakota Transmission Authority (NDTA) hired Barr Engineering Co. (Barr) to update the electrical load forecast study Barr completed in 2019 and summarized in the "Power Forecast 2019: Williston Basin Oil and Gas Related Electrical Load Growth Forecast" report (reference (1)). The previous study is referred to as the "PF Study." The work summarized in this memorandum is referred to as the "PF Study - 2021 Update," and its purpose is to update the previously completed forecasts for the oil and gas production broad load category and the large industrial/commercial broad load category with newly available information. New point sources identified in this update may be constructed with their own source of electrical generation; however, the goal of this study is to identify anticipated electrical loads regardless of how those loads will be supplied.

1.1 PF Study - 2021 Update Approach

Barr used the same methods as the PF Study, except when noted throughout this report. For additional information on the methods used, see reference (1).

The PF Study organized baseline and forecasted energy consumption estimates into three broad categories: oil and gas production, large industrial/commercial, and population. Given the purpose of the update and because new information from North Dakota State University (NDSU) forecasting population is not available at this time, Barr did not update the population broad category. Newly available information for the oil and gas production and large industrial/commercial broad categories includes updated oil and gas production forecast data from the North Dakota Pipeline Authority (NDPA), based on projected oil prices and recently identified future point load sources (Section 2) and updated point source information.

1.2 Study Area

The study area comprises 20 counties and portions of four others in western North Dakota which encompass the Williston Basin. The study area is served by 11 electrical cooperative (co-op) service areas, as shown in Figure 1-1, who purchase power from Basin Electric Power Cooperative (BEPC) or Montana-Dakota Utilities (MDU). The study area is unchanged from the PF Study and is illustrated in Figure 1-1.

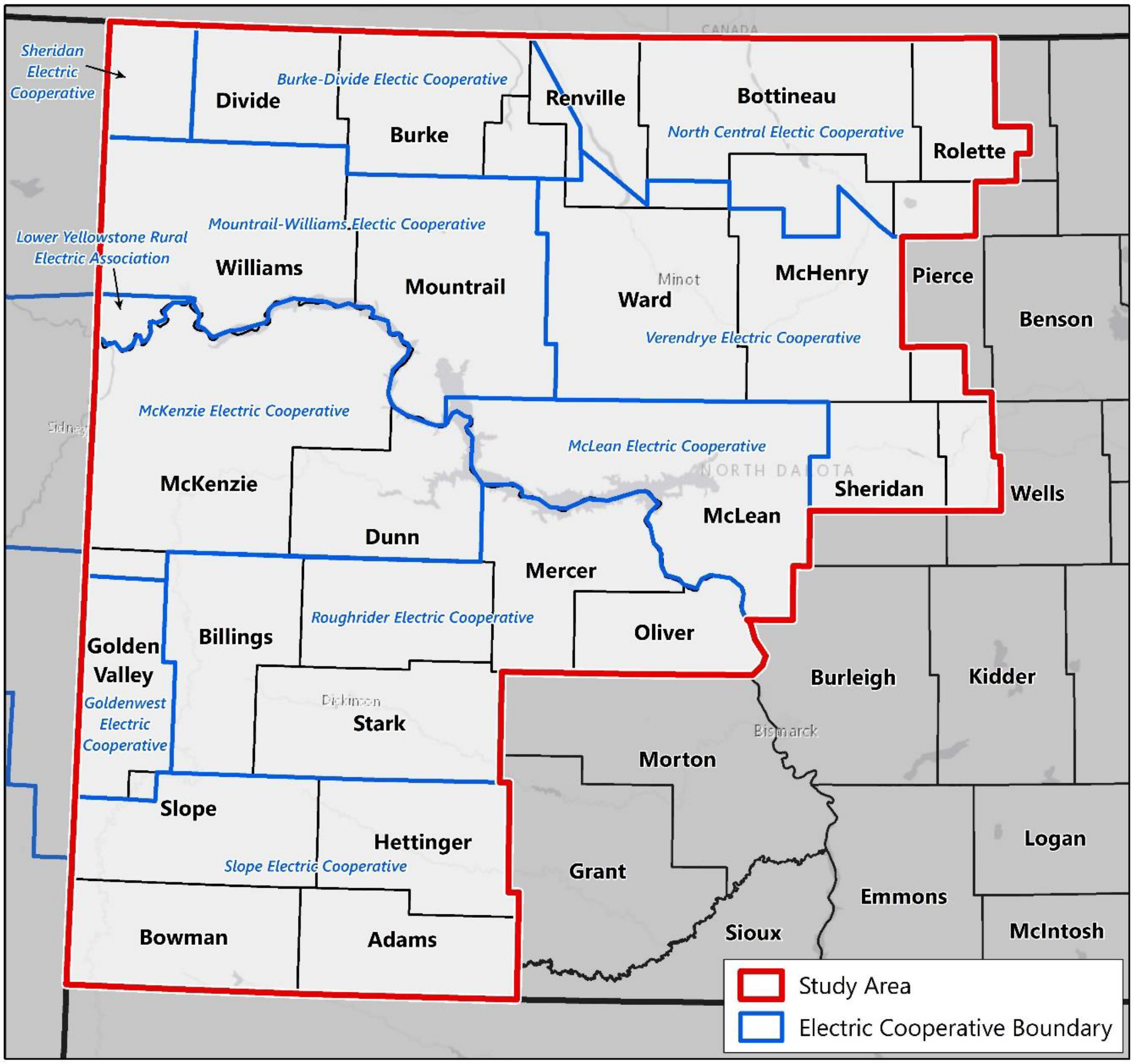

Figure 1-1 **Study Area**

2 Electrical Consumption Forecast Methodology

The study area's electrical energy consumption growth continues to be influenced by the oil and gas sector. Large industrial loads that are planned or currently being developed also significantly impact the study forecast results. This section describes the methodology for each electrical load broad category analyzed in the study and notes where there are differences from the PF Study.

2.1 NDPA Oil and Gas Production Forecast Estimates

For the oil and gas production broad load category, the PF Study's consensus scenario corresponds with the NDPA's current "high" and "low" forecasted oil and gas production volumes (at the time of the PF Study, NDPA referred to them as Case 1 and Case 2, respectively). NDPA emailed Barr the raw data used in the PF Study update (reference (2)). Refer to Figure 2-1 for estimated oil production totals and Figure 2-2 for estimated gas production totals.

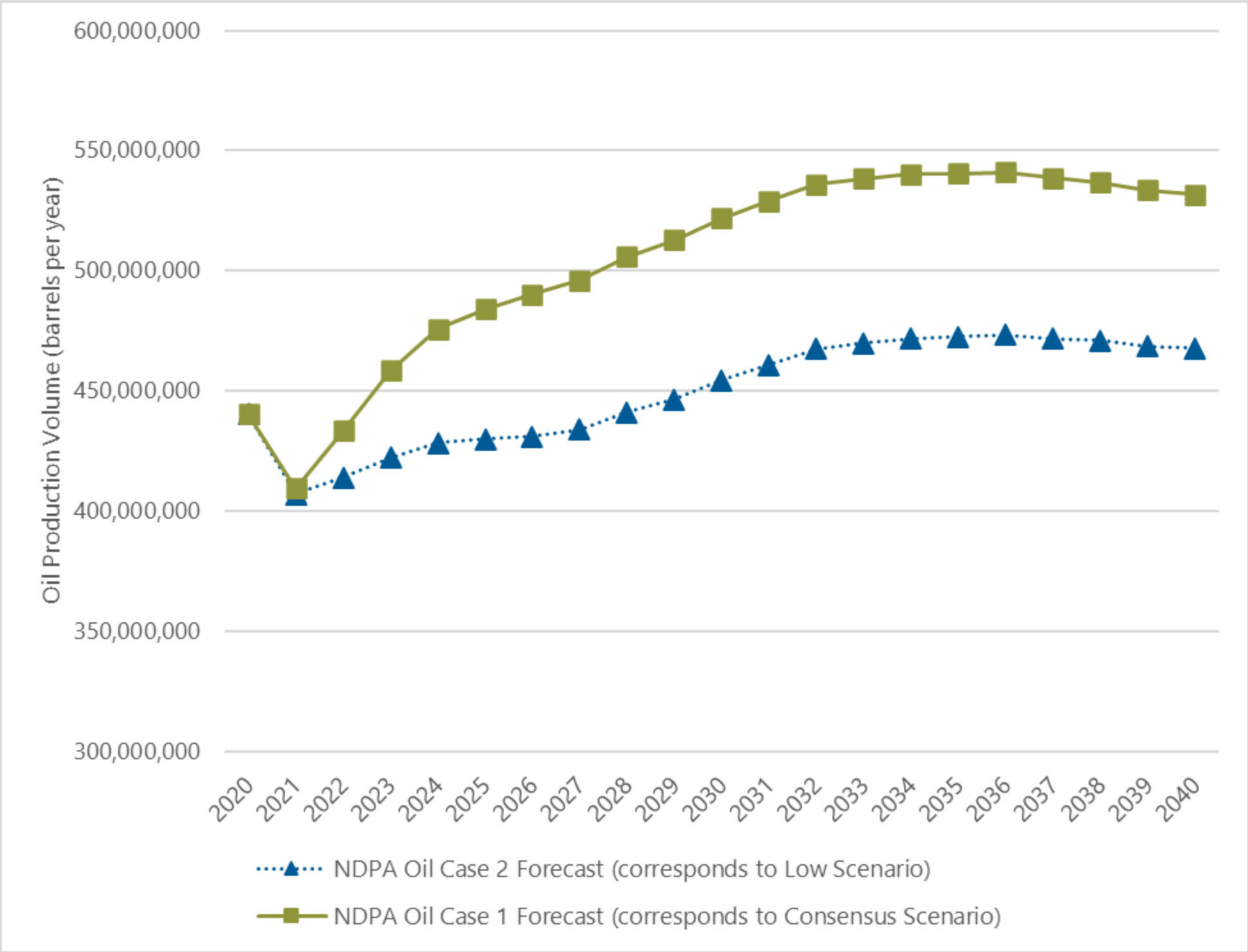

Figure 2-1 NDPA Forecast: Oil Production Volumes

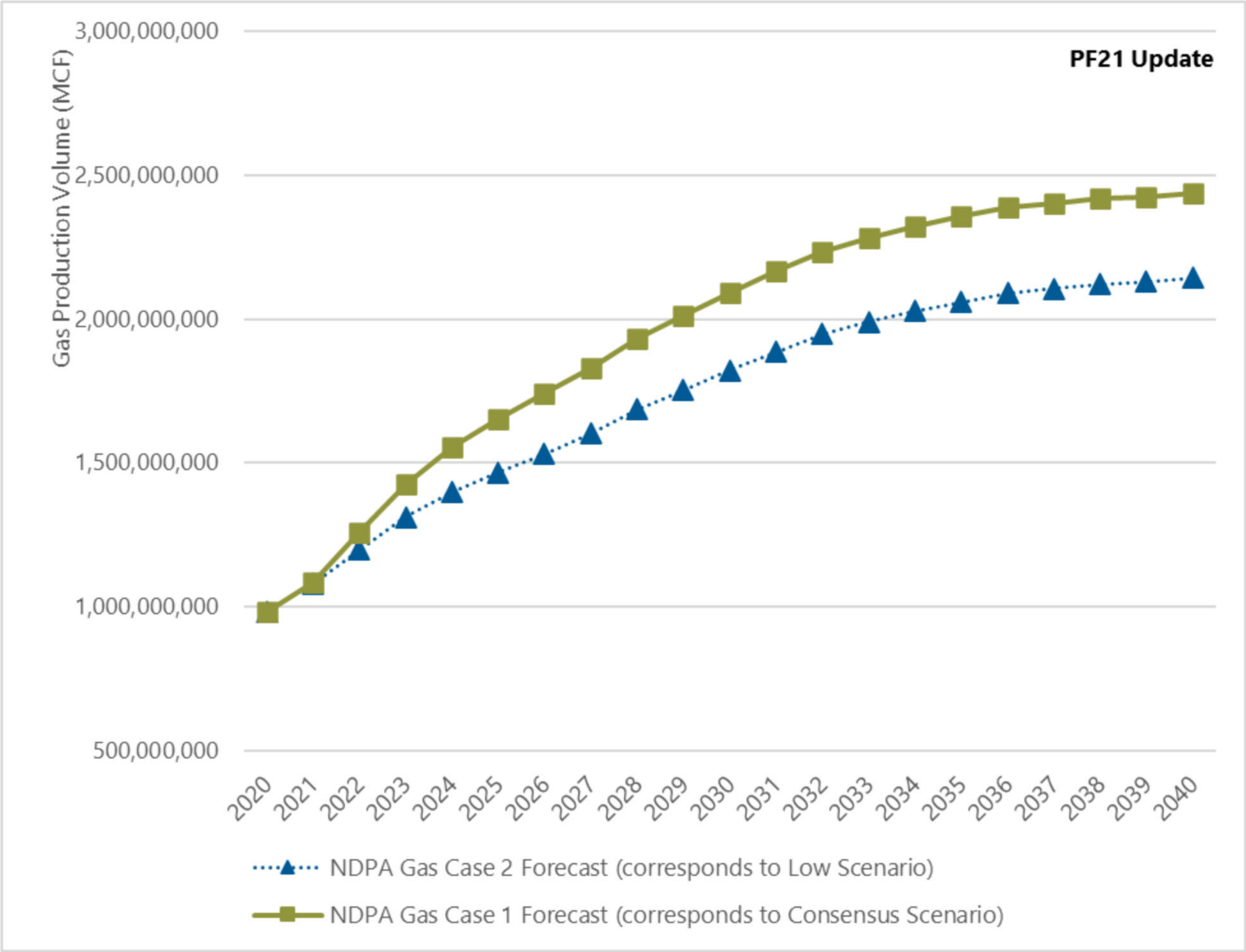

Figure 2-2 NDPA Forecast: Gas Production Volumes

For comparison purposes, Figure 2-3 and Figure 2-4 are provided to illustrate the NDPA forecasted oil and gas production rates at the time of the PF Study versus the PF Study – 2021 Update. Overall, oil production rates are forecasted to be lower, but given updated information on the oil-to-gas ratio, the total volume of forecasted gas production is higher.

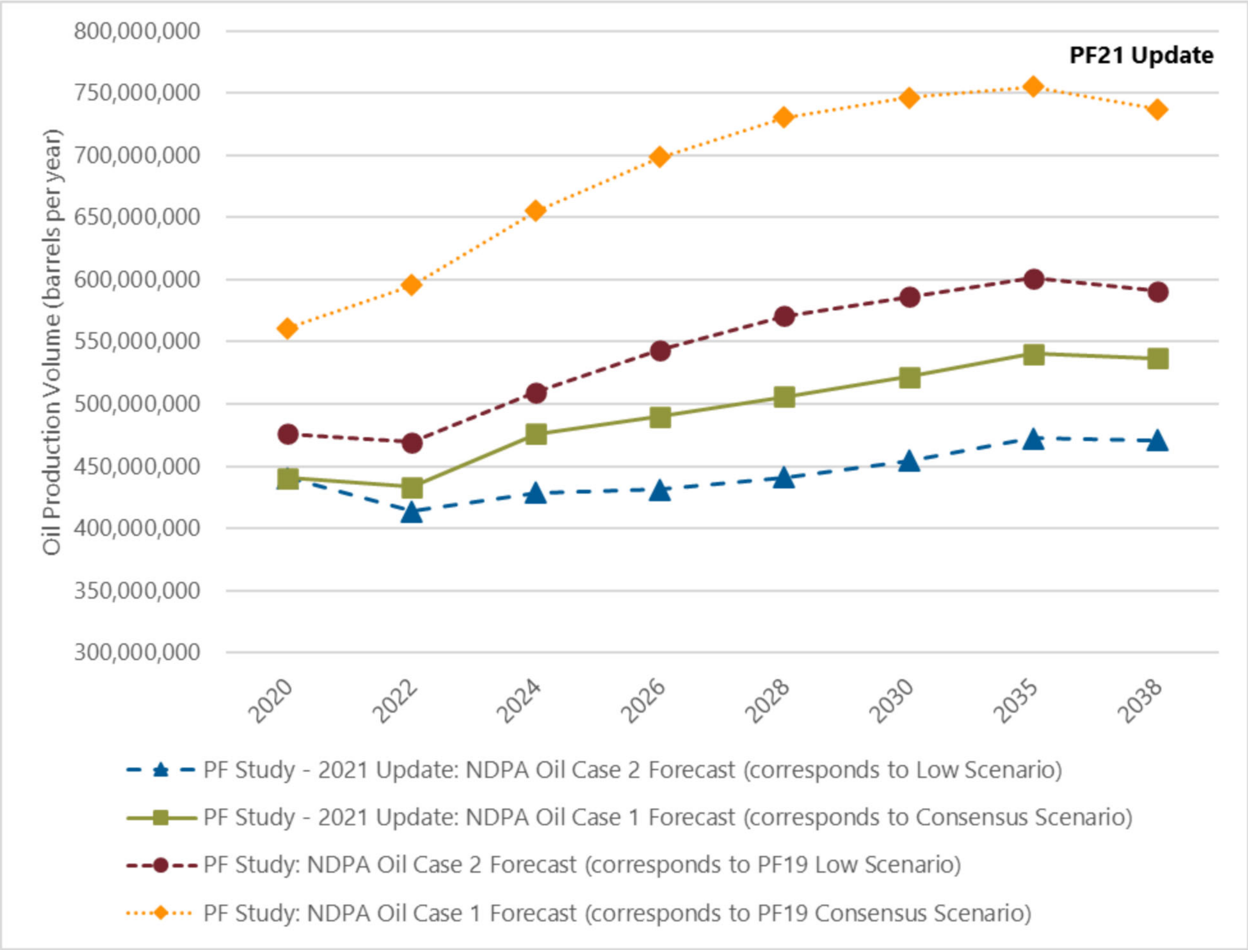

Figure 2-3 NDPA Forecast PF Study vs. PF Study - 2021 Update: Oil Production Volumes

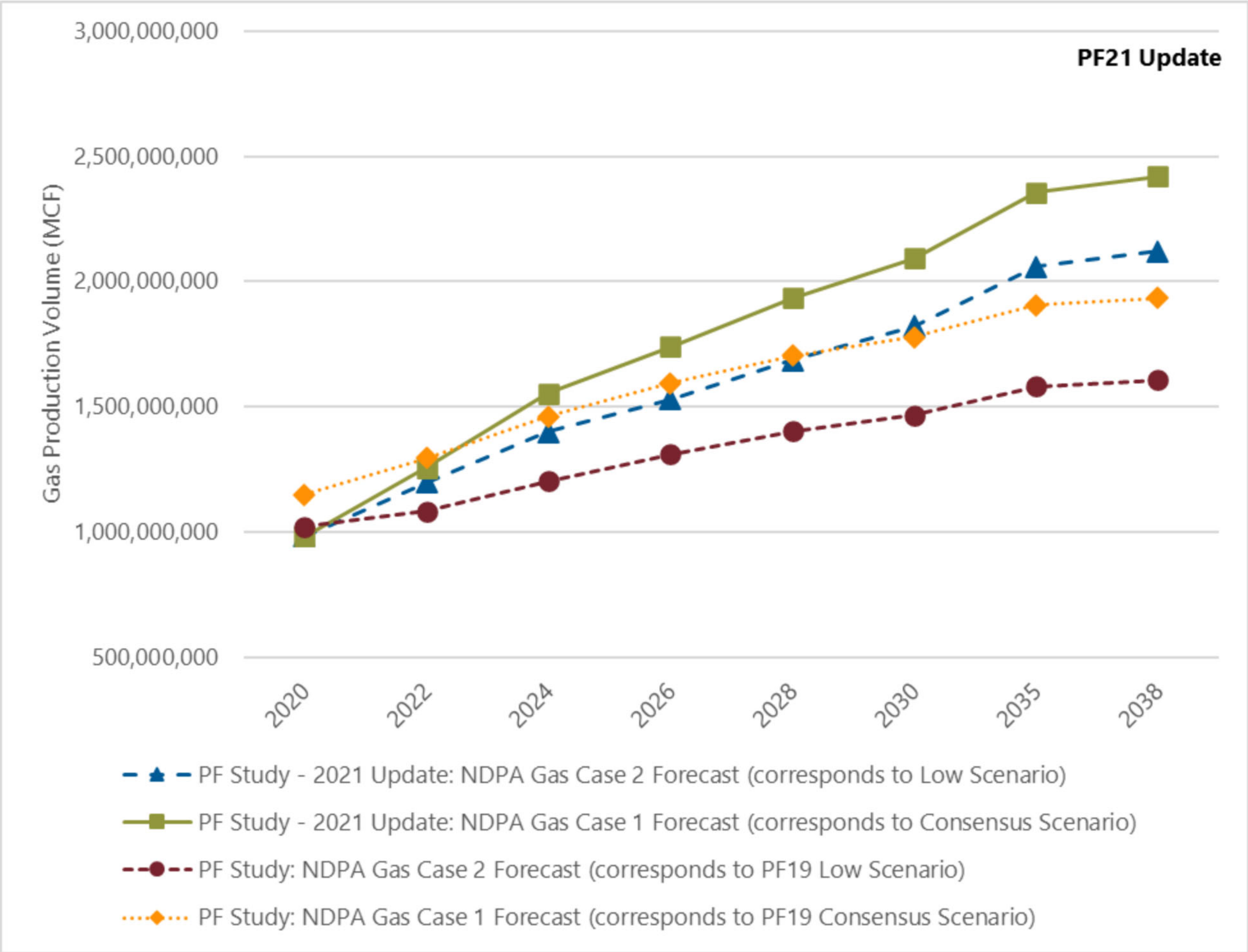

Figure 2-4 NDPA Forecast PF Study vs. PF Study - 2021 Update: Gas Production Volumes

2.2 Baseline Data

Barr relied on 2020 Sales to Ultimate Customer data provided in Form EIA-861 from the U.S. Energy Information Administration (EIA) to compile the baseline electrical consumption data in kWh by co-op region (reference (3)). This differed from the PF Study because Basin Electric Power Cooperative (BEPC) and Montana-Dakota Utilities provided the prior study's baseline information directly to Barr. Additionally, Barr included approximately 1,100-gigawatt-hours (GWh) of load associated with Dakota Gasification Company (DGC) in the PF Study - 2021 Update, which was not included in the PF Study. DGC was not included in the PF Study because it was and is not a wholesale basis sale. It is powered by the Antelope Valley energy complex internal to Basin Electric. DGC is being included in the PF Study - 2021 Update because the facility is in the process of being sold and would no longer be internal to BEPC upon completion of a sale.

Barr incorporated total MWh sales as provided by EIA for the following electrical cooperatives, which are located entirely within our study area: Burke-Divide, McKenzie, McLean, Mountrail-Williams, North Central, Roughrider, Slope, and Verendrye. In addition, data for the North Dakota portion of Lower Yellowstone Cooperative was obtained directly from the EIA data. Barr manipulated the EIA data in the following ways to accommodate the spatial distribution of the baseline data within the study area:

- Supplemented data from annual reports to include individual cooperative annual reports (reference (3)) to determine the total baseline for the Goldenwest and Sheridan electrical cooperatives

- Adjusted the baseline electrical consumption data for the Goldenwest and Sheridan electrical cooperatives and MDU as a function of the total cooperative area percentage of land within the study area

The PF Study - 2021 Update's baseline energy consumption for 2020 was approximately 11,217 GWh (including DGC, as noted above, which accounts for approximately 1,104 GWh), distributed as shown in Figure 2-5. Excluding DGC's load from that number for comparison to the PF Study, total energy consumption in 2020 was approximately 89% of the forecasted 2020 low scenario total and approximately 83% of the forecasted 2020 consensus scenario total in the PF Study. For comparison, because of the COVID-19 related demand decreases, the actual 2020 oil production was approximately 93% of the low scenario, and approximately 78% of the consensus oil production scenario assumed in the PF Study.

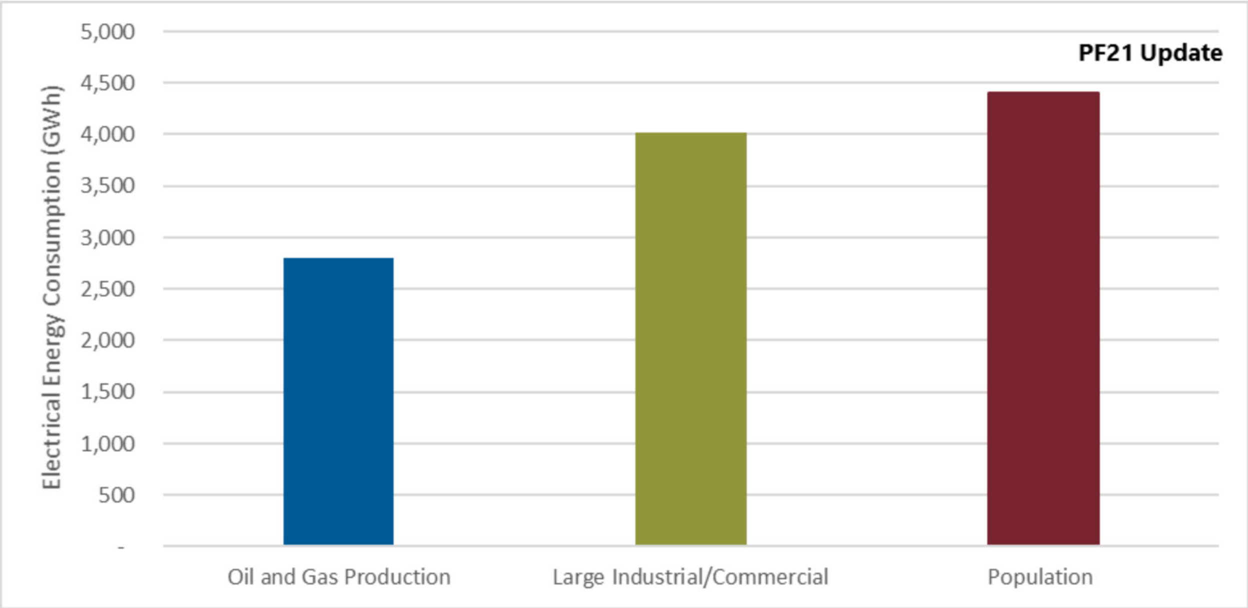

Figure 2-5 Baseline (2020) Electrical Energy Consumption Distribution by Broad Load Category

2.3 Spatial Distribution of Baseline and Forecast Data

Methods for spatially distributing baseline and forecast data did not differ from the PF Study with the one exception. Barr removed the oil transmission pipeline pump station loads, which were calculated as a total and distributed evenly across the pipeline corridor. These loads were removed because the total electrical load associated with the pump stations was deemed insignificant.

2.4 Oil and Gas Forecast Methods

Barr used the same approach and methods defined in the PF Study to forecast electrical consumption for the oil and gas production broad category with two exceptions; generally, the energy required to pump products to the ground surface, process the oil and gas, and dispose of the waste products were estimated. Future electrical energy consumption growth was estimated for the PF Study - 2021 Update as a function of projected oil and gas production volumes forecasted by the North Dakota Pipeline Authority (NDPA) in the same way as the PF Study.

The PF Study – 2021 Update methods differed from the PF Study as follows:

- Increased step-change gas capture to 92% and ramp to 99% over five years to reflect the effect of 2020 compared to the mandated capture rate
- Estimated initial well pressure from the depth of formation compared to using a static initial well pressure of 5,500 psig

2.5 Large Industrial/Commercial Forecast Methods

The PF Study's large industrial/commercial load category included gas processing plants, oil refineries, and oil transmission pipeline pumps. Barr repeated the forecasting methods described in Section 2.5.1 and forecasted additional potential point sources as described in Section 2.5.2. The large industrial point loads are subdivided into two groups to capture these two methods:

- Large Industrial/Commercial Forecast Methods Reflecting Estimated Oil and Gas Production
- Large Industrial/Commercial – Point Sources Identified as part of PF Study - 2021 Update

2.5.1 Large Industrial/Commercial Forecast Methods Reflecting Estimated Oil and Gas Production

As noted in Section 2.3, the PF Study - 2021 Update does not include the oil transmission pipeline pumps as a separate calculated load in this category. Generally, this category largely comprised the forecasted large industrial/commercial gas processing plant consumption as a function of the projected gas production and processing. The PF Study notes the study area's natural gas processing plants' capacity as a current and ongoing bottleneck. Because the typical gas-to-oil ratio reflected in NDPA's 2021 total forecasted gas production (Figure 2-3 and Figure 2-4) is greater than the ratio assumed in the PF Study, the ongoing bottleneck is still anticipated, but the needs may be more significant. Additionally, the geographic locations of the required new gas processing plants are expected to be different from what was projected in the previous PF Study.

Future large industrial/commercial uses related to oil and gas production and processing, and included with the estimated forecasted total electrical energy consumption for this load category, included:

- The Davis Refinery project near Belfield, North Dakota, with a capacity of 49,000 barrels (bbl)/day, was included in the PF Study but has been delayed; the PF Study - 2021 Update assumes a 2024 start date. The same total electrical energy consumption of 66,150 MWh reflected in the PF Study is used in the PF Study - 2021 Update.

- New gas processing plants representing a total *additional* capacity of 1,900 million cubic feet/day were assumed with the anticipated use of approximately 260 megawatts (MW) of power at full capacity.
- A natural gas liquids (NGL) fractionation plant was added to supply existing propane demand and to supply anticipated ethane demand for petrochemical projects. This point source was added given the higher projections of natural gas production (refer to Figure 2-2). Barr assumed a total of 70,000 MWh in McKenzie County for the hypothetical fractionation plant.

Adding the NGL fractionation plant when calculating total gas processing needs and electrical energy consumption required for processing was the only change in Barr's methods between the two studies.

2.5.2 Large Industrial/Commercial – Point Sources Identified as part of PF Study - 2021 Update

In the PF Study, other large industrial/commercial consumers such as arc furnaces, a recycling operation, and coal gasification facilities were omitted because their growth rate is not directly correlated to oil and gas production volumes, which was the sole focus of the previous study. For the PF Study – 2021 Update, Barr modified this approach and included additional point sources that are anticipated to have a significant potential impact on the overall electrical load in the study area. Some of these new projects will use commodities from the oil and gas production as feedstock; the feedstock volumes used are comparatively small, and the projects are unlikely to be influenced by, nor have any influence on, the volumes of oil and gas produced. Other new point loads are completely unrelated to oil and gas and are anticipated to be driven by other market factors (refer to Section 3).

The estimated forecasts for carbon capture (loads associated with collection and purification of CO_2 from the source or gas stream and delivering it to the fenceline), carbon sequestration (loads associated with transporting CO_2 from the fenceline to the disposal site and disposing it into a suitable, deep formation), carbon dioxide pipeline compressor stations, data centers, greenhouses, and petrochemical facilities projects are included in the PF Study – 2021 update. Based on conversations with industry experts, public news releases, professional knowledge, and analysis of market conditions, Barr compiled a list of potential new point sources with large electrical consumption and placed them into three sub-categories with guesstimates of the start dates for the purpose of distributing the loads over time and throughout the study period. The sub-categories are:

A. Projects summarized in Table 2-1 are included in the overall study results provided in Figure 4-1; these are projects that are either under construction or nearing commercialization (some have received financial support such as funding from the state of North Dakota),

B. Projects that have near-term commercial promise and use proven technology by established suppliers (summarized in Table 2-2)

C. Projects that have mid- to long-term promise but still require some development (summarized in Table 2-3).

Some point sources are shown in both the B and C sub-categories. The repeated point sources are generic industries that may include multiple facilities. Barr estimated a maximum demand for the C sub-category and a more modest demand in the B sub-category. Additional notes explaining these ranges are provided in Table 2-2 and Table 2-3. These maximum and more modest demand estimates provide the basis for the range provided in Section 4.2.1.

Table 2-1 Sub-category A Large Industrial/Commercial Point Sources

Point source description	Estimated initial year of operation	Estimated initial energy demand [1]
Carbon sequestration – Blue Flint Ethanol facility[2][3]	2023	30 MW
Carbon capture and sequestration – Coal Creek Station carbon capture [3]	2025 – 1st unit 2028 – 2nd unit	350 MW
Carbon capture and sequestration – Project Tundra[2]	2024	175 MW
Carbon sequestration - Dakota Gasification[2]	2022	500 kW
Carbon sequestration - Red Trail Energy carbon capture[2]	2022	3.3 MW
Carbon sequestration - Summit Carbon Solutions[2]	2024	300 kW
Gas Pipeline Compressor Stations - Bakken to Grand Forks gas pipeline (assumes 2 locations)	2024	5.8 MW
Data center – data center one under construction near Williston[2]	2022	250 MW
Data center – data center two planned near Coal Creek	2023	50 MW
Greenhouse - MHA greenhouse near Parshall[2]	2022	30 MW
Petrochemicals - Belfield Refinery[2]	2022	65 MW
Petrochemicals - Cerilon Gas to liquids facility near Trenton[3]	2023	85 MW
Petrochemicals - Wellspring Hydro facility near Trenton[3]	2024	35 MW
Hydrogen Hub – conversion of DGC[3]	2024	negligible
Valence Natural Gas Solutions[3]	2022	negligible

[1] Values are based on publicly available information, various methods depending on the process, and best professional judgment. Values included are for power demand; annual energy consumption will vary based on capacity factor. Refer to Table 4-5 for additional information

[2] Currently in development

[3] awarded funding from CSEA

Table 2-2 Sub-category B Large Industrial/Commercial Point Sources

Point source / generic industry	Point Sources / Generic industry or process Description	Initial Year	Initial Load (MWh)	Load in 2040 (MWh)
Petrochemicals - Hydrocarbon gas to high-value carbon	This process involves a low-value gaseous hydrocarbon being decomposed into hydrogen and carbon. The carbon forms into graphene, graphite, and ultra-high purity carbon black, all of which are the highest value forms. Market drivers for this process include the low cost of electricity and gas and the high demand for ultra-pure forms of carbon.	2022	15,000	120,000
Petrochemicals - Natural gas to chemicals	This process and potential electrical energy use are summarized in the IHS presentation of 2014 given by Bari and Glatzer to North Dakota (reference (4)).	2025	131,000	131,000
Petrochemicals – Plastics, all types	This line item considers plastics manufacturing (an area of interest in North Dakota for the past decade) as an industry and not any specific project. While each potential project itself is potentially not likely, the possibility that at least one of them will succeed is high. Barr anticipates that additional projects will follow after the first project proves its financial viability. Energy consumption values are based on a presentation by Korom and Kopecky at the 2019 North Dakota Planning Association annual meeting (reference (5)). Barr assumed 20% of the maximum value reported for the mid-probability estimate. However, since the loads were calculated for the 2019 North Dakota Planning Association annual meeting, NDPA has revised upward by a factor of about two times the mass rate of ethane production. This implies that maximum electric energy consumption for plastics could potentially be twice as high as the values released by Korom and Kopecky in 2019.	2026	915,000	4,000,000
Carbon capture and sequestration – Leland Olds	If Project Tundra proves profitable, carbon capture and sequestration may also be applied elsewhere. This facility is assumed as one that may be retrofitted with carbon capture and sequestration. However, it is also possible that a new generation will be constructed (e.g., a new gas-fueled combined cycle plant) with sufficient capacity to both replace Leland Olds and serve new potential new loads. Consequently, the probability that Leland Olds will be retrofitted is modest.	2026	411,000	411,000
Carbon Dioxide Pipeline Compressor Stations - out of state CO_2 for disposal	This line item includes potential loads from compressor stations for future carbon dioxide pipeline projects (excepting Summit Carbon Solutions, which is accounted for in Sub-category A.)	2032	36,800	45,300
Data center – adjacent to Coal Creek	A data center near Coal Creek is included in Sub-category A; however, the size of the potential load is uncertain. The total load assumed ranges from 50 MW up to 350 MW.	2023	876,600	876,600

Point source / generic industry	Point Sources / Generic industry or process Description	Initial Year	Initial Load (MWh)	Load in 2040 (MWh)
Data centers generally	Other data centers not yet identified in other locations are likely. We estimate a 50% probability that total demand could be 400 MW by 2040.	2024	2,628,000	2,628,000
Greenhouses generally	Following the greenhouse under construction on Fort Berthold Reservation and the greenhouse planned for Spiritwood (outside of our study area), other greenhouses are likely. We estimate a 50% probability that additional demand attributable to greenhouses could be 15 MW by 2040.	2025	30,000	30,000

Table 2-3 Sub-category C Large Industrial/Commercial Point Sources

Assumed point source / generic industry	Description	Initial year	Initial load (MWh)	Load in 2040 (MWh)
Petrochemicals - Natural gas to chemicals	This process and potential electrical energy use are summarized in the IHS presentation of 2014 given by Bari and Glatzer to North Dakota (reference (4)).	2024	131,000	2,431,000
Petrochemicals – Plastics, all types	This line item considers plastics manufacturing (an area of interest in North Dakota for the past decade) as an industry and not any specific project. While each potential project itself is not likely, the possibility that at least one of them will succeed is more than 90%. Barr anticipates that additional projects will follow after the first project proves its financial viability. Energy consumption values are based on a presentation by Korom and Kopecky at the 2019 North Dakota Planning Association annual meeting (reference (5)). For the low-probability estimate, Barr assumed 50% of the maximum value reported. However, since the loads were calculated for the 2019 North Dakota Planning Association annual meeting, NDPA has revised upward by a factor of about two times the mass rate of ethane production. This implies that maximum electric energy consumption for plastics could potentially be twice as high as the values released by Korom and Kopecky in 2019.	2026	704,000	16,000,000
Petrochemicals – ethane cracker	This process would involve an ethane cracker that would take advantage of the plentiful supply of ethane from the Bakken. However, this entails a $5 billion investment by a petrochemical supermajor, which we consider a low probability, even though it is possible. Also, the Clean Sustainable Energy Authority will be promoting new, cleaner projects that would be in direct competition with the traditional ethane cracking process.	2030	876,600	876,600
Carbon capture and sequestration – AVS or Coyote	If Project Tundra proves profitable, carbon capture and sequestration may also be applied elsewhere. Antelope Valley Station (AVS) or Coyote Station are additional examples of where it may occur.	2026	894,000	894,000
Carbon Dioxide Pipeline Compressor Stations - out of state CO2 for disposal	This line item includes all CO_2 pipeline projects except Summit Carbon Solutions. The Department of Mineral Resources has stated that dozens of potential projects have expressed interest, so we estimate there is a possibility for total compressor / pump station load to be as high as 10 MW in the study area.	2026	7300	87,600
Data centers generally	Other data centers not yet identified in other locations are likely. We estimate that total demand could be as high as 1000 MW by 2040.	2024	2628000	8,766,000
Greenhouses generally	If greenhouses prove economically attractive, we estimate additional loads could be as high as 20 MW.	2027	30,000	180,000

2.6 Population Forecast Methods

The population broad category was determined in the PF Study by taking the overall baseline electrical consumption data and subtracting the total baseline numbers from the other two categories. The forecasted electrical energy consumption totals for the population load category were determined for the PF Study based on the growth rates provided in the "Williston Basin 2016: Employment, Population, and Housing Forecasts" study completed by North Dakota State University (NDSU; reference (6)). Labor resources constrain North Dakota development, and in fall 2021, they were ranked third in the nation for the number of job opportunities per 100,000 people (reference (7)). Worker shortages contributed to flat oil production in summer 2021 (reference (8)).

NDSU has not updated the population forecast study but anticipates updating it in 2022. Given that updated forecast information is not available at the time of the PF Study - 2021 Update, the population forecast was not modified. The same electrical load forecasted in the PF Study was assumed for the PF Study - 2021 Update. For comparison purposes, Table 2-4 summarizes previously forecasted population totals versus 2020 Census totals (reference (9)). The data presented requires the following information to interpret the numbers:

- As noted in PF Study, NDSU included both permanent populations and temporary workforces in the population forecasts. The 2020 Census totals reflect only permanent populations, accounting for at least a portion of the lower 2020 population totals reflected in Table 2-4.
- As a generality and based on discussions with NDSU, Barr understands service populations typically account for an additional 7 to 10 percent of a county's total population. The actual population in the study area in 2020 is approximately 9 percent lower than the previously projected 2020 population forecast.

Table 2-4 Previously Forecasted Population Totals Versus 2020 Census Actuals

County	2020 Estimated Population Total in PF Study[1]	Total Population in 2020 per U.S. Census Data[2]
Adams	2,600	2,200
Billings	1,000	900
Bottineau	7,000	6,400
Bowman	3,500	3,000
Burke	2,400	2,200
Divide	2,600	2,200
Dunn	5,000	4,100
Golden Valley	2,100	1,700
Hettinger	2,900	2,500
McHenry	6,600	5,300
McKenzie	14,200	14,700
McLean	11,000	9,800
Mercer	9,900	8,400
Mountrail	11,400	9,800
Oliver	1,900	1,900
Pierce	800	1,400
Renville	2,600	2,300
Rolette	10,900	8,000
Sheridan	600	800
Slope	800	700
Stark	36,100	33,600
Ward	75,300	69,900
Wells	2,200	900
Williams	40,400	41,000
Grand Total	253,800	233,700

[1] Includes service population totals reflected in NDSU's Low Scenario, Mid numbers.
[2] Totals included in 2020 Census data do not include service population.

3 Key Considerations and Drivers

The PF Study provided contextual background information and noted that various factors may have opposing effects on the ultimate growth, making quantifying their net result difficult or impossible. Most or all the potential new point sources described in this report are or would be the result of one or more market drivers, primarily including the following:

- The North Dakota's Clean Sustainable Energy Authority (CSEA), established by the legislature in 2021, is charged with facilitating the rapid development of new energy-related projects to enhance clean, sustainable energy production. The CESA was appropriated $25 million for grants in the 2021 – 2023 biennium (reference (10)).
- The legislature mandated that the Legacy Fund (currently $8.6 billion) invest 20% of its assets into projects in North Dakota (reference (11)).
- Market forces, federal tax incentives, and North Dakota's proactive attitude toward carbon capture are anticipated to result in major new investments in the state for carbon sequestration.
- Additionally, winter 2020/2021 demonstrated that Texas may be unreliable for energy and petrochemicals projects. This could encourage petrochemical project development outside the US Gulf Coast and potentially in North Dakota.

3.1 45Q Tax Credits

A considerable portion of the new load is predicted to come from carbon capture and sequestration. These projects are driven by the tax credits authorized under Section 45Q of US Code, Title 26. Because Congress can change this at any time, its future is difficult to predict. However, because public attitudes and market drivers are providing pressure to reduce carbon emissions, it is more likely than not that the credits will remain for the next 20 years. Barr assumed tax credits would remain at current values for the study period duration.

The significant disparity in pricing between sequestering CO_2 and using it for enhanced oil recovery (EOR) implies that the vast majority of CO_2 volume will be sequestered. Using CO_2 for EOR is not predicted to outweigh the pricing differential, so there is no benefit to oil producers. Therefore, we assume using CO_2 for EOR will be relatively small in the next 20 years. This is discussed further in Section 3.3.

3.2 Gas re-injection

A common practice in some oil plays to reduce flaring and increase oil production is to reinject the gas produced back into the reservoir. This has not yet been widely adopted in North Dakota but probably will be used more in the coming years. Gas reinjection will increase the energy required for producing the oil, but this additional energy will likely come from gas-fueled compressors. The study assumes that the overall impact on electric energy consumption from gas re-injection will be minimal, and therefore modifications to Barr's methods were not made.

3.3 CO2 for EOR

EOR may be applied to wells that are about 20 years old and have reached a low level of production depending on the price of oil, cost of CO_2 and electricity, and relative internal rate of return for drilling a new well versus adding EOR. In the near term, the Cedar Creek Anticline is likely to begin using CO_2

supplied by pipeline from Wyoming for EOR. Much of the CO_2 supplied by this pipeline will be used in wells on the Montana side of the border; very little is expected to be used in North Dakota, and therefore we have ignored its impact for purposes of this study.

To quantify the upper bound of CO_2 volumes for EOR, we tabulated the age of wells by each year through the study period. Presently, there are very few 20-plus-year-old wells, but this number rapidly increases six years from now (Table 3-1).

Table 3-1 Summary of Ages of Oil and Gas Wells in Study Area

Well Age	Number of Oil and Gas Wells[1]
All wells	17,469
5 years or older	14,878
8 years or older	12,026
11 years or older	5,481
14 years or older	2,637
17 years or older	1,697
20 years or older	1,497

[1] Active, Inactive and Drilled Wells, September 2021 Data

3.4 Hydrogen Hub

There is currently much discussion regarding developing a hydrogen or ammonia production hub centered in western North Dakota. Depending on the configuration and extent of production, there could be a minimal to very large impact on electrical energy consumption. Of all the potential new projects, those surrounding a hydrogen hub have significant lead times and uncertainty. Therefore, we have not included electrical load from the formation of a hydrogen hub in this study.

3.5 Global Supply Chains

The COVID-19 pandemic caused significant disruptions in the global supply chains and demonstrated the advantage of having domestic sources for manufacturing inputs. North Dakota has the feedstocks to supply 30% of the worldwide demand for PVC plastic, but at present does not produce it. Meanwhile, China produces nearly 50% of the global PVC supply. Consequently, PVC pricing has skyrocketed in the last two years, and supplies have been unreliable.

Much of the world's supply of industrial chemicals are produced in the U.S. Gulf Coast. Between the energy policies of ERCOT impacting reliability, hurricanes, and aging facilities, the reserves of these commodities have become unreliable. North Dakota has sufficient feedstocks and attractive pricing to profitably and reliably replace much of the U.S. Gulf Coast chemicals production.

While these opportunities can potentially have significant electrical load impacts, there is a high degree of uncertainty, and these types of projects were not included in this study.

4 Results

The PF Study – 2021 Update's estimated total amount of additional electrical energy consumption required to support the anticipated load growth of all three broad load categories is approximately 27,400 GWh (or 244% of the base load) for the low scenario and approximately 29,600 GWh (or 264% of the base load) for the consensus scenario. The total estimated energy in GWh for the low scenario and the consensus scenario is illustrated in Figure 4-1. As noted in Section 4.2, by the end of the study period, the Large Industrial/Commercial Point Sources Identified as part of PF Study - 2021 Update makes up approximately 34-37% of the total anticipated electrical energy consumption total in the year 2040.

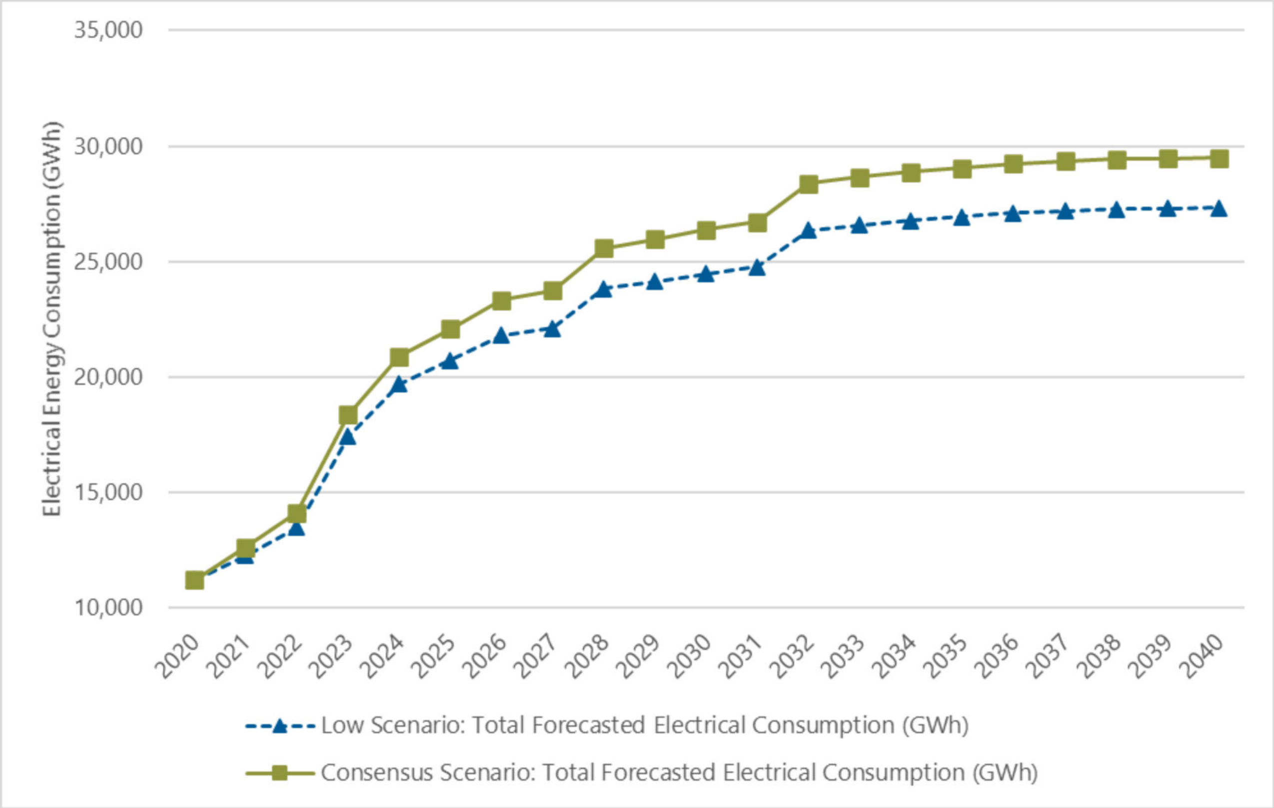

Figure 4-1 Study Area Forecasted Electrical Energy Consumption – 2021 Update

For purposes of comparison, the total forecasted electrical energy consumption estimated in the PF Study – 2021 Update compared to the PF study is illustrated in Figure 4-2.

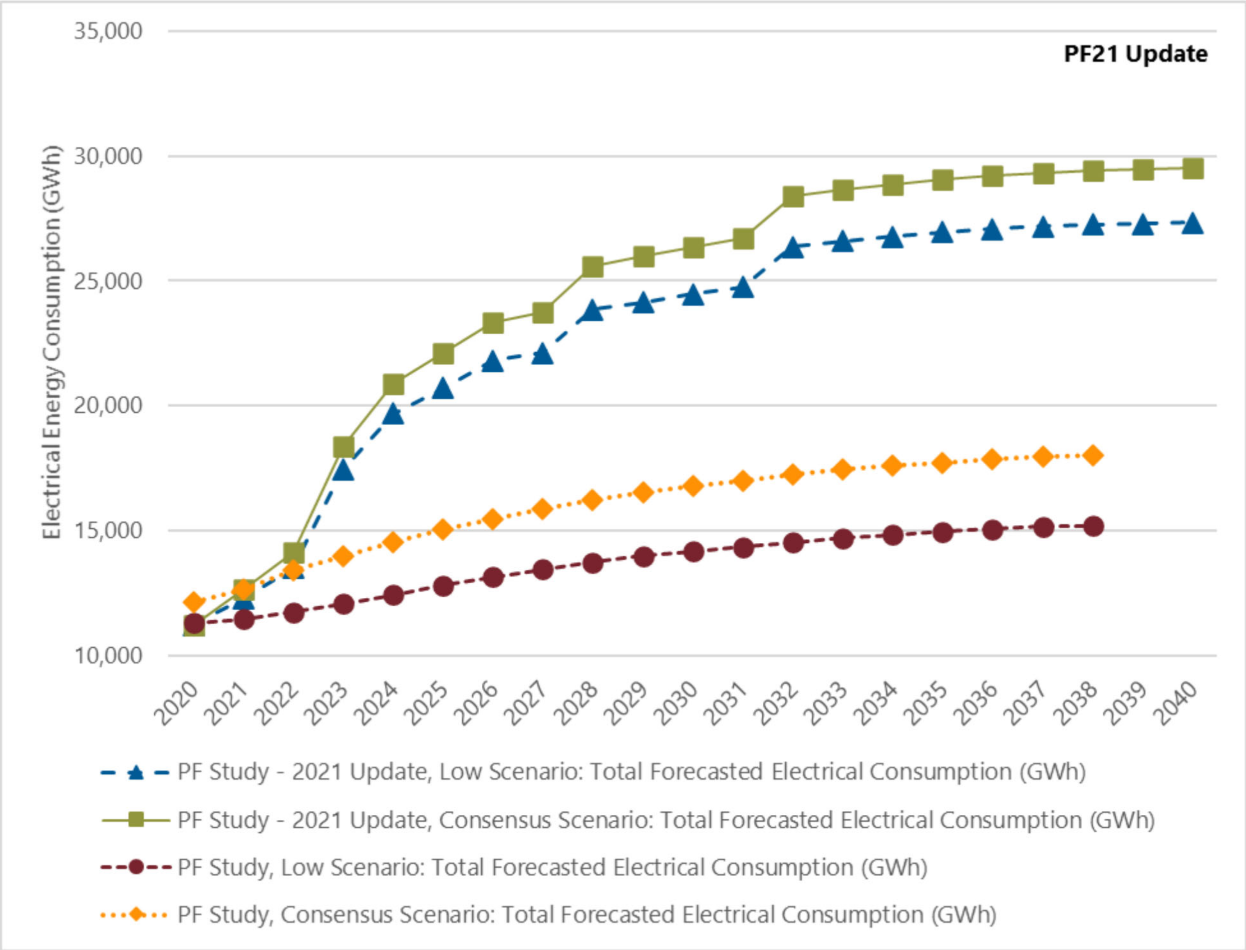

Figure 4-2 Comparison of 2021 forecasted energy consumption vs PF19 study

A breakdown of these totals by broad load category is illustrated in Figure 4-3 for the low scenario and Figure 4-4 for the consensus scenario.

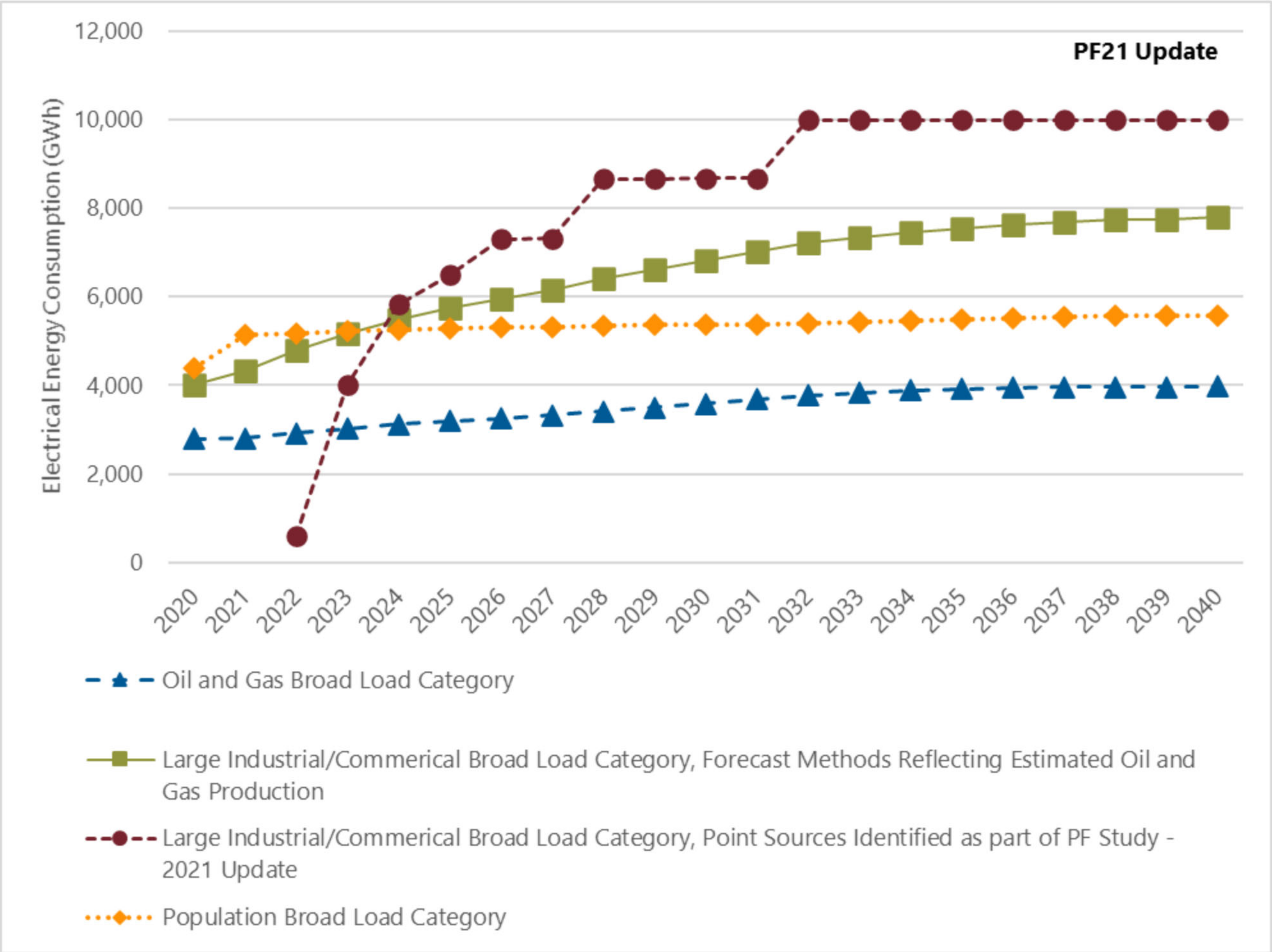

Figure 4-3 PF Study - 2021 Update by Broad Load Category, Low Scenario

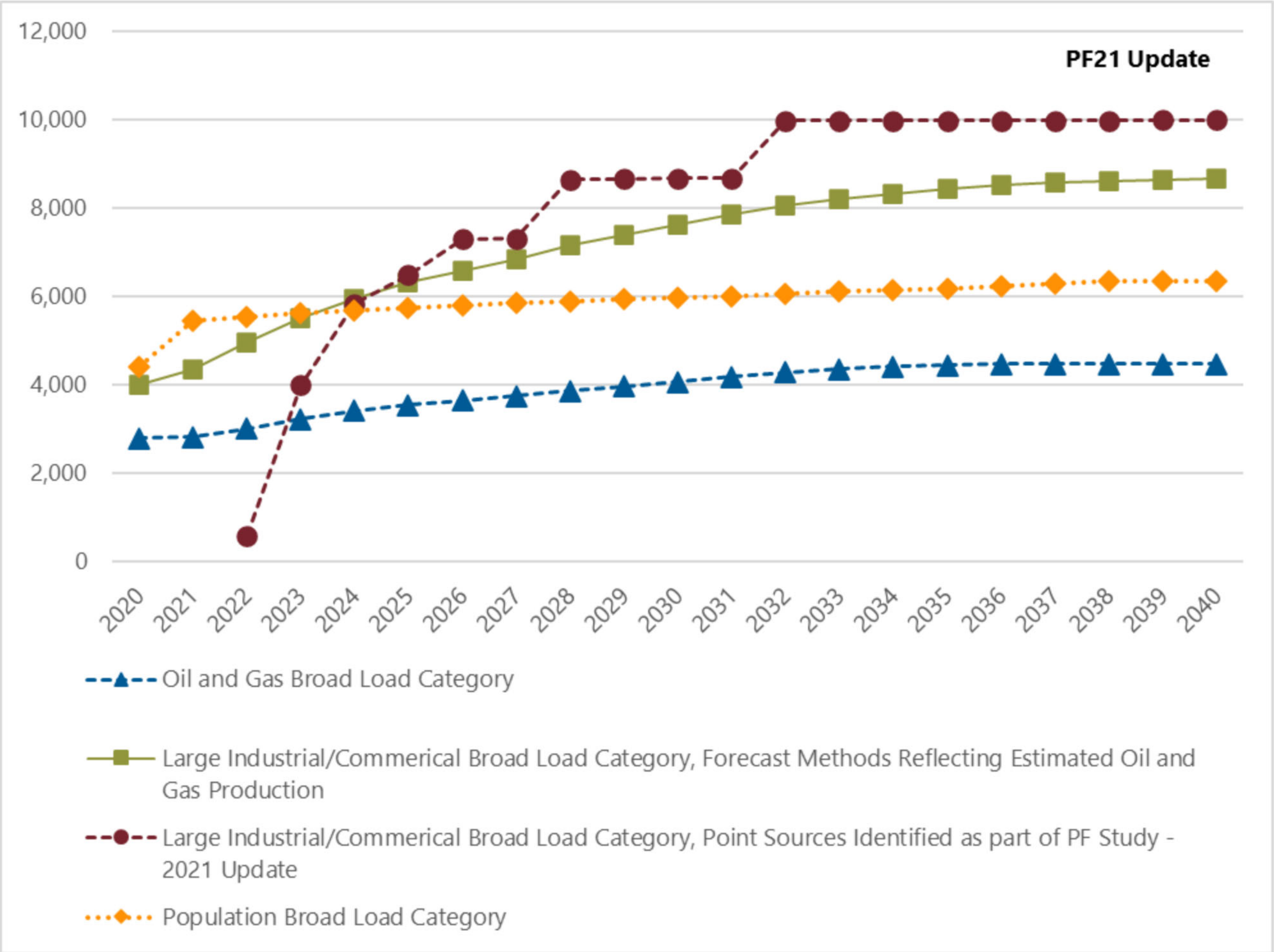

Figure 4-4 PF Study - 2021 Update by Broad Load Category, Consensus Scenario

At the end of the study period (2040), the low scenario forecasts a total need of 27,400 GWh, and the consensus forecasts a total need of 29,600 GWh of electrical energy consumption. Compared to the baseline, this represents an increase of 16,200 GWh for the low scenario and 18,400 GWh for the consensus scenario. This represents an increase in generation capacity of 2,250 MW to 2,560 MW (calculated using a 92% load factor and an 86% capacity factor) above the capacity demand.

Much of the growth is in load categories that have nearly flat demand curves (e.g., oil and gas production and large industrial/commercial sources related to oil and gas production) and do not readily lend themselves to interruptible power supply.

The state's current base load generating capacity is assumed to be the same as the PF19 Study or 4,380 MW (reference (1)). The North Dakota base load resources are operating well above industry averages, but their capacity ratings will decrease about 30% as they install carbon capture systems. New base load or equivalent will likely be selected by utilities that need to meet this increased demand.

There are several options, but the options are limited by demand for lower carbon intense resources and a push to use renewable alternatives. Developers have a strong interest in building more wind generation in North Dakota. In the mid-2021 annual report from the North Dakota Transmission Authority, there were projects totaling 5,045MW of wind generation capacity in the Southwest Power Pool (SPP) queue for western North Dakota that were seeking approval to connect to the grid. These projects will likely be part of the solution for new generation; however, wind projects in North Dakota have about a 50% capacity factor, and the variability of the generation is in sync thru most of the area. Dependence on wind resources will require that other generation is available for periods when there is a lack of wind.

Solar generation complements wind generation. Currently, there are no utility-scale solar installations in North Dakota, and it faces some hurdles from North Dakota weather. The year-round average capacity factor is about 15%, and the winter capacity factor drops to 1-2% in January. Thus, backup generation is also required for solar generation.

North Dakota has abundant natural gas, so a new base load capacity could also be supplied by adding a 2x1 combined cycle plant (based on the GE 7F.05 rated 756 MW), with an annual capacity factor of between 61% (low scenario) to 86% (consensus scenario). An alternative mid-load capacity solution with fast dispatch rates would allow for maximum use of base-loaded, lignite-fueled generation and intermittent wind power.

Other typical power plants with fast dispatch rates to match intermittent generation are the GE LMS-100 and the Wartsila 20V34SG natural gas-fueled engines. Multiple installations of these engines would be required but could be distributed throughout the system. Other manufacturers also offer competitive models.

With a low carbon focus, we need to acknowledge that natural gas-fueled plants emit CO_2, but commercial technologies are being developed to remove CO_2 in these plants.

Another option that adds diversity is long-distance transmission. DC transmission projects to the east and west have been proposed by companies that seem likely to make some additions happen. DC transmission options provide efficient, reliable, and easily controllable additions. Such additions would make it more feasible for renewable options to serve the growth in North Dakota, in distant parts of the country, and along with that be a source of import when North Dakota renewable generation is not operating.

In summary, the power forecast presents challenges for meeting the electrical needs of the industries located in North Dakota. These industries, along with their power suppliers, will need to plan well ahead to assure that those needs are met.

The following subsections provide additional details for the totals by broad load category and include tables with the same reported years as the PF Study for comparison purposes.

4.1 Oil and Gas Production

The forecasted oil and gas production load category's total electrical energy consumption is shown in Figure 4-5.

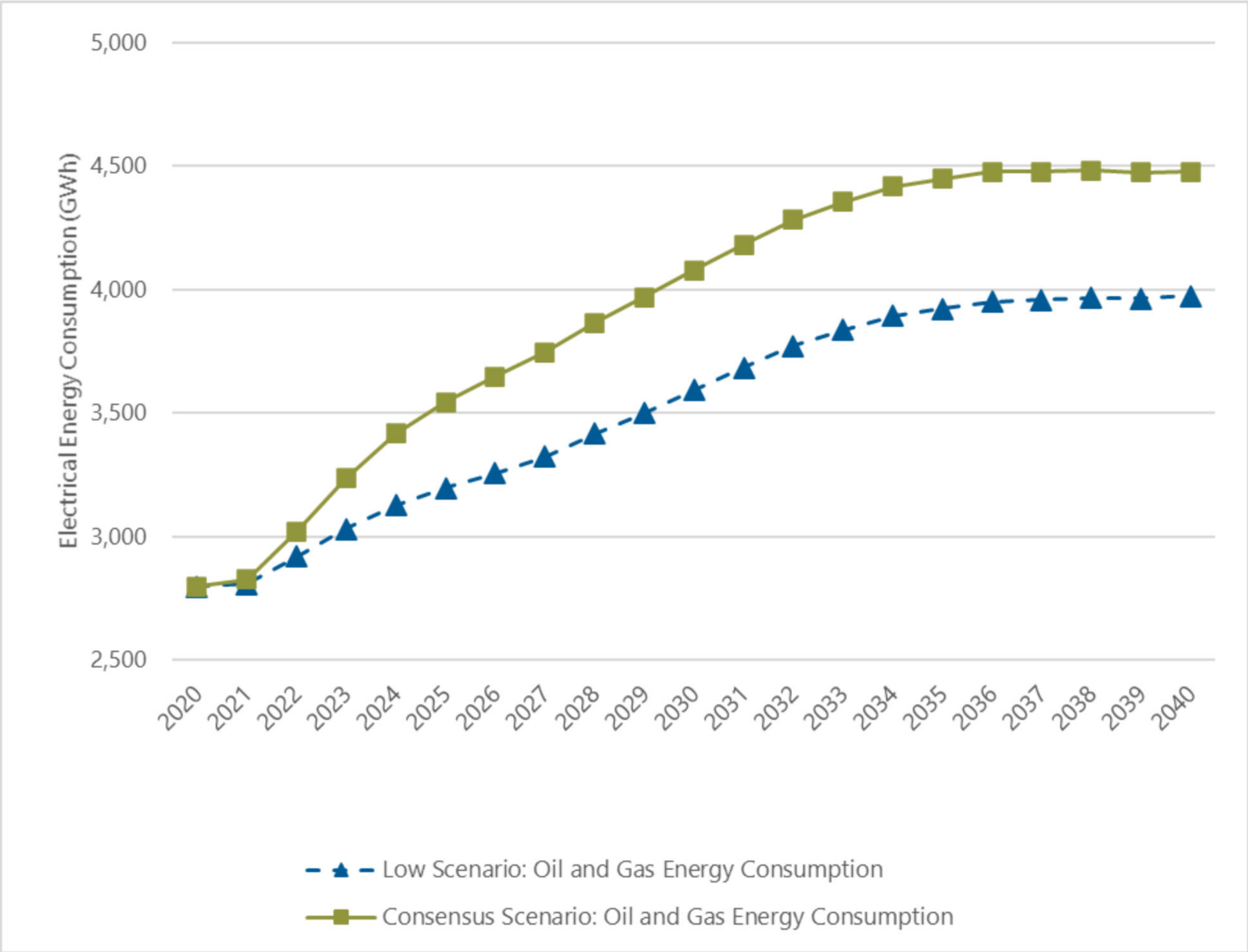

Figure 4-5 Oil and Gas Production Forecasted Electrical Energy Consumption – 2021 Update

The forecasted oil and gas production load category's total electrical energy consumption by county for the low scenario is provided in Table 4-1.

The forecasted oil and gas production load category's total electrical energy consumption by county for the consensus scenario is provided in Table 4-2.

Table 4-1 Low Scenario: Relative Per-County Forecasted Electrical Energy Use Associated with Oil and Gas Production

County	2020 (MWh)	2022 (MWh)	2024 (MWh)	2026 (MWh)	2028 (MWh)	2033 (MWh)	2038 (MWh)	2040 (MWh)
Billings	70,000	71,000	73,000	75,000	77,000	82,000	84,000	84,000
Bottineau	34,000	35,000	36,000	36,000	37,000	39,000	39,000	39,000
Bowman	158,000	160,000	161,000	163,000	165,000	169,000	170,000	170,000
Burke	42,000	38,000	44,000	47,000	52,000	63,000	66,000	66,000
Divide	50,000	44,000	53,000	57,000	63,000	79,000	82,000	82,000
Dunn	423,000	446,000	483,000	508,000	537,000	608,000	635,000	639,000
Golden Valley	6,000	6,000	6,000	6,000	6,000	6,000	7,000	7,000
McHenry	1,000	1,000	1,000	1,000	1,000	2,000	2,000	2,000
McKenzie	1,065,000	1,110,000	1,180,000	1,223,000	1,276,000	1,414,000	1,456,000	1,457,000
McLean	11,000	11,000	13,000	14,000	15,000	18,000	18,000	18,000
Mountrail	404,000	429,000	467,000	489,000	517,000	590,000	613,000	614,000
Renville	15,000	15,000	15,000	16,000	16,000	17,000	17,000	17,000
Slope	13,000	13,000	14,000	14,000	14,000	14,000	14,000	14,000
Stark	30,000	30,000	31,000	31,000	32,000	33,000	34,000	34,000
Ward	300	300	300	300	300	400	400	400
Williams	475,000	508,000	551,000	576,000	608,000	704,000	732,000	731,000
Grand Total	2,797,300	2,917,300	3,128,300	3,256,300	3,416,300	3,838,400	3,969,400	3,974,400

Table 4-2 Consensus Scenario: Relative Per-County Forecasted Electrical Energy Use Associated with Oil and Gas Production

County	2020 (MWh)	2022 (MWh)	2024 (MWh)	2026 (MWh)	2028 (MWh)	2033 (MWh)	2038 (MWh)	2040 (MWh)
Billings	70,000	72,000	76,000	79,000	82,000	88,000	90,000	90,000
Bottineau	34,000	35,000	36,000	36,000	37,000	39,000	39,000	39,000
Bowman	158,000	160,000	161,000	163,000	165,000	169,000	170,000	170,000
Burke	42,000	42,000	56,000	63,000	69,000	83,000	86,000	86,000
Divide	50,000	50,000	71,000	80,000	90,000	109,000	111,000	110,000
Dunn	423,000	460,000	525,000	566,000	604,000	687,000	715,000	717,000
Golden Valley	6,000	6,000	6,000	6,000	6,000	7,000	7,000	7,000
McHenry	1,000	1,000	1,000	1,000	1,000	2,000	2,000	2,000
McKenzie	1,065,000	1,144,000	1,276,000	1,352,000	1,424,000	1,583,000	1,623,000	1,621,000
McLean	11,000	12,000	15,000	17,000	19,000	22,000	22,000	22,000
Mountrail	404,000	447,000	516,000	557,000	595,000	679,000	703,000	703,000
Renville	15,000	15,000	15,000	16,000	16,000	17,000	17,000	17,000
Slope	13,000	13,000	14,000	14,000	14,000	14,000	14,000	14,000
Stark	30,000	30,000	31,000	32,000	32,000	34,000	35,000	35,000
Ward	300	300	300	300	300	400	400	400
Williams	475,000	531,000	618,000	666,000	712,000	823,000	849,000	845,000
Grand Total	2,797,300	3,018,300	3,417,300	3,648,300	3,866,300	4,356,400	4,483,400	4,478,400

1.1 Large Industrial/Commercial Forecast Methods Reflecting Estimated Oil and Gas Production

The large industrial/commercial load forecasted energy consumption using the PF Study method reflecting estimated oil and gas production forecasts (refer to Section 2.5.1) is shown in Figure 4-6.

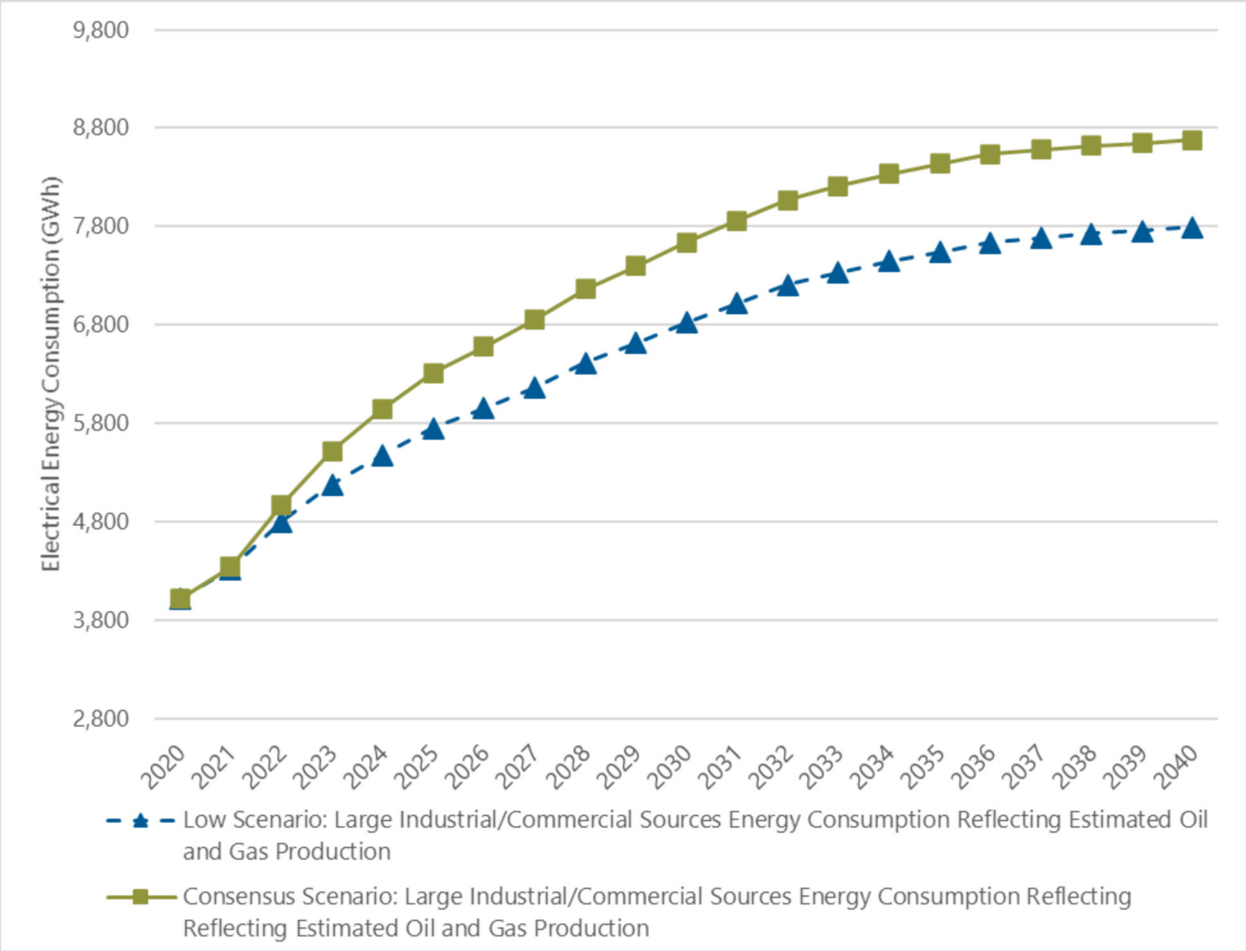

Figure 4-6 Large Industrial/Commercial Sources Forecasted Electrical Energy Consumption Reflecting Estimated Oil and Gas Production

The large industrial/commercial load forecasted energy consumption using the PF Study method and reflecting oil and gas production forecasts (refer to Section 2.5.1) for the low scenario is provided in Table 4-3.

Table 4-3 Low Scenario: Relative Per-County Forecasted Electrical Energy Use Associated with Large Industrial/Commercial Sources Reflecting Oil and Gas Forecasts

County	2020 (MWh)	2022 (MWh)	2024 (MWh)	2026 (MWh)	2028 (MWh)	2033 (MWh)	2038 (MWh)	2040 (MWh)
Billings	19,000	113,000	117,000	119,000	118,000	118,000	118,000	119,000
Bowman	29,000	34,000	40,000	43,000	41,000	41,000	42,000	42,000
Burke	4,000	5,000	132,000	372,000	610,000	1,145,000	1,234,000	1,250,000
Divide	19,000	26,000	29,000	28,000	28,000	27,000	29,000	29,000
Dunn	235,000	282,000	327,000	353,000	342,000	339,000	346,000	349,000
McKenzie	1,545,000	1,848,000	2,143,000	2,387,000	2,519,000	2,498,000	2,547,000	2,570,000
Mercer	1,104,000	1,104,000	1,104,000	1,104,000	1,228,000	1,720,000	1,858,000	1,865,000
Mountrail	188,000	252,000	290,000	281,000	278,000	262,000	282,000	286,000
Stark	106,000	111,000	116,000	118,000	117,000	117,000	118,000	118,000
Williams	771,000	1,032,000	1,187,000	1,148,000	1,137,000	1,072,000	1,157,000	1,171,000
Grand Total	4,020,000	4,807,000	5,485,000	5,953,000	6,418,000	7,339,000	7,731,000	7,799,000

The large industrial/commercial load forecasted energy consumption using the PF Study method and reflecting oil and gas production forecasts (refer to Section 2.5.1) for the consensus scenario is provided in Table 4-4.

Table 4-4 Consensus Scenario: Relative Per-County Forecasted Electrical Energy Use Associated with Large Industrial/Commercial Sources Reflecting Oil and Gas Forecasts

County	2020 (MWh)	2022 (MWh)	2024 (MWh)	2026 (MWh)	2028 (MWh)	2033 (MWh)	2038 (MWh)	2040 (MWh)
Billings	19,000	114,000	119,000	122,000	122,000	121,000	122,000	122,000
Bowman	29,000	35,000	43,000	48,000	47,000	46,000	47,000	48,000
Burke	4,000	6,000	150,000	433,000	715,000	1,336,000	1,430,000	1,444,000
Divide	19,000	27,000	33,000	33,000	33,000	31,000	33,000	34,000
Dunn	235,000	293,000	358,000	395,000	386,000	383,000	389,000	392,000
McKenzie	1,545,000	1,921,000	2,347,000	2,661,000	2,835,000	2,814,000	2,859,000	2,879,000
Mercer	1,104,000	1,104,000	1,104,000	1,104,000	1,244,000	1,800,000	1,953,000	1,959,000
Mountrail	188,000	267,000	329,000	327,000	326,000	306,000	327,000	330,000
Stark	106,000	112,000	119,000	123,000	122,000	122,000	122,000	123,000
Williams	771,000	1,095,000	1,349,000	1,337,000	1,334,000	1,252,000	1,340,000	1,353,000
Grand Total	4,020,000	4,974,000	5,951,000	6,583,000	7,164,000	8,211,000	8,622,000	8,684,000

4.2 Large Industrial/Commercial – Point Sources Identified as part of PF Study - 2021 Update

The large industrial/commercial load forecasted energy consumption for point sources identified as part of PF Study – 2021 Update (refer to Section 2.5.2) is shown in Figure 4-7. As noted in Section 2.5.2, these point sources are either under construction or have received significant financial support from the state of North Dakota as summarized in Table 2-1. Barr forecasted one energy consumption load for large industrial/commercial load forecasted energy consumption for point sources identified as part of PF Study – 2021 Update and did not distinguish between a low and consensus scenario. Therefore, the totals included in Table 2-1 are reflected in the study's overall results.

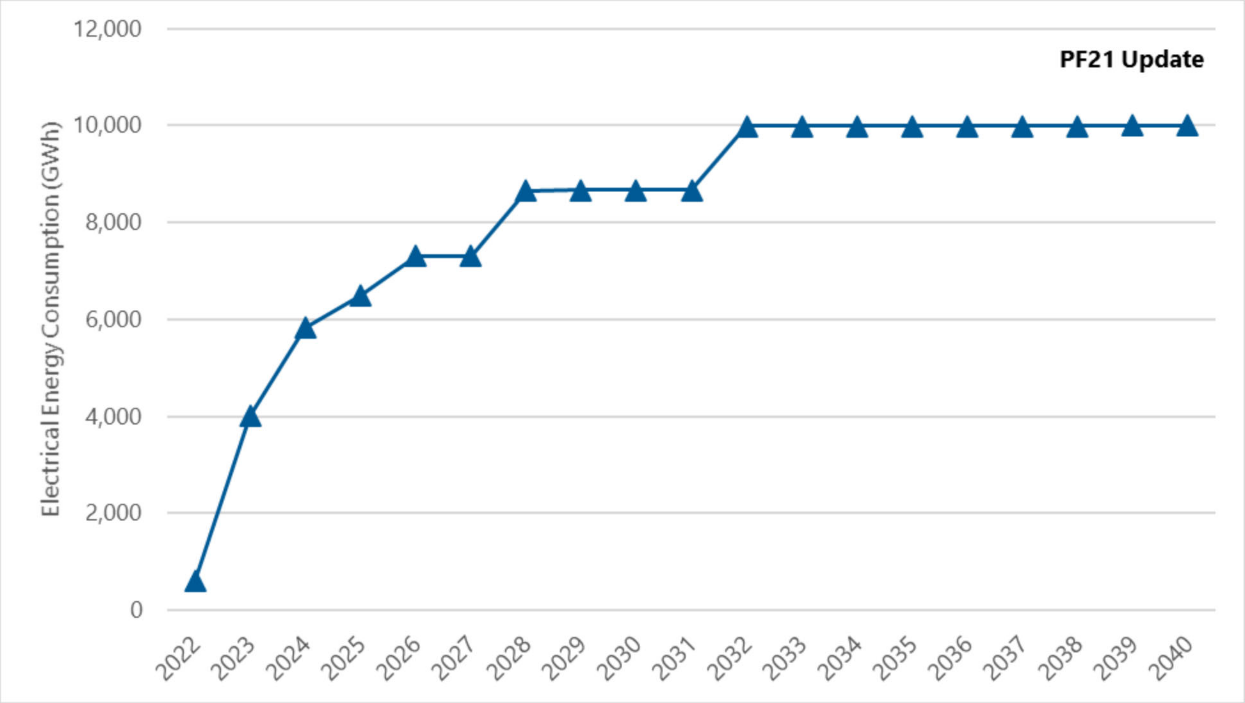

Figure 4-7 Large Industrial/Commercial Sources Forecasted Electrical Energy Consumption Reflecting Point Sources Identified as part of PF Study – 2021 Update

The large industrial/commercial load forecasted energy consumption for point sources identified as part of PF Study – 2021 Update (refer to Section 2.5.2 and Table 2-1) is provided in Table 4-5.

Table 4-5 Forecasted Electrical Energy Use Associated with Large Industrial/Commercial Sources Forecasted Electrical Energy Consumption Reflecting Point Sources Identified as part of PF Study – 2021 Update

Co-op Service Area [1]	2022 (MWh)	2024 (MWh)	2026 (MWh)	2028 (MWh)	2033 (MWh)	2038 (MWh)	2040 (MWh)
Lower Yellowstone Rural Electric Association area	70,000	1,665,000	1,884,000	1,884,000	1,884,000	1,884,000	1,884,000
McLean Electric Cooperative area	-	468,000	1,703,000	3,044,000	4,385,000	4,385,000	4,385,000
Mountrail-Williams Electric Cooperative area	430,000	2,273,000	2,281,000	2,285,000	2,279,000	2,281,000	2,285,000
Roughrider Electric Cooperative area	99,000	1,407,000	1,407,000	1,409,000	1,409,000	1,409,000	1,409,000
Verendrye Electric Cooperative area	-	21,000	30,000	34,000	28,000	30,000	34,000
Grand Total	599,000	5,834,000	7,305,000	8,656,000	9,985,000	10,059,000	9,997,000

[1] The added electric load served by the specified cooperative may be less than the values listed here because some projects are proposing to have onsite generation for some or all of their required electric power. These values are the estimated total new loads, regardless of whether the power is self-generated and/or purchased from the co-op.

These additional point sources, if realized, total approximately 10,067 GWh by the end of the study period, which would surpass the total electrical energy consumption load projected by the end of the study period for the large industrial/commercial load forecasted energy consumption using the PF Study method reflecting estimated oil and gas production forecasts (total approximately 7,798 GWh for the low scenario and approximately 8,682 GWh for the consensus scenario at the end of the study period).

4.2.1 Large Industrial/Commercial – Point Sources Identified as part of PF Study - 2021 Update Subcategories B and C

Barr estimated additional electrical energy consumption for subcategory B (Table 2-2) and subcategory C (Table 2-3) point sources described in Section 2.5.2

The full range for the large industrial/commercial load forecasted energy consumption for point sources identified as part of PF Study – 2021 Update for all three sub-categories reflecting generic industries that may include multiple potential facilities is shown in Figure 4-8.

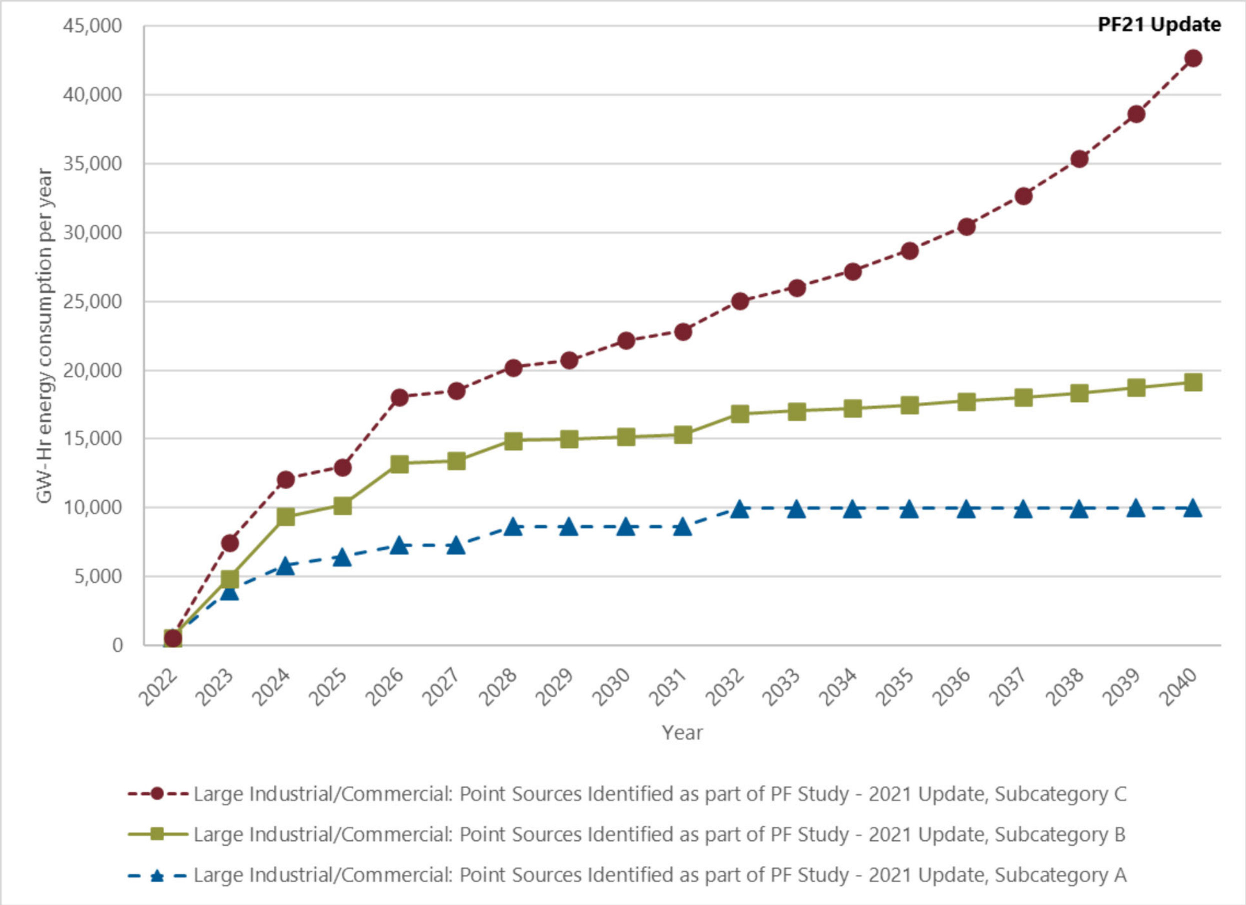

Figure 4-8 Large Industrial/Commercial Sources Forecasted Electrical Energy Consumption Reflecting Potential Range of Point Sources Identified as part of PF Study – 2021 Update

4.3 Population

The population broad load category is unchanged from the PF Study estimates (reference (1)), as noted in Section 2.6. The total baseline load was 4,400 GWh determined by the method described in Section 2.2.

Barr assumed the last two years of the study that were not included in the PF Study (2039 and 2040) to be equal to the last year included in the PF Study (2038). For reference, the previously reported totals are included in Table 4-6 for the low scenario and Table 4-7 for the consensus scenario.

Table 4-6 PF Study, Low Scenario: Relative Per-County Forecasted Electrical Energy Use Associated with Population

County	2022 (MWh)	2024 (MWh)	2026 (MWh)	2028 (MWh)	2033 (MWh)	2038 (MWh)
Adams	45,000	45,000	45,000	45,000	45,000	46,000
Billings	70,000	70,000	70,000	70,000	69,000	70,000
Bottineau	100,000	101,000	101,000	101,000	102,000	104,000
Bowman	21,000	22,000	22,000	22,000	22,000	22,000
Burke	55,000	55,000	56,000	55,000	55,000	55,000
Divide	25,000	25,000	25,000	25,000	25,000	25,000
Dunn	590,000	594,000	595,000	595,000	599,000	616,000
Golden Valley	154,000	157,000	159,000	160,000	161,000	161,000
Hettinger	129,000	129,000	129,000	129,000	127,000	129,000
McHenry	240,000	239,000	240,000	240,000	241,000	241,000
McKenzie	373,000	384,000	394,000	405,000	419,000	435,000
McLean	120,000	120,000	120,000	120,000	120,000	121,000
Mercer	165,000	165,000	165,000	164,000	163,000	163,000
Mountrail	1,056,000	1,108,000	1,141,000	1,175,000	1,215,000	1,259,000
Oliver	109,000	109,000	109,000	109,000	109,000	109,000
Pierce	38,000	38,000	38,000	38,000	38,000	38,000
Renville	85,000	85,000	85,000	85,000	85,000	86,000
Rolette	50,000	50,000	50,000	50,000	50,000	50,000
Sheridan	84,000	84,000	84,000	84,000	84,000	84,000
Slope	101,000	102,000	101,000	101,000	100,000	99,000
Stark	368,000	374,000	376,000	376,000	375,000	389,000
Ward	286,000	288,000	290,000	292,000	298,000	306,000
Wells	37,000	37,000	37,000	37,000	37,000	37,000
Williams	874,000	872,000	869,000	879,000	892,000	929,000
Grand Total	5,175,000	5,253,000	5,301,000	5,357,000	5,431,000	5,574,000

Table 4-7 PF Study, Consensus Scenario: Relative Per-County Forecasted Electrical Energy Use Associated with Population

County	2022 (MWh)	2024 (MWh)	2026 (MWh)	2028 (MWh)	2033 (MWh)	2038 (MWh)
Adams	47,000	48,000	48,000	48,000	48,000	49,000
Billings	72,000	73,000	73,000	72,000	73,000	74,000
Bottineau	104,000	106,000	107,000	107,000	108,000	112,000
Bowman	23,000	23,000	23,000	24,000	24,000	24,000
Burke	57,000	58,000	58,000	58,000	59,000	60,000
Divide	27,000	26,000	26,000	27,000	28,000	28,000
Dunn	657,000	676,000	690,000	702,000	720,000	750,000
Golden Valley	160,000	162,000	164,000	166,000	167,000	170,000
Hettinger	131,000	131,000	131,000	131,000	131,000	134,000
McHenry	247,000	250,000	253,000	253,000	255,000	256,000
McKenzie	409,000	426,000	440,000	456,000	488,000	522,000
McLean	124,000	125,000	126,000	126,000	128,000	129,000
Mercer	169,000	170,000	171,000	171,000	172,000	173,000
Mountrail	1,136,000	1,196,000	1,238,000	1,282,000	1,343,000	1,408,000
Oliver	109,000	109,000	109,000	109,000	109,000	109,000
Pierce	38,000	38,000	38,000	38,000	38,000	38,000
Renville	90,000	90,000	90,000	91,000	91,000	92,000
Rolette	50,000	50,000	50,000	50,000	50,000	50,000
Sheridan	84,000	84,000	84,000	84,000	84,000	84,000
Slope	105,000	105,000	105,000	105,000	104,000	104,000
Stark	407,000	419,000	423,000	425,000	432,000	453,000
Ward	304,000	307,000	309,000	311,000	318,000	331,000
Wells	37,000	37,000	37,000	37,000	37,000	37,000
Williams	946,000	977,000	1,005,000	1,030,000	1,101,000	1,162,000
Grand Total	5,533,000	5,686,000	5,798,000	5,903,000	6,108,000	6,349,000

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