

Economic Impacts of Relicensing the Clinton Clean Energy Center (CCEC)

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Overview

Economy-Wide Impacts of Retiring CCEC in 2026

Retiring CCEC early (compared to relicensing until 2046) would result in:



\$15 Billion Cumulative Net Loss in State GDP

Concentrated almost entirely in the seven counties surrounding CCEC
Net state GDP impact is negative in all years



1,100 Lost Jobs in Illinois

600 direct jobs at the plant are lost
Plus an additional loss of 500 jobs (on average) in Illinois



\$3.4 Billion Cumulative Loss in Tax Revenue

\$0.8 billion less in state tax revenue
\$2.6 billion less in federal tax revenue

Notes: Dollar values are undiscounted nominal dollars.

Power Sector Impacts of Retiring CCEC in 2026

Retiring CCEC early would also:



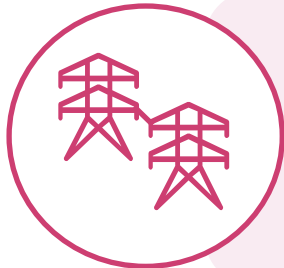
Increase Emissions by over 34 Million Metric Tons (MMT) Over 20 Years

CCEC reduces annual emissions by 1.7 MMT on average, offsetting around 35% of Chicago's annual on-road vehicle emissions (or ~400,000 light duty vehicles)¹



Limit Flexibility and Impede Progress in Meeting Clean Energy and Emissions Goals

CCEC accounts for 6% of Illinois' annual electricity demand
Its annual generation is equivalent to ~30% of in-state renewable generation²



Reduce Around-the-Clock Supply, Increasing the Challenge of Meeting Growing Electricity Demand Reliably

CCEC license renewal will provide enough energy to offset 15% of the output of the existing gas and coal plants that are mandated to retire by state policy³

Notes:

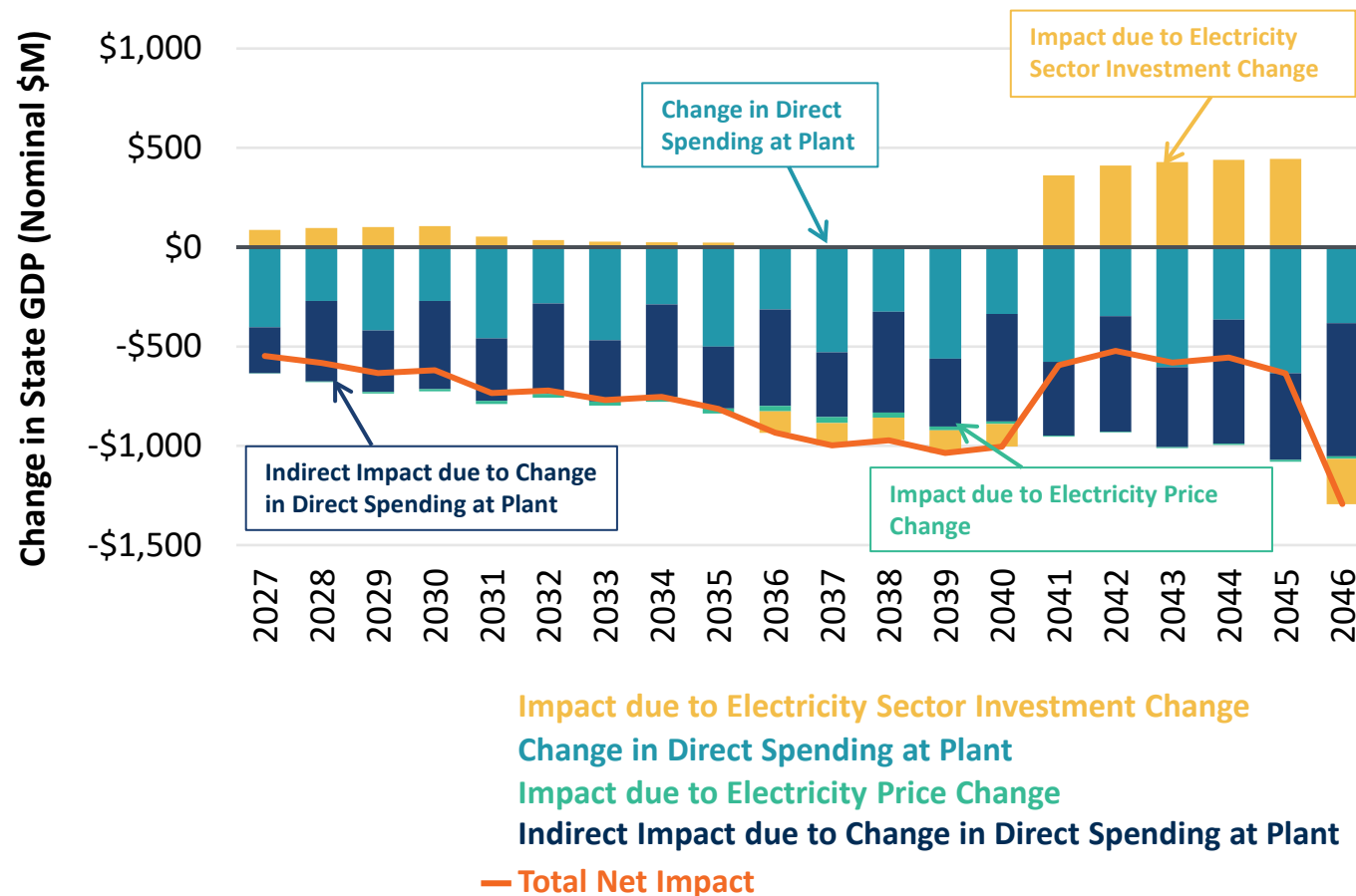
¹ On-road vehicles produced 5.11 MMT of GHG emissions in Chicago in 2022 ([Regional GHG Emissions Inventory](#)); emissions offset is equivalent to ~400,000 light-duty vehicles (LDVs) ([EPA GHG Emissions](#))

² CCEC produces about 8 TWh/year; 2023 retail electricity sales were 131 TWh; 2023 utility-scale renewable generation was 24 TWh ([EIA Electricity Data Browser](#))

³ Scheduled plant closures will result in 23 TWh of annual gas generation losses and 31 TWh of annual coal generation losses ([IL Department of Labor](#))

CCEC Retirement Impact on Illinois GDP

State GDP Impact

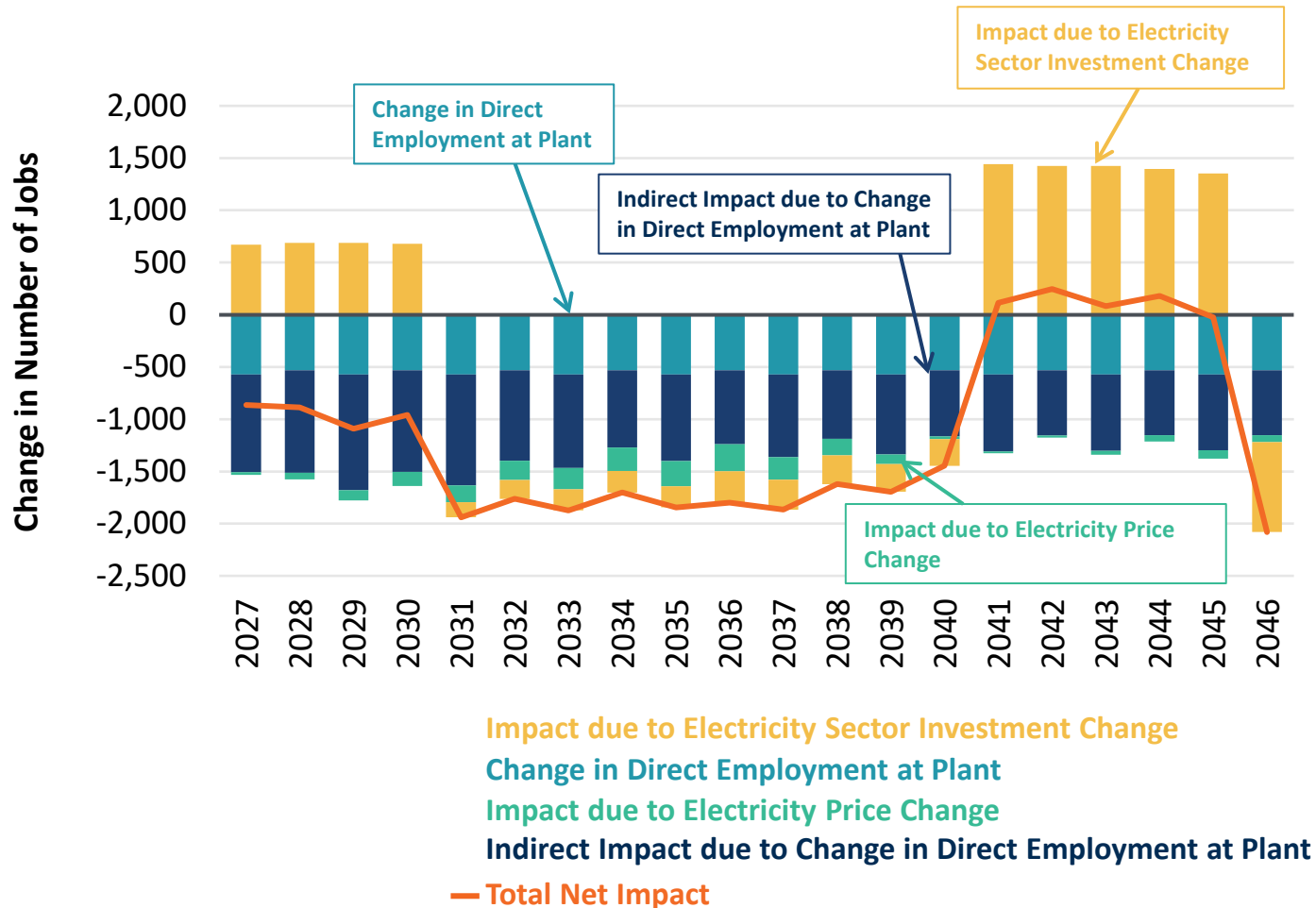


Key Observations

- Negative GDP impacts are driven primarily by the loss in plant expenditures and employment that occur with retiring the Clinton plant.
- GDP impacts are moderated by investment in additional in-state generation resources needed after Clinton's closure.
 - Positive GDP impact of these partially offsets the GDP losses driven by plant closure and higher power prices.
 - This analysis conservatively models the large majority of new resources in Illinois (to meet resource adequacy and RPS requirements) as being sited in-state. If a greater share of these resources are sited out-of-state, the positive offset would be smaller.
- Clinton alternates refueling years on a 24-month fuel cycle.

CCEC Retirement Impact on Employment in Illinois

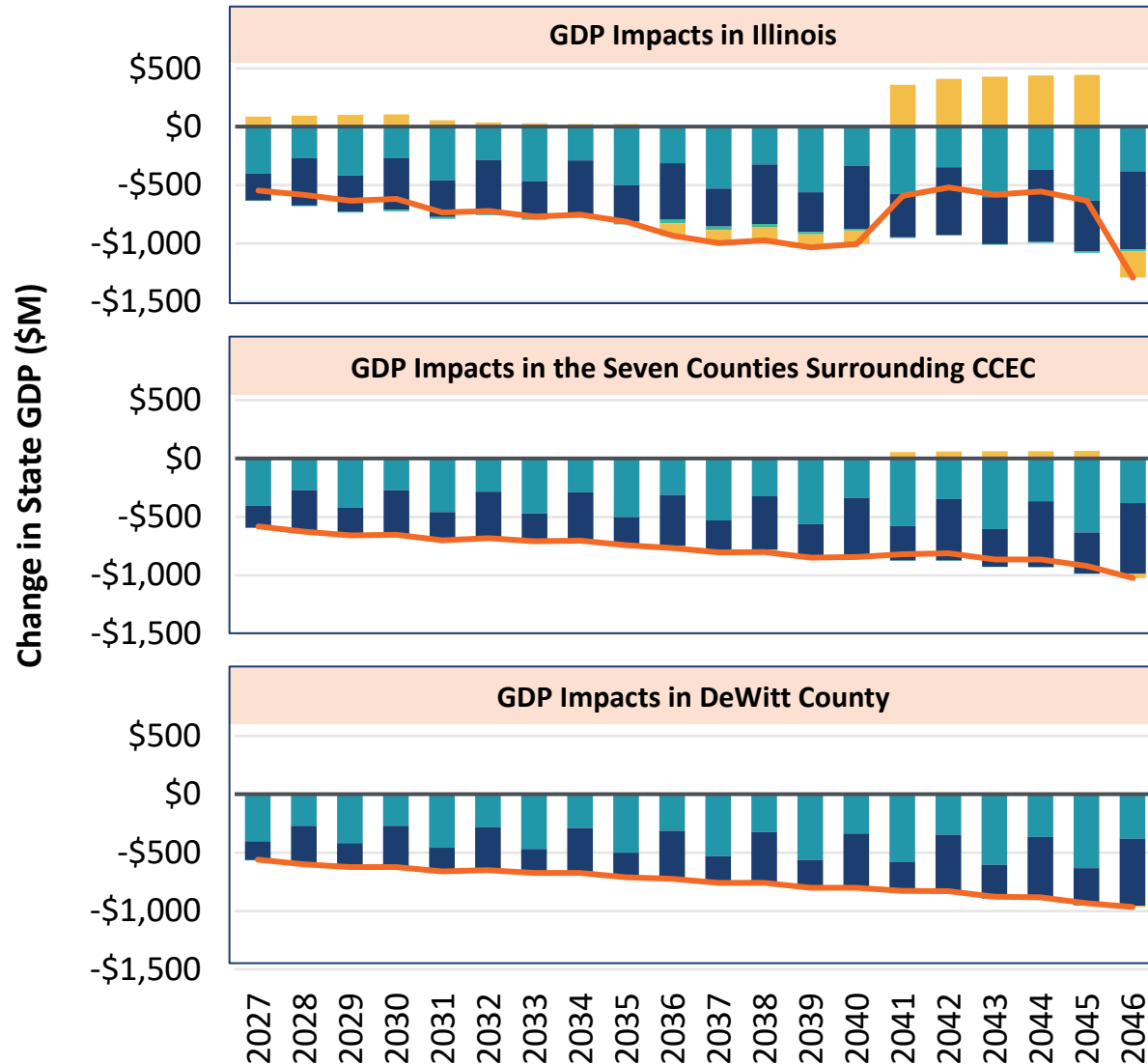
State Employment Impact



Key Observations

- Negative overall employment impacts are driven primarily by the direct employment effects, and loss in plant expenditures that occur with retiring the Clinton plant.
- Employment can be more sensitive to indirect effects (indirect impacts are relatively larger).
 - Electricity price effect in particular – employers facing higher electricity prices have less to spend on labor.
- Employment impacts are moderated by investment in additional in-state generation resources needed after Clinton's closure.
 - These positive employment impacts partially offset the direct and indirect employment losses resulting from plant closure and higher electricity prices.
 - This analysis conservatively models the large majority of new resources in Illinois as being sited in-state. If a greater share of these resources are sited out-of-state, this positive GDP contribution would be smaller, and overall impacts more negative.

GDP Impacts are Highly Localized



- The negative GDP impacts of CCEC closure are concentrated almost entirely in the seven counties surrounding CCEC, as reduced economic activity due to plant closure is driven by proximity to DeWitt county where CCEC is located.
- Investments in additional in-state generation resources needed to replace CCEC are spread widely across the state, thus do not offset the local concentration of other impacts.
- As a result, the local economy experiences most of the negative GDP impacts of plant closure, but very little of the positive impacts from additional electricity sector investments.

Impact due to Electricity Sector Investment Change

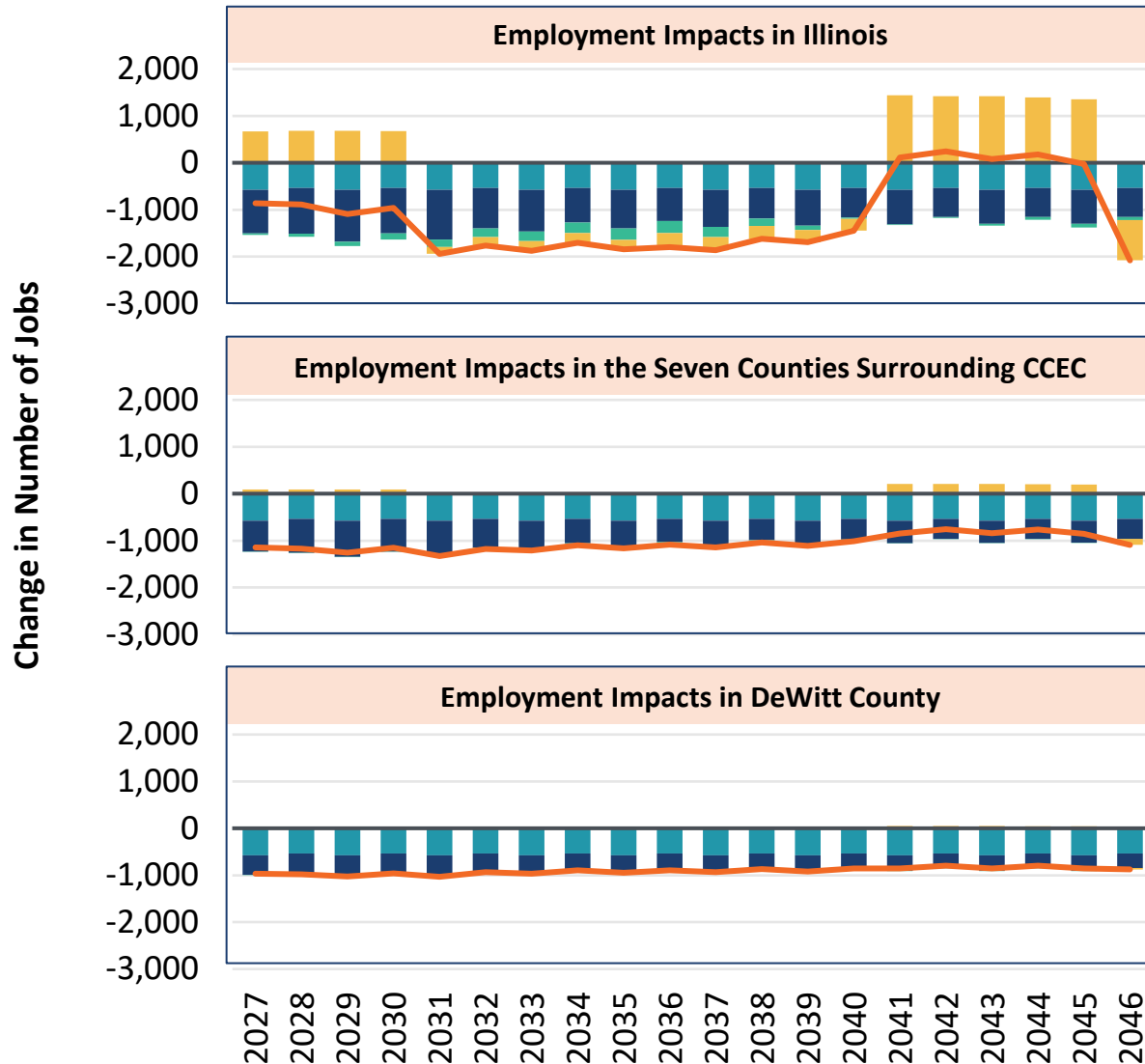
Impact due to Direct Plant Spending and Employment

Impact due to Electricity Price Change

Indirect Impact due to Change in Direct Spending at Plant

— Total Net Impact

Employment Impacts are also Highly Localized



- The negative employment impacts of CCEC closure are heavily concentrated in the seven counties surrounding CCEC.
 - Virtually all the direct employment impact is local, and so is much of the indirect impact – the negative GDP impacts that influence employment are also localized.
- Investments in additional in-state generation resources are spread widely across the state, thus do not offset the local concentration of other impacts.
- As a result, the local economy experiences most of the negative employment impacts, but very little of the positive impacts from additional electricity sector investments.

Impact due to Electricity Sector Investment Change

Impact due to Direct Plant Spending and Employment

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CCEC Retirement Impact on Tax Revenue

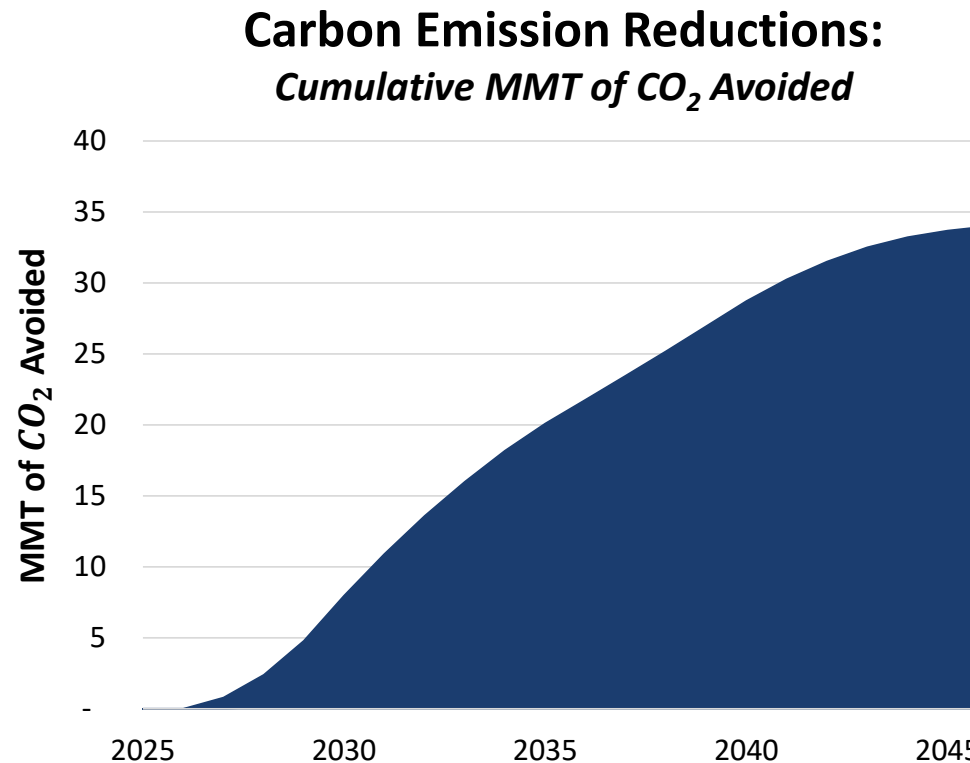
The cumulative reduction in state tax revenue through 2046 is estimated as \$733 million, and \$2,593 million for federal tax revenue. The negative tax revenue impacts are heavily concentrated in the seven counties surrounding CCEC.

| Effect on Tax Revenue (\$ Million) | | | |
|------------------------------------|------------------|--------------------|------------------|
| Region | State Tax Impact | Federal Tax Impact | Total Tax Impact |
| State Level | -\$773 | -\$2,593 | -\$3,366 |
| Seven Counties Surrounding CCEC | -\$779 | -\$2,614 | -\$3,393 |
| DeWitt County | -\$755 | -\$2,532 | -\$3,287 |

Sources and Notes:
Tax revenue is approximated as a fixed portion of GDP based on their historical relationship.
1. State tax revenue estimated using average over 2014-2023 of IL tax revenue as percent of IL GDP (5%)
2. Federal tax revenue estimated using average over 2014-2023 of federal tax revenue as percent of federal GDP (17%)

CCEC Retirement Impact on Emissions

Clinton's clean energy generation will reduce total CO₂ emissions by approximately 34 million metric tons (MMT) over 20 years of operation (2026-2046). Clinton produces the same amount of energy annually as one-third of renewable resources in the state and accounts for approximately 6% of Illinois' annual electricity demand (as of 2023).¹



- Extending Clinton avoids substantial CO₂, particularly in the early years.
- Impact diminishes in later years as the grid becomes cleaner overall and there is less CO₂ to avoid.

¹ CCEC produces about 8 TWh/year; 2023 retail electricity sales were 131 TWh; 2023 total utility-scale renewable generation was 24 TWh ([EIA Electricity Data Browser](#)).

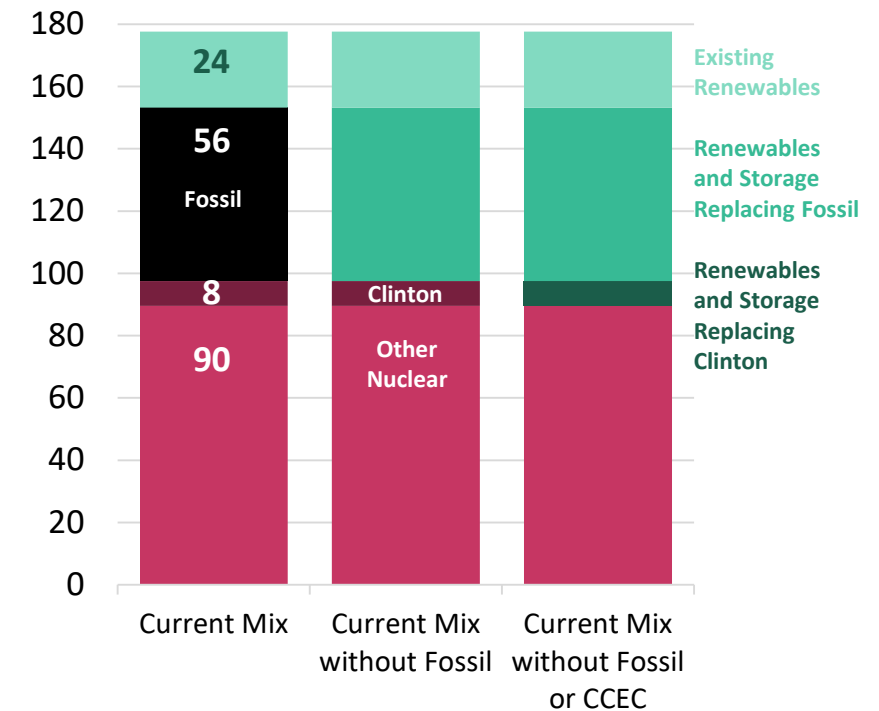
Overview of Modeled Policies

- **Renewable and Clean Energy Goals:**
 - Clean energy targets are modeled at the state level, including technology-specific procurement targets.
- **Emissions Reduction Goals:**
 - For PJM, carbon emissions limits are modeled based on state decarbonization goals.
 - For MISO, carbon emissions limits are modeled based on a combination of state and utility decarbonization goals.
- **Inflation Reduction Act:**
 - Production tax credits (PTC) are modeled for solar, onshore wind, and nuclear generation. Hydrogen PTCs are incorporated into the fuel costs for H2 resources.
 - Investment tax credits (ITC) are modeled for offshore wind and battery storage.
- **Section 45Q Credit for Carbon Oxide Sequestration**
 - Tax credit for carbon capture and storage (CCS) is modeled for all new and retrofitted CCS units.
- **Climate and Equitable Jobs Act:**
 - Currently, we model a 2045 zero-emissions deadline for IL as outlined in CEJA. The emissions limit slopes linearly from present-day levels down to zero in 2045.
 - [CEJA](#) does not explicitly call for the retirement of fossil units. However, plants that don't comply with emissions targets by the deadline (e.g., through CCS) will be forced to retire. Our model implements a phased retirement or retrofit of fossil units according to the timeline identified by the [IL Dept. of Labor](#).

Climate and Equitable Jobs Act (CEJA) Requirements

- **CEJA is modeled at the statewide and individual unit level.**
 - We model a 2045 decarbonization goal for Illinois' electric sector as well as a phased retirement of fossil plants.¹
- **To meet CEJA requirements, Illinois will need to replace fossil generation with clean energy. Without CCEC, additional clean energy will be needed.**
 - 1.6 GW of renewables and storage are needed in Illinois to replace the 1.1 GW loss from CCEC. Across MISO, an additional 1.2 GW of renewables and storage and 0.75 GW of gas are also needed.³
- **If CEJA standards are not achieved, economic benefits (GDP, tax revenue and employment) driven by clean energy investments would be lower.**
 - Failing to meet Illinois' carbon-free targets would result in less investments in clean energy resources, which partially offset the negative economic impacts of CCEC's closure.

Comparing Generation Mix² (TWh)



¹ Climate and Equitable Jobs Act Economic and Workforce Effects Preliminary Analysis, ([IL Department of Labor](#))

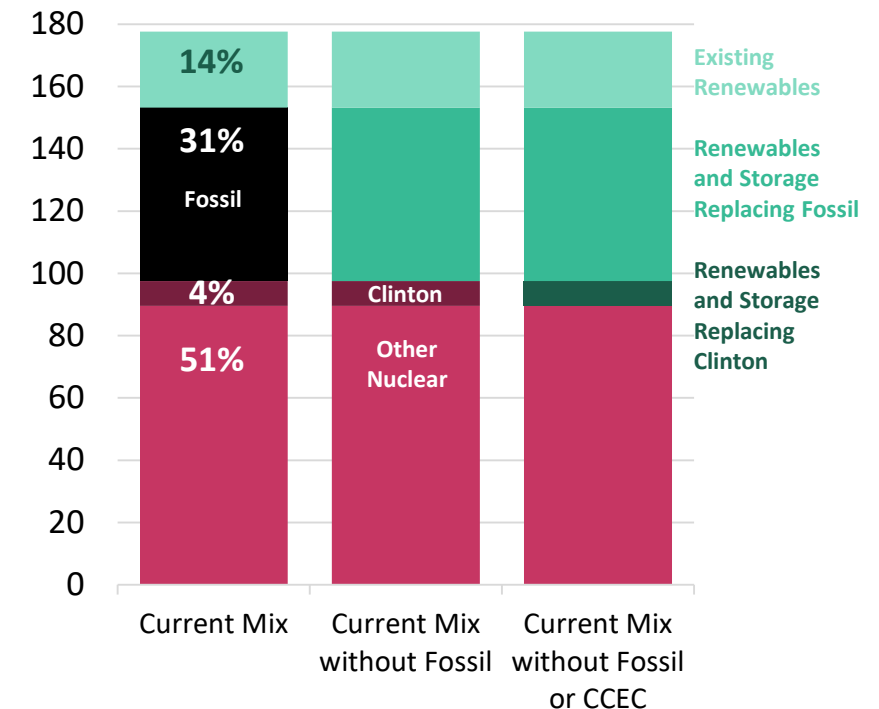
² Figure illustrates impact of CCEC and CEJA retirements on today's resource mix; values reflect Illinois' 2023 generation mix based on EIA data ([EIA Electricity Data Browser](#))

³ Values are based on gridSIM analysis; Further details on modeled policies and resource buildout are available in gridSIM Model Assumptions appendix

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Economic Impacts of Relicensing the Clinton Clean Energy Center (CCEC)

Project Overview

We examine the macroeconomic and power sector impacts of relicensing the **Clinton Clean Energy Center (CCEC)** in Illinois. To capture the interdependencies between the electricity sector and regional economic growth, our analysis integrates two modeling tools, characterizing first the electricity system, and also the broader economy:

- **gridSIM**, Brattle's power sector capacity expansion model, is used to simulate the power sector impacts of relicensing the CCEC. Energy demand, resource adequacy, market regulations and clean energy policies in MISO and PJM as well as those in neighboring markets were accounted for in the analysis. To model the impact of relicensing on the interchange between MISO and PJM, the two electricity markets that supply electricity in Illinois, gridSIM optimizes capacity expansion in both markets.
- **REMI Policy Insight Model**, a dynamic economic impact assessment tool, is used to simulate regional economic impacts. The model evaluates key macroeconomic indicators in Illinois including state GDP, employment and industrial production. Economic impacts consider two channels: the direct loss in employment and spending in DeWitt county due to closure of CCEC; and the power sector impacts driven by changes in the generation resource mix (i.e., changes in customer electricity costs and resource investment in Illinois).

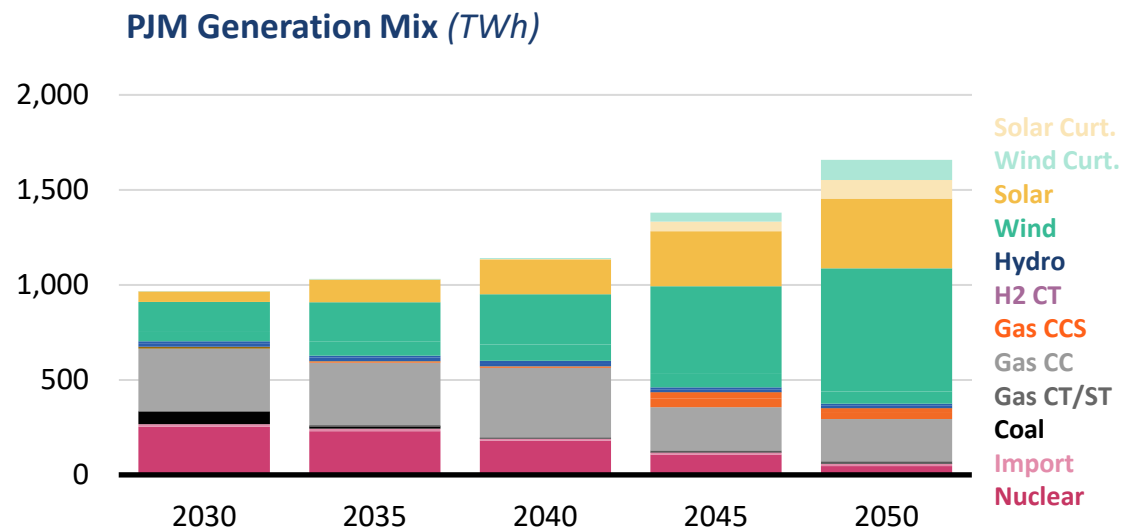
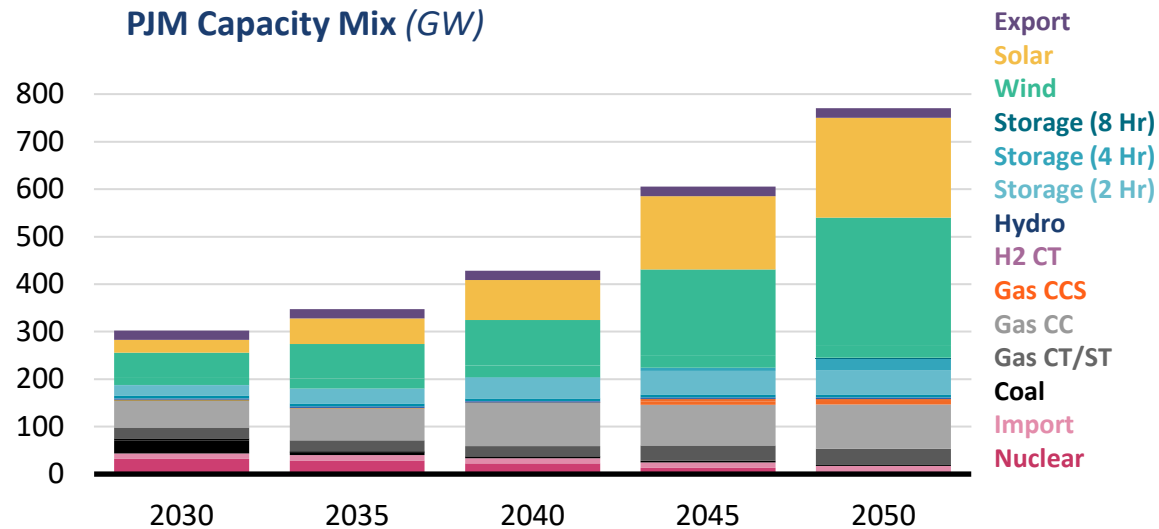
We assess the value of extending the plant's license by comparing two scenarios:

- Reference scenario: CCEC license is renewed and it operates until the end of the renewed license (2046).
- Alternate scenario: CCEC retires at end of current license (2026).

Power Sector Modeling

REFERENCE SCENARIO RESULTS

Capacity and Generation Mix in PJM

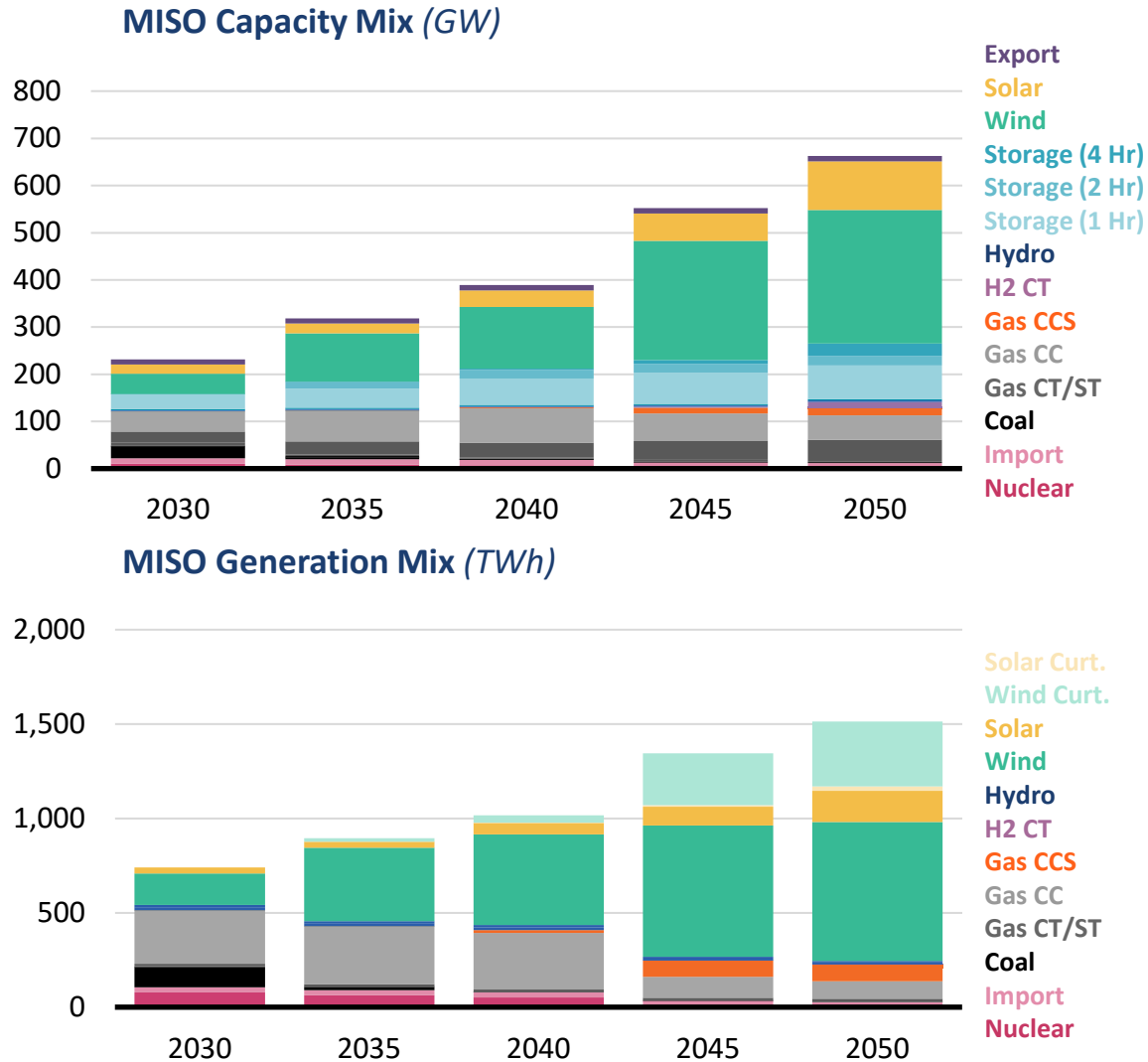


Comparison to National Renewable Energy Laboratory (NREL) Cambium 2023 Data*:

- Buildout of ELCC resources as a whole (at resource portfolio level) is aligned in 2040.
 - Total wind and solar capacity in 2040 is 204 GW in SIM and 217 GW reported by NREL.
 - Penetration of ELCC resource type (wind vs. solar) differs due to differences in modeled capacity accreditation. (gridSIM explicitly models how intermittent and correlated renewables affect system capacity; Cambium makes simplifying assumptions).
- gridSIM's remaining gas capacity of 118 GW + 12 GW CCS in 2045 is consistent with NREL Cambium's high electrification scenario, which shows 125 GW.
- Up-to-date project pipeline and retirement data are not fully accounted for in Cambium Report. Retirement schedule of nuclear plants also differs.

* High Electrification scenario, <https://scenarioviewer.nrel.gov/>

Capacity and Generation Mix in MISO



Comparison to MISO Futures Report*:

- Total wind capacity is between the Futures 2A and 3A scenarios. Solar capacity is lower due to differences in resource accreditation and generation profiles. Battery penetration is aligned with combined Battery & DER capacity in the Futures scenarios.
- Penetration of gas plants, *particularly peakers***, is higher in gridSIM (107 GW in 2040 vs. ~80 GW in report). This is explained by:
 - More aggressive carbon reduction and renewable penetration constraints that result in 83% to 99% carbon reduction by 2042 across the three futures. Based on state and utility-level data, our model finds the 2042 MISO carbon reduction target in gridSIM to be 72%.
 - How renewable resources are assumed to contribute to meeting peak load. Futures report assumes exogenous capacity credit for ELCC resources (e.g., solar starts with 50% capacity credit and decreases by 3% starting in year 2028 and does not go below 20%).

* https://cdn.misoenergy.org/Series1A_Futures_Report630735.pdf

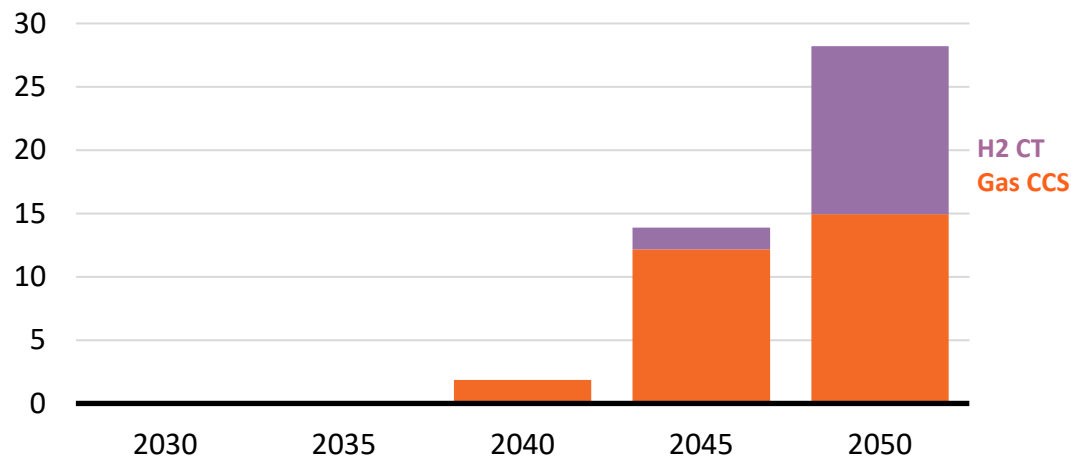
** MISO Futures Report also states that natural gas resource builds represent peaker plants that operate during ramping hours when wind and solar generation is sparse.

Dispatchable Emerging Technology Capacity

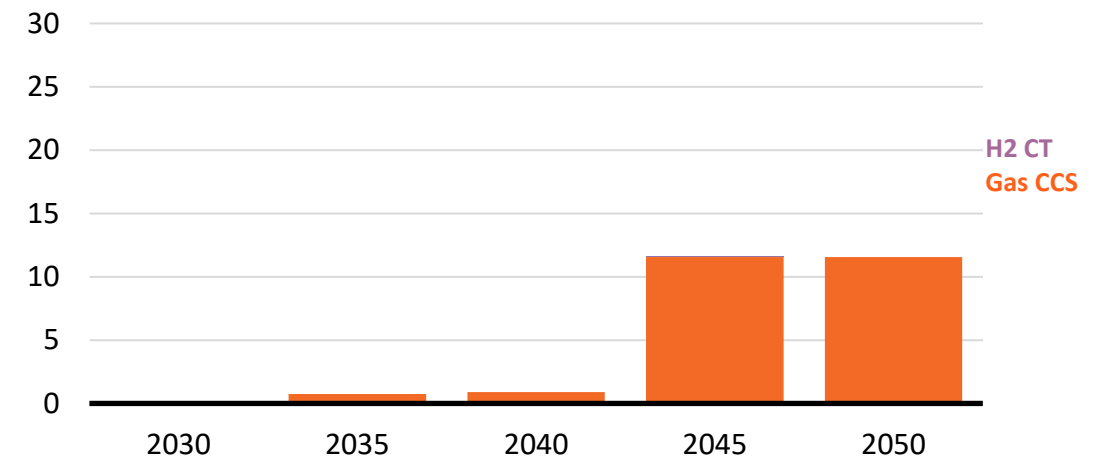
Model Results and Comparison to Public Reports:

- gridSIM allows Carbon Capture and Storage (CCS) resources to be used at scale starting in 2030.
- Hydrogen to be used for generation starting 2036.
- The model can build CCS resources as soon as 2030, but only economically chooses to do so in 2036 onwards.
- Dispatchable emerging technology resources make up 4% of the 2050 MISO capacity mix and 1.6% of the 2050 PJM capacity mix.
- While MISO has more dispatchable emerging technology capacity than PJM, generation from these resources are similar in magnitude.
- MISO Futures Report, *MISO Future 2* shows 29 GW of dispatchable emerging technology capacity in 2042.
- The PJM Cambium Report shows 5 GW of CCS capacity in 2040.

MISO Capacity Mix (GW)



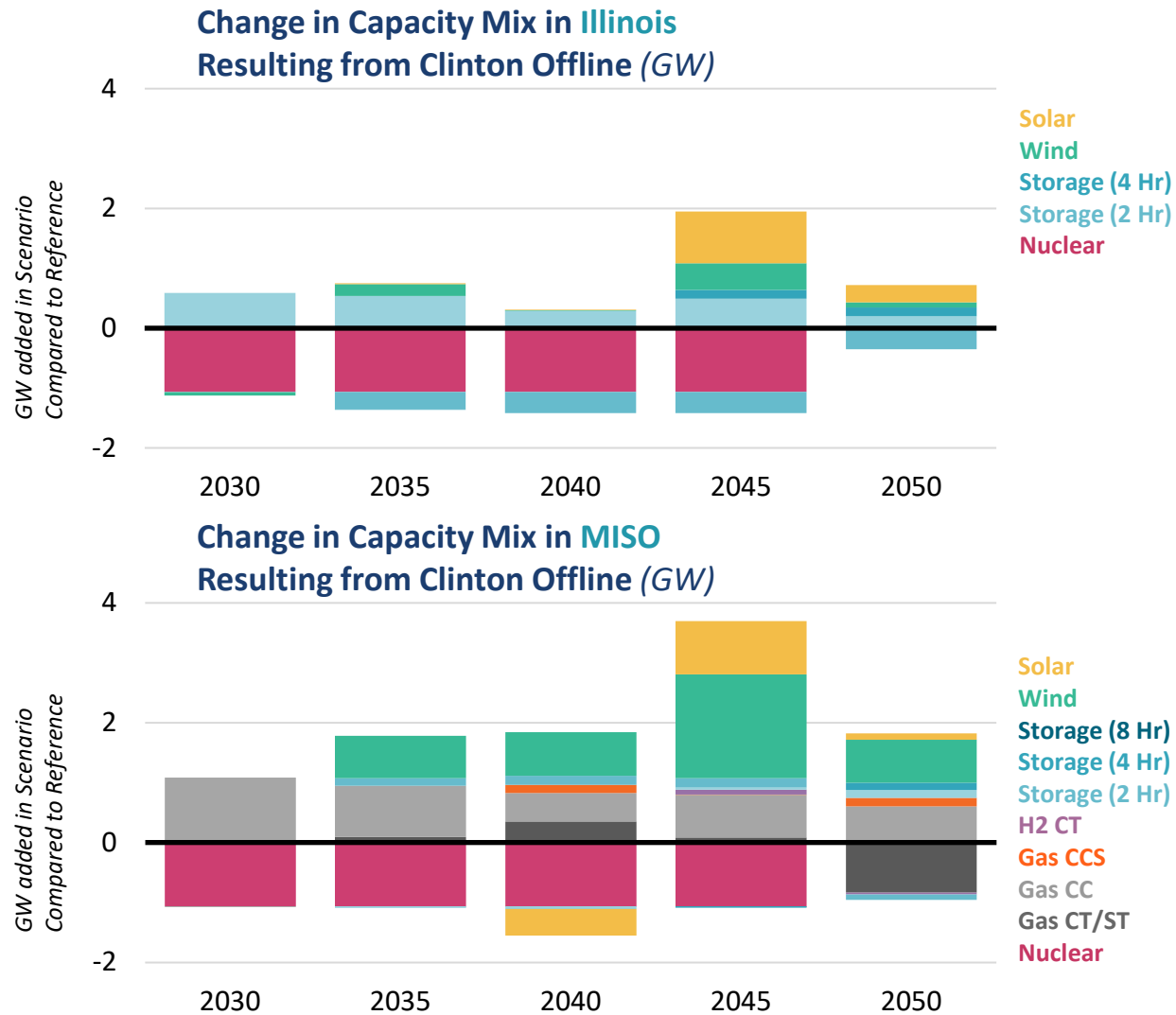
PJM Capacity Mix (GW)



CCEC Retires in 2026

POWER SECTOR IMPACTS

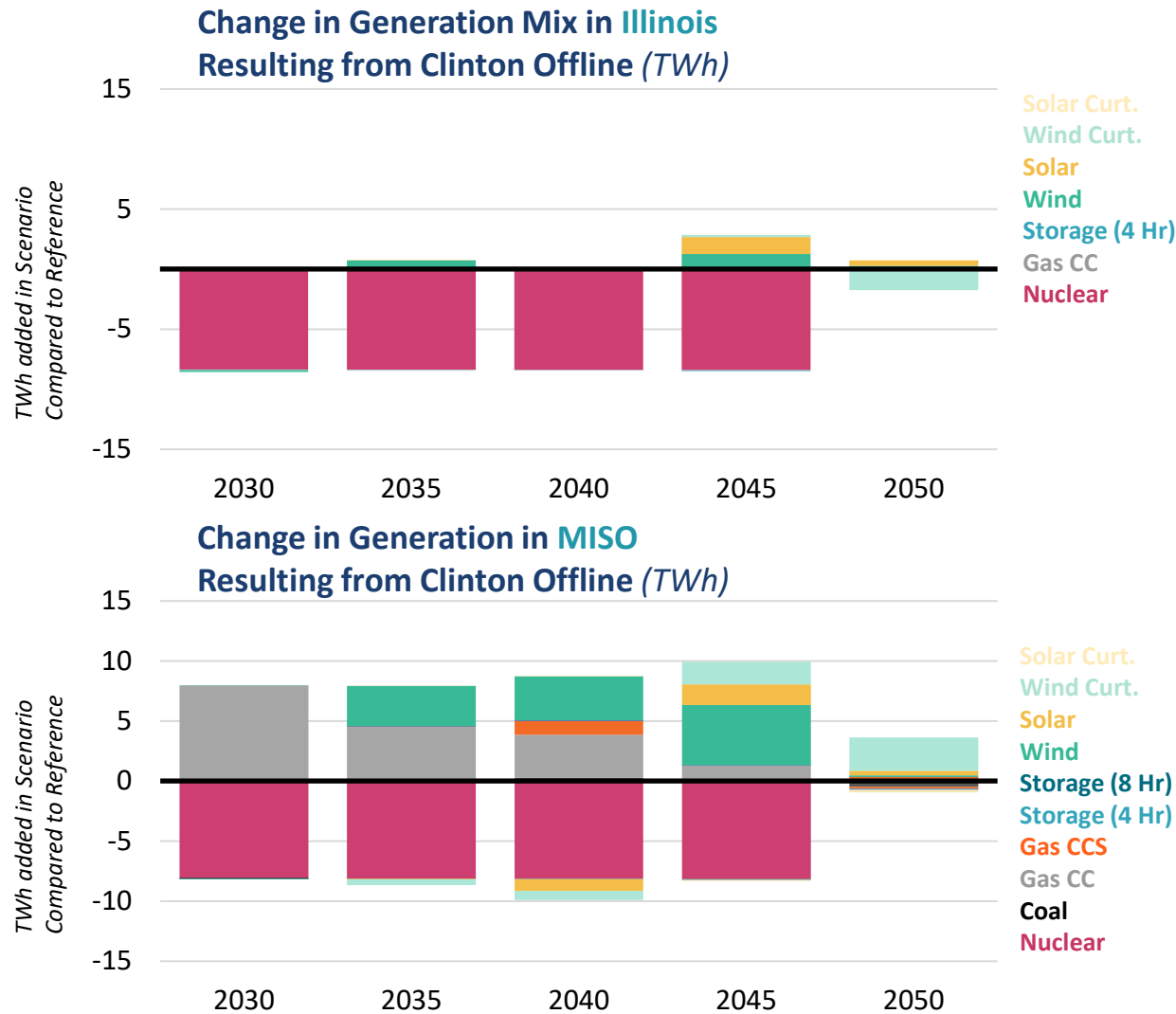
Capacity Impacts in Illinois and MISO



Retiring Clinton leads to:

- In MISO, a combination of more fossil resource builds (Gas CT and CC) for reliability, and more renewables and storage (especially post-2035) to meet emissions goals.
- Minor impact on PJM's capacity mix.
- As a result of CEJA, none of the change in natural gas capacity occurs in Illinois.
- Renewable and storage capacity in Illinois determined based on state RPS targets and Illinois' historical portion of capacity within the MISO-Central region (Zones 4, 5, and 6).
- Zone 4 local resource adequacy obligations are largely met via internal resource builds in Illinois (or equivalent resources) as well as capacity imports from neighboring zones (zonal capacity import limits are not binding).

Generation Impacts in Illinois and MISO



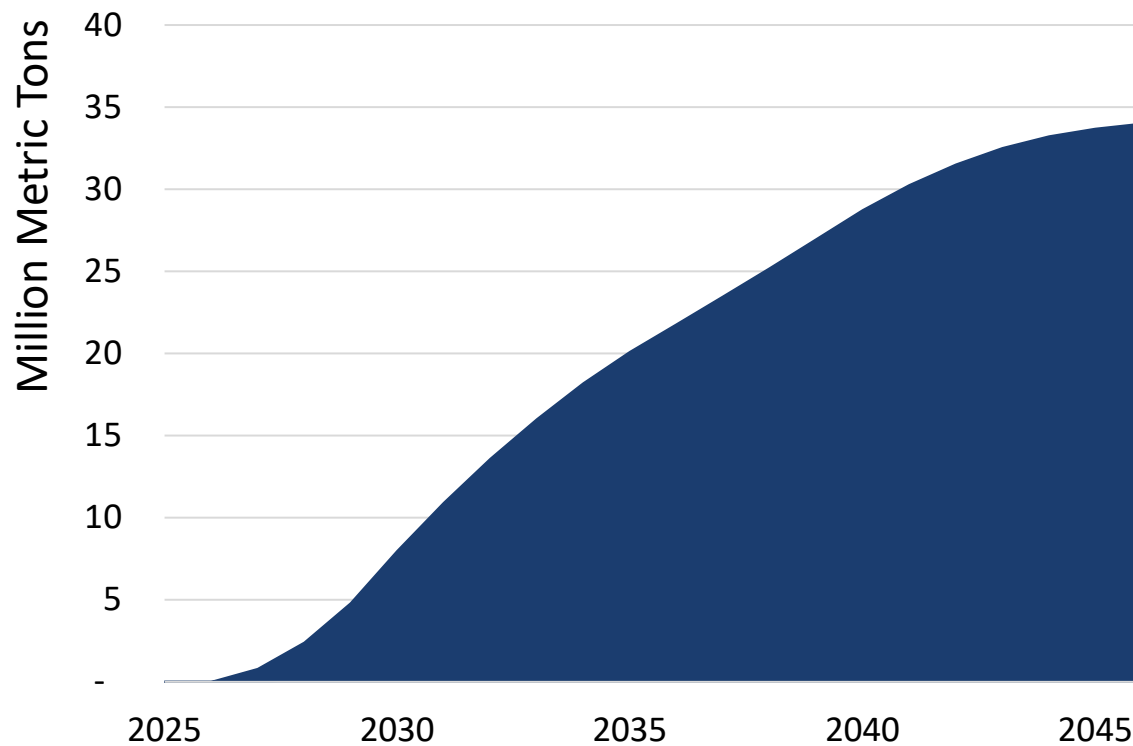
Retiring Clinton leads to:

- Increased fossil generation and more air pollution in MISO, particularly before 2045 when MISO goals are less stringent.
 - Generation from Clinton is almost entirely replaced by generation from gas combined cycle plants in the near-term; by renewables in the longer term.
- Much of the change in renewable resource generation occurs outside of Illinois.
- As a result of CEJA, none of the change in fossil resource generation occurs in Illinois.
- For the MISO portion of Illinois, renewable and storage generation in Illinois determined based on state RPS targets and Illinois' historical portion of capacity within the MISO-Central* region.

*MISO-Central is modeled as a single region composed of Local Resource Zones (LRZs) 4, 5, and 6. Within MISO-Central, IL specific capacity is determined based on historical capacity share by state. Resulting capacity in IL is consistent with CEJA, the state's RPS targets and resource adequacy requirements in MISO and PJM.

CCEC Retirement Impact on Emissions

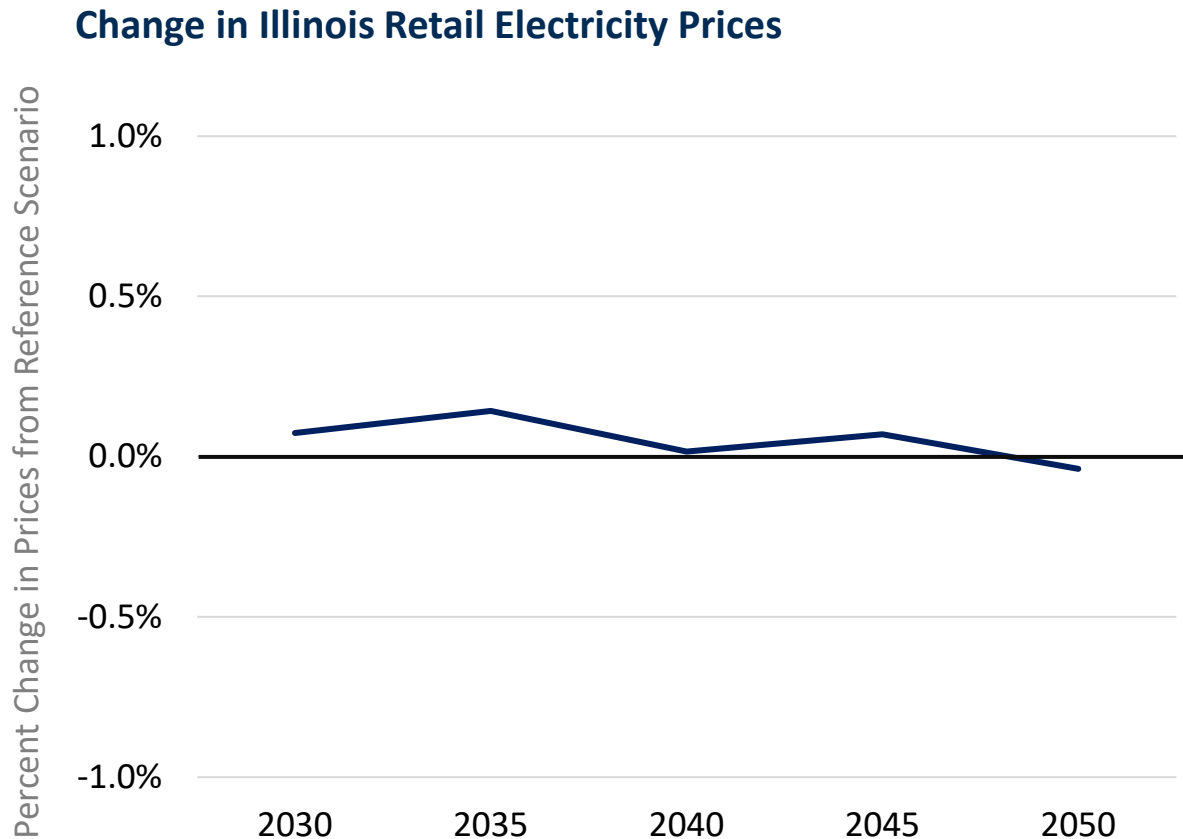
Cumulative emission increase from Clinton Off



- **Retiring Clinton leads to:**

- Large emissions increase as more fossil resources are built and used for generation in MISO (outside of Illinois) when Clinton is retired.
- ~34 million metric tons of additional CO₂ emissions by 2046.
- Emissions steadily increase until 2042; emissions continue to increase more slowly thereafter due to Illinois' zero carbon standard and differences in resources in non-IL portions of MISO.

Retail Electricity Price Impact



The retail electricity price impact shown above is calculated as one-third of the wholesale electricity price impact. Wholesale prices (\$/MWh) are the sum of energy, capacity, and ZEC prices. IL prices are calculated as the load-weighted average of MISO-Central and PJM-ComEd regions. Further details are available in gridSIM Model Assumptions appendix

- **Retiring Clinton leads to:**

- Increased wholesale energy prices are due to a high portion of Clinton's generation being replaced by dispatchable generation in neighboring states (largely gas generation before 2045).
 - ▶ Increase in retail electricity rates in Illinois in earlier years due to higher wholesale energy and capacity prices; in later years, changes in retail electricity rates are largely determined by changes in wholesale energy prices.
- Higher capacity prices through 2035 are due to lower utilization of storage resources. Capacity prices decrease post-2035 as energy margins increase.
- Further penetration of renewables due to IL's zero carbon standard imposed in 2045 results in declining energy prices between 2045-2050, contributing to lower retail electricity rates.

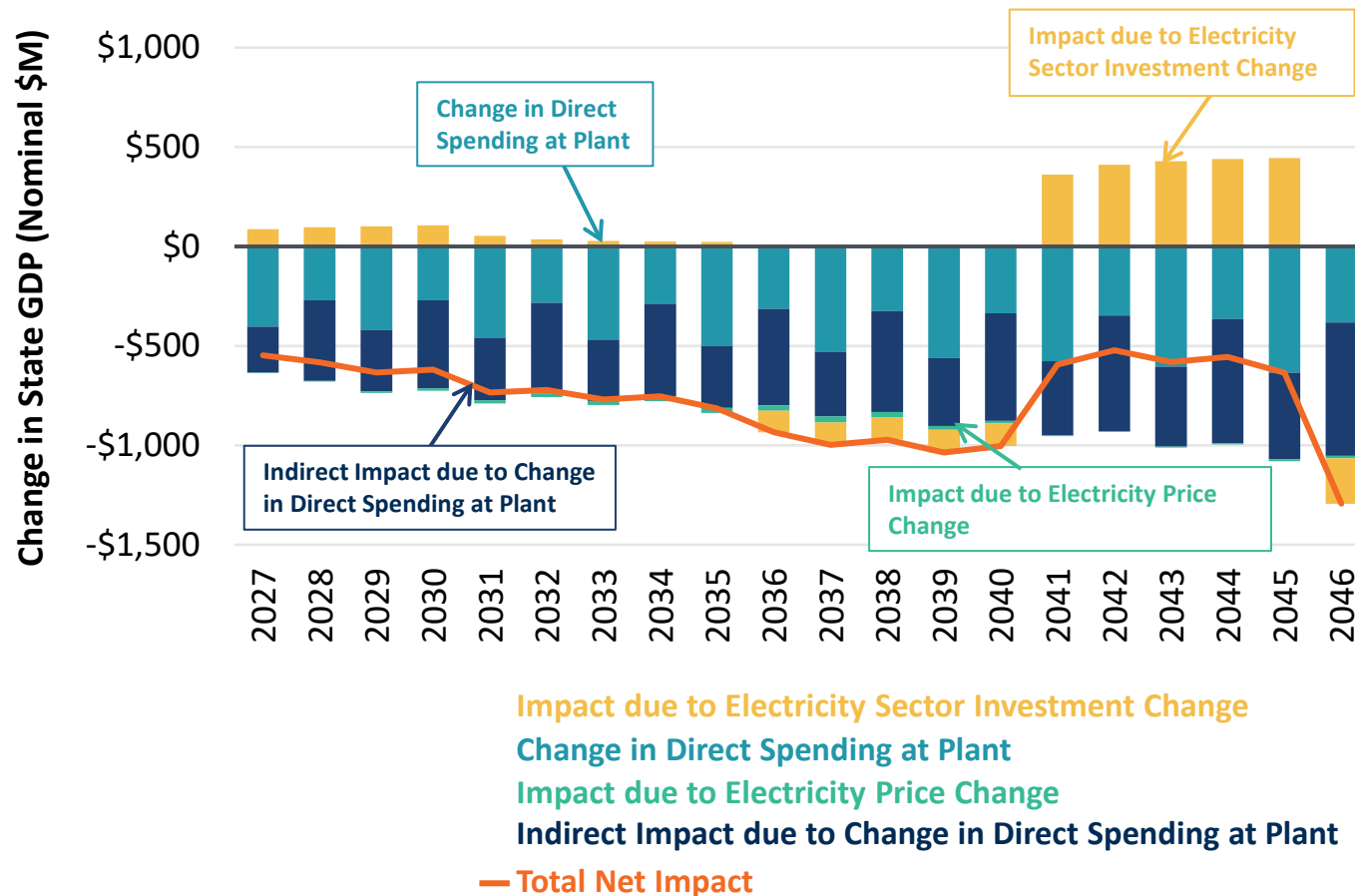
CCEC Retires in 2027

ECONOMY-WIDE IMPACTS



CCEC Retirement Impact on Illinois GDP

State GDP Impact

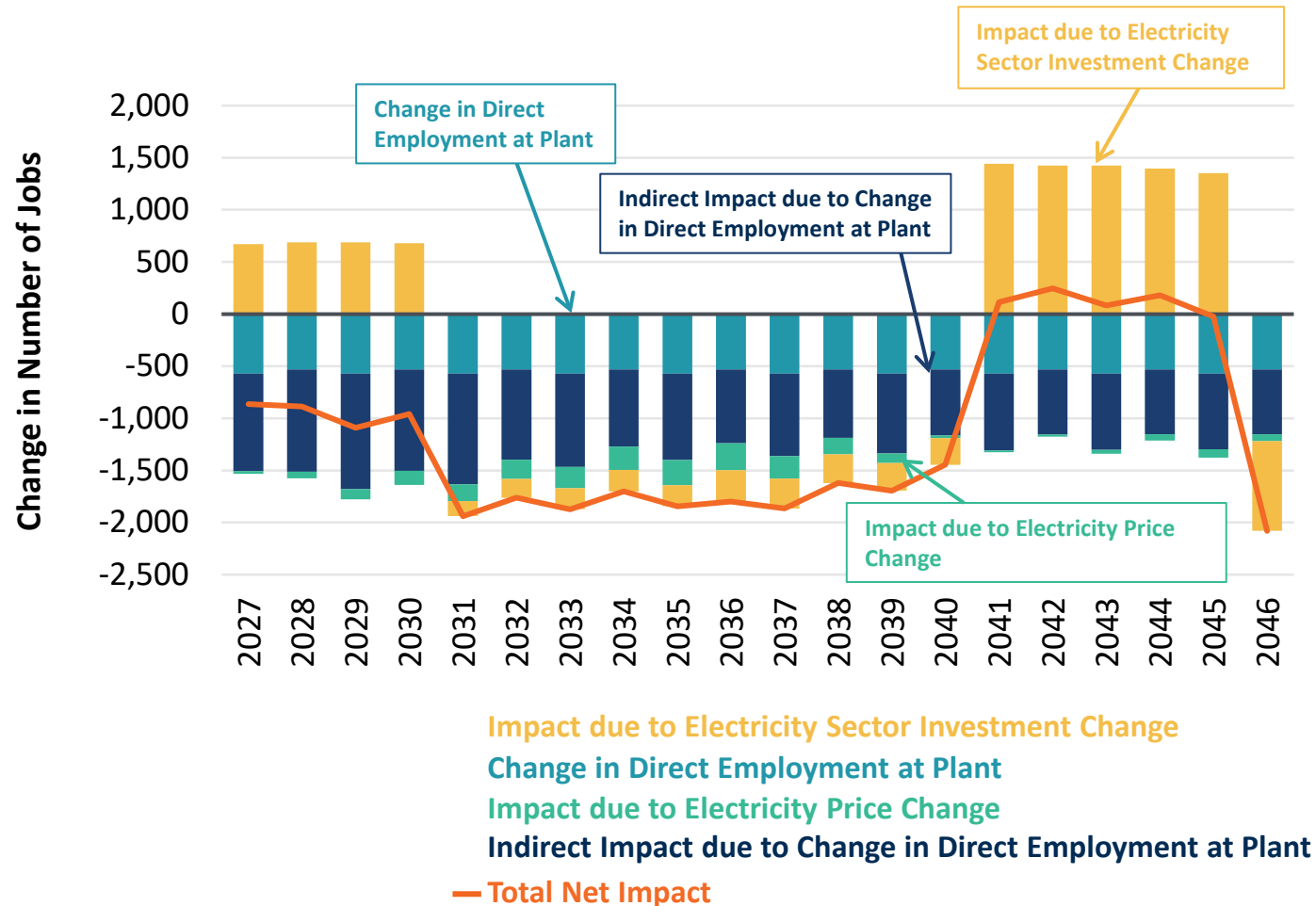


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CCEC Retirement Impact on Tax Revenue

The cumulative reduction in state tax revenue through 2046 is estimated as \$733 million, and \$2,593 million for federal tax revenue. The negative tax revenue impacts are heavily concentrated in the seven counties surrounding CCEC.

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Distribution of Impacts Across Neighboring Counties

The distribution of impacts across neighboring counties are driven by inter-county relationships that include:

- **Industry-level trade flows**, which dictate where DeWitt businesses spend on their supply chain and DeWitt consumers spend their disposable personal income.
- **Commuting patterns**, which dictate how much income earned in DeWitt stays locally or is spent in the surrounding counties from which workers commute.
- **Population migration**, specifically in response to changing economic conditions.

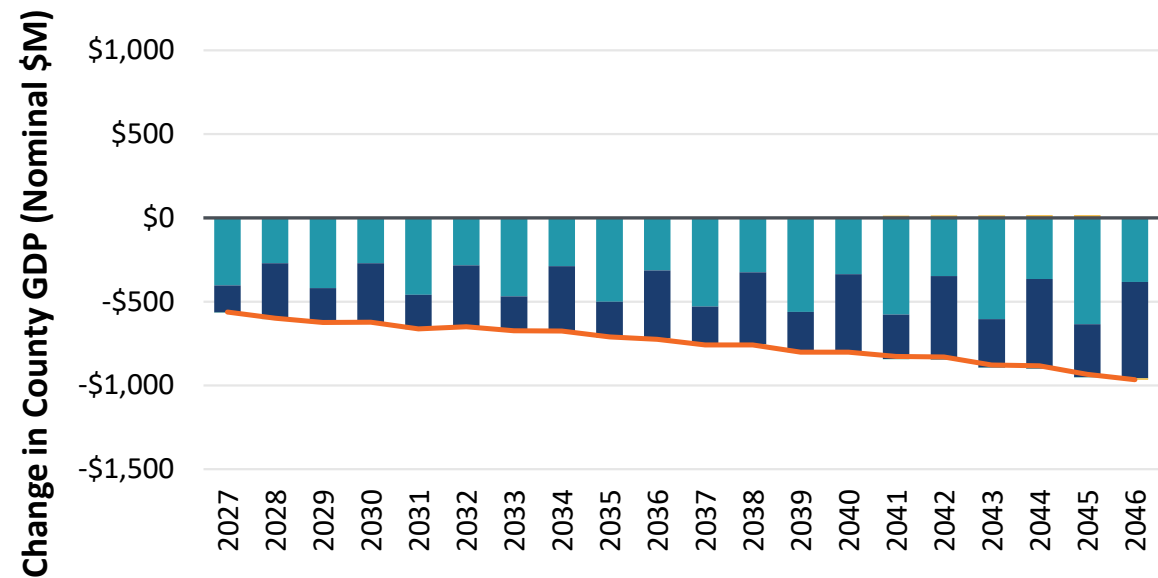
The model assumes people stay or relocate into a region over time based on relative employment opportunities and earnings.

McLean County, a relatively large neighboring county to DeWitt, experiences negative employment gains for the duration of the forecast period, however at a declining rate after year three. Clinton's workers are employed over time by McLean County's relatively large natural resources and services sectors. Indirect and induced employment related to employee earnings will also shift from DeWitt towards McLean county over time.

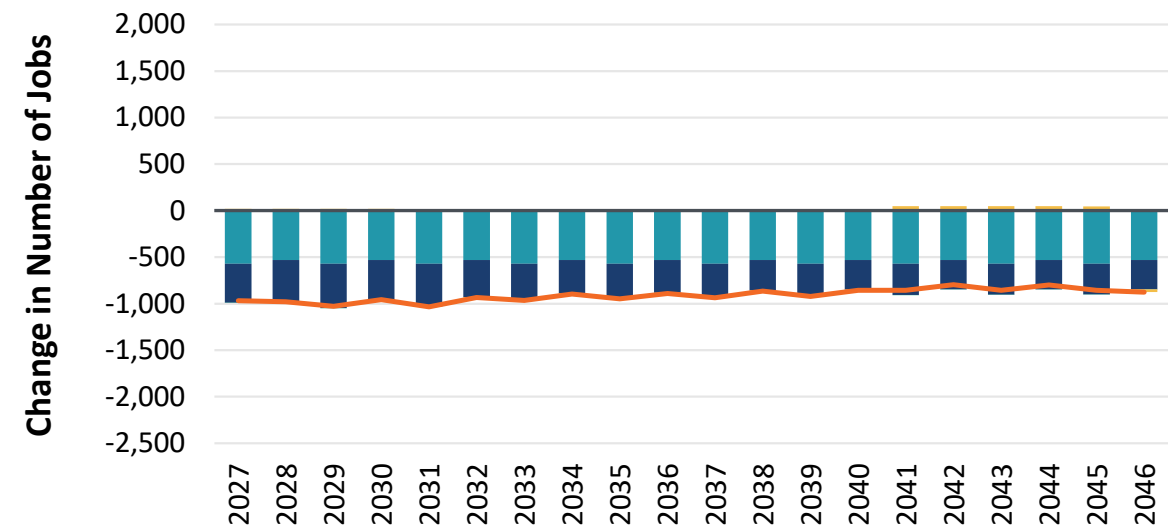
Among the counties surrounding CCEC, electricity sector investments are highest in Macon County, a neighboring county with a relatively large utility industry. As the investment in additional in-state generation resources needed after CCEC's closure is distributed regionally based on the size of the regions' utility industry, Macon county shows relatively large electricity sector investments that can offset the losses resulting from plant closure and higher electricity prices.

DeWitt County Impact

County GDP Impact
Clinton Off Scenario



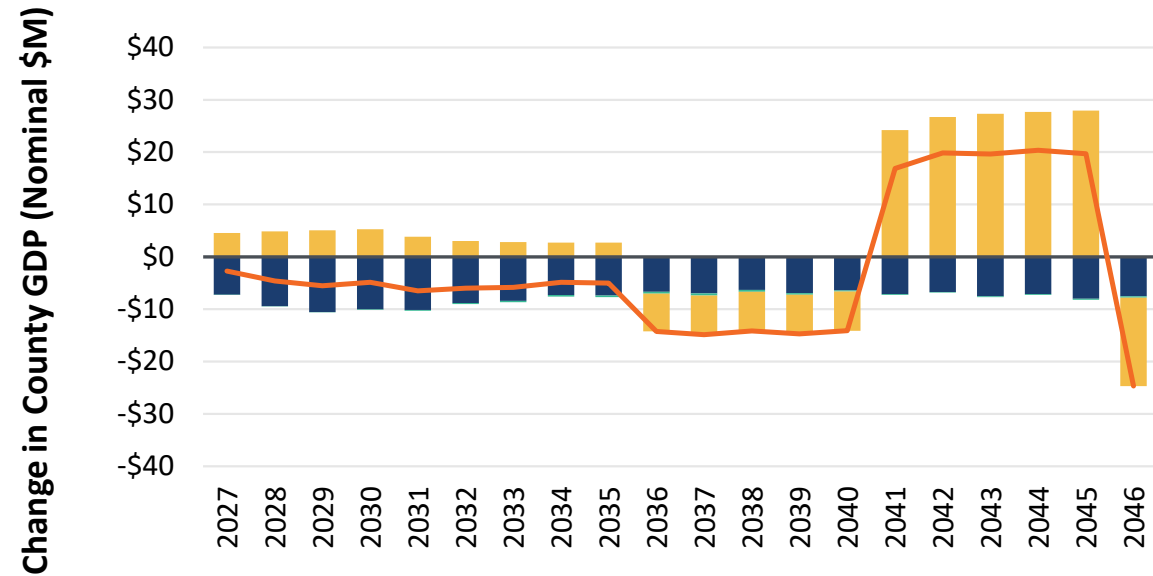
Employment Impact
Clinton Off Scenario



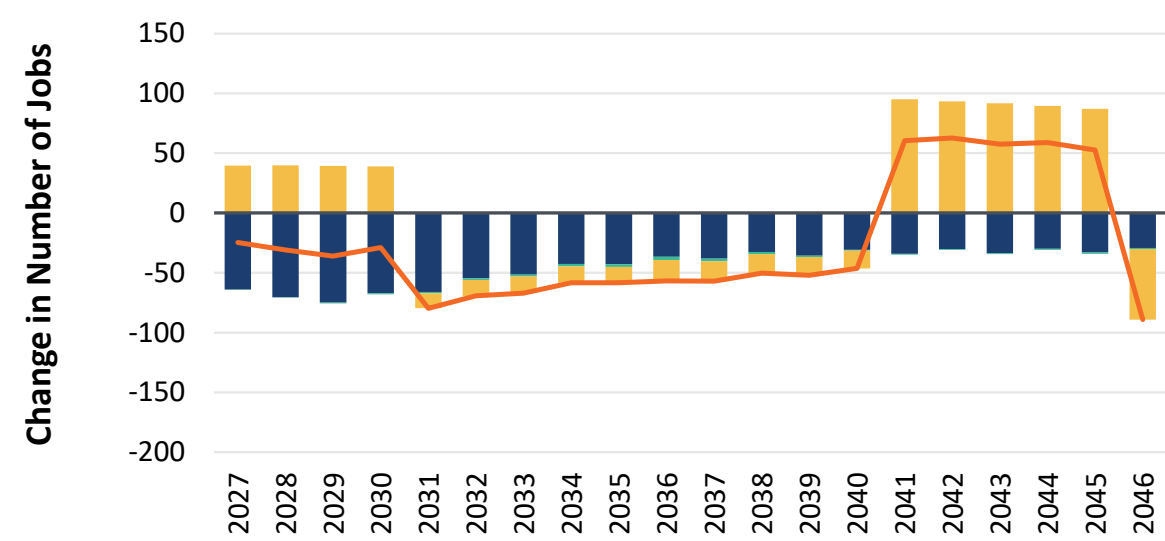
- Impact due to Electricity Sector Investment Change
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Macon County Impact

County GDP Impact
Clinton Off Scenario



Employment Impact
Clinton Off Scenario

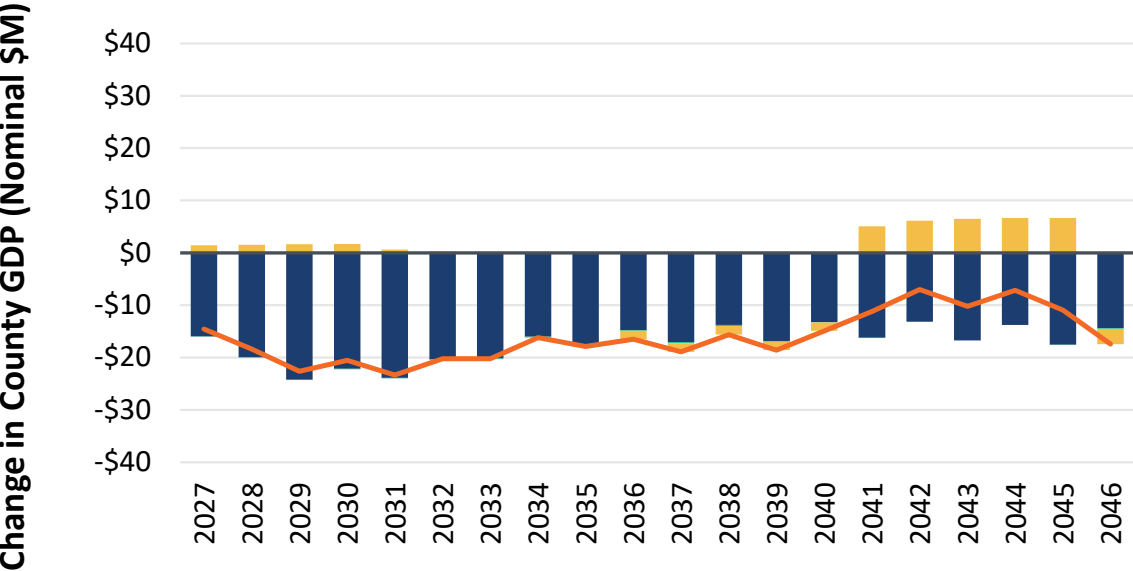


Macon County has a larger utility sector than other neighboring counties, resulting in a larger electricity sector investment impact.

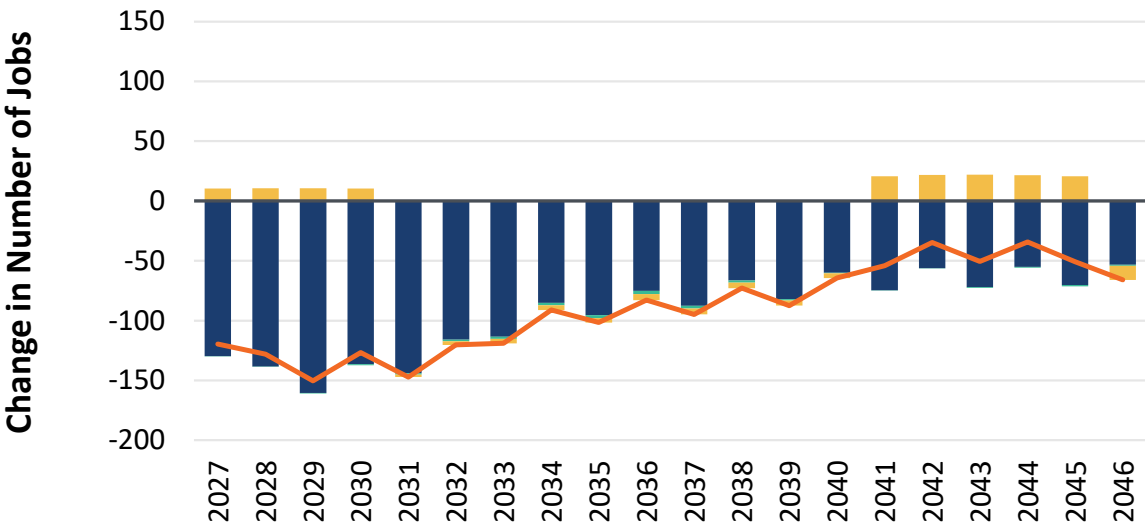
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McLean County Impact

County GDP Impact
Clinton Off Scenario



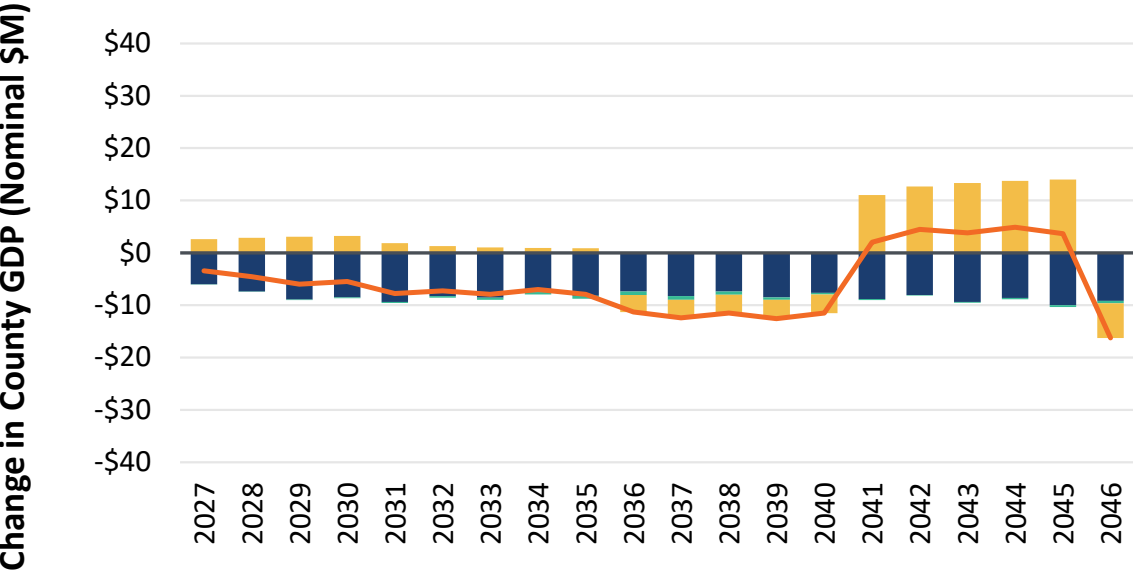
Employment Impact
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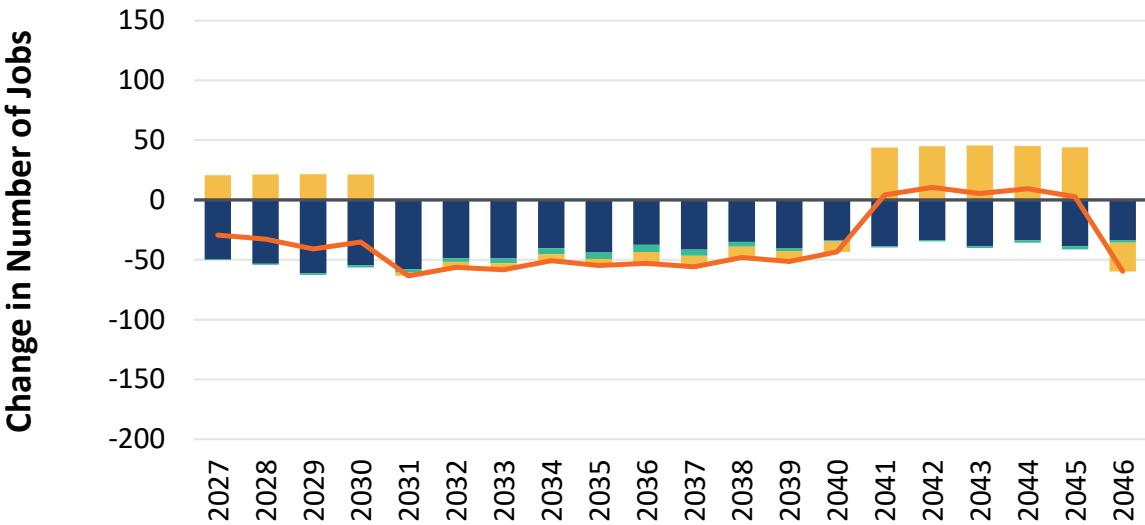
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Sangamon, Tazewell, Piatt, and Logan Counties Impact

County GDP Impact
Clinton Off Scenario



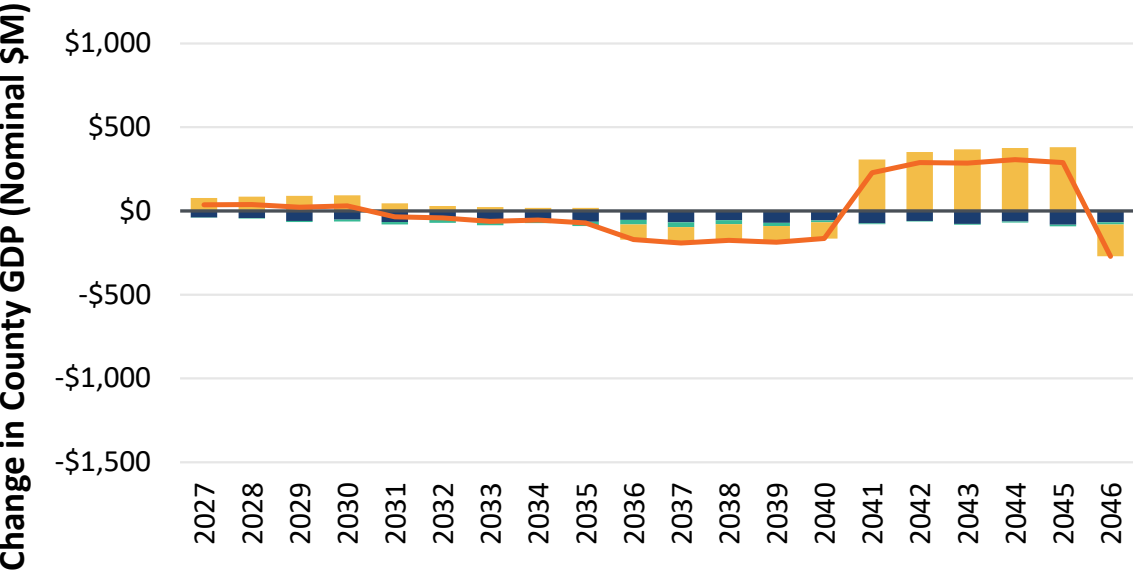
Employment Impact
Clinton Off Scenario



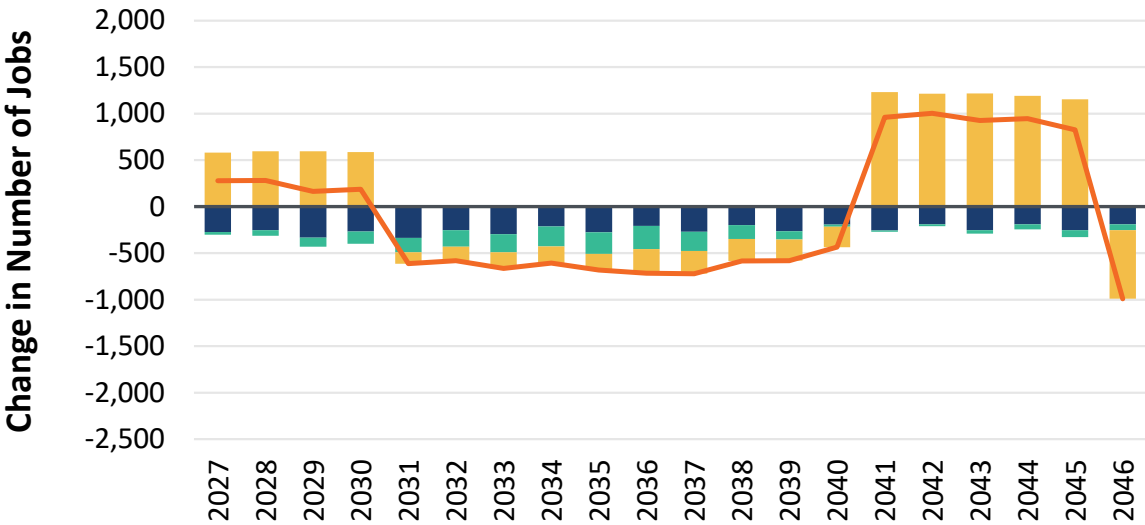
- Impact due to Electricity Sector Investment Change
- Impact due to Direct Plant Spending and Employment
- Impact due to Electricity Price Change
- Indirect Impact due to Change in Direct Spending at Plant
- Total Net Impact

All Other IL Counties Impact

County GDP Impact
Clinton Off Scenario



Employment Impact
Clinton Off Scenario



Impact due to Electricity Sector Investment Change
Impact due to Direct Plant Spending and Employment
Impact due to Electricity Price Change
Indirect Impact due to Change in Direct Spending at Plant
— Total Net Impact

Technical Appendix

Model framework and assumptions

REMI Model Assumptions

Modeling Economy-Wide Impacts in REMI

The **REMI Policy Insight Model** is a dynamic forecasting and policy analysis tool. REMI integrates input-output, computable general equilibrium and econometric methodologies to simulate policy impacts. The model evaluates key macroeconomic indicators including GDP, employment and industrial production.

We modeled the following aspects of relicensing the Clinton Clean Energy Center (CCEC):

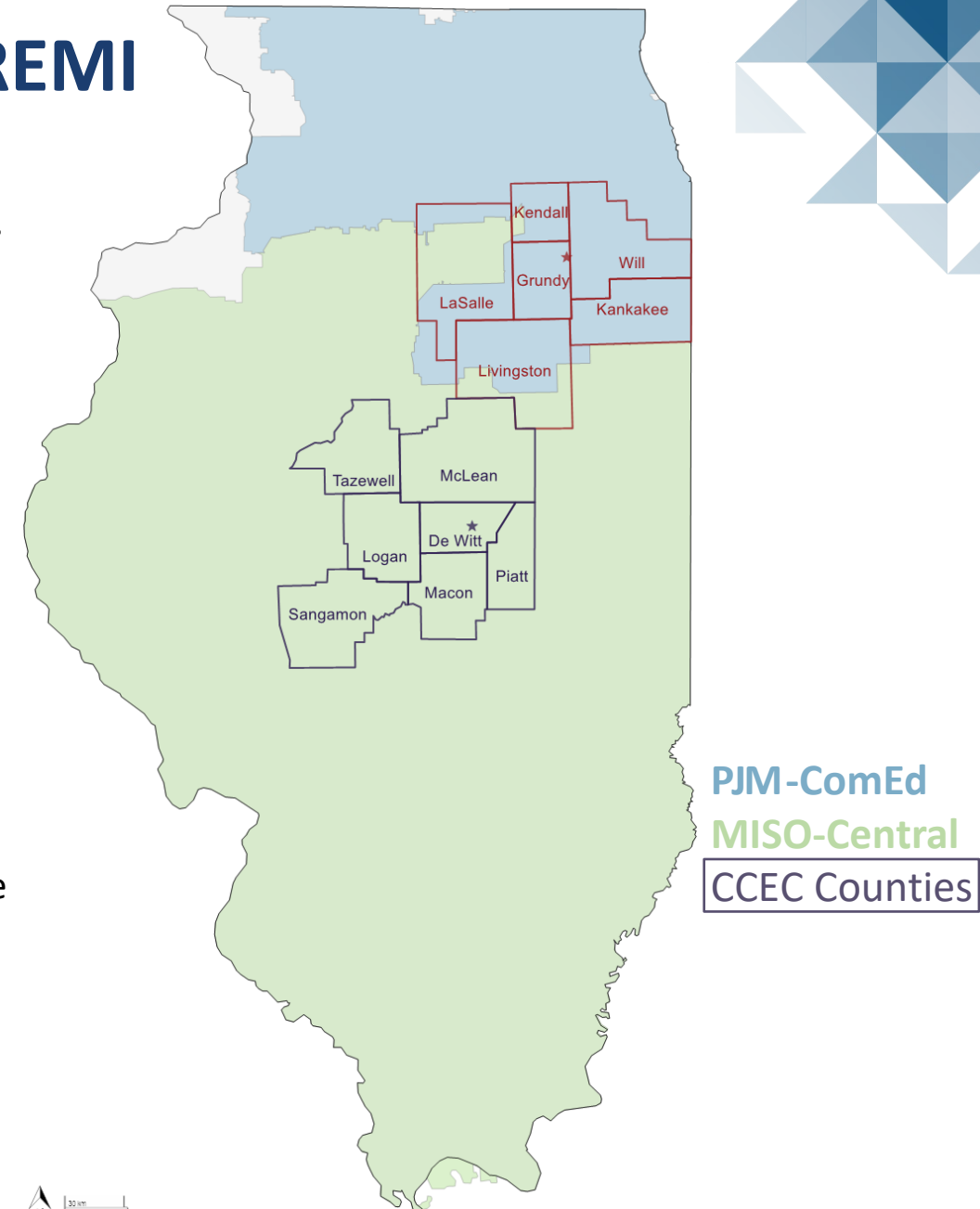
- **Direct Employment and Spending at CCEC:** All direct investments to operate Clinton were exogenously specified and are assumed to occur in DeWitt County. Resulting GDP and employment impacts in IL driven by the operation of CCEC are assessed using REMI.
- **Economic Activity Driven by Net Electricity Sector Impacts:** Changes in the power sector are estimated using Brattle's proprietary capacity expansion model, gridSIM. These projected impacts, including changes to the generation resource mix and electricity rates, are modeled in REMI to assess the impact IL's GDP and employment. Changes in system costs due to CCEC retiring are distributed across counties based on county population.

Two scenarios were analyzed:

- A reference scenario in which CCEC's license is extended
- An alternate scenario in which CCEC stops operations at currently scheduled retirement year

Modeling Electricity Price Impacts in REMI

- The retirement of CCEC results in change in electricity prices in IL. Change in electricity prices impacts consumption of both electricity and non-electricity goods and services for firms and households in the regional economy. Increase in prices often results in lower overall consumption for households and lower output for producers.
- REMI models the percent change in electricity prices at the commercial, industrial and consumer level, using price changes specific to PJM or MISO (determined by gridSIM).
 - For DeWitt county (the county in which CCEC is located) and its six neighboring counties, price changes are assigned based on the electricity market in which each county is predominantly located.
 - For the rest of Illinois, price changes are weighted proportionally to the population in the PJM and MISO regions.



gridSIM Model Assumptions

Modeling Electricity Sector Impacts in gridSIM



gridSIM, Brattle’s power sector capacity expansion model, was used to simulate the power sector impacts of relicensing the Clinton Clean Energy Center (CCEC). Energy demand, resource adequacy, market regulations and clean energy policies in Clinton’s regional electricity market as well as those in neighboring markets were accounted for in the analysis.

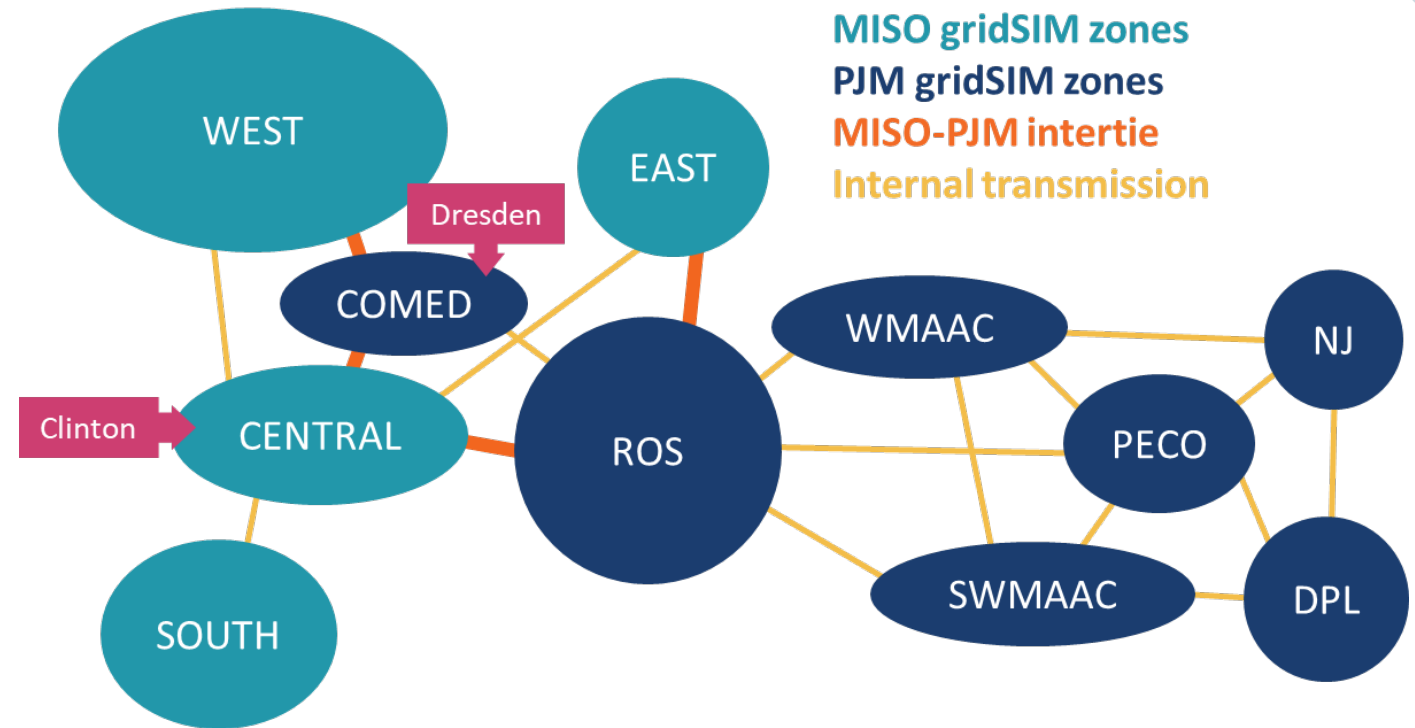
While CCEC is located within the PJM electricity market, other parts of Illinois fall within the MISO electricity market. MISO and PJM are connected, and power constantly flows between them depending on the conditions in each grid—retiring CCEC would therefore have material impacts on both markets. As such, MISO and PJM were modeled as a joint power system, allowing us to better capture these impacts. Power flows to other neighboring markets were also accounted for using historical data.

Two modeling scenarios were analyzed:

- A reference scenario in which CCEC’s license is extended
- An alternate scenario in which CCEC stops operations at currently scheduled retirement year

gridSIM Model Topology

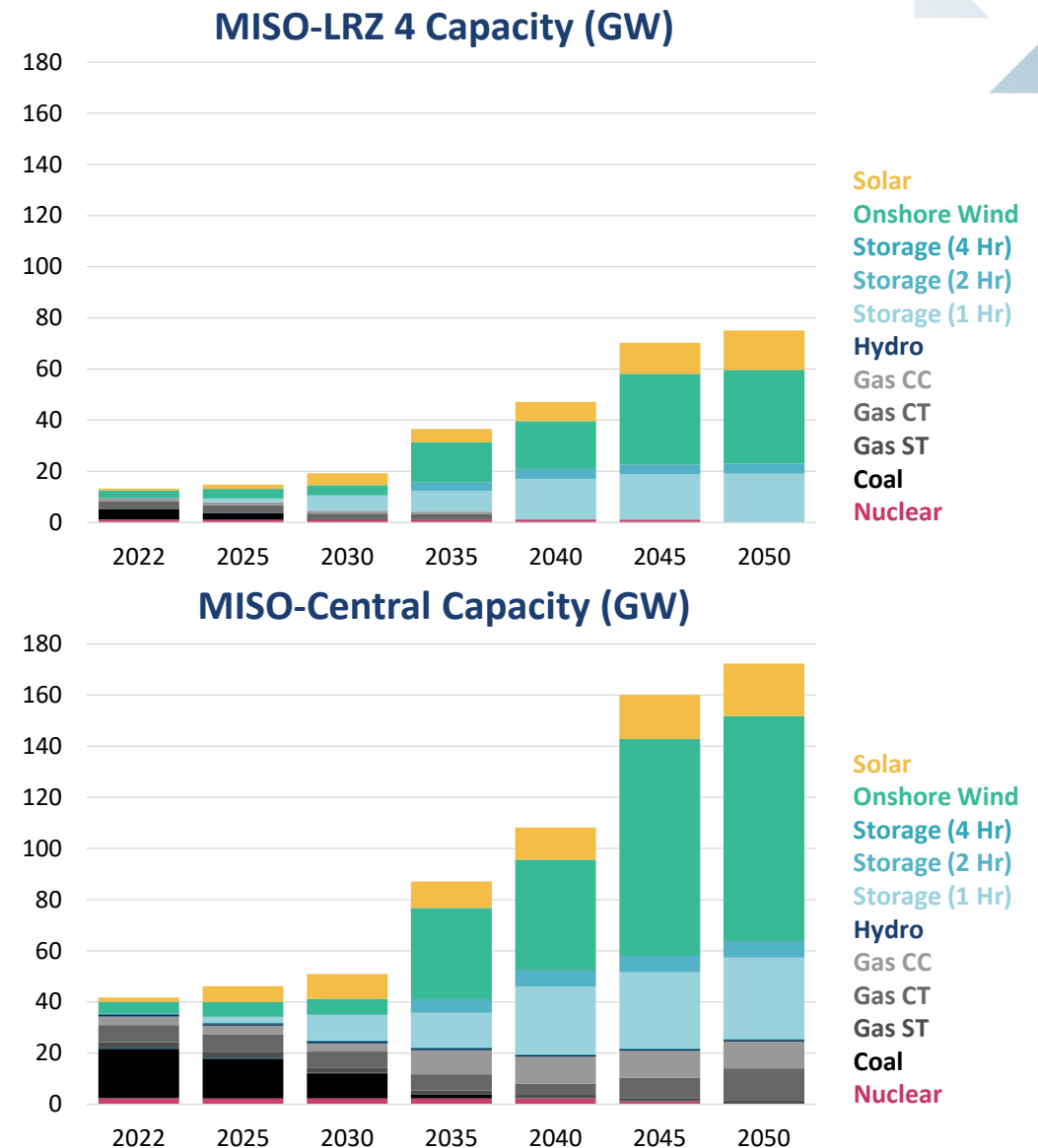
- gridSIM optimizes capacity expansion and generation across both MISO and PJM. Model topology is based on a pipe and bubble framework representing 11 MISO and PJM zones.
- Interchange limits between two connected zones are calibrated based on the physical transmission limits specified in the EPA's Integrated Planning Model (IPM).¹
- Net power flow between MISO and PJM at the system level is calibrated to maximum historical net transfer based on EIA Interchange Data.²



¹ [EPA's Integrated Planning Model](#) (v6 2021 Reference Case). Transmission limits from [Table 3-20](#) "Annual Transmission Capabilities of U.S. Model Regions."

² <https://www.eia.gov/opendata/browser/electricity/rto/interchange-data>.

- Historical capacity by state.
- Planned additions and retirements in each state.
- State policies, including CEJA and RPS targets (most new renewable builds in the MISO-Central region takes place in Illinois due to CEJA).
- Resource adequacy requirements in MISO and PJM.



Load Growth Modeling

PJM inputs:

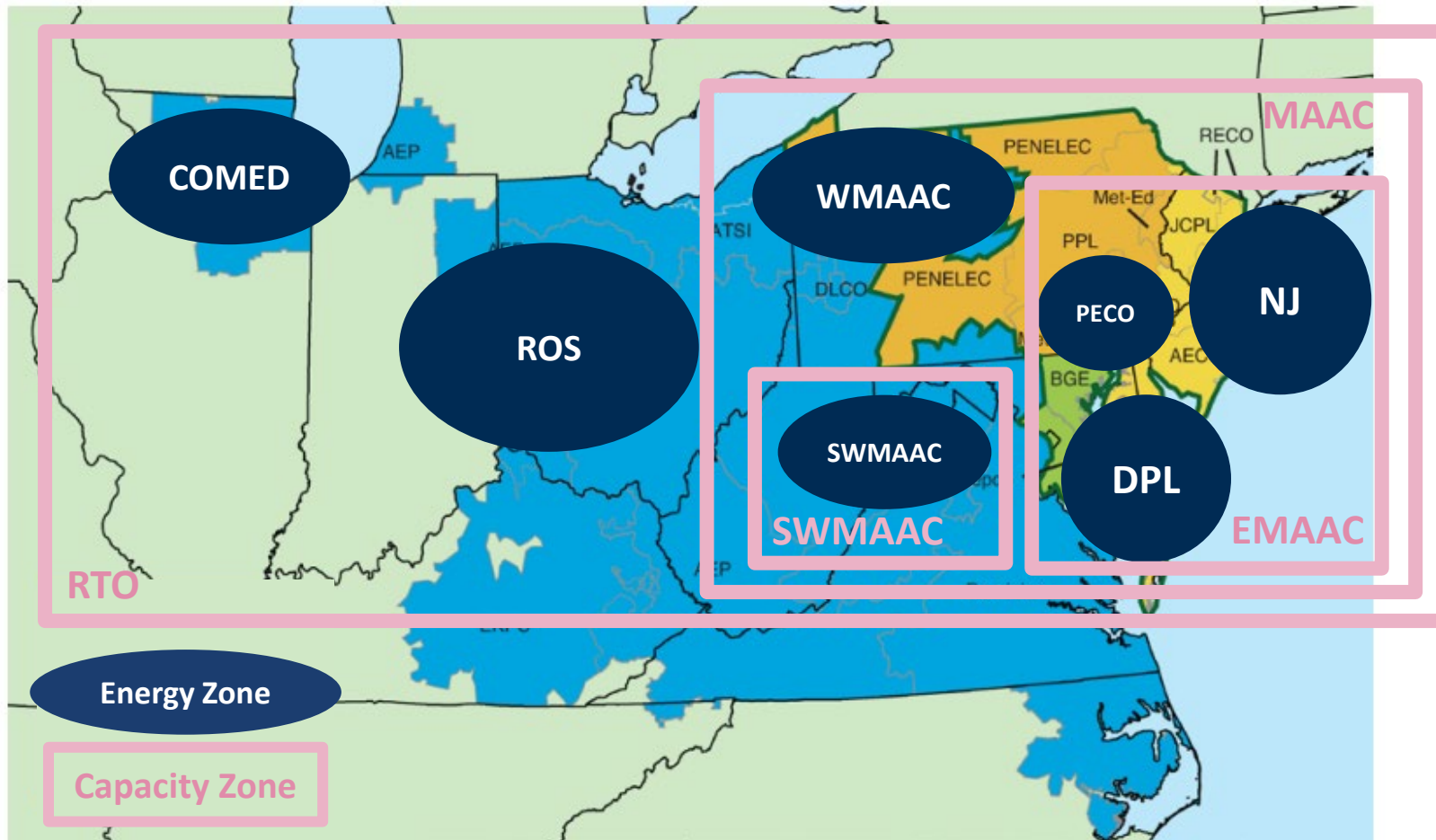
- [PJM 2024 Load Forecast Report](#): includes projections of electric vehicle, heating load and behind-the-meter generation.
 - Heating load shapes were derived using heating degree day data from [NOAA](#).

MISO inputs:

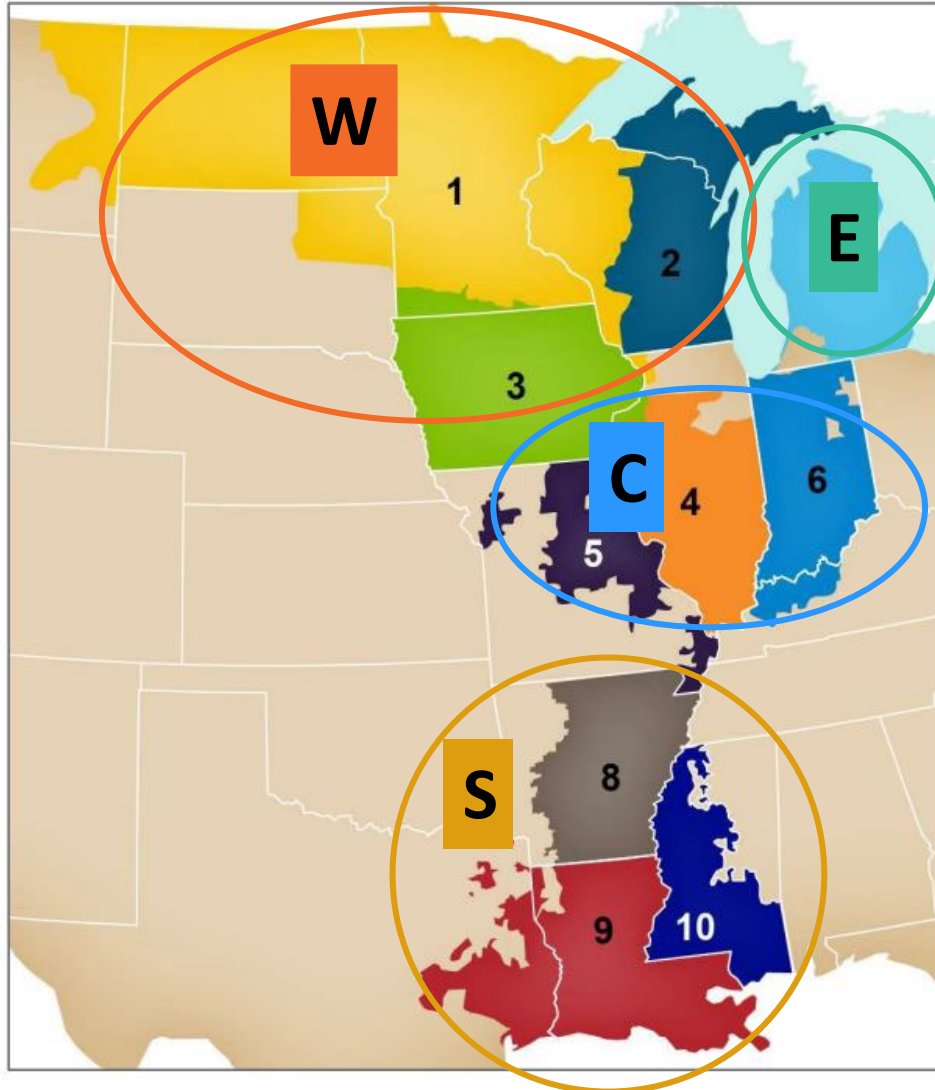
- Base load growth forecasts to 2050 from [2023 MISO Independent Energy and Peak Demand Forecast](#) by Purdue University.
 - Transport & heating electrification not considered in base.
- Anticipated EV uptake based on Future 2 of MISO's [Futures Report](#).
 - EV load shapes taken from US DOE [EVI-Pro Lite](#) tool.
- Anticipated electrified heating uptake based on Future 2 of MISO's Futures Report.

Nested Capacity Zones in PJM

PJM's Nested Capacity Zones



Modeled MISO Zones



| SIM Zone | Local Resource Zones |
|----------|----------------------|
| WEST | 1, 2, 3 |
| CENTRAL | 4, 5, 6 |
| EAST | 7 |
| SOUTH | 8, 9, 10 |

Sub-regional Planning

- These zones are used in the MTEP process to review transmission solutions on a more local basis
- Solutions submitted, reviewed, and analyzed by stakeholders



Overview of Modeled Policies

- **Renewable and Clean Energy Goals:**

- Clean energy targets are modeled at the state level, including technology-specific procurement targets.

- **Emissions Reduction Goals:**

- For PJM, carbon emissions limits are modeled based on state decarbonization goals.
- For MISO, carbon emissions limits are modeled based on a combination of state and utility decarbonization goals.

- **Inflation Reduction Act:**

- Production tax credits (PTC) are modeled for solar, onshore wind, and nuclear generation. Hydrogen PTCs are incorporated into the fuel costs for H2 resources.
- Investment tax credits (ITC) are modeled for offshore wind and battery storage.

- **Section 45Q Credit for Carbon Oxide Sequestration**

- Tax credit for carbon capture and storage (CCS) is modeled for all new and retrofitted CCS units.

- **Climate and Equitable Jobs Act:**

- Currently, we model a 2045 zero-emissions deadline for IL as outlined in CEJA. The emissions limit slopes linearly from present-day levels down to zero in 2045.
- [CEJA](#) does not explicitly call for the retirement of fossil units. However, plants that don't comply with emissions targets by the deadline (e.g., through CCS) will be forced to retire. Our model implements a phased retirement or retrofit of fossil units according to the timeline identified by the [IL Dept. of Labor](#).

Modeled Policies in PJM

| State | Renewable and Clean Energy Goals | Emissions Reduction Goals (2005 Baseline) |
|-----------------------|--|--|
| Delaware | RPS : 40% by 2035 (10% from solar) | 50% reduction by 2030, 100% by 2050 (de.gov) |
| DC | RPS : 100% by 2032 (5.5% Solar) | Carbon free by 2032 (dccouncil.gov) |
| Illinois ¹ | RPS : 40% by 2030, 50% by 2040 (55% solar and 45% wind) CES : 100% by 2045 | Carbon free by 2045 (ilga.gov) |
| Maryland | RPS : 52.5% by 2030 (50% Tier I, 2.5% Tier II) | 60% reduction by 2031, net zero by 2045 (md.gov) |
| New Jersey | RPS : 52.5% by 2032 (50% Class I, 2.5% Class II) CES : 100% by 2050 | Carbon free by 2050 (nj.gov) |
| North Carolina | RPS : 12.5% (completed) | Carbon free by 2050 |
| Ohio | RPS : 8.5% by 2026 | n/a |
| Pennsylvania | RPS : 18% (completed) | 80% reduction by 2050 (pa.gov) |
| Virginia | RPS : 100% by 2050 (APCo), 100% by 2045 (DOM) CES : 100% by 2050 (APCo), 100% by 2045 (DOM) | Carbon free by 2045 (va.gov) |

¹ RPS and CES obligations are split proportionally based on the amount of IL load located in MISO vs PJM.

Modeled Policies in MISO

| State | Renewable and Clean Energy Goals | Emissions Reduction Goals (2005 Baseline) |
|-----------------------|---|--|
| Illinois ¹ | RPS : 40% by 2030, 50% by 2040 (55% solar and 45% wind) CES : 100% by 2045 | Carbon free by 2045 (ilga.gov) |
| Indiana | RPS : 10% by 2025 | n/a |
| Iowa | RPS : 105 MW (completed 2007) | n/a |
| Louisiana | RPS : 80% by 2050 | Net zero GHG by 2050 (MISO) |
| Minnesota | RPS : 10% solar by 2030, 55% by 2035 CES : 90% by 2035, 100% by 2040 | Carbon free by 2040 (MISO) |
| Michigan | RPS : 50% by 2030, 60% by 2035, 100% by 2040 | Carbon neutral by 2050 (MISO) |
| Missouri | RPS : 15% by 2021 (2% from solar) | n/a |
| Wisconsin | RPS : 10% by 2015 | Carbon free by 2050 (MISO) |

¹ RPS and CES obligations are split proportionally based on the amount of IL load located in MISO vs PJM.

[illegible]

Climate and Equitable Jobs Act (CEJA)

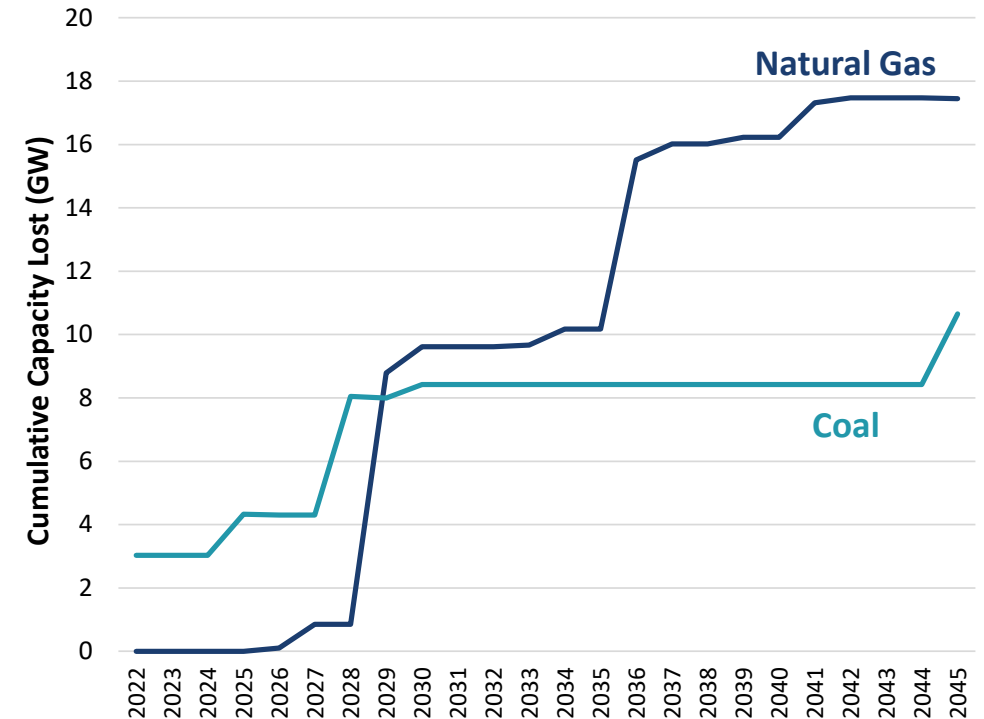
- **Statewide Emissions:**

- We model a 2045 decarbonization goal for IL's electric sector, which slopes linearly from present-day levels down to zero carbon emissions in 2045.

- **Unit Level Emissions:**

- CEJA mandates zero emissions deadlines for GHG-emitting units according to their NOx and SO2 emissions and the unit's proximity to an environmental justice (EJ) community or equity investment eligible community (EIEC).
 - ▶ Plants that don't comply with emissions targets by the deadline (e.g., through CCS) will be forced to retire.
- We model a phased retirement of fossil plants based on analysis by the IL Dept. of Labor, which identifies retirement dates for each coal and gas plant in the state.

Coal and Gas Retirements in Illinois



Source: [Climate and Equitable Jobs Act Economic and Workforce Effects Preliminary Analysis](#), Illinois Department of Labor.

Nuclear Assumptions

- **Generation:** Nuclear generation is modeled using a monthly average capacity factor for each ISO. This average capacity factor is based on 5 years of historical data (2018-2023).
- **Retirements:** Retirements of all nuclear units in PJM and MISO (except Clinton/Dresden) are consistent with license information from the [Nuclear Energy Institute](#).
 - In the Reference scenario, Clinton is assumed to operate to the extended retirement year (2046). In the Retirement scenario, Clinton is assumed to retire in 2027.
 - In both scenarios, Dresden is assumed to operate to its extended retirement year (2049 for Unit 2; 2051 for Unit 3).

Summary of Clinton Assumptions

| Assumption | Clinton |
|-------------------------------------|---------|
| Net Summer Capacity (MW) | 1,065 |
| Currently scheduled retirement year | 2027* |
| Extended retirement year | 2046 |

*Note: The scheduled retirement for Clinton is 9/29/2026. gridSIM retires units annually, so the plant's retirement is modeled at the start of 2027.

Carbon Capture and Sequestration (CCS) Costs and Operations

- Model can choose to retrofit existing NG CC or Coal units or build new NG CCs with CCS beginning in 2030.
- Increased costs and reduced efficiency due to parasitic load.
- 45Q Credit of \$60/ton applied based on credit for geologically sequestered CO₂ with EOR, meeting certain wage requirements.
 - Only CCS resources constructed prior to 2033 are eligible, but we assume the credit will be extended through all model years.

Parameters for Gas and Coal with Carbon Capture

| Parameter | Assumption | Source |
|----------------------------------|--|---|
| First Allowed Build Year | 2030 | NREL, DOE |
| Carbon Capture Rate | 95% | NREL ATB 2023 |
| Capital Cost (\$/kW) | New NG CC w/ CCS: \$2,716 NG CC Retrofit: \$1,325 Coal Retrofit: \$2,137 | NREL ATB 2023 |
| FOM (\$/kW-yr) | New NG CC w/ CCS: \$65 NG CC Retrofit: \$68 Coal Retrofit: \$153 | NREL ATB 2023 |
| VOM (\$/MWh) | New NG CC w/ CCS: \$4.76 NG CC Retrofit: \$4.95 Coal Retrofit: \$17.17 | NREL ATB 2023 |
| Fuel Cost | No change in fuel cost assumptions | |
| Transport and Sequestration Cost | \$15/ton-CO ₂ | Energy Futures Initiative |
| Tax Credits | \$60/ton-CO ₂ from 45Q Credit | congress.gov |
| Parasitic Losses | 30% losses from parasitic load | Advanced Post-Combustion CO2 Capture (mit.edu); Global CCS Institute |

Hydrogen Costs and Operations

- Model can build hydrogen turbines or retrofit existing NG CTs beginning in 2036.
- PTC credit of \$3/kg is applied through 2043.

Parameters for Hydrogen Gas Turbine

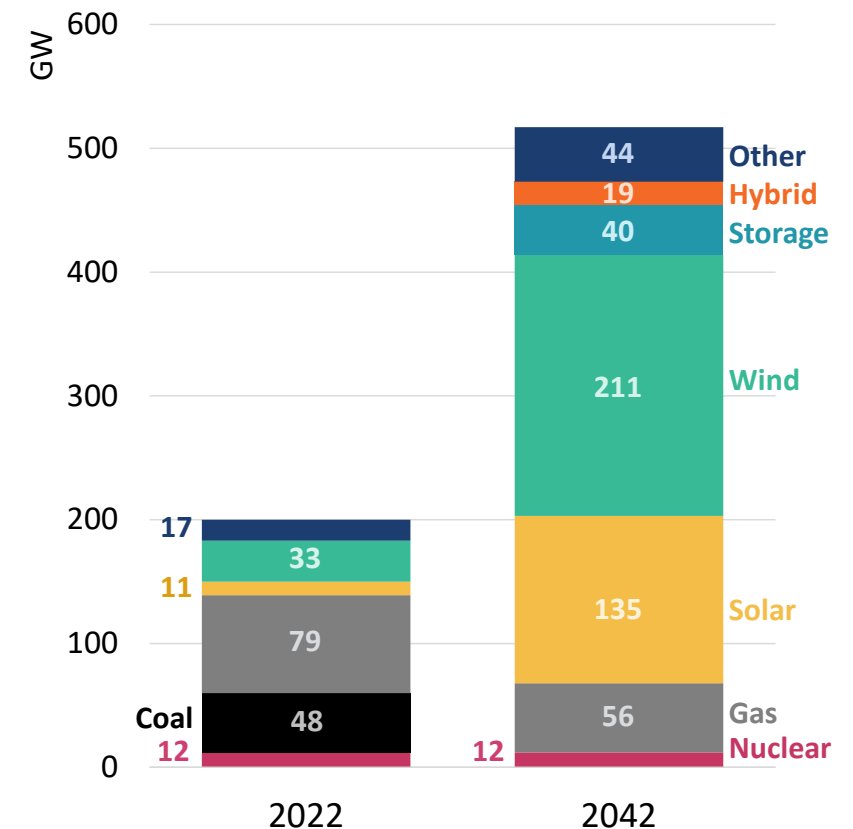
| Parameter | Assumption | Source |
|--------------------------|--|---|
| First Allowed Build Year | 2036 | MISO Futures report adds “Flex” resources in 2027; IL production cost modeling introduces zero emissions fuels in 2045 |
| Operating Parameters | Operations are the same as NG CT | |
| Capital Cost (2020\$/kW) | New build: \$1,320 and follows same cost trajectory through 2050 as NG CT from NREL ATB Retrofit: 25% of NG CT capital cost | MIT 2021 (new build); ETN Global (retrofit) |
| FOM | Same as NG CT | NREL ATB 2023 |
| VOM | Same as NG CT | NREL ATB 2023 |
| Fuel Cost | Production and delivery cost: \$6.25/kg or \$46.64/MMBtu | Production cost of hydrogen produced through polymer electrolyte membrane (PEM) electrolysis from DOE H2A Production Analysis , Baseline scenario. Delivery costs from DOE Liftoff Report . |
| Tax Credits | Production Tax Credit (PTC) of \$3/kg | DOE |

Storage Assumptions

- Annual build limits are implemented for storage resources in MISO to align with the 2023 MISO Futures report.¹
- Storage build limits are derived from Future 3A (the most aggressive decarbonization scenario) to set an upper bound on storage penetration.
- Between 2022-2042, Future 3A adds 40 GW of Battery, 19 GW of Hybrid, and 44 GW of Other.
 - We assume 9.5 GW of Hybrid resources are batteries.
 - The report indicates that the majority of “Other” is comprised of demand response, non-PV distributed generation, and energy efficiency. We include “Other” in our calibration of storage resources to acknowledge uncertainty in storage penetration.
- This results in around 94 GW added over 20 years. As such, we have implemented a 5 GW annual build limit for storage.

¹ https://cdn.misoenergy.org/Series1A_Futures_Report630735.pdf

2022 and 2042 Capacity Mix for MISO Future 3A



Retail Electricity Price Impact

- **Energy prices (\$/MWh):**
 - Energy prices are calculated as the marginal cost of energy in each hour. The annual energy price is the load-weighted average price.
- **Capacity prices (\$/MW-yr):**
 - Capacity costs are calculated based on Net Cost of New Entry (CONE). Net CONE is the sum of fixed O&M and capital costs minus revenues obtained through the energy, ancillary services, and ZEC markets.
 - Net CONE is divided by each resource's accredited capacity to obtain a \$/MW-yr cost. The capacity price is set by the most expensive resource in each zone.
- **Wholesale electricity prices (\$/MWh):**
 - Energy, capacity, and ZEC prices are converted to \$/MWh and summed to calculate an all-in wholesale electricity price.
- **All-in retail electricity price impact (%):**
 - The retail price impact is calculated as one-third of the wholesale electricity price impact, based on the assumption that T&D costs remain fixed.

Notice and Disclaimer

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All results and any errors are the responsibility of the authors and do not represent the opinions of The Brattle Group or its clients.

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