

A Clean Energy Future is Cheaper than Coal for JEA's Customers

June 2022



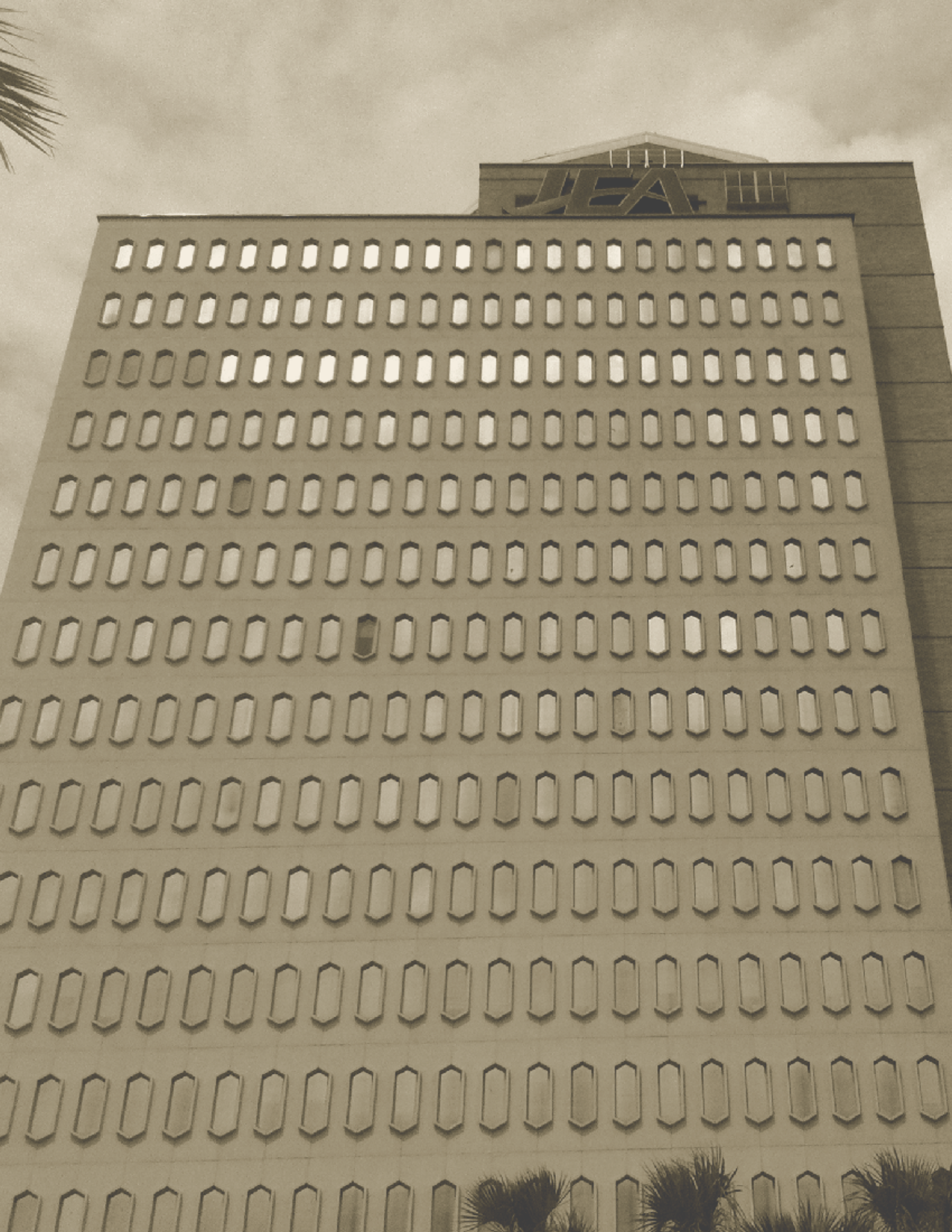


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EXECUTIVE SUMMARY

JEA is Florida's largest municipal utility, serving nearly 490,000 customers in Jacksonville. In 2021, JEA met 98 percent of their electricity demand with fossil fuels, including two large coal units at the Northside Generating Station.

JEA has made a series of decisions that have led to rising costs. The utility raised customer bills by roughly 12 percent at the end of 2021, and additional cost increases are likely as fossil fuel prices continue to rise.

But there is another path forward. JEA has an opportunity to reduce costs for their customers while significantly reducing greenhouse gas emissions and local air pollution. JEA is currently developing an Integrated Resource Plan (IRP) that will guide the next ten to twenty years of its power generation. The IRP presents JEA an opportunity to examine the current costs of its fleet of power plants as well as assess the current market for cost effective, clean options.

For this report, Sierra Club used a robust, open-source electricity sector planning model that was developed by researchers at MIT and Princeton and published in multiple peer-reviewed studies. This model was used to evaluate the benefits of retiring coal and transitioning to clean, carbon-free electricity sources like solar and energy storage. We find:

- Retiring and replacing Northside Units 1 and 2 with clean, renewable energy could save JEA customers at least \$15 million per year, and possibly \$60 million per year or more if fossil fuel prices remain high. At the same time this transition could reduce JEA's carbon dioxide emissions by 55 percent, and local air pollution emissions by over 65 percent.

- A more ambitious transition to 80% carbon-free electricity sources by 2030 can meet JEA's electricity demand reliably, and is cheaper than JEA's current plan if fossil fuel prices remain elevated. Moreover, this more ambitious clean energy portfolio protects customers from extreme fossil fuel price spikes like those we have experienced in early 2022, while reducing carbon dioxide emissions by nearly 80 percent and virtually eliminating local air pollution from power plants.

JEA needs to seize this opportunity in their ongoing IRP process, to lower costs for customers, reduce exposure to volatile fossil fuel prices, and transition to a reliable portfolio of clean energy resources. Specifically, JEA should:

- Retire Northside units 1 and 2 by 2030 or sooner and meet future resource needs with clean, renewable energy sources, not fossil fuels
- Establish plans to significantly reduce greenhouse gas emissions and local air pollution from JEA's power plants by 2030
- Adopt more ambitious energy efficiency targets and programs to offset demand growth and lower customer costs and prioritize efficiency investments in low income and high energy burden communities
- Account for fuel price volatility in resource planning and choose portfolios that lower risks
- Use all-source requests for proposals to get the best deal on clean energy portfolios

JACKSONVILLE RELIES ON EXPENSIVE, DIRTY, AGING COAL POWER

JEA is a municipal electric and water utility in the city of Jacksonville, Florida. The utility provides electricity service to nearly 490,000 customers, making it the fourth largest utility (and the largest municipal utility) in Florida.

Nationally, JEA is the fifth largest municipal utility. JEA's service territory is shown in Figure 1 below. JEA has long been reliant on coal and gas to generate electricity, and has a history of mismanagement and decisions that impose substantial costs on customers. The utility raised customer bills by roughly 12% at the end of 2021, and additional cost increases are likely as fossil fuel prices rise and the high cost of power purchased from the Vogtle 3 and 4 nuclear reactors are passed through to customers.

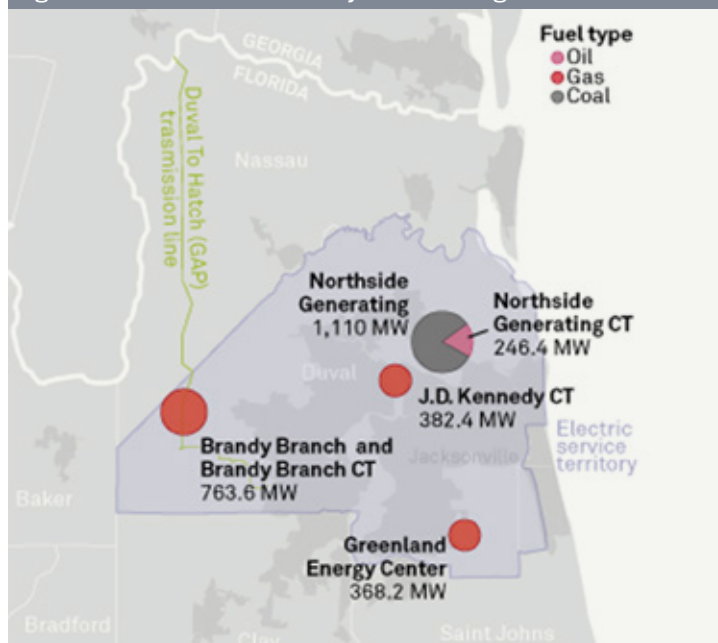
This report outlines a path for JEA to reduce costs for customers, while at the same time reducing the risk of future cost increases driven by volatile fossil fuel prices and putting JEA on a pathway to significantly reduce greenhouse gas emissions and local air pollution. JEA is currently in the process of developing an Integrated Resource Plan (IRP) that will guide the next ten to twenty years of its power generation. The IRP presents JEA an opportunity to examine the current costs of its fleet of power plants as well as assess the current market opportunities for cost effective, clean options.

Unfortunately, JEA has a very small margin of error when it comes to making a plan that won't expose its ratepayers to financial risk. JEA's decision in 2008 to sign on with the Municipal Electric Authority of Georgia (MEAG), which is a part owner of the Vogtle nuclear plant, has left JEA's ratepayers exposed to increasing financial uncertainty as the nuclear plant continues to run over budget and over schedule. In fact, MEAG informed JEA that its share of the Vogtle nuclear plant is \$3.2 billion and JEA's payments on the roughly \$2.8 billion of debt issued by MEAG to date totals \$2.6 billion for fiscal years 2022 through 2043.¹ "For every month of delay, JEA officials say the construction expense increase adds \$8 million in costs for its ratepayers."²

At the same time, fossil fuel prices have shot up substantially. Fossil gas, used to generate 65% of JEA's electricity in 2021, has seen price increases of 140% or more in one year. According to data reported to EIA, coal purchased by JEA to burn at Northside has seen prices double in the past year. Continued reliance on fossil fuels exposes customers to volatile global commodity markets, and these risks and costs are passed through to customers in the form of higher rates.

With these costs looming, it is incumbent upon JEA to create a path to reliable, efficient, resilient, and affordable energy. The following report will demonstrate that investments in renewable energy, energy storage, and demand-side efficiency and conservation programs will clear a path to meet each of these criteria. More importantly, through investments in renewable energy JEA will safeguard its ratepayers from the volatility that comes with fuel delivery specific to burning fossil fuels. JEA's future can not only be clean and reliable but it can save ratepayers from price spikes that are beyond the control of the utility.

Figure 1: JEA Service Territory and Existing Power Plants



Source: S&P Global. Size of circles representing power plants reflects generating capacity (MW).

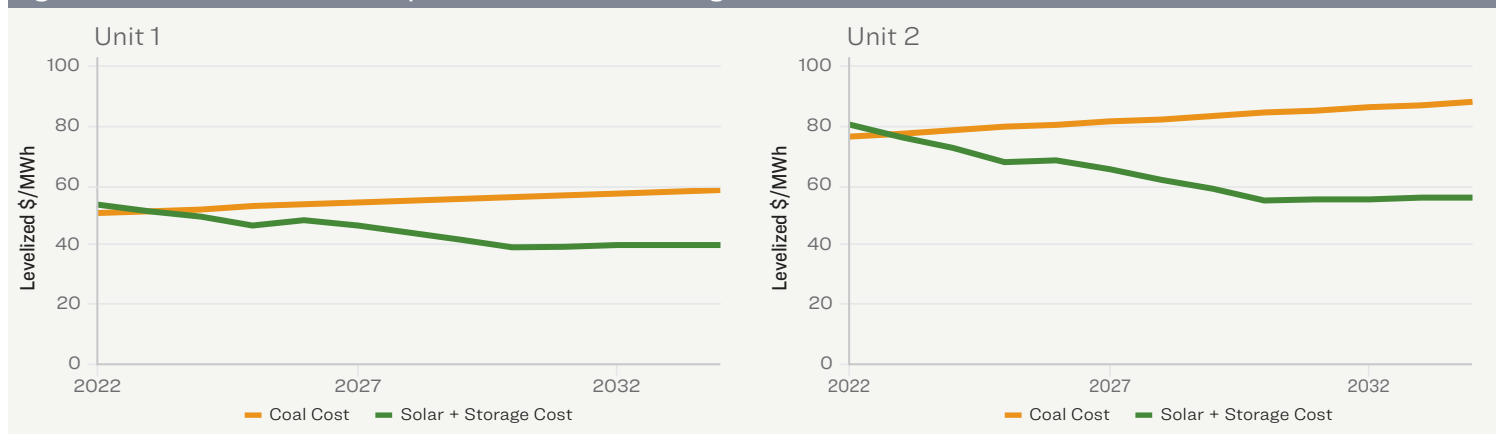
JEA meets over 98% of their energy needs with coal, gas and oil — fossil fuels that contribute to climate change.³ In 2020, JEA agreed to retire their share of one unit of Plant Scherer, one of the largest coal-burning power plants in the US.⁴ However, coal still accounts for 22 percent of JEA's energy mix, down only slightly from 24 percent in 2020. Gas accounted for over 76 percent of JEA's energy mix in 2021, including gas power purchased from neighboring utilities.⁵ While gas has somewhat lower direct greenhouse gas emissions, gas production, processing and transportation emits significant amounts of methane, a greenhouse gas that is over 80 times as potent as carbon dioxide.⁶

JEA plans to continue operating two coal-fired units at their Northside power plant indefinitely. These two units were originally built in 1966 and 1972, but JEA rebuilt the plant's boilers in 2000. However, these units are significant polluters. In 2021, Northside Units 1 and 2 emitted 1.7 million metric tons of carbon dioxide (CO₂), 1,383 tons of sulfur dioxide (SO₂), and 386 tons of nitrogen oxides (NO_x), and the Northside facility has been in the three largest NO_x emitters among Florida Power Plants since 2020 and 2021. CO₂ emissions are the main driver of climate change, while SO₂ and NO_x are potent local air pollutants with significant health impacts. According to analysis conducted by Clean Air Task Force, these two coal units result in an estimated 11 premature deaths per year, and additional health impacts like 112 additional asthma attacks per year.⁷ Northside 1 and 2 both lack best-in-class controls for nitrogen oxides, called selective catalytic reduction controls.

Northside's coal units are also expensive. Based on publicly available data on fuel costs, as well as estimates of operating and maintenance costs and going-forward capital expenditures and operations, Northside units 1 and 2 have an expected going-forward cost (cost of simply continuing operations, excluding recovery of past investments) of \$51/MWh and \$76/MWh, respectively.⁸

For comparison, the full cost of building and operating new solar in Florida is estimated at roughly \$35/MWh today based on publicly available cost estimates and, recent power purchase agreements in the region are as low as \$25/MWh. However, solar alone isn't a complete replacement for a dispatchable power plant. But pairing solar with multiple hours of battery energy storage can provide the same or better reliability benefit as a fossil fuel plant, in many cases. Solar plus storage, sized to meet the annual energy output and capacity provided by Northside 1 and 2, is expected to be cheaper to build and operate after 2023 than the cost of continued operations of these coal plants. Figure 2 below shows the levelized cost of energy (LCOE) of solar plus storage, as compared to the cost of continuing to operate Northside 1 and 2.

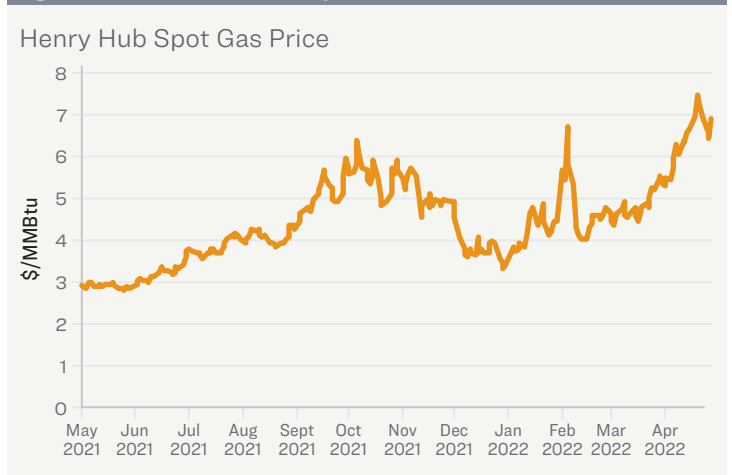
Figure 2: Cost of Continued Coal Operations vs. Solar + Storage



Source: Sierra Club Analysis

In addition, JEA relies significantly on gas-burning power plants. Gas accounted for 65% of JEA's energy mix, and JEA plans to continue to rely on fossil gas for the majority of their energy needs through 2030. Gas prices are extremely volatile. As Figure 3 shows gas prices have nearly doubled over the last year. Like many other utilities, JEA does not bear the risk of gas price swings. They pass through fuel costs to customers, putting their customers on the hook for significant cost increases. Gas not only has significant price risk, but reliability issues. In February 2021, freezing temperatures across Texas froze gas supplies and power plants. Because gas supplies and power plants froze, they were not able to provide energy just when it was needed most. Gas plant outages were the main driver of blackouts that put over 4 million customers in the dark for days during freezing temperatures.⁹

Figure 3: Gas Price Volatility



Source: S&P Global

JEA has previously stated their intention to retire Northside Unit 3 by 2026, an inefficient, inflexible, and uneconomic gas unit co-located with the coal units described above. Our modeling in this study accounts for this anticipated retirement. However, JEA has not formally committed to this retirement, and it is not reflected in their latest Ten Year Site Plan (TYSP).¹⁰

A CLEAN ENERGY TRANSITION FOR JEA IS AFFORDABLE AND FEASIBLE

Sierra Club conducted an analysis using publicly available data and an open source capacity expansion modeling software called GenX developed by researchers at MIT and Princeton.¹¹ Details of this analysis, data sources, key inputs, and modeling approach are provided in the appendix. This analysis selects a combination of existing power plants (like JEA's existing and planned plants) and new resources (such as solar and storage) that minimizes electricity system costs, simulates the dispatch of JEA's electricity system in every hour of the year, and ensures the resulting system is reliable across a wide range of grid conditions.

We evaluated and compared three scenarios, each modeled using a resource portfolio, demand projection and expected costs as of 2030:

- **JEA'S PLAN:** This scenario is based on JEA's resource portfolio from their 2021 Ten Year Site Plan, with the removal of Northside 3 which is expected to retire in 2026. As JEA's Ten Year Site Plan does not include the retirement of Northside 3, we allow additional gas capacity (combined cycle or open cycle gas turbine) to be selected by the model to meet incremental capacity needs. This scenario uses JEA's load forecast and planned energy efficiency from the same TYSP.

- **RETIRE COAL:** This scenario makes the following changes to JEA's Plan. First in this scenario we retire Northside Units 1 and 2, and allow only clean energy resources (wind, solar, energy storage) to replace the units. In addition, this scenario incorporates 0.9% of additional incremental energy efficiency per year, offsetting expected load growth through 2030. Other assumptions are consistent with the JEA's Plan scenario. This scenario results in a system that meets over 60% of demand with carbon emissions-free energy sources.

- **80% CARBON-FREE:** This scenario is the same as above, but includes a target of 80% of demand being met by carbon-free resources (wind, solar, energy storage, and JEA's committed share of Vogtle 3 and 4 nuclear units). This scenario conservatively assumes no federal policy support for clean energy technologies, and reflects the current phase-down of tax credits for new renewable energy.

For each of these cases, we evaluated three sensitivities. First, we develop a central estimate of fuel cost, which assumes average annual gas prices of \$3.90/MMBtu (based on US Energy Information Agency estimates) and

coal prices of \$3/MMBtu (based on historical coal prices, assumed to remain constant in real terms). These are conservatively low, especially given recent spikes in gas prices that have propelled fossil gas prices above \$7 per MMBtu. Second, we evaluated a case where gas and coal fuel costs both rise by 30%. And finally, we evaluated the cost of these portfolios with the central fuel price assumption, but assuming CO₂ emissions were valued at \$25/ton.¹²

The following sections compare the costs, resource mix and emissions outcomes between the JEA's Plan scenario and the Retire Coal and 80% Carbon-Free scenarios.

Retiring and replacing Northside Units 1 and 2 with clean energy could save JEA customers \$15 million per year

The coal retirement scenario yields at least \$15 million per year in savings relative to JEA's Plan. These savings are even more significant across fuel price and carbon cost sensitivities, from \$15 million per year in the baseline case to over \$80 million per year with a modest value given to CO₂ emissions.

In addition to saving money across all cases, the coal retirement scenario reduces CO₂ emissions by 55% relative to JEA's fossil fuel heavy plan.¹³ This plan has JEA supplying 42% of their annual energy needs from solar power by 2030, (up from 5% in their Ten Year Site Plan), with cumulative energy efficiency investments offsetting another 8% of total electricity demand.

In addition to cost savings, retiring Northside 1 and 2 and meeting JEA's system needs with new clean energy resources would dramatically reduce health-harming air pollution. While JEA's plan results in an estimated 1.6

million pounds of NO_x and another 1.6 million pounds of SO₂ per year, retiring these two coal units would cut JEA's NO_x emissions by 65% and SO₂ emissions by an astonishing 99%.

In addition to raising costs for customers, JEA's plan to continue operating Northside 1 and 2 would continue to produce local air pollution, impacting the health of local communities in Jacksonville, and retirement of the plant is the most cost-effective way for JEA to reduce air pollution emissions. If the units were required to install selective catalytic reduction controls for nitrogen oxides, continuing to operate these plants would increase annual costs by an estimated \$25 million. Accelerated retirement saves customers money under any circumstances, but notably protects customers from bearing future costs associated with reducing air pollution and mitigating health impacts from these coal plants.

Table 1: Cost Savings and Emissions Reductions: Coal Retirement Scenario		
	JEA'S PLAN	RETIRE COAL
Baseline Annual Costs (\$)	\$502.6 million	\$487.1 million
Savings		\$15.5 million (3%)
High Coal and Gas Prices (\$)	\$595.4 million	\$533.4 million
Savings		\$62.0 million (10%)
\$25/ton CO ₂ Cost (\$)	\$620.9 million	\$540.6 million
Savings		\$80.3 million (13%)
Annual CO ₂ Emissions (metric tons)	4.7 million	2.1 million (55% reduction)
Annual NO _x Emissions (lbs)	1.6 million	0.5 million (65% reduction)
Annual SO ₂ Emissions (lbs)	1.6 million	6,000 (99% reduction)

Note: All cost figures in 2019 base year dollars. Costs only include going-forward fixed and variable costs for existing resources and annualized capital plus fixed and variable operating costs for new resources.

Figure 4: Capacity and Generation Mix Across Scenarios

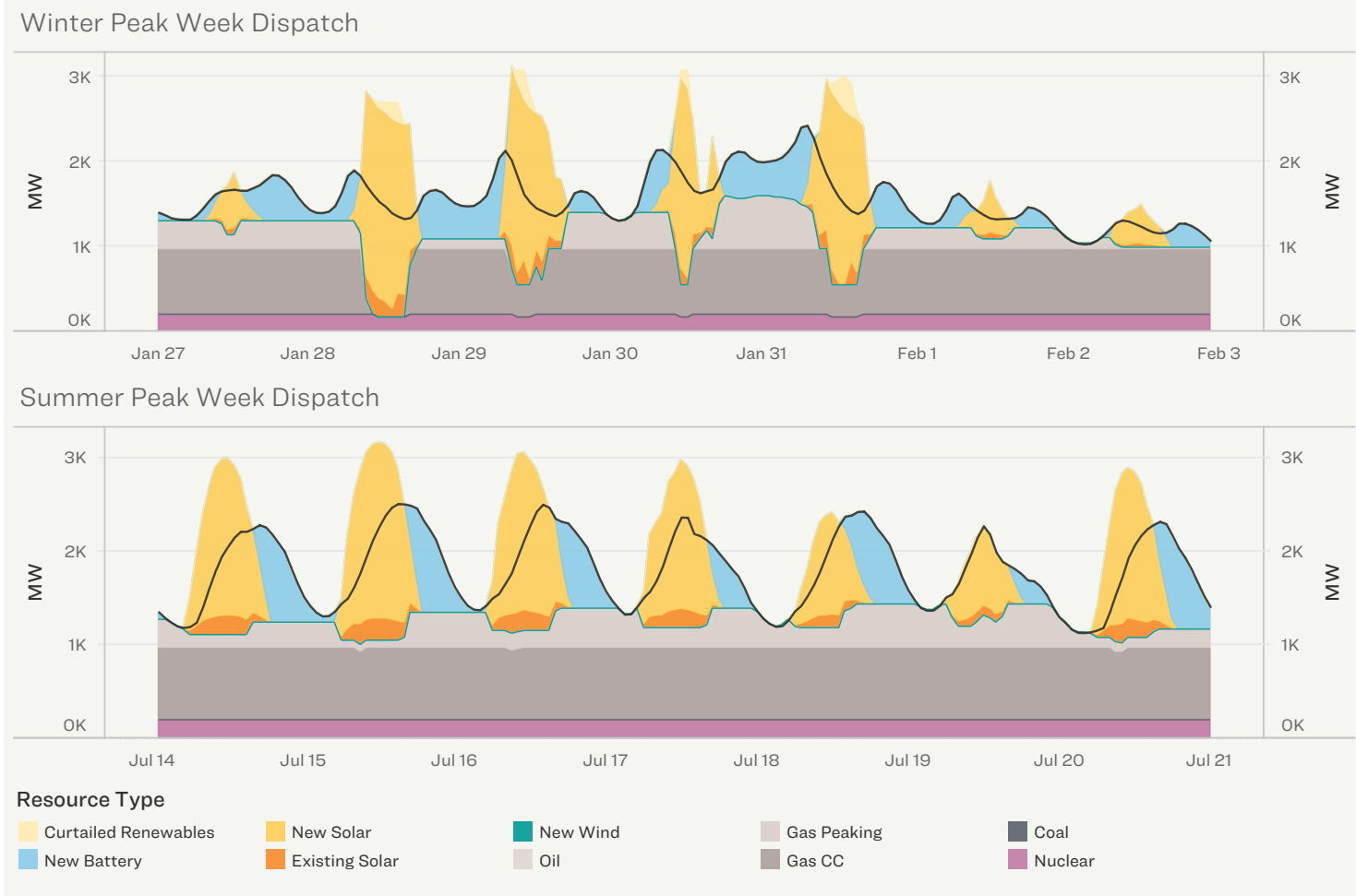


Note: Energy Efficiency shown only includes incremental energy efficiency above JEA's Plan.

This coal retirement scenario meets demand and reliability requirements in each hour of the year without building new fossil generating capacity. Both during summer and winter,

demand reduction from energy efficiency coupled with solar power and battery energy storage effectively addresses demand even during the most challenging peak periods.

Figure 5: System Dispatch During Week of Winter and Summer Peak — Coal Retirement Scenario



A grid with 80% carbon-free and renewable electricity is reliable and cost effective

The 80% carbon-free scenario looks at a more ambitious scale of transformation, but still yields an electricity system that can meet demand in each hour of the year, under a wide range of grid conditions, while maintaining affordability for customers. Under this scenario, 65% of annual electricity consumption is met by renewable energy resources like wind and solar, with energy efficiency offsetting an additional 8% of demand. JEA’s share of the Vogtle 3 and 4 nuclear units, which are present in all scenarios modeled, round out the remaining carbon-free electricity. This scenario reduces CO₂ emissions by 79% relative to JEA’s plan, and the average cost of these emissions reductions is roughly \$15/ton.

Under the baseline fuel costs, the 80% carbon-free scenario adds approximately \$4 per MWh to the cost of generating electricity relative to the JEA’s Plan scenario, under \$5 per month for the average residential electricity consumer. However, this estimate does not reflect the potential for expanded federal support for clean energy resources like renewable energy, storage and transmission, which would reduce the cost of this scenario. Taking into account volatile fuel prices and the cost of carbon, these scales flip. A 30% increase in coal and gas prices from the baseline (well below

the magnitude of recent gas price spikes) would make JEA’s fossil fuel heavy plan cost \$15 million more per year than an 80% carbon-free portfolio. Under a modest \$25/ton CO₂ cost, the 80% carbon-free portfolio is roughly \$37 million cheaper than JEA’s plan.

Table 2: Cost Savings and Emissions Reductions: 80% Carbon-Free Energy

	JEA’S PLAN	80% CARBON-FREE
Baseline Annual Costs (\$)	\$502.6 million	\$559.2 million
High Coal and Gas Prices (\$)	\$595.4 million	\$580.3 million
Savings		\$15.1 million (2.5%)
\$25/ton CO₂ Cost (\$)	\$620.9 million	\$583.6 million
Savings		\$37.3 million (6%)
Annual CO₂ Emissions (metric tons)	4.7 million	1.0 million (79% reduction)
Annual NO_x Emissions (lbs)	1.6 million	0.2 million (87% reduction)
Annual SO₂ Emissions (lbs)	1.6 million	500 (~100% reduction)

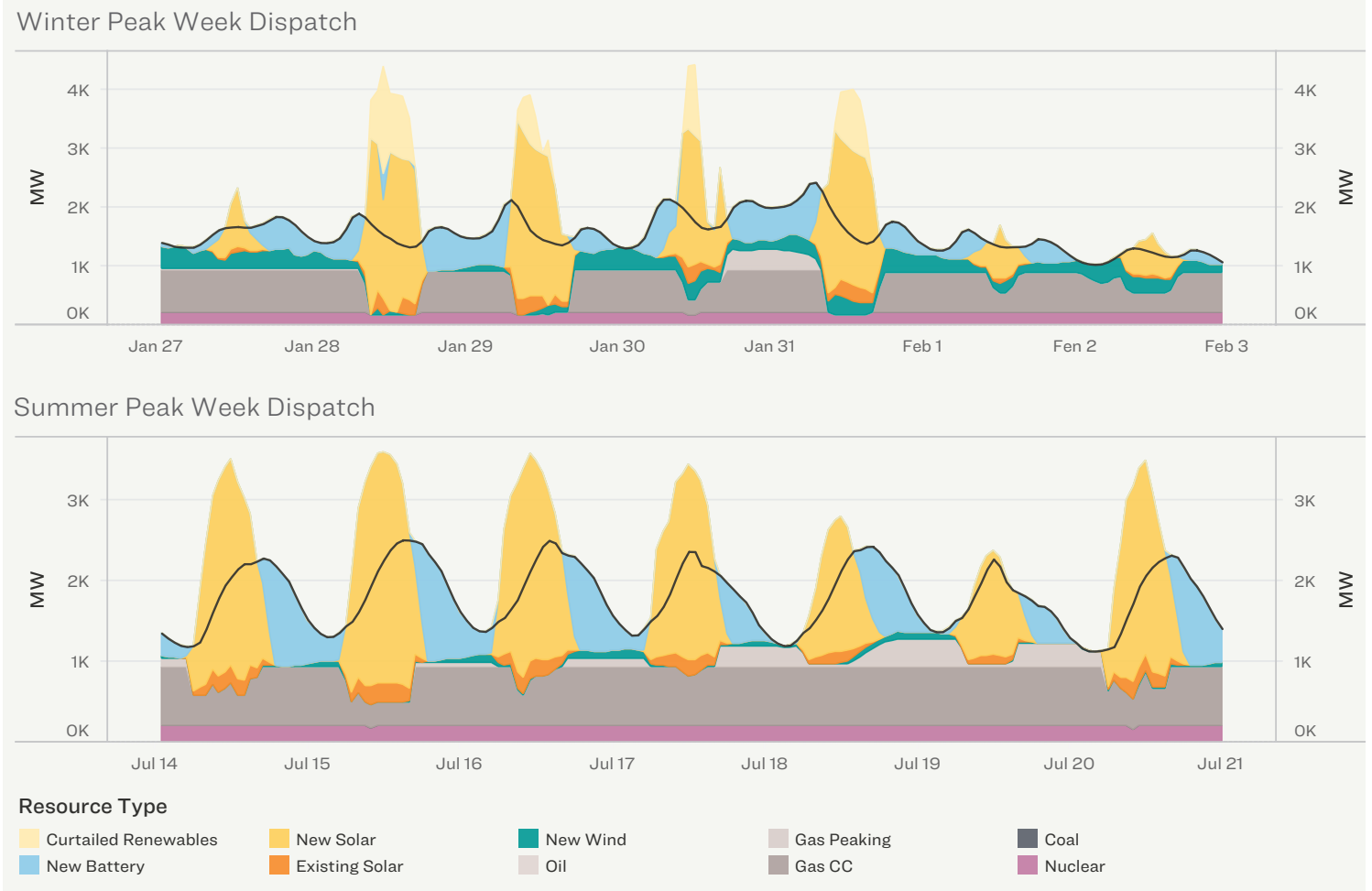
Note: All cost figures in 2019 base year dollars. Costs only include going-forward fixed and variable costs for existing resources and annualized capital plus fixed and variable operating costs for new resources.

This scenario allows the optimization model to select retirement of resources that are no longer needed or cost

effective, given the goal of 80% carbon-free electricity. In doing so, the model chooses to retire all units at Northside, including both coal units (1 and 2), the gas steam unit (3), and oil-fired peaking generators that are no longer needed to meet demand or a 15% reserve margin in any hour of the

year. This scenario builds a total of nearly 3,400 MW of solar, 910 MW of wind, and 1,460 MW of battery energy storage. This diversified portfolio of clean energy resources works together to reliably meet demand at lowest cost.

Figure 6: System Dispatch During Week of Winter and Summer Peak – 80% Carbon-Free Scenario



NOW IS THE TIME FOR JEA TO END COAL AND PLAN A TRANSITION TO CLEAN ENERGY

As JEA embarks on an integrated resource planning process, the utility has an opportunity to immediately save customers money and begin a transition to clean energy resources by retiring Northside 1 and 2, and replacing the energy, capacity and grid services from these fossil fuel power plants with a portfolio of renewable energy, energy storage and investments in energy efficiency. This is a no-regrets course of action, yielding savings across a wide range of scenarios. In addition, JEA has an opportunity to demonstrate leadership in a rapid transition to clean energy. This transition will protect JEA's customers from harmful fossil fuel price volatility and pollution.

This analysis yields several key recommendations:

1. Retire Northside units 1 and 2 by 2030 or sooner and meet future resource needs with clean, renewable energy sources, not fossil fuels

This study indicates that retirement of Northside Units 1 and 2, alongside the expected retirement of Unit 3, will yield significant benefits to customers, and can be achieved while avoiding the need for new gas power plants. The benefits of retirement and replacement with a portfolio of clean energy resources only increase under scenarios of high fuel costs or additional environmental compliance costs.

2. Establish plans to significantly reduce greenhouse gas emissions and local air pollution from JEA's power plants by 2030

JEA should set ambitious goals to significantly reduce greenhouse gas emissions and local air pollution emissions from their power plants by 2030. This report demonstrates that resource mixes that achieve substantial reductions in emissions can lower costs and reduce exposure to volatile fossil fuel prices. Even without federal policy support, a resource mix that reduces CO₂ emissions by more than 80 percent relative to JEA's current plan is affordable, reliable and lowers risks for customers.

3. Adopt more ambitious energy efficiency targets and programs and prioritize efficiency investments in low income and high energy burden communities

JEA should adopt more ambitious energy efficiency targets and programs, and incorporate these targets into their resource planning process. This study incorporates the benefits of achieving an additional 0.9% of incremental energy savings per year, in addition to the 0.25% incremental energy savings projected in JEA's Ten Year Site Plan. Energy efficiency investments can be prioritized for communities experiencing high cost burdens associated with their energy bills. In addition, while not the focus of this study, JEA can potentially realize significant savings through other demand side management measures like demand response and encouraging demand flexibility, particularly targeting end uses that can reduce summer and winter peak electricity demand.

4. Account for fuel price volatility in resource planning and choose portfolios that lower risks

Volatile fossil fuel prices are often borne by customers, but those customers are often left out of the decisions to build new infrastructure that might lock in exposure to risky fossil fuels for decades to come. JEA's IRP should properly account for fossil fuel price volatility and select portfolios of resources that not only are lower cost overall, but minimize the risk to customers of fuel price volatility. Renewable energy, energy storage, and energy efficiency are resources whose costs are predictable, largely up-front investment, and not dependent on fossil fuels, resulting in excellent protection against volatile fuel prices.

5. Use all-source requests for proposals to get the best deal on clean energy portfolios

Utilities across the country are increasingly using competitive all-source solicitations to attract low-cost bids for renewable energy, energy storage, and demand-side resources. A fair and transparent all-source requests for proposal process can provide JEA with information about the market cost of new resources, as well as an opportunity to assemble a portfolio of resources that together meet JEA's system reliability and energy needs at the lowest cost. RMI's "How to Build Clean Energy Portfolios" provides a practical guide and examples for designing and implementing effective all-source RFP processes.¹⁴

APPENDIX: ANALYSIS AND DATA SOURCES

Open-Source Modeling with GenX

This analysis uses an open-source electricity planning model called GenX. GenX was developed by researchers at MIT and Princeton University, and has been used as the basis for many peer-reviewed academic papers.¹⁵

In addition to being freely available, GenX has several advantages over traditional capacity expansion models used by utilities. This model reflects a high degree of temporal granularity, allowing for modeling of hourly, sequential dispatch of an electricity system across all hours of the year, incorporating operational constraints like the startup costs of thermal power plants and limited duration of battery energy storage. This detailed hourly dispatch is co-optimized with new resource entry, allowing the model to select those resources that have the greatest value relative to their cost, accounting for how those resources are operated and the make-up of the entire system being modeled.

Finally, GenX allows for a novel assessment of reliability needs, through the ability to capture reliability constraints across all hours of the year, rather than simply focusing on peak demand hours. In this modeling we have assumed a 15% planning reserve margin (equivalent to NERC's reference reserve margin for the FRCC region), but apply this to each hour, such that the system needs sufficient resources to meet demand with available resources plus a reserve margin, in a wide variety of grid conditions. This is a very conservative definition of reliability needed, as it strictly requires a 15% reserve margin above demand, even in an off-peak hour with zero wind or solar output.

For the purposes of this paper, we have narrowed the scope of this modeling in several ways, because of data availability and computational resources.

First, we model JEA as a single zone, assuming contracted resources like Vogtle 3 and 4 and the PPA with FPL are within JEA's system. This assumption conservatively excludes spare capacity that likely exists outside of JEA's system, as well as potential benefits of marketing excess energy production to neighboring utilities.

Second, rather than model each year in succession using fuel prices, new resource costs, and demand estimates for each year, this analysis looks at a snapshot of 2030. While this doesn't allow the model to select an optimal retirement year, any resource that is uneconomic in 2030 should be investigated further to determine the best timing for retirement and new build replacement.

Demand

Data on electricity demand for each hour of the year was constructed based on two data sources. First, hourly demand for JEA's balancing area was extracted from JEA's FERC Form 714 filing for the calendar year 2019. This hourly demand was scaled to match the total annual "net energy for load" for 2030 of 13,903 GWh, per JEA's 2021 Ten Year Site Plan.

Energy Efficiency

Incremental energy efficiency for the clean energy scenarios was calculated by assuming that JEA's net energy for load in 2030 remained fixed at the level projected in JEA's

RESOURCE	TYPE	MW	HEAT RATE (MMBTU/MWH)	VARIABLE O&M (\$/MWH)	FIXED O&M (\$/MW-YR)	MAINTENANCE CAPEX (\$/MW-YR)	TOTAL FIXED GOING-FORWARD COST (\$/MW-YR)
Kennedy 7	Gas Peaking	179	11.2	2.71	3,500	7,280	10,780
Kennedy 8	Gas Peaking	179	11.2	2.71	3,500	7,280	10,780
Brandy Branch CT	Gas Peaking	179	11.2	2.06	3,400	7,280	10,680
Brandy Branch CC	Gas CC	568	6.8	1	11,000	15,600	26,600
Greenland 1	Gas Peaking	179	10.9	1.5	3,100	7,280	10,380
Greenland 2	Gas Peaking	179	10.9	1.5	3,100	7,280	10,380
Northside 1	Coal	293	9.4	3.99	26,400	30,160	56,560
Northside 2	Coal	293	12.1	3.99	26,400	30,160	56,560
Northside 33 36	Oil	200	18.4	177	3,800	7,280	11,080
Vogtle 3	Nuclear	100	10.4	2.71	92,000	28,080	120,080
Vogtle 4	Nuclear	100	10.4	2.71	92,000	28,080	120,080
FPL PPA	Gas CC	200	6.8	1	11,000	15,600	26,600
Existing Solar	Solar	289	-	-	10,000	-	10,000

Sources: S&P Global (O&M Estimates), EIA (Heat Rate, Maintenance Capex). All dollar values converted to real 2019 dollars.

RESOURCE	TYPE	HEAT RATE (MMBTU/MWH)	VARIABLE O&M (\$/MWH)	INVESTMENT COST (\$/MW-YR)	FIXED O&M (\$/MW-YR)	MAINTENANCE CAPEX (\$/MW-YR)	TOTAL FIXED GOING-FORWARD COST (\$/MW-YR)
NewCT 1	Gas	10	5	49,000	21,000	7,280	28,280
NewCC 1	Gas	7	1	57,000	27,000	15,600	42,600
NewBattery	Battery	—	0.3	12,000 plus 9,000 per MWh-yr	3,000 plus 2,250 per MWh-yr	—	3,000
NewSolar	Solar	—	—	34,000	17,000	—	17,000
NewWind	Wind	—	—	50,000	39,000	—	39,000

Sources: Calculated from NREL Annual Technology Baseline 2021, EIA/Sargent and Lundy

Ten Year Site Plan for 2021, 12,808 GWh. This sum was applied to each hour in proportion to that hour's demand. This represents a total 8% reduction in demand versus JEA's plan, or an incremental 0.9% energy savings per year from 2021 through 2030. This is on top of approximately 0.3% incremental energy savings per year already reflected in JEA's ten year site plan and accounted for in the load forecast used in the JEA's plan scenario, for a total incremental annual energy savings of 1.2% per year, in line with many US utilities.

The cost of energy efficiency programs to realize these energy savings was based on ACEEE analysis¹⁶ of utility energy efficiency programs, which found the average levelized cost of saved energy for utility energy efficiency programs was \$25 per MWh. This figure was applied to the total MWhs saved due to incremental energy efficiency in 2030, for a total cost of \$27.3 million (which offsets the cost of additional electricity generation resources).

Supply Options

EXISTING RESOURCES

Our analysis assumed existing resources that would be online by 2030, consistent with JEA's 2021 TYSP, except for the assumed retirement of Northside Unit 3 prior to 2030. This 2030 portfolio includes JEA's share of Vogtle 3 and 4, currently under construction, as well as JEA's supply agreement with Florida Power and Light, which is represented as a combined cycle gas resource in this modeling. Only going-forward costs are considered for these resources. Sunk investment costs are not included, as they are not assumed to be avoidable with resource retirement.

The table below shows the capacity, heat rate, and estimated going-forward operating and maintenance costs and maintenance capital investment used in this analysis for each existing and anticipated new resource. Assumptions for yet-to-be commissioned resources were based on proxies. Values for Vogtle 3 and 4 O&M costs were based on reported operating costs for Vogtle 1 and 2. The FPL PPA was assumed to have the same values as Brandy Branch CC, representative of a modern combined cycle plant in FL.

In addition to O&M costs, ongoing maintenance capital costs were included by type of generator, based on analysis by Sargent and Lundy for the Energy Information Agency.¹⁷

In addition to the costs above, this modeling reflects the costs and operational constraints around cycling power plants. Start costs, startup fuel and cycling parameters (minimum uptime and downtime, minimum generation) were not available for these plants specifically, so assumptions based on typical operating parameters by type of plant were made, informed by studies by the National Renewable Energy Lab.¹⁸

NEW RESOURCES

For new resources, we assumed new gas combined cycle and combustion turbine units could be built in the JEA's plan scenario, while new wind, solar and storage could be built in the coal retirement and 80% carbon-free scenarios. Costs for new resources were based on NREL's Annual Technology Baseline "moderate" scenario, and are converted to annualized values in real 2019 dollars based on asset lifetimes, capital recovery factors and adjustments for tax and depreciation assumptions as reflected in NREL's Annual Technology Baseline levelized cost of energy calculation. Incremental capital expenditures for gas generation technologies were added, based on Sargent and Lundy's study for EIA referenced above.

For new batteries, capital costs and O&M are separated into two parts — those that vary with the power rating of the battery (MW) and those that vary with the energy rating of the battery (MWh). This allows the model to choose the battery duration that has the greatest value, given renewable resource and demand profiles and resource options and costs.

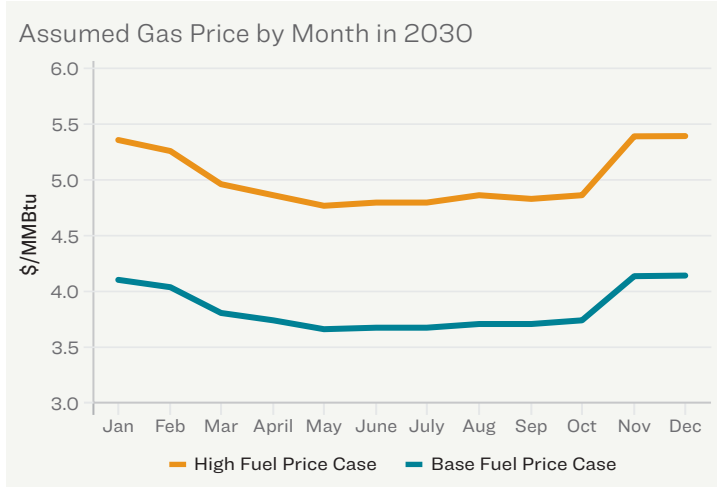
SCENARIO	NEW RESOURCES AVAILABLE	RETIREMENTS
JEA's Plan	Gas CCGT and CT	Northside 3 Assumed
Retire Coal	Solar, Wind, Battery	Northside 1-3 Assumed
80% Carbon-Free	Solar, Wind, Battery	Any Fossil Plant Can be Retired Endogenously (NS3 Assumed to be Retired)

The costs for new renewable energy resources reflect current policy. However, expanded clean energy tax incentives could significantly reduce the cost to customers of wind, solar and energy storage resources, resulting in significantly more savings.

FUEL COSTS

As discussed above, fossil fuel costs can be very volatile and any projection to 2030 has a high degree of uncertainty. For this analysis, we address this by using commonly accepted projections and analyzing the impact of significant price variability on the cost of resulting portfolios.

For gas, we start with the gas fuel price delivered to electric sector users in the southeastern US for 2030, based on the EIA’s Annual Energy Outlook 2022 Reference Case. This resulted in a value of \$3.90 per MMBtu in 2019 dollars. This value was then “shaped” based on S&P monthly forward curves for the region, so that the annual average remained \$3.90 per MMBtu, better reflecting the seasonality of gas prices in the southeastern US.



Coal prices were assumed to remain at \$3 per MMBtu (in real 2019 dollars), based on estimated coal costs for Northside 1 and 2 in recent years. However, according to EIA Form 923 data, coal deliveries to Northside Generating Station have ranged from \$2.50 to \$4.50 per MMBtu in the last three years, reflecting uncertainty around this central estimate.

JEA has one oil-fired peaking plant. We assume fuel for this plant is consistent with EIA’s 2022 AEO Reference Case estimate for distillate fuel oil (DFO), at \$19.50 per MMBtu. The model did not run this plant in any scenario, due to high fuel costs.

As noted in the report, fossil fuel prices are highly volatile. Coal deliveries at Northside in recent years have varied by as much as \$2 per MMBtu, and gas prices as of March 2022 have experienced enormous recent volatility, and

currently sit above the value assumed in this analysis for 2030. To address this volatility, we estimate what costs for each portfolio would be if costs were 30% higher than assumed in the baseline case. For coal, this amounts to fuel prices of \$3.90 per MMBtu, well within the range of historical prices. For gas, this results in an annual average price of \$5.07 per MMBtu, below price levels experienced in early 2022. Pricing in US gas markets is increasingly driven by demand for exports to other countries where gas prices are much higher, further linking domestic price volatility with global energy markets.

RENEWABLE ENERGY

Renewable energy resources were modeled in hourly granularity, based on 2019 weather year data for wind and solar. This production data was gathered from renewables.ninja, a service that uses hourly, gridded weather data from NASA’s MERRA-2 dataset to estimate hourly production of solar and wind power projects, based on turbine power curves and assumed facility data. For both solar and wind, production estimates were made based on weather data at Jacksonville International Airport.

The resulting renewable energy resource profiles estimate a solar capacity factor of 25% relative to the alternating current (AC) rating of the solar plant, or 18% on a direct current (DC) basis. This is because the rating on a solar plant’s inverter and interconnection are typically smaller than the total amount of solar panels installed.¹⁹ Combined with the cost data described above, this assumes a levelized cost of energy from solar of roughly \$23/MWh. This data puts wind capacity factors in Jacksonville at 21% annually. This is low relative to high-wind resources in the US, and results in a levelized cost of energy of roughly \$48/MWh. However, the model selects some wind in the 80% carbon-free scenario because wind performs well at times that solar is less available, such as during winter cold spells.

Using a full year of hourly renewable energy resource data, alongside a full year of hourly demand profiles, allows for unique insight on the reliability of a grid with high levels of renewable energy. This approach captures long-run correlations between wind, solar and demand; for instance, solar in Florida typically performs very well during hot summer afternoons with high demand, while wind performs well during periods of cold winter weather when demand may be rising. Moreover, this approach allows for modeling that can select the right amount of storage, with the right duration, to accompany renewable energy resources to reliably meet demand across a range of seasons, accounting for when renewable energy is produced and when storage is needed to meet demand.

Detailed Results

COST

Annual Costs in 2030 (in real 2019 dollars)

	JEA'S PLAN	RETIRE COAL	80% CARBON-FREE
Total Generation Costs (\$ million)	502.6	459.8	531.9
Energy Efficiency Cost (\$ million)		27.3	27.3
Total Cost (\$ million)	502.6	487.1	559.2
Fuel Costs: Baseline (\$ million)	309.3	154.2	70.1
Fuel Costs: High (\$ million)	402.1	200.4	90.2
CO ₂ Cost at \$25/t (\$ million)	118.4	53.5	24.4
SCR Retrofit Cost (\$ million)	25.8		

EMISSIONS

	JEA'S PLAN	RETIRE COAL	80% CARBON-FREE
CO ₂ Emissions (million metric tons)	4.7	2.1	1.0
NO _x (short tons)	784.9	273.8	100.6
SO ₂ (short tons)	803.3	3.0	0.3

CAPACITY AND ENERGY MIX

Installed Capacity by Resource (MW)

RESOURCE	TYPE	JEA'S PLAN	RETIRE COAL	80% CARBON-FREE
Kennedy 7	Gas CT	179.0	179.0	179.0
Kennedy 8	Gas CT	179.0	179.0	179.0
Brandy Branch CT	Gas CT	179.0	179.0	179.0
Brandy Branch CC	Gas CC	568.0	568.0	568.0
Greenland 1	Gas CT	179.0	179.0	179.0
Greenland 2	Gas CT	179.0	179.0	179.0
Northside 1	Coal	293.0	0.0	0.0
Northside 2	Coal	293.0	0.0	0.0
Northside 3	Gas Steam	0.0	0.0	0.0
Northside 33–36	Oil	200.0	200.0	0.0
Vogtle 3	Nuclear	100.0	100.0	100.0
Vogtle 4	Nuclear	100.0	100.0	100.0
FPL PPA	Gas CC	200.0	200.0	200.0
Existing Solar	Solar	289.0	289.0	289.0

Installed Capacity by Resource (MW), cont.

RESOURCE	TYPE	JEA'S PLAN	RETIRE COAL	80% CARBON-FREE
New CC	Gas CC	704.4	0.0	0.0
New Battery	Battery	0.0	1,105.4 (8,117.4 MWh, 7.4 hours duration)	1,456.3 (9,679.9 MWh, 6.6 hours duration)
New Solar	Solar	0.0	2,231.6	3,402.8
New Wind	Wind	0.0	0.0	908.6

Generation by Resource Type (MWh)

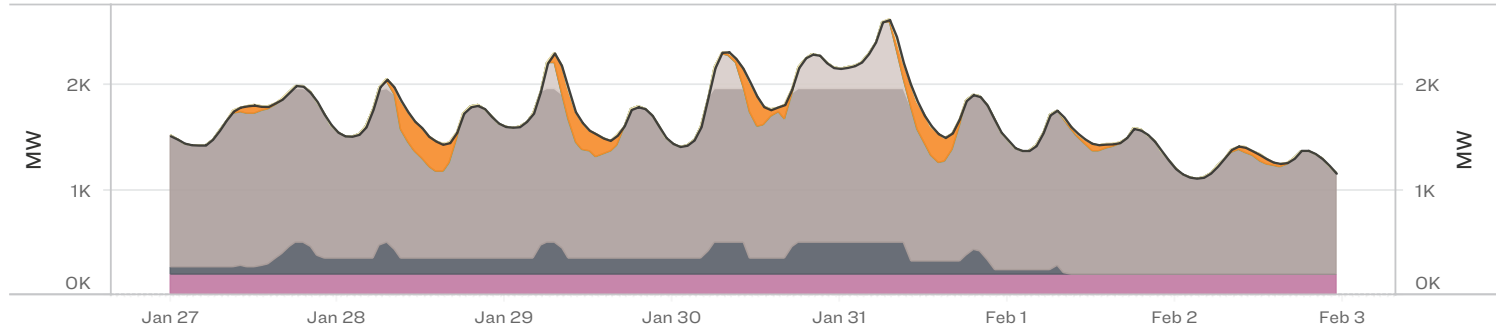
RESOURCE	TYPE	JEA'S PLAN	RETIRE COAL	80% CARBON-FREE
Kennedy 7	Gas CT	3,289	1,073	0
Kennedy 8	Gas CT	3,181	766	0
Brandy Branch CT	Gas CT	37,189	20,270	0
Brandy Branch CC	Gas CC	4,409,682	3,685,744	2,124,764
Greenland 1	Gas CT	148,344	300,514	24,581
Greenland 2	Gas CT	135,220	281,049	30,162
Northside 1	Coal	895,715	0	0
Northside 2	Coal	0	0	0
Northside 3	Gas Steam	0	0	0
Northside 33–36	Oil	0	0	0
Vogtle 3	Nuclear	875,633	858,461	812,388
Vogtle 4	Nuclear	875,684	858,609	827,242
FPL PPA	Gas CC	1,670,349	1,276,991	492,190
Existing Solar	Solar	694,979	652,245	560,715
New CC	Gas CC	4,153,722	0	0
New Battery	Battery	0	1,956,309	3,033,402
New Solar	Solar	0	5,227,301	6,900,995
New Wind	Wind	0	0	1,585,450
Energy Efficiency	Energy Efficiency		1,091,998	1,091,998

Note: Energy from battery represents discharge only. Generation from other resources include energy used to charge battery.

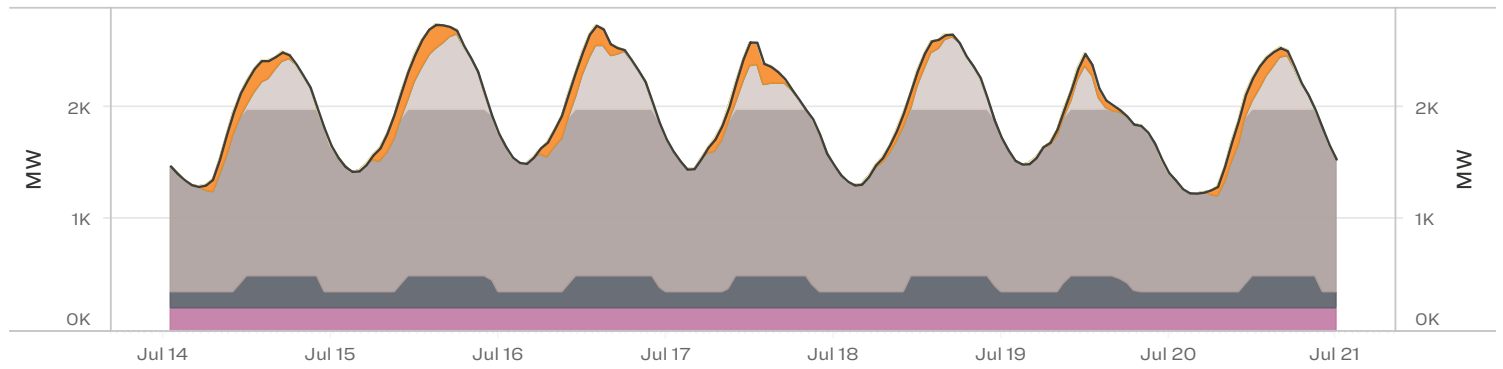
Winter and Summer Peak Period Dispatch

JEA'S PLAN

Winter Peak Week Dispatch



Summer Peak Week Dispatch

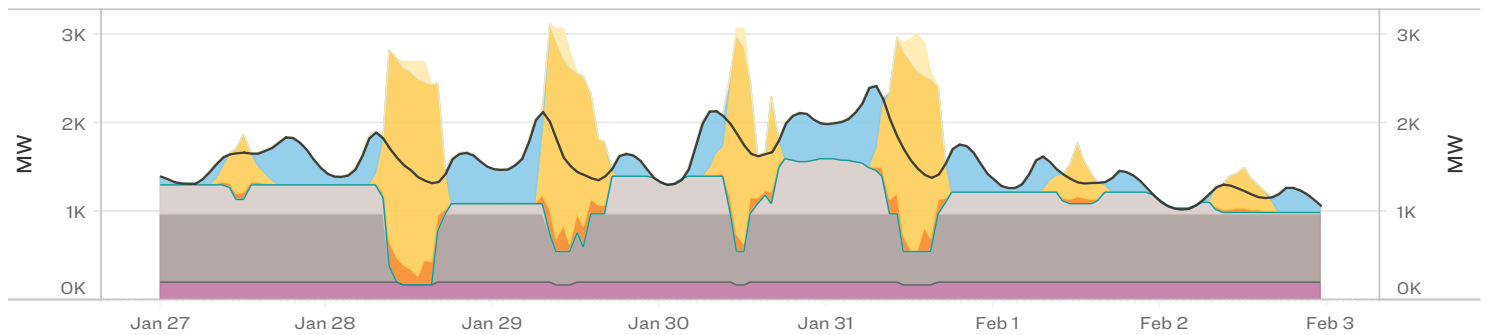


Resource Type

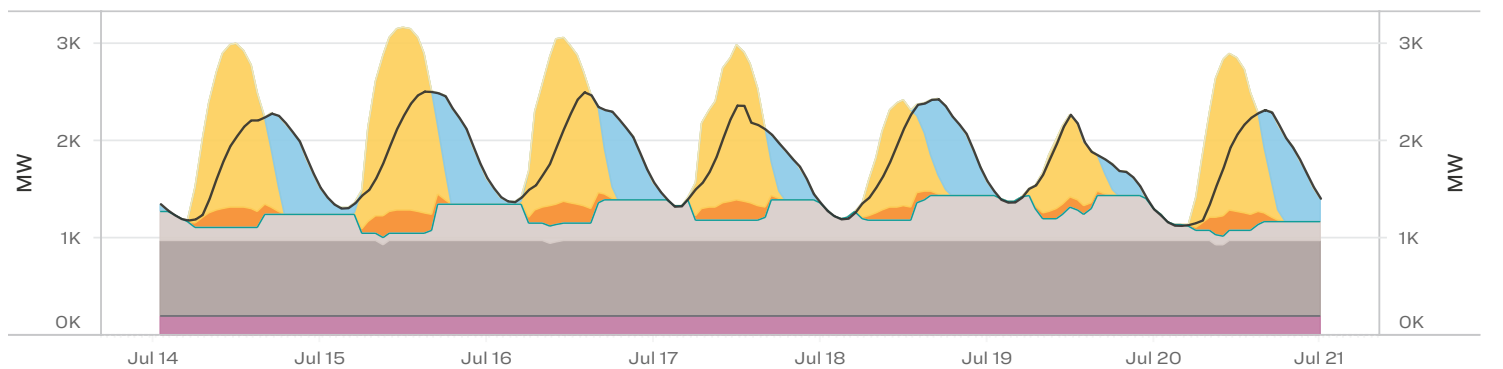


RETIRE COAL

Winter Peak Week Dispatch



Summer Peak Week Dispatch

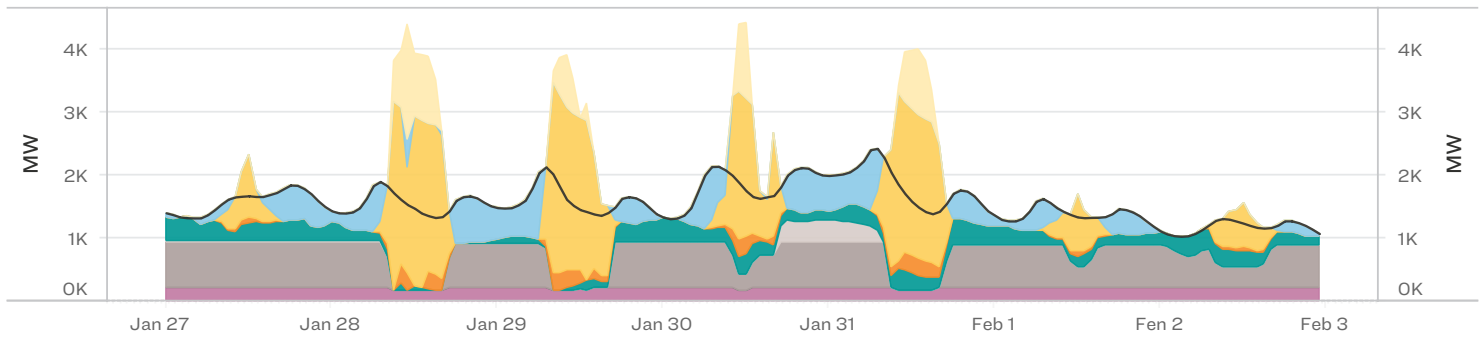


Resource Type

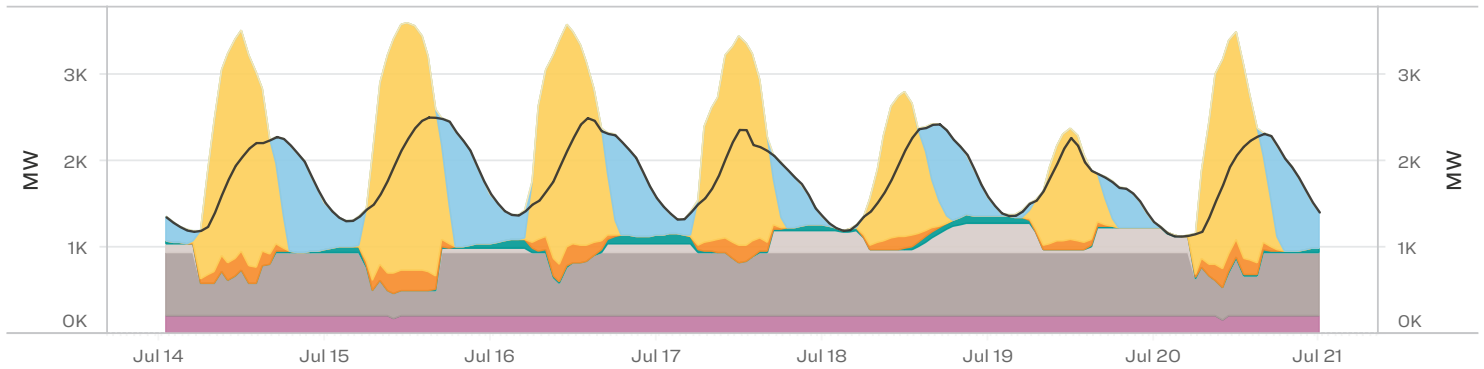


80% CARBON-FREE

Winter Peak Week Dispatch



Summer Peak Week Dispatch



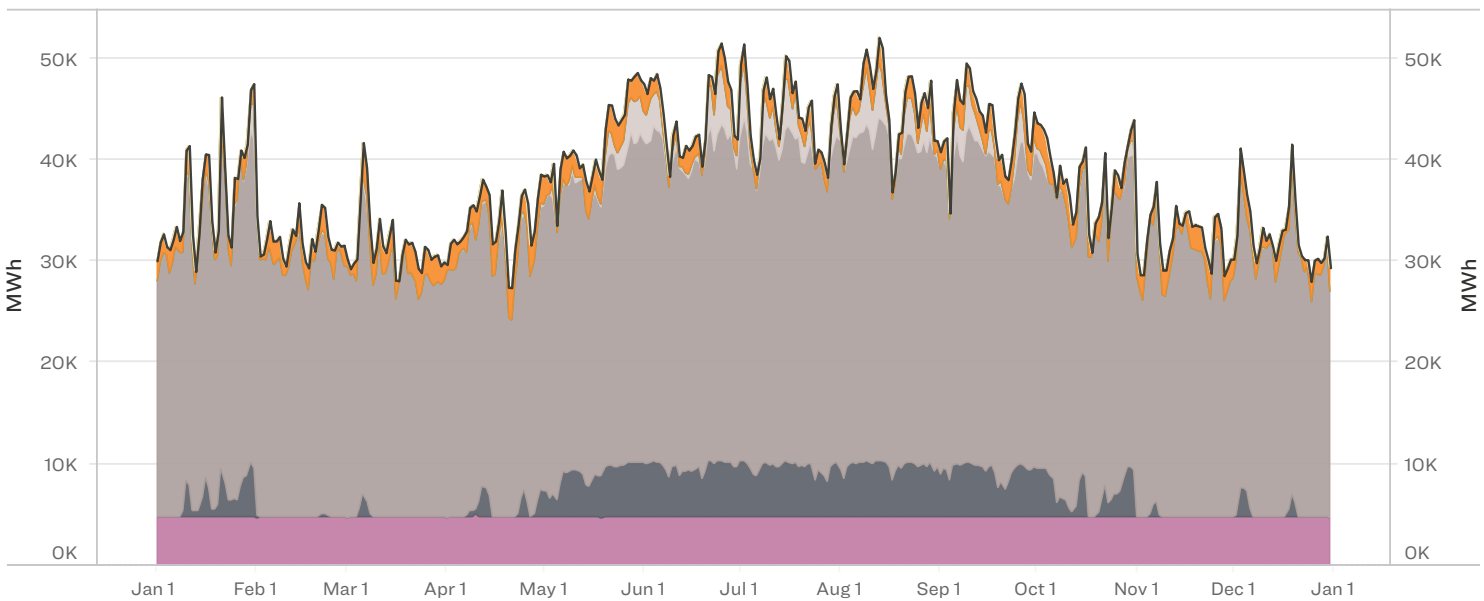
Resource Type

- Curtailed Renewables
- New Solar
- New Wind
- Gas Peaking
- Coal
- New Battery
- Existing Solar
- Oil
- Gas CC
- Nuclear

Daily Energy Balance

JEA'S PLAN

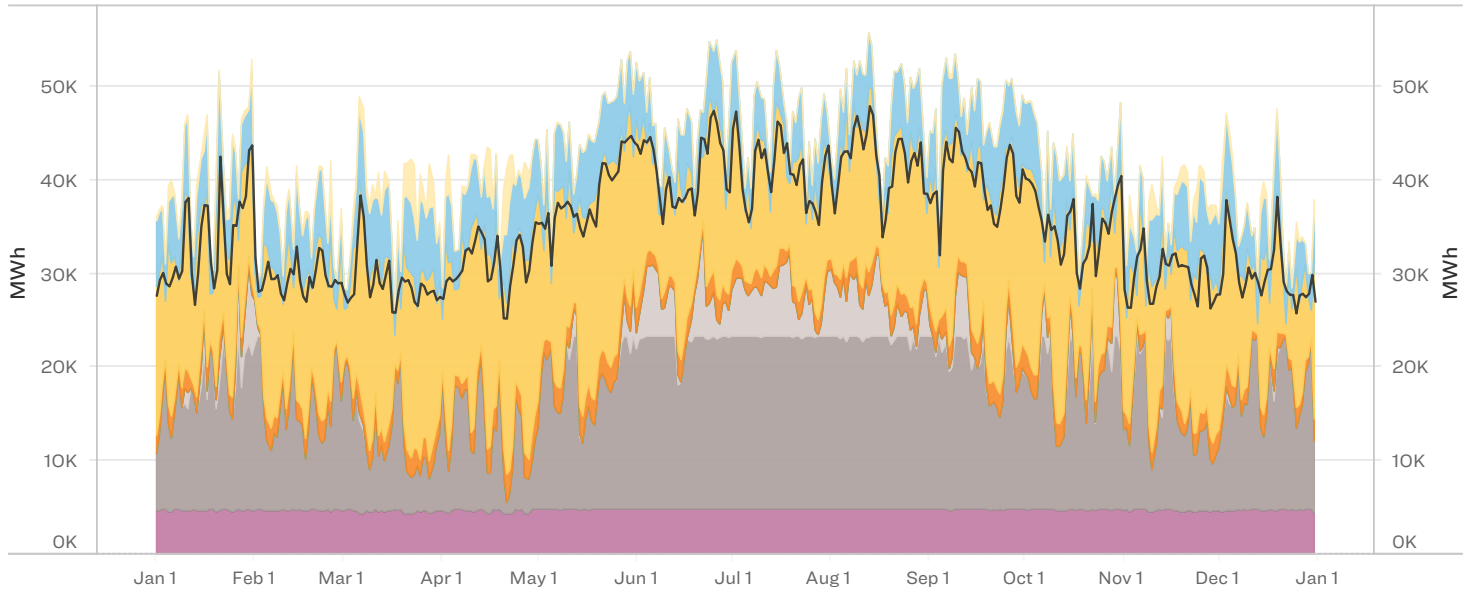
Daily Energy



Resource Type

- Curtailed Renewables
- New Solar
- New Wind
- Gas Peaking
- Coal
- New Battery
- Existing Solar
- Oil
- Gas CC
- Nuclear

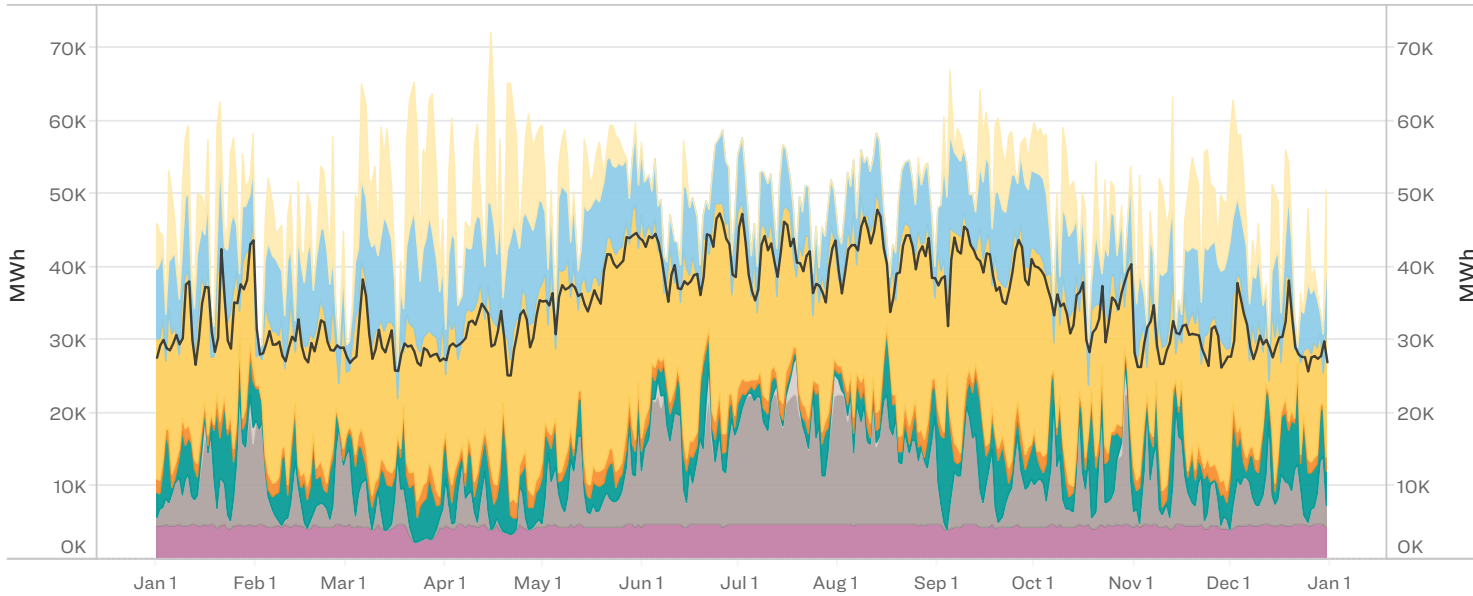
RETIRE COAL
Daily Energy



Resource Type

- Curtailed Renewables
- New Solar
- New Wind
- Gas Peaking
- Coal
- New Battery
- Existing Solar
- Oil
- Gas CC
- Nuclear

80% CARBON-FREE
Daily Energy



Resource Type

- Curtailed Renewables
- New Solar
- New Wind
- Gas Peaking
- Coal
- New Battery
- Existing Solar
- Oil
- Gas CC
- Nuclear

ENDNOTES

- 1 Daily Record, "JEA hedging bets on Plant Vogtle timeline," January 2022. <https://www.jaxdailyrecord.com/article/jea-hedging-bets-on-plant-vogtle-timeline>
- 2 Daily Record, "JEA hedging bets on Plant Vogtle timeline," January 2022. <https://www.jaxdailyrecord.com/article/jea-hedging-bets-on-plant-vogtle-timeline>
- 3 JEA Ten Year Site Plan, 2022, <http://www.psc.state.fl.us/Files/PDF/Utilities/Electricgas/TenYearSitePlans/2022/JEA%20-%20Revised.pdf>
- 4 https://www.jea.com/About/Media_Relations/2020_06_26_JEA_Board_Approves_Plant_Scherer_Transaction/
- 5 JEA Ten Year Site Plan, 2022, <http://www.psc.state.fl.us/Files/PDF/Utilities/Electricgas/TenYearSitePlans/2022/JEA%20-%20Revised.pdf>
- 6 See https://www.sierraclub.org/sites/www.sierraclub.org/files/program/documents/1818-FrackedGasClimateChange-Report_05_web.pdf for more information about the climate impacts of upstream methane emissions. More detail on the global warming potential of methane is provided by the IPCC: https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf
- 7 [https://www.tollfromcoal.org/#/map/\(title:667/detail:667/map:667/FL\)](https://www.tollfromcoal.org/#/map/(title:667/detail:667/map:667/FL))
- 8 Sierra Club estimate based on fuel cost data reported to the US Energy Information Agency (EIA), S&P Global estimates of other operations and maintenance costs, and EIA estimates of going-forward capital requirements for coal plants.
- 9 UT Austin Energy Institute, "The Timeline and Events of the February 2021 Texas Electric Grid Blackouts, July 2021. Also see FERC and NERC, "The February 2021 Cold Weather Outages in Texas and the South Central United States," November 2021, <https://www.ferc.gov/media/february-2021-cold-weather-outages-texas-and-south-central-united-states-ferc-nerc-and>.
- 10 JEA Ten Year Site Plan, 2021, <http://www.psc.state.fl.us/Files/PDF/Utilities/Electricgas/TenYearSitePlans/2021/JEA.pdf>
- 11 Details about GenX and access to the model can be found at <https://energy.mit.edu/genx/>.
- 12 \$25/ton is selected as an illustrative mid-range number, consistent with policy proposals to place a cost on carbon dioxide emissions. However, it is well below the federal Social Cost of Carbon of \$51/ton.
- 13 Our calculation of CO₂ emissions only includes direct emissions, and does not include additional methane leakage in gas production and transportation, accounting for which can nearly double the climate impact of burning gas. By reducing gas consumption as well as coal consumption, the coal retirement scenario also reduces emissions of methane, a potent greenhouse gas.
- 14 RMI, "How to Build Clean Energy Portfolios," <https://rmi.org/how-to-build-ceps/>
- 15 For more information and access to the model, see: <https://energy.mit.edu/genx/>
- 16 ACEEE, "The Cost of Saving Electricity for the Largest U.S. Utilities: Ratepayer-Funded Efficiency Programs in 2018," June 2021, https://www.aceee.org/sites/default/files/pdfs/cost_of_saving_electricity_final_6-22-21.pdf
- 17 EIA, Sargent and Lundy, "Generating Unit Annual Capital and Life Extension Costs Analysis," December 2019, <https://www.eia.gov/analysis/studies/powerplants/generationcost>
- 18 NREL, "Power Plant Cycling Costs", 2012, <https://www.nrel.gov/docs/fy12osti/55433.pdf>
- 19 NREL's ATB assumes an inverter loading ratio of 1.3x, meaning the DC rating of panels is 30% larger than the AC rating of the plant. This is typical of solar plant design, and usually results in a small amount of excess energy being clipped, but much better capacity factors and utilization of interconnection and transmission.



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