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Energy Storage and Power Plant Decommissioning

October 2021

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U.S. DEPARTMENT OF ENERGY

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Summary

Through the lens of energy storage deployment, stakeholders can consider more broadly how improvements and investments in the grid can respond to local social and health challenges. Fossil-fuel power plants generate greenhouse gas emissions and health-affecting criteria pollutants, and plants are often disproportionately located in disadvantaged communities. This has resulted in an energy system that places increased health and environmental burdens on vulnerable populations. This report discusses how a strategic integration of energy storage in power plant decommissioning plans can mitigate these negative effects while providing energy system, environmental, and societal co-benefits (Table S.1).

Table S.1. Energy Storage Benefit Attributes

Energy Storage Benefit	Category of Benefit	Benefit Description
Non-Energy Benefits	Environmental	Emissions reduction Support clean energy delivery Less land use
	Economic	Utility cost of compliance – Avoided fines – Avoided collections and terminations – Avoided safety-related emergency calls
	Social	Job creation Bill reductions – Avoided demand charges – Time-of-Use (TOU) rates Enhanced reliability – Avoided power outages – Avoided disruption costs – Backup generation – Higher property values
Energy System Benefits	Systemic	Service reliability Grid flexibility Reduced transmission congestion Voltage support Blackstart
	Economic	Increased efficiency Decreased system cost – Avoided startup costs of other generators

This report examines three fossil-fuel power plant decommissioning strategies to assess the role of energy storage in enabling an equitable clean energy transition. The analysis showed how storage could enable reduction of fossil-fuel sources from the grid while enabling increased renewable energy integration into the electric grid. The report offers recommendations for future work, including the need to further develop the non-energy benefit attributes of energy storage systems with a focus on the benefits accrued to local communities to understand past decisions and inform future decision-making tools that account for environmental, economic, and social impacts, particularly those on disadvantaged communities.

Acknowledgments

The authors thank those who reviewed the draft versions of the report for their thoughtful comments and suggestions. We also thank the U.S. Department of Energy's Office of Electricity Energy Storage Program for funding the research presented in this report.

Acronyms and Abbreviations

BTM	behind-the-meter
CAISO	California Independent Service Operator
CCA	community choice aggregator
CESA	California Energy Storage Alliance
EBCE	East Bay Community Energy
EE	energy efficiency
CalEPA	California Environmental Protection Agency
FPL	Florida Power & Light
GHG	greenhouse gas
NJ BPU	New Jersey Board of Public Utilities
NYPA	New York Power Authority
OCEI	Oakland Clean Energy Initiative
PG&E	Pacific Gas & Electric
PV	photovoltaic
RE	renewable energy
T&D	transmission and distribution
TOU	Time-of-Use
VOLL	value of lost load

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1.0 Introduction

Energy storage can play a variety of roles in fossil-fuel plant decommissioning and replacement in the clean energy transition. With fossil-fuel power plants reaching the end of their working lives, many are set to retire in the next decade (Pontecorvo 2020). In such cases, energy storage could fill the gap of providing the critical services that were traditionally offered by fossil fuels in the energy system (Deloitte 2015). Replacing peaker plants, which generally run only when there is a high demand, with storage, and repurposing fossil-fuel power plant sites with renewable energy (RE) plus storage are economically viable options that have significant direct energy and non-energy benefits (Figure 1). With storage prices rapidly falling, there is a clear market case for increased storage deployment (Patel 2019). Between 2015–2018, the price of utility-scale battery storage fell 70% in the U.S. (EIA 2020).

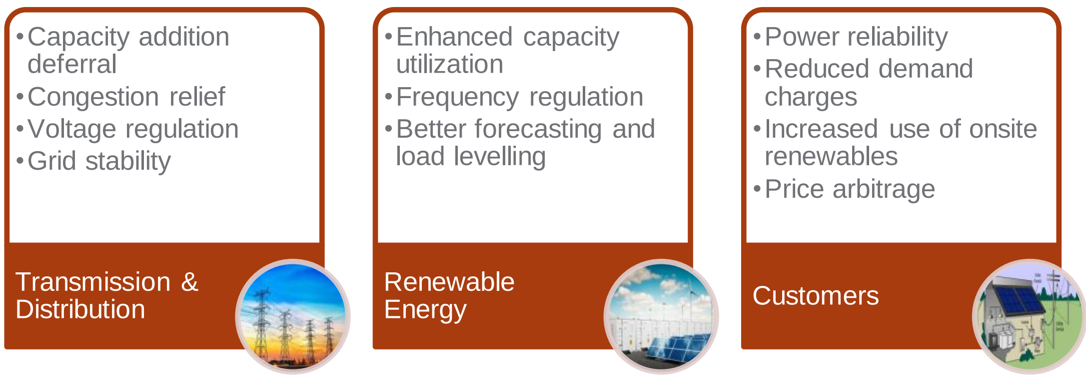

Figure 1. Grid benefits of energy storage.

Integrating energy storage with fossil-fuel plant decommissioning strategies offers benefits for wide range of stakeholders in the energy system (Saha 2019). For federal, state, and local governments, replacing fossil-fuel power plants with storage capacity could support their decarbonization and energy transition goals. States' clean energy mandates and tax incentives are encouraging the co-location of storage with clean energy generation facilities. The New York Power Authority (NYPA) released its VISION2030 plan to achieve emissions-free electricity by 2035, including a commitment of 450 MW energy storage deployment (Colthorpe 2021). New York's Climate Leadership and Community Protection Act sets a goal of achieving 100 percent zero-emission electricity by 2040 including a 3,000 MW energy storage target by 2030 (New York State 2020).

The intermittency of RE requires features in the energy system that can match supply and demand effectively, which currently is being supported by nonrenewable backup units (Verdolini et al. 2016). However, a fully decarbonized energy system will need storage capacity and network stability mechanisms for optimal operation and functionality. Energy storage equips utilities with the operational flexibility to provide safe, clean, and reliable energy. In addition, for fenceline and frontline communities,[1] switching to storage may offer targeted benefits by minimizing air pollution. Low-income and minority populations are disproportionately affected by fine particulate pollutants because companies tend to avoid locating power plants upwind affluent communities (Thind et al. 2019).

[1] Fenceline communities are those living in closest proximity to dangerous facilities whereas frontline communities are those that experience the first and worst of air pollution resulting from energy systems.

The locational flexibility of storage is key in enabling the rapid decommissioning of fossil-fuel baseload and peaker power plants across the country. Natural gas-and oil-fired peaker plants are mostly expensive, inefficient to run, and emit increased carbon dioxide (CO_2) and health-affecting pollutants (Lin and Damato 2011; Krieger 2020). Storage provides dual support by allowing the removal of these polluting plants from the grid, while simultaneously enabling increased RE integration. A New Jersey storage analysis report shows the potential of an "increase of up to 100% in photovoltaic (PV) installations when combined with suitably sized ES" (Rutgers 2019, pp. 6). Since the emissions reductions impact of storage installations is dependent on how the storage system is charged, replacing a fossil-fueled generator with energy storage will not guarantee emissions reductions; achieving that goal will require additional steps to ensure that the storage is charged by clean energy sources.

This report discusses the energy and non-energy benefits of integrating storage in plant decommissioning strategies to support the energy transition process (see Section 2). It describes the relationships and benefits of placing storage installations within a plant footprint or in place of a traditional plant. In Section 3, case studies illustrate these motivations in practice—at the Oakland Energy Facility, Centralia Power Plant, and Manatee Power Plant.

2.0 Energy Storage Benefits

Energy storage can provide multiple sources of value across energy system scales. Storage can add reliability and flexibility capabilities to the bulk grid, balancing the intermittency of RE sources. It can also provide outage reduction benefits and backup power services at the distribution and customer level. This report further explores the ability of storage to create plant-scale and community-scale benefits and identifies areas for future valuation analysis and development.

Storage has expansive value for the energy system as a generation, transmission and distribution (T&D), and behind-the-meter (BTM) asset (Hewett et al. 2016; Olinsky-Paul 2019). Valuing the full benefits of storage requires accounting for the non-energy benefits, which relate to the values that energy storage participants—utility companies, individuals, communities, or society—receive in addition to the benefits to the energy system. Non-energy benefits in this sense could include resiliency, reduced outages, decreased pollution, increased property values, lower compliance costs, lower utility bill, job creation, and reduced land use (Woods and Stanton 2019).

These benefits are well-documented in literature, and a brief overview and taxonomy are provided below, with regard to the relationship between storage systems installed as part of or in place of power plants. Fossil fuels have supported the energy system as a baseload generation asset, guaranteeing supply reliability and stabilizing wholesale markets. Oil- and gas-fired peaker plants also supported variable peaks in electricity demand. These power system services came at the cost of increased greenhouse gas (GHG) emissions and health-affecting criteria pollutants. In addition, most plants tended to be located in disadvantaged communities, thereby increasing the health and environmental burdens on these vulnerable populations (Lukanov and Krieger 2019). Energy storage deployments offer an attractive option for retiring and replacing the existing power plant infrastructures. The strategic integration of storage in plant decommissioning plans provides energy system, environmental, and societal co-benefits.

2.1 Environmental and Societal Benefits

2.1.1 Avoided Energy Outages

Reduced outages benefit electric utilities and ratepayers. For ratepayers, these benefits are realized in the form of the avoided disruptions in day-to-day life activities. Although it might be hard to fully measure or value the benefits in quantitative terms, the resultant cost reductions from disruptions are significant for customers. For example, for vulnerable customers such as the elderly and/or those with disabilities who might depend on electronic devises, power outages cause life-threatening risks. Hence, valuing the benefits of avoided energy outages as a result of storage installations is needed to enhance better integration in the energy system. Currently, the “value of lost load” (VOLL) is used to estimate the avoided outage benefits to participants (Woods and Stanton 2019). Future valuation methods need to capture the avoided outage benefits of storage in critical and community-serving facilities such as hospitals, senior housing, community centers, schools, and emergency shelters (Rutgers 2019).

2.1.2 Increased Property Value

The increased property value benefit could be assumed in two ways. First, in cases where storage is used as a generating asset, it helps to reduce emissions by replacing fossil fuels. The environmental benefits in this transition could translate to increased property value for owners in close proximity to fossil-fuel infrastructure. Second, for ratepayers with storage installed in buildings, the capability to keep heating and cooling systems reliably operational and the decrease in energy cost could lead to an increased property value. A study by the Appraisal Journal found that for every $1 decrease in the annual utility bill, property value increases by approximately $20 (NREL 2008).

2.1.3 Job Creation

The job creation benefits of energy storage could support communities in revitalizing their economies. This is especially critical for regions that will be negatively affected by the energy transition. For example, in the Centralia case study (see Section 3.2), the decision to build storage capacity in the plant decommissioning strategy led to research and development efforts creating jobs and work opportunities in the storage supply chain (TransAlta USA 2020). The job creation potential would also continue during battery manufacturing, engineering, construction, operation and maintenance, and management during the energy storage asset lifecycle. The California Energy Storage Alliance (CESA) reported that energy storage projects in California have supported approximately 20,510 jobs and they project that number might increase up to 113,190 jobs in the next 10 years (Noh 2020).

2.1.4 Reduced Land Use

The increased deployment of energy storage decreases the need to build or maintain power plants to support peak demand. As shown with the Oakland and Manatee case studies, replacing peaker plants with energy storage for system reliability results in additional benefits of less land being used for power production. Decreasing the land required for power plants allows communities to use the spare land for alternative public-serving uses including parks, conservations, commercial and residential facilities, health centers, schools, and recreation centers (Woods and Stanton 2019).

2.1.5 Reduced Emissions

The integration of storage technologies allows for the reduction of GHG emissions (Colthorpe 2021). Currently, the exact benefits of storage relative to GHG emissions are uncertain (Pimm et al. 2021). This is the case if fossil-fuel sources are used to charge storage and the stored reserve is being used instead of RE output (Arabzadeh et al.; 2019 Saha 2019). The uncertainty might be resolved as the grid switches to increased RE generation and storage is charged with output from clean energy sources (Patel 2019). Storage-enabled reduced peak demand could also indirectly lead to reduced emissions because it decreases the generation and transmission capacity needed (Eyer and Corey 2010).

2.1.6 Equity Advancement

Because of its locational flexibility, storage can be deployed in highly affected communities to provide targeted community benefits and advance energy equity (Table 1). Storage systems and business models could be designed and implemented to help reduce the energy burden for vulnerable groups. For example, the storage benefit of curbing expensive demand charges on community-serving and affordable housing facilities could assist residents with energy affordability. Backup power from storage could also enhance community energy security by supporting grid reliability and resilience (Tarekegne et al. 2021). In addition, the strategic deployment of storage in underserved communities could provide benefits, including energy independence and revenue generation, to revitalize those communities.

Table 1. Local non-energy benefits provided by energy storage.

Benefit Title	Benefit Category(ies)	Description
Emissions reduction	Environmental	Storage facilitates the removal of fossil fuels from the grid through decommissioning strategies and RE expansion.
Energy costs	Economic, social	Storage creates a resource to manage peak demand and reduce cost.
Equity enhancement	Social, economic	Storage systems can provide targeted benefits to underserved communities including revenue generation and energy independence.
Increased property value	Economic	Storage provides the capability to keep heating and cooling systems reliably operational and may decrease energy costs leading to an increased property value.
Job creation	Economic, social	Storage creates job opportunities across the asset’s lifecycle, including battery manufacturing, operation, maintenance, and management.
Less land use	Environmental, social	Storage decreases the need to build new or maintain existing power plants.
Resilience benefits	Social, economic	Storage mitigates energy outages and disruption costs (financial and otherwise).

2.2 Energy System Benefits

2.2.1 Generation Benefits

The generation benefits of storage are related to its capability to store energy during charging cycles and to provide supply to the grid when needed. This allows for generation arbitrage opportunities to sell electricity during times of high rates (Krishnamurthy et al. 2017). In this case, storage helps reduce energy costs and increase revenue potential. As shown in the Oakland and Manatee cases, storage can be used to support peak capacity and reduce and/or defer the need to build additional generating capacity or expensive T&D systems. In addition, storage provides ancillary services including frequency regulation due to its fast response to frequency needs. For power plant retirement plans, these generating service capabilities are key in replacing the generating and operational capacity of the retired assets.

2.2.2 Transmission and Distribution Benefits

The key contributions of storage with regard to T&D systems are that it allows for the deferral of upgrades (or eliminates the need to build new infrastructure), it alleviates system congestion,. The location flexibility of storage makes it attractive for mitigating the impact of transmission congestion (Hledik et al. 2017). The congestion in the system and potential charges could be mitigated by strategically deploying storage assets downstream of choke points (Fitzgerald et al. 2015).

2.2.3 Behind-the-Meter Storage

BTM storage offers energy benefits to energy end-users. For example, energy storage could provide backup power and energy service reliability during outages that occur naturally and/or as a result of technical system failures (Olinsky-Paul 2019). This is beneficial for critical infrastructure such as health facilities and shelters. BTM storage also allows customers to reduce their reliance on the electricity grid by storing excess electricity from rooftop solar or other onsite generation, leading to decreased overall energy use from the grid and decreased electricity bills (Hewett et al. 2016). Customers can also lower their utility bills by storing electricity from the grid during times of low rates and avoiding higher rates. Similarly, affordable housing facilities can use storage to avoid peak demand charges, thereby alleviating the residents' energy burden (Davis 2019).

3.0 Replacing Fossil-fuel Power Plants with Energy Storage

The following sections provide an overview of local energy effects and non-energy benefits of energy storage, with a focus on the role of energy storage in fossil-fuel plant decommissioning and replacement strategies. The section offers a brief summary of three case studies—at the Dynegy Oakland, Centralia, and Manatee power plants—where storage was integrated into plant decommissioning strategies to play the dual role of enabling the reduction of fossil sources from the grid while allowing increased integration of renewable sources into the electric grid. These case studies are intended to show the essential role of storage in accelerating deep decarbonization and the possibilities of enabling a just transition from fossil fuels.

3.1 Oakland Energy Facility, California (1978–2022)

The Dynegy Oakland Petroleum Liquid Power Plant is a three-unit energy generating plant with an operating capacity of 223.5 MW (County Office 2021). The plant converts energy into bulk electrical power to service the Alameda County electrical grid electricity consumers. This peaker plant offers up to 40 MW of support to the grid for 10 hours/day to guarantee energy reliability under the California Independent Service Operator (CAISO) Reliability-Must-Run contract (ENEFIRST 2020).

The power plant is located in the historical Jack London Square in downtown Oakland. According to the California Environmental Protection Agency (CalEPA), the plant's fenceline communities faced one of the state's worst pollutions (Table 2) (Chhabra 2018). The 43-year-old plant (in operation since 1978) is set to be retired in 2022 (Chhabra 2018). Pacific Gas & Electric (PG&E), the utility service provider, is responsible for finding ways to maintain long-term local grid reliability in the aftermath of the power plant retirement and the resultant loss of capacity on the grid (ENEFIRST 2020). This plant retirement highlights the factors utilities, state policymakers, and communities have to consider when exploring options (or issues) related to plant decommissioning processes.

Table 2. Dynegy Oakland Energy Plant summary description (Source: PSE Healthy Energy 2020a).

Entry	Factor	Data
Plant Description	Name (EIA ID)	Oakland Power Plant (6211)
	Fuel	Jet fuel
	Age	42
	MW	224
Operation and emissions	Capacity factor	0.2%
	Run hours/start	NA
	Heat rate (MMBtu/MWh)	15.5
	CO_2 rate (T/MWh)	0.20
	NO_x rate (lb/MWh)	7.4
	% MWh high ozone days	NA
Demographics (3-mile radius)	Population	196,253
	% Non-white	63%
	% Poverty	20%
	EnviroScreen score	72
Plant Status	Status	Retiring 2022
	Replacement plans	Solar + Storage

EIA ID = U.S. Energy Information Administration identifier; CO_2 = Carbon dioxide; NO_x = Nitrogen oxides; MW = megawatt; MWh = megawatt-hour

3.1.1 Plant Retirement Process Overview

During CAISO's 2015–2016 Independent System Operator Transmission Plan planning process, the retirement of the Oakland Energy Facility was flagged as a potential local transmission reliability concern (ENEFIRST 2020). The business-as-usual procedure in this case would be to either repower the retiring plant with natural gas or build a high-power transmission line through Oakland. However, with the region's history of high levels of toxic particulates and air pollution, repurposing the plant with natural gas would extend pollution in the area. The second option requires expensive T&D investment in addition to the siting impacts in a heavily populated downtown area. Siting T&D infrastructure could negatively affect communities and disturb local businesses. Considering these constraints, CAISO focused on local clean energy resources to address the local transmission reliability needs. PG&E put forth a plan to replace the plant with expansion in distributed resources including clean energy generation, energy system upgrades, and energy storage (PG&E 2019). The output of the collaboration was the Oakland Clean Energy Initiative (OCEI) that was approved by CAISO during the 2017-2018 transmission planning process (CAISO 2020).

Under the OCEI, PG&E worked with East Bay Community Energy (EBCE), the community choice aggregator (CCA) that serves the Oakland area (EBCE 2020). The design of the projects included a portfolio mix of solar, energy storage, and demand response. Multiple stakeholders weighed in on the revitalization proposal, including the City of Oakland, local businesses, environmental groups, and West Oakland Environmental Indicators Project. Community groups like the Local Clean Energy Alliance worked with EBCE to prioritize local economic outcomes and environmental justice in the strategy to meet the local energy reliability requirements.

3.1.2 Plant Replacement with Energy Storage

Implementing the OCEI provides local environmental benefits and a cleaner electric portfolio. In 2019, Vistra Energy and esVolta/Tierra Robles Energy Storage, LLC were chosen to develop utility battery storage systems to partially replace the capacity of the retiring plant. The facilities will have 36.25 MW and 7 MW capacities, respectively (Dohrety 2020). The storage system will draw electricity from the grid when demand is low and supply power in times of increased demand. It will serve the grid in meeting demand changes and securing reliability (ACORE 2020). Utilizing storage in decommissioning the Dynegy Oakland Power Plant will reduce toxic emissions and may lead to improved indoor air quality, health outcomes, and comfort and quality of life for frontline communities (PSE Healthy Energy 2020a). This in turn may improve property values, facilitate new business attractions, and create jobs in the community. The cost-savings from storage may be passed on to ratepayers to lower the energy burden on low-income customers while reducing their service disconnection risks.

3.2 Centralia Power Plant, Washington (1973 – 2025)

The Centralia Power Plant is a 1,459.8 MW capacity coal-fired energy facility owned and operated by TransAlta in Centralia, Washington (Global Energy Monitor 2021). The facility operated two generating units, each with a 729.9 MW capacity. Unit 1 had been in operation since 1972 and was retired in December 2020, 10 years earlier than the plant's expected useful life. Unit 2 came into service in 1973 and it is scheduled for retirement in 2025 with 15 years left of its expected useful life. The coal for the power plant is sourced from Rawhide Mine in Peabody, Wyoming, and Spring Creek Mine in Navajo, Wyoming.

3.2.1 Plant Retirement Process Overview

Washington State's efforts in curbing GHG emissions were behind the decision to close the power plant units. In 2006, the power plant emissions per megawatt-hour were approximately carbon dioxide (CO_2) 7,974,564 T, sulfur dioxide (SO_2) 1668 T, nitrogen oxides (NO_x) 9699 T, and mercury 315 lb (Global Energy Monitor 2021; Vartan 2018). In 2009, environmental stakeholders (for example, Earthjustice) appealed the renewal of Centralia's air pollution permit and led the effort to close the power plant (Earthjustice 2009).

In 2010, the Washington legislature introduced a bill that removes the state tax exemption for Centralia, which amounted to $4 million/year (Global Energy Monitor 2021). The tax exemption was initially passed in exchange for the plant to use locally mined coal. However, the Centralia coal mine was closed in 2006. In 2011, the state proposed a 2015 retirement timeline on the account of the plant's impact on human and environmental health (Ecology 2020). However, the state reached an agreement with plant owner/operator TransAlta to extend the retirement period to allow TransAlta to recoup its investment while also planning to finance a $55 million Coal Transition Fund (TransAlta 2015). The transition fund will be used to assist workers and communities affected by the plant closure. Governor Christine Gregoire signed the TransAlta Energy Transition Bill in 2011 and set the plant's shutdown schedules. As of 2021, Unit 2 of the Centralia Power Plant is the only commercial coal-fired power plant in Washington State.

Environmental and labor groups have played significant roles in negotiating benefits for older workers to retain benefits. The extended plant retirement timeline allowed 40% of workers to reach retirement age before plant closure. It also added 8 years for non-retirees in their current jobs (Centralia Coal Transition Grants 2021). The Coal Transition Fund will pay $25 million for clean energy projects, $10 million in grants for EE and weatherization projects (with specific carve-out for low- to moderate-income households), and $20 million for economic and community development. The community development payment includes an $8 million fund for payout for displaced workers and an additional $1 million for education and retraining. Displaced workers will get a lump sum payment of $44,000 and they can apply for education grants of up to $15,000 (McIntosh 2020).

3.2.2 Plant Replacement with Energy Storage

To replace the retiring plant, PNNL is collaborating with TransAlta to assess the feasibility of building an energy storage supported renewable capacity on the retiring Centralia coal power plant site — a 200 MW/800 MWh battery plus 100 MW photovoltaic system. A grant in the amount of $350,000 has been approved from the $25 million clean energy transition fund. This work will assess the potential of storage to improve reliability of RE while providing investment in the community. The battery system will be charged by the solar energy plant at the old Centralia coal mine site.

3.3 Manatee Power Plant, Florida (1970s–2021)

The Manatee Power Plant is a 1,638 MW capacity two-unit natural gas power plant built in the 1970s and operated by the Florida Power & Light Company (FPL) in Parrish, Florida (Table 3) (Proctor 2019).

Table 3. Manatee Power Plant summary description (Source: PSE Healthy Energy 2020b).

Entry	Factor	Data
Plant Description	Name (EIA ID)	Manatee (6042)
	Fuel	Natural gas
	Age	44
	MW	1727

Entry	Factor	Data
Operation and emissions	Capacity factor	11.2%
	Run hours/start	23.4
	Heat rate (MMBtu/MWh	11
	CO_2 rate (T/MWh)	0.7
	NO_x rate (lb/MWh)	0.7
	%MWh high ozone days	1
Demographics (3-mile radius)	Population	677
	% Non-white	28%
	% Poverty	16%
	Cumulative Vulnerability Index (median = 150)	112
Plant Status	Status	Retiring 2022
	Replacement plans	Solar + Storage

EIA ID = U.S. Energy Information Administration identifier; CO_2 = Carbon dioxide; NO_x = Nitrogen oxides; MW = megawatt; MWh = megawatt-hour

3.3.1 Plant Retirement Process Overview

FPL decided to replace Manatee's gas-fired generation with battery storage at least partly due to the utility's plan to eliminate over 1 million tons of CO_2 emissions from its portfolio and generate $100 million in savings for ratepayers (FPL 2019). This plan includes installing 30 million solar panels by 2030. Following several smaller battery installations across the state, FPL realized the low costs of battery technology can be used to replace the Manatee plant and to serve customers with solar energy. In their 2020 FPL Gulf Ten-Year Site Plan, the Manatee units are described as "inefficient compared to current generation technology," and will therefore be retired (FPL 2020). The battery is expected to be installed on the property by the end of 2021.

3.3.2 Plant Replacement with Energy Storage

The replacement for the planned plant retirement is a 409 MW capacity energy storage facility (Manatee Energy Storage Center). According to FPL, this will be the world's largest energy storage system. The storage system will cover a 40-acre parcel of land and will distribute 900 MWh of electricity (FPL 2019). The storage technology will help Florida realize the full benefits of its abundant solar power and other clean energy resources. The Manatee Energy Storage will be powered by the FPL solar plant and will replace the two aging gas-fired peaker plants. The solar plus storage system offers a compounded benefit in saving customers money (approximately $100 million savings to ratepayers), reducing emissions (1 million tons of CO_2), improving service reliability, increasing clean energy integration, and creating new jobs (approximately 70 new jobs during construction) (FPL 2019).

4.0 Conclusion

This report has provided a review of three fossil-fuel power plant decommissioning strategies. The case studies were chosen to assess the role of energy storage in enabling an equitable clean energy transition future. As such, the report offers a summary of the key energy and non-energy benefits of storage for the various stakeholders that interact with the energy system. The main similarity across the three case studies is the identification of storage as the technology of choice to support energy transition. In all three power plant decommissioning strategies, storage plays the dual role of enabling the reduction of non-RE sources from the grid, while enabling increased RE integration into the electric grid (Table 4). As future work continues to assess the non-energy benefits of energy storage systems, researchers, utilities, and policymakers need to work with communities to understand past decisions and inform future decision-making tools that account for environmental, economic, and social impacts, particularly impacts on disadvantaged and fenceline communities.

Table 4. Energy storage benefits in fossil-fuel power plant decommissioning.

Benefit	Description
Reliable and affordable energy supply	• Supports variable RE and expanded electrification advancements • Provides energy security during physical and cyber-security threats
Clean environment	• Provides increased and effective RE integration • Reduces the need for new baseload/peaker power plant construction
Strong energy infrastructure	• Enhances grid flexibility • Supports efficient power plant operation, transmission, and distribution

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