# THE ECONOMICS OF CLEAN ENERGY PORTFOLIOS

HOW RENEWABLE AND DISTRIBUTED ENERGY RESOURCES ARE OUTCOMPETING AND CAN STRAND INVESTMENT IN NATURAL GAS-FIRED GENERATION

BY MARK DYSON, ALEXANDER ENGEL, AND JAMIL FARBES

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# ABOUT US

## About Rocky Mountain Institute

Rocky Mountain Institute (RMI)—an independent nonprofit founded in 1982—transforms global energy use to create a clean, prosperous, and secure low-carbon future. It engages businesses, communities, institutions, and entrepreneurs to accelerate the adoption of market-based solutions that cost-effectively shift from fossil fuels to efficiency and renewables. RMI has offices in Basalt and Boulder, Colorado; New York City; Washington, D.C.; and Beijing.

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# EXECUTIVE SUMMARY

### The current rush to gas in the US electricity system could lock in $1 trillion of cost through 2030

The US power grid is the largest, most complicated, most expensive, and likely the oldest continually operating machine in the world, but it is not aging gracefully. The grid has fueled the US economy for over a century, but requires significant reinvestment to maintain the same level of cost-effective, reliable service for the next century. In particular, the fleet of thermal power plants that convert fuel to electricity is aging, with over half of thermal capacity more than 30 years old and expected to reach retirement age by 2030.

Recent advances in power plant technology and the currently low price of natural gas mean that new natural gas-fired turbines are more efficient and less costly to run than aging power plants. This has led to a "rush to gas," with utilities and independent power plant developers having announced plans to invest over $110 billion in new gas-fired power plants through 2025. Extrapolating this trend to 2030 suggests that over $500 billion will be required to replace all retiring power plants with new natural gas-fired capacity. This will lock in another $480 billion in fuel costs and 5 billion tons of $CO_2$ emissions through 2030, and up to 16 billion tons through 2050.

**50%**
of US thermal power plant capacity is likely to retire by 2030

**$520 BILLION**
is required for natural gas-fired power plants to replace retiring capacity

**$480 BILLION**
is required for fuel to run those power plants through 2030

## "Clean energy portfolios" represent a promising alternative to new gas-fired power plants

Natural gas-fired power plants are not the only resource options capable of replacing retiring capacity. Renewable energy, including wind and solar, and distributed energy resources, including batteries, have fallen precipitously in price in the last 10 years. At the same time, developer and grid-operator experience with these resources has demonstrated their ability to provide many, if not all, of the grid services typically provided by thermal power plants. Together, these technologies can be combined into "clean energy portfolios" of resources that can provide the same services as power plants, often at net cost savings.

**TABLE ES-1**

GRID SERVICES AVAILABLE FROM CLEAN ENERGY PORTFOLIO RESOURCES

<table>
<tr><th rowspan="2">RESOURCE</th><th colspan="4">SERVICE</th></tr>
<tr><th>Energy</th><th>Peak Capacity</th><th>Flexibility</th><th>Additional Network Stability*</th></tr>
<tr><td>Energy Efficiency</td><td>Reduces consumption</td><td>Reduces peak load</td><td>Flattens ramps</td><td>n/a</td></tr>
<tr><td>Demand Response</td><td>n/a</td><td>Reduces peak load</td><td rowspan="2">Can actively respond to ramp events, in both directions</td><td>Current-generation active load-management technologies can provide reserves and frequency regulation</td></tr>
<tr><td>Distributed** and Utility-Scale Battery Energy Storage</td><td>n/a</td><td>Provides active power injection</td><td>Can provide reserves, frequency support (including synthetic inertia), voltage support, and black start</td></tr>
<tr><td>Distributed** Renewable Energy</td><td rowspan="2">Energy generator</td><td rowspan="2">Can reliably produce at "capacity credit" during peak hours</td><td rowspan="2">Balanced portfolios can reduce ramp rates</td><td rowspan="2">When renewable resource is available, can provide reserves, frequency regulation, and voltage support</td></tr>
<tr><td>Utility-Scale Renewable Energy</td></tr>
</table>

* includes distribution-level voltage support and other ancillary services
** includes behind-the-meter and front-of-the-meter deployments

Source: RMI analysis, adapted from EPRI

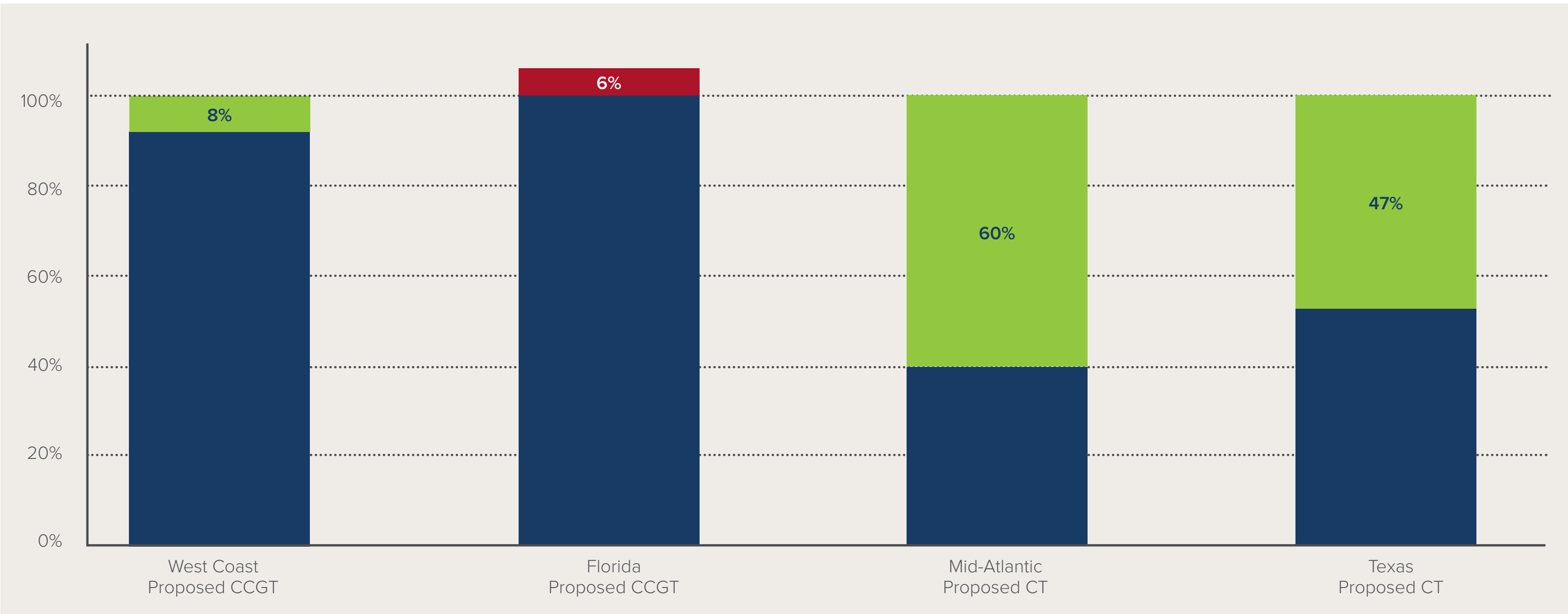
## Clean energy portfolios are cost-competitive with proposed natural gas-fired power plants in four diverse case studies from across the US

This study compares the costs of four natural gas-fired power plants currently proposed for construction across the US against optimized, region-specific clean energy portfolios of renewable energy and distributed energy resources (DERs) that can provide the same services. We analyzed two announced combined-cycle gas turbine (CCGT) power plants, planned for high capacity-factor operation, and two announced combustion turbine (CT) power plants, planned for peak-hour operation.

In only one case did we find that the net cost of the optimized clean energy portfolio is slightly (~6%) greater than the proposed power plant; in the other three cases, an optimized clean energy portfolio would cost 5–60% less than the announced power plant. Factoring in expected further cost reductions in distributed solar and/or a $7.50/ton price on $CO_2$ emissions, all four cases show that an optimized clean energy portfolio is more cost-effective and lower in risk than the proposed gas plant.

**FIGURE ES-1**

NET COST OF CLEAN ENERGY PORTFOLIOS ACROSS FOUR CASE STUDIES, RELATIVE TO PROPOSED GAS-FIRED POWER PLANTS

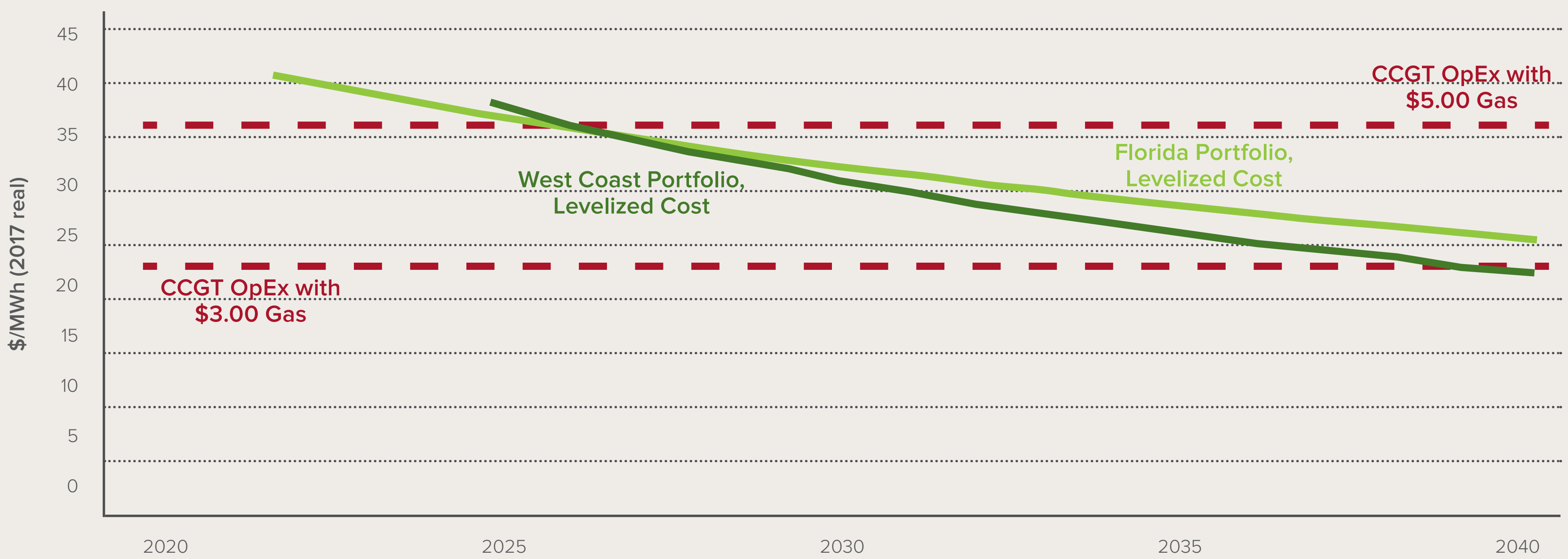


## Low-cost clean energy portfolios threaten to strand investments in natural gas-fired power plants

In addition to competing with proposed gas-fired power plants on a levelized cost basis, clean energy portfolios will also increasingly threaten the profitability of existing power plants. Comparing the future operating costs of the two proposed CCGTs in this study against new-build clean energy portfolios, we find that, depending on gas price forecasts, the clean energy portfolio's levelized, all-in costs will fall below marginal operating costs of the CCGTs well within the planned operating lifetime of the proposed plants. In other words, the same technological innovations and price declines in renewable energy that have already contributed to early coal-plant retirement are now threatening to strand investments in natural gas.

**FIGURE ES-2**

COMPARISON OF COMBINED CYCLE OPERATING COSTS VS. CLEAN ENERGY PORTFOLIO LEVELIZED COSTS, 2020–2040




- ▶ **Assuming gas prices between $3–5/MMBtu, combined-cycle operating costs will vary between $23/MWh and $36/MWh**
- ▶ **Optimized clean energy portfolios, depending on location and technology mix, will cost less to build than CCGTs cost to run by 2026 (assuming $5/MMBtu gas) or ~2040 (assuming $3/MMBtu gas)**

## To mitigate stranded asset risk and minimize ratepayer costs, investors and regulators should carefully reexamine planned natural gas infrastructure investment

Our analysis reveals that across a wide range of case studies, regionally specific clean energy portfolios already outcompete proposed gas-fired generators, and/or threaten to erode their revenue within the next 10 years. Thus, the $112 billion of gas-fired power plants currently proposed or under construction, along with $32 billion of proposed gas pipelines to serve these power plants, are already at risk of becoming stranded assets. This has significant implications for investors in gas projects (both utilities and independent power producers) as well as regulators responsible for approving investment in vertically integrated territories.

- **$93 billion of proposed investment is at risk for merchant gas power plant developers**
  - Approximately 83% of announced gas projects are proposed for restructured markets, where independent power producers bear market risk if these assets see their revenue fall under competition from renewables and DERs.
  - Investors should reassess the risk profiles of gas projects and, in particular, consider the reduced useful lifetimes of gas-fired power plants under competition from clean energy resources, to mitigate the erosion of shareholder value.

- **Ratepayers face $19 billion of locked-in costs**
  - The remaining 17% of gas-fired power plants proposed are in vertically integrated jurisdictions, where state-level regulators are responsible for approving proposals to build new gas plants and for allowing utilities to recover costs through customer rates.
  - To avoid the risk of locking in significant ratepayer costs for gas-fired resources that are increasingly uneconomic, regulators should carefully consider alternatives to new gas power plant construction before allowing recovery of costs in rates.

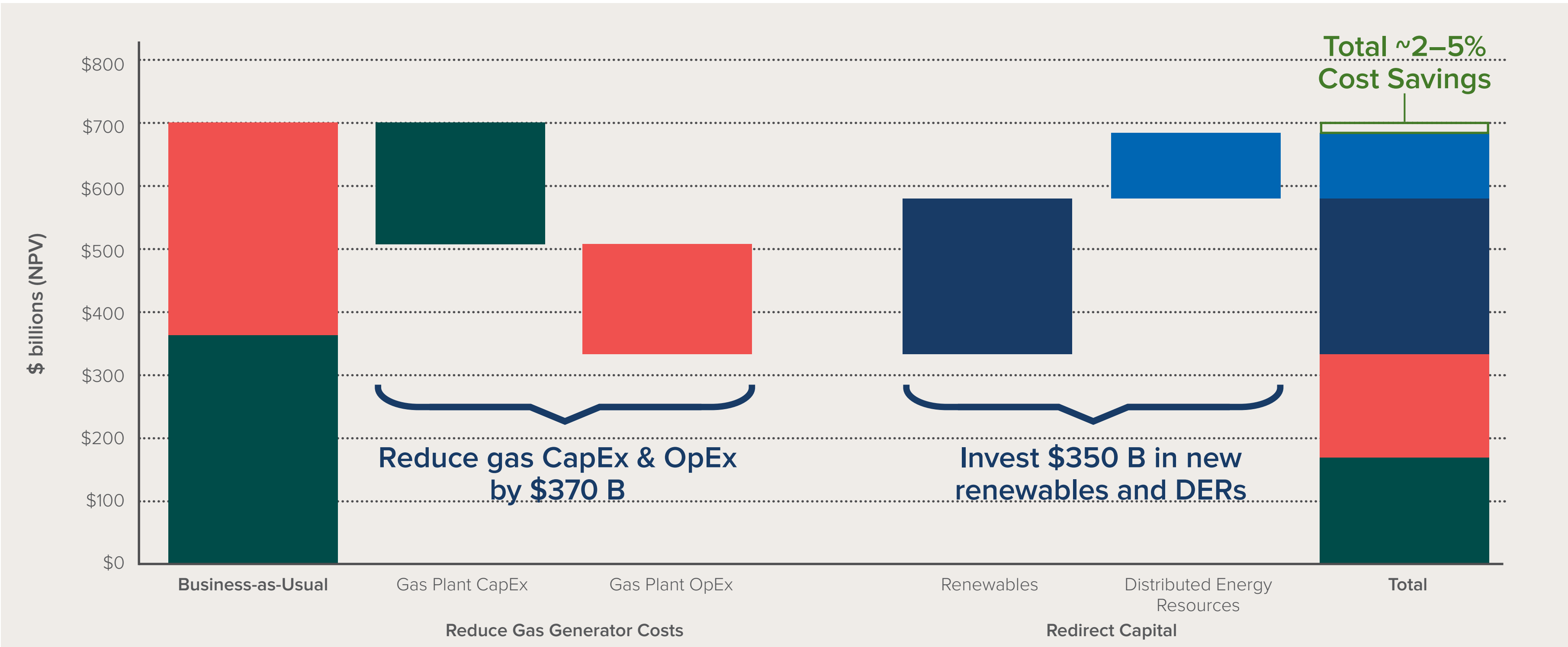
In both regulated and restructured electricity markets, there is a significant opportunity to redirect capital from uneconomic, risky investment in new gas toward clean energy portfolio resources, at a net cost savings.

## Clean energy portfolios represent a $350 billion market opportunity for renewables and DERs through 2030

The emerging cost-effectiveness of clean energy portfolios versus new gas suggests a significant opportunity to offset a majority of planned spending on new gas plants, and instead prioritize investments in renewables and DERs, at a net cost savings on a present value basis. This investment trajectory would unlock a market for renewables and DERs many times larger than today's, minimize risk to investors, enable net cost savings for American electricity customers, and reduce carbon emissions by 3.5 billion tons through 2030. This estimate excludes any value of DERs to the distribution system beyond peak load reduction, any value of avoided fuel price risk, and any cost on carbon emissions; including these factors could increase the addressable market and savings potential significantly.

**FIGURE ES-3**

MARKET OPPORTUNITY FOR CLEAN ENERGY PORTFOLIOS IN THE US, 2018–2030



## Current regulatory incentives, market rules, and resource planning processes limit the ability to capture the full value offered by clean energy portfolios

Clean energy portfolios represent a cost-effective alternative to investment in new gas-fired power plants, with a potentially accessible market in the hundreds of billions of dollars through 2030, while avoiding the fuel price risks and $CO_2$ emissions associated with new natural gas power plants. However, the industry is just beginning to recognize and capture the benefits of these resources, and execution of clean energy portfolio projects remains relatively low compared to their potential. Coordinated action by several stakeholder groups can accelerate adoption.

### RECOMMENDATIONS

**For regulators and market operators:** *Study alternatives and level the playing field.*

- **Seek broad input:** Solicit input from alternative-solution providers as part of the approval process for proposed power plant investments
- **Align incentives:** In states with rate-based generation, adjust utility earnings incentives to put clean energy portfolios on a level playing field with traditional capital investments by rewarding least-cost resources more effectively than does the traditional return-on-capital business model
- **Open up market participation:** In restructured markets, allow participation of distributed resources in wholesale market products historically designed with thermal generators in mind

**For utilities:** *Revolutionize resource planning and procurement processes.*

- **Update planning:** Accurately reflect system needs and the capabilities and potential of clean energy portfolio technologies, including distributed and demand-side options, to meet those needs
- **Scale deployment quickly:** Limit pilots of already-proven technology, and move quickly toward scaled deployment
- **Procure solutions:** Request technology-neutral solutions from the market, and move toward standard tariff- or market-based incentive structures to procure them

**For technology providers and project developers:** *Offer holistic, low-cost solutions to meet grid needs.*

- **Integrate multiple technologies:** Where utilities seek or markets support turnkey alternatives to gas plants, partner across vendors to optimize bids and deployment accordingly
- **Drive down costs:** Leverage technology to reduce the costs of system design, customer acquisition, operational integration, and other “soft” costs
- **Generate confidence:** Work with planners and system operators to characterize discrete grid service needs, including measurement and verification, and validate performance characteristics of portfolio technologies

## 02 INTRODUCTION

# INTRODUCTION

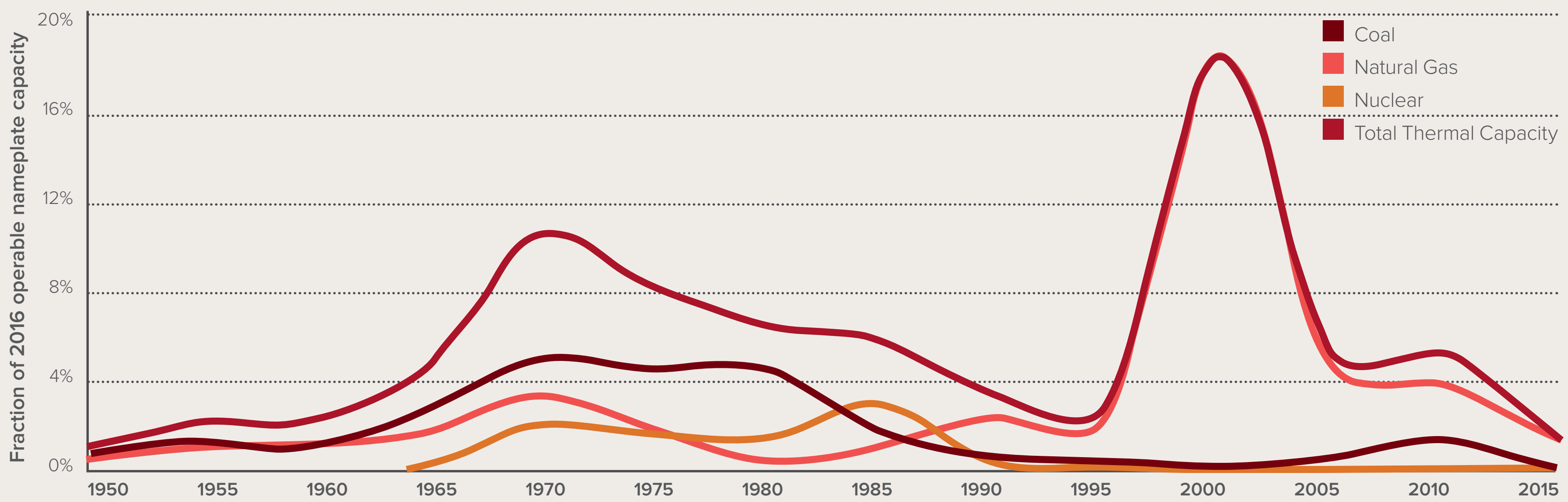
## The US grid relies on an aging fleet of thermal power plants, and is shifting to rely more heavily on natural gas

The fleet of thermal generators that powers the US grid is aging. 52% of thermal capacity (42% of total capacity) is over 30 years old. To meet forecasted load growth (**much of which hasn't materialized**) and replace retiring capacity, utilities and independent power producers have invested heavily in new natural gas-fired generation capacity in recent years, leading to 32% of electricity in 2017 coming from natural gas.

30% of existing thermal capacity—mostly coal and nuclear but some gas—was built between 1960 and 1984 and is nearing retirement age. Gas-fired plants built in the 1990s and 2000s will likely remain in operation for several decades.

**FIGURE 1**

DISTRIBUTION OF THERMAL POWER PLANT CAPACITY BY FUEL TYPE AND ON-LINE DATE




Sources: EIA Form 860, EIA Form 923 through Nov. 2017

## Approximately 50% of existing thermal power plants are likely to retire by 2030

The age of the fleet and current market trends suggest a coming wave of retirements of existing thermal assets. Based on average age at retirement for recently closed plants, approximately 50% of the existing thermal fleet may retire by 2030.

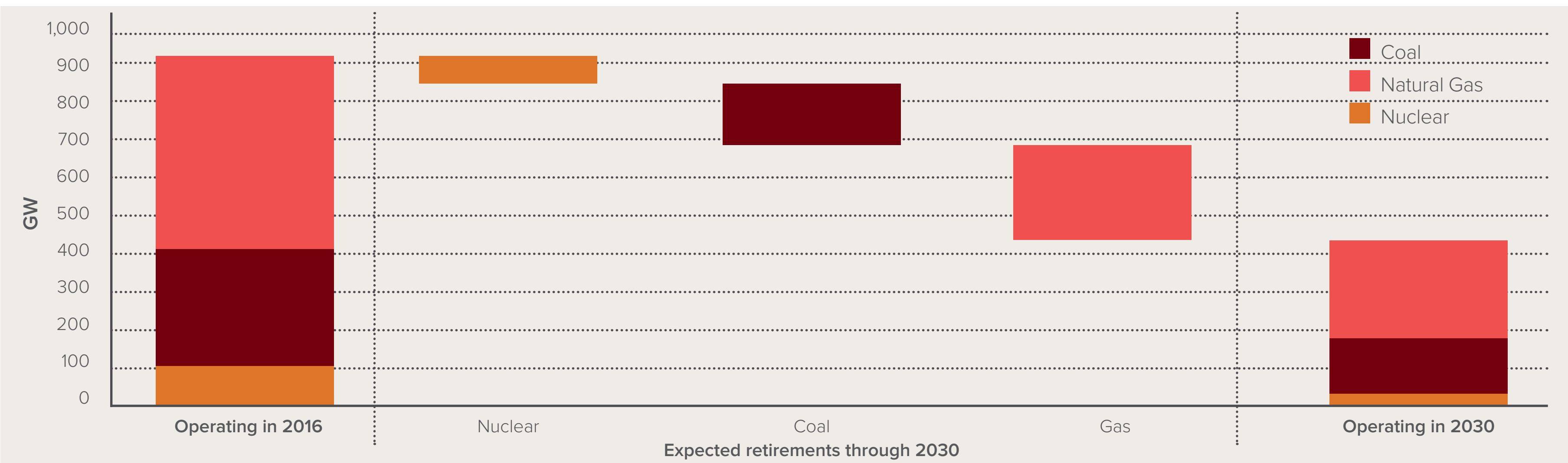
- **Coal:** The average retirement age of closed plants to date is 54 years, but that age may decline given recent trends, in particular recent pressure from low natural gas prices.

- **Nuclear:** Average retirement age for the US nuclear fleet is 45 years, according to S&P Global projections. As with coal plants, low gas prices have accelerated retirement pressure on nuclear plants in restructured markets.

- **Gas:** The average historical retirement age of natural gas-fired power plants is between 29 and 51 years, depending on prime mover technology. The most recent "rush to gas" in the 1990s and 2000s resulted in significant, relatively new gas capacity that can be expected to remain in operation through 2030 and beyond, but there are many older plants that are still operating that are costly to run and are likely to retire soon.

**FIGURE 2**

EXISTING US THERMAL GENERATION CAPACITY RETIREMENT OUTLOOK

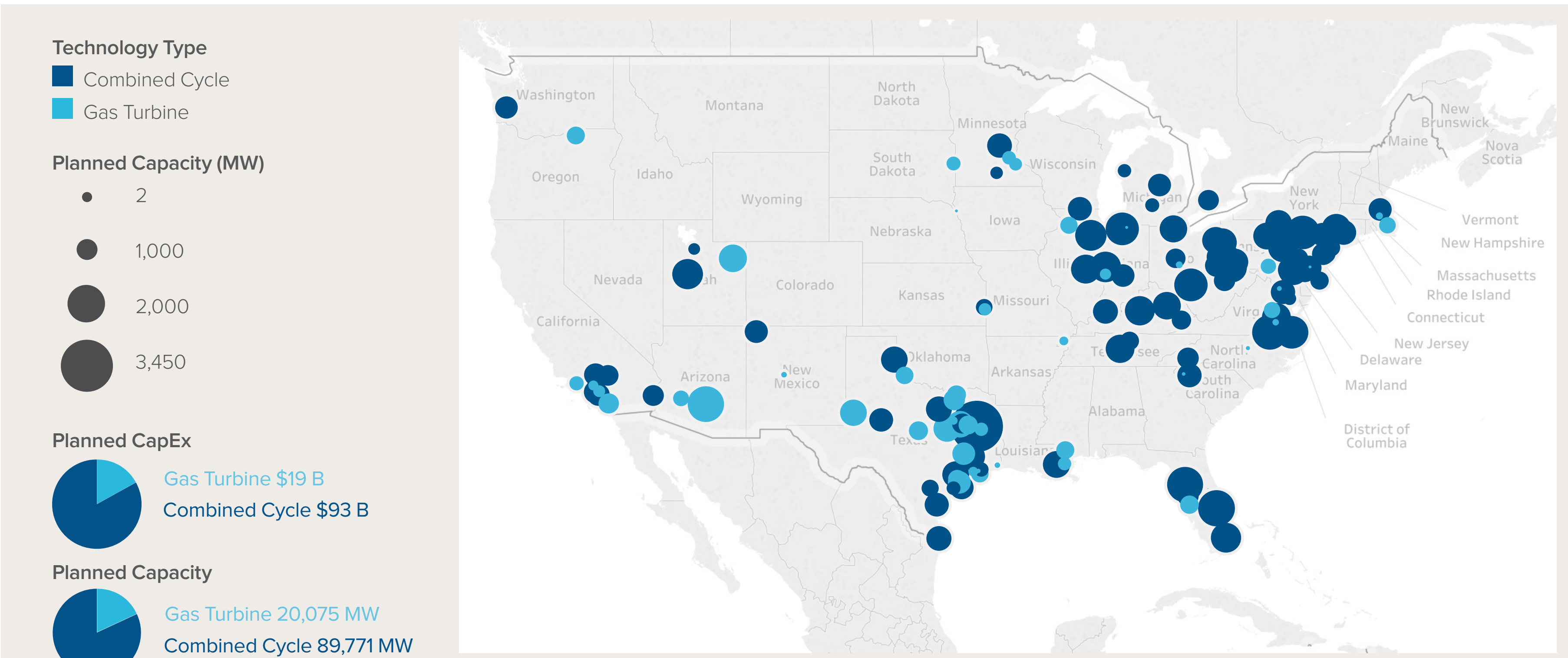


## 110 GW of new gas projects have been announced for construction through 2025, largely to replace retiring assets

The wave of plant retirements and the currently low price of natural gas have spurred a new rush to gas. Utilities and independent power producers across the United States have announced plans to construct over 110 GW of new gas-fired power plant capacity. The majority of announced projects are combined-cycle combustion turbine (CCGT) units, expected to run at high capacity factor and replace so-called "baseload" power plants, mainly coal and nuclear, that have retired or are expected to retire soon. Combustion turbine (CT) projects make up the remainder of planned capacity, and are designed to run primarily during peak load hours and/or balance variable renewable generation.

**FIGURE 3**

PROPOSED NEW NATURAL GAS-FIRED POWER PLANTS IN THE US




Source: RMI analysis of S&P Global data

## Through 2030, the current trend of gas power plant investment could lock in over $1 trillion of costs

Replacing plants expected to retire with new gas-fired capacity will require significant capital investment and lock in fuel costs for decades, with fuel price volatility risk passed on to end customers. Assuming that existing plants are retired at their unit type-average age, and that new CCGTs replace high-capacity factor plants while new CTs replace peaking units, on the order of $520 billion dollars in new capital investment—supporting the development of 480 GW of new power plants—is required through 2030.[1] Running these plants at unit type-average capacity factors (i.e., 60% for CCGTs, 11% for CTs) would require a cumulative $480 billion in fuel purchases—and emit over 5 billion tons of $CO_2$—in the same time period.

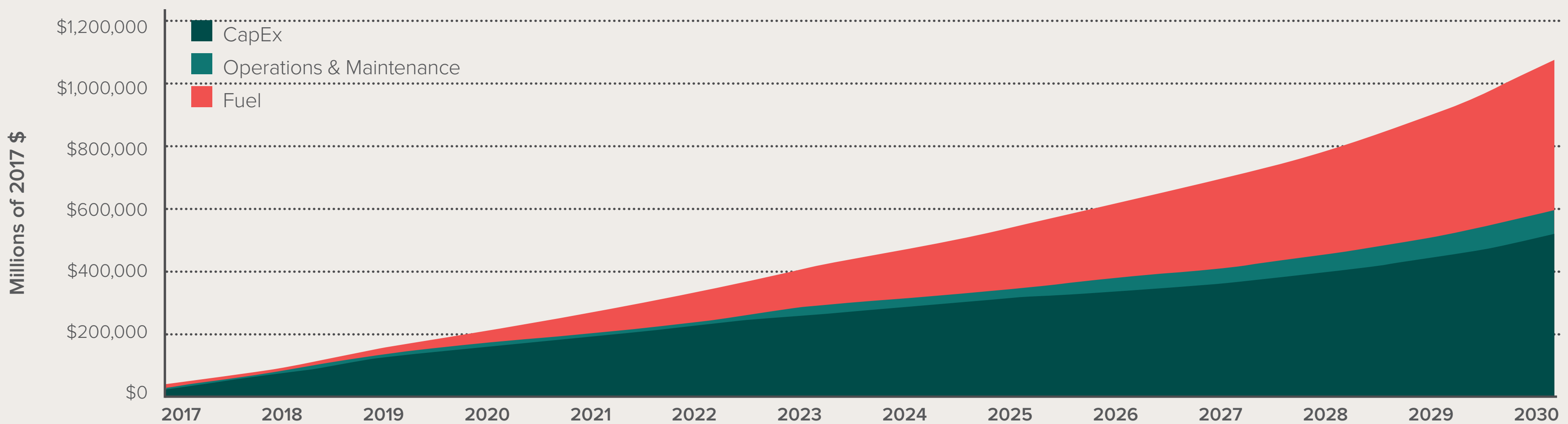
Beyond 2030, these generators would emit approximately 16 billion tons of $CO_2$ through their expected 20-year lifetimes, locking in emissions for generations to come.

- **$520 billion in CapEx through 2030 for new gas plants, incurred upon retirement of existing assets**
- **$480 billion in fuel costs through 2030, with an associated 5 billion tons of $CO_2$ emissions**

[1] Assuming a 1:1 replacement of retiring thermal capacity with new generators is conservative; EIA 860 data show that in the last 10 years, new thermal generation has been built at almost a 2:1 ratio to retirements.

**FIGURE 4**

CUMULATIVE COSTS FOR NEW GAS PLANTS



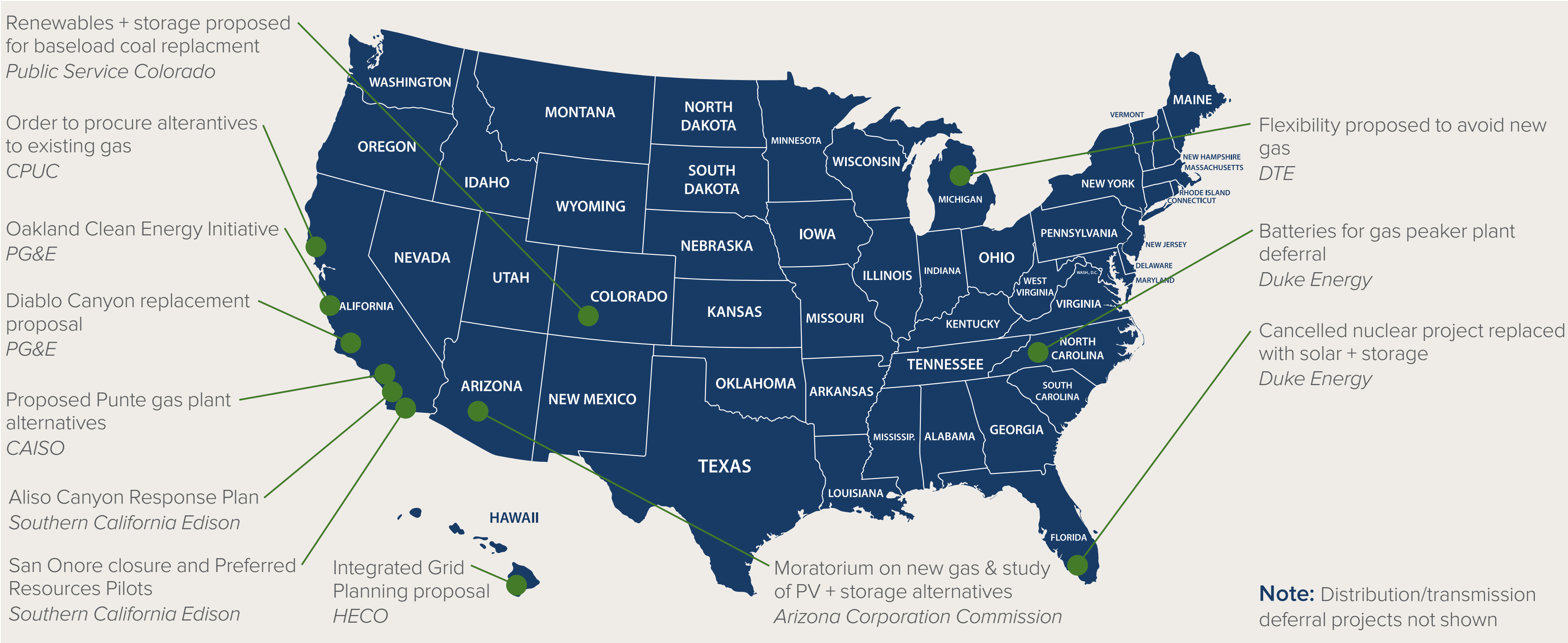

Source: RMI analysis of EIA data

## Utilities and developers across the country are beginning to evaluate alternatives to new thermal power plant investment

Recognizing the significant investment and locked-in fuel costs of building new power plants, utilities, developers, and other stakeholders across the country are examining the cost-effectiveness of portfolios of renewable energy and distributed energy resources (DERs) that can provide the same services as a new thermal power plant at lower cost and lower emissions. This market opportunity is nascent, but growing quickly.

**FIGURE 5**

ALTERNATIVES TO NEW THERMAL POWER PLANT INVESTMENT UNDER CONSIDERATION




**Note:** Distribution/transmission deferral projects not shown

## Proposed alternatives to new power plants often consist of “clean energy portfolios” of energy efficiency, demand flexibility, renewable energy, and energy storage

Few proposed alternatives to new power plants rely on a single technology. Rather, they typically rely on a diverse, balanced portfolio of mature and emerging resource options. Together, these resources form clean energy portfolios that can effectively complement, defer, or avoid investment in traditional grid infrastructure.

### RESOURCE OPTIONS FOR CLEAN ENERGY PORTFOLIOS:

- **Energy efficiency:** Physical measures, software controls, or other strategies to reduce the amount of energy required to perform a given service (e.g., insulation and smart thermostats to reduce heating and cooling energy use)
- **Demand flexibility:** Load controls to enable electricity consumption to shift through time without reducing overall energy use or service quality (e.g., thermal storage in water heater tanks, managed charging of electric vehicles)
- **Variable renewable energy:** Behind-the-meter and front-of-the-meter distributed and utility-scale solar photovoltaics (PV) and wind turbines that provide weather-dependent, nondispatchable energy
- **Battery energy storage:** Dedicated battery storage assets, either in front of the meter or behind the meter, providing energy balancing and flexibility via controlled charging and discharging

## Clean energy portfolios can avoid significant investment and operational costs associated with new gas-fired power plants, as shown by cost trends, expanding capabilities, and emerging best practices

Four emerging trends combine to suggest that well-designed portfolios of clean energy resources can cost-effectively provide all grid services that would otherwise be met by construction of new gas-fired power plants.

### TRENDS SUPPORTING THE GROWTH OF CLEAN ENERGY PORTFOLIOS:

» **Costs**

Prices of clean energy portfolio technologies have fallen dramatically in recent years, such that they can compete even with currently low, but inherently volatile, costs of new gas-fired generation.

» **Capabilities**

Pilots and scaled deployment have demonstrated the ability of renewable energy and aggregated DERs to provide reliably dispatchable capacity and other reliability services, often as well as thermal power plants.

» **Planning approaches**

Advances in planning approaches and software tools can allow utilities and market operators to accurately account for the resource potential and capabilities of renewable energy and DERs.

» **Procurement processes**

Emerging best practices in resource procurement can allow utilities and system operators to efficiently procure DERs at scale.

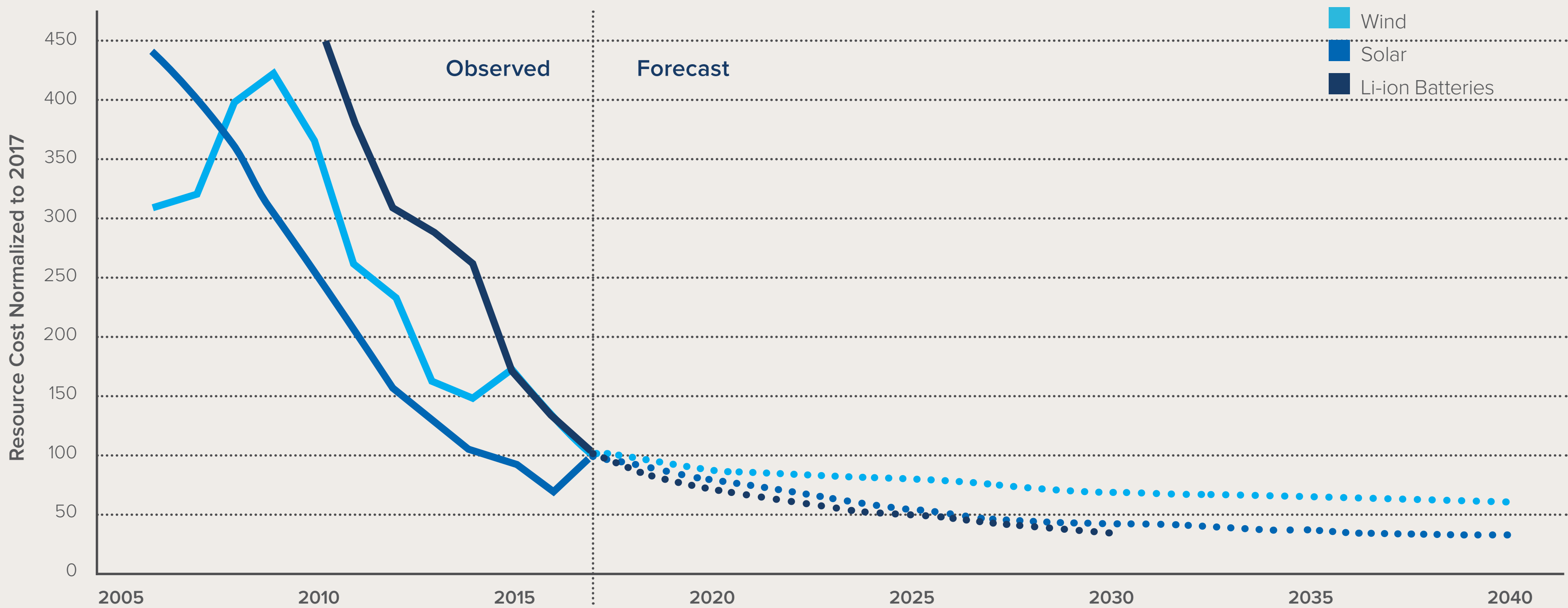
## Prices of clean energy portfolio technologies have fallen dramatically in recent years compared to thermal power plant costs

The thermal power plant market has cooled considerably in recent years, with little room for innovation to bring down costs for these mature technologies. **Analysis** from the investment bank Lazard suggests that levelized costs for new coal and nuclear facilities have essentially plateaued, and recent experience in the US suggests nuclear projects are **getting more expensive**, while new coal projects are being **outcompeted by gas**.

The opposite is true for clean energy portfolio technologies like wind, solar, and battery energy storage, with technology prices falling by **66%**, **86%**, and **73%**, respectively, since 2009–2010. **Data** from 2017 and early 2018 suggest that these resources are already more economical than just the operating costs of existing coal and nuclear generation, let alone the levelized cost of new thermal power plants.

**FIGURE 6**

HISTORICAL AND FORECAST COST DECLINES FOR WIND, SOLAR, AND BATTERIES




Source: RMI analysis of BNEF, LBNL data

## Utilities and project developers have expanded the range of services available from clean energy portfolio technologies

Utilities and third-party operators are beginning to actively manage renewable energy, energy efficiency, demand flexibility, and storage in order to provide multiple value streams to customers, utilities, and the grid at large.

- **Energy efficiency:** Efficiency investments used to be valued only based on energy savings, but planners are also beginning to value the peak-demand savings and load-shape improvements (i.e., reduced ramp rates) associated with this resource.

- **Demand flexibility:** Traditional "demand response" programs typically provide peak load savings for a small number of hours per year, but a new generation of programs is now being used to provide active flexibility and thus more sources of grid value, including renewable energy integration. Lower connectivity costs and machine learning approaches have lowered prices and increased capabilities of demand-flexibility products.

- **Variable renewable energy:** Wind and solar used to be viewed as "in the noise" by grid operators and planners, providing only nondispatchable energy when available, but recently grid operators have demonstrated the ability of renewable energy projects to provide flexibility and ancillary services by leveraging the capabilities of smart inverters.

- **Battery energy storage:** Battery energy storage has historically been deployed and operated to provide a limited number of services to the grid (e.g., demand-charge management in commercial buildings, solar self-consumption), but can technically provide at least 13 distinct sources of value to the grid. New projects are increasingly being designed and operated with this "value stacking" opportunity in mind.

Tesla's Powerpack 2 project with Kaua'i Island Utility Cooperative in Hawaii

Image courtesy of Tesla

## Clean energy portfolios are now able to provide the same set of grid services as thermal power plants

Experience across the country suggests that clean energy portfolios can provide all of the same technical services as thermal power plants. All new gas plants are planned and built to provide different combinations of near-constant energy production, peak capacity, and/or flexibility to balance load and renewable energy variability, while some are also expected to be used to meet network-specific needs (e.g., voltage regulation, black start). Recent experience deploying renewable and distributed energy technologies has shown that well-designed portfolios of these technologies can serve all of these needs.

**TABLE 1**

GRID SERVICES AVAILABLE FROM CLEAN ENERGY PORTFOLIO RESOURCES

| RESOURCE | SERVICE | | | |
|---|---|---|---|---|
| | **Energy** | **Peak Capacity** | **Flexibility** | **Additional Network Stability*** |
| **Energy Efficiency** | Reduces consumption | Reduces peak load | Flattens ramps | n/a |
| **Demand Response** | n/a | Reduces peak load | Can actively respond to ramp events, in both directions | Current-generation active load-management technologies can provide reserves and frequency regulation |
| **Distributed** and Utility-Scale Battery Energy Storage** | n/a | Provides active power injection | | Can provide reserves, frequency support (including synthetic inertia), voltage support, and black start |
| **Distributed** Renewable Energy** | Energy generator | Can reliably produce at "capacity credit" during peak hours | Balanced portfolios can reduce ramp rates | When renewable resources is available, can provide reserves, frequency regulation, and voltage support |
| **Utility-Scale Renewable Energy** | | | | |

* includes distribution-level voltage support and other ancillary services
** includes behind-the-meter and front-of-the-meter deployments

Source: RMI analysis, adapted from EPRI

## New approaches to resource planning allow planners to identify cost-effective clean energy portfolio alternatives to new gas

Traditional grid planning approaches and software solutions typically rely on a set of assumptions about resource characteristics, economic potential, and capabilities that limit the selection of portfolios of renewable and distributed energy resources when compared with gas-fired power plants and other traditional investments. New tools and approaches are beginning to allow for fair comparison.

### BARRIERS TO CLEAN ENERGY PORTFOLIO TECHNOLOGIES IN TRADITIONAL RESOURCE PLANNING:

- **Limited representation of capabilities of renewables and DERs.** Software tools used for utility investment planning typically artificially limit the ability of renewables (e.g., by assigning a low peak capacity credit) and DERs (e.g., by ignoring active management capabilities) to provide grid services.

- **Inability to select DERs as investment options.** Investment planning tools typically treat energy efficiency, distributed solar, and other DERs as load modifiers, not as significant resource investment options.

- **Limited interaction with alternative solution providers.** System planning studies often rely on out-of-date assumptions of alternative resource costs, which are declining rapidly, instead of seeking up-to-date pricing from market participants.

### OPPORTUNITIES FOR CLEAN ENERGY PORTFOLIOS AFFORDED BY NEW APPROACHES AND TOOLS:

- **Disaggregated system-level constraints.** Emerging planning approaches disaggregate system-level constraints, including reliability services like frequency and voltage support, and allow for nontraditional resources to provide them where they can.

- **Direct competition between DERs and central generation.** Existing market products (e.g., California's Demand Response Auction Mechanism) and proposed planning approaches (e.g., Hawaiian Electric's Integrated Grid Planning proposal) explicitly consider and reward DERs as competitive resources that meet grid service needs.

- **Regular market input.** Emerging best practices allow for utilities to understand market conditions and current pricing levels (e.g., through preliminary requests for information) and use that understanding to inform resource planning activities.

## Emerging procurement practices can enable cost-effective deployment of alternatives to gas generation

At the same time as resource planning approaches are evolving to better capture the value of portfolios of renewables and DERs, utilities are developing procurement practices to facilitate acquisition of resources identified as high-value options by planning studies.

- **Pay-for-performance energy efficiency:** A number of utilities have tested procurement of efficiency from aggregators via a "pay for performance" method that can reduce costs by minimizing measurement and verification burdens while ensuring that utilities pay only for savings delivered. This approach can mobilize market forces to identify and deliver the highest-value energy savings opportunities.

- **Portfolio-based procurement strategies:** Utilities including Consolidated Edison and Southern California Edison have deployed multi-hundred megawatt-scale procurement strategies for portfolios of DERs, including energy efficiency, demand response, batteries, and distributed generation that can meet system needs at least cost within a specific geographic area.

- **All-source solicitations:** Open solicitations for generating capacity have expanded in recent years to include nontraditional alternatives, including renewable energy and battery energy storage. Utilities including Arizona Public Service and Xcel Energy Colorado have issued requests for proposals that result in renewable and storage bids at lower energy and/or capacity costs than thermal generation resources.

## This study assesses the cost-effectiveness of optimal clean energy portfolios as alternatives to four proposed new-build natural gas-fired power plants across the United States

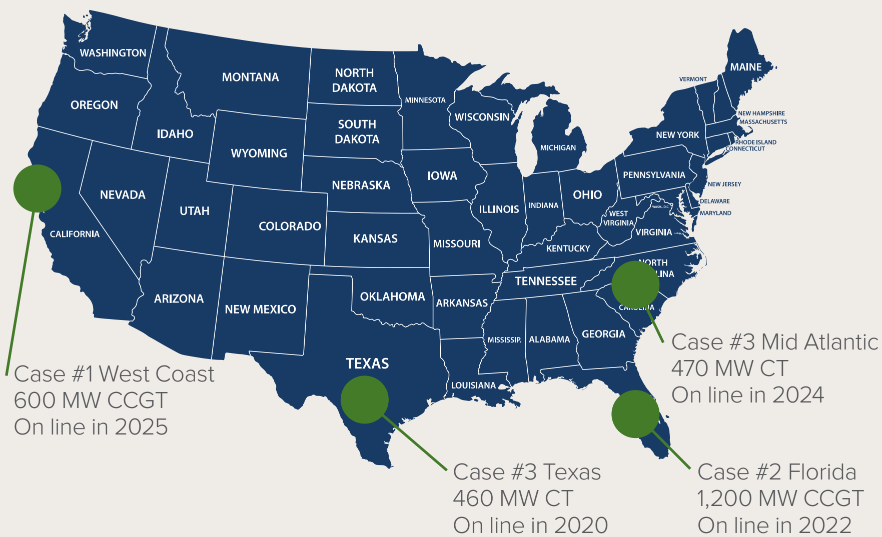
This analysis compares the costs of proposed power plants versus optimized, state-specific portfolios of DERs and utility-scale renewables (clean energy portfolios). We analyze four case studies, based on actual proposals to build new gas plants that are at various stages of the planning process.[2] In each case, we identify a least-cost clean energy portfolio that can provide the grid services that otherwise would be provided by the proposed gas plant.

[2] We analyze alternatives to four announced projects to ensure technically robust results, but we have rounded our reporting of several parameters for each case in order to provide a more generalizable view into the different case studies.

**FIGURE 7**

CASE STUDY LOCATIONS AND ANALYTICAL APPROACH

### POWER PLANT CASE STUDY LOCATIONS AND CHARACTERISTICS




### ANALYTICAL APPROACH

1. **Identify grid services: How much energy, capacity, and flexibility would be provided by the proposed gas plant?**
2. **Assess resource potential: What quantity of efficiency, demand flexibility, and renewable energy could be feasibly deployed in a clean energy portfolio alternative?**
3. **Estimate resource costs: How much will region-specific DERs and renewable resources cost to deploy, now and in the future?**
4. **Optimize least-cost portfolio: What resources, in what combination, can deliver grid services at least cost?**

# 03 APPROACH AND METHODOLOGY

# APPROACH AND METHODOLOGY

## This study relies on a detailed modeling tool to assess the grid service needs met by gas plants, the potential for and costs of alternative resources, and optimized clean energy portfolio structures and costs

We assess each of the four case studies using an original RMI modeling tool to develop estimates of the net present value (NPV) of expenditures on capital costs (CapEx) and operational costs (OpEx) for both the clean energy portfolio and the proposed gas plant in each case. The model includes four components, highlighted below; see Appendix B for further detail on model structure.

1. The **service requirement model** estimates the energy, capacity, and flexibility provided by the business-as-usual (BAU) plant. We model the plant's contribution to system-level reliability by including an approximation of **effective load carrying capacity** (ELCC) for renewables and DERs.

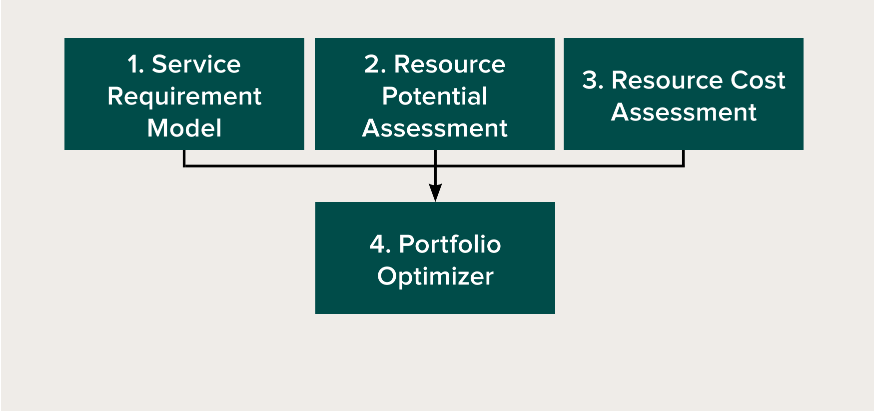
2. The **resource potential assessment** estimates the regional potential of renewable energy (RE), end-use and sector-level energy efficiency (EE), and sector-level demand flexibility (DF).

3. The **resource cost assessment** estimates present values of CapEx and OpEx for available clean energy portfolio resources.

4. The **portfolio optimizer** identifies the lowest-total-cost clean energy portfolio of available resources that can provide the same services identified by the service requirement model.

**FIGURE 8**

COMPONENTS OF CLEAN ENERGY PORTFOLIO OPTIMIZATION TOOL



## Four distinct model components are used to identify least-cost clean energy portfolios (1/2)

### SERVICE REQUIREMENT MODEL

This component estimates future hourly system net load starting in the first year of service of the proposed plant. The model is based on projected load growth and planned renewable additions. It identifies the 50 peak net load hours across all seasons for each year modeled to calculate capacity service requirements, and the single hour of highest system net-load increase for each year modeled to calculate flexibility constraints. Monthly energy service requirements are based on the estimated gas plant operating profile, determined by a dispatch model, and the planned capacity factor provided by the utility integrated resource plan (IRP) associated with each case.

### RESOURCE POTENTIAL ASSESSMENT

The resource assessment module performs bottom-up estimates of energy efficiency and demand flexibility potential by end use, along with top-down potential estimates that constrain total potential across end uses for each customer sector. Top-down estimates for EE potential are calculated from EPRI state-level economic potential for EE savings by sector. Demand flexibility achievable participation by sector is calculated from Federal Energy Regulatory Commission (FERC) state-level potential data. Bottom-up, end use-specific EE estimates are calculated from the US Energy Information Administration's 2015 Residential Energy Consumption Survey (RECS) and 2012 Commercial Buildings Energy Consumption Survey (CBECS) electrical end-use shares for the applicable region, the number of customers for a given case study, and average energy savings for a given end-use technology. Demand flexibility end-use potential is estimated in the same fashion, based on a number of devices from RECS and CBECS, along with typical peak reduction from enabling demand response (DR) for those end uses. Renewable energy-supply profiles are sourced from National Renewable Energy Laboratory (NREL) hourly data, with capacity constraints defined by NREL regional potential estimates. The modeled capabilities of renewable energy, EE, and DR to meet the grid service requirements from Step 1 explicitly take into account the hourly correlation between resource availability and the system-level net-load profile modeled in future years. The model also de-rates the ability of DR and battery energy storage to provide capacity and flexibility during long-duration peak-load events. To ensure that demand flexibility providing capacity does not lead to customer fatigue or excessive "rebound" in other hours, we model the costs associated with control strategies that can shift load while maintaining customer comfort (e.g., precooling using air conditioning, water heater storage tank temperature stratification).

[3] In the Texas CT case, monthly energy requirements are based on average monthly capacity factors for similar CTs in the region.

## Four distinct model components are used to identify least-cost clean energy portfolios (2/2)

### RESOURCE COST ASSESSMENT

Renewable-energy and energy-storage CapEx and OpEx costs and annual CapEx declines are taken from Lazard's *Levelized Cost of Energy Analysis—Version 11.0* and *Levelized Cost of Storage Analysis—Version 3.0*, and from Bloomberg New Energy Finance. The cost of new transmission needed to tie new renewables into the system is assumed to be $5/MWh, of which 70% is CapEx and 30% is fixed O&M, based on RMI's 2012 Reinventing Fire analysis of average incremental transmission costs for high-renewable grids. Energy efficiency resource costs are based on national average costs of running an effective EE program, and are adapted for specific end-use resources from the levelized savings weighted-average costs from Lawrence Berkeley National Laboratory's *Trends in the Program Administrator Cost of Saved Electricity 2009–2013* study. DR cost estimates are also program based, and calculated for each sector from the 75th-lowest percentile annual DR program costs reported by utilities on EIA's Form 861.

### CLEAN ENERGY PORTFOLIO OPTIMIZER

The clean energy portfolio optimizer draws on the other components to define the constraints and objective function of a linear program that finds the lowest-cost portfolio of resources that can provide at least as much monthly energy, capacity during the 50 peak hours, and single-hour ramp capability during the highest period of system-level net-load ramp as the announced natural gas-fired power plant, while staying within resource potential limitations. Once the portfolio is calculated, postprocessing steps ensure there is sufficient additional energy generated by the portfolio to serve the estimated demand-flexibility and energy-storage cycles. Our modeling constraints do not necessarily guarantee that the identified clean energy portfolio can dispatch at exactly the same level as the proposed gas plant during each hour of the modeled years; such a criterion would be overly conservative as it would assume ex ante a dispatch profile that depends on the gas plant's marginal cost structure and would ignore the cost structure differences between renewables and DERs relative to other dispatchable resources in each case study jurisdiction that would lead to least-cost resource dispatch. By enforcing constraints to meet system-level capacity and flexibility needs at least as well as the proposed gas plant, while producing an equal or greater amount of electricity each month, the portfolio optimizer ensures that all system needs can be met while taking into account the opportunities to dispatch clean energy portfolio resources according to their real cost structures, not according to the cost structure of natural gas-fired generation.

## The model draws on public data sources, and focuses on a tractable and conservative analysis

The model draws on a variety of data sources to define key requirements for each proposed plant and to assess clean energy portfolios in a manner that is conservative, tractable, and generalizable to other locations in the US.

**TABLE 2**

DATA DRAWN ON FOR THE MODEL

| DATA INPUT | TYPES OF DATA SOURCES |
|---|---|
| **Resource Potential** data for estimating and bounding the resource potential of EE, DR, and renewable energy | End-use survey data, EE- and DR-measure impact data, sector-level EE and DR potential, renewable potential estimates |
| **Resource Cost** data for clean energy portfolio resources and conventional resources, including CapEx, OpEx and estimated cost declines where appropriate | Lazard levelized cost of energy (LCOE) and BNEF price forecasts, EIA Annual Energy Outlook 2017 fuel prices, LBNL EE program-cost survey data, FERC and EIA DR program-cost survey data |
| **Resource Parameters** including region-specific renewable production profiles, end-use load shapes, and DR operational assumptions that take into account operational capabilities across long-duration peak-load events | Varies, including: proprietary survey data (i.e., end-use load profiles), National Renewable Energy Laboratory resource profile estimates (i.e., regional renewable energy production), and previous RMI modeling on demand flexibility |
| **Case-Specific Parameters** for each of the case study jurisdictions: on-line date, service requirements, and data for bottom-up estimates of EE and DR potential | Jurisdiction- and utility-specific planning documents and customer data, plant details |

The model ensures portfolios provide at least as much energy, capacity, and flexibility as the proposed gas plant in each case. We do not enforce constraints on other services (e.g., voltage support, black start capacity) that gas plants can provide but, as noted previously, clean energy portfolio technologies are generally able to provide these services, and as a conservatism we do not value these and other potential benefits provided (e.g., value to the transmission and distribution system, or provision of ancillary services by energy storage resources). Our modeling approach is consistent in level of detail with many utility integrated-resource-planning tools, which select portfolios based on energy, capacity, and flexibility, and rely on detailed postprocessing to model other power flow-related constraints. The only component we consider outside the cost for a clean energy portfolio to provide comparable energy, capacity, and flexibility is the value of energy produced or saved by the portfolios in excess of expected annual energy generation from the proposed gas plant, which we value in a post-processing step at a conservative estimate of the avoided marginal production cost of other power plants on the system.

# 04 FINDINGS

# FINDINGS

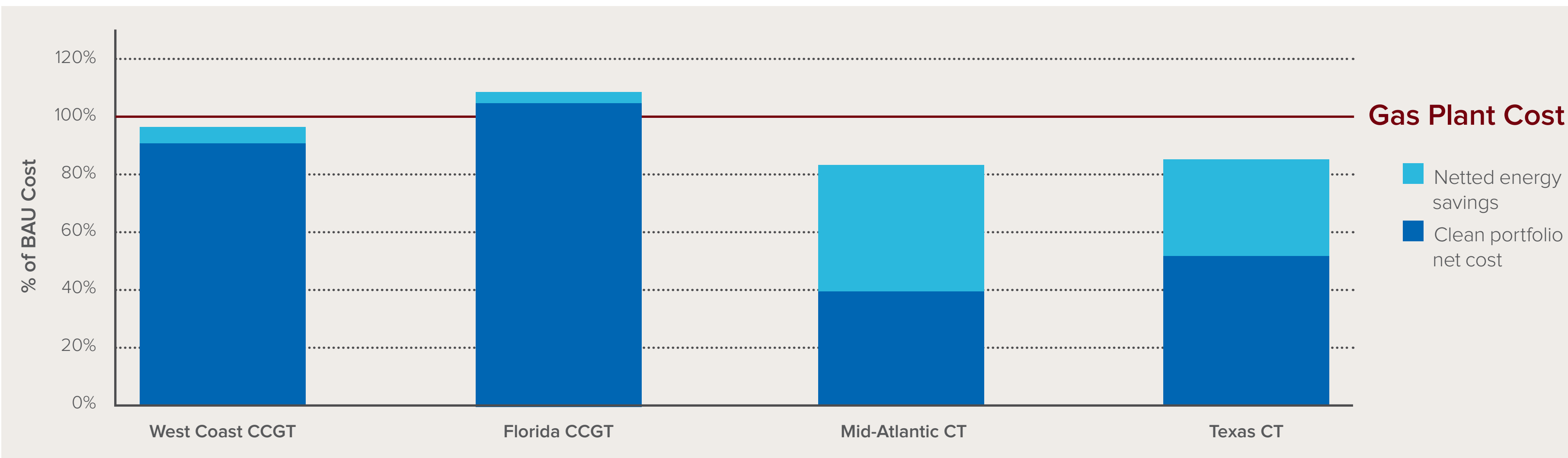
## Clean energy portfolios are cost-competitive with proposed gas-fired power plants across all four case studies

In each of the four cases, clean energy portfolios are cost-competitive with the investment and operating costs of the proposed gas-fired power plant, on an unsubsidized net-present-value basis. In one case, the net cost of the optimized clean energy portfolio is ~6% greater than the proposed power plant, due to several conservatisms discussed in following slides; in the other three cases, an optimized clean energy portfolio would cost from 8% to as much as 60% less than the announced power plant. The NPV of savings across all four cases is $308 million, and avoided $CO_2$ emissions total 157 million tons.

**Note on Figure 9:** “Netted energy savings” refers to the value of energy produced by clean energy portfolios in excess of that provided by the gas-fired generator alternative in each case. We value this energy conservatively at a levelized value equivalent to the avoided operating costs from a highly efficient CCGT. However, even valuing the “excess” energy at $0/MWh does not change the cost-effectiveness finding.

**FIGURE 9**

NET PRESENT COST COMPARISON: NEW GAS VS. CLEAN ENERGY PORTFOLIOS

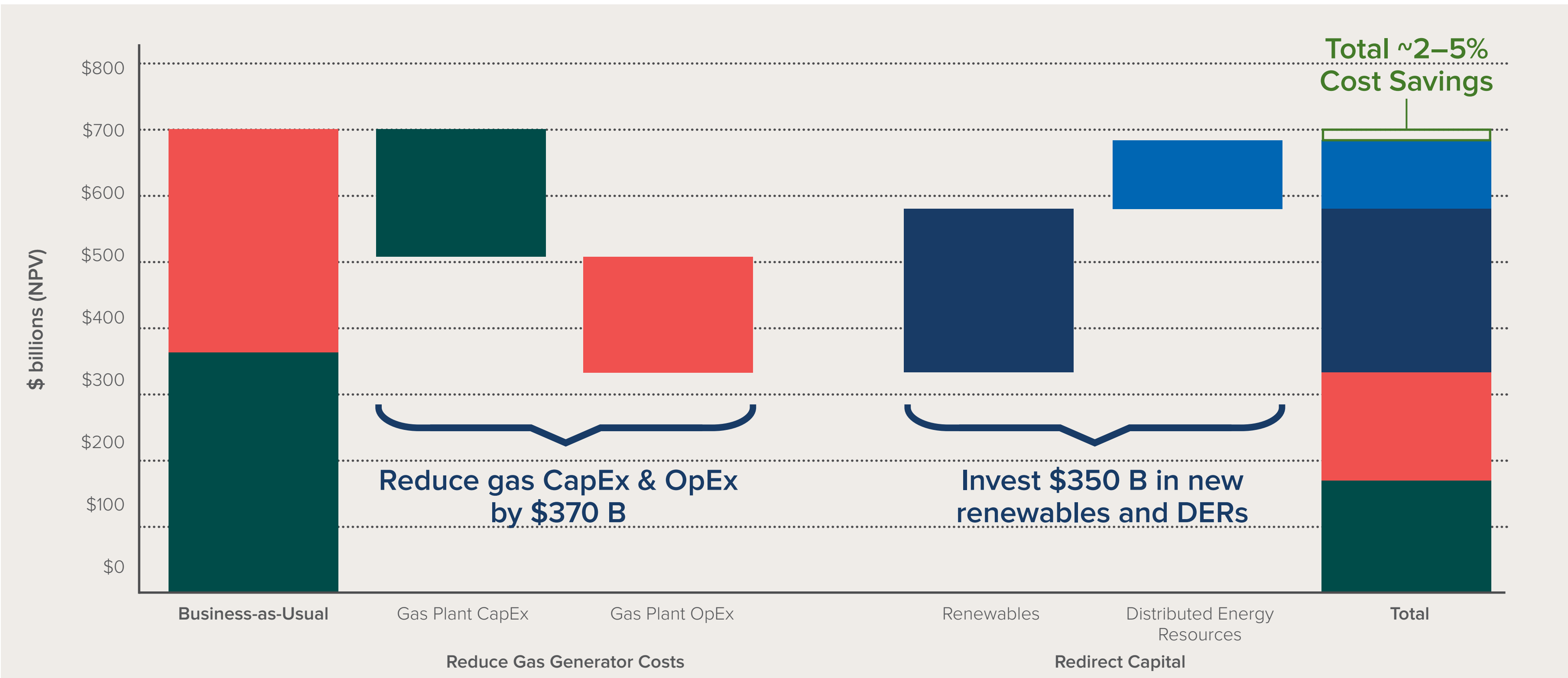


## Clean energy portfolios built to avoid new gas plants represent a potential $350 billion market for renewable energy and distributed energy resources through 2030

The cost-competitiveness of the clean energy portfolio case studies presented here suggests a significant opportunity to offset a majority of planned spending on new gas plants, and instead prioritize investment in renewables and DERs at a net cost savings. Using a national assessment of power plant retirement and potential gas capacity investment, we used conservative estimates of national energy efficiency, demand flexibility, and renewable energy adoption to assess what grid services could be provided by these resources, and thus to determine what level of investment in new gas-fired power plants and associated fuel use could be avoided. (See Appendix A for methodology details.)

**FIGURE 10**

MARKET OPPORTUNITY FOR CLEAN ENERGY PORTFOLIOS IN THE US, 2018–2030



## West Coast CCGT Plant: Summary of case study results

### ABOUT THE CASE STUDY

**Drivers of need:**

The West Coast utility proposing to build this new gas-fired CCGT plant expects modest growth of peak load and energy sales. By 2035, 65% of the utility's energy is expected to come from renewables, primarily new solar resources. To integrate this new capacity, it plans to repower a third of its natural gas plants, making them more efficient and flexible to accommodate additional renewable capacity.

**The proposed gas-fired power plant:**

The proposed CCGT plant is expected to help meet the utility's peak capacity needs as well as provide energy to balance the variability of a large portfolio of PV generation, at an average annual capacity factor of 63%.

### KEY FINDINGS IN THIS CASE STUDY

- 8% net present cost reduction from investing in a clean energy portfolio instead of the proposed CCGT plant.
- Avoids 23 million tons of $CO_2$ over 20 years of the proposed plant's operation.
- The clean energy portfolio resource mix dominated by wind, efficiency, demand response, and storage resources.
- Solar is absent from the portfolio owing to a projected net load dominated by new solar; this portfolio must provide energy and capacity when solar is not available.

## West Coast CCGT Plant: A clean energy portfolio dominated by wind and EE and supported by storage meets energy and capacity requirements

- A large amount of expected solar additions in the broader region drives the composition of this portfolio, with resources selected to provide energy in the winter months (when the CCGT plant would be operating at a high capacity factor) and provide capacity and flexibility in the summer during high-net load hours.

- The winter energy requirements drive the selection of nearly all available EE resources (representing ~4.2% of 2025 energy sales) and the large amount of wind selected (~3% of NREL-estimated potential).

- Demand response resources (~52% of estimated achievable potential) focus on end uses that can provide capacity and flexibility during summer peak hours. Summer net load-peak conditions occur during evenings when the sun has set, and there is only modest air conditioning load to respond as demand response resources, creating a need for energy storage to provide capacity during these times when flexible loads are limited.

**FIGURE 11**

CLEAN ENERGY PORTFOLIO COMPOSITION – WEST COAST

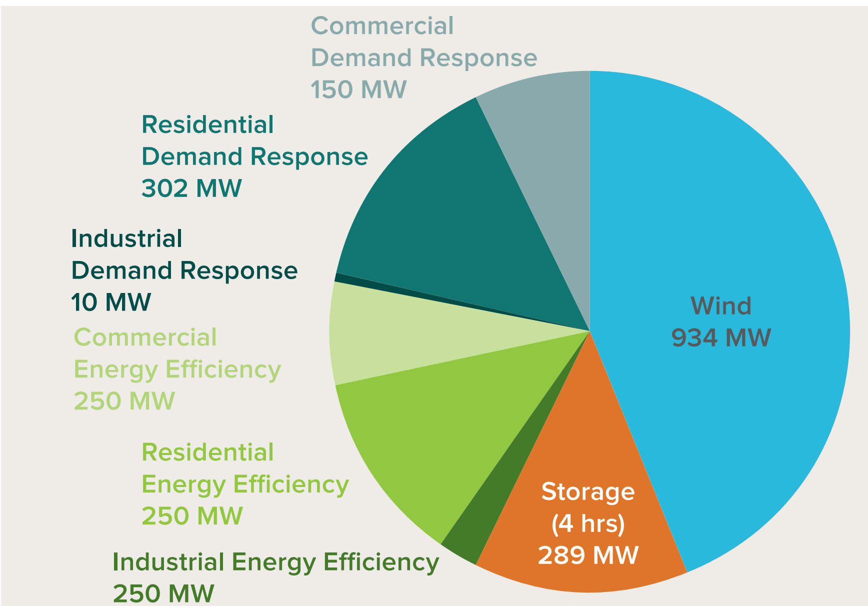
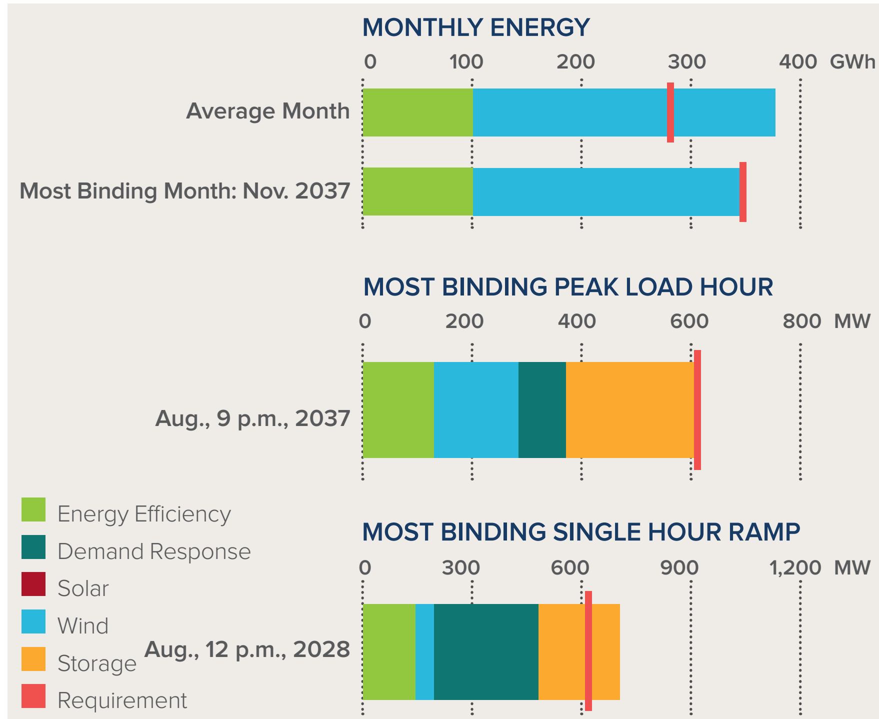



**FIGURE 12**

CLEAN ENERGY PORTFOLIO CONSTRAINTS – WEST COAST



## West Coast CCGT Plant: A higher-CapEx, lower-OpEx clean energy portfolio saves over $120 million in net present cost over 20 years

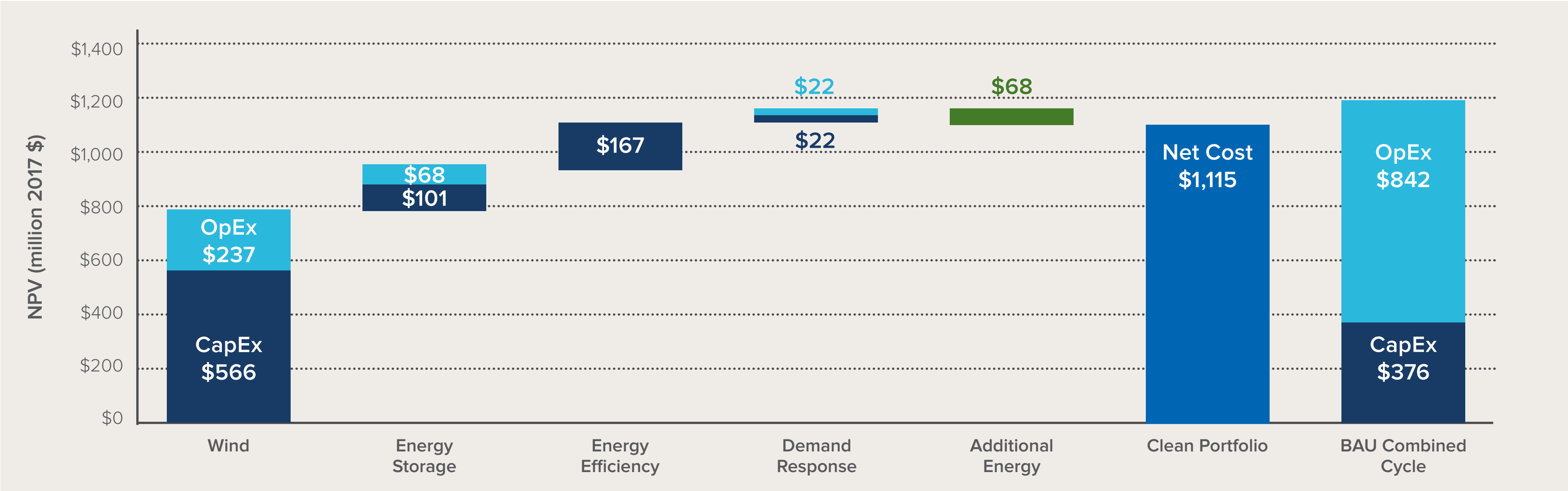
- Neglecting the additional energy produced by the portfolio, this portfolio costs ~2% less than the proposed BAU plant. The additional energy from wind and EE, after accounting for energy needed to charge the storage resources and enable load shifting, produce roughly 8% savings over the BAU scenario.

- The cost structure of this clean energy portfolio is atypical for traditional large-scale utility investments in energy and flexible capacity: 72% CapEx and 28% OpEx. Roughly one-fifth of that OpEx is tied to the cost of operating the storage in the portfolio, at ~$26/MWh.

- Wind and EE provide all of the energy for the portfolio, and roughly half the capacity, while accounting for 80% of the cost. Demand-flexibility investment targeting key flexible end uses provides significant capacity (~20%) and flexibility (~30%) at less than 4% of the clean energy portfolio's cost.

**FIGURE 13**

COST BREAKDOWN OF CLEAN ENERGY PORTFOLIO VERSUS GAS-FIRED POWER PLANT – WEST COAST



## Florida CCGT Plant: Summary of case study results

### ABOUT THE CASE STUDY

**Drivers of need:**

The large Florida utility proposing to build this CCGT plant expects moderate growth in energy sales and peak load, both around 1% per year. To meet this demand growth, it plans to increase capacity by nearly 20%, half from renewables and half from natural gas. In addition to these capacity additions, the utility is planning to modernize its older natural gas plants to make them more efficient and flexible.

**The proposed gas-fired power plant:**

This large combined-cycle natural gas plant is part of the utility's overall modernization effort, and is expected to primarily provide continuous energy, with an expected capacity factor of 90%. It will also provide 1,200 MW of firm capacity and flexibility.

### KEY FINDINGS IN THIS CASE STUDY

- Under base-case assumptions, the clean energy portfolio would cost an estimated 6% more than the proposed gas-fired power plant.
- While the clean energy portfolio costs slightly more, it avoids 66 million tons of $CO_2$ over 20 years of the proposed plant's operation; these avoided emissions cost an equivalent of ~$8/ton of $CO_2$.
- The clean energy portfolio resource mix is dominated by wind imported from out of state (i.e., Oklahoma or Texas), efficiency, and demand response resources, with a smaller contribution from in-state solar resources.
- Imported, high-capacity factor wind provides high-value energy during winter months, overcoming the required transmission costs for out-of-state wind, which nearly double the capital cost of wind resources.

## Florida CCGT Plant: Imported wind, in-state solar, and EE combine to meet high energy service requirements

- The very high capacity factor of the BAU plant, 90%, results in similar amounts of energy required every month of the year from the clean energy portfolio, including winter months. This limits the value of solar resources selected (<1% of NREL solar potential) due to their high summer versus winter production.
- Winter energy needs drive the selection of imported wind (<1% of NREL wind potential), despite it carrying an additional cost for transmission into the state (~$20/MWh), because it generates energy more consistently throughout the year and throughout the day.
- The EE (~3.1% of 2022 energy sales) and DR (~27% of estimated achievable potential) in the portfolio focus on summer-focused flexibility strategies (e.g., air conditioning precooling), as well as loads with relatively high load factors and more hours to shift flexible load, such as water heating and refrigeration. The quantity of DR available from these high-load factor end uses provides ample capacity and flexibility, which obviates the need for storage in the portfolio.

**FIGURE 14**

CLEAN ENERGY PORTFOLIO COMPOSITION – FLORIDA

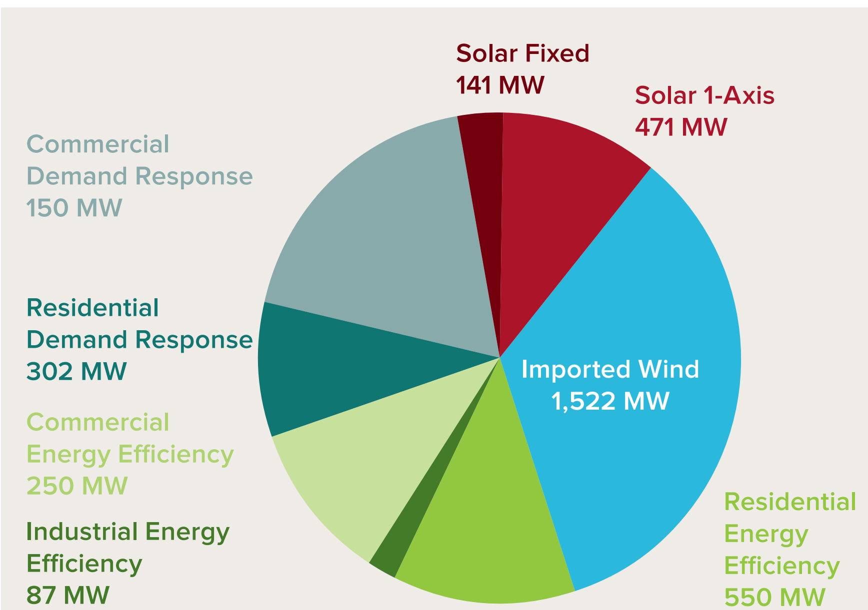
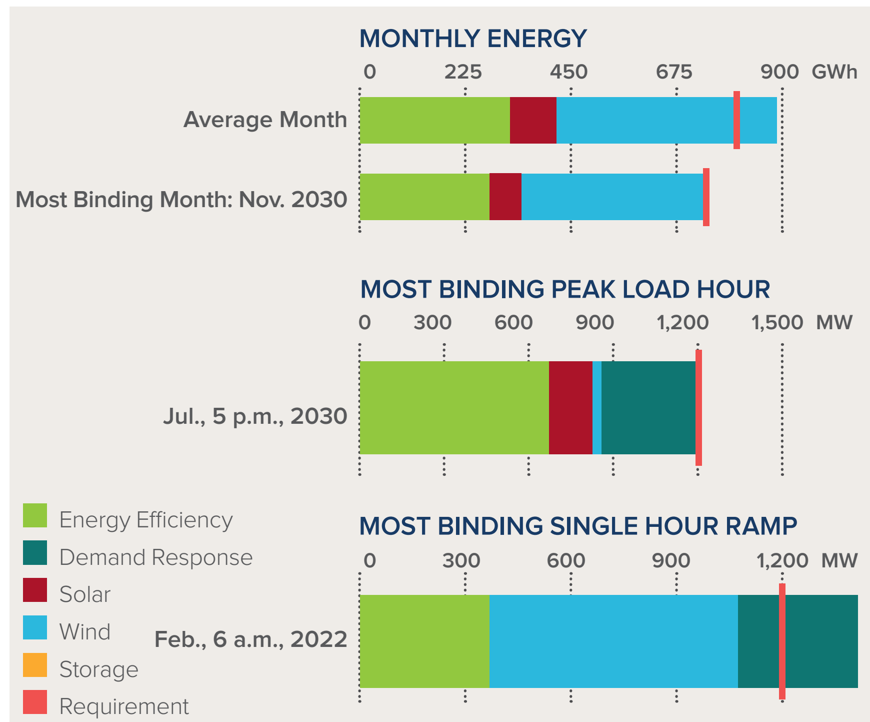



**FIGURE 15**

CLEAN ENERGY PORTFOLIO CONSTRAINTS – FLORIDA



## Florida CCGT Plant: A clean-portfolio alternative has a 6% higher net present cost, but has a dramatically lower risk of increasing fuel costs and much smaller operating costs

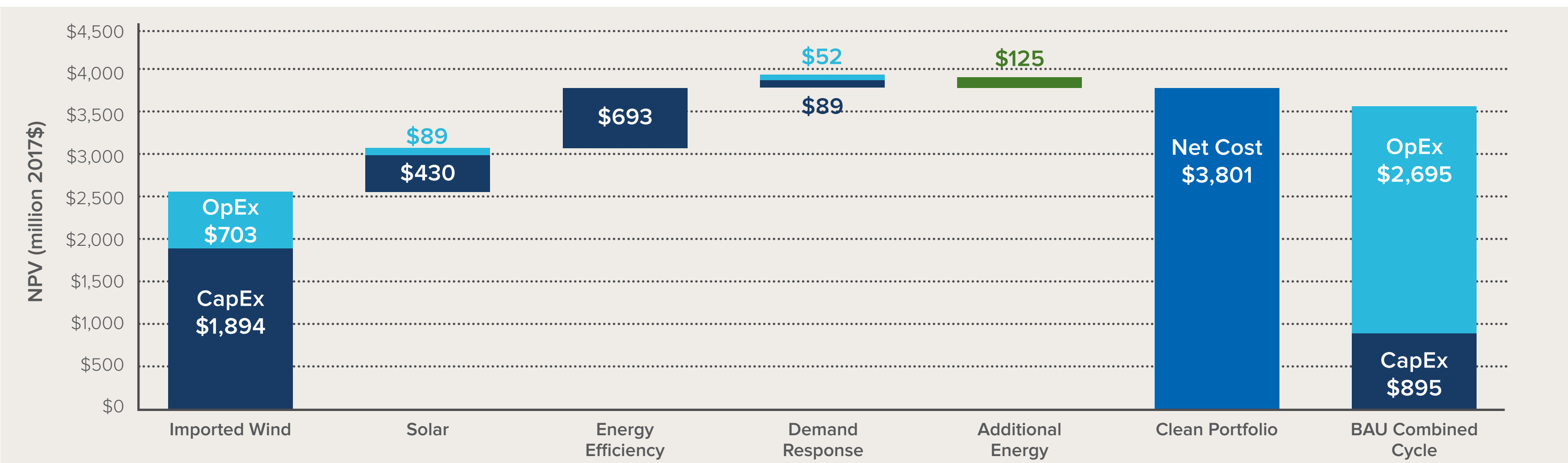
- The total costs of the clean energy portfolio exceed those of the proposed CCGT plant, with a difference of about 10%. Accounting for the benefit of the additional energy creates more than $120 million in present value savings and reduces the cost difference to about 6% relative to the $3.6 billion net present cost of the CCGT plant.

- Nearly two-thirds of the CCGT plant's net present cost is OpEx, 90% of which is fuel. The clean energy portfolio's cost structure requires more than three times the up-front capital, but provides large amounts of energy at almost no marginal cost; as such, the portfolio can stabilize rates that would otherwise be heavily exposed to volatile natural gas prices.

- The price premium of roughly $200 million in net present cost saves 66 million tons of $CO_2$ over 20 years of operations.

**FIGURE 16**

COST BREAKDOWN OF CLEAN ENERGY PORTFOLIO VERSUS GAS-FIRED POWER PLANT – FLORIDA



## Florida CCGT Plant: Feasible cost declines in distributed solar projects or modest carbon pricing could result in a clean energy portfolio with net cost at parity with the proposed CCGT plant

- We assume a cost of in-state transmission that increases delivered solar PV LCOE by 13% over busbar costs. Distributed (e.g., behind-the-meter or community-scale) solar can avoid the cost of new in-state transmission included in our core analysis.

- Community-scale solar has a large potential for cost savings, with near-term manufacturing and distribution advances that could significantly lower the LCOE of these projects **to below $30/MWh by 2025**.

- Assuming distributed solar LCOE of $33/MWh, which is comparable to early 2020s bids seen recently for utility-scale solar in the Southeast region, would eliminate transmission costs for in-state solar, increase the amount of solar in the optimal portfolio by ~70%, and result in a portfolio net cost equal to the proposed BAU plant.

- Separately, a $7.55/ton levelized price on $CO_2$ emissions over 20 years of plant operations would result in a clean energy portfolio at cost parity with the proposed CCGT plant.

**FIGURE 17**

COMPARISON OF FLORIDA PORTFOLIOS: CURRENT-COST VS. LOWER-COST SOLAR SCENARIOS

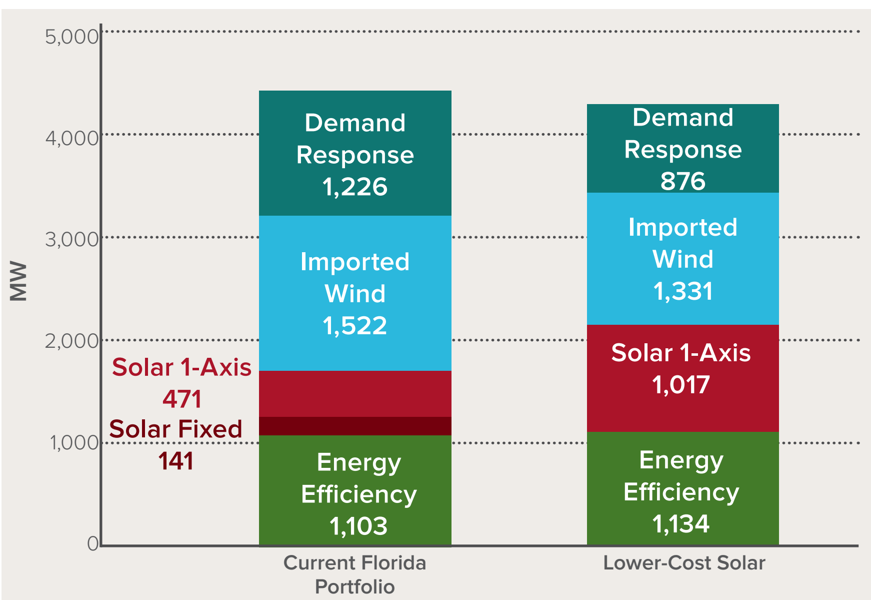
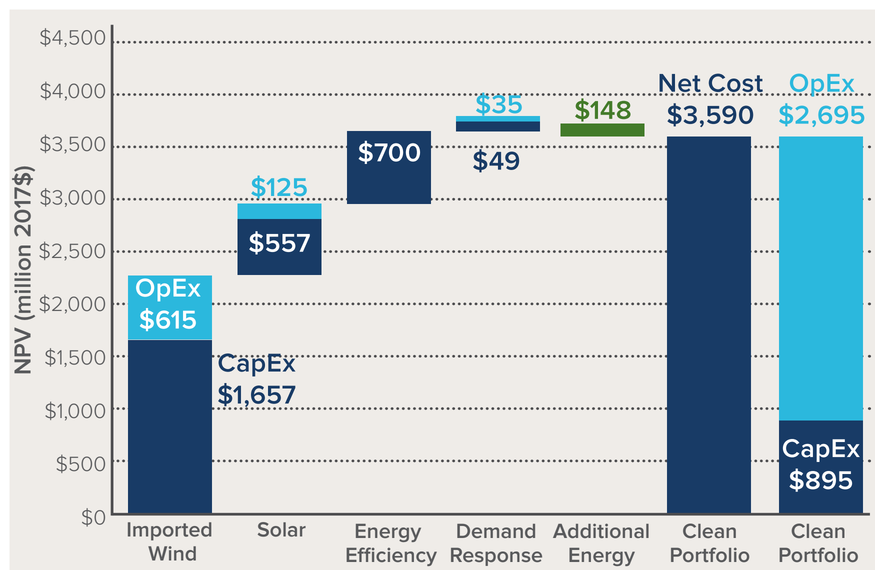



**FIGURE 18**

COST BREAKDOWN OF FLORIDA CLEAN ENERGY PORTFOLIO WITH LOWER-COST SOLAR VERSUS GAS-FIRED POWER PLANT



## Mid-Atlantic CT Plant: Summary of case study results

### ABOUT THE CASE STUDY

**Drivers of need:**

The large mid-Atlantic utility proposing to build this new CT plant expects moderate growth in energy sales and peak load, both around 1% per year. It expects winter peak growth to exceed that of summer growth, shifting it to a winter-peaking utility by 2030. The shift to a winter peak combined with limited winter capacity prompted an increase in winter reserve margins; to replace retiring capacity and meet its expected growth and reserve needs, the utility plans to increase its portfolio capacity by nearly 35%, one-third renewable and two-thirds thermal.

**The proposed gas-fired power plant:**

This simple-cycle natural gas plant is expected to provide flexibility and winter capacity, increasing the latter by 475 MW.

### KEY FINDINGS IN THIS CASE STUDY

- The clean energy portfolio represents a potential 60% net-present-cost reduction versus the proposed CT plant.
- The clean energy portfolio avoids 1.3 million tons of $CO_2$ over 20 years of the proposed plant's operation.
- The clean energy portfolio resource mix is dominated by efficiency, demand response, and storage resources to provide peak savings and flexibility.

## Mid-Atlantic CT Plant: To meet growing winter peak-capacity requirements, this clean energy portfolio focuses on seasonal EE and DR end uses

- There are much greater capacity service requirements than energy or flexibility for this jurisdiction, and the proposed CT plant is expected to provide very little energy. The portfolio produces much more energy than the CT plant would, as the capacity from the EE resources (~1% of 2025 energy sales) is needed to supplement that of available DR resources (~27% of estimated achievable potential).

- Winter capacity is a growing need in this jurisdiction due to significant electric heating loads in the region. The optimal portfolio includes high levels for space-heating EE and DR, as these loads are well matched to providing winter capacity. Electric water heaters are also common in the region, and thus the model selects water-heating demand flexibility at a high level to provide nearly half of the dispatchable capacity in this case. In addition, ~40% of selected residential DR is from air conditioning, which provides for summer capacity needs.

- Multiple peak periods and consecutive hours of peak conditions on the same days cause the portfolio to include much more six-hour storage than four-hour storage, to ensure there is sufficient stored energy on a given

**FIGURE 19**

CLEAN ENERGY PORTFOLIO COMPOSITION – MID-ATLANTIC

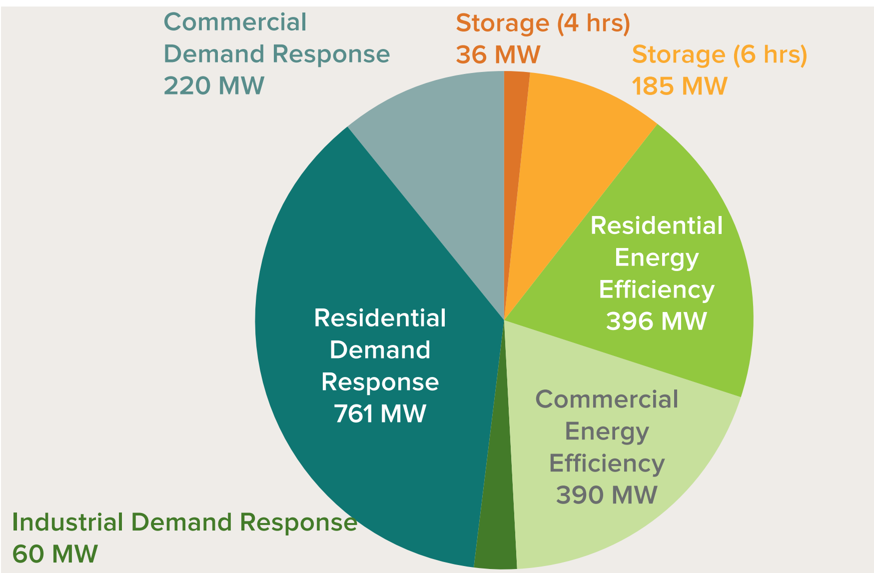
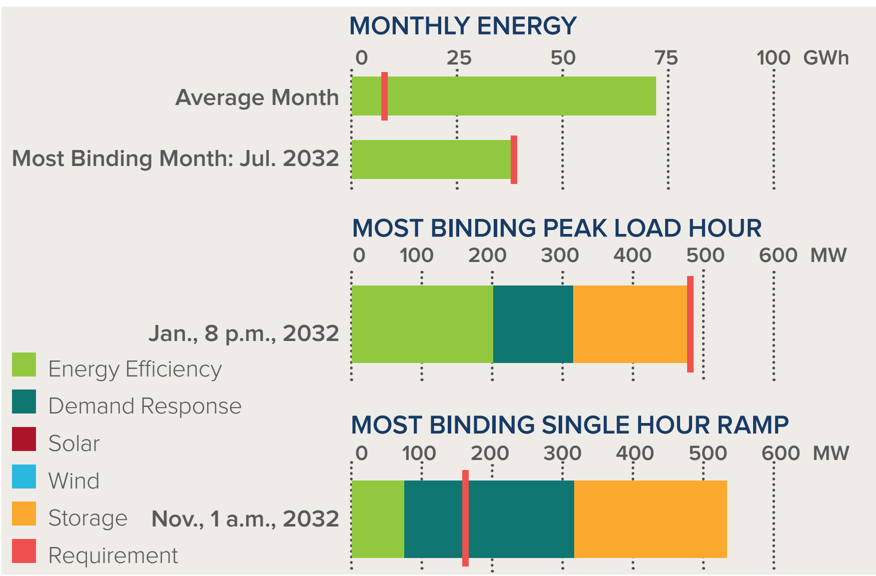



**FIGURE 20**

CLEAN ENERGY PORTFOLIO CONSTRAINTS – MID-ATLANTIC

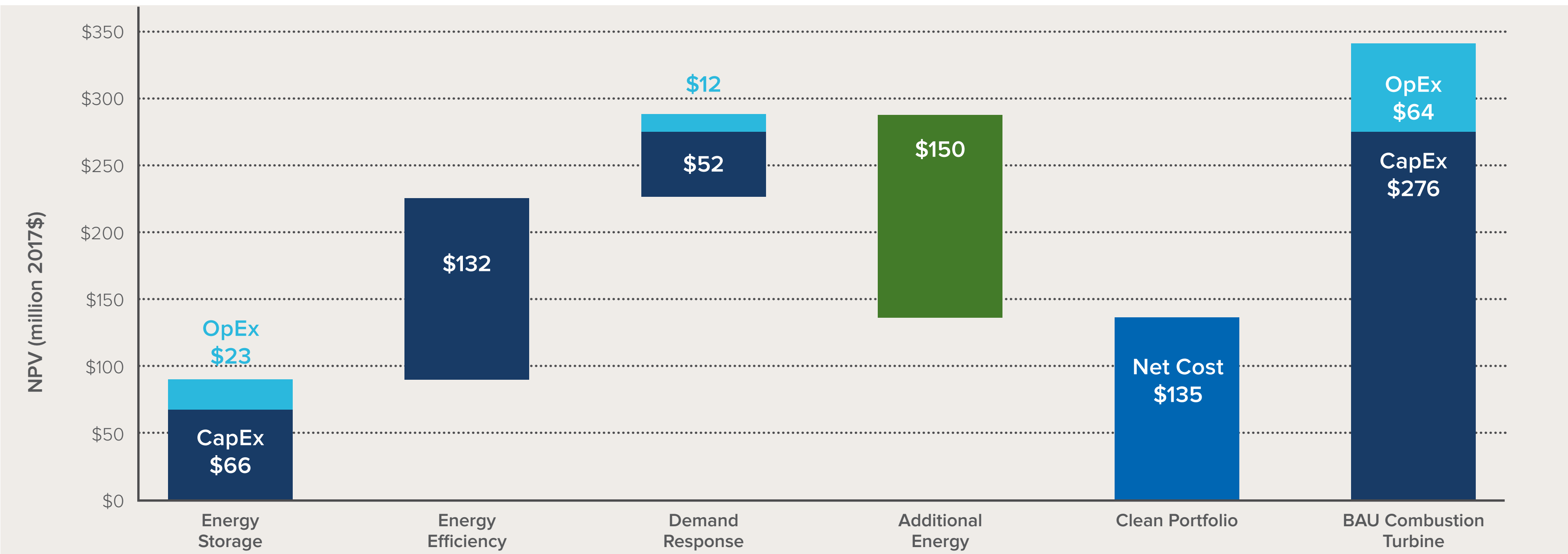


## Mid-Atlantic CT Plant: Even without accounting for the value of additional energy, the clean energy portfolio has a net present cost 17% lower than the proposed CT plant

- In contrast to the CCGT cases, the CapEx for this clean energy portfolio is lower cost than the CapEx of the proposed CT plant by $24 million dollars. Including an estimated value of the additional energy, beyond what is needed for charging the storage and enabling demand flexibility, leads to a to a net cost that is 60% lower than the CT plant's net present cost.
- Resource constraints on high-value DR resources drive investments in energy storage as well as EE. Selecting EE along with DR creates a much cheaper alternative to the peaker plant than energy storage could provide on its own.
- Given the low energy requirement for a peaker plant, the EE resources provide a significant added benefit of zero-marginal cost energy beyond the peaker plant service requirements.

**FIGURE 21**

COST BREAKDOWN OF CLEAN ENERGY PORTFOLIO VERSUS GAS-FIRED POWER PLANT – MID-ATLANTIC



## Texas CT Plant: Summary of case study results

### ABOUT THE CASE STUDY

**Drivers of need:**

The Texas market operator (ERCOT) expects moderate growth of energy sales and peak load, both around 1% per year. Growth in net load will be much lower, owing to planned renewable additions equivalent to 20% of current capacity, mostly wind additions. The renewable additions together with peak growth may create a need to support variable renewable energy with dispatchable resources in the future.

**The proposed gas-fired power plant:**

The proposed CT plant would provide 450 MW of capacity and flexibility, while likely operating at a low average capacity factor throughout most of the year.

### KEY FINDINGS IN THIS CASE STUDY

- The clean energy portfolio represents a 42% net-present-cost reduction over the proposed peaker plant.
- The clean energy portfolio avoids 2 million tons of $CO_2$ over 20 years of the proposed plant's operation.
- The clean energy portfolio resource mix is dominated by demand response, efficiency, and energy-storage resources.

## Texas CT Plant: A DR- and EE-heavy portfolio can provide as much capacity as the proposed peaker

- Service requirements for this portfolio are shaped by a Texas grid that will have significant new wind capacity installed over the lifetime of the proposed CT plant. This clean energy portfolio selects EE (~0.4% of 2020 energy sales) and DR (~9% of estimated achievable potential) resources in end uses that complement a wind-driven net-load profile, with high load factors and coincidence with Texas's net-load peak during summer evenings.

- For demand response, all available industrial and water heating end uses are selected for the portfolio on account of their high load factors, which make them particularly valuable forms of demand flexibility.

- Residential space cooling is also selected at the maximum amount allowed for both EE and DR, and provides the capacity in the summer and late afternoon during system peaks when low levels of wind drive high-net load conditions.

**FIGURE 22**

CLEAN ENERGY PORTFOLIO COMPOSITION – TEXAS

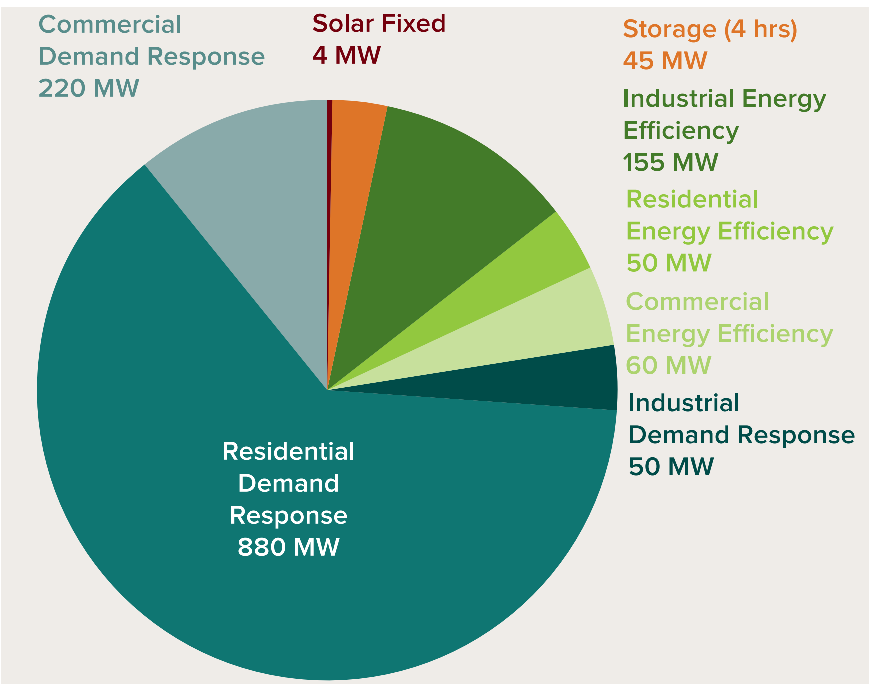
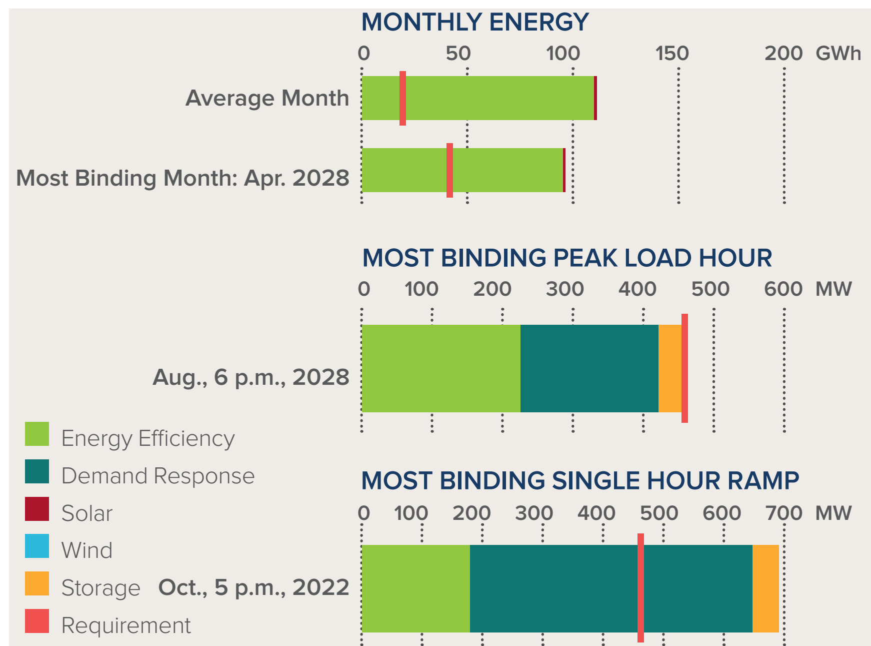



**FIGURE 23**

CLEAN ENERGY PORTFOLIO CONSTRAINTS – TEXAS



## Texas CT Plant: The net cost of a clean energy portfolio offers over 25% savings on the CapEx of the proposed CT plant, with a total present value cost 42% lower than the CT plant

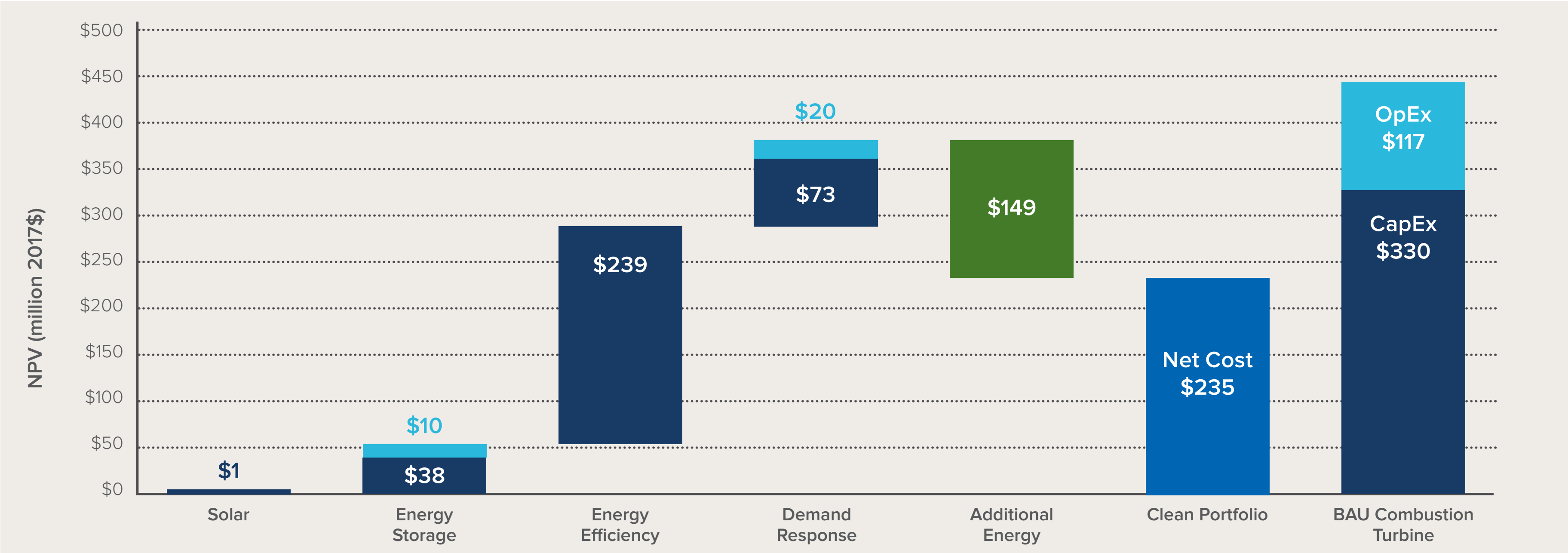
- The clean energy portfolio can meet all of the service requirements of the proposed CT plant for lower net cost than the CapEx required to build the proposed peaker plant, with the benefit of significantly more energy.

- Over 85% of the clean energy portfolio's total cost is from DR and EE, which provide most of the capacity and almost all of the energy for the portfolio. A small amount of storage investment ensures the portfolio can provide flexibility at all hours of the day.

- As with the other peaker-plant case study, inclusion of both DR and EE as resource investment options leads to a much lower-cost alternative to the BAU peaker plant than storage alone could provide.

**FIGURE 24**

COST BREAKDOWN OF CLEAN ENERGY PORTFOLIO VERSUS GAS-FIRED POWER PLANT – TEXAS

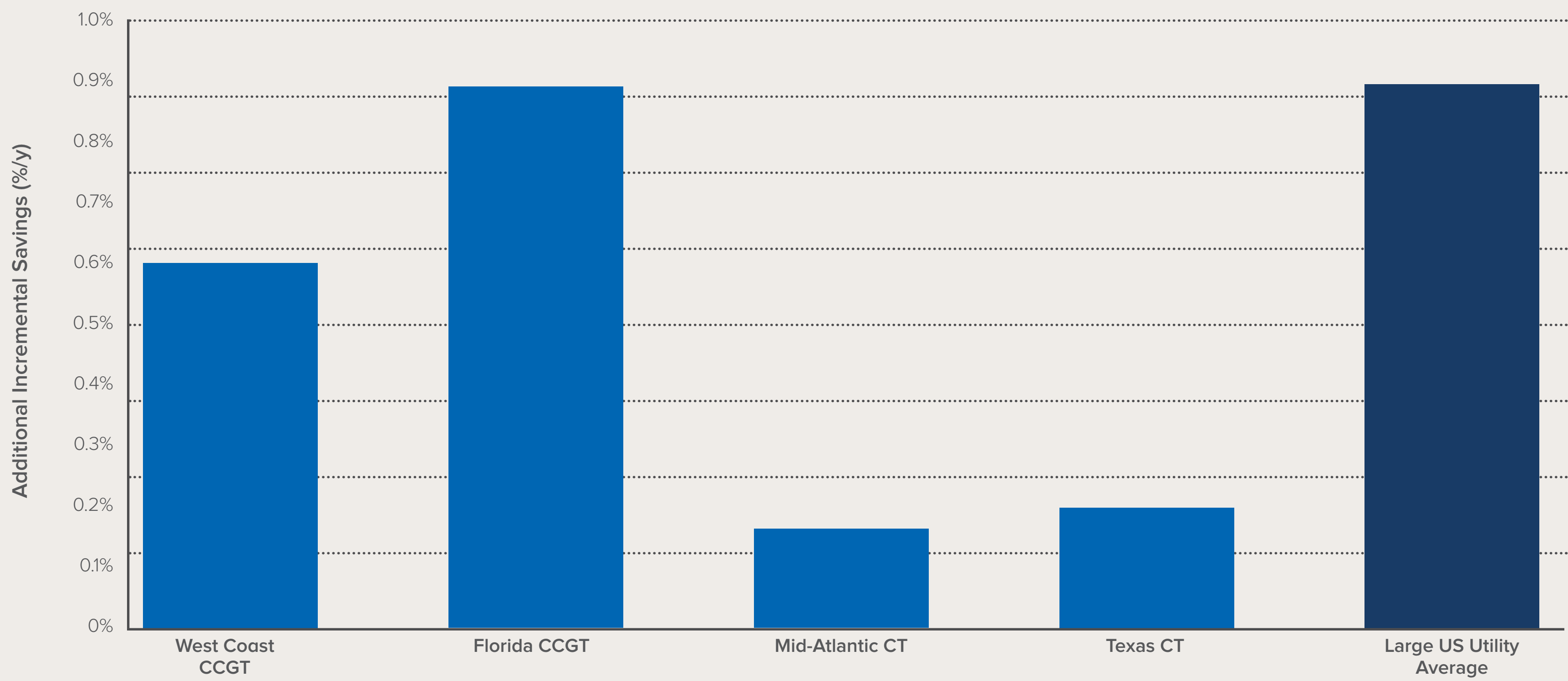


## All four case studies rely on a significant but demonstrably achievable investment in energy efficiency

All four case studies rely heavily on investment in energy efficiency to meet energy and capacity needs that would otherwise be provided by proposed gas plants. However, the efficiency investment necessary in each case, measured as a percentage of annual sales saved through energy efficiency from 2018 through the in-service date of each proposed plant, is significantly lower than the average levels of incremental savings across large utilities in the US. In other words, in each case, and particularly in the CT-plant case studies, the utility jurisdiction in question could achieve below-average efficiency savings and still provide sufficient efficiency for a clean energy portfolio to obviate the proposed gas plant.

**FIGURE 25**

INCREMENTAL EFFICIENCY SELECTED IN CASE STUDY PORTFOLIOS VS. NATIONAL UTILITY-LEVEL AVERAGE




Source: RMI analysis; ACEEE 2017 Utility Energy Efficiency Scorecard

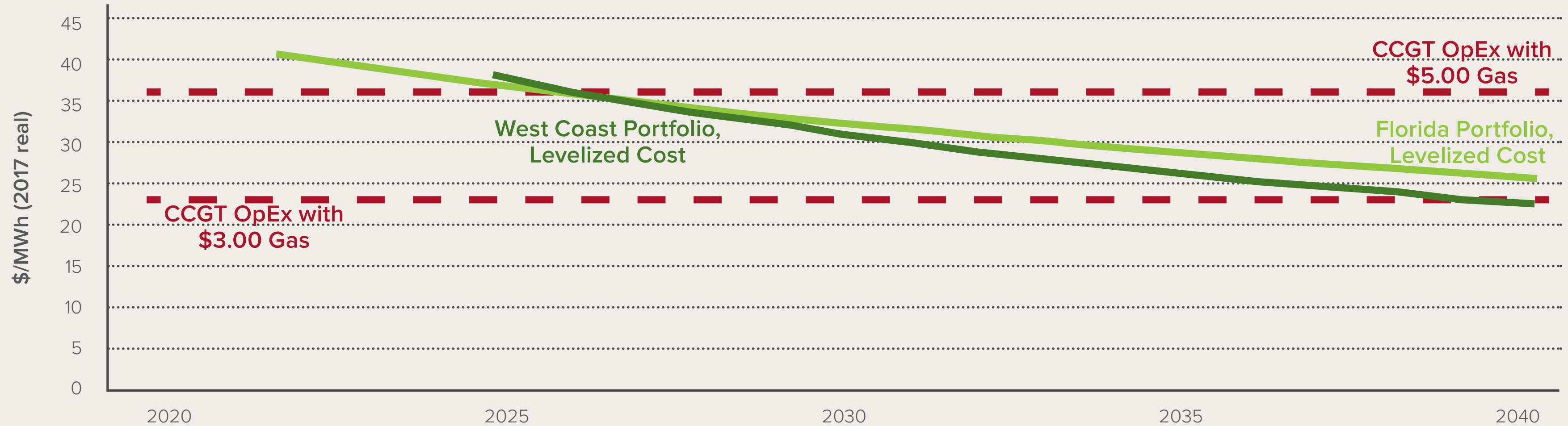
## Clean energy portfolios' costs are likely to decline to a point where they will outcompete just the operational costs of CCGT plants

In addition to competing with new gas plants on a levelized cost basis, clean energy portfolios will also soon threaten the profitability of existing power plants. Comparing the future operating costs of the two proposed CCGT plants in this study against new-build clean energy portfolios in future years, we find that, depending on gas price forecasts, the clean energy portfolio's levelized, all-in costs will be below the marginal operating costs of both of the CCGT plants well within the planned operating lifetime of the proposed plants. In other words, in the next 10–25 years, it will likely be cheaper to build all-new, CCGT-equivalent clean energy portfolios than it will be to run existing CCGTs.

For CT projects, our analysis shows that portfolios largely reliant on EE and DR can offer the same services at lower net cost, while others have found that **solar plus storage** or **storage alone** are already outcompeting peaking capacity. Thus, any new peaking capacity built, with significantly higher operating costs than new CCGT plants, will face an even earlier stranded asset risk from clean energy portfolios.

**FIGURE 26**

COMPARISON OF COMBINED CYCLE OPERATING COSTS VS. CLEAN ENERGY PORTFOLIO LEVELIZED COSTS, 2020–2040




- Assuming gas prices between $3–5/MMBtu, combined-cycle operating costs will vary between $23/MWh and $36/MWh
- Optimized clean energy portfolios, depending on location and technology mix, will cost less to build than CCGTs cost to run by 2026 (assuming $5/MMBtu gas) or ~2040 (assuming $3/MMBtu gas)

# 05 IMPLICATIONS AND CONCLUSIONS

# IMPLICATIONS AND CONCLUSIONS

## To mitigate stranded asset risk and minimize ratepayer costs, investors and regulators should carefully reexamine planned gas investment

Our analysis reveals that, across a wide range of case studies, regionally specific clean energy portfolios already outcompete proposed gas-fired generators, and/or threaten to significantly erode their revenue within the next 10 years. Thus, the $112 billion of gas-fired power plants currently proposed or under construction, along with $32 billion of proposed gas pipelines to serve these power plants, are already at risk of becoming stranded assets. This has significant implications for investors in gas projects (both utilities and independent power producers) as well as regulators responsible for approving investment in vertically integrated territories.

» **$93 billion of proposed investment is at risk for merchant gas power plant developers**

» Approximately 83% of announced gas projects are proposed for restructured markets, where independent power producers bear market risk if these assets see their revenue fall under competition from renewables and DERs.

» Investors should reassess the risk profiles of gas projects, and in particular consider the reduced useful lifetimes of gas-fired power plants under competition from clean energy resources, to mitigate the erosion of shareholder value.

» **Ratepayers face $19 billion of locked-in costs**

» The remaining 17% of announced gas projects are proposed for vertically integrated jurisdictions, where state-level regulators are responsible for approving proposals to build new gas plants and for allowing utilities to recover costs through customer rates.

» To avoid the risk of locking in significant ratepayer costs for gas-fired resources that are increasingly uneconomic, regulators should carefully consider alternatives to new gas-fired power plant construction before allowing recovery of costs through rates.

## Our study's overall modeling approach relies on a conservative treatment of resource planning

Our findings are dramatic, yet they are driven by a fundamentally conservative assessment of the relative cost-effectiveness of clean energy portfolios versus new natural gas-fired power plants. In particular, our single-asset planning framework severely limits the cost savings available, relative to leading-edge resource planning approaches.

### SINGLE ASSET-BASED PLANNING

» An asset-based planning approach to assess the cost-effectiveness of so-called "virtual power plants," which is the approach we have taken, constrains the clean energy portfolio in each case to meet key grid services that would otherwise be met by the gas plant; it does not allow any of those services to come from other assets on the system, and thus presents "drop in" replacements for single assets.

» This approach ignores the fact that other generators operated within the utility jurisdictions we modeled have slack capacity available, for low incremental cost. This is most clearly observable in organized wholesale markets, but is also demonstrably the case in regions without independent system operators/regional transmission operators, where utilities can enter into bilateral contracts for capacity in addition to using slack capacity in their own system.

### NEXT-GENERATION RESOURCE PLANNING

» To expand on existing best practices in utility planning, a next-generation resource planning process would characterize disaggregated grid service requirements both across the transmission and distribution network and over time as existing resources retired. Such a process would allow for meeting these service requirements with all potential resources.

» In a way that is distinct from an asset-specific clean energy portfolio assessment, this approach would optimize across the full cost structure of providing reliable energy services within a given jurisdiction, including trade-offs between meeting near-term needs at least cost versus investing in long-run, cost-optimal solutions.

## Advances in resource planning can unlock greater cost savings from alternative resources than asset-specific analysis

The emerging paradigm—and our study's analytical treatment—of virtual power plants as discrete alternatives to single gas-fired plant investments is inherently limiting in its scope to the extent it ignores broader system benefits and co-optimization opportunities across new and existing resources, value-stacking for technologies that can be used for multiple services, and cost-sharing between technologies deployed as part of an integrated portfolio. However, an asset-specific approach can serve as a useful point of departure for more holistic planning efforts that, over time, can unlock further cost savings from portfolios of renewable and distributed energy resources.

**TABLE 3**

CONTINUUM OF APPROACHES TO COMPARE CLEAN RESOURCES TO THERMAL GENERATION

| | Targeted DER/RE Support | Virtual Power Plants (the approach taken in this study) | Next-Generation Resource Planning |
|---|---|---|---|
| **Planning Objective** | **Scale market for specific technologies** by providing out-of-market support | **Avoid construction of a specific power plant** by providing the same set of grid services with a clean energy portfolio | **Meet grid service needs at least cost** through characterization of disaggregated grid services and technologies' ability and cost to meet them |
| **Examples** | • Renewable portfolio standards<br>• Energy storage targets<br>• Efficiency savings | **Regulated:**<br>• Duke Asheville CT plant (NC)<br><br>**Restructured:**<br>• Puente CT plant proposal (CA) | **Regulated:**<br>• HECO Integrated Grid Planning proposal (HI)<br><br>**Restructured:**<br>• New York REV Distributed System Platform |
| **Cost Savings Potential** | **Limited:** many sources of avoidable costs (e.g., future generator CapEx) are not internalized into the support program | **Moderate:** avoidable costs outside of the asset under consideration are not considered | **High:** all potential avoided costs can be considered and optimized as part of resource portfolio design |

## Our analysis includes four additional conservatisms that limit the estimated cost-effectiveness of clean energy portfolios

### 1) NO DISTRIBUTED BENEFITS

**a.** We assume zero value to the transmission or distribution system of energy efficiency, demand flexibility, and behind-the-meter and front-of-the-meter storage.

**b.** However, there are often significant net benefits associated with deploying peak demand-reducing technologies on the transmission and distribution system, either in a targeted way to avoid specific infrastructure investments (e.g., **new substations**, **new power lines**) or *ex post* as observed reductions in net load forecasts **negate planned spending**.

**c.** Deployment of DERs as "non-wires solutions" is a **growing trend in the US**, and these projects could be pursued in parallel to clean energy portfolios to avoid investing in gas plants, unlocking additional avoided cost opportunities and improving the value proposition of clean energy portfolios.

### 2) ZERO-COST FUEL PRICE VOLATILITY

**a.** We assume that fuel price volatility does not add any risk premium or other incremental cost to our assumed operating expense for new gas-fired generators.

**b.** In reality, generation owners often hedge gas prices, which is not costless. Even without hedging, fuel price uncertainty imposes **measurable costs** on utilities and/or their customers, which should be considered in the resource planning decision-making process.

### 3) ZERO-COST CARBON EMISSIONS

**a.** We assume that carbon dioxide emissions associated with new natural gas-fired generator investments are costless, consistent with present-day emissions costs facing most generators.

**b.** However, several states already price carbon emissions, if at low levels, and there is momentum to expand carbon pricing at the state level.

**c.** To address the uncertainty of future carbon pricing, which will be resolved much closer to multiyear political timescales than multidecade asset lifetimes, **many utility IRPs include a $CO_2$ price**. Including this in our clean energy portfolio analysis would increase the relative cost of the examined gas generators relative the clean energy portfolio cost.

### 4) NO RISK ADJUSTMENT IN INVESTMENT COSTS

**a.** We use a deterministic planning process that assumes perfect foresight of load growth trends and broader system evolution (e.g., renewable adoption levels) as a key driver of resource operation, and thus present-value costs.

**b.** However, this approach ignores the risks of load growth failing to materialize or other threats to asset profitability in the future, and the **associated benefits** of investing in small, modular resources that minimize the risk of locking in large liabilities.

**c.** Including the risk benefits of modular investments versus multibillion-dollar gas-fired power plants would further bolster the business case of clean energy portfolios.

## Action from utilities, regulators, and technology providers can accelerate adoption of clean energy portfolios and associated customer cost savings

Clean energy portfolios represent a cost-effective alternative to investment in new gas-fired power plants, with a potentially accessible market in the hundreds of billions of dollars through 2030, while avoiding the fuel price risks and $CO_2$ emissions associated with new natural gas power plants. However, the industry is just beginning to recognize and capture the benefits of these resources, and execution of clean energy portfolio projects remains relatively low compared to their potential. Coordinated action by several stakeholder groups can accelerate adoption.

**Regulators and market operators:** *Study alternatives and level the playing field.*

- Regulators and market operators should ensure that they are fully informed of the emerging capabilities and costs of renewable energy projects and DERs, and design technology-neutral revenue models and market products that incentivize least-cost resources.

**Utilities:** *Revolutionize resource planning and procurement processes.*

- Utilities can take advantage of the recent advances in resource planning approaches and software tools, and use these tools to guide scaled procurement of solutions that can meet grid service needs at least cost.

**Technology providers and project developers:** *Offer holistic, low-cost solutions to meet grid needs.*

- Renewable energy and DER technology providers can continue to tailor their offerings to the needs of the market, and generate confidence in their products' abilities to cost-effectively meet grid service needs.

## Regulators and market operators can learn from leading jurisdictions, solicit market input, and level the playing field between resource options as they shape planning processes

### » Seek broad input:

- Solicit input from solution providers to ensure visibility of market-validated cost and capability data for resources whose costs are changing rapidly.

- Require a minimum level of data transparency so that aggregators, technology developers, and other market participants can provide technically credible alternatives to power plant investments.

### » Align incentives:

- For utilities with regulator-allowed rates of return on generation assets, clean energy portfolio investment options may already represent a lucrative opportunity to drive shareholder value, given the typically capital-heavy cost structures of clean energy portfolio technologies versus the fuel-heavy cost structures of gas-fired power plants.

- For technologies that often represent capital cost savings compared to gas plants (e.g., energy efficiency, demand flexibility) or that can provide value via contracted services (e.g., behind-the-meter batteries), **evolved incentive structures and business model adjustments** (e.g., performance-based ratemaking, alternative earnings mechanisms) can incentivize utilities to procure such technologies that might otherwise be at odds with a return-on-capital business model.

### » Open up market participation:

- Market designers in restructured markets have an opportunity to reshape existing rules designed around thermal generators in order to make the rules more technology-neutral, and allow all resources to compete on equal footing.

- Now that thermal generators are no longer the least-cost option to meet grid service needs, market operators can enact rules that will allow the participation of clean energy portfolio resources (including aggregated DERs) in wholesale market products.

## Improvements to planning methodologies and procurement practices can allow utilities to capture the value of clean energy portfolios

### » Update planning tools and processes:

- Accurately reflect the emerging capabilities of clean energy portfolio technologies on both sides of the meter to meet system needs. For example, solar providing ancillary services, demand flexibility providing load shifting in addition to traditional load shedding, and battery storage providing multiple value streams.

- Consider demand-side resources in the investment planning process, including their contributions beyond traditional valuations. For example, targeted energy efficiency provides peak capacity in addition to annual energy savings, and demand flexibility technologies can provide ancillary services.

- Engage service providers early and often, to ensure that planning assumptions around quickly evolving technology prices and capabilities are as up-to-date as possible.

### » Scale deployment quickly:

- Leverage lessons and best practices from peer utilities that have already piloted clean-portfolio technologies.

- Limit pilots of already proven technology, and move quickly toward scaled deployment so that successfully tested technologies can successfully defer or obviate major thermal generation investments.

### » Procure solutions, not technologies:

- In seeking market offers for investments or programs, specify planning requirements that allow planners to request technology-neutral solutions from the market, rather than specifying candidate resources more narrowly.

- Where multiple technologies are required to offset a traditional power plant investment, develop internal processes and tools, or seek aggregator services, that can streamline their integration into existing operational practices.

## Technology providers and project developers can offer holistic, low-cost solutions to meet grid needs

### » Integrate multiple technologies

- Where utilities seek or markets support turnkey gas alternatives provided by a single aggregator, partner across vendors to optimize bids and deployment accordingly.

- Recognize and embrace the individual role of specific technologies in providing grid services (e.g., renewables and energy efficiency for nondispatchable energy, energy storage and demand flexibility for flexible capacity).

### » Drive down soft costs

- Leverage technology to reduce the costs of system design, customer acquisition, operational integration, and other soft costs that can otherwise drive up multiasset portfolio costs.

- Seek out existing pathways and solutions for integrating new resources (e.g., utility energy efficiency-program portfolios, emerging distributed energy resource management system platforms) to avoid duplicative soft costs.

### » Generate confidence

- Work with planners and system operators to characterize discrete grid service needs, including measurement and verification, and design solutions to provide those services.

- Seek third-party validation of clean energy portfolio technologies' capabilities in order to generate confidence in portfolio-level ability to provide services otherwise provided by thermal power plants, and share data transparently to validate operational behavior.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