# World Economic Forum

## In collaboration with Accenture

Shaping the Future of Energy & Materials
System Value Framework – US Market Analysis
October 2020

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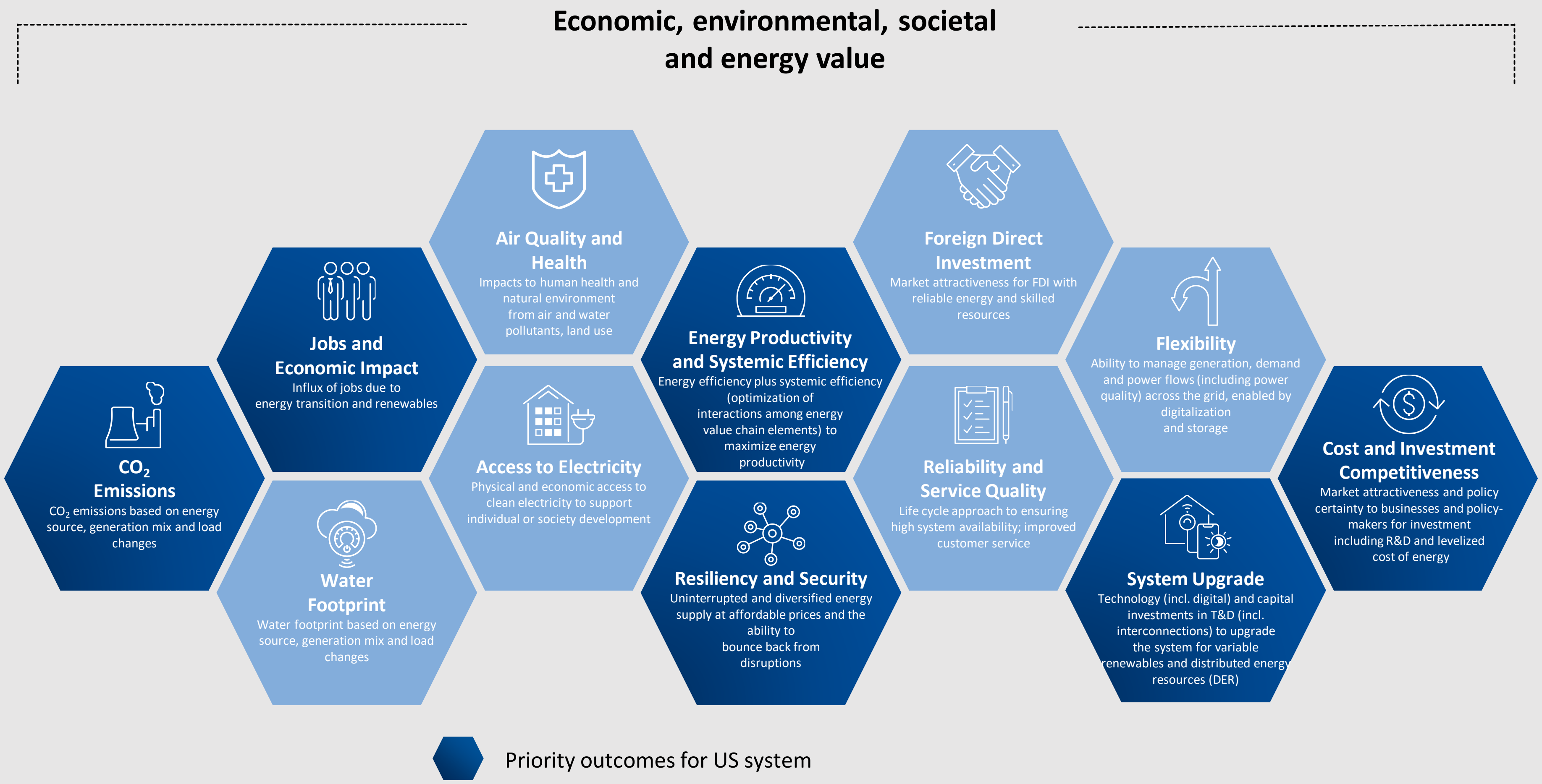
# System Value of the clean energy transition in the United States

The System Value framework more holistically evaluates economic, environmental, social and technical outcomes of potential energy solutions across markets. The framework aims to **shift political and commercial focus beyond cost to include value.**

**Using the System Value framework, the World Economic Forum, supported by Accenture, conducted analysis across several geographies** as part of market evaluations **that examined recovery opportunities to accelerate economic growth and the clean energy transition**.

Key system value dimensions for the US have been prioritized across the framework based on current market dynamics and its relative maturity of transition towards net-zero integrated energy system.



**Economic, environmental, societal and energy value**

**$CO_2$ Emissions**
$CO_2$ emissions based on energy source, generation mix and load changes

**Jobs and Economic Impact**
Influx of jobs due to energy transition and renewables

**Water Footprint**
Water footprint based on energy source, generation mix and load changes

**Air Quality and Health**
Impacts to human health and natural environment from air and water pollutants, land use

**Access to Electricity**
Physical and economic access to clean electricity to support individual or society development

**Energy Productivity and Systemic Efficiency**
Energy efficiency plus systemic efficiency (optimization of interactions among energy value chain elements) to maximize energy productivity

**Resiliency and Security**
Uninterrupted and diversified energy supply at affordable prices and the ability to bounce back from disruptions

**Foreign Direct Investment**
Market attractiveness for FDI with reliable energy and skilled resources

**Reliability and Service Quality**
Life cycle approach to ensuring high system availability; improved customer service

**Flexibility**
Ability to manage generation, demand and power flows (including power quality) across the grid, enabled by digitalization and storage

**System Upgrade**
Technology (incl. digital) and capital investments in T&D (incl. interconnections) to upgrade the system for variable enewables and distributed energy resources (DER)

**Cost and Investment Competitiveness**
Market attractiveness and policy certainty to businesses and policy-makers for investment including R&D and levelized cost of energy

⬢ Priority outcomes for US system

# United States recovery solutions

## Solutions to improve resiliency

### Renewables Expansion

Proposed **multi-year extensions of the investment tax credit (ITC) and production tax credit (PTC)** could increase **solar** capacity by 25% (+33 GW) and **onshore wind** by 14% (+22 GW) over 2025 base case projections, with additional ITC, process and infrastructure support able to expand the nascent **offshore wind** industry (+11 GW).

**300 Mt**
Less $CO_2$ emissions from electricity generation through 2025

**250k**
Incremental jobs created in 2025

**$34bn**
Human health benefits from air quality improvements through 2025

Costs
**$25-29bn**
Present value cost to government of ITC/PTC extension through 2025

### Transmission Investment

Potential to increase renewable deployment, wind capacity by 11% (+18 GW) and solar by 2% (+3 GW) in 2025, through **transmission expansion, interconnection and reinforcement**.

**121 Mt**
Less $CO_2$ emissions from electricity generation through 2025

**60-110k**
Incremental jobs created in 2025

**$14bn**
Human health benefits from air quality improvements through 2025

### Efficiency Investment

Replicating the investment level of the 2009 US Recovery Act, the US could achieve efficiency gains through implementing **smart buildings and energy infrastructure**, keeping energy costs low for consumers.

**103 Mt**
Less $CO_2$ emissions from electricity generation through 2025

**550k**
One-year jobs created through 2025

**$12bn**
Human health benefits from air quality improvements through 2025

Costs
**$20bn**
Potential investment through recovery stimulus

### Electrification and Demand Optimization

Greater support for **battery storage systems, road transport electrification and electric heat pumps** can boost system flexibility and reliability while cutting emissions.

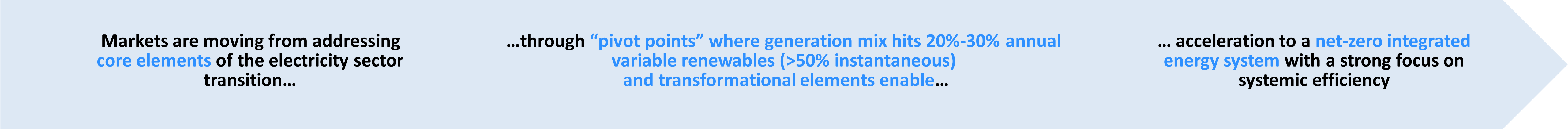
**5-9 Mt**
Less cross-sector $CO_2$ emissions through 2025

**22-25k**
Incremental jobs created in 2025

**$2bn**
Human health benefits from air quality improvements through 2025

Note: Above $CO_2$ and human health benefit figures represent cumulative, incremental savings in addition to 2025 base case projections.

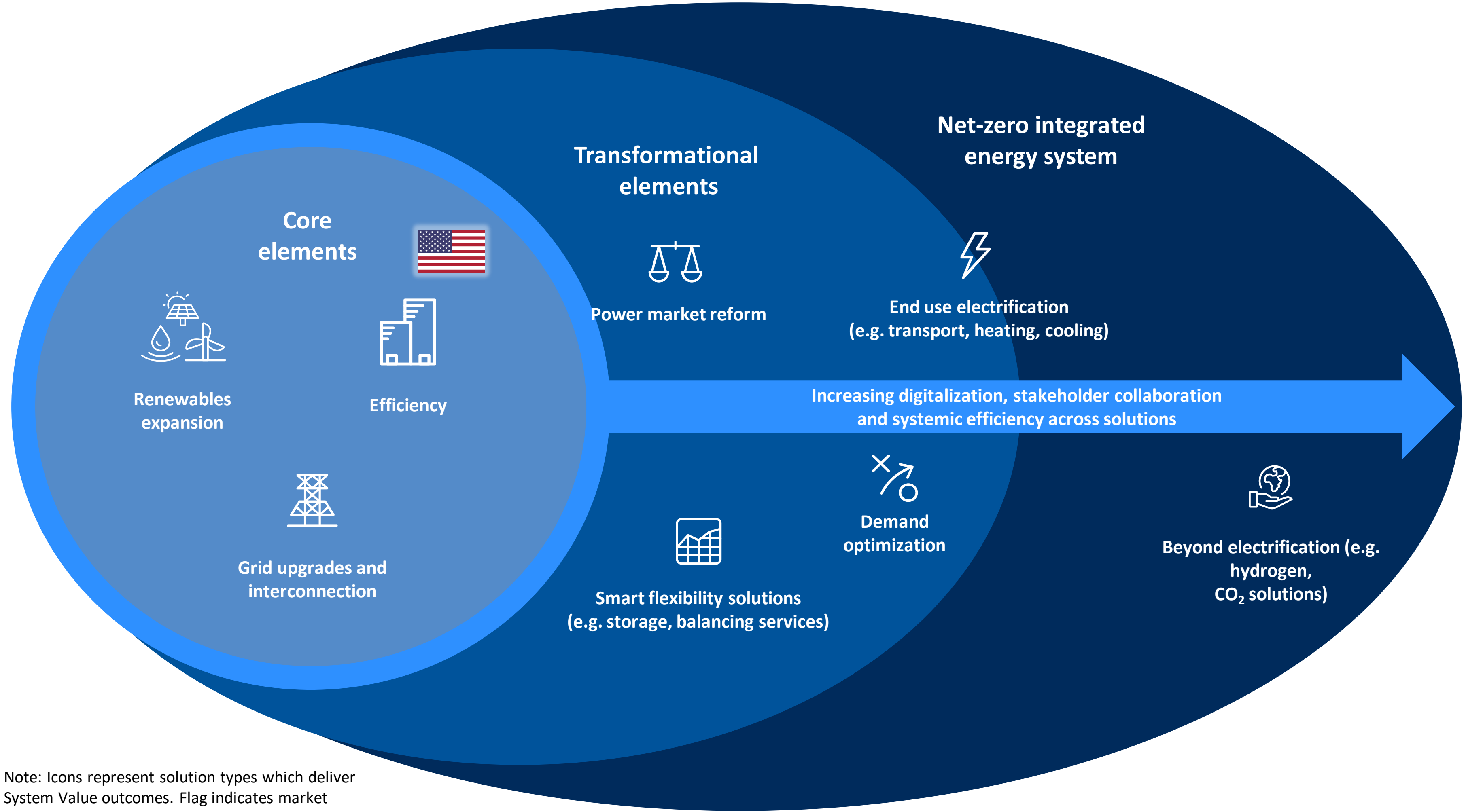
# US path to maximize System Value



Markets are moving from addressing core elements of the electricity sector transition…

…through "pivot points" where generation mix hits 20%-30% annual variable renewables (>50% instantaneous) and transformational elements enable…

… acceleration to a net-zero integrated energy system with a strong focus on systemic efficiency



The US is at a pivot point in three large markets (CAISO, ERCOT, SPP), but **much of the US is in core transition**

**Recovery solutions** deliver against **core transition elements**, with some movement towards the pivot point

**State net-zero goals** are pushing the US towards a future integrated energy system

Note: Icons represent solution types which deliver System Value outcomes. Flag indicates market progression along the path.

# Analysis purpose and overview

**The World Economic Forum, supported by Accenture,** has developed the **System Value framework** to move beyond cost to a **more holistic evaluation** of energy sector opportunities **across economic, environmental, societal and energy system value dimensions**.

The US electricity market was one of several markets chosen to demonstrate how the System Value framework can be used to evaluate opportunities that **accelerate economic recovery and a clean energy transition**.

The following analysis of the US electricity market aims to answer several key questions for energy industry leaders and can be leveraged to consider opportunities to pursue and prepare for conversations with a range of stakeholders.

- What is the state of COVID-related stimulus and recovery activity at the US federal level?
- What short- to medium-term growth opportunities exist that can spur economic recovery and accelerate the clean energy transition?
- How can stakeholders move beyond a cost-centric dialogue to consider the value of outcomes to the economy, environment, society and energy system?

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# Energy transition trends shaping the US electricity industry

**Digitalization**

| | |
|---|---|
| **Increasing electrification** | • **Buildings**: Smart, efficient electric appliances changing the load profile of buildings; heating/cooling also being electrified.<br>• **Mobility**: Electrification of passenger vehicles and fleets. Heavy duty transport exploring electrification and Power-to-X options.<br>• **Industry**: Electrification of light industrial applications and Power-to-X applications beginning to support new net-zero carbon goals of heavy industry and agriculture. |
| **Growth of green technology** | • **Utility-scale renewable generation**: New capacity is dominated by utility-scale renewables.<br>• **Distributed energy generation**: Decreasing costs driving increase in rooftop PV, batteries and microgrids.<br>• **Energy efficiency technologies**: Decreasing and controlling consumer demand, and therefore the need for new capacity. |
| **Network of the future** | • **Resilient grid**: Pressure to ensure power supply, withstand intense environmental events and cybersecurity threats.<br>• **Flexibility**: Need for greater flexibility through storage, matching forecasting to variable generation, increased interconnection and demand management.<br>• **Development**: Reinforcing or building out new grid capacity, often in face of customer NIMBY objections. |
| **Enterprise customer goals** | • **Corporate sustainability goals**: 200+ companies have made 100% renewable commitment as part of RE100 initiative.<br>• **PPA growth**: Increasing share of wind and solar development financed by industrial and commercial customer commitments.<br>• **Energy management**: Growing interest in site-level energy data and analysis to optimize energy usage, purchases and generation. |
| **Consumer activism** | • **Youth activism**: Youth-led climate activist groups such as Sunrise Movement impact political conversation and proposals.<br>• **New values beyond price**: Additional considerations motivate consumers, from buying green electricity to efficiency.<br>• **Digital expectation**: Consumers, influenced by other industries and companies, expect seamless digital interactions.<br>• **Greater choice**: Consumers adopt a more active role, increasing self supply and optimizing consumption. |
| **Investor activism** | • **Sustainable generation scrutiny**: Activist investors target electric utilities to accelerate decarbonization efforts.<br>• **Pressure on financiers**: Activist investors put pressure on banks to limit or halt financing for carbon intensive projects.<br>• **Investors going green**: Large investors BlackRock and Vanguard pledge to include sustainability in investment criteria. |
| **Cities in transition** | • **Systemic efficiencies**: Increased focus on building electrification, new green mobility and cross-sector efficiency optimization.<br>• **Net-zero and air quality**: From transit to buildings, cities move to net-zero and circular economy principles, improving air quality; more than 100 million people live in communities with a 100% renewable electricity target through efforts such as Sierra 100.<br>• **Wired well-being**: City digital solutions and public space design broaden utility infrastructure use, e.g. broadband, 5G. |
| **Investment in clean energy technology** | • **Driving down costs**: Investments to drive down cost and scale technologies, e.g., hydrogen production, transport and use; 10 MW+ electrolysers; lithium ion batteries; CCUS; floating offshore wind.<br>• **R&D in new technologies**: New clean energy technology, i.e. storage technologies beyond lithium-ion, new materials. |

*Sources: RE100; Blackrock; Vanguard; Accenture analysis*

# Digitalization underpins the energy transition

**AUTOMATION**

Routine tasks executed without human intervention (e.g. substation inspections)

**IT/OT**

Integration of operations and information technologies across networks

**PLATFORMS**

Cloud platforms providing new ways of delivering energy services

**SECURITY**

Protection for the connected ecosystem

**Digital is an enabler for all energy transition trends**

**MOBILITY**

Mobility solutions extending to customers and field workers

**ROBOTICS**

Physical activities conducted by machines

**ANALYTICS**

Cognitive analytics and big data applications (e.g. generation and demand forecasting)

**SOCIAL**

Premium collaboration and multidisciplinary decision making

# US COVID-19 impact on energy transition trends

| | | |
|---|---|---|
| Digitalization | Increasing electrification | • **Building gas ban momentum slows**: COVID-19 slows momentum of local government bans of natural gas in new building construction. |
| | Growth of green technology | • **Distributed generation tumbles**: US distributed solar installations hit hard, with Q2 2020 residential installations down 23% compared to Q1 2020.<br>• **Energy efficiency pauses**: Non-essential utility work suspended, affecting energy efficiency efforts in the short term. |
| | Network of the future | • **COVID-19 shifts load**: Load impacts differ by geography but often include later morning peaks.<br>• **Record share of renewables**: Share of renewables tops coal in US for a record 40 consecutive days.<br>• **Lower load impacts curtailment**: Renewables share rises due to lower demand, with CAISO reporting in March 2020 a 5%-8% drop in demand on weekdays and record levels of renewable curtailment on the system. |
| | Enterprise customer goals | • **PPA market slowdown**: COVID-19 decreases PPA activity in short term, although new corporate sustainability pledges continue.<br>• **Cash-strapped companies**: Many segments – products, manufacturing, financials, transport, infrastructure – may not be in a solid financial situation to move forward with PPA deals.<br>• **Supply chain impacts**: Delays to equipment and labor put tax credits at risk. |
| | Consumer activism | • **Remote workforce**: 30% of workers plan to increase the amount they work from home in the future. Half of those who had never worked from home before now plan to work from home more often in the future.<br>• **Digital adoption**: With COVID-19 accelerating customer digital adoption and a reliance on digital communications, companies will need to ensure positive customer experience across all customer groups, including elderly and income challenged. |
| | Investor activism | • **Opening for activists**: The pandemic provides activists and shareholders a chance to make the case for changes to investment strategy around energy, with causal links between air pollution levels and COVID-19 fatality rates. |
| | Cities in transition | • **Air pollution drops**: PM2.5 levels fall by 25% in New York City and 31% in Los Angeles in April due to less traffic and industry.<br>• **Budget shortfalls**: Nearly 90% of US city leaders anticipate budget shortfalls in 2020, affecting city services and staffing.<br>• **Population conditionality in stimulus**: Direct federal stimulus in March 2020 was limited to cities and counties with populations larger than 500,000, although some states funneled money to smaller municipalities. |
| | Investment in Clean Energy Technology | • **Eyes on stimulus and infrastructure packages**: 2009 Recovery Act put forward billions of dollars in federal funding to support clean energy R&D and led to significant clean energy expansion in the following decade. |

*Sources: S&P Global; Utility Dive (1, 2); GreenTech Media (1, 2, 3); SEIA; CBS News; Renews; LevelTen Energy; Accenture Research; Harvard School of Public Health; Bloomberg; Washington Post; Pew Trust; Obama White House Archives*

# COVID-19 impact on US electricity market

As of September 2020, EIA projects year-over-year retail electricity sales for 2020 to fall 2.4%, primarily affecting coal generation and caused by lower demand from commercial and industrial (C&I) sectors.

**Demand drops for C&I, rises for residential**

- Year-over-year electricity consumption changes
  - ○ Residential to rise 3.5%
  - ○ Commercial to drop 6.4%
  - ○ Industrial to drop 6.0%

**Share of renewables in generation mix to match coal**

- Coal generation share expected to fall from 24% in 2019 to 20% in 2020 as cost-competitiveness lags
- Renewable generation share forecast to increase from 17% in 2019 to 20% in 2020, matching coal's share

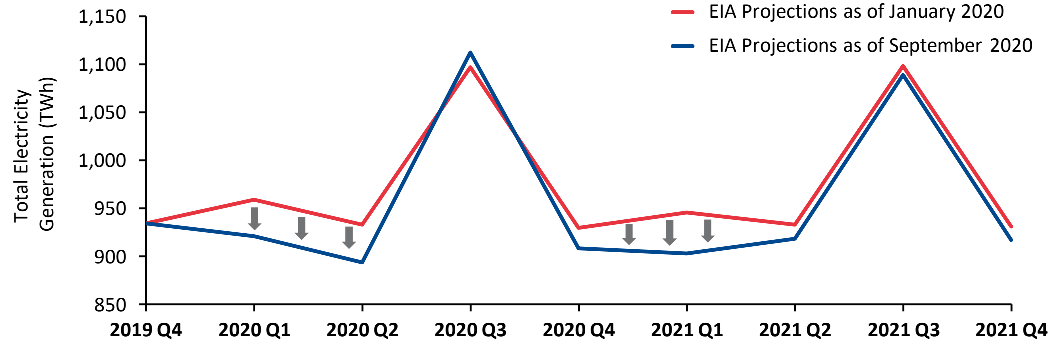
**Wind and solar deployments slow**

- Renewable additions hurt in the short term by supply chain impacts, worker restrictions and tax equity market
- Distributed solar installations particularly affected, with Q2 2020 residential installations down 23% compared to Q1 2020

**Recovery timing uncertain**

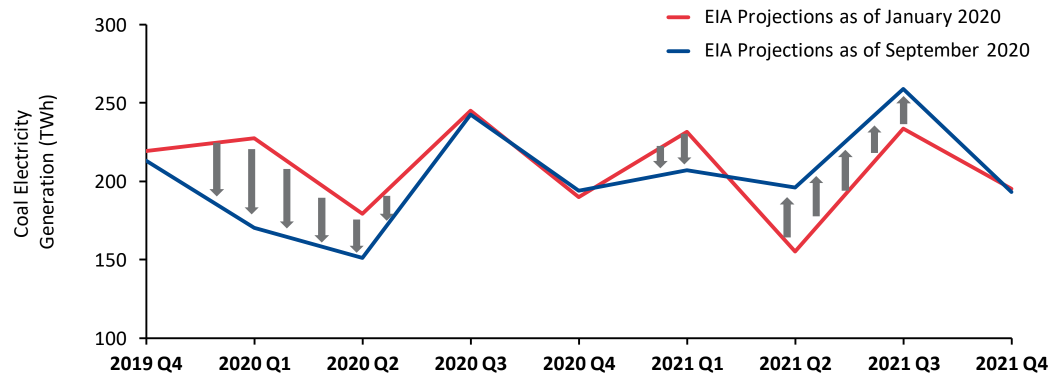
- When electricity demand from commercial and industrial segments will return close to pre-COVID-19 state is uncertain as COVID-19 impacts continue
- Questions surround economic viability of coal plants and if COVID-19 will accelerate closures

## Projected COVID-19 impact on US total electricity generation



| | 2020 Q1 | 2020 Q2 | 2020 Q3 | 2020 Q4 | 2021 Q1 | 2021 Q2 | 2021 Q3 | 2021 Q4 |
|---|---|---|---|---|---|---|---|---|
| Change from pre-COVID projection | -4.0% | -4.2% | 1.4% | -2.3% | -4.5% | -1.6% | -0.8% | -1.5% |

## Projected COVID-19 impact on US coal electricity generation[1]



| | 2020 Q1 | 2020 Q2 | 2020 Q3 | 2020 Q4 | 2021 Q1 | 2021 Q2 | 2021 Q3 | 2021 Q4 |
|---|---|---|---|---|---|---|---|---|
| Change from pre-COVID projection | -25.2% | -15.8% | -0.9% | 2.2% | -10.6% | 26.4% | 10.8% | -1.0% |

*Sources: EIA September 2020 Short-Term Energy Outlook; EIA January 2020 Short-Term Energy Outlook; Solar Energy Industries Association (SEIA); GreenTech Media*

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[1] *September 2020 EIA Short-Term Energy Outlook, pg. 4: "EIA expects production to rise to 600 million short tons in 2021, up 89 million short tons (17%) from 2020. This forecast increase reflects rising demand for coal from US electricity generators because of higher natural gas prices compared with 2020."*

# COVID-19 impact on US clean energy jobs

Through July 2020, US clean energy jobs declined by 15% versus pre-COVID-19 employment levels, with jobs starting to return to both clean energy (10k+ increase) and the overall US economy (1.8m increase) in July.

**Total clean energy job losses stood at more than 500,000 as of July 2020**

- More than 500,000 US clean energy workers lost their jobs from March through July 2020
- June and July 2020 saw recovery with over 116,000 clean energy job additions
- Impacted workers are even higher than reported figures as furloughed and underemployed workers are excluded

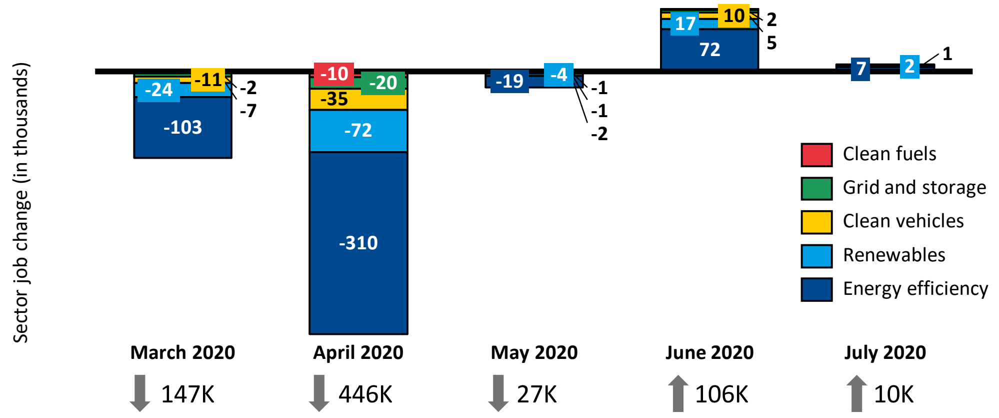
**Energy efficiency and renewables jobs hit hard**

- Energy efficiency represented 70% of clean energy job losses from March through June 2020, losing more than 350,000 jobs
- Job losses from the renewables sector amounted to 16% of total clean energy job losses from March through June 2020, losing more than 80,000 jobs

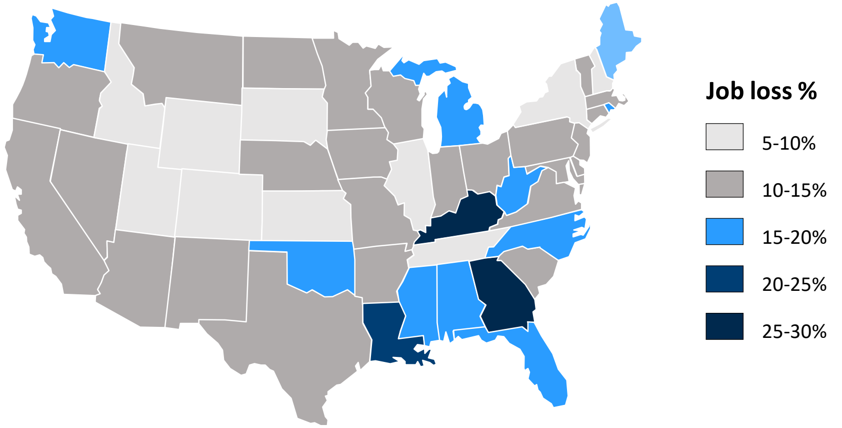
**Hispanic/Latino clean energy workers most affected**

- Hispanic and Latino clean energy workers are the hardest-hit demographic
- The US clean energy workforce is about 14% Hispanic/Latino, but an estimated 25% of the job losses in the clean energy industry through April were Hispanic/Latino workers

## Clean energy job changes by sector (March – July 2020)



## Snapshot: April 2020 clean energy job losses by state[1]

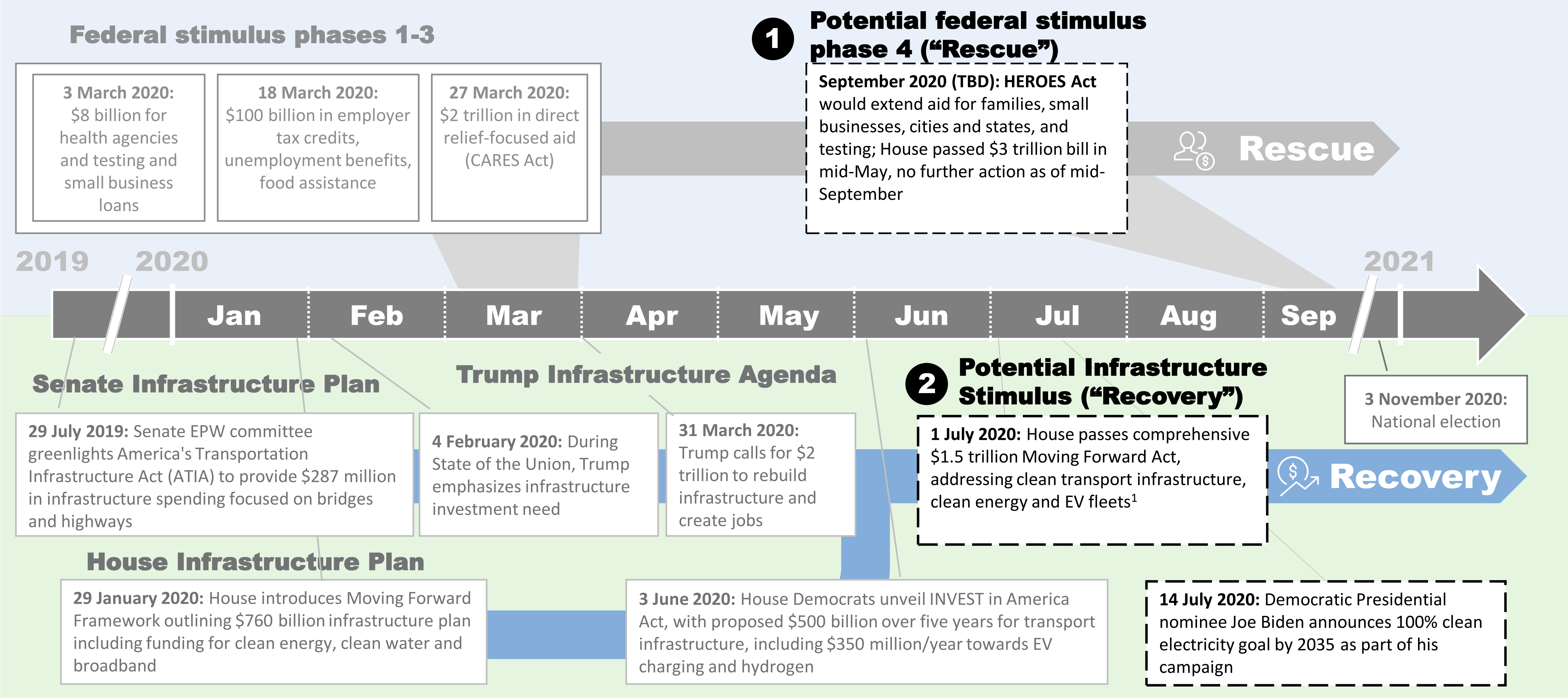


Sources: BW Research Partnership; Solar Energy Industries Association (SEIA); Washington Post

*As of September 2020*

# US federal stimulus timeline

As of September 2020, recovery-targeted legislative proposals have been put forward through infrastructure bills, most notably the Moving Forward Act, which passed the House of Representatives in July 2020, although none have received votes in both chambers.



## Federal stimulus phases 1-3

**3 March 2020:** $8 billion for health agencies and testing and small business loans

**18 March 2020:** $100 billion in employer tax credits, unemployment benefits, food assistance

**27 March 2020:** $2 trillion in direct relief-focused aid (CARES Act)

## ❶ Potential federal stimulus phase 4 ("Rescue")

**September 2020 (TBD): HEROES Act** would extend aid for families, small businesses, cities and states, and testing; House passed $3 trillion bill in mid-May, no further action as of mid-September

## Senate Infrastructure Plan

**29 July 2019:** Senate EPW committee greenlights America's Transportation Infrastructure Act (ATIA) to provide $287 million in infrastructure spending focused on bridges and highways

## Trump Infrastructure Agenda

**4 February 2020:** During State of the Union, Trump emphasizes infrastructure investment need

**31 March 2020:** Trump calls for $2 trillion to rebuild infrastructure and create jobs

## House Infrastructure Plan

**29 January 2020:** House introduces Moving Forward Framework outlining $760 billion infrastructure plan including funding for clean energy, clean water and broadband

**3 June 2020:** House Democrats unveil INVEST in America Act, with proposed $500 billion over five years for transport infrastructure, including $350 million/year towards EV charging and hydrogen

## ❷ Potential Infrastructure Stimulus ("Recovery")

**1 July 2020:** House passes comprehensive $1.5 trillion Moving Forward Act, addressing clean transport infrastructure, clean energy and EV fleets[1]

**14 July 2020:** Democratic Presidential nominee Joe Biden announces 100% clean electricity goal by 2035 as part of his campaign

**3 November 2020:** National election

*Sources: National Public Radio; ABC News; Speaker.gov; USA Today; CNN; US EPW Committee; New York Times; Whitehouse.gov; Washington Post; House.gov; Moving Forward Act (1, 2); Utility Dive*

[1] *Moving Forward Act includes provisions previously included in proposed INVEST in America and GREEN Acts.*

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# Recovery solution selection criteria

**Selected recovery solutions are required to meet the following criteria:**

**1 Accelerates the energy transition**

*The solution moves the market closer to net-zero emissions*

**2 Stimulates economic recovery**

*Implementation of the solution should stimulate job creation by 2021+*

**3 Enables meaningful System Value assessment**

*It should be possible to model and assess the solution for meaningful results within a 2025 time horizon*

# Recovery solutions can support US post-COVID-19 economy and advance the clean energy transition

| | Renewables Expansion | Transmission Investment | Efficiency Investment | Demand Optimization and Electrification |
|---|---|---|---|---|
| **Solution overview** | **Multiyear proposed extensions of ITC and PTC can increase solar capacity by 25% and onshore wind by 14%** over 2025 base case projections, with additional process and infrastructure support to expand nascent offshore wind industry | **Greater investment in transmission has the potential to increase wind capacity by 11%, stimulate job creation and create net benefits** for consumers and the environment | Building on the 2009 US Recovery Act's success, **tens of thousands of people can be put back to work quickly to achieve efficiency gains** and keep energy costs low for consumers | With more renewables, the potential for clean electrification of buildings, mobility and industry grows. **Greater emphasis must be placed on matching energy mix to load profiles through digitalization, demand optimization and storage** |
| **Capacity and generation impact** | • 66 GW incremental solar and wind capacity through 2025[1]<br>• Replaces 291 TWh of coal through 2025 (7% of 2021-2025 base case total) | • 21 GW incremental wind and solar capacity through 2025<br>• Replaces 121 TWh of coal through 2025 (3% of 2021-2025 base case total) | • Duplicating $20 billion energy efficiency investment from 2009 Recovery Act replaces 103 TWh of coal through 2025 (2.6% of 2021-2025 base case total) | • 300 MW of incremental annual storage from ITC<br>• 7-13 TWh of increased load by 2025 from heat pumps (0.7-1.4m), public EV fleets (100-200k), E-buses (10k) |
| **$CO_2$ emissions** | ↓ 300 Mt<br>Cumulative reduction in base case electricity emissions through 2025[2], 152 Mt or 11.3% reduction in 2025 | ↓ 121 Mt<br>Cumulative reduction in base case electricity emissions through 2025, 66 Mt or 4.9% reduction in 2025 | ↓ 103 Mt<br>Cumulative reduction in base case electricity emissions through 2025, 26 Mt or 1.9% reduction in 2025 | ↓ 5-9 Mt<br>Reduction in $CO_2$ emissions through 2025 across transportation, buildings and energy |
| **Water footprint** | ↓ 512bn liters<br>Cumulative reduction in water footprint through 2025 | ↓ 212bn liters<br>Cumulative reduction in water footprint through 2025 | ↓ 183bn liters<br>Cumulative reduction in water footprint through 2025 | *Not included in analysis* |
| **Jobs impact** | ↑ >250k<br>Economy-wide jobs in 2025 | ↑ 60-110k<br>Annual economy-wide jobs | ↑ 550k<br>Total one-year jobs created through 2025 | ↑ 22-25k<br>Additional industry jobs through 2025 |
| **Human health** | ↑ $34bn<br>Human health benefits through 2025 from decreased air pollution[3] | ↑ $14bn<br>Human health benefits through 2025 from decreased air pollution | ↑ $12bn<br>Human health benefits through 2025 from decreased air pollution | ↑ $2bn<br>Human health benefits through 2025 from decreased air pollution |

While not included in above solutions, *hydrogen and carbon capture, utilization and storage (CCUS) technologies* hold significant promise as key components to achieve decarbonization across the energy, transportation, and industrial sectors in the coming years. The US Department of Energy budget for hydrogen and fuel cell technologies stood at over $200 million in FY19, and the IEA[4] notes that the US is home to 11 of 20 global CCUS facilities under development as of June 2020, spurred by new investment incentives to expand and enhance the 45Q tax credit.[4]

*Note: Above recovery solutions assume each is enacted in isolation. Base case generation and capacity figures from BNEF. Figures are rounded, summed totals. For additional analysis detail, please see solution slides.*

*[1] 66 GW incremental capacity addition is comprised of the following additions: 33 GW solar from ITC extension, 22 GW onshore wind from PTC extension, 11 GW offshore wind from industry support and ITC.*

*[2] $CO_2$ emission changes are relative to combined total from coal and natural gas, with percentages reflecting drop in 2025 emissions compared to 2025 base case. Mt = million (metric) tonnes.*

*[3] Estimated human health benefits from reduced NOx, SO2, PM2.5 levels from lower fossil fuel generation.*

*[4] IEA; US Department of Energy*

# ITC Extension: Solar

**Overview**

A five-year extension of the US Investment Tax Credit (ITC) is being sought by renewable industry groups such the Solar Energy Industries Association (SEIA) and members of Congress through the Moving Forward Act to help stimulate the US economy and advance the clean energy transition.

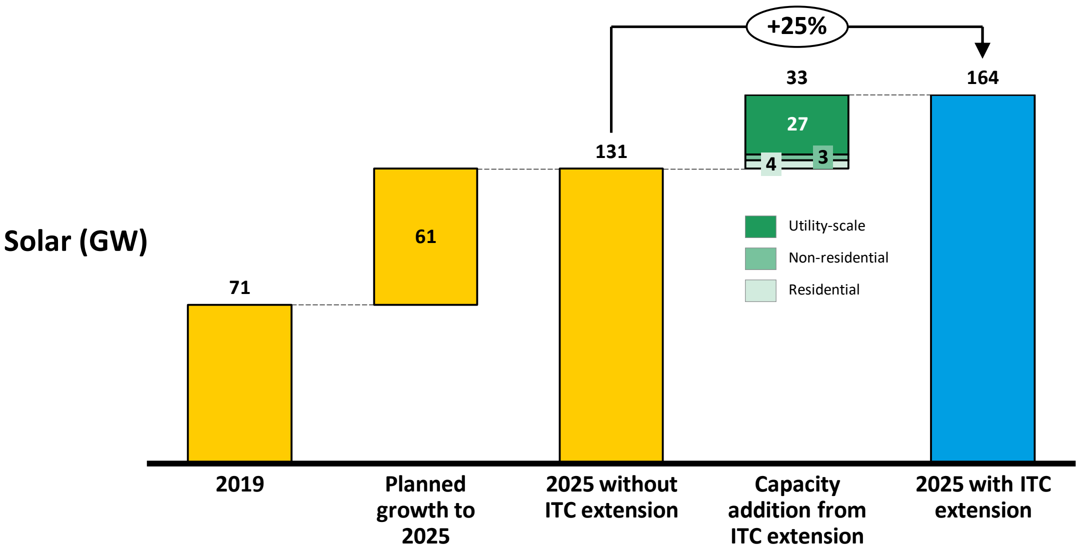
**Benefits of solar ITC extension**

If passed, a proposed five-year ITC extension would drive additional solar capacity beyond current projections across utility-scale, distributed non-residential and residential sectors. An estimated 33 GW of additional solar PV through 2025 could be added (26-27 GW utility-scale, 2-3 GW non-residential, 3-4 GW residential), a 25% increase over status quo projections.

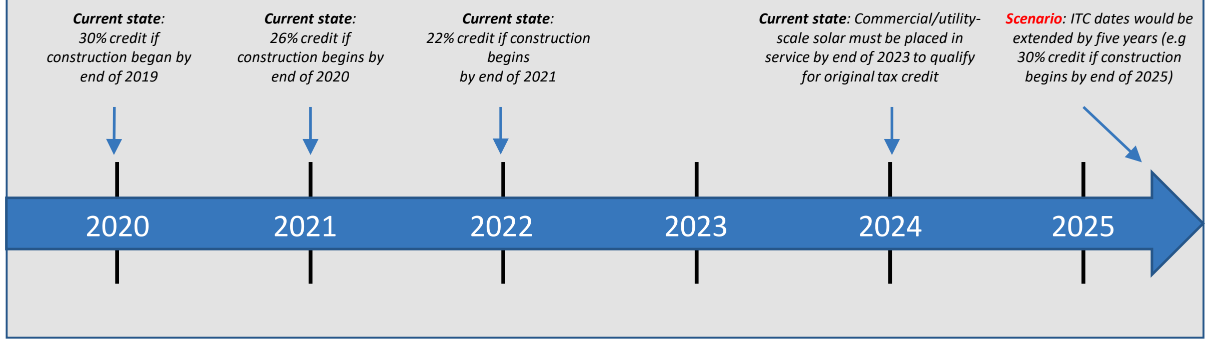
Increased solar capacity additions would decrease projected emissions and provide human health benefits from lower coal generation given the low marginal cost of solar. While the cost of the ITC to the federal government from incremental generation could exceed $10 billion, estimated health benefits and job creation outweigh this cost.

Tens of thousands of solar-related jobs would be created as a result of the ITC extension, aiding the post-COVID-19 economic recovery.

## Projected solar capacity additions from ITC extension



## Current and proposed ITC timeline


***Current state**: 30% credit if construction began by end of 2019*

***Current state**: 26% credit if construction begins by end of 2020*

***Current state**: 22% credit if construction begins by end of 2021*

***Current state**: Commercial/utility-scale solar must be placed in service by end of 2023 to qualify for original tax credit*

***Scenario**: ITC dates would be extended by five years (e.g 30% credit if construction begins by end of 2025)*

## System Value impacts of solar ITC extension compared to base case

**Benefits**

⬇ **131 Mt**
Cumulative reduction in base case electricity $CO_2$ emissions through 2025

⬇ **209bn L**
Cumulative reduction in base case water footprint through 2025 in liters

⬆ **114k**
Economy-wide job impact in 2025

⬆ **$15bn**
Human health benefits through 2025 from decreased air pollution

**Costs**

**$10-12bn**
Present value cost to federal government of incremental solar ITC extension through 2025[1]

*Sources: SEIA (1, 2), Utility Dive, Wood Mackenzie, GreenTech Media, Accenture analysis*

*[1] Estimated ITC cost does not include potential applicability of ITC to existing planned capacity that may qualify for the incentive*

# PTC Extension: Onshore Wind

**Overview**

In addition to the ITC, a five-year extension of the Production Tax Credit (PTC) is being sought to accelerate onshore wind development, with qualifying facilities able to claim the credit for the first 10 years of production. The current version of the PTC expires at the end of 2020, with two recent short-term extensions:

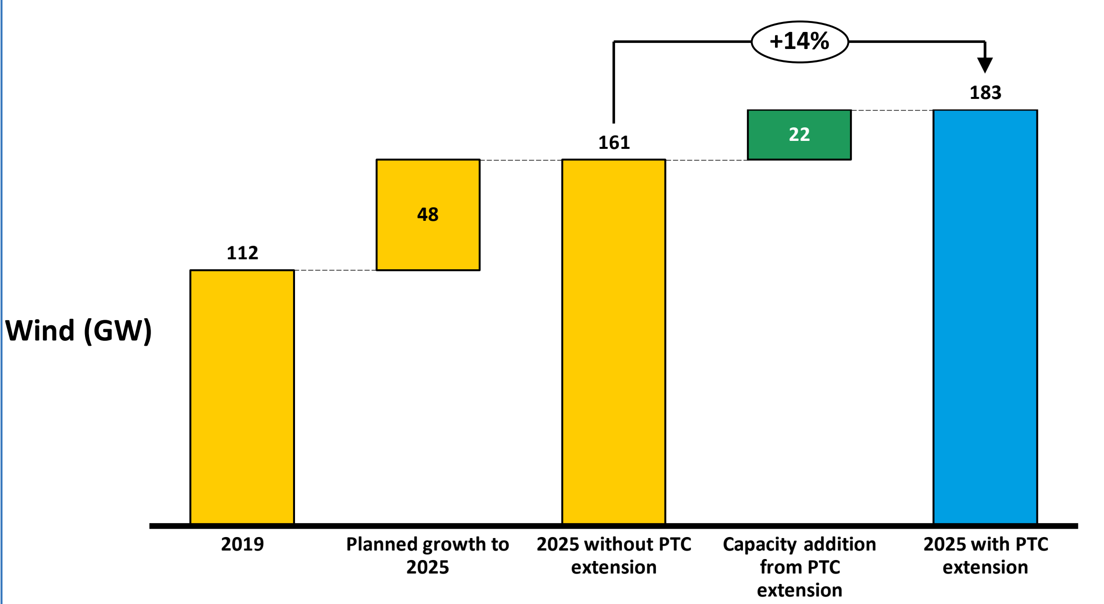
- At the end of 2019, the PTC was extended by one year to include onshore wind projects that begin construction by the end of 2020.
- In late May 2020, the US Internal Revenue Service (IRS) granted a one-year extension of safe harbor deadlines to help with COVID-related project delays.

**Benefits of PTC extension**

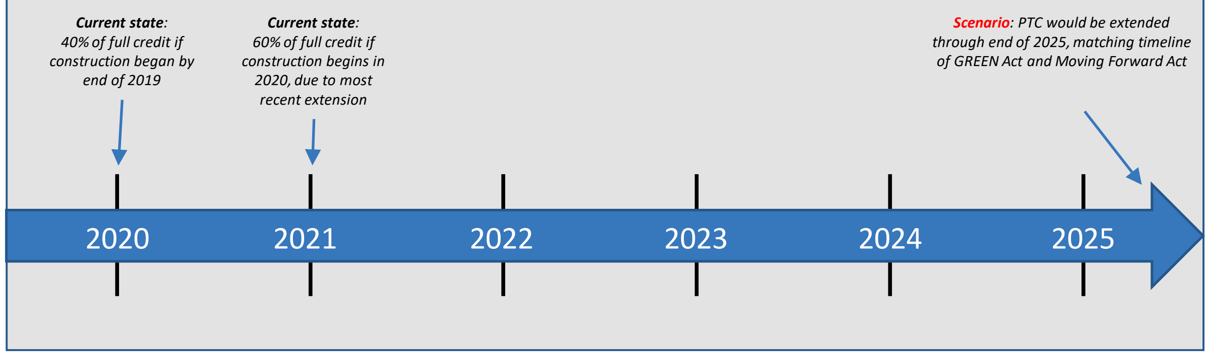
If passed, a proposed PTC extension could drive an estimated 22 GW of additional onshore wind capacity through 2025, a 14% increase over base case projections. While the cost of PTC to federal government from incremental generation is an estimated $10 billion, health benefits and job creation are likely to outweigh this cost.

Increased onshore wind capacity would decrease projected emissions by lowering coal generation given low marginal costs. Additionally, tens of thousands of wind-related jobs would be created as a result of the PTC extension.

## Projected capacity additions from PTC extension



## Current and proposed PTC timeline



***Current state**: 40% of full credit if construction began by end of 2019*

***Current state**: 60% of full credit if construction begins in 2020, due to most recent extension*

***Scenario**: PTC would be extended through end of 2025, matching timeline of GREEN Act and Moving Forward Act*

## System Value impacts of PTC extension compared to base case

**Benefits**

⬇ **138 Mt**
Cumulative reduction in base case electricity $CO_2$ emissions through 2025

⬇ **244bn L**
Cumulative reduction in base case water footprint through 2025 in liters

⬆ **107k**
Economy-wide job impact in 2025

⬆ **$16bn**
Human health benefits through 2025 from decreased air pollution

**Costs**

**$3bn**
Present value cost to federal government of incremental PTC extension through 2025

*Sources: Utility Dive; IRS; Congressional Research Service; NREL; GREEN Act; Accenture analysis*

# Offshore Wind (1 of 2): Industry Expansion

**Overview**

At the end of 2019, Bloomberg New Energy Finance projected nearly 3 GW of US offshore wind deployment by 2025. However, with only 30 MW of deployed capacity as of early 2020, the US lacks a significant domestic supply chain to support future growth.

With increasing state mandates, the US can improve processes and scale up the domestic supply chain, workforce and infrastructure to provide additional support to accelerate the industry and provide needed jobs. These actions can help realize AWEA's 9 GW base case projection for offshore wind capacity by 2025.

**Opportunities to support the offshore wind industry**

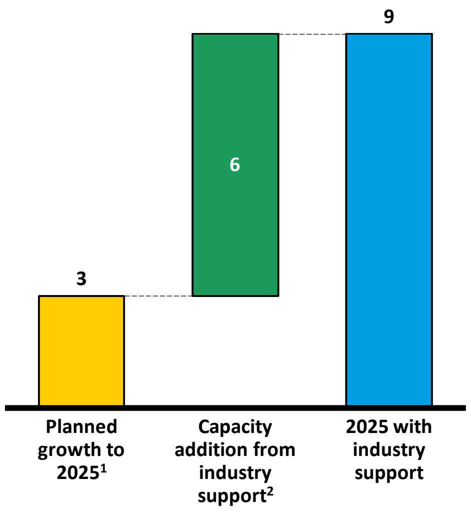
Several opportunities have been identified by AWEA, the Business Network for Offshore Wind, and UNLEASH to support US offshore wind in the near future:

- Add more regulatory review staff to the Bureau of Ocean Energy Management to reduce the backlog of offshore wind permitting documents currently pending review and accelerate project approvals
- Identify additional offshore wind lease areas and schedule adequate future offshore lease sales to reach established state goals
- Modernize shipyards to support construction and maintenance activities
- Have government agencies support talent development and training
- Subsidize capital investment in turbine component manufacturing facilities near East Coast ports that can construct larger turbines and towers

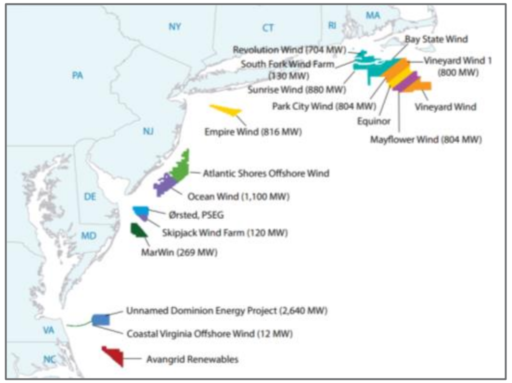
**Local supply chain support**

To date, local supply chain development has been an integral component of state energy policies to catalyze domestic offshore wind industry. States with active offshore wind procurement plans often explicitly treat the development of an in-state supply chain as one of the key non-price decision criteria. States can continue to support this development during COVID-19 recovery.

## Projected capacity additions



## US East Coast offshore wind projects and lease areas



## System Value impacts of offshore wind industry support compared to base case

**Benefits**

| | | | |
|---|---|---|---|
| ↓ **17 Mt** | ↓ **32bn L** | ↑ **19k** | ↑ **$1.5bn** |
| Cumulative reduction in base case electricity $CO_2$ emissions through 2025 | Cumulative reduction in base case water footprint through 2025 in liters | Economy-wide job impact in 2025 | Human health benefits through 2025 from decreased air pollution |

*Sources: AWEA; Special Initiative on Offshore Wind; US Offshore Wind Conference; Business Network for Offshore Wind; UNLEASH Lab; SquirePattonBoggs; Forbes; Accenture analysis*

*[1] BNEF January 2020 figures, [2] AWEA base case*

# Offshore Wind (2 of 2): ITC Extension

**Overview**

In addition to supporting solar capacity expansion, the Moving Forward Act includes a five-year ITC extension to support offshore wind development. If passed, this extension could help drive additional offshore wind capacity to the higher range of current AWEA projections (14 GW by 2025).

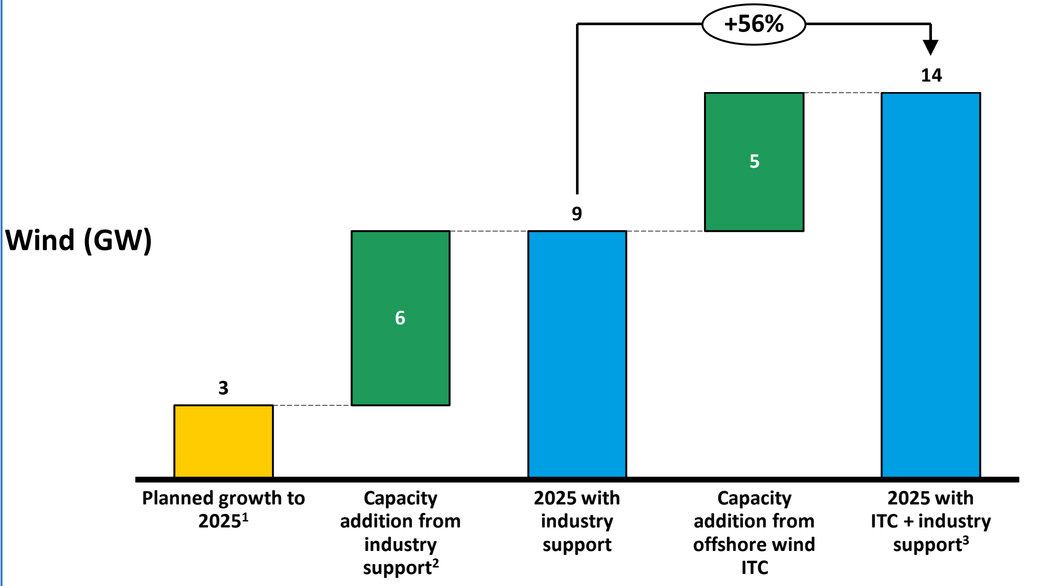
**Benefits**

The proposed five-year ITC extension could add an estimated 5 GW of additional offshore wind capacity through 2025. While cost of offshore wind ITC to federal government from incremental generation is an estimated $13-15 billion, health benefits over the course of asset lifespan and job creation would likely outweigh this cost.

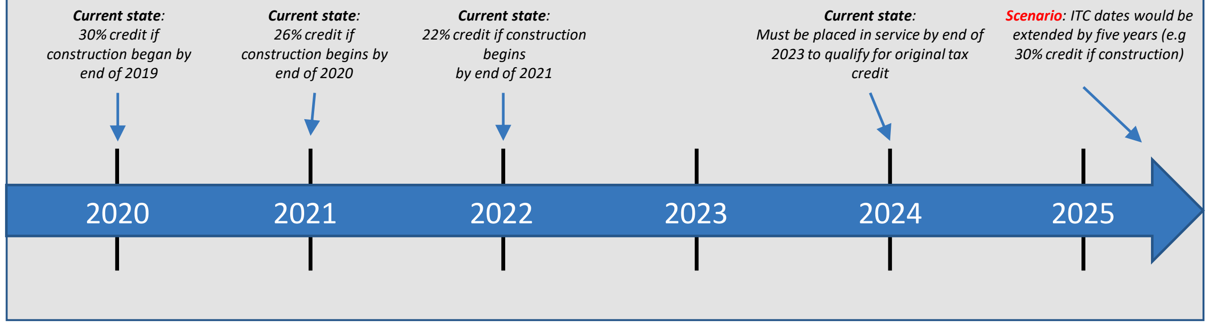
Increased capacity additions would accelerate the clean energy transition in the Northeast US and decrease projected emissions by lowering coal and natural gas generation given low marginal cost.

Although not included in this analysis, further reductions in natural gas and peaking plants are possible with two-way transmission of Canadian hydro and offshore wind in the Northeast US, with hydro serving as a balancing resource.

## Projected offshore wind capacity additions from ITC extension



## Current and proposed ITC timeline



***Current state:*** *30% credit if construction began by end of 2019*

***Current state:*** *26% credit if construction begins by end of 2020*

***Current state:*** *22% credit if construction begins by end of 2021*

***Current state:*** *Must be placed in service by end of 2023 to qualify for original tax credit*

***Scenario:*** *ITC dates would be extended by five years (e.g 30% credit if construction)*

## System Value impacts of offshore wind ITC extension compared to base case

| Benefits | | | | Costs |
|---|---|---|---|---|
| ⬇ **15 Mt** | ⬇ **27bn L** | ⬆ **11k** | ⬆ **$1.2bn** | **$12-14bn** |
| Cumulative reduction in base case electricity $CO_2$ emissions through 2025 | Cumulative reduction in base case water footprint through 2025 in liters | Economy-wide job impact in 2025 | Human health benefits through 2025 from decreased air pollution | present value cost of 11 GW incremental capacity to federal government from ITC extension through 2025 |

*Sources: GreenTech Media (1, 2); AWEA (1 , 2); Accenture analysis*

*[1] BNEF January 2020 figures, [2] AWEA 2025 base case, [3] AWEA 2025 high scenario*

*Analysis and cost estimates assume transmission investment is part of the developer cost*

# Transmission Investment

**Overview**

Greater transmission investment and process improvements being sought by industry groups such as AWEA have the potential to stimulate job creation, alleviate congestion and drive more renewable capacity, creating net benefits for consumers and the environment.

**Benefits from transmission investment**

- *Environmental benefit*: Greater interconnection lowers curtailment of renewable resources as high-potential resource areas often lie far from large population centers.
- *Economic benefit*: Transmission investment will add transmission and renewables jobs, enable greater system stability, and lower wholesale market prices.
- *Customer benefit*: MISO has calculated that new transmission benefits are 2.6-3.9 times their cost and provide $13-50 billion in net benefits over the next 20 to 40 years.

**Recommendations sought by industry groups to improve US transmission**

- *Planning*: Require ISO planners to engage in forward-looking transmission planning, including integration of variable generation and storage that proactively includes public policy requirements established by state or federal laws or regulations, environmental regulations, market forces and new technologies.
- *Paying*: Transmission infrastructure can be furthered through broader cost allocation.
- *Permitting*: One of the main barriers is the difficult state siting process, which often requires multiple US states to approve lines. Establishing a workable US federal backstop siting authority for electric transmission lines could alleviate this roadblock.

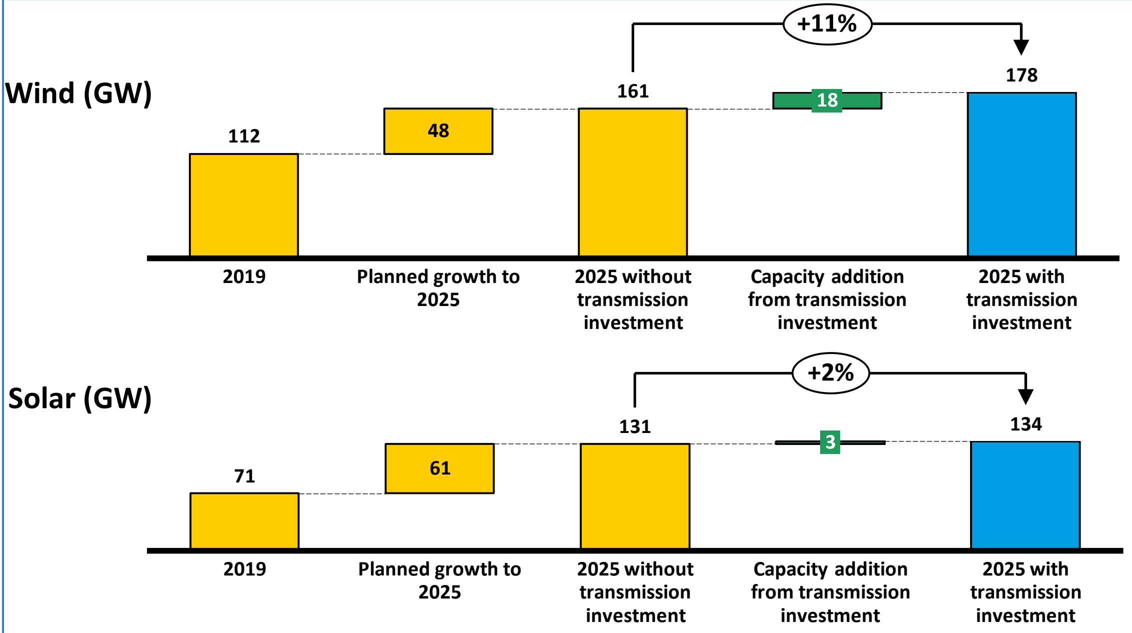
**TSO-DSO collaboration**

Greater TSO-DSO collaboration, increased investments in digitalization areas such as digital controls, and a shift to time-of-use (ToU) pricing can complement transmission and renewable investments for further system improvement.

**Cross-border projects between Canada and the Northeast US**

Greater cross-border interconnection can provide load balancing, cost savings and carbon benefits at a regional level by linking hydro in Quebec with US offshore wind. Demonstrating value to residents in areas hosting transmission lines is a key factor.

## Projected capacity additions from transmission investment



## System Value impacts of transmission investment compared to base case

**Benefits**

**⬇ 121 Mt**
Cumulative reduction in base case electricity $CO_2$ emissions through 2025

**⬇ 212bn L**
Cumulative reduction in base case water footprint through 2025 in liters

**⬆ 60-110k**
Annual economy-wide job impact through 2025

**⬆ $14bn**
Human health benefits through 2025 from decreased air pollution

*Sources: AWEA; Wind Solar Alliance; GreenTech Media; DOE; MIT Center for Energy & Environmental Policy Research; Accenture analysis*
*Note: Proposed US transmission lines have potential to bring more than 20 GW of additional renewable energy online in coming years*

# Efficiency Investment

**Overview and definition**

Energy efficiency employs more workers than any other clean energy field, nearly 2.4 million US workers pre-COVID-19. While social distancing guidelines must be top of mind, improving efficiency is a major prospect for recovery packages. For purposes of this evaluation, “efficiency” is defined as initiatives and actions that decrease energy usage, including energy conservation.

Assuming a $20 billion investment towards energy efficiency similar to the American Recovery and Reinvestment Act of 2009 (ARRA or 2009 Recovery Act), the US could achieve a reduction of 103 TWh in generation in 2025, accelerating the reduction in coal generation.

**2009 Recovery Act (ARRA) benefits**

- *Investment*: Nearly $20 billion (22%) of ARRA’s $90 billion in clean energy appropriations went towards energy efficiency to support jobs and clean energy transition.
- *Job creation*: DOE study showed economy-wide gain of 62,000 jobs from $2.28 billion of energy efficiency funding allocated through the Energy Efficiency and Conservation Block Grant Program (27 jobs per $1 million invested).
- *Energy savings*: ARRA support helped weatherize more than 1 million homes between 2009 and 2012.

**Efficiency opportunities for COVID-19 recovery**

- *School and university smart efficiency retrofits*: Smart building retrofit opportunity for schools and universities, with funding distributed to states and local jurisdictions through Block Grant Program ($1 billion allocated to retrofits through Block Grant Program in 2009 ARRA)
- *Weatherization Assistance Program:* Increased funding to help those hurt most by pandemic’s economic consequences ($5 billion allocated in 2009 ARRA)
- *Financial incentives*: Rebates, financing, and loan activities provide 2x energy savings over retrofits per dollar spent ($480 million allocated to financial incentives through Block Grant Program in 2009 ARRA)
- *Federal, state and municipal facilities*: Energy savings from smart technology and efficiency upgrades to government facilities will benefit US taxpayers ($8.8 billion allocated in 2009 ARRA)

## 2009 Recovery Act clean energy allocations

| Category | Initial allocation ($B) |
|---|---|
| Renewable generation | $26.6 |
| **Energy efficiency** | **$19.9** |
| Transit | $18.1 |
| Grid modernization | $10.5 |
| Advanced vehicles | $6.1 |
| Green innovation and job training | $3.5 |
| CCUS | $3.4 |
| Clean energy equipment manufacturing | $1.6 |
| Other | $0.4 |

## System Value impacts of efficiency investment

**Benefits**

↓ **103 Mt**
Cumulative reduction in base case electricity $CO_2$ emissions through 2025

↓ **183bn L**
Cumulative reduction in base case water footprint through 2025 in liters

↑ **550k**
Equivalent one-year jobs created if 2009 ARRA investment is matched

↑ **$12bn**
Human health benefits through 2025 from decreased air pollution

**Costs**

**$20B**
Investment dollars through federal government stimulus

*Sources: DOE; Obama White House Archives; BNEF; 2020 Sustainable Energy in America Factbook; Accenture analysis*
*Note: Job impacts include direct, indirect and induced job creation as defined by DOE and are based on illustrative timeline through end of 2023. ARRA refers to the American Recovery and Reinvestment Act of 2009.*

# Demand Optimization and Electrification

**Overview**

As more renewables are deployed, the clean electrification potential for buildings, mobility and industry grows. Greater emphasis on grid flexibility, achieved through increased digitalization, smart technology, demand optimization and storage, is needed. Additionally, physical and digital distribution system upgrades are necessary to deliver more variable generation, with 70% of US transformers more than 25 years old.

**Demand optimization and electrification opportunities for COVID recovery**

- *Expand storage ITC*: US Storage ITC phases out in 2020; extending and expanding the storage ITC as proposed by the Energy Storage Association to include multiple stand-alone technologies has potential to increase annual deployments by 300 MW, according to Wood Mackenzie.
- *Invest in EV charging infrastructure*: Proposed $1.1 billion in federal grants and rebates could generate 10,000 jobs and deploy hundreds of thousands of chargers nationwide, with focus on designated EV corridors.
- *Advance public EV fleets*: With over 1.3 million automobiles owned by US state, county and municipal entities, there is great potential for government entities to convert their passenger fleets to EVs, with California setting a 50% purchase goal by 2025.
- *Increase funding of electric buses*: Building on state-allocated VW settlement funds, the US federal government can increase funding for electric bus deployment for public transit and schools, with $520 million annual incremental funding towards electric transit buses and $50 million towards electric school buses per year put forward in recent congressional bills.[1]
- *Deploy efficient electric heat pumps*: Shifting some of the 70 million consumers who have oil, propane or natural gas HVAC systems to efficient electric heat pumps can decrease emissions and allow demand to shift energy usage to times with higher renewable output or lower cost. Policy-makers can integrate heat pumps into portfolio standards and introduce all-electric new construction requirements, with Maine instituting a target and rebate program to install 100,000 heat pumps by 2025.
- *Incorporate time of use (ToU) pricing and demand response*: To increase grid flexibility and achieve benefits from greater share variable renewables, electrification and storage, rate structures can be shifted to ToU rates and utilities increase utilization of demand response as a tool to match supply.

## System Value impacts of Demand Optimization and Electrification investments

| | | | | |
|---|---|---|---|---|
| **Storage ITC** | ↑ **300 MW**<br>Annual storage deployment increase | ↑ **9k**<br>Incremental storage industry jobs from Storage ITC | **$180m**<br>Estimated tax expenditure from storage ITC through 2025 | |
| **EV charging infrastructure** | ↑ **300k+**<br>EV chargers deployed from $1.1B investment | ↑ **10k**<br>Additional jobs related to EV charging infrastructure funding | **$1.1bn**<br>Federal grants and rebates towards EV charging infrastructure | |
| **Public EV fleets**[2] | ↑ **100-200k**<br>Public fleet EVs deployed through 2025 (EVs as 25%-50% of 2025 purchases) | ↓ **3-6k**<br>Additional jobs related to EV charging infrastructure funding | ↓ **0.6-1.2 Mt**<br>Total reduced $CO_2$ emissions in MT through 2025 | |
| **Electric buses** | ↑ **10k+**<br>Electric transit and school buses deployed through 2025 with federal support | ↓ **0.8 Mt**<br>Total reduced $CO_2$ emissions in Mt through 2025 | ↑ **$1.5bn**<br>Human health benefits through 2025 | **$2bn+**<br>Proposed incremental federal grant money through 2025 |
| **Electric heat pumps**[3] | ↑ **0.7-1.4m**<br>Electric heat pump conversions (5%-10% of replacements by 2025) | ↓ **3.4-6.8 Mt**<br>Total reduced $CO_2$ emissions in MT through 2025 | ↑ **$0.3-0.7bn**<br>Human health benefits through 2025 from decreased air pollution | |

*Sources: Energy Storage Association (1, 2, 3); PV Tech; NREL; INVEST in America Act; CLEAN Future Act; Transportation Infrastructure Act; US DOE; ACEEE; US PIRG; Thomas Built Buses; Mass. Dept. of Energy Resources; US DOT; Transit Chicago; RMI; Maine.gov; Accenture analysis*

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[1] *Bus analysis examined proposed funding in INVEST in America Act and CLEAN Future Act*

[2] *Range reflects base case (25% EV public fleet passenger vehicle sales by 2025) and accelerated scenarios (50% of 2025 sales)*

[3] *Range reflects base case (5% replacements by 2025) and accelerated scenarios (10%), analysis based on figures from RMI 2018 Study*

# Contents

# System Value of clean energy transition

System Value benefits are seen across all US solutions.

**Economic, environmental, societal and energy value**

⬢ System Value dimension with quantitative analysis

⬢ System Value dimension with qualitative analysis

⬡ Priority System Value dimension

| | **$CO_2$ Emissions**<br>$CO_2$ emissions based on energy source, generation mix and load changes | **Water Footprint**<br>Water footprint based on energy source, generation mix and load changes | **Access to Electricity**<br>Physical and economic access to clean electricity to support individual or society development | **Jobs and Economic Impact**<br>Influx of jobs due to energy transition and renewables | **Air Quality and Health**<br>Impacts to human health and natural environment from air and water pollutants, land use | **Resiliency and Security**<br>Uninterrupted and diversified energy supply at affordable prices and the ability to bounce back from disruptions | **Energy Productivity and Systemic Efficiency**<br>Energy efficiency plus systemic efficiency to maximize energy productivity | **Foreign Direct Investment**<br>Market attractiveness for FDI with reliable energy and skilled resources | **Reliability and Service Quality**<br>Life cycle approach to ensuring high system availability; improved customer service | **Flexibility**<br>Ability to manage generation, demand and power flows (incl. power quality) across the grid, enabled by digitalization and storage | **System Upgrade**<br>Technology (incl. digital) and capital investments in T&D to upgrade the system for variable renewables and DERs | **Cost and Investment Competitiveness**<br>Market attractiveness and policy certainty for investment, incl. R&D and levelized cost of energy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Renewables Expansion** | **300 Mt**<br>Reduction in base case electricity $CO_2$ emissions through 2025 | **512bn L**<br>Reduction in water footprint through 2025 in liters | | **>250k**<br>Economy-wide jobs in 2025 | **$34bn**<br>Human health benefits through 2025 | ◐ | ◐ | | ○ | ○ | ◐ | High range of utility-scale LCOE is less than low end of coal LCOE range |
| **Transmission Investment** | **121 Mt**<br>Reduction in base case electricity $CO_2$ emissions through 2025 | **212bn L**<br>Reduction in water footprint through 2025 in liters | | **60-110k**<br>Annual incremental economy-wide jobs | **$14bn**<br>Human health benefits through 2025 | ● | ● | | ◐ | ◐ | ● | **$1-$10/MWh**<br>Average levelized transmission capital cost for renewables (Berkeley Lab) |
| **Efficiency Investment** | **103 Mt**<br>Reduction in base case electricity $CO_2$ emissions through 2025 | **183bn L**<br>Reduction in water footprint through 2025 in liters | | **550k**<br>Total one-year jobs created through 2025 | **$12bn**<br>Human health benefits through 2025 | ○ | ● | | ● | ● | ● | |
| **Demand Optimization and Electrification** | **5-9 Mt**<br>2025 $CO_2$ emission reduction across transport, buildings and energy | | | **22-25k**<br>Additional industry jobs through 2025 | **$2bn**<br>Human health benefits through 2025 | ● | ● | | ● | ● | ● | |

🟦 *Analysis performed for given System Value dimension and recovery solution. For more detail, please see specific solution and/or relevant System Value dimension slide(s).*

⬜ *System Value dimension not as relevant to geographic market or not considered with given recovery solution.*

Relative System Value dimension benefit for given solution within market

● High benefit ◐ Medium benefit ○ Minimal-to-no benefit

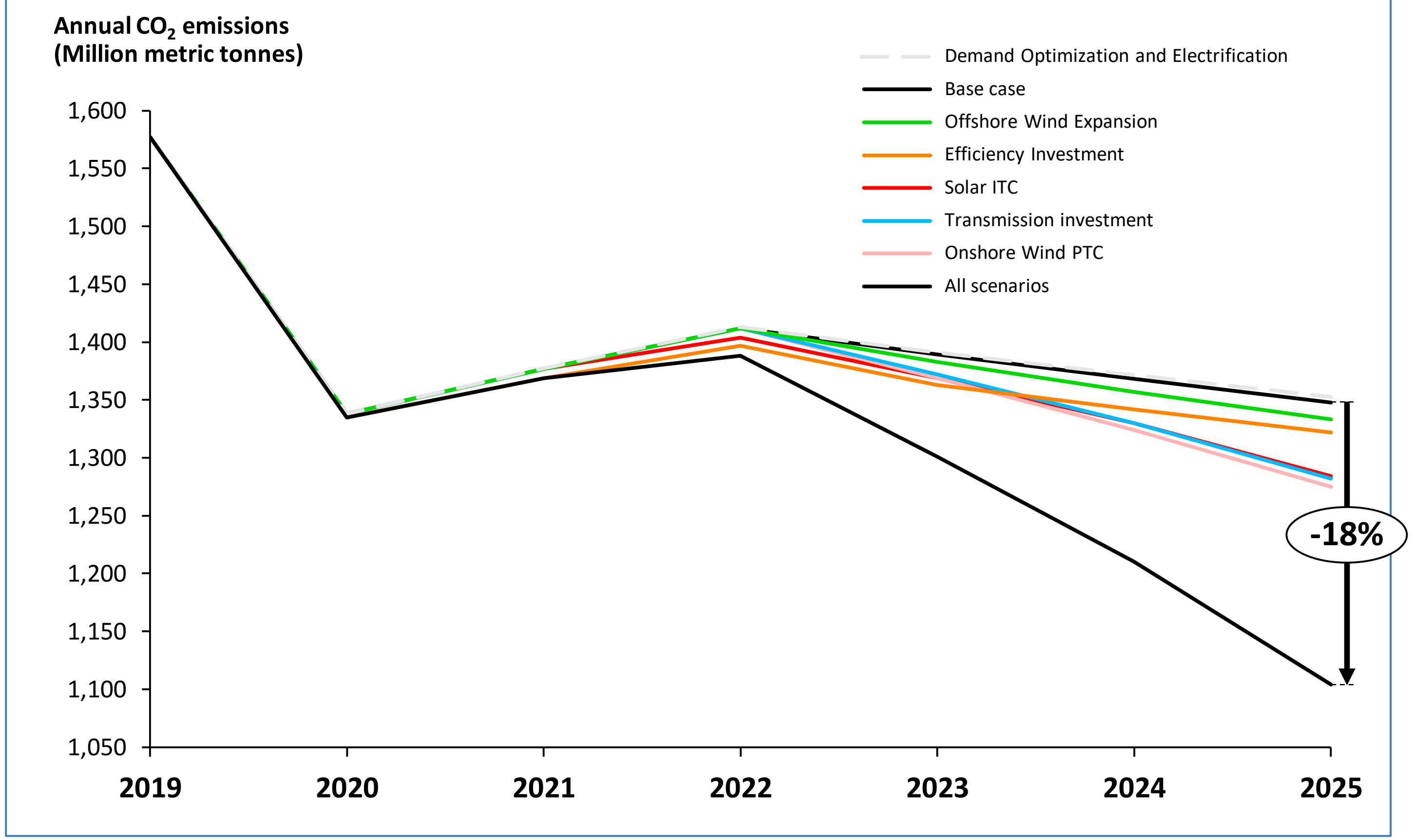
# System Value dimension: $CO_2$ emissions

The differential in electricity generation from coal and natural gas was examined to calculate $CO_2$ emissions benefits across US recovery solutions, with a combined effect of lowering electricity sector $CO_2$ emissions by 18% over base case in 2025.

**Cumulative electricity sector $CO_2$ emission impact by solution through 2025**

| | | |
|---|---|---|
| **Renewables Expansion** | **Solar ITC** | ↓ **131 Mt**<br>1.9% of projected<br>2021-2025 base case footprint |
| | **Onshore Wind PTC** | ↓ **138 Mt**<br>2.0% of projected<br>2021-2025 base case footprint |
| | **Offshore Wind** | ↓ **32 Mt**<br>0.5% of projected<br>2021-2025 base case footprint |
| **Transmission Investment** | | ↓ **121 Mt**<br>1.7% of projected<br>2021-2025 base case footprint |
| **Efficiency Investment** | | ↓ **103 Mt**<br>1.5% of projected<br>2021-2025 base case footprint |
| **Demand Optimization and Electrification**[2] | | ↑ **11 Mt**<br>0.2% of projected<br>2021-2025 base case footprint |
| **All solutions** | | ↓ **513 Mt**<br>7.4% of projected<br>2021-2025 base case footprint |

**$CO_2$ emissions from electricity sector across solutions (coal and natural gas)**[1]



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*Sources: 2018 US EIA statistics, published February 2020; Accenture analysis*

*[1] Emissions from electricity generation sources outside coal and natural gas were not evaluated*

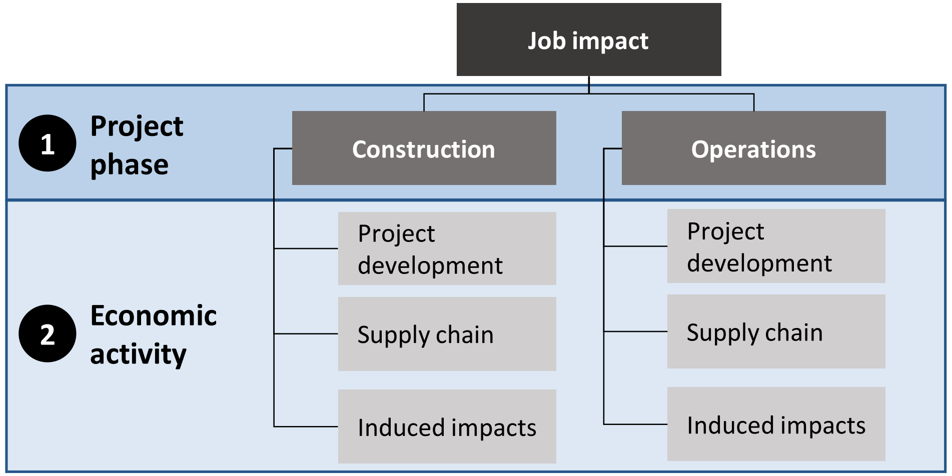
*[2] Demand Optimization and Electrification solution shifts emissions from transportation and buildings sectors to electricity, leading to an increase in electricity emissions but an overall decrease of economy-wide $CO_2$ emissions by 7 Mt on average in scenarios. 11 Mt is average increase in electricity sector emissions through 2025 in scenario.*

# System Value dimension: Jobs impact

Implementing solutions can create hundreds of thousands of jobs through 2025.

## Methodology for Renewables Expansion recovery solutions[1]

Two dimensions were examined to calculate job impact:
**project phase** and **economic activity**



| | |
|---|---|
| **Project development** | Labour from companies engaged in development and on-site construction and operation of power generation and transmission (no materials) |
| **Supply chain** | Labour from supporting industries driven by increase in demand for goods and services from direct on-site project spending (e.g. construction material, component suppliers, equipment manufacturers, analysts, attorneys) |
| **Induced impacts** | Jobs driven by reinvestment and spending of earnings by direct and indirect beneficiaries (e.g. local restaurants, hotels, retail establishments, childcare providers) |

## Job impact across solutions

| | | |
|---|---|---|
| **Renewables Expansion[1]** | **Solar ITC** | **114k**<br>Economy-wide job impact in 2025 |
| | **Onshore Wind PTC** | **107k**<br>Economy-wide job impact in 2025 |
| | **Offshore Wind** | **30k**<br>Economy-wide job impact in 2025 |
| **Transmission Investment[1]** | | **60-110k**<br>Annual incremental economy-wide jobs |
| **Efficiency Investment[2]** | | **550k**<br>Total one-year jobs created through 2025 |
| **Demand Optimization and Electrification[3]** | | **22-25k**<br>Additional industry jobs through 2025 |

*Sources: NREL JEDI model; DOE; Obama White House Archives; Accenture analysis. Note: analysis does not take into account any potential job impacts from lower fossil fuel generation.*

[1] *Solar, onshore wind, offshore wind, transmission job impacts based on NREL's JEDI model (300 MW wind farm, 50 MW solar farm, 345kV 250-mile transmission line).*

[2] *Energy efficiency figures based on 2009 Recovery Act job impact figures ($20 billion investment).*

[3] *Job figures from Demand Optimization and Electrification reflect different methodology and are specific to energy technology and utilities, not economy-wide job impact.*

# System Value dimension: Energy productivity and systemic efficiency

US energy productivity will increase by improved matching and optimization of supply and demand through the identified solutions.

**Energy productivity and systemic efficiency benefits by solution**

| | | |
|---|---|---|
| **Renewables Investment** | ◐ | • Renewables deployment can be prioritized towards high availability geographies that maximize capacity factors, getting more for less.<br>• Increased distributed solar, benefitting from ITC extension, has potential to lower T&D losses due to more local generation. |
| **Transmission Investment** | ● | • Transmission line build-out can improve systemic efficiency by reducing congestion and curtailment.<br>• Greater interconnection and transmission planning at a regional level improves balancing of resource variability (reducing wasted) and improving cost effectiveness of achieving a zero-carbon future, such as onshore wind in the interior to high demand areas and offshore wind and hydropower in the Northeast US and Canada. |
| **Efficiency Investment** | ● | • End consumer efficiency improvements can be achieved across sectors through smart appliances, greater building efficiency and energy conservation, achieving the same work or economic output for less electricity. |
| **Demand Optimization and Electrification** | ● | • Demand optimization can improve systemic efficiency by increasing energy productivity, better aligning supply and demand to ensure cost-effective generation and minimized curtailment.<br>• Electric vehicles and heat pumps are more energy efficient than their fossil fuel counterparts. According to the US Department of Energy, EVs convert over 77% of the electrical energy to power at the wheels, whereas gasoline vehicles only convert 12%-30% of the energy stored in gasoline. |

Sources: US Department of Energy (DOE); MIT Center for Energy & Environmental Policy Research

Relative System Value dimension benefit for given solution within market ● High benefit ◐ Medium benefit ○ Minimal-to-no benefit

# System Value dimension: Resiliency and security

With the US electrical grid facing resiliency challenges from COVID-19, increasingly severe natural disasters and cyberattacks, the clean energy transition can help benefit grid resiliency through more distributed, digital and secure operations.

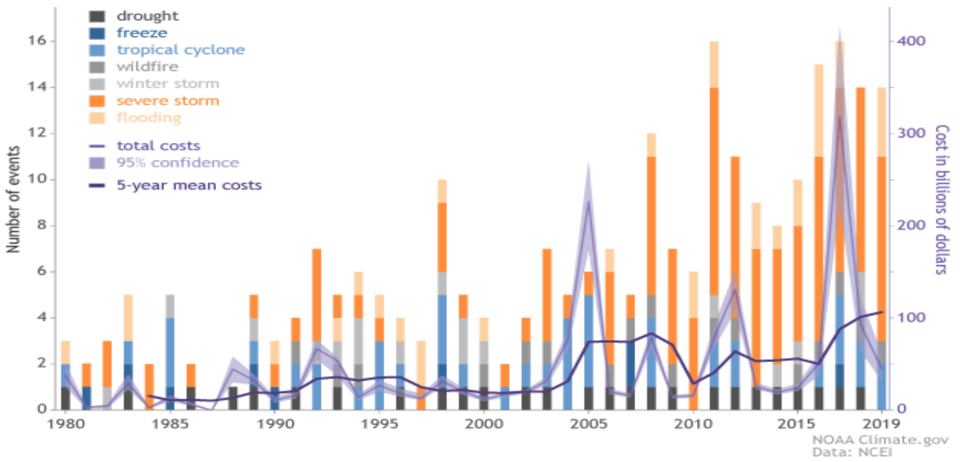
**Threats to US electrical system resiliency**

- The **COVID-19 pandemic** has tested US grid resiliency as in-person operations of centralized generation and grid assets have been challenged by worker illness and ability to socially distance.
- From wildfires and hurricanes to severe storms and winter events, utilities face increased pressure as the **severity of natural disasters** grows with climate change. Puerto Rico's grid was severely affected by Hurricane Maria in 2017 with billions in damages.
- **Cybersecurity threats** are of great concern for US grid operators as digital applications increase. Traditionally, managing major outage risks meant dealing with issues such as component failure or inclement weather via robust mitigation and recovery plans. Today, however, resilience plans for governments and energy ecosystem stakeholders must integrate a carefully designed cyber resilience strategy.

**How the clean energy transition can bolster system resiliency**

- Transition lowers fuel import reliance and insulates from price volatility
- Renewable energy is significantly less reliant on on-site workers to operate, facing fewer challenges in a pandemic
- Greater transmission investment would increase resiliency as more power is made available from other regions
- A more distributed, digital system can be sectionalized
- DERs, such as EVs and storage, can form the basis for solutions to support local resiliency where the network itself has failed
- Increased storage and microgrids can protect critical facilities
- Demand optimization schemes can automatically switch off load

### The number and cost of billion-dollar US disasters is rising



### Recovery solution impact on System Value dimension

| **Renewables Expansion** | **Transmission Investment** |
|---|---|
| ◐ Domestic energy source with operations allowing for social distancing | ● Greater interconnection to diversify electricity sources from affected areas |
| **Efficiency Investment** | **Demand Optimization and Electrification** |
| ○ No material benefit | ● Storage aids during disasters and longer-term interruptions |

Source: EIA, Climate.gov, Wall Street Journal, E&E News, Accenture Research

Relative system value dimension benefit for given solution within market ● High benefit ◐ Medium benefit ○ Minimal-to-no benefit

# System Value dimension: System upgrade

Investments in grid infrastructure and digital solutions across transmission and distribution will be needed for the US to achieve a greater variable renewable system.

**Overview**

- One of the most significant challenges to achieving a clean energy transition will be modernizing US grid infrastructure to enable a system able to transact much more variable, decentralized and disaggregated power.
- The physical and digital infrastructure needed to support variable renewables and DERs spans transmission and distribution, as wind and solar can be connected to both.

**Network upgrades across the value chain**

- Renewable generation can be paired with storage and digital platforms to increase dispatchability and control over the production profile, run assets in portfolios and enable predictive maintenance.
- An expansion of the transmission and distribution network and connectivity across the US market will shift the grid from a one-way, baseload network with centralized production to two-way, variable sources of energy from utility-scale renewables and DERs.
- At the end-consumer and retail level, installing smart, efficient technology and devices such as smart meters, smart thermostats, smart EV chargers, smart heat pumps and residential and commercial energy management systems will allow improved system balancing and better management of grid congestion and constraints.
- Across the value chain, improving digital capabilities using sensors, data, analytics, AI, machine learning and automation will support the clean energy transition and shift to a more variable, decentralized and disaggregated system.

**Recovery solution impact on System Value dimension**

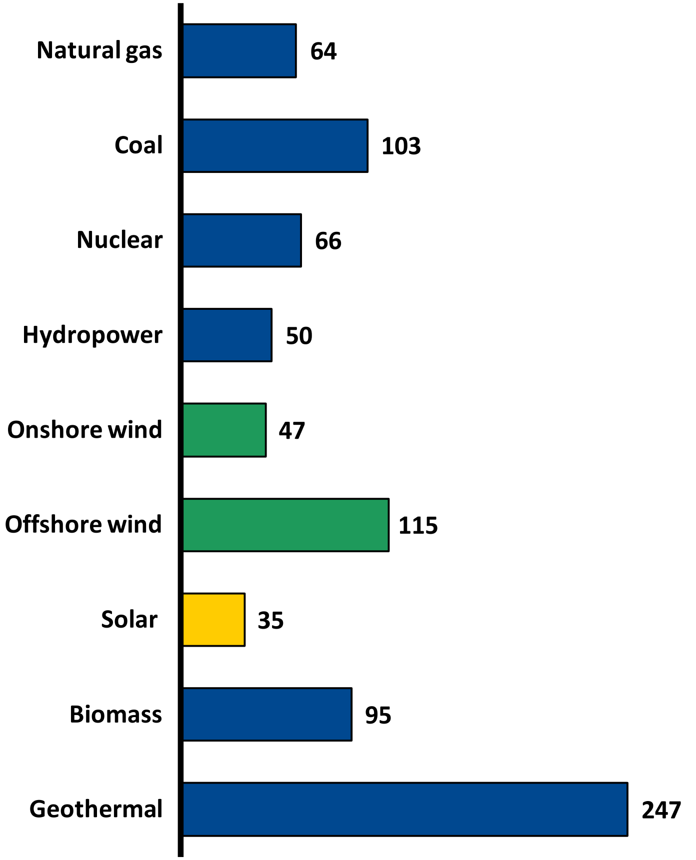
| | | |
|---|---|---|
| **Renewables Expansion** | ◐ | Minimal standalone benefit to network upgrades, rather the impetus for upgrades |
| **Transmission Investment** | ● | Transmission investment is an essential network upgrade to spur utility-scale renewables, opening up possibility for greater interconnection and balancing across states and regions |
| **Efficiency Investment** | ● | Smart technology and digitalization of buildings and appliances enables two-way communication, unlocking load shifting capabilities |
| **Demand Optimization and Electrification** | ● | Adding storage and digitalization allows more dispatchable renewable energy, while electrification of vehicles and HVAC systems can play a key role with demand optimization |

Relative System Value dimension benefit for given solution within market ● High benefit ◐ Medium benefit ○ Minimal-to-no benefit

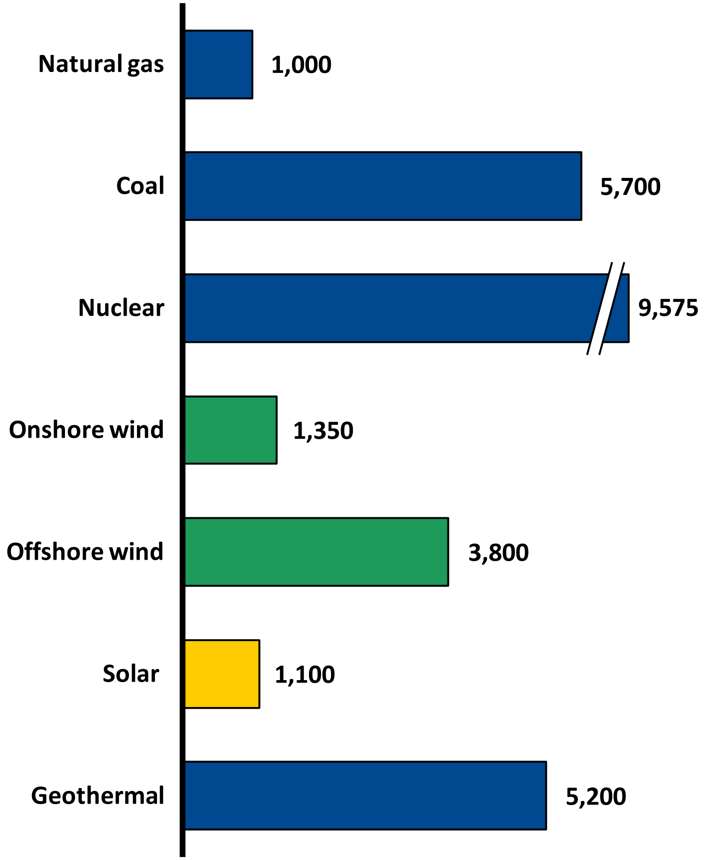
*Source: Accenture - Energy Transition in Utilities*

# System Value dimension: Cost and investment competitiveness

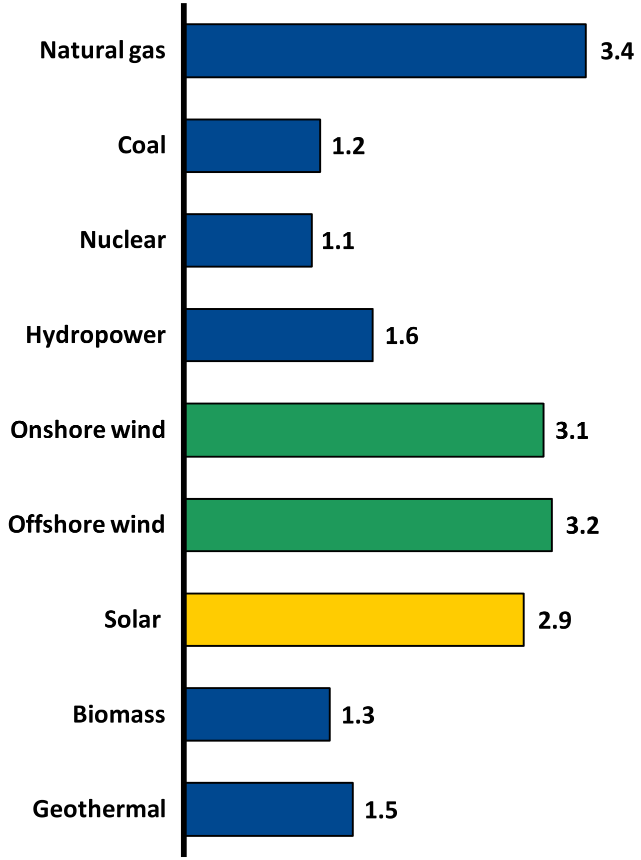
When considering new capacity addition options such as wind and solar, levelized cost of energy (LCOE), project capital expenditures and levelized cost of transmission remain important considerations for project developers, investors and regulators.



**Levelized cost of energy (LCOE) [$/MWh]**



**Installed project capex ('000 $/MW)**



**Levelized cost of transmission [$/MWh]**

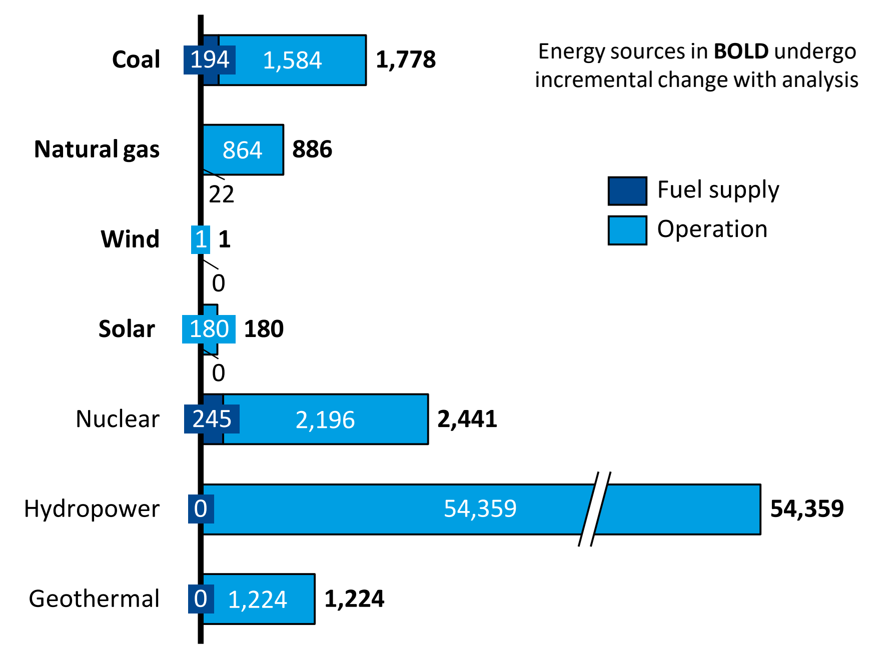
*Sources: EIA Annual Energy Outlook 2020; Lazard LCOE Analysis 2019*

*Note: Average Levelized Cost of Transmission figures from EIA Annual Energy Outlook 2020, Berkeley Lab quantified average range of renewables transmission cost to be $1-10 per MWh in October 2019 report.*

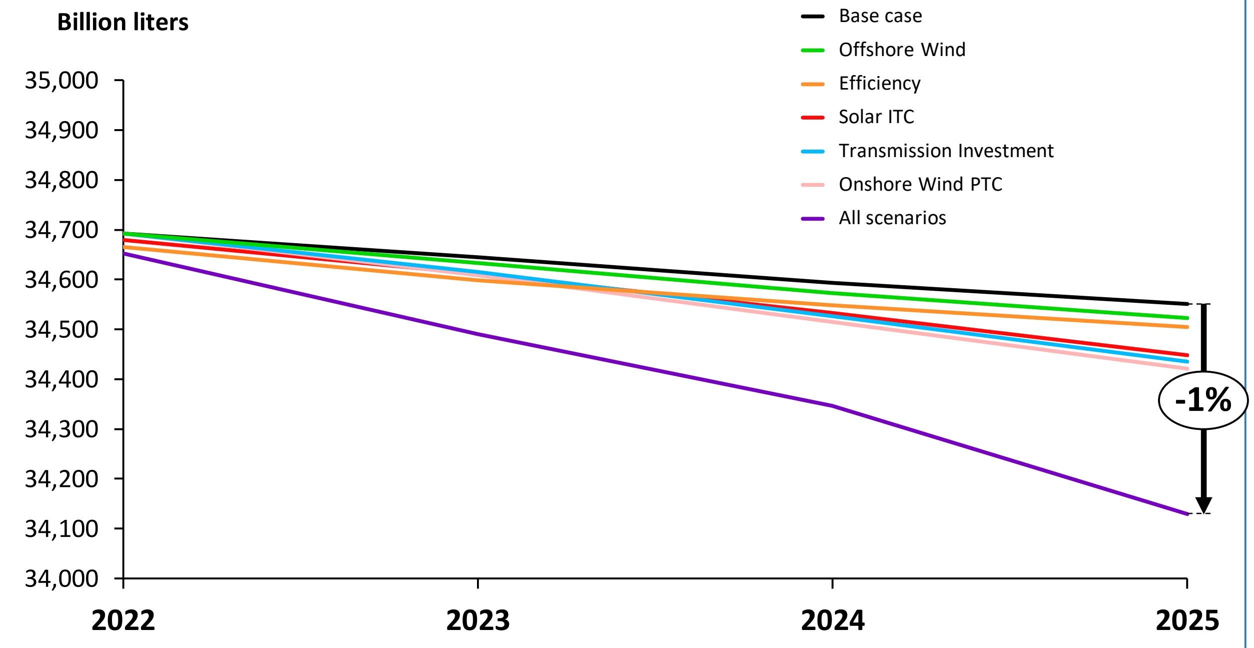
# System Value dimension: Net water footprint

While the US does not experience significant water scarcity at present, fuel supply and electricity production should be evaluated in terms of risk of water shortage, particularly on a regional basis.

## Water footprint across generation sources (liters/MWh)



## Total annual water footprint across solutions[1]



## Cumulative water footprint impact through 2025 by solution

| Solar ITC | Onshore Wind PTC | Offshore Wind | Transmission Investment | Efficiency Investment | All solutions |
|---|---|---|---|---|---|
| ⬇ **209bn liters**<br>0.12% of projected 2021-2025 base case footprint | ⬇ **244bn liters**<br>0.14% of projected 2021-2025 base case footprint | ⬇ **59bn liters**<br>0.03% of projected 2021-2025 base case footprint | ⬇ **212bn liters**<br>0.12% of projected 2021-2025 base case footprint | ⬇ **183bn liters**<br>0.10% of projected 2021-2025 base case footprint | ⬇ **908bn liters**<br>0.52% of projected 2021-2025 base case footprint |

*Sources: Royal Society of Chemistry; Accenture analysis*

*Biomass, not included in above graph, assumes same water footprint as firewood in analysis (563k liters per MWh)*

*[1] Analysis excludes Demand Optimization and Electrification solution*

# System Value dimension: Air quality and health (1 of 2)

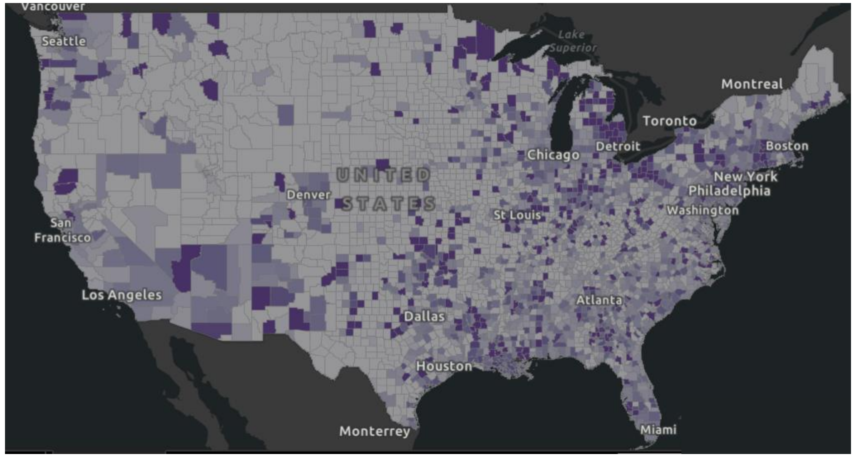
An April 2020 study from Harvard has linked higher COVID-19 death rate to areas in the US with high PM2.5 emissions.

**Harvard study findings**

- In April 2020, Harvard's School for Public Health released the first US nationwide study to show a **statistical link between COVID-19 deaths and other diseases associated with long-term exposure to PM2.5**.
- The study concluded that a **small increase in long-term exposure to PM2.5 leads to a large increase in the COVID-19 death rate**.
- An increase of only 1 µg/m3 in PM2.5 was associated with a 15% increase in the COVID-19 death rate.
- Findings such as these can bolster the rationale for accelerating the clean energy transition.

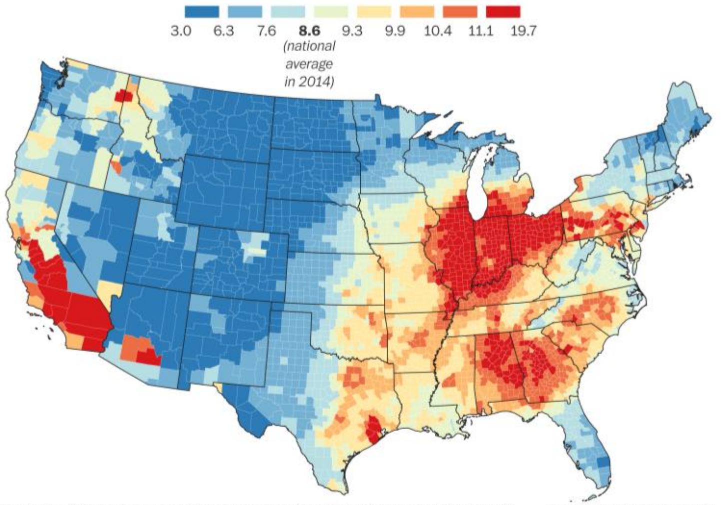
**US COVID-19 Fatality Rate**

*(Johns Hopkins data, as of 22 May 2020)*



**Daily Average PM2.5 Concentration**

*(2014 figures)*



Source: Robert Wood Johnson Foundation County Health Rankings THE WASHINGTON POST

*Sources: Harvard University; Johns Hopkins; Washington Post*

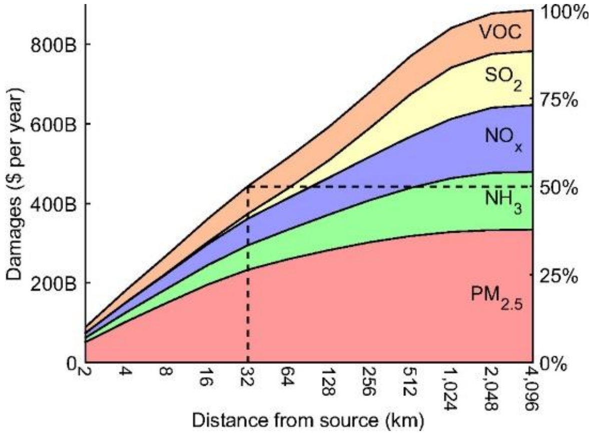
# System Value dimension: Air quality and health (2 of 2)

Lower air pollutants across solutions to have an estimated $62 billion in cumulative human health benefits through 2025.

**US overview**

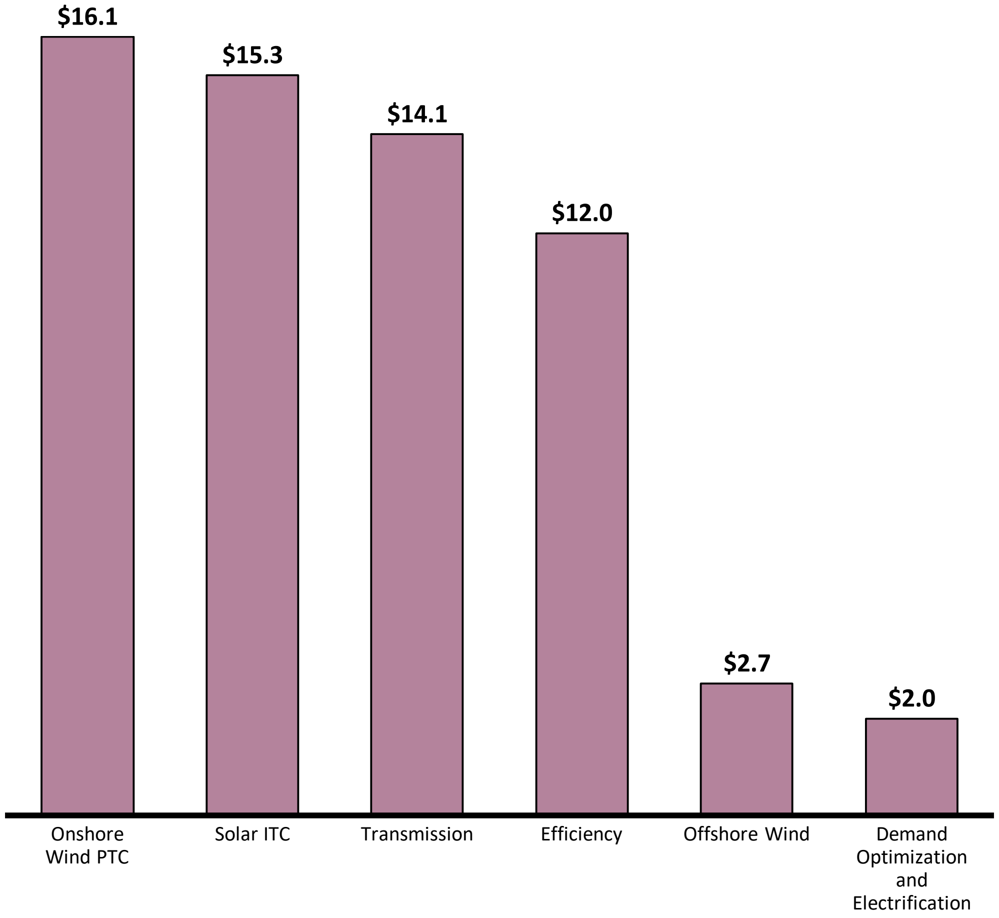
- Studies have linked air pollution to **more than 100,000 annual premature deaths** in the US from heart attacks, strokes and other illnesses, at a **cost to society of $886 billion**
- Air pollutants are estimated to be responsible for **5%-10% of the total US annual premature mortality**
- While air pollution impacts are often tied to proximity to pollution sources, studies have found that **half of air quality-related premature mortality results from emissions from outside that state**
- **Emissions from electric power generation have the greatest cross-state impact** as a fraction of their total impact

**Cumulative damages by pollutant and distance**



- Dotted line shows that 50% of pollutant damages occur within 32km of source
- Most PM2.5 damage is close to source compared to other pollutants, such as $SO_2$

**Cumulative human health benefits by solution through 2025 ($B)[1]**



*Sources: Nature; National Academy of Sciences; MIT; Washington Post*

[1] *Calculations based on $NO_X$ US EPA statistics; $SO_2$ US EIA statistics; Primary PM2.5 EPA statistics;* US EPA (1 , 2); *DOE human health benefit estimates*

# System Value dimension: Flexibility

The need to manage generation, demand and power flows across the grid will grow as the US sees an increasing share of variable generation, with transmission, smart efficiency, demand optimization and electrification investments poised to improve flexibility.

## Spotlight on ERCOT

- ERCOT manages the flow of electric power on the Texas interconnection, representing **90% of the electric load in Texas and more than 25 million customers**.
- The ERCOT region has the **strongest load growth in the US** and one of the highest shares of variable renewables in its electricity mix.
- The **share of wind generation has grown dramatically** in ERCOT over the past decade, **from 6% in 2009 to 19% in 2018**.
- **ERCOT's approach to integrating renewables** has included **changes to the operation of the power system, market structure, management of demand resources and use of flexible baseload generation.**
- **Curtailment has decreased** from 17% in 2009 to 2.5% in 2018, with a minimum of 0.5% in 2014. The reductions in transmission congestion and wind curtailment are mostly due to the **construction of new transmission lines** from West Texas **enabled by the Competitive Renewable Energy Zones (CREZ)**.
- **ERCOT is vulnerable to price volatility** as it is electrically isolated from the Eastern and Western interconnections. **Being an electrical island makes ERCOT particularly affected by the variability of wind and solar generation**.

## Recovery solution impact on System Value dimension

| | | |
|---|---|---|
| **Renewables Expansion** | ○ | Limited material benefit from increased wind and solar as it causes greater flexibility need for grids |
| **Transmission Investment** | ● | Greater grid interconnection, digitalization and collaboration across entities can enable flexibility and more variable renewable generation mix |
| **Efficiency Investment** | ● | Reduced, manageable load through smart efficiency solutions can help prevent grid peaks and match demand to supply |
| **Demand Optimization and Electrification** | ● | Increased storage, EV batteries and heat pumps provide system operators with flexibility through demand optimization |

Relative system value dimension benefit for given solution within market ● High benefit ◐ Medium benefit ○ Minimal-to-no benefit

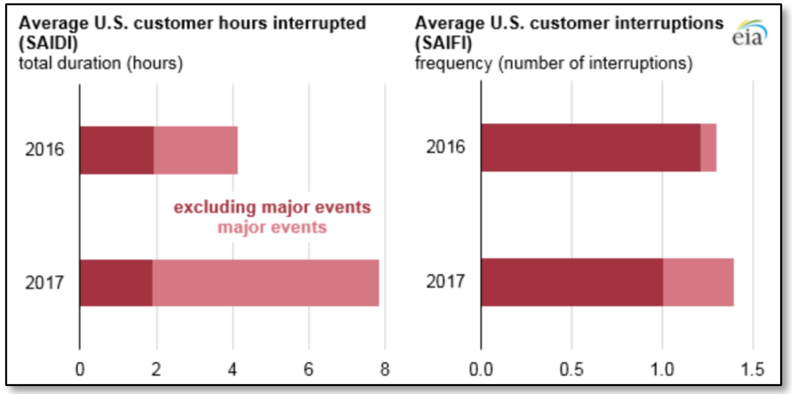
*Sources: ERCOT; Accenture*

# System Value dimension: Reliability and service quality

The US electrical grid has a high degree of reliability with few interruptions outside major events, such as severe weather, with increase in renewables in the short term unlikely to cause any impacts.

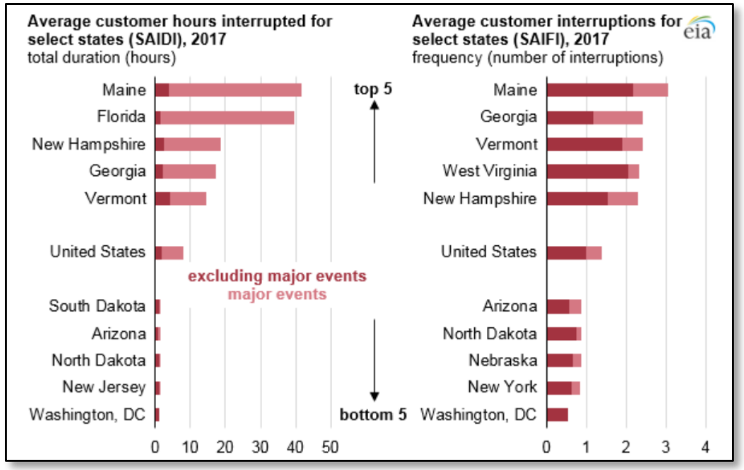
## US sees strong reliability across electric grid

- Outside of major events, US electricity customers experience approximately one interruption per year of less than two hours on average
- Total hours of interruption are largely attributed to major events, such as in 2017, when there were larger impacts due to a more active hurricane season



## Differences among US states largely due to major events

- States ranking highest in service interruptions are often disproportionately affected by severe weather events such as hurricanes (e.g. Florida) and winter weather (e.g. Maine)



## Recovery solution impact on System Value dimension

### Renewables Expansion

○ No material benefit

### Transmission Investment

◐ Greater interconnection can alleviate congestion

### Efficiency Investment

● Efficiency can lower demand when the grid is strained, helping to prevent outages

### Demand Optimization and Electrification

● Storage and EV batteries provide backup for interruptions

*Source: EIA*

Relative system value dimension benefit for given solution within market ● High benefit ◐ Medium benefit ○ Minimal-to-no benefit