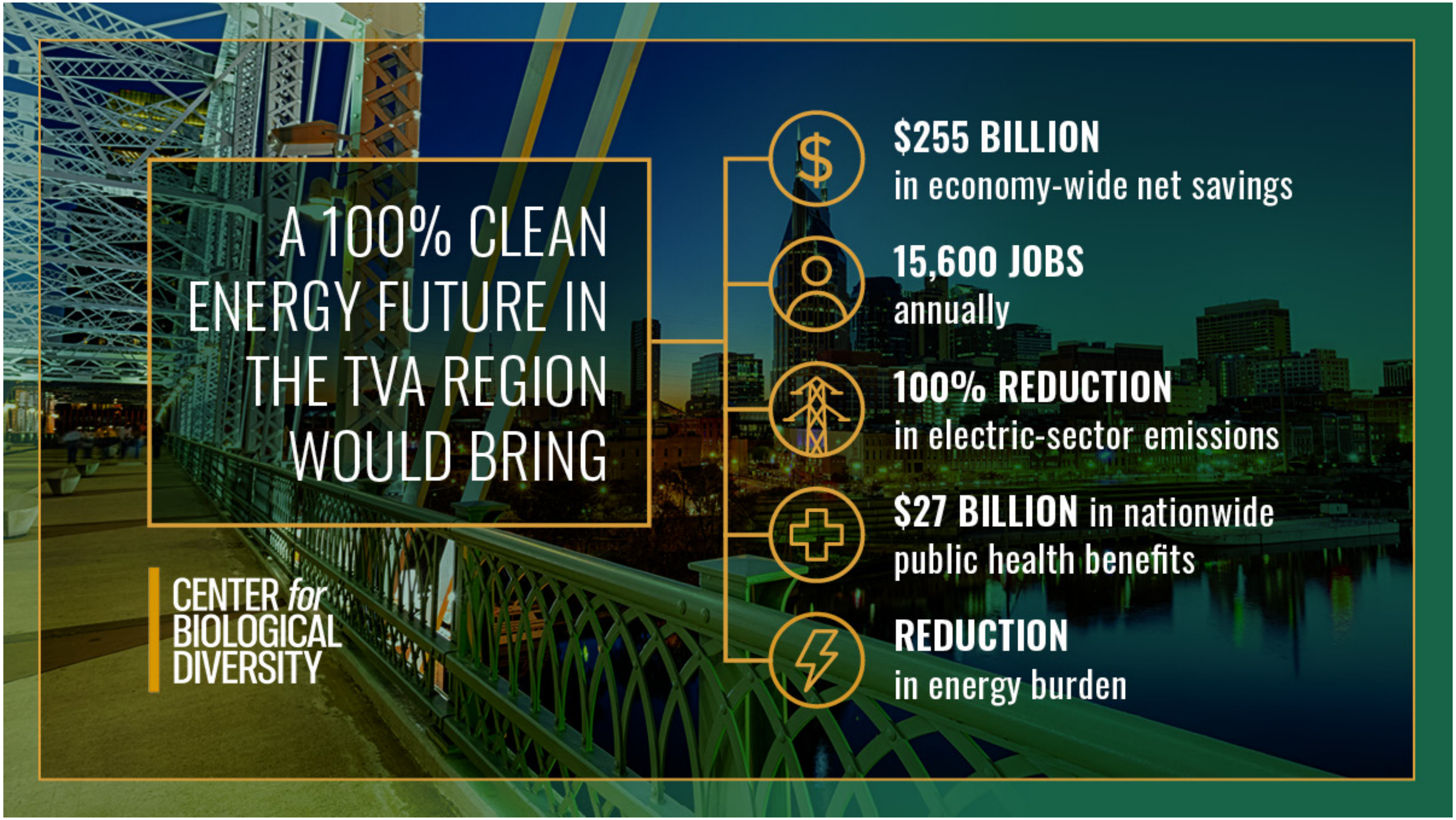
TVA's Clean Energy Future

Prepared by Synapse Energy Economics

On behalf of GridLab and Center for Biological Diversity

March 13, 2023

Is TVA prepared to meet national clean energy goals?



Project Overview

- Conduct analysis of TVA's clean energy pathways using electric-sector capacity expansion and dispatch model
  - Evaluate a "TVA Baseline" scenario, a more ambitious "100% Clean Energy"
  - Evaluate an "Ambitious DER" sensitivity with even more distributed energy resources than the "100% Clean Energy" case
  - Evaluate electric sector in light of impacts from electrification and the Inflation Reduction Act
- Perform other analyses of the impacts of a clean energy transition
  - Jobs and economic impacts
  - Rates, bills, and energy burden
  - Public health impacts
  - Water and waste impacts
  - Land use impacts

100% clean energy generation on a pathway to economy-wide decarbonization

Figure 1. Electricity generation and loads, 2020 actuals and 2050 projected

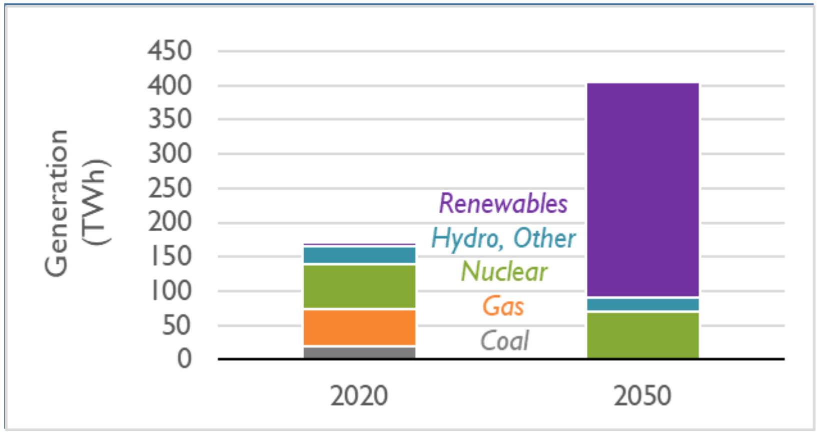
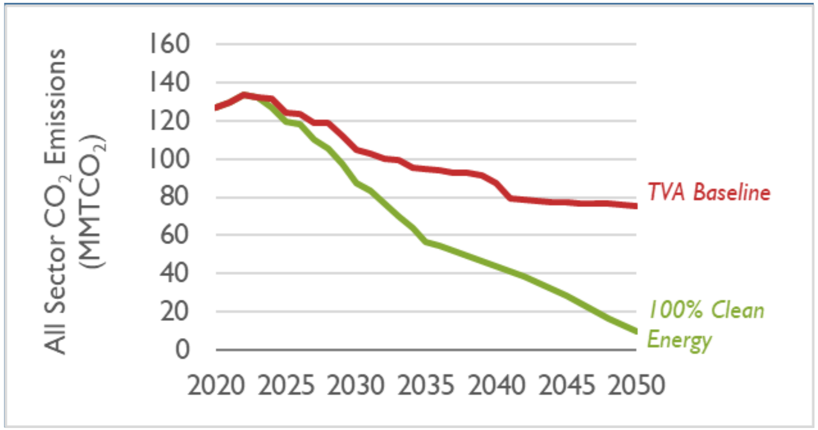


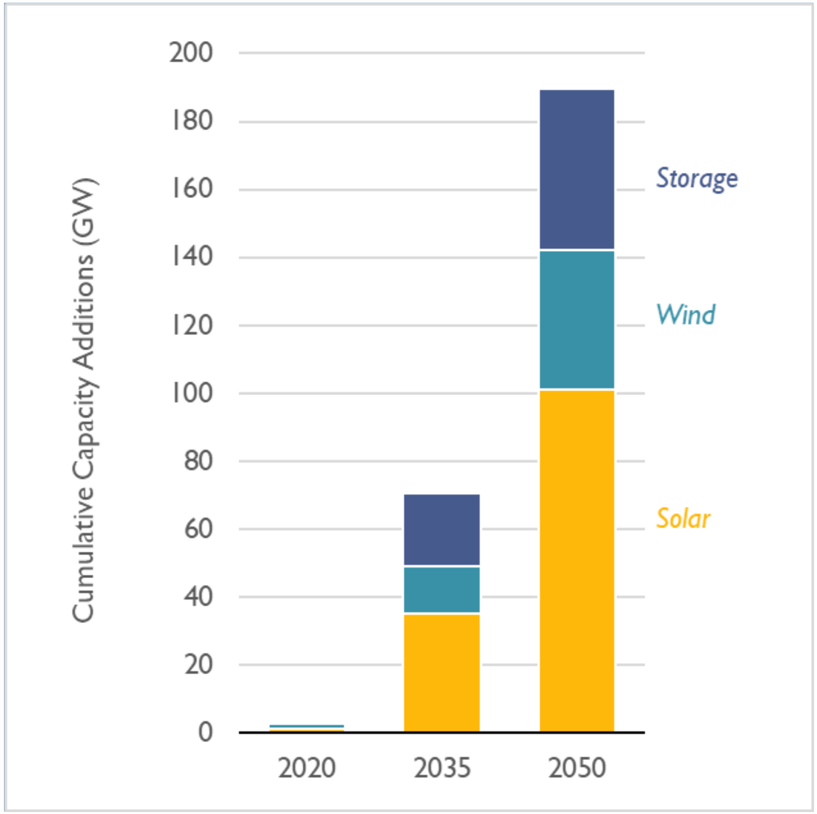
Figure 2. Greenhouse gas emissions from electric, buildings, transportation, and industrial sectors



- **2020 Electricity Demand:** 164 TWh
  - Generation from fossil sources met 45 percent of that demand.
- **2050 Electricity Demand:** 406 TWh
  - Ambitious electrification policies in line with the Biden Administration's goals to decarbonize the electric sector by 2035 and reach net-zero emissions by 2050
- **78 percent** of demand would be met from **wind, solar, and battery storage resources**.
- 100% clean energy pathway would lead to a reduction in all-sector greenhouse emissions of **92 percent by 2050.**

What will it take?

Figure 3. Capacity built in the 100% Clean Energy Scenario



- Ambitious build-out of solar, wind, and battery storage resources.
- In 100% Clean Energy scenario, total renewable capacity rises from zero GW today to **70 GW in 2030** and **190 GW in 2050**.
- This translates into annual builds of about:
  - 3.6 GW per year for solar
  - 1.5 GW per year for wind
  - 1.7 GW per year for storage
- Renewables are built due to increasing electricity demand. More renewables powering electric end uses means reduced demand for gasoline and natural gas for heating.
- Land use:
  - 4 GW of distributed solar by 2050 would occupy just 4 percent of the estimated total rooftops in TVA's service territory
  - Utility-scale build out equivalent to 480 MW per county occupying 2,700 acres
  - Most modeled wind resources are built outside of TVA's service territory, requiring new transmission interconnection

What's at stake for consumers?

Figure 4. Single-year and cumulative net costs, 100% Clean Energy versus TVA Baseline (2021 $ billion)

	2035	2050	Cumulative
Electric System	-$1.2	-$4.6	-$53.9
Buildings	$0.0	$0.6	$9.2
Transportation	$8.1	$22.0	$277.2
Other	$0.1	$3.9	$23.0
Net Savings	**$7.1**	**$21.8**	**$255.6**

A clean energy and electrification transition results in $255 billion in cost savings for TVA consumers

- Electric sector costs increase due to new resources built to accommodate increased electricity demand.
- In each scenario, the model **switches to solar, wind, and storage as the least-cost option.**
- Increased costs in the electric sector are offset by savings in the transportation and buildings sectors, even accounting for the cost of building out a charging network.
- Reduced fossil fuel use results in **$27 billion cumulative** public health savings
- Social cost of carbon benefits total **$265 billion cumulatively**

How will households be affected?

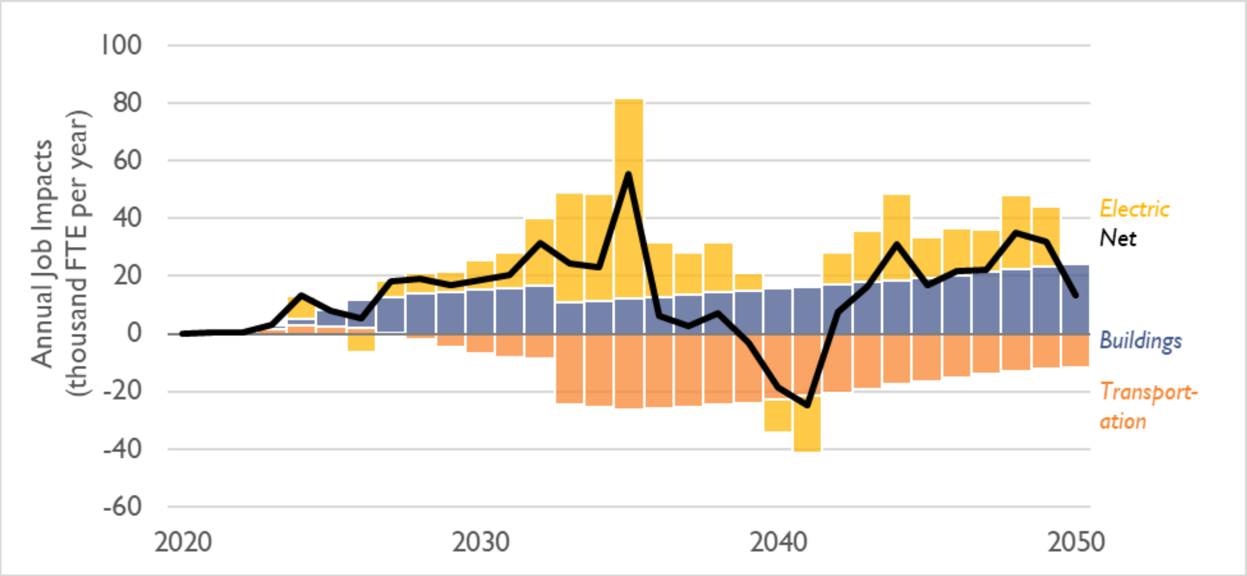
Figure 5. Modeled electricity rates, bills, and energy burden

	2020	2035		2050	
	Actual	*TVA Baseline*	*100% Clean Energy*	*TVA Baseline*	*100% Clean Energy*
Electricity rates (2021 cents/kWh)					
Residential	11.5	10.7	9.0	9.7	8.0
Commercial	10.9	10.6	9.8	10.4	7.7
Industrial	4.4	4.3	4.4	4.2	3.3
Monthly electric bill (2021 $/customer)					
Residential	$131	$131	$141	$129	$149
Energy burden (% of household income)					
Residential	7%	7%	5%	6%	3%

- Residential electric bills are projected to increase by about $18 per month.
- This is because we are assuming that consumers are powering more of the transportation and home heating end uses via electricity.
- These increases are offset by energy efficiency, a resource that TVA and local utilities have historically ignored while the rest of the country has moved ahead.
- Energy burdens (the share of a household's spending on energy usage) is projected to **decrease from 7% to 3%** as a result of a shift away from spending on expensive, inefficient fossil fuels.

100% clean energy results in 15,600 net jobs per year

Figure 6. Job impacts from the 100% Clean Energy scenario, relative to the TVA Baseline scenario



- A clean energy deployment leads to about **15,600 net jobs** in TVA's territory per year.
- This is after accounting for decreased employment in the fossil fuel sector, and the fact that a large amount of the clean energy builds happen in other parts of the country.
- Job impacts in the electric and buildings sector tend to be net positive due to investments in new resources and equipment. Transportation job impacts are estimated to be net negative because EVs are cheaper to operate and maintain, and are projected to be slightly cheaper than ICE vehicles by the mid-2030s.

Thank you!

Appendices

Policy Recommendations

Congress should:

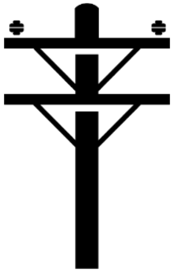
- **Hold TVA accountable through oversight hearings**
- **Pass legislation to mandate transparent planning, transmission access, and a pathway to 100% clean energy**

TVA Board should:

- Demand a plan for 100% clean energy by 2035
- Prioritize DER and environmental justice
- Boost resilience and reliability

The Federal Government should:

- Issue an Executive Order calling for 100% clean energy
- DOE analyze decarbonization pathways for TVA



Local Power Companies should:

- Revisit long-term power agreements with TVA

Contact

Synapse Energy Economics	**Patrick Knight** Senior Principal pknight@synapse-energy.com
Center for Biological Diversity	**Gaby Sarri-Tobar** Energy Justice Campaigner gsarritobar@biologicaldiversity.org
GridLab	**Taylor McNair** Program Manager taylor@gridlab.org

Key findings

- **The 100% Clean Energy scenario produces economy-wide net savings of $255 billion over the study period throughout the Tennessee Valley.** Although wholesale electric sector system costs rise from about $5 billion today to $9 billion in 2050, these cost increases are more than offset by fuel savings outside the electric sector, including a reduction in transportation fossil fuel expenditures of $195 billion over 30 years. Electric sector cost increases are primarily driven by capacity additions needed to power newly electrified measures, and is not due to switching from fossil fuels to clean energy.
- **Through continued emphasis on energy efficiency, residential energy burdens fall from 7 percent today to 3 percent by 2050.** Residential energy burden is defined as the amount of money a household spends on energy, relative to its income. Through an emphasis on more efficient clean energy and away from less efficient and volatile fossil sources, households spend less on their energy needs in a clean energy future. This is in spite of a 13 percent increase in monthly electricity bills, which is more than offset by a marked decrease in household fossil fuel spending on gasoline and home heating fuels.
- **Both primary scenarios achieve (and sometimes exceed) their clean energy targets with no reliability issues.** With the level of temporal resolution we modeled (8 three-hour blocks per day in a typical week) we did not see any hours with unserved energy. In addition, the modeled scenarios met both summer and winter reserve requirements every year. We note that a full evaluation of reliability in an all-clean electric grid would require more detailed stochastic analysis.
- **The TVA Baseline scenario shows that electric-sector emissions in 2050 can be reduced by 99 percent with no increases in costs.** We observed electric system costs of about $5 billion in every year of the TVA Baseline case. This suggests that clean energy deployment is already a least-cost option for TVA, even without enforced decarbonization constraints.

Key findings (continued)

- **Ambitious building decarbonization in the 100% Clean Energy scenario adds no new net electricity demand.** Because many TVA customers currently heat with inefficient electric resistance heating, switching to more efficient heat pumps offsets any additional electricity demand created by switching from natural gas heating to heat-pump-driven electric heating. Instead, most load growth is due to transportation electrification and industrial electrification, each representing about half of the total increase in load by 2050. Moderate and reasonable increases in the deployment of conventional energy efficiency measures throughout the study period helps to defer load growth.
- **An emphasis on flexible demand resources can help minimize the construction of battery storage and utility-scale solar resources.** By better utilizing advanced demand response and distributed resources, TVA could avoid the construction of 2 GW of utility-scale solar and over 20 GW of battery storage. By analyzing increased levels of distributed resources in our "Ambitious DER" scenario, we found that TVA consumers could reduce wholesale electric sector costs by $1.5 billion in 2050 alone.
- **Both scenarios project a shift away from TVA-owned resources.** The TVA Baseline scenario models 45 TWh of wind power purchase agreements (PPA) with neighboring regions by 2050; the 100% Clean Energy scenario has 130 TWh of non-TVA wind PPAs (about one-third of TVA's total generation). This is largely due to the more favorable economics and better capacity factors of midwestern wind, even accounting for (a) TVA's new eligibility for federal clean energy tax credits under the IRA (2022) and (b) cost of transmission lines to neighboring regions to facilitate this wind. This is a marked shift away from TVA's approach to procuring power today, where only a small fraction of energy comes from out-of-Valley renewables.

Key findings (continued)

- **A clean energy transition adds about 15,600 job-years to the economy in TVA's service territory.** Job additions are driven by the construction of new solar, storage, and heat pump resources, as well as savings on energy expenditures.
- **A clean energy transition creates vast amounts of public health and societal benefits.** The 100% Clean Energy scenario leads to $27 billion in nationwide public health benefits related to avoided heart attacks, respiratory illnesses, and premature death. It also provides $265 billion in cumulative societal benefits, based on the latest estimates of social cost of carbon from the U.S. Environmental Protection Agency (EPA). Switching away from fossil fuels to clean energy sources eliminates the creation of coal ash and more than halves water consumption from power plants.
- **Land-use impacts in the Tennessee Valley can be minimized through an emphasis on distributed resources.** We found that to achieve the level of utility-scale solar in the 100% Clean Energy scenario, each county in TVA's service territory would need to build the equivalent of just 480 MW solar facilities, or roughly two large solar farms. Meanwhile, to achieve the level of distributed solar assumed in the 100% Clean Energy scenario, only 4 percent of rooftops in the Tennessee Valley would need to add solar. An increase in that portion of rooftop solar could minimize the utility-scale solar impacts on land use.

Scenarios Analyzed

	TVA Baseline	100% Clean Energy	Ambitious DER
Required electric sector CO_2 emissions reductions	None	80% by 2030, 100% by 2035 (relative to 2005)	Same as 100% Clean Energy
Electrification and energy efficiency	Minimal electrification and energy efficiency according to 2019 TVA IRP	Ambitious electrification and energy efficiency aimed at economy-wide decarbonization by 2050	Same as 100% Clean Energy
Distributed energy	Follows "Base" case in 2019 IRP: DG PV: 1.2 GW (2030); 2.7 GW (2050) DG storage: None	Follows "Medium" case in 2019 IRP: DG PV: 1.7 GW (2030); 4.4 GW (2050) DG storage: 25 MW (2030); 270 MW (2050)	Follows "High" case in 2019 IRP: DG PV: 2.1 GW (2030); 6.3 GW (2050) DG storage: 180 MW (2030); 1.1 GW (2050)
Demand response and flexible load	Follows 2019 IRP: 1.9 GW conventional DR (2050)	Follows 2019 IRP: 1.9 GW conventional DR (2050)	1.9 GW conventional DR (2050) 32 GW flexible load (2050) (Components of flexible load vary by duration and price paid)
Changes to reserve margins	No changes to current TVA requirements (17% summer, 25% winter)	Assumes year-round 17% reserve margin beginning in 2024	Same as 100% Clean Energy

All other assumptions are identical between scenarios. All differences in outputs results from differences in the three above inputs.

Top-level results

	2020	2035		2050	
	Actual	*TVA Baseline*	*100% Clean Energy*	*TVA Baseline*	*100% Clean Energy*
CO_2 emissions reduction					
Electric sector reductions (target)	51%	84% (n/a)	100% (100%)	99% (n/a)	100% (100%)
All sector	-	26%	55%	27%	92%
Share of generation (%)					
Coal	12%	0%	0%	0%	0%
Gas	31%	24%	0%	2%	0%
Nuclear	38%	39%	30%	35%	17%
Hydro and other	16%	17%	22%	18%	19%
Renewable	3%	20%	48%	46%	64%
Wind	3%	4%	19%	22%	32%
Utility-scale solar	0%	15%	27%	21%	30%
Distributed solar	0%	1%	1%	2%	2%
Battery storage & demand response	-	-	-	-	-
Load (TWh)	164	169	192	179	327
Operating capacity (GW)					
Coal	7	0	0	0	0
Gas	15	13	1	6	0
Nuclear	8	8	8	8	8
Hydro and other	7	7	6	6	6
Renewable	2	22	72	60	191
Wind	1	2	14	13	41
Utility-scale solar	0	13	33	34	97
Distributed solar	0	2	2	3	4
Battery storage & demand response	1	5	23	11	49

Notes: Electric sector emission reductions are given relative to 2005. All Sector emission reductions are given relative to 2020. Battery storage is shown as having no generation due to having net negative energy requirements. "Other" includes biomass and other miscellaneous sources. Throughout this report, "all sector emissions" include CO_2 emissions from the electric, motor vehicle, and building sectors, but not non-CO_2 GHG emissions, upstream emissions, or emissions from airplanes, agriculture, and other sectors of the economy.

