VOICES OF EXPERIENCE

Decarbonization Strategy & Grid Planning

Decoding Decarbonization

A Utility Handbook
February 2024

U.S. DEPARTMENT OF **ENERGY**

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Smart Electric Power Alliance

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About SEPA

The Smart Electric Power Alliance (SEPA) helps all electric power stakeholders accelerate the transformation to a carbon free electricity system. SEPA concentrates our focus on the following areas to maximize impact: Transportation, Storage, Resilience, Emerging Technology, and Policy.

SEPA delivers value to our members through research, education, events, working groups, peer engagements, and member projects. We facilitate collaboration, develop innovative strategies and guidance for regulatory and business innovation, and provide actionable solutions for our members and partner organizations. For more information, visit www. sepapower.org.

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Introduction

Utilities are pursuing increasingly ambitious clean energy, renewable energy, and/or net-zero targets. This handbook is intended to establish a state of the industry and a common understanding, in supporting the "Voices of Experience" discussions on utility decarbonization. This handbook is also intended to be a tool that utilities can use to engage their customers and communities.

Since the Smart Electric Power Alliance (SEPA) began tracking utility carbon-reduction targets in 2019, the number of utilities and utility parent companies that have adopted a voluntary carbon-reduction target has grown by nearly 90%. Achieving these targets requires precise planning, innovative strategies, and stakeholder inclusion in decision-making. This handbook draws on utility decarbonization research to provide an overview of the electric utility industry's progress in setting and achieving decarbonization targets.[1] It covers utility and mandatory targets, explains key terminology, and offers insight into the frameworks guiding utilities' decarbonization efforts.

Utility Decabonization Target Terminology

Electric utilities can take a variety of actions to help accelerate electricity decarbonization. Comparing actions and commitments requires a shared understanding of terms. Many common terms, such as "clean," "renewable," "carbon-free," and "net-zero emissions" have differing meanings. Commitments to "100% carbon-free electricity" may include technologies such as nuclear or hydropower in addition to renewable resources, address methane or other non-carbon GHG emissions, and be measured annually or over some other time-scale.

Table 1 identifies common utility decarbonization target terminology drawn from and consistent with the definitions used by the Intergovernmental Panel on Climate Change (IPCC), the Science Based Targets initiative (SBTi), the U.S. Energy Information Administration (EIA), and the Net Zero Climate Initiative. In some cases, we have modified the language to facilitate a common understanding, and we note where definition debates remain.

DIFFERING DEFINITIONS

As momentum towards a carbon-free energy future grows, a dialogue is emerging around the terminology used to describe carbon reduction commitments. For example, some entities use the terms "net-zero carbon" and "carbon neutral" interchangeably (as this handbook does), while others see differences between them. "Net-zero" may indicate that any emissions that occur are removed (e.g., through carbon capture and sequestration (CCS)) and "carbon neutral" may mean that emissions are offset, maybe indirectly, (e.g., planting trees).

Similarly, terms may have distinct meanings in different contexts. For example, the term "net-zero" is also used in the building construction/renovation industry to refer to "net-zero energy." The U.S. Department of Energy defines a Net-Zero Energy Building as, "An energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy."[2] Although building a net-zero energy house may support a net-zero carbon goal, the two terms are not equivalent and should not be used interchangeably. It is important to clarify definitions to ensure that subsequent discussions begin with a common understanding.

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1 This handbook draws on the following SEPA resources: Tiers of Electricity Decarbonization and Utility Carbon Reduction Strategies. See the appendix for direct QR codes to these publications.

2 National Institute of Buildings Sciences. (2015). A Common Definition for Zero Energy Buildings. In U.S. Department of Energy (p. 4). U.S. Department of Energy. https://www.energy.gov/sites/default/files/2015/09/f26/bto_common_definition_zero_energy_buildings_093015.pdf

Table 1. Utility Decarbonization Target Terminology

Term	Type of Emissions	Definition	Example(s)
Absolute Zero Emissions / Zero Emissions / Emissions Free	CO_2 / GHG (CO_2e)	No emissions are attributable to activities such as generation. Under this definition, no offsets or balancing of residual emissions with removals are used.	*Commit to producing no CO_2 or other GHG emissions by a certain date.*
Carbon Neutral / Net Zero Emissions	CO_2 / GHG (CO_2e)	Emissions are balanced by actions to remove an equivalent amount of emissions over a specified period.	*Install carbon capture and sequestration (CCS) technology on a fossil fuel power plant or purchase renewable energy credits (RECs) to capture emissions to reach carbon neutrality.*
Clean Energy	N/A	Energy generated from non-carbon emitting resources.	*Examples of non-carbon emitting resources include wind, biomass, geothermal, hydropower, solar , nuclear, and green hydrogen.*
Relative Reduction	CO_2 / GHG (CO_2e)	Emissions reduction as a percentage relative to the emissions level of a baseline period.	*Reduce emissions 90% by 2050 compared to an emissions baseline year of 2005.*
Renewable Energy	N/A	Energy generated from naturally replenishing sources.	*Examples of renewable energy sources include biomass, hydropower, geothermal, wind and solar.[3]*

Drawing on the comprehensive data in SEPA's Utility Carbon-Reduction Tracker™ database, Figure 1 presents a detailed breakdown of the various types of voluntary utility decarbonization commitments. As Figure 1 illustrates, nearly half of these commitments are aimed towards achieving net-zero emissions. This significant trend underscores a prevailing industry sentiment: utilities are increasingly recognizing the necessity of incorporating emissions removal strategies in their pursuit of zero emissions.

Figure 1. Breakdown of Voluntary Target by Type

Renewable Energy 6.90%
Carbon Neutral 4.60%
Relative Reduction 13.80%
Carbon-Free 20.70%
Clean Energy 4.60%
Net-Zero 49.40%

n=87
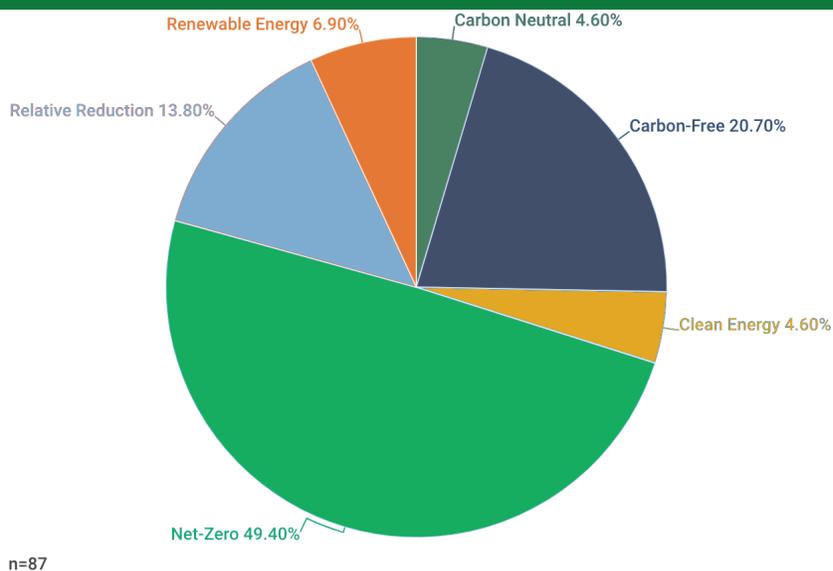
Source: SEPA. Utility Carbon-Reduction Tracker™

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3 Oxford Net Zero. (n.d.). What is Net Zero? Net Zero Climate; Oxford University. https://netzeroclimate.org/what-is-net-zero/

Utilities

The electric utility industry's adoption of carbon-reduction targets began in 2000, when the Seattle City Council, Washington (WA) announced a target to achieve net-zero greenhouse gas (GHG) emissions for the city's electric utility, Seattle City Light. Five years later, Seattle City Light became the first U.S. electric utility to achieve a net-zero GHG emissions target.[4] However, it would not be until December 2018, with Xcel Energy's adoption of its 100% carbon-free electricity target by 2050, that utilities' adoption of carbon-reduction targets began to accelerate significantly. Since Xcel's 2018 announcement, more than 80 U.S. utilities and utility parent companies have announced voluntary long-term targets for reducing GHG emissions. These targets span from commitments to achieve a 100% renewable electricity supply by 2030 to net-zero GHG emissions by 2050

Figure 2. Map of Utility Decarbonization Targets
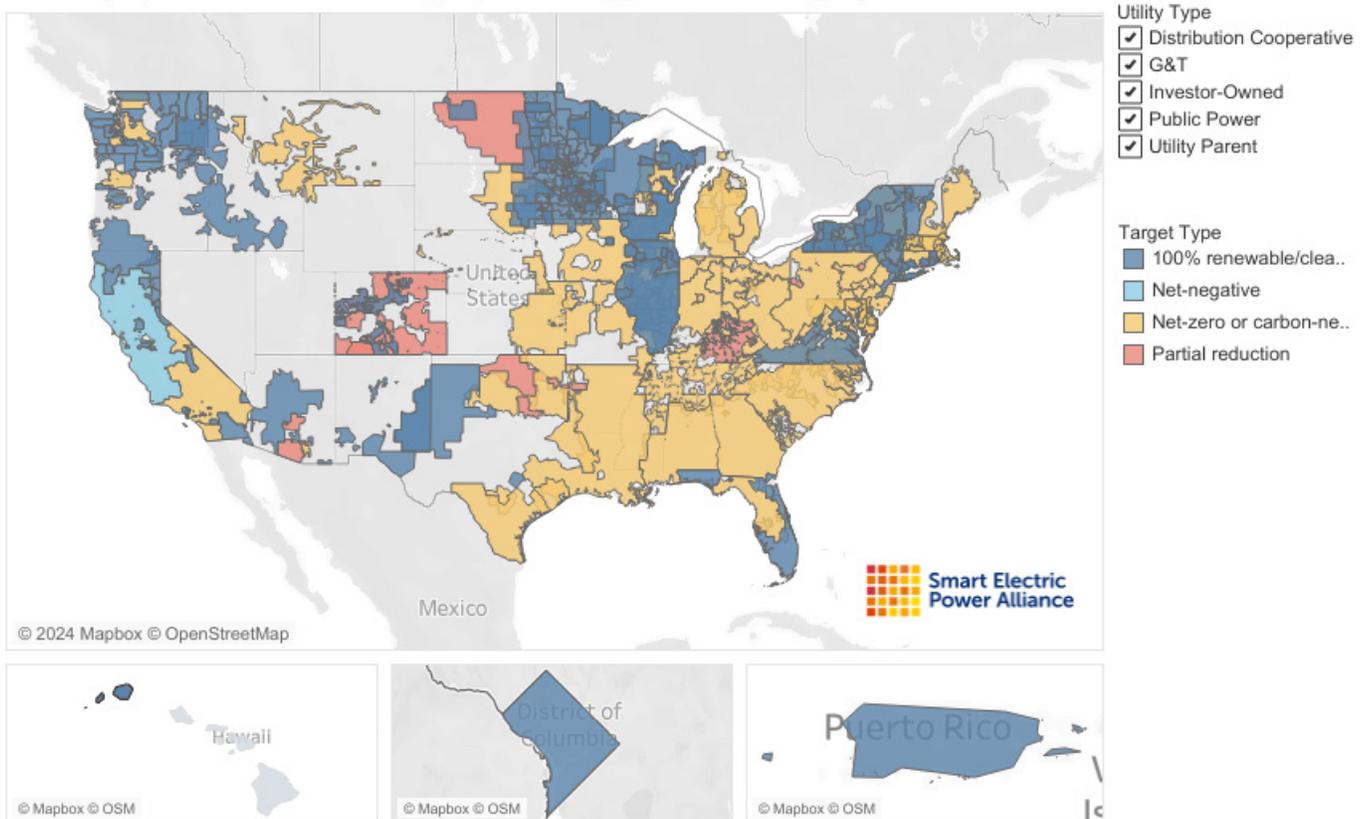
This map displays carbon-reduction targets adopted by individual electric utilities, as well as individual electric utilities that are subject to a state-level 100% requirement. It also displays carbon-reduction adopted voluntarily by parent companies of utilities that provide retail electric distribution service. A target adopted by a utility parent does not necessarily require individual utilities owned by the parent to comply with the overarching target.
Source: SEPA. Utility Carbon-Reduction Tracker™

Today, nearly 20 years after Seattle City Light became the first U.S. utility to achieve a 100% decarbonization target, 80% of U.S. electric customer accounts are served by an individual utility, or a utility owned by a parent company, with a 100% decarbonization target.[5]

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4 As of 2021, 86% of Seattle City's Light's delivered electricity was sourced from hydropower.

5 SEPA's Utility Carbon-Reduction Tracker™ defines "100% decarbonization target" to include 100% carbon-free energy targets, 100% clean or renewable energy, and net-zero carbon or GHG emissions targets.

Figure 3. Breakdown of Voluntary and Mandatory Decarbonization Commitments by Utility Type

Legend: ● Parent Company ● Investor-Owned ● Cooperative ● Public Power / Municipal ● Other*
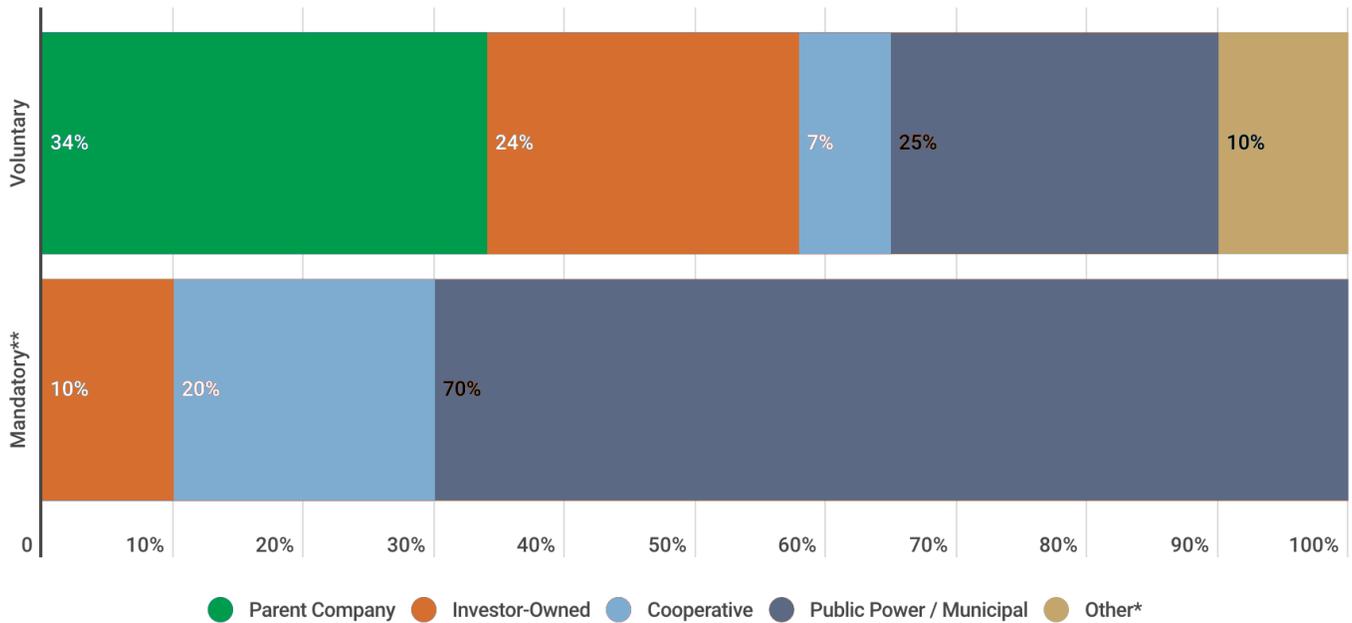
*"Other" data category includes both generation and transmission cooperatives and public power authorities.

**Includes only 100% decarbonization targets.

Source: SEPA. Utility Carbon-Reduction Tracker™

Drivers of Utility Decarbonization Target Adoption

Many utilities and utility parent companies with established decarbonization targets have documented their decarbonization commitments through various published resources, such as press releases, action plans, and strategic roadmaps. Additionally, within these documents, utilities have cited a range of reasons for adopting decarbonization targets, including (in no particular order):

- **Compliance:** Adherence to mandates from public utility commissions, as well as legislative and other regulations specifically targeting decarbonization.
- **Financial and Economic Benefits:** Economic incentives and financial benefits associated with decarbonization and improved carbon accounting practices.
- **Emerging Technology:** The availability and commercial viability of clean energy technologies, offering alternatives to fossil-based generation.
- **Market Demand:** A strong push from customers, communities, stakeholders, and shareholders for sustainability and environmental stewardship.
- **Risk Management:** A need to manage climate change risks and improve climate resilience.
- **Environmental, Social, and Governance (ESG):** Alignment with corporate ESG objectives.

2030 CLUB

In 2023, SEPA announced the 2030 Club, an initiative to recognize utilities across the U.S. that have established some of the most aggressive voluntary decarbonization targets. The utilities recognized as members of this group have all voluntarily committed to achieving at least an 80% reduction in carbon emissions or to transitioning to a generation supply of at least 80% clean energy resources by 2030.

The 2030 Club currently includes 26 utilities, ranging from the country's largest utility parent companies to small municipal and electric cooperative utilities. Members of the 2030 Club vary significantly in their business models, geographic location, size, and generation portfolios. The number of customers they serve ranges from approximately 8,000 to more than 5.5 million.

States

As of January 2024, 15 U.S. states, the District of Columbia (D.C.), and Puerto Rico have established either a binding, statutory 100% clean or renewable energy standard, or net-zero requirement that applies to a total of 564 individual utilities, which serve ~38% of U.S. electric customer accounts. These requirements can apply to specific utilities or types of utilities (such as one IOU or all IOUs within a state), to all utilities (all IOUs, municipal utilities, and co-ops within the state), or to the entire jurisdiction's economy. Less-enforceable state policy actions, such as executive orders, non-binding targets, and sub-100% requirements are not included in the Utility Carbon-Reduction Tracker Carbon-Reduction Tracker™, but can play a critical role in advancing industry and utility carbon-reduction strategies. While these requirements may be less than fully enforceable or fall short of 100% requirements, they remain key drivers of emissions reduction. They can also facilitate more ambitious actions in instances where the policy landscape may not support stricter mandates.

Figure 4. Map of U.S. State, District, and Territory Statutory 100% Decarbonization Mandates
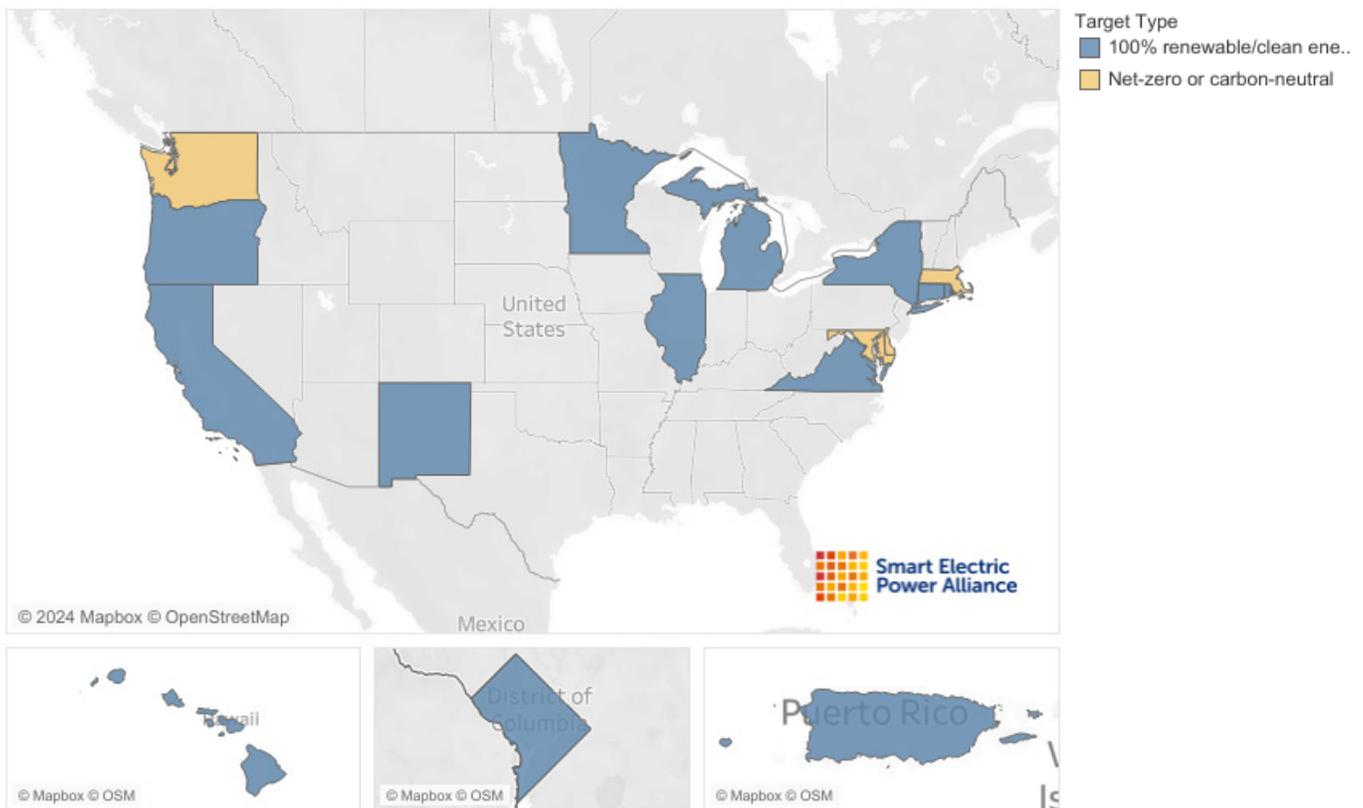
This map displays U.S. states that have established a binding 100% clean or renewable energy standard, or a binding net-zero requirement that applies to electric distribution utilities. These requirements can apply to specific utilities, to specific types of utilities, or economy-wide. Related state policy actions that are less enforceable, including executive order and non-binding goals, are not displayed.
Source: SEPA. Utility Carbon-Reduction Tracker™

Table 2 summarizes current U.S. state, district, and territory statutory 100% requirements, including the target type, target sector (economy-wide or electricity sector-specific), target attainment year, and utilities subject to the requirements.

Table 2. Overview of U.S. State, District, and Territory Statutory 100% Decarbonization Requirements					
State	**Attainment Year**	**Economy-Wide vs. Energy Sector Specific Requirements**	**Utilities Subject to Requirement**	**Utilities Required to Submit Separate Clean Energy Plans**	**Summary**
CA	2045	Energy sector specific	All	No	100% renewable energy and zero-carbon resources by 2045 (applies to all retail sales of electricity to California end-use customers)
CT	2040	Energy sector specific	All	No	*Zero GHG emissions from electricity supplied to electric customers by 2040*
DE	2050	Energy sector specific	All	No	Net-zero statewide GHG emissions by 2050 (applies to all electric utilities)
DC	2032	Energy sector specific	Pepco (DC)	No	100% renewable energy by 2032 (applies to all retail electric sales)
HI	2045	Energy sector specific	All	No	100% renewable energy by 2045 (applies to net electricity generation)
IL	2045	Energy sector specific	All	No	Zero CO2e emissions by 2045 (applies to electric generating units)
MA	2050	Economy-wide	All	No	Net-zero statewide GHG emissions by 2050
MD	2045	Economy-wide	All	No	Net-zero statewide GHG emissions by 2045
MI	2040	Energy sector specific	All	No	100% clean energy by 2040 (applies to total retail electric sales)
MN	2040	Energy sector specific	All	No	100% carbon-free electricity by 2040 (applies to all retail electric sales)
NM	2045	Energy sector specific	IOUs	No	100% zero-carbon resources by 2045 (applies to retail sales of electricity by IOUs)
NY	2040	Energy sector specific	All	No	Zero GHG emissions from statewide electrical demand system by 2040
OR	2040	Energy sector specific	Portland General Electric, Pacific Power	Yes	100% GHG-emission-free electricity by 2040 (applies to retail sales to consumers)
PR	2050	Energy sector specific	PREPA	No	100% renewable energy by 2050 (applies to electric utilities)
RI	2033	Energy sector specific	Rhode Island Energy	No	100% renewable energy by 2033 (applies to retail electricity sales to Rhode Island end-use customers)
RI	2050	Economy-wide	All	No	Net-zero statewide GHG emissions by 2050
VA	2045	Energy sector specific	Dominion Energy (VA)	No	100% renewable energy by 2045 (applies to Phase II utilities)
VA	2050	Energy sector specific	Appalachian Power (VA)	No	100% renewable energy by 2050 (applies to Phase I utilities)

WA	2030	Energy sector specific	All	Yes	100% GHG-neutral electricity by 2030 (applies to all retail sales of electricity to Washington customers)
WA	2045	Energy sector specific	All	Yes	100% non-emitting and renewable electricity by 2045 (applies to all retail sales of electricity to Washington customers)

Examples of less-enforceable state policy actions that do not appear in the Utility Carbon-Reduction Tracker™ include:
- Maine has an economy-wide target of reducing GHG emissions by 80% by 2050 and an 80% renewable portfolio standard (RPS) by 2030.
- New Jersey and Wisconsin have carbon-free electricity targets established by executive order.[6]

Although executive orders and non-binding targets are not enforceable, they are an important step in pushing toward a carbon-free future and can set the stage for statutory requirements. For example, Connecticut's 2022 statutory requirement (SB 10) of 100% carbon-free electricity by 2040 built on a prior 2019 executive order.[7] Minnesota's 2023 law mandating 100% carbon-free electricity by 2040[8] also built on previous governor-led non-binding policy proposals and targets,[9] and is also complemented by prior voluntary carbon-reduction targets by Xcel Energy and Minnesota Power, the state's largest investor-owned electric utilities.

Voluntary utility targets can also work in parallel with state targets via legislation and regulatory mechanisms. For example, in Colorado, 2019 laws (SB 19-236 and HB19-1261) codified Xcel Energy's 2018 voluntary target to reduce GHG pollution 80% by 2030 and achieve 100% carbon-free electricity by 2050. These laws also established a voluntary state-wide target to reduce economy-wide carbon emissions 90% by 2040.[10] Additionally, the 2021 Colorado Greenhouse Gas Pollution Reduction Roadmap and its development leveraged the 2019 law incentivizing other utilities to commit to 80% (or greater) GHG reductions by 2030. Other Colorado utilities such as Holy Cross Energy and Platte River Power Authority have implemented voluntary 100% carbon-free targets, and have filed clean energy resource plans that meet, or exceed, an 80% GHG reduction by 2030.[11]

As states advance a variety of carbon-reduction policy approaches, utility targets, plans, and strategies can complement and advance meaningful decarbonization actions.

Municipalities

Beyond utility and state-level decarbonization targets and mandates, municipalities nationwide are increasingly instrumental in the electric system's decarbonization efforts. Throughout the U.S., hundreds of cities have pledged to achieve 100% decarbonization targets.[12] Some of these municipalities are advancing their commitments in partnership with local municipal utilities, while others are situated within the service territories of larger utilities and are collaborating to procure clean energy for their communities.

For example, in 2022, the City Council of New Orleans, Louisiana, established an ambitious goal to achieve 100% clean electricity by 2035.[13] The city is served by the electric utility parent company the Entergy Corporation, which has set its own

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6 Clean Energy States Alliance. (2023). Table of 100% Clean Energy States.

7 The Executive Order issued directed DEEP (and PURA, as appropriate) to "analyze pathways and recommend strategies for achieving a 100% zero carbon target for the electric sector by 2040."

8 Minnesota Legislature. (2023). SF 4.

9 Utility Dive. (2021). Minnesota governor accelerates state's carbon-free power target 10 years, to 2040.

10 Colorado Legislature. (2019). Senate Bill 19-236.; Utility Dive. (2018). Xcel commits to eliminate carbon emissions by 2050.; Utility Dive. (2019). Colorado Gov Polis unveils roadmap to 100% renewables by 2040, signs 11 clean energy bills.

11 Holy Cross Energy and Platte River Power Authority are not rate-regulated by the Colorado Public Utilities Commission. Their clean energy resource plans have been statutorily approved by Colorado's Air Quality Control Division.

12 National League of Cities. (2023). How to Get Your Local Government to 100 Percent Clean Electricity

13 City of New Orleans Office of Resilience & Sustainability. (2022). Net Zero by 2050: A Priority List for Climate Action in New Orleans

net-zero carbon dioxide emissions target by 2050. This scenario exemplifies how a major U.S. city is leading the charge in setting decarbonization targets, necessitating a collaborative effort with its electric utility to expedite decarbonization within a specific service area, potentially ahead of the utility's broader service territory. New Orleans's unique regulatory authority over Entergy New Orleans, a subsidiary of Entergy Corporation, positions it distinctively to pursue such an aggressive decarbonization target. The City Council's regulatory oversight enables it to align the subsidiary's objectives with the city's broader environmental goals.[14]

KEY MARKET AND REGULATORY CONSIDERATIONS FOR UTILITY DECARBONIZATION

SEPA's electric industry decarbonization research has highlighted the significant influence of market and regulatory frameworks on utility decarbonization strategies. Vertically integrated utilities, controlling the entire service chain from generation to distribution, often find decarbonization more manageable due to direct oversight of their generation resources. Meanwhile, utilities in deregulated or restructured markets, prevalent in the Northeast, Mid-Atlantic, and parts of the Midwest U.S., face a more complex path. Regulations in these regions typically prohibit utilities from owning generation assets, limiting their direct influence over the carbon footprint of the electricity they supply. For instance, the State of Illinois mandates zero CO2e[15] emissions by 2045 for all electric generating units, not the utilities themselves, illustrating the indirect control utilities have in such markets. Consequently, utilities in restructured states often limit their decarbonization targets to areas within their direct control, such as through transportation electrification of company fleets.

Next Steps

Ongoing growth in emissions reduction commitments underscores the industry's recognition of the imperative of bold, timely action on decarbonization. States, municipalities, and utilities all play pivotal roles through a mix of voluntary targets, binding targets, and less-enforceable policy actions. As stakeholders across the industry strive towards common objectives, establishing clear definitions for decarbonization terminology is crucial. This clarity will enable more effective communication, thereby enhancing the impact and value of decarbonization efforts in the coming years. In this context, this handbook aims to establish a common understanding and support 'Voices of Experience' discussions on utility decarbonization, fostering a unified approach to these critical efforts.

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14 City of New Orleans Office of Resilience & Sustainability. (2022). Net Zero by 2050: A Priority List for Climate Action in New Orleans

15 CO_2e stands for carbon dioxide equivalent, which is a standardization metric used to measure emissions from various greenhouse gasses by their global-warming potential.

Appendix
Glossary of Key Utility Decarbonization Terminology

Term	Type of Emissions	Definition	Example(s)
Abatement	Carbon Dioxide (CO2) Greenhouse Gas (GHG) / CO2 equivalent (CO2e)	Avoid or reduce emissions inside the acting entity's value chain.[15]	Commit to burning natural gas instead of coal for energy generation.
Absolute Zero Emissions / Zero Emissions / Emissions Free	CO2 / GHG (CO2e)	No emissions are attributable to activities such as generation. Under this definition, no offsets or balancing of residual emissions with removals are used.[17]	Commit to producing no CO2 or other GHG emissions by a certain date.
Carbon Neutral / Net Zero Emissions	CO2 / GHG (CO2e)	Emissions are balanced by actions to remove an equivalent amount of emissions over a specified period.[18]	Install carbon capture and sequestration (CCS) technology on a fossil fuel power plant or purchase renewable energy credits (RECs) to capture emissions to reach carbon neutrality.
Clean Energy	N/A	Energy generated from non-carbon emitting sources.	Examples of non-carbon emitting resources include wind, biomass, geothermal, hydropower, solar , nuclear, and green hydrogen.
Compensation	CO2 / GHG (CO2e)	Avoid or reduce emissions outside the acting entity's value chain.[19]	Commit to funding a reforestation project.
Emissions Avoidance	CO2 / GHG (CO2e)	Activities that prevent emissions from happening.	Deploy energy efficiency programs.
Emissions Offsetting	CO2 / GHG (CO2e)	Reducing emissions (including through avoided emissions), or increasing emissions removals through activities external to an actor, in order to compensate for emissions, such that an actor's net contribution to global emissions is reduced.	Purchase carbon credits or funding restoration to offset carbon emissions. Offsetting is typically arranged through a marketplace for carbon credits or other exchange mechanisms.[20]
Emissions Removal / Neutralization	CO2 / GHG (CO2e)	Activities removing emissions from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products. Neutralization is the act of removing an equivalent amount of carbon to what is emitted.	Invest in afforestation and reforestation, soil carbon enhancement, bioenergy with carbon capture and storage (BECCS), direct air capture, CCS, mineralization, or enhanced weathering.
Relative Reduction	CO2 / GHG (CO2e)	Emissions reduction as a percentage relative to the emissions level of a baseline period.	Reduce emissions 90% by 2050 compared to an emissions baseline year of 2005.

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16 Pineda, A. C., Chang, A., & Faria, P. (2020). Foundations for Science-Based Net-Zero Target Setting in the Corporate Sector Version 1.0. In SBTi. Science Based Targets Initiative. https://sciencebasedtargets.org/resources/files/foundations-for-net-zero-full-paper.pdf

17 Oxford Net Zero. (n.d.). What is Net Zero? Net Zero Climate; Oxford University. https://netzeroclimate.org/what-is-net-zero/

18 Intergovernmental Panel on Climate Change. (2019). Annexes. In IPCC. Intergovernmental Panel on Climate Change. https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_AnnexI_Glossary.pdf

19 Pineda, A. C., Chang, A., & Faria, P. (2020). Foundations for Science-Based Net-Zero Target Setting in the Corporate Sector Version 1.0. In SBTi. Science Based Targets Initiative. https://sciencebasedtargets.org/resources/files/foundations-for-net-zero-full-paper.pdf

20 Oxford Net Zero. (n.d.). What is Net Zero? Net Zero Climate; Oxford University. https://netzeroclimate.org/what-is-net-zero/

Renewable Energy	N/A	Energy generated from naturally replenishing sources	Examples of renewable energy sources include biomass, hydropower, geothermal, wind and solar.

QR Codes for Additional Utility Decarbonization Resources

Utility Carbon Reduction Strategies | SEPA (sepapower.org)

Tiers of Electricity Decarbonization | SEPA (sepapower.org)

Utility Carbon-Reduction Tracker™ | SEPA (sepapower.org)

LA100 and LA100 Equity Strategies | NREL (nrel.gov)

Puerto Rico 100 | NREL (nrel.gov)