

Year-on-Year Growth In Residential Electricity Prices In The United States (2000-2024)

Residential Electricity Price Growth In The U.S. 2000-2024

- ▶ Retail residential electricity rates in the United States have climbed steadily over the previous several decades. In 2022, prices increased by 10.7 percent year on year, the fastest rate since the turn of the century. Residential prices are expected to climb further, increasing by 4% in 2023 compared to the previous year.

Drivers of Electricity Price Growth

- ▶ The price of electricity is influenced by the many energy sources utilized for generating, such as coal, gas, oil, renewable energy, or nuclear. In the United States, electricity expenses are strongly linked to [natural gas prices](#). As the commodity is exposed to higher-paying overseas markets, U.S. prices are projected to climb, as they did during the 2022 energy crisis. Electricity consumption is also predicted to rise, particularly in areas that may require more heating or cooling as climate change progresses, raising electricity prices.

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Which States Pay The Most For Electricity?

- ▶ Electricity rates vary widely by state and location. Hawaii has the highest power prices in the United States, at around 43 cents per kilowatt-hour as of May 2023, owing to the high cost of crude oil needed to generate the state's electricity. In comparison, Idaho has one of the lowest retail rates. Much of the state's energy is provided by hydroelectricity, which requires almost no fuel. In addition, development expenditures might be stretched out over several decades.

Year-on-Year Growth In Residential Electricity Prices In The United States (2000-2024)

Serial Number	Year	Annual Growth (Percentage)
1	2000	0.9%
2	2001	4.2%
3	2002	-1.6%
4	2003	3.2%
5	2004	2.6%
6	2005	5.4%
7	2006	10.3%

Year-on-Year Growth In Residential Electricity Prices In The United States (2000-2024)

Serial Number	Year	Annual Growth (Percentage)
8	2007	2.4%
9	2008	5.7%
10	2009	2.2%
11	2010	0.2%
12	2011	2.6%
13	2012	1.6%
14	2013	1.4%

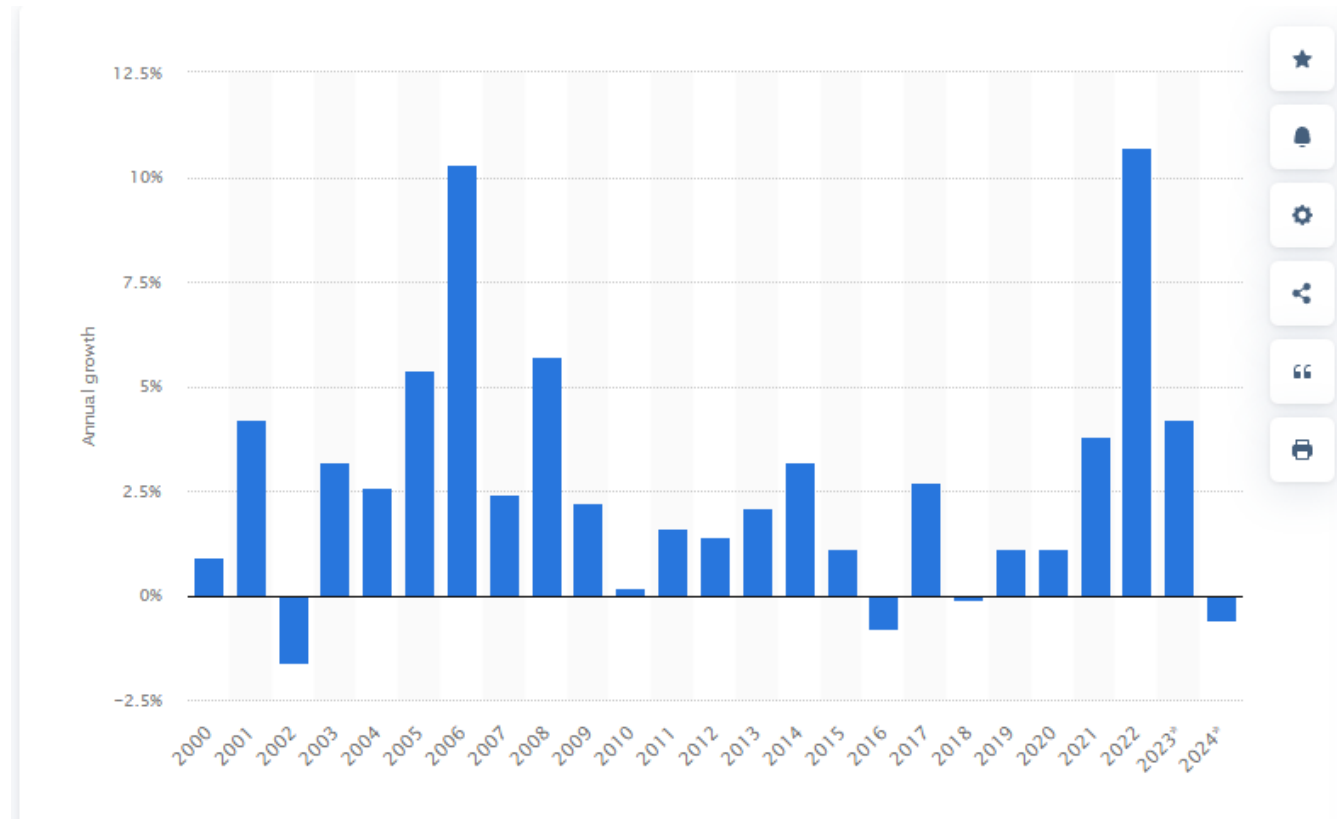
Year-on-Year Growth In Residential Electricity Prices In The United States (2000-2024)

Serial Number	Year	Annual Growth (Percentage)
15	2014	3.2%
16	2015	1.1%
17	2016	-0.8%
18	2017	2.7%
19	2018	-0.1%
20	2019	1.1%
21	2020	1.1%

Year-on-Year Growth In Residential Electricity Prices In The United States (2000-2024)

Serial Number	Year	Annual Growth (Percentage)
22	2021	3.8%
23	2022	10.7%
24	2023	4.2%
25	2024	-0.6%

Year-on-Year Growth In Residential Electricity Prices In The United States (2000-2024)



Cost and Performance Characteristics of New Generating Technologies

Table 1 represents our assessment of the cost to develop and install various generating technologies used in the electric power sector. Generating technologies typically found in end-use applications, such as combined heat and power or roof-top solar photovoltaics (PV), will be described elsewhere in the Assumptions document. The costs shown in Table 1, except as noted below, are the costs for a typical facility for each generating technology before adjusting for regional cost factors. Overnight costs exclude interest accrued during plant construction and development. Technologies with limited commercial experience may include a technological optimism factor to account for the tendency to underestimate the full engineering and development costs for new technologies during technology research and development. All technologies demonstrate some degree of variability in cost, based on project size, location, and access to key infrastructure (such as grid interconnections, fuel supply, and transportation). For wind and solar PV, in particular, the cost favorability of the lowest-cost regions compound the underlying variability in regional cost and create a significant differential between the unadjusted costs and the capacity-weighted average national costs as observed from recent market experience. To reflect this difference, we report a weighted average cost for both wind and solar PV, based on the regional cost factors assumed for these technologies in AEO2022 and the actual regional distribution of the builds that occurred in 2020 (Table 1).

Cost and Performance Characteristics of New Generating Technologies (Report provided by - Sargent & Lundy, December 2019)

Table 1. Cost and performance characteristics of new central station electricity generating technologies

Technology	First available year ^a	Size (MW)	Lead time (years)	Base overnight cost ^b (2021\$/kW)	Technological optimism factor ^c	Total overnight cost ^{d,e} (2021\$/kW)	Variable O&M ^f (2021 \$/MWh)	Fixed O&M (2021\$/kW-y)	Heat rate ^g (Btu/kWh)
Ultra-supercritical coal (USC)	2025	650	4	\$4,074	1.00	\$4,074	\$4.71	\$42.49	8,638
USC with 30% carbon capture and sequestration (CCS)	2025	650	4	\$5,045	1.01	\$5,096	\$7.41	\$56.84	9,751
USC with 90% CCS	2025	650	4	\$6,495	1.02	\$6,625	\$11.49	\$62.34	12,507
Combined-cycle—single-shaft	2024	418	3	\$1,201	1.00	\$1,201	\$2.67	\$14.76	6,431
Combined-cycle—multi-shaft	2024	1,083	3	\$1,062	1.00	\$1,062	\$1.96	\$12.77	6,370
Combined-cycle with 90% CCS	2024	377	3	\$2,736	1.04	\$2,845	\$6.11	\$28.89	7,124
Internal combustion engine	2023	21	2	\$2,018	1.00	\$2,018	\$5.96	\$36.81	8,295
Combustion turbine— aeroderivative ^h	2023	105	2	\$1,294	1.00	\$1,294	\$4.92	\$17.06	9,124
Combustion turbine—industrial frame	2023	237	2	\$785	1.00	\$785	\$4.71	\$7.33	9,905
Fuel cells	2024	10	3	\$6,639	1.09	\$7,224	\$0.62	\$32.23	6,469
Nuclear—light water reactor	2027	2,156	6	\$6,695	1.05	\$7,030	\$2.48	\$127.35	10,443
Nuclear—small modular reactor	2028	600	6	\$6,861	1.10	\$7,547	\$3.14	\$99.46	10,443
Distributed generation—base	2024	2	3	\$1,731	1.00	\$1,731	\$9.01	\$20.27	8,923
Distributed generation—peak	2023	1	2	\$2,079	1.00	\$2,079	\$9.01	\$20.27	9,907
Battery storage	2022	50	1	\$1,316	1.00	\$1,316	\$0.00	\$25.96	NA
Biomass	2025	50	4	\$4,524	1.00	\$4,525	\$5.06	\$131.62	13,500
Geothermal ^{l,j}	2025	50	4	\$3,076	1.00	\$3,076	\$1.21	\$143.22	8,813
Conventional hydropower ^j	2025	100	4	\$3,083	1.00	\$3,083	\$1.46	\$43.78	NA
Wind ^e	2024	200	3	\$1,718	1.00	\$1,718	\$0.00	\$27.57	NA
Wind offshore ^l	2025	400	4	\$4,833	1.25	\$6,041	\$0.00	\$115.16	NA
Solar thermal ^l	2024	115	3	\$7,895	1.00	\$7,895	\$0.00	\$89.39	NA
Solar photovoltaic (PV) with tracking ^{e, i, k}	2023	150	2	\$1,327	1.00	\$1,327	\$0.00	\$15.97	NA
Solar PV with storage ^{l, k}	2023	150	2	\$1,748	1.00	\$1,748	\$0.00	\$33.67	NA

Cost and Performance Characteristics of New Generating Technologies

Table 2 shows a full listing of the overnight costs for each technology and electricity region, if the resource or technology is available to be built in the given region. The regional costs reflect the impact of locality adjustments, including one to address ambient air conditions for technologies that include a combustion turbine and one to adjust for additional costs associated with accessing remote wind resources. Temperature, humidity, and air pressure can affect the available capacity of a combustion turbine, and our modeling addresses these possible effects through an additional cost multiplier by region. Unlike most other generation technologies where fuel can be transported to the plant, wind generators must be located in areas with the best wind resources. Sites that are located near existing transmission with access to a road network or are located on lower development-cost lands are generally built up first, after which additional costs may be incurred to access sites with less favorable characteristics. We represent this trend through a multiplier applied to the wind plant capital costs that increases as the best sites in a region are developed.

Cost and Performance Characteristics of New Generating Technologies (Source - U.S. Energy Information Administration, Office of Electricity, Coal, Nuclear and Renewables Analysis)

Table 2. Total overnight capital costs of new electricity generating technologies by region

2021 dollars per kilowatt

Technology	1 TRE	2 FRCC	3 MISW	4 MISC	5 MISE	6 MISS	7 ISNE	8 NYCW	9 NYUP	10 PJME	11 PJMW	12 PJMC	13 PJMD
Ultra-supercritical coal (USC)	\$3,786	\$3,897	\$4,259	\$4,371	\$4,422	\$3,918	\$4,721	NA	\$4,614	\$4,763	\$4,064	\$5,120	\$4,385
USC with 30% CCS	\$4,777	\$4,903	\$5,294	\$5,437	\$5,480	\$4,935	\$5,846	NA	\$5,729	\$5,883	\$5,094	\$6,254	\$5,477
USC with 90% CCS	\$6,252	\$6,411	\$6,841	\$7,072	\$7,078	\$6,473	\$7,495	NA	\$7,303	\$7,508	\$6,601	\$7,994	\$7,015
CC—single-shaft	\$1,085	\$1,107	\$1,235	\$1,246	\$1,277	\$1,117	\$1,441	\$1,912	\$1,445	\$1,443	\$1,197	\$1,446	\$1,377
CC—multi-shaft	\$944	\$968	\$1,098	\$1,117	\$1,146	\$979	\$1,259	\$1,725	\$1,238	\$1,266	\$1,037	\$1,327	\$1,170
CC with 90% CCS	\$2,668	\$2,693	\$2,877	\$2,884	\$2,928	\$2,718	\$3,021	\$3,422	\$2,953	\$2,996	\$2,756	\$3,124	\$2,871
Internal combustion engine	\$1,898	\$1,940	\$2,073	\$2,155	\$2,131	\$1,966	\$2,209	\$2,769	\$2,125	\$2,209	\$1,980	\$2,408	\$2,056
CT—aeroderivative	\$1,145	\$1,168	\$1,354	\$1,357	\$1,398	\$1,193	\$1,456	\$1,864	\$1,405	\$1,448	\$1,242	\$1,591	\$1,317
CT—industrial frame	\$692	\$707	\$822	\$826	\$851	\$723	\$886	\$1,144	\$854	\$882	\$753	\$971	\$800
Fuel cells	\$6,933	\$7,041	\$7,362	\$7,680	\$7,534	\$7,159	\$7,815	\$9,201	\$7,498	\$7,748	\$7,138	\$8,261	\$7,358
Nuclear—light water reactor	\$6,636	\$6,779	\$7,157	\$7,807	\$7,530	\$7,000	\$7,964	NA	\$7,430	\$7,781	\$6,878	\$8,556	\$7,158
Nuclear—small modular reactor	\$7,032	\$7,197	\$7,841	\$8,176	\$8,173	\$7,287	\$8,441	NA	\$8,040	\$8,459	\$7,376	\$9,438	\$7,660
Distributed generation—base	\$1,563	\$1,595	\$1,779	\$1,795	\$1,840	\$1,609	\$2,076	\$2,754	\$2,081	\$2,079	\$1,724	\$2,083	\$1,984
Distributed generation—peak	\$1,839	\$1,877	\$2,174	\$2,180	\$2,246	\$1,916	\$2,339	\$2,994	\$2,257	\$2,326	\$1,995	\$2,555	\$2,116
Battery storage	\$1,316	\$1,320	\$1,301	\$1,364	\$1,319	\$1,347	\$1,357	\$1,351	\$1,321	\$1,325	\$1,313	\$1,329	\$1,325
Biomass	\$4,198	\$4,313	\$4,669	\$4,824	\$4,835	\$4,348	\$5,372	\$7,292	\$5,389	\$5,483	\$4,611	\$5,493	\$5,255
Geothermal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Conventional hydropower	\$4,498	\$5,495	\$2,186	\$1,453	\$2,959	\$4,378	\$2,025	NA	\$4,144	\$4,305	\$3,752	NA	\$3,808
Wind	\$2,757	NA	\$1,552	\$1,411	\$1,690	\$1,411	\$1,870	NA	\$2,281	\$1,870	\$1,411	\$2,055	\$1,948
Wind offshore	\$5,901	\$7,080	\$6,984	NA	\$7,234	NA	\$7,047	\$6,079	\$7,370	\$6,755	\$5,524	\$7,999	\$6,293
Solar thermal	\$7,616	\$7,731	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Solar PV with tracking	\$1,304	\$1,279	\$1,323	\$1,372	\$1,357	\$1,290	\$1,370	\$1,612	\$1,357	\$1,397	\$1,320	\$1,440	\$1,317
Solar PV with storage	\$1,692	\$1,710	\$1,761	\$1,817	\$1,792	\$1,727	\$1,828	\$2,078	\$1,796	\$1,832	\$1,721	\$1,905	\$1,781

Cost and Performance Characteristics of New Generating Technologies (Source - U.S. Energy Information Administration, Office of Electricity, Coal, Nuclear and Renewables Analysis)

Table 2. Total overnight capital costs of new electricity generating technologies by region

2021 dollars per kilowatt

Technology	SRCA	SRSE	SRCE	SPPS	SPPC	SPPN	SMSG	CANO	CASO	NWPP	24 RMRG	25 BASN
Ultra-supercritical coal (USC)	\$3,920	\$3,979	\$4,032	\$3,947	\$4,193	\$3,991	\$4,159	NA	NA	\$4,406	\$4,119	\$4,297
USC with 30% CCS	\$4,939	\$4,985	\$5,059	\$4,952	\$5,226	\$4,999	\$5,215	NA	NA	\$5,480	\$5,159	\$5,353
USC with 90% CCS	\$6,485	\$6,542	\$6,620	\$6,451	\$6,778	\$6,497	\$6,758	NA	NA	\$7,090	\$6,658	\$6,967
CC—single-shaft	\$1,103	\$1,116	\$1,150	\$1,115	\$1,183	\$1,104	\$1,085	\$1,590	\$1,553	\$1,264	\$1,023	\$1,106
CC—multi-shaft	\$968	\$980	\$1,016	\$979	\$1,051	\$971	\$934	\$1,398	\$1,359	\$1,096	\$880	\$987
CC with 90% CCS	\$2,684	\$2,698	\$2,759	\$2,688	\$2,777	\$2,647	\$2,448	\$3,071	\$3,036	\$2,833	\$2,303	\$2,586
Internal combustion engine	\$1,977	\$1,982	\$2,017	\$1,962	\$2,068	\$1,982	\$2,001	\$2,398	\$2,355	\$2,133	\$1,975	\$2,114
CT—aeroderivative	\$1,186	\$1,196	\$1,241	\$1,194	\$1,279	\$1,203	\$1,086	\$1,529	\$1,491	\$1,341	\$1,051	\$1,198
CT— industrial frame	\$718	\$726	\$753	\$724	\$777	\$729	\$658	\$934	\$910	\$816	\$637	\$728
Fuel cells	\$7,211	\$7,205	\$7,304	\$7,080	\$7,376	\$7,143	\$7,243	\$8,299	\$8,203	\$7,585	\$7,104	\$7,567
Nuclear—light water reactor	\$7,090	\$7,035	\$7,263	\$6,807	\$7,198	\$6,805	\$7,058	NA	NA	\$7,640	\$6,837	\$7,648
Nuclear—small modular reactor	\$7,323	\$7,380	\$7,547	\$7,306	\$7,759	\$7,368	\$7,465	NA	NA	\$8,083	\$7,386	\$8,028
Distributed generation—base	\$1,589	\$1,608	\$1,657	\$1,606	\$1,705	\$1,591	\$1,563	\$2,290	\$2,238	\$1,821	\$1,474	\$1,593
Distributed generation—peak	\$1,905	\$1,922	\$1,994	\$1,919	\$2,055	\$1,932	\$1,744	\$2,456	\$2,394	\$2,154	\$1,688	\$1,924
Battery storage	\$1,359	\$1,340	\$1,357	\$1,310	\$1,318	\$1,302	\$1,333	\$1,371	\$1,373	\$1,348	\$1,305	\$1,357
Biomass	\$4,364	\$4,397	\$4,455	\$4,368	\$4,641	\$4,460	\$4,777	\$6,119	\$5,981	\$4,939	\$4,732	\$4,731
Geothermal	NA	NA	NA	NA	NA	NA	\$3,135	\$3,109	\$2,517	\$3,043	NA	\$3,076
Conventional hydropower	\$2,120	\$4,599	\$2,377	\$4,550	\$1,917	\$1,802	\$3,655	\$3,867	\$3,723	\$3,083	\$3,681	\$4,023
Wind	\$1,683	\$1,907	\$1,411	\$1,411	\$1,552	\$1,552	\$1,411	\$3,116	\$2,447	\$2,057	\$1,411	\$1,411
Wind offshore	\$5,437	NA	NA	NA	NA	NA	NA	\$9,112	\$9,560	\$6,836	NA	NA
Solar thermal	NA	NA	NA	\$7,693	\$7,991	\$7,614	\$7,980	\$9,400	\$9,282	\$8,493	\$7,668	\$8,510
Solar PV with tracking	\$1,343	\$1,276	\$1,318	\$1,278	\$1,328	\$1,287	\$1,300	\$1,447	\$1,440	\$1,332	\$1,315	\$1,327
Solar PV with storage	\$1,739	\$1,721	\$1,742	\$1,709	\$1,765	\$1,727	\$1,736	\$1,903	\$1,898	\$1,795	\$1,729	\$1,791

Understanding Carbon Footprints

Our carbon footprint is the total amount of greenhouse gasses we release into the atmosphere through our actions and lifestyle choices. Everything from the cars we drive, the energy that powers our home, to the food we eat contributes to our carbon footprint.

Reducing our carbon footprints is crucial because our current collective carbon footprint is pushing our planet to its limits, and will have catastrophic consequences for our species and life on earth as we know it. Recently we dedicated an entire post to listing how SMEs can do more to become net zero and be more environmentally responsible, but a quick recap may be in order:

- ▶ Reducing our individual and collective footprints are key to slowing down climate change due to, and hold additional benefits. Here are a few simple actions to start reducing your carbon footprint today:
 - ▶ Travel smart: Opt for public transportation, carpooling, biking, or walking whenever possible.
 - ▶ Energy efficiency: Upgrade to energy-efficient appliances and light bulbs.
 - ▶ Mind your diet: Eat more plant-based meals and reduce food waste.
 - ▶ Conserve water: Fix leaks and reduce water waste in your home.

Understanding Carbon Footprints

Understanding and acting to reduce your carbon footprint individually is the first step toward a more sustainable lifestyle, but this alone will not be enough to combat climate change. We need a system to support collaborative and business driven activities. It's here that carbon credits become increasingly important - By offering a practical way for organizations to balance out emissions they can't yet eliminate.

The synergy between reducing our carbon footprint and utilizing carbon credits to account for emissions we can't eliminate, is pivotal in our journey toward environmental stewardship.

Carbon Credits - Unlocking Sustainability

Carbon credits are a groundbreaking mechanism designed to reduce global greenhouse gas emissions, acting as a bridge to a more sustainable future. By purchasing carbon credits, individuals and businesses can offset their unavoidable carbon footprint, contributing to environmental preservation and sustainability projects worldwide.

Carbon credit are at the forefront of the battle against climate change, serving a key role in encouraging both companies and individuals to cut down their carbon emissions through financial incentives. These incentives not only make it more appealing to invest in eco-friendly practices but also bring crucial funding to environmental projects that might not have seen the light of day without this support. Moreover, by acting as a universal carbon currency, carbon credits foster a spirit of global cooperation, uniting countries and communities in a shared mission to reduce emissions worldwide. This collective effort is essential as we work towards a more sustainable future, demonstrating the power and potential of carbon credits in driving meaningful environmental progress.

The Kyoto Protocol: Setting the Stage for Carbon Credits

The Kyoto Protocol, established under the United Nations Framework Convention on Climate Change (UNFCCC) in 1997, marked the inception of formalized global efforts to curb greenhouse gas (GHG) emissions. This landmark treaty set forth binding emissions reduction targets for 37 industrialized nations and the European Union, aiming to reduce emissions to 5% below 1990 levels between 2008 and 2012. A subsequent amendment in 2012 extended these targets to 2013-2020. Central to the Kyoto Protocol was the innovative concept of carbon credits, designed to provide economic incentives for emissions reductions. The Protocol introduced Emissions Trading, the Clean Development Mechanism (CDM), and Joint Implementation (JI), laying the foundation for the global carbon credit framework.

Key facts:

- ▶ The Kyoto Protocol committed developed countries to emissions reduction targets of 5% below 1990 levels between 2008-2012. This was later extended to 2013-2020 with an amended treaty.
- ▶ The innovative mechanisms introduced included Emissions Trading, CDM, and JI which provided the blueprint for carbon credits trading.

Paris Agreement: A New Dawn in Global Climate Cooperation

The Paris Agreement, adopted in 2015, emerged as a robust successor to the Kyoto Protocol, reflecting a global shift towards more inclusive and ambitious climate action. Unlike the Kyoto Protocol, which placed binding targets on developed countries alone, the Paris Agreement encourages all nations to contribute towards global emissions reduction. This inclusive framework aims to limit global temperature rise to well below 2°C, with an ambition of 1.5°C above pre-industrial levels. The Paris Agreement introduced the Sustainable Development Mechanism (SDM), poised to replace the Kyoto Protocol's Clean Development Mechanism (CDM), signifying a transformation in the realm of carbon credits and setting a new trajectory for global environmental strategies.

Key facts:

- ▶ The Paris Agreement set a more ambitious goal of limiting global warming to 1.5°C compared to the Kyoto Protocol's 2°C target.
- ▶ It has a universal framework encouraging all countries to contribute, unlike the Kyoto Protocol's binding targets just for developed nations.
- ▶ Introduced the SDM to replace the CDM, reflecting an evolution in carbon credits post-Kyoto.

Why Some Countries Opted Out: Economic and Strategic Considerations

The Kyoto Protocol faced resistance from some major emitting countries due to concerns surrounding economic competitiveness and equity. The U.S., citing potential economic drawbacks and the lack of binding commitments on developing countries, chose not to ratify the Protocol. Canada withdrew in 2011, expressing concerns over the Protocol's ability to effectively address global emissions without the participation of major emitters like the U.S. and China. These decisions underscored the complex interplay of economic, strategic, and environmental considerations that influence international climate agreements and the operationalization of carbon credits.

Key facts:

- ▶ The U.S. and Canada opted out due to concerns over economic impacts and equity without developing nations' commitments.
- ▶ Highlights the strategic considerations alongside environmental ones in climate agreements.

Carbon Credits - A Mechanism to Meet Targets

The Kyoto Protocol introduced pioneering mechanisms like Emissions Trading, the Clean Development Mechanism (CDM), and Joint Implementation (JI) to help nations meet their emissions reduction targets. These mechanisms provided the blueprint for the evolution of the carbon credit system, allowing for the trading of emission allowances and fostering international collaboration on carbon sequestration projects. The Paris Agreement further refined these mechanisms, introducing the Sustainable Development Mechanism (SDM) to build upon the successes and lessons learned from the Kyoto-era mechanisms, thereby enhancing the global carbon credit framework.

Key facts:

- ▶ Emissions Trading, CDM, and JI were introduced under Kyoto as innovative ways to meet reduction targets.
- ▶ Paris Agreement's SDM builds on these mechanisms to further improve the carbon credits system.

The Decline of the CDM: Transitioning to a New Era

With the advent of the Paris Agreement, the Clean Development Mechanism (CDM) saw a decline in prominence as the Sustainable Development Mechanism (SDM) emerged. This transition reflects the global community's adaptive approach to evolving environmental challenges. The SDM, with its broader scope and enhanced flexibility, aims to address the shortcomings of the CDM, offering a more robust framework for carbon credit initiatives. The shift from CDM to SDM signifies a continued evolution in the mechanisms governing carbon credits, aligning with the ambitious global climate goals set forth by the Paris Agreement.

Key facts:

- ▶ The CDM is being replaced by the more robust SDM under Paris reflecting an adaptive approach.
- ▶ SDM has a wider scope and flexibility compared to CDM.

Challenges in Participation: Navigating Global Climate Dynamics

The participation challenges faced by the [Kyoto Protocol](#) highlight the complexities inherent in global climate agreements. Major emitters like the U.S. and China's reluctance to commit to binding emissions reduction targets under the Kyoto Protocol underscored the need for a more inclusive approach. The Paris Agreement, with its universal framework for climate action, addresses some of these challenges by encouraging all nations, regardless of their economic status, to contribute towards global emissions reduction. However, the nuances of national and global priorities continue to influence the level of participation and commitment to carbon credit initiatives.

Key facts:

- ▶ Universal participation under Paris was designed to address the lack of major emitters' commitment under Kyoto.
- ▶ National interests still impact countries' levels of commitment to climate agreements.

The Role of the International Transaction Log (ITL): Ensuring Transparency and Accountability

The [International Transaction Log \(ITL\)](#) plays a crucial role in the operationalization of carbon credits by ensuring transparency, accountability, and efficiency in carbon credit transactions. Established by the Secretariat of the Conference of Parties, the ITL meticulously records carbon credit transactions, preventing potential issues like double-counting of reductions or the sale of identical credits multiple times. The ITL, by bridging national emissions trading registries and the UNFCCC, exemplifies the global commitment to a transparent and accountable carbon credit system, underpinning the credibility of international emissions trading initiatives.

Key facts:

- ▶ The ITL prevents double-counting and ensures transparency in carbon credits trading.
- ▶ It bridges national registries and UNFCCC to enable international cooperation.

Risks and Mitigation in Carbon Credit Projects: Ensuring Viability and Sustainability

Carbon credit projects, inherent with regulatory and market risks, necessitate robust mitigation strategies to ensure their viability and sustainability. The complexities of regulatory approvals, monitoring actual emissions, and navigating volatile market dynamics pose challenges to carbon credit projects. Leveraging approved CDM technologies and entering into long-term fixed-price contracts can significantly reduce these risks. The evolving carbon credit framework, transitioning from CDM to SDM under the Paris Agreement, reflects a continued effort to address these risks and enhance the sustainability of carbon credit projects.

Key facts:

- ▶ Regulatory and market risks pose viability challenges for carbon credit projects.
- ▶ CDM methodologies and long-term contracts help mitigate risks.

Controversies in Land Use Projects: Navigating Carbon Sequestration Challenges

Land use projects under the Kyoto Protocol aimed at GHG removals and emissions reductions through activities like afforestation and reforestation. However, they faced resistance due to challenges in estimating and tracking GHG removals over extended periods. The complexities of measuring carbon sequestration, particularly in vast forested areas, underscore the controversies and challenges inherent in the carbon credits domain. The Paris Agreement, with its enhanced framework for carbon credit initiatives, offers avenues to address some of these challenges, promoting a more robust and transparent approach to land use projects within the carbon credits framework.

Key facts:

- ▶ Estimating and monitoring carbon sequestration from land use projects is complex.
- ▶ Caused controversies under Kyoto but Paris Agreement provides scope to improve.

Carbon Credits - Unlocking Sustainability

One credit equals one ton of carbon dioxide. These credits are generated by projects that reduce, avoid, or remove greenhouse gas emissions from the atmosphere, such as:

- ▶ Renewable energy projects (wind, solar, hydro)
- ▶ Reforestation and forest conservation
- ▶ Energy efficiency improvements

Understanding and participating in the carbon credit system, empowers us to take meaningful steps towards a sustainable future. Utilizing this tool responsibly can help us achieve balance and sustainability for our planet. Engaging with carbon credits puts us in an active role in reducing emissions, both as individuals, and as businesses. Recognizing and participating in the carbon credit economy is the mainstream opportunity for businesses to become part of broader solutions for climate change. It allows offsetting carbon footprints and directly contributing to the fight against global warming. Moreover, involvement supports innovation by funding projects dedicated to creating a more sustainable and cleaner world. Purchasing carbon credits offers companies a practical step towards making a real difference, and complements efforts to shrink carbon footprints.

Carbon Credits - Unlocking Sustainability

Carbon credits have long past moved beyond being a theoretical concept and are making a tangible impact on our planet right now. Carbon credit projects worldwide are funding initiatives that significantly reduce emissions and promote sustainability already. Some projects are examples of such successes in a variety of fields:

Renewable Energy

- ▶ Renewable energy projects involve the generation of electricity from renewable sources such as solar, wind, hydro, or geothermal power. These projects help reduce greenhouse gas emissions by displacing fossil fuel-based power generation. Renewable energy projects such as wind farms generate carbon credits based on the amount of greenhouse gas emissions they displace compared to conventional fossil fuel-based power generation. These credits can then be sold on the carbon market, providing an additional source of revenue for the project and making it even more financially viable.

Carbon Credits - Unlocking Sustainability

Energy Efficiency

- ▶ Energy efficiency projects aim to reduce energy consumption and improve energy efficiency in buildings, industries, and transportation. By implementing energy-saving measures such as upgrading insulation, installing efficient lighting systems, or optimizing industrial processes, businesses can help reduce greenhouse gas emissions associated with energy use, reduce their carbon footprints, and earn carbon credits. This carbon credit income can offset some of the required upfront investment, while longer term operational cost savings provide the justification for the rest.

Afforestation

- ▶ Trees act as carbon sinks, sequestering carbon dioxide through photosynthesis. Afforestation and reforestation projects help offset emissions and contribute to climate change mitigation because trees trap greenhouse gasses that would otherwise be free in the atmosphere. This is the logic through which creating new forests or restoring degraded ones are activities that are also eligible for earning carbon credits.

Carbon Credits - Unlocking Sustainability

Methane Capture

- ▶ Methane is a potent greenhouse gas with a much higher warming potential than carbon dioxide. Methane gas is usually emitted during the production and transport of coal, oil, and natural gas. By capturing methane emissions from sources such as landfills or [livestock operations](#) and using it as a fuel or converting it into other products, [methane capture and utilization projects](#) help reduce greenhouse gas emissions and promote sustainability goals, and are therefore eligible for earning carbon credits. With these projects in mind, we'll understand why investing in carbon credits is not just good for the environment but can also be beneficial for us.

The Ripple Effect

- ▶ The impact of carbon credit supported projects extends far beyond reducing carbon emissions and is repeatedly proven to offer downstream benefits to the society, the economy, and the environment - These projects often lead to the creation of local jobs in green industries, providing communities with new employment opportunities. Additionally, initiatives such as clean cookstove projects significantly reduce air pollution, which in turn improves the health of those communities. Furthermore, reforestation and conservation efforts play a crucial role in protecting endangered species and their natural habitats, preserving biodiversity. This multifaceted impact underscores the value of carbon credit projects in fostering a healthier, more sustainable, and economically vibrant world. Investing in carbon credits as an individual or a company is a direct contribution to these impactful projects - By offsetting your carbon footprint through carbon credits, you support a cycle of improvement that extends far beyond just carbon reduction. It's a tangible way to take responsibility for your environmental impact and contribute to a positive change in the world.

Carbon Credits - Unlocking Sustainability

Carbon Credits Foster Sustainable Growth

Now that we've established how carbon credits are both a tool for offsetting emissions and a catalyst for sustainable growth, it's easy to see how funding carbon credits stimulate sustainable practices across sectors:

- ▶ Renewable Energy Expansion - Carbon credits finance the development of renewable energy sources, reducing reliance on fossil fuels and promoting cleaner air.
- ▶ Innovation in Green Technology - Investments in carbon credits fuel research and development in green technologies, paving the way for breakthroughs in sustainability.
- ▶ Sustainable Agriculture - Carbon credit projects support sustainable farming practices that improve soil health, conserve water, and reduce greenhouse gas emissions.

The carbon credit system not only addresses environmental issues but also offers economic benefits. By participating in projects funded by carbon credits, we're not just tackling climate change; we're also sparking significant economic opportunities. These projects often demand skilled labor, leading to the creation of new job opportunities within the burgeoning green industries. Moreover, by encouraging the adoption of low-carbon technologies, carbon credits are unlocking new markets and revenue streams for forward-thinking businesses, particularly those pioneering in sustainability.

These incentives are drawing global investments into sustainable initiatives, with a marked impact in developing countries where such financial injections can lead to transformative changes. Through our collective engagement in the carbon credit market, we're contributing to the fight against climate change, supporting environmentally responsible economic development, and steering the global economy towards a low-carbon future. This commitment to carbon credits transcends mere environmental stewardship; it signifies a proactive investment in crafting a sustainable and thriving future for our planet.

Carbon Credits - Unlocking Sustainability

Beyond Emission Reductions

- ▶ Now that we've established some of the peripheral benefits carbon credits provide beyond mere accountability, let's take a deeper look at the environmental conservation, social development, and economic benefits carbon credits are already offering communities worldwide:

Environmental Conservation

- ▶ Carbon credit projects play a crucial role in preserving and restoring vital habitats, protecting endangered species, and maintaining biodiversity through natural habitat conservation. They also support forest restoration efforts, like reforestation and afforestation, which capture carbon and enhance soil health and water cycles, contributing significantly to environmental sustainability.

Social Advancements

- ▶ Carbon credits have a significant impact on communities, not only improving public health by enhancing air quality through projects that reduce emissions but also funding education initiatives. This support gives communities valuable tools for sustainable development, showcasing the profound benefits of carbon credits beyond just environmental preservation.

Economic Benefits

- ▶ Carbon credit initiatives drive sustainable growth by providing training and employment, creating sustainable livelihoods for local communities. These projects often lead to improved infrastructure, such as better roads and clean water supplies, demonstrating the economic benefits and upliftment they bring to areas where they are implemented.

Carbon Credits - Unlocking Sustainability

A Holistic Approach to Sustainability

- ▶ Investing in carbon credits lets everyone contribute to a healthier planet, stronger communities, and a sustainable economy. These credits support projects that reduce emissions and also improve people's lives by providing better access to essential services and enhancing livelihoods. They ensure that caring for the environment is a key part of our economic growth. This approach shows the importance of carbon credits in creating a future where the planet's health, social fairness, and economic well-being are all connected.

The Future of Carbon Credits

- ▶ As we look towards the future, carbon credits stand out as a pivotal element in the global strategy against climate change. Their role in reducing emissions, supporting sustainable projects, and driving economic growth underscores their potential to shape a sustainable future for all.

Evolving Markets and Technologies

- ▶ Investing in carbon credits helps everyone contribute to a healthier planet, stronger communities, and a sustainable economy. These credits support projects that reduce emissions and also improve people's lives by providing better access to essential services and enhancing livelihoods. They ensure that caring for the environment is a key part of our economic growth. This approach shows the importance of carbon credits in creating a future where the planet's health, social fairness, and economic well-being are all connected.

Challenges and Opportunities

- ▶ The road ahead for carbon credits is filled with challenges that also bring opportunities for growth and betterment. Developing universal standards will help ensure that carbon credits are both effective and reliable. By making carbon credits more accessible to small businesses and individuals, we can make the fight against climate change more inclusive. Furthermore, integrating carbon credits into wider sustainability strategies will enhance their overall impact, pushing us closer to our environmental goals.
- ▶ The future of carbon credits is a reflection of our collective commitment to a sustainable planet. Through informed action, investment, and advocacy, we can harness the power of carbon credits to drive significant, positive change in the world, ensuring a greener, more sustainable tomorrow for generations to come.

Carbon Credit Compliance Markets

Compliance markets are established by governments and are mandatory for certain industries or sectors. These markets use carbon credits as a means of compliance to ensure that companies meet mandatory targets. Carbon credits in these markets are typically allocated or auctioned off by governments, and companies can buy or sell these credits on a secondary market.

Examples of compliance markets are:

- ▶ [The European Union Emissions Trading System \(EU ETS\)](#)
- ▶ [The California Cap-and-Trade Program.](#)

Carbon Credit Voluntary Markets

Voluntary markets are not regulated by governments and are driven by companies and individuals who voluntarily choose to offset their emissions. Carbon credits for these markets are often generated through projects that reduce or remove greenhouse gasses, and these credits can be bought directly from project developers or through specialized platforms. These markets provide an opportunity for companies to take responsibility for their carbon footprint and demonstrate their commitment to sustainability.

Examples of voluntary markets are:

- ▶ [The Verified Carbon Standard \(VCS\).](#)
- ▶ [The Gold Standard.](#)

How are Carbon Credits Issued?

Carbon credits can be issued for projects that can be proven to reduce carbon emissions or absorb carbon from the environment. These may include, but are not limited to:

- ▶ Renewable energy initiatives.
- ▶ Energy efficiency programs.
- ▶ Afforestation & reforestation projects.
- ▶ Waste management schemes.

These projects not only help to reduce emissions but also contribute to sustainable development and job creation. By issuing carbon credits for these projects, governments, international organizations and private enterprises can support their implementation and ensure they are financially viable. Let's take a closer look at how each of the above projects are leveraged to create carbon credits:

- ▶ Issuing Carbon Credits from Wind Farms
 - ▶ By generating clean, renewable energy, [wind farms](#) help to reduce the demand for fossil fuels and the associated greenhouse gas emissions. The emission reductions achieved by the wind farm can be quantified and converted into carbon credits, which can then be sold on the carbon market.

How are Carbon Credits Issued?

- ▶ Issuing Carbon Credits from Afforestation
 - ▶ These projects help to absorb carbon dioxide from the atmosphere and store it in [biomass by planting trees](#). The amount of carbon dioxide absorbed by the trees can be quantified and converted into carbon credits. These credits can then be sold to companies or individuals looking to offset their emissions.
- ▶ Issuing Carbon Credits from Waste Management
 - ▶ Waste management schemes create carbon credits by implementing methods to reduce carbon dioxide and methane emissions associated with waste, typically through activities such as food rescue, plastic recycling, and landfill gas management. Public and private waste management organizations can generate carbon credits that can be traded in carbon markets. This not only helps in environmental conservation but also provides economic benefits through the sale of these credits.

Carbon Offset Projects' Auxiliary and Ancillary Benefits

Carbon offset projects provide multiple benefits beyond emission reductions. They often contribute to sustainable development, create jobs, and support local communities. For example, a renewable energy project can provide clean electricity to remote areas that previously relied on fossil fuels. A reforestation project can create employment opportunities for local communities and protect biodiversity.

By issuing carbon credits for these projects, the carbon market provides a financial incentive for their implementation. This helps to attract investment and support the growth of sustainable practices. Carbon offset projects also contribute to the transition to a low-carbon economy by promoting renewable energy, sustainable agriculture, and other climate-friendly activities.

How are Carbon Credits Certified?

The certification process is an essential step in issuing carbon credits and ensuring their credibility and integrity. Certification bodies are responsible for verifying that emission reduction projects meet specific criteria and standards before issuing carbon credits. This process involves a thorough assessment of the project's methodology, monitoring systems, and emission reduction calculations.

The certification process begins with project developers submitting a project design document (PDD) to the certification body. The PDD outlines the project's objectives, methodologies, and expected emission reductions. The certification body reviews the PDD and conducts an initial assessment to determine if the project meets the necessary requirements.

If the project is deemed eligible, it moves on to the validation stage. During validation, the certification body conducts an on-site visit to verify that the project is being implemented according to the approved methodology. This includes reviewing monitoring systems, data collection methods, and emission reduction calculations.

Once validation is complete, the certification body issues a validation report and registers the project with a unique identification number. The project can then begin generating carbon credits based on its verified emission reductions. These credits are typically issued in the form of tradable certificates, which can be bought and sold on the carbon market.

Examples of certification bodies include the aforementioned VCS and Gold Standard, as well as the [Climate Action Reserve](#). These organizations have established rigorous standards and guidelines for carbon credit projects and provide independent verification and certification services. By certifying carbon credits, they ensure projects meet the necessary criteria and contribute to real emission reductions.

Carbon Credits Verification

Verification is another crucial step in issuing carbon credits and ensuring their credibility and integrity. Verification bodies such as Det Norske Veritas ([DNV](#)), [SGS](#), and [TÜV SÜD](#), have extensive experience in verifying emission reduction projects and ensuring compliance with international standards. By providing independent verification services, they help to build trust in the carbon market and ensure the integrity of carbon credits.

Carbon Credits Verification Process

Verification begins with project developers submitting a verification report including detailed information on the project's emission reduction calculations, monitoring systems, and data collection methods to the verification body.

The verification body then reviews the report and conducts an independent assessment to determine if the project meets the necessary requirements.

Verification bodies may request additional information or conduct on-site visits to verify a project's data's accuracy. This includes reviewing monitoring equipment, data collection procedures, and emission reduction calculations. The verification body also checks for any potential errors or inconsistencies in the project's documentation.

Once the assessment is complete, the verification body issues a verification statement that confirms the accuracy of the project's emission reduction calculations. This statement is then used by the certification body to issue carbon credits for the project. The verification body may also provide recommendations for improving monitoring systems or data collection methods to ensure ongoing compliance with standards.

Carbon Credits - Government's Role

Governments play a crucial role in issuing carbon credits and driving emission reductions. They establish policies and regulations that set emission reduction targets for industries and sectors, and they oversee the allocation and trading of carbon credits. Government agencies are responsible for issuing and monitoring carbon credits, ensuring that they are valid and meet the necessary criteria.

Government policies on carbon credits vary from country to country, but they generally aim to incentivize emission reductions and promote sustainable practices. These policies can include cap-and-trade systems, carbon taxes, renewable energy incentives, and other measures that encourage companies to reduce their emissions. By issuing carbon credits, governments provide a tangible incentive for companies to invest in emission reduction projects.

Government agencies responsible for issuing carbon credits also vary depending on the country. In some cases, it may be a dedicated agency or department within the government that is responsible for overseeing the carbon market. In other cases, it may be a regulatory body or an environmental agency that is tasked with monitoring emissions and issuing carbon credits.

Carbon Credits - International Organizations' Role

International organizations play a significant role in issuing carbon credits and reducing emissions on a global scale. These organizations work to establish standards and guidelines for carbon credit projects, provide technical assistance to project developers, and facilitate the trading of carbon credits.

One example of an international organization involved in carbon credits is the United Nations Framework Convention on Climate Change ([UNFCCC](#)), which oversees the Clean Development Mechanism (CDM), which allows developing countries to earn carbon credits by implementing emission reduction projects. The CDM has been instrumental in promoting sustainable development and technology transfer in developing countries.

Another example is the International Civil Aviation Organization's Carbon Offsetting and Reduction Scheme for International Aviation ([CORSA](#)), which aims to offset the growth in international aviation emissions by requiring airlines to purchase carbon credits from approved projects. This initiative is expected to play a significant role in reducing emissions from the aviation sector.

Another important activity by international organizations is the funding and support for carbon credit projects. For example, the World Bank's Forest Carbon Partnership Facility ([FCPF](#)) provides financial incentives for countries to reduce emissions from deforestation and forest degradation. By issuing carbon credits for these projects, international organizations can help to mobilize private sector investment and promote sustainable development.

Carbon Credits - Private Enterprises' Role

As mentioned earlier, private entities and companies are key players in the carbon market, both as buyers and sellers of carbon credits.

Private Enterprise Carbon Credit Buyers

Many companies choose to meet compliance requirements, sustainability goals, or corporate social responsibility commitments by electing to offset their emissions through the purchase of carbon credits from projects that reduce or remove greenhouse gasses.

Private Enterprise Carbon Credit Sellers

There are also private companies that specialize in issuing carbon credits. The financial model on which these companies operate involves the development and implementation of emission reduction projects similar to the ones listed above through which they earn carbon credits for the attributable emissions reductions. These credits are then sold at a profit on carbon markets.

Examples of private companies issuing carbon credits may include:

- ▶ Renewable energy developers.
- ▶ Waste management companies.
- ▶ Forestry organizations.

Not only do these companies prove the financial incentive for others to make similar investments, and contribute to the transition to a low-carbon economy, but they also play a crucial role in promoting sustainable practices and educating for emission reductions.

Carbon Credits - Private Enterprises' Role

Private Enterprises' Role in Education

- ▶ An important aspect of private companies' involvement with carbon credits is the promotion of carbon credit projects through marketing and communication efforts - Often companies choose to highlight their carbon offset initiatives for branding purposes, as part of their sustainability strategies, or their corporate social responsibility efforts. These activities help raise awareness and encourage others to follow suit. By showcasing the benefits of carbon credits, private companies can inspire others to join the fight against climate change.

The Carbon Market Advisory

The Carbon Market Advisory: This will be the preliminary study of your renewable / CO2 removal technology / carbon sequestration project to find the entry point to local or international carbon credit markets. And selling carbon credits.

CERs are units (carbon credits) issued by UNFCCC, measured in tonnes of CO₂ equivalent.

[Carbon Credits Exchange StoneX®](#) (NASDAQ: SNEX) StoneX can help you navigate renewable energy credits (RECs) and carbon offsets.

Tesla got carbon credits! Selling regulatory credits is a tidy business for Tesla. It earns them by making and selling electric vehicles, then sells the credits to manufacturers whose new-vehicle fleets exceed emissions limits set by various authorities, including in China, the European Union and the state of California.

The Carbon Market Advisory

How Tesla Is Banking Billions In Regulatory Emissions Credits Carbon Credit

A carbon credit is a permit that allows the holding company to release a certain amount of carbon dioxide or other greenhouse gases. One load requires a mass equal to one ton of carbon dioxide to be released. The carbon allowance is one half of a "cap-and-trade" scheme.

How much is 1 carbon credit worth?

1 carbon credit is worth approximately \$40 to \$80 and as mentioned above, one carbon credit has a monetary value on the compliance and voluntary carbon markets of \$40 to \$80, on average. However, this can be expected to fluctuate greatly with supply and demand, which is also fueled by regulations.

Nuclear Power Plants - How Do They Work

Nuclear power plants generate electricity through a process called nuclear fission, which involves splitting atoms of uranium or plutonium. Here's a simplified overview of how a nuclear power plant works:

- ▶ **Nuclear Fuel:**
 - ▶ The heart of a nuclear power plant is the reactor core, where nuclear fission occurs.
 - ▶ Fuel rods containing uranium-235 or plutonium-239 are placed in the reactor core.
 - ▶ When a neutron strikes the nucleus of a uranium or plutonium atom, it can cause the nucleus to split into two smaller nuclei, releasing a large amount of energy in the form of heat.
- ▶ **Control Rods:**
 - ▶ Control rods made of materials such as boron or cadmium are inserted into the reactor core.
 - ▶ These control rods absorb neutrons, regulating the rate of the nuclear reaction.
 - ▶ By adjusting the position of the control rods, operators can control the power output of the reactor.
- ▶ **Heat Generation:**
 - ▶ As nuclear fission reactions occur in the reactor core, they produce a tremendous amount of heat.
 - ▶ This heat is used to generate steam by heating water in a separate system called the primary coolant loop.

Nuclear Power Plants - How Do They Work

▶ Steam Generation:

- ▶ The steam produced by the primary coolant loop is directed to a turbine.
- ▶ The high-pressure steam causes the turbine blades to spin.

▶ Electricity Generation:

- ▶ The spinning turbine is connected to a generator, which converts mechanical energy into electrical energy.
- ▶ The generator produces electricity, which is then transmitted to the electrical grid for distribution to homes, businesses, and industries.

▶ Cooling:

- ▶ After passing through the turbine, the steam is condensed back into water in a separate system called the secondary coolant loop.
- ▶ The condensed water is then returned to the primary coolant loop to be heated again by the reactor core.
- ▶ Heat generated during the process is often released into the environment through cooling towers or bodies of water.

Overall, nuclear power plants harness the energy released from nuclear fission to produce electricity efficiently and reliably, with minimal greenhouse gas emissions compared to fossil fuel-based power plants. However, the operation of nuclear power plants requires careful regulation and safety measures to mitigate the risks associated with radioactive materials and potential accidents.

Nuclear Plants' Power Generating Costs in The U.S. 2002-2022

- ▶ The generation of electricity through nuclear power plants in the United States costs 30.92 U.S. dollars per megawatt-hour in 2022.
- ▶ Production costs were highest in 2012, when they came to 51.22 U.S. dollars in 2022 prices, but have decreased ever since.
- ▶ Some 772 terawatt-hours of electricity is generated by U.S. nuclear plants every year.

Nuclear Power in the USA

- ▶ The USA is the world's largest producer of nuclear power, accounting for about 30% of worldwide generation of nuclear electricity.
- ▶ The country's nuclear reactors produced 772 TWh in 2022, 18% of total electrical output.
- ▶ Vogtle 3 was connected to the grid in April 2023, followed by unit 4 in March 2024.
- ▶ The Inflation Reduction Act was signed into law in August 2022. The Act provides support for existing and new nuclear development through investment and tax incentives for both large existing nuclear plants and newer advanced reactors, as well as high-assay low enriched uranium (HALEU) and hydrogen production.
- ▶ Some states have liberalized wholesale electricity markets, which makes the financing of capital-intensive power projects difficult, and coupled with lower gas prices since 2009, have put the economic viability of some existing reactors and proposed projects in doubt.

Electricity Sector

- ▶ **Total generation (in 2022):** 4502 TWh
- ▶ **Generation mix:** natural gas 1742 TWh (39%); coal 909 TWh (20%); nuclear 804 TWh (18%); wind 440 TWh (10%); hydro 286 TWh (6%); solar 189 TWh (4%); biofuels & waste 66.8 TWh; oil 41.5 TWh; geothermal 19.6 TWh.
- ▶ **Import/export balance:** 41.2 TWh net import (56.9 TWh imports; 15.7 TWh exports)
- ▶ **Total consumption:** 4071 TWh
- ▶ **Per capita consumption:** c. 12,000 kWh in 2022

Electricity Sector

- ▶ In its [Annual Energy Outlook 2022](#), the US Energy Information Administration's (EIA's) reference case shows electricity demand growth averaging 1% per year through to 2050.
- ▶ Nuclear power plays a major role in electricity provision across the country. The US fleet is operated by 30 different power companies across 30 different states. Since 2001 these plants have achieved an average capacity factor of over 90%. The average capacity factor has risen from 50% in the early 1970s, to 70% in 1991, and it passed 90% in 2002, remaining at around this level since. In 2019 it was a record 94%, compared with wind (32%) and solar PV (22%) (EIA data). The industry invests about \$7.5 billion per year in maintenance and upgrades of the plants.
- ▶ Given that nuclear plants generate nearly 20% of the nation's electricity overall and about 55% of its carbon-free electricity, even a modest increase in electricity demand would require significant new nuclear capacity in order to maintain this share. If today's nuclear plants retire after 60 years of operation, 22 GWe of new nuclear capacity would be needed by 2030, and 55 GWe by 2035 to maintain a 20% nuclear share.

How Are Fossil Fuels Used To Generate Electricity in the USA

- ▶ In the USA, fossil fuels are a major source of electricity generation, accounting for a significant portion of the country's energy mix. The primary fossil fuels used for electricity generation in the USA are coal, natural gas, and, to a lesser extent, petroleum. Here's how each of these fossil fuels is used to generate electricity:
- ▶ Coal:
 - ▶ Coal-fired power plants are one of the oldest and most common methods of generating electricity in the USA.
 - ▶ Coal is typically pulverized into a fine powder and then burned in a boiler to produce steam.
 - ▶ The steam produced from burning coal is used to drive a turbine connected to a generator, which converts mechanical energy into electrical energy.
 - ▶ Coal-fired power plants often use technologies such as flue gas desulfurization (scrubbers) and electrostatic precipitators to reduce emissions of sulfur dioxide (SO₂), nitrogen oxides (NO_x), and particulate matter.

How Are Fossil Fuels Used To Generate Electricity in the USA

▶ Natural Gas:

- ▶ Natural gas-fired power plants have become increasingly popular in the USA due to the abundance of natural gas resources and advancements in gas turbine technology.
- ▶ Natural gas can be burned directly in a gas turbine to produce mechanical energy, which is then used to drive a generator to produce electricity (known as simple cycle gas turbine).
- ▶ Alternatively, natural gas can be used in combined-cycle power plants, where the exhaust heat from a gas turbine is captured to generate steam, which drives a steam turbine connected to a generator (known as combined-cycle gas turbine).
- ▶ Combined-cycle power plants are more efficient than simple cycle plants and are often used for baseload and peaking power generation.

How Are Fossil Fuels Used To Generate Electricity in the USA

▶ Petroleum:

- ▶ Petroleum (primarily in the form of fuel oil) is used less frequently than coal and natural gas for electricity generation in the USA, primarily due to its higher cost and environmental concerns.
- ▶ Petroleum-fired power plants operate similarly to natural gas-fired plants, where the fuel is burned to produce steam that drives a turbine connected to a generator.
- ▶ Petroleum-fired power plants are typically used as backup or emergency generators or in regions where other fuel sources are not readily available.

Overall, fossil fuel-fired power plants play a significant role in meeting electricity demand in the USA, providing baseload, intermediate, and peaking power generation. However, concerns about air pollution, greenhouse gas emissions, and climate change have led to increased interest in cleaner and renewable energy sources as alternatives to fossil fuels for electricity generation.

Fossil fuels are the largest sources of energy for electricity generation

- ▶ Natural gas was the largest source—about 40%—of U.S. electricity generation in 2022. Natural gas is used in steam turbines and gas turbines to generate electricity.
- ▶ Coal was the third-largest energy source for U.S. electricity generation in 2022—about 18%. Nearly all coal-fired power plants use steam turbines. A few coal-fired power plants convert coal to a gas for use in a gas turbine to generate electricity.
- ▶ Petroleum was the source of less than 1% of U.S. electricity generation in 2022. Residual fuel oil and petroleum coke are used in steam turbines. Distillate—or diesel—fuel oil is used in diesel-engine generators. Residual fuel oil and distillates can also be burned in steam and gas turbines.

Cost of Operating Plants Powered by Fossil Fuels

- ▶ EIA sorted these coal plants into three groups based on their average operating and maintenance costs. The highest cost group operated at costs ranging from \$28 per megawatthour (MWh) to \$40/MWh, and the lowest cost group operated at \$20/MWh to \$26/MWh. A middle group operated near the fleet average, ranging from \$26/MWh to \$28/MWh from 2008 through 2017.
- ▶ The costs to run and maintain a power plant in the United States varies greatly by the type of power plant being operated. In 2017, an advanced nuclear power plant had fixed costs that totaled about 101.28 U.S. dollars per kilowatt per year, while its variable costs reached 2.32 U.S. dollars per megawatt hour. In comparison, a conventional gas/oil combination cycle plant has about 11.11 U.S. dollars per kilowatt per year in fixed costs with 3.54 U.S. dollars per megawatt hour in variable costs.
- ▶ Fixed costs of power plants generally include capital and land costs, which include labor as well as costs associated with obtaining approvals and permits. Variable operating costs depend on the amount of energy produced by the plant. For fossil fuel plants, fuel costs make up most of the rest of the operating costs. In contrast, renewables tend to have no fuel costs, with the exception of biomass, and nuclear power plants also tend to have very low fuel costs. Labor and maintenance costs tend to make up the bulk of operational costs for these plants.

Renewable Sources of Energy Production

- How Do They Work?

Renewable sources of energy production harness naturally replenishing resources to generate electricity. Unlike fossil fuels, which are finite and produce greenhouse gas emissions when burned, renewable energy sources offer clean, sustainable alternatives for meeting energy needs. Here's an overview of how some common renewable energy sources work:

▶ Solar Energy:

- ▶ Solar energy is generated by capturing sunlight and converting it into electricity using photovoltaic (PV) panels or concentrating solar power (CSP) systems.
- ▶ PV panels contain semiconductor materials that absorb sunlight and generate direct current (DC) electricity through the photovoltaic effect.
- ▶ In CSP systems, mirrors or lenses focus sunlight onto a receiver, where the concentrated heat is used to generate steam and drive a turbine connected to a generator.
- ▶ Solar energy systems can be installed on rooftops, in solar farms, or in utility-scale solar power plants, providing clean electricity for residential, commercial, and industrial applications.

Renewable Sources of Energy Production

- How Do They Work?

▶ Wind Energy:

- ▶ Wind energy is generated by harnessing the kinetic energy of wind to drive wind turbines and generate electricity.
- ▶ Wind turbines consist of blades mounted on a rotor connected to a generator.
- ▶ When the wind blows, it causes the blades to rotate, spinning the rotor and generating electricity.
- ▶ Wind farms, consisting of multiple wind turbines, are often installed in areas with strong and consistent wind patterns, such as coastal regions or open plains.
- ▶ Wind energy is a widely deployed renewable energy source and contributes significantly to electricity generation in many countries.

▶ Hydropower:

- ▶ Hydropower, or hydroelectric power, is generated by capturing the energy of flowing water and converting it into electricity.
- ▶ Hydropower plants typically consist of dams, reservoirs, turbines, and generators.
- ▶ When water is released from a reservoir and flows through turbines, the kinetic energy of the moving water is converted into mechanical energy, which drives the turbines and generates electricity.
- ▶ Hydropower plants can vary in size from small-scale run-of-river installations to large-scale dams with reservoirs for storing water and regulating electricity generation.

Renewable Sources of Energy Production

- How Do They Work?

▶ Biomass Energy:

- ▶ Biomass energy is generated from organic materials such as wood, agricultural residues, and municipal solid waste.
- ▶ Biomass can be burned directly to produce heat or converted into biogas through anaerobic digestion or thermochemical processes.
- ▶ Biogas can be used to generate electricity in gas turbines or internal combustion engines, or it can be upgraded to biomethane and injected into natural gas pipelines.
- ▶ Biomass energy provides a renewable and potentially carbon-neutral source of electricity and heat, depending on the feedstock and production process.

These renewable energy sources offer sustainable alternatives to fossil fuels for electricity generation, helping to reduce greenhouse gas emissions, mitigate climate change, and promote energy independence. Additionally, advancements in technology and decreasing costs have made renewable energy increasingly competitive with conventional energy sources in many parts of the world.

Renewable Sources of Energy Production

- Costs

AVERAGE RENEWABLE ENERGY COSTS

- ▶ While coal is at \$102/MWh - on average, renewable energy costs in comparison are as follows:
- ▶ Wind power: \$20/MWh
- ▶ Solar power: \$37/MWh
- ▶ Hydro power: \$85/MWh

Converting the entire U.S. power grid to 100 percent renewable energy in the next decade is technologically and logistically attainable, and would cost an estimated \$4.5 trillion, according to a [recent analysis](#). According to the [Greentech Media reports](#), the estimate represents the cost of replacing all fossil fuels and nuclear power with hydroelectricity, biomass, geothermal, wind, and solar. The price tag would drop to \$4 trillion if nuclear were allowed to remain part of the energy mix.

Renewable Sources of Energy Production

- Costs

To achieve 100 percent renewable energy over the next 10 years, the analysis finds that there would first have to be a massive buildout of wind and solar capacity, costing \$1.5 trillion. Next, the U.S. would need to add 900 gigawatts of battery storage, raising the price tag to \$4 trillion. Lastly, the U.S. would need to double its transmission lines – from 200,000 miles today to 400,000 miles – to handle the new distributed power system, costing another \$700 billion.

The estimate is based on current technology and does not factor in future innovation, according to Greentech Media. Analysts at Wood Mackenzie also found that the \$4.5 trillion price tag stays the same whether the U.S. completes the transition in 10 years or 20.

Renewable Sources of Energy Production

- ▶ Wind energy was the source of about 10.2% of total U.S. utility-scale electricity generation and accounted for 47.6% of electricity generation from renewable sources in 2022. Wind turbines convert wind energy into electricity.
- ▶ Hydropower plants produced about 6.2% of total U.S. utility-scale electricity generation and accounted for 28.7% of electricity generation from renewable sources in 2022. Hydropower plants use flowing water to spin a turbine connected to a generator.
- ▶ Solar energy provided about 3.4% of total U.S. utility-scale electricity and accounted for 15.9% of utility-scale electricity generation from renewable sources in 2022. Photovoltaic (PV) and solar-thermal power are the two main types of solar electricity generation technologies. PV conversion produces electricity directly from sunlight in a photovoltaic cell. Most solar-thermal power systems use steam turbines to generate electricity. EIA estimates that about 0.06 trillion kWh of electricity were generated with small-scale solar photovoltaic systems.
- ▶ Biomass was the source of about 1.3% of total U.S. utility-scale electricity generation and accounted for 5.9% of electricity generation from renewable sources in 2022. Biomass is burned directly in steam-electric power plants, or it can be converted to a gas that can be burned in steam generators, gas turbines, or internal combustion engine generators.
- ▶ Geothermal power plants produced about 0.4% of total U.S. utility-scale electricity generation and accounted for 1.9% of electricity generation from renewable sources in 2022. Geothermal power plants use steam turbines to generate electricity.

Comparison of CMPES With Other Forms of Energy Sources

- ▶ In an era where the need for sustainable energy solutions is paramount, Continuous Motion Power Extraction Systems (CMPES) stand out as a pioneering technology offering numerous advantages over traditional energy sources. CMPES devices harness kinetic energy from natural phenomena such as wind, ocean currents, and river flows, offering a plethora of benefits that outshine conventional fossil fuels and even renewable sources like wind, solar, hydro, biomass, and geothermal energy. Here's why CMPES devices represent the future of energy generation:
- ▶ **Efficiency and Reliability:** CMPES devices boast exceptional efficiency and reliability. Unlike intermittent renewable sources such as wind and solar, CMPES systems operate continuously, ensuring a stable and reliable energy supply. By harnessing the perpetual motion of natural phenomena, CMPES devices guarantee consistent energy production regardless of weather conditions or time of day.
- ▶ **Environmental Sustainability:** One of the most significant advantages of CMPES technology is its minimal environmental impact. Unlike fossil fuels, which contribute to air and water pollution and exacerbate climate change, CMPES devices produce clean energy with virtually no greenhouse gas emissions or harmful byproducts. By mitigating environmental degradation and reducing carbon footprints, CMPES devices play a crucial role in combating climate change and preserving ecosystems.

Comparison of CMPES With Other Forms of Energy Sources

- ▶ **Cost-Effectiveness:** CMPES technology offers compelling cost advantages over traditional energy sources. While fossil fuel extraction and combustion entail substantial operational and environmental costs, CMPES devices leverage natural kinetic energy at minimal ongoing expenses. Moreover, with advancements in manufacturing and deployment processes, the upfront costs of CMPES installations continue to decline, making them increasingly competitive with conventional energy sources. Compared to traditional energy sources such as energy sources fueled by fossil fuels or solar or wind, the cost of operating CMPES devices is \$____/MWh, making it far cheaper. Moreover, the developmental cost associated with CMPES devices is far lesser, being ____\$, compared to other sources of energy production, which by comparison are way higher.
- ▶ **Scalability and Adaptability:** CMPES devices are highly scalable and adaptable to diverse geographic locations and energy demands. Whether deployed offshore to harness ocean currents, along riverbanks to utilize hydrokinetic energy, or in urban environments to capture kinetic energy from traffic, CMPES systems can be tailored to specific settings and requirements. This versatility ensures widespread accessibility and applicability, empowering communities to transition towards sustainable energy solutions.
- ▶ **Technological Innovation and Potential:** As a nascent technology, CMPES represents a frontier of innovation and potential for further advancements. Ongoing research and development efforts aim to enhance the efficiency, durability, and cost-effectiveness of CMPES devices, paving the way for greater adoption and integration into global energy infrastructures. With continuous innovation, CMPES technology holds the promise of revolutionizing the energy landscape and catalyzing the transition towards a renewable energy future.

In conclusion, Continuous Motion Power Extraction Systems (CMPES) emerge as a transformative solution poised to supplant traditional energy sources and accelerate the transition towards a sustainable and resilient energy ecosystem. By harnessing the kinetic energy of natural phenomena with unparalleled efficiency, reliability, and environmental stewardship, CMPES technology represents a beacon of hope for a brighter and greener future.