CIF CLIMATE INVESTMENT FUNDS

CTF COST OF RENEWABLE ENERGY TECHNOLOGIES

An in-depth analysis of the cost of the different renewable energy technologies in the CTF portfolio

// June 2023

RESULTS DEEP DIVE SERIES//

CIF Program: Clean Technology Fund (CTF)

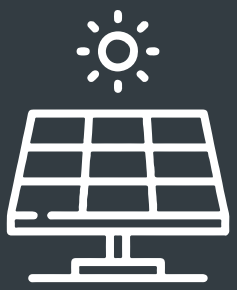
TOPICS

- Results and Impact
- Clean Technology
- Renewable Energy

RESULTS: CAPACITY-WEIGHTED CONSTRUCTION COSTS

HIGHEST COST PER MW

Energy Storage



Solar

Geothermal

Need continued concessional finance support

LOWEST COST PER MW

Wind

Technology becoming mainstream

AVERAGE DOLLAR PER MW OF INSTALLED CAPACITY IN THE CTF PORTFOLIO

Disaggregated by technology	Energy storage	Solar	Geo-thermal	Mixed	Multiple	Wind
CTF Financing Share	$0.80 Mn	$0.38 Mn	$0.42 Mn	$0.69 Mn	$0.36 Mn	$0.31 Mn
Total Project Cost	$6.17 Mn	$3.99 Mn	$3.28 Mn	$2.91 Mn	$2.88 Mn	$2.80 Mn

ACKNOWLEDGMENTS

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RESULTS DEEP DIVE SERIES

The Climate Investment Funds (CIF) is committed to rigorous and inclusive monitoring and reporting (M&R) on investments' contributions toward net-zero emissions and adaptive, climate-resilient, just, and socially inclusive development pathways. The M&R Results Deep Dive series is a supplement to CIF's annual results reports — while annual M&R provides a systematic synthesis of portfolio performance against each program's core indicators, the Deep Dives provide in-depth reviews of these results within specific thematic or developmental dimensions of climate change. As such, they offer greater granularity on the drivers and implications of various performance characteristics.

1. INTRODUCTION

Renewable energy (RE) generation (e.g., from solar, wind, hydro, and geothermal sources) is a critical sector for climate change mitigation and the global transition to net-zero emissions. However, the introduction of RE technologies to new markets with well-established conventional thermal technologies includes substantial first-mover and teething costs for upfront construction outlays (proxy costs for the United States, which has a growing RE market, are: US$1,655 per megawatt (MW) for solar facilities; US$1,498/MW for wind; US$1,116/MW for natural gas plants; and US$795/MW for oil-fired);[1] infrastructure for RE integration; and technological and know-how imports, among others.[2] Such costs can be prohibitive for the development of new assets, particularly in developing countries with nascent or historically limited investment flows in RE. To bridge this gap, multiple climate funds invest in RE projects in emerging economies, aiming to increase uptake, and spur scaling and replication effects that can make RE cost-competitive against traditional thermal sources.

This Results Deep Dive focuses on results achieved by the Climate Investment Funds' (CIF) Clean Technology Fund (CTF) and examines the average investment value (in USD) per MW of installed capacity, differentiated by technology type. The CTF provides resources to support large and utility-scale investments in clean technology projects in low- and middle-income countries (Figure 1 displays the CTF portfolio by technology type). The resources contribute to financing the demonstration, deployment, and transfer of low-carbon technologies with significant potential for reducing long-term greenhouse gas (GHG) emissions. For RE projects, CTF's concessional financing facilitates demonstration of the viability of the underlying technologies and bears most of the contextual risks by crowding in investment from other sources. The goal is that, in the long-term, once costs and risks have been reduced, deploying RE technologies in emerging markets will no longer require third-party concessional finance.

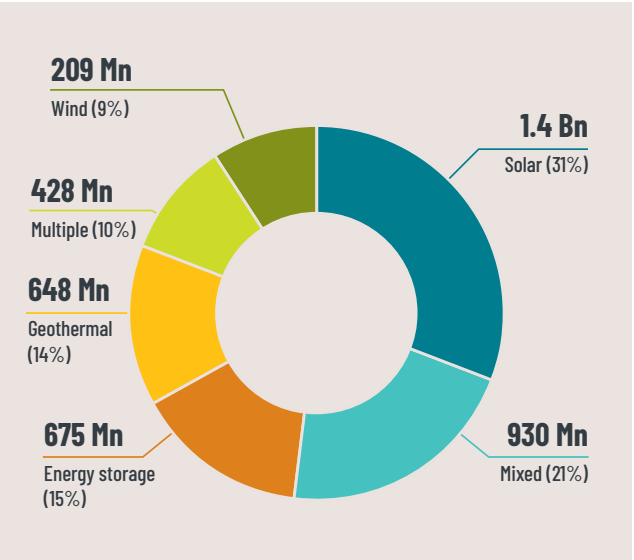

FIGURE 1. CTF financing by technology type

Source: CTF financing data for RE projects

The following analysis is based on all approved RE and mixed RE-energy efficiency CIF projects with a target for delivering installed capacities. The analysis draws on project reports submitted to CIF by the multilateral development banks (MDBs). Technologies are analyzed by energy source, and are divided into the categories of geothermal, hydro, solar, wind, and other.[3]

2. RESULTS OVERVIEW

Over the past five years, the CTF has added over 7.2 gigawatts (GW) of installed capacity, bringing the cumulative total to 12.4 GW. At the inception of the fund, wind and hydro made up most of the installed capacity in the CTF portfolio. However, over time, solar and mixed have increasingly come to dominate the portfolio, highlighting its evolving nature and shifts in the types of projects supported (Figure 2 shows the change in distribution over time).

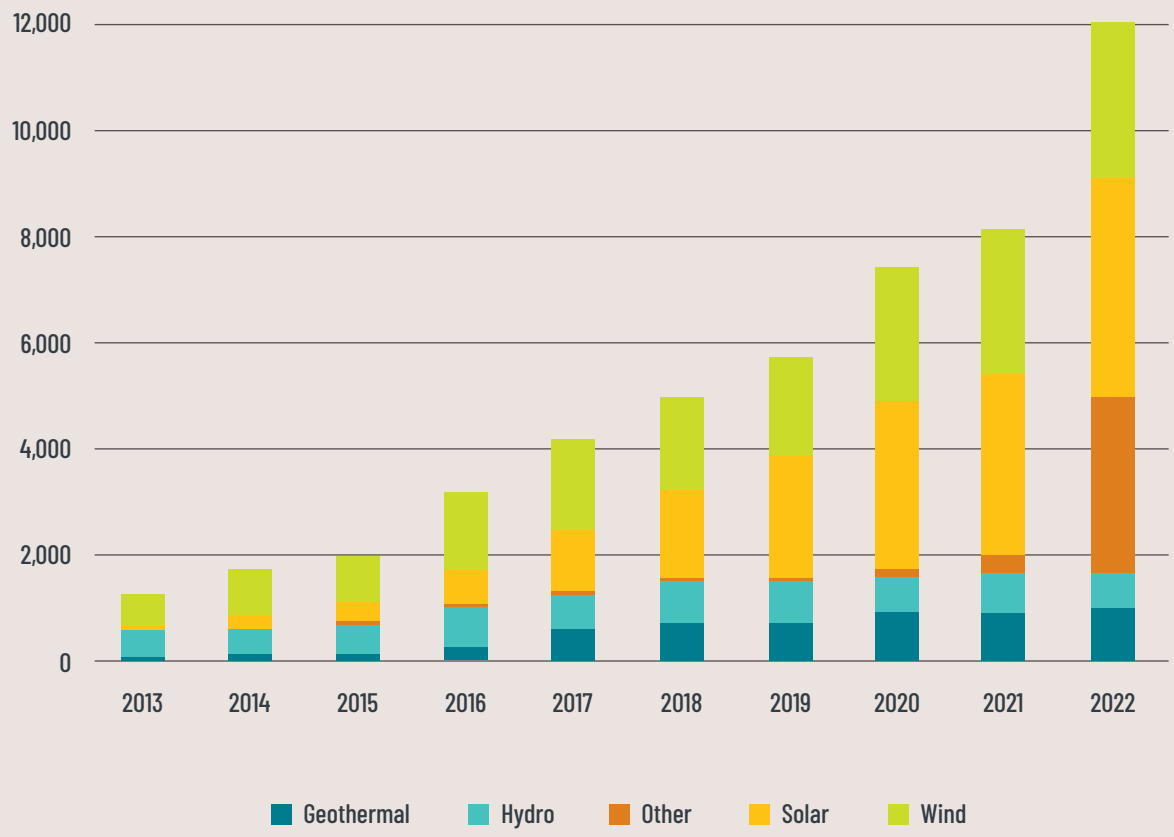

FIGURE 2. Breakdown of achieved cumulative installed capacity, disaggregated by source

Source: CTF results data

3. DEEP DIVE RESULTS: COST PER MW BY RE TECHNOLOGY

The cost of RE has fallen significantly in the past 20 years, primarily due to more competitive economies of scale and technological innovations.[4] As more RE technologies are deployed, prices should continue falling, making them more competitive, increasing demand, and thus leading to further innovation and deployment.[5] However, the prices for some conventional fossil fuels, such as natural gas, are still lower than RE prices.

TABLE 1. Capacity-weighted average construction costs by technology type[6]

Technology	Cost
Solar	$1.8 million
Onshore Wind	$1.4 million
Natural Gas	$1.1 million
Geothermal	$4–5 million

Source: EIA

An analysis of the CTF portfolio found that, within generation technologies, the lowest investment cost per MW was in wind, driven by innovations in wind technology and cost reductions in the supply chain (see Figure 2 for details).[7] This is congruent with the wider market data, (the average price per MW of solar is US$1.8 million versus US$1.4 million for onshore wind), as shown in Table 1 above.[8]

Outside of renewable energy investments, the cost of energy storage projects, which contribute to the increased absorption and integration of variable RE supply, is high per MW of installed storage capacity. The price for energy storage technologies, however, has fallen significantly due to reduction of costs in lithium technologies.[9] Many newly approved CTF projects, beyond the recently launched Global Energy Storage Program (GESP), incorporate the use of energy storage in their RE projects. Prior to 2016, no energy storage projects were approved under the CTF. Nevertheless, between 2016 and 2022, energy storage projects accounted for 17 percent of the total project approvals. For example, the DPSP III Renewable Energy and Access Project (REAP) in Burkina Faso, which was approved in 2021, and aims to increase the usage of solar energy for energy access in rural areas, includes a sub-component to promote energy storage technologies.

In general, the cost per MW of installed capacity is driven by the maturity of the technology in use. Newer technologies, which may be regarded as relatively unproven, and lack the innovation to drive down costs in the supply chain and improve efficiency, are relatively more expensive.[10]

TABLE 2. Average dollar per MW of installed capacity in the CTF portfolio, disaggregated by technology[11]

Technology[12]	Average Dollar per MW – CTF Financing Share (millions $)	Average Dollar per MW – Total Project Cost (millions $)[13]
Energy Storage[14]	0.80	6.17
Solar	0.38	3.99
Geothermal	0.42	3.28
Mixed[15]	0.69	2.91
Multiple[16]	0.36	2.88
Wind	0.31	2.80

Source: CTF financing and results data

Khalladi Wind Farm, Tangier, Morocco

3.1 Generation Capacities: Wind

Because of the increased competition and innovation, the price of wind energy has decreased significantly.[17] Together with other advances in the sector (e.g., increases in project size; increases in turbine size; and lower capital costs), CTF investments have supported efforts to effectively mitigate key risks. In a majority of cases, therefore, concessional financing may no longer be necessary to deliver wind investments in emerging markets due to technological advances such as innovations in wind turbine designs, which are now larger in size, and therefore produce more electricity.[18] This shift is also reflected in the fact that wind projects no longer feature in recent CTF project approval requests, and in wind's decreasing share of added capacity within the CTF portfolio, from 47 percent in reporting year 2013, to 25 percent in 2023. The average cost per installed capacity for the first set of wind projects, approved in 2010, reached US$2 million per MW, while the wind project approved in 2014 cost around US$1.8 million per MW of installed capacity, highlighting the gradual decline in the cost of this technology. Meanwhile the share of other, relatively higher-cost technologies (e.g., geothermal), continues to increase.

3.2 Generation Capacities: Solar

While the cost of solar installations has declined over time, Concentrated Solar-Thermal Power (CSP) remains more expensive than wind energy. Solar accounts for the largest share of achieved installed capacity in the CTF portfolio (33 percent), including solar photovoltaic (SPV) (27 percent) and CSP (6 percent) technologies. CSP projects have a slightly higher investment cost per MW than SPV projects (US$0.450 vs US$0.350, respectively) given that CSP projects, whose average project size is larger (average of $2.9 billion for an SPV project versus $6.5 billion for a CSP), require additional components such as steam turbines and thermochemical reactors. These capital costs raise total cost factors, congruent with larger market data, whereas the average expected installed capacity is lower (972 MW for SPV projects versus 286 MW for CSP projects).[19] Despite the higher cost of CSP, energy storage is less of an issue due to the inclusion of Thermal Energy Storage technologies (TES). The use of TES provides a more stable source of energy in comparison to a conventional SPV, which requires a very costly battery storage system. [20,21]

3.3 Generation Capacities: Geothermal

The share of achieved capacity in geothermal power has been increasing in the CTF portfolio. Geothermal projects require a longer implementation process before becoming fully operational. At the end of 2014, geothermal installed capacities represented around 3 percent of the CTF total; by the end of 2021, this figure had grown to 8 percent, and is expected to continue increasing as more projects, approved early in the portfolio, mature to become operational.

While geothermal power has also seen global cost reductions over time, costs for this technology remain higher than for other RE technologies such as wind and solar.[22,23] This is largely driven by pre-operational risks and costs. Indeed, establishing the full steam potential of a geothermal asset requires an exploration phase, which raises the risk profile. Consequently, the exploration phase needs drilling technologies to gauge the steam potential. This phase can account for over 15 percent of the overall project cost, and the process alone can take up to three years.[24,25] Thus, while the cost has fallen over time, geothermal technology entails a high level of risk due to significant upfront investment in equipment.[26] Geothermal projects, therefore, entail continued concessional support to ramp up potential. Geothermal energy is not dependent on weather; thus, once established, it is a promising green power source that can deliver high capacity around the clock at low running cost.[27]

3.4 Energy Storage

The cost of energy storage technologies, per MW of installed capacity, significantly exceeds that of generation technologies. There are two underlying reasons for this; first, the price of lithium-ion batteries remains high, although it has fallen significantly, and is expected to continue to fall in the coming years.[28] Second, limited innovation has occurred to date to improve the energy density (the amount of electrical energy that is stored in a unit of battery) of existing energy storage technologies.[29]

Yet, this higher cost is balanced by the technology's significant transformational properties, which enable greater energy generation via the multiplicative effects of storing excess RE produced at off-peak hours, and allow for smoothing out solar and wind's inherent natural intermittency.[30] Therefore, energy storage is critical to unlock the full potential of green and renewable energy sources and thereby to mitigate climate change; this goal drives CTF's priority to support such projects to bring down their cost, reduce risks, and crowd in financing from other parties, including the private sector.

Cerro Pabellón Geothermal Plant, Chile

4. CHALLENGES AND CONSIDERATIONS

Each technology, and the related CTF investments in this technology, presents a complex picture, in which different factors are weighed against one another to determine the imperatives of investment. For example, energy storage has by far the highest cost of the technologies analyzed in this Results Deep Dive — partly because the underlying technology is relatively new. However, it holds important potential benefits because of its capacity to complement and multiply the benefits of variable energy sources. Similarly, geothermal involves high upfront costs and additional risk, yet it has unique benefits due to its ability to deliver around-the-clock baseload power.

The shifts in portfolio distribution, in response to shifting costs and needs, highlight the need for climate fund portfolios to remain dynamic and flexible. This entails de-emphasizing some technologies, as they become more mainstream and more successful in attracting private sector investment (as seen with wind) while increasing investment in, support of, and focus on other new technologies, particularly those that can complement and multiply the benefits of more established technologies.

Theppana Wind Farm, Thailand

ENDNOTES

1 Proxy data for the United States via the U.S. Energy Information Administration, Form EIA-860, *2020 Annual Electric Generator Report.*

2 Puyeyo, A., and Linares, P. 2012. Renewable Technology Transfer to Developing Countries: One Size Does Not Fit All. Institute of Development Studies: IDS Working Paper 412.

3 Other can refer to renewable energy sources not listed above, such as biomass, or sources that are undetermined at project inception.

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10 Ritchie, Hannah. The price of batteries has declined by 97% in the last three decades. https://ourworldindata.org/battery-price-decline. 2021. Our World in Data.

11 Based on all renewable energy projects in the CTF portfolio

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13 Total project financing, including components not related to the renewable part, such as technical assistance and capacity building.

14 While renewable energy from energy storage comes from the technologies listed, this analysis specifically looks at the MW average dollar per MW from energy storage projects, regardless of the source.

15 *Mixed* refers to projects supporting the integration of different types of renewable energy into the grid.

16 *Multiple* refers to projects that have a variety of subprojects that work on different technologies.

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28 Ritchie, Hannah. The price of batteries has declined by 97% in the last three decades. https://ourworldindata.org/battery-price-decline. 2021. Our World in Data.

29 Ibid.

30 Govindarajalu, C., De Sisternes, F., and Chavez, S. 2021. Stationary Energy Storage to Transform Power Systems. in Developing Countries. World Bank. https://openknowledge.worldbank.org/bitstream/handle/10986/35666/Stationary-Energy-Storage-to-Transform-Power-Systems-in-Developing-Countries.pdf

THE CLIMATE INVESTMENT FUNDS

The Climate Investment Funds (CIF) is one of the largest multilateral climate funds in the world. It was established in 2008 to mobilize finance for low-carbon, climate-resilient development at scale in developing countries. Fifteen contributor countries have pledged over US$11 billion to the funds. To date CIF committed capital has mobilized more than $64 billion in additional financing, particularly from the private sector, over 70 countries. CIF's large-scale, low-cost, long-term financing lowers the risk and cost of climate financing. It tests new business models, builds track records in unproven markets, and boosts investor confidence to unlock additional sources of finance. Recognizing the urgency of CIF's mission, the G7 confirmed its commitment to provide up to $2 billion in additional resources for CIF in 2021.

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