SUSTAINABLE DATA CENTERS ROADMAP

Preface

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ICEF
Innovation for Cool Earth Forum

PRAISE FOR THE ICEF ROADMAPS

The ICEF roadmaps "provide essential information on different aspects of our energy systems and how they might change over time. I recommend them for anyone interested in this challenging topic."
Vaclav Smil — energy historian and Distinguished Professor, University of Manitoba

"The ICEF Roadmaps provide important research on a wide range of technologies for helping achieve net zero emissions. They are an important resource for anyone working on these issues."
Hoesung Lee — former Chair, Intergovernmental Panel on Climate Change

"The ICEF Roadmaps...are an excellent resource for researchers and practitioners who cross disciplinary boundaries to develop transformative solutions for climate change."
Alissa Park — Dean, UCLA School of Engineering

"Climate challenges are vast, and AI can accelerate solutions across domains. The *[ICEF Artificial Intelligence for Climate Change Roadmap (Second Edition)](#)* delivers an unprecedented, rigorous catalog of AI applications, both clarifying today's state of play and preparing us for the opportunities and demands of tomorrow."
Nicole Iseppi — Director of Energy Innovation, Bezos Earth Fund

"The application of AI solutions to climate mitigation is a crucial new front in the battle against climate change. Through our work across this ecosystem, we have found no better researched or more comprehensive framework in this critical area than the *[ICEF Artificial Intelligence for Climate Change Roadmap (Second Edition)](#)*"
Uday Khemka — Chairman, The Green Artificial Intelligence Learning Network

"The ICEF Roadmaps have covered topics vital to fighting climate change, including CO_2 utilization, direct air capture and carbon mineralization. I urge anyone working on these topics to study these roadmaps, which have been foundational for our work."
Larry Linden — Trustee, Advocates for Climate Innovation

PREFACE

Investment in data centers is booming. Several forecasts project that trillions of dollars will be spent on data centers and related infrastructure in the years ahead.[1-3] These investments are fueled by the explosive growth in attention to artificial intelligence (AI), as well as data centers' central role in much of the modern economy, including in e-commerce, email systems, video streaming and more.

This surging investment is raising concerns about data centers' energy and environmental impacts. Data centers use enormous amounts of electricity, creating challenges for electric grids in many regions. That electricity can and often does produce greenhouse gases and local air pollutants. Data centers also use water, result in electronic waste and often change land use patterns. These impacts have led to growing local opposition to new data centers in many countries.

At the same time, data centers' electricity demand can help accelerate adoption of clean energy. Data center owners and operators are the world's largest purchasers of solar and wind power. Several hyperscale data center owners are investing in innovative low-carbon power technologies in the hopes of bringing these technologies to market more quickly. Work is underway to turn flexible load at some data centers into grid assets.

This year's ICEF Roadmap explores these topics. In this Roadmap, a team of 12 coauthors examine data centers' energy use, strategies for improving data centers' energy efficiency, greenhouse gas emissions from data centers, strategies for using data centers to accelerate deployment of low-carbon power, data centers' water use and government data center policies around the world, as well as related topics. The Roadmap offers specific, actionable recommendations in each chapter. Our goal is to provide a useful resource for experts and non-experts alike.

This Roadmap builds on the body of literature produced annually in connection with the ICEF conference. Previous ICEF Roadmaps have addressed the following topics:

- Artificial Intelligence for Climate Change Mitigation (Second Edition) (2024)

- Artificial Intelligence for Climate Change Mitigation (2023)

- Low-Carbon Ammonia (2022)

- Blue Carbon (2022)

- [Carbon Mineralization](#) (2021)

- [Biomass Carbon Removal and Storage (BiCRS)](#) (2020)

- [Industrial Heat Decarbonization](#) (2019)

- [Direct Air Capture](#) (2018)

- [Carbon Dioxide Utilization](#) (2017 and 2016)

- [Energy Storage](#) (2017)

- [Zero Energy Buildings](#) (2016)

- [Solar and Storage](#) (2015)

The ICEF Innovation Roadmap Project aims to contribute to the global dialogue about solutions to the challenge of climate change. We welcome your thoughts, reactions and suggestions.

David Sandalow
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1. Jesse Noffsinger, et al. The cost of compute: A $7 trillion race to scale data centers. 2025 Published by McKinsey & Company; Available from https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/the-cost-of-compute-a-7-trillion-dollar-race-to-scale-data-centers.

2. Vivian Lee, et al. Breaking Barriers to Data Center Growth. 2025 Published by Boston Consulting Group; Available from https://web-assets.bcg.com/pdf-src/prod-live/breaking-barriers-data-center-growth.pdf.

3. John Minnix. 255 Data Center Stats (September-2025) (Brightlio Blog). 2025 Published by Brightlio; Available from https://brightlio.com/data-center-stats/.

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