

An aerial view of a city at dusk, with a blue network overlay of glowing nodes and lines connecting various points across the cityscape. The text "POWERED BY Cambium" is overlaid on the left side of the image.

POWERED BY
Cambium

Cambium Datasets

Pieter Gagnon

National Renewable Energy Laboratory

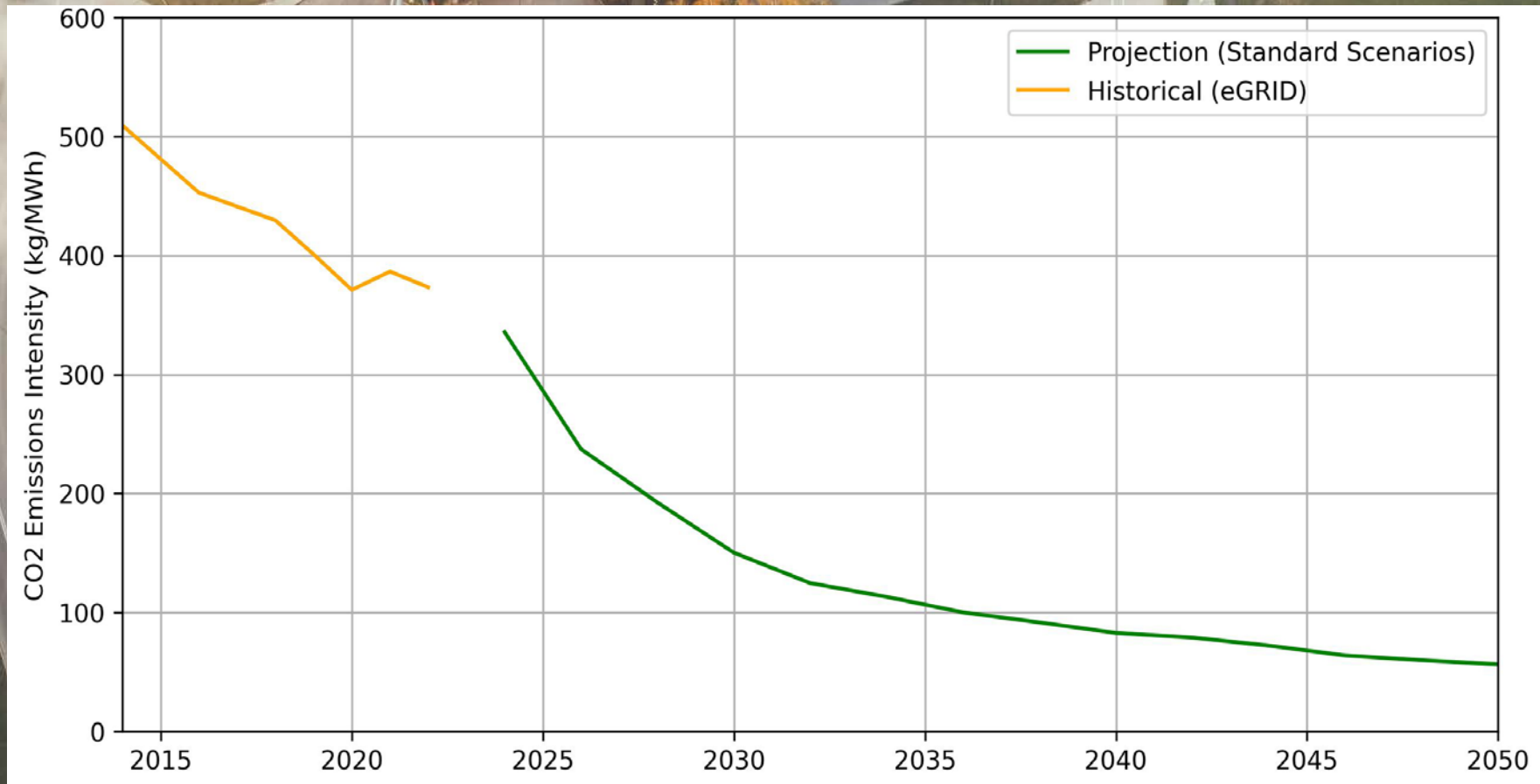
Aug. 13, 2024

Forward-looking analysis...



...with a changing
electric grid.

Example: Grid Emissions Intensity Over Time



What Is Cambium?

- Annually-updated database
- 5th edition upcoming
- 6 business-as-usual-style scenarios, 2 decarbonization projections

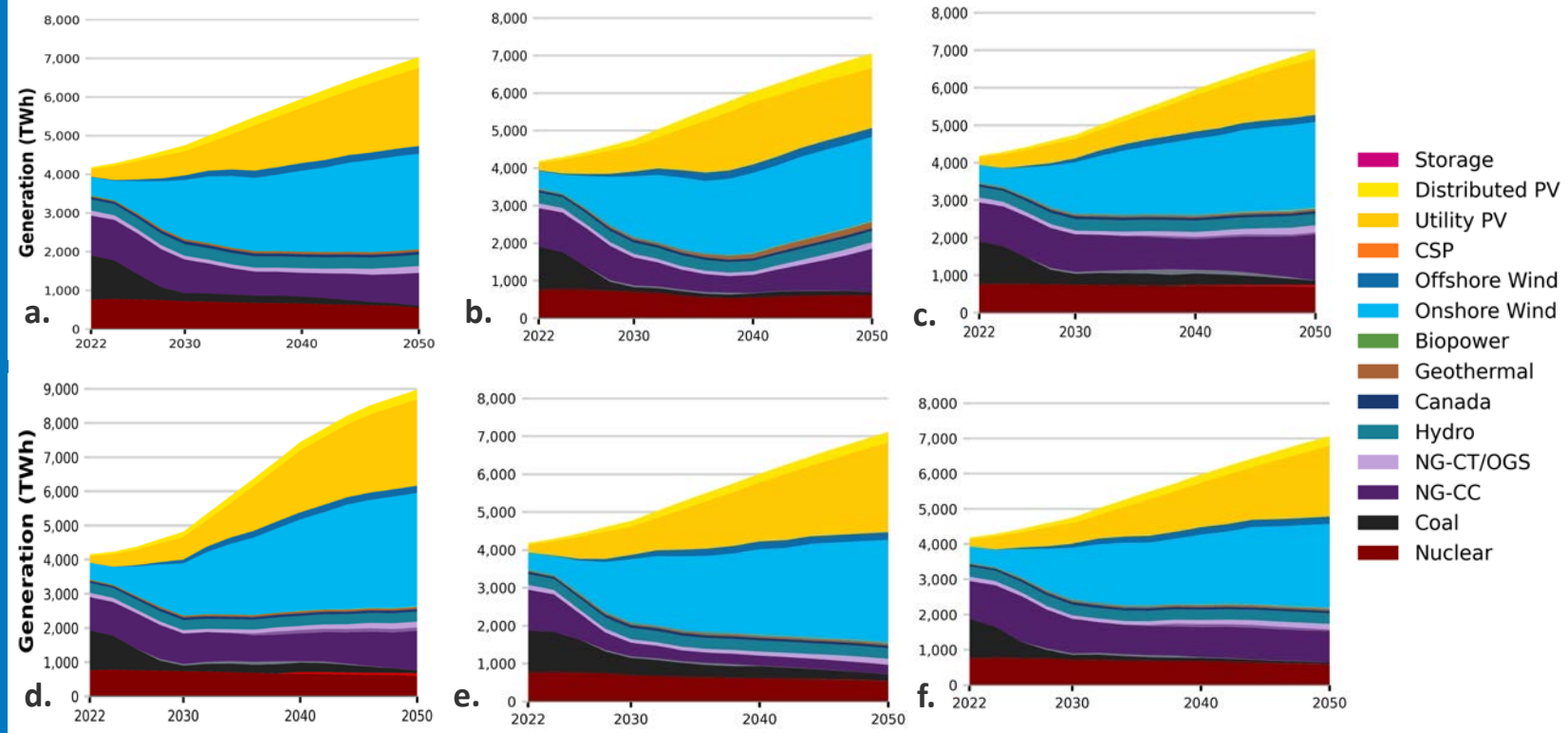
“Business-As-Usual” Cases:

- a. Mid-Case
- b. Advanced Renewable Energy
- c. Conservative Renewable Energy
- d. High Demand Growth
- e. High Gas Prices
- f. Low Gas Prices

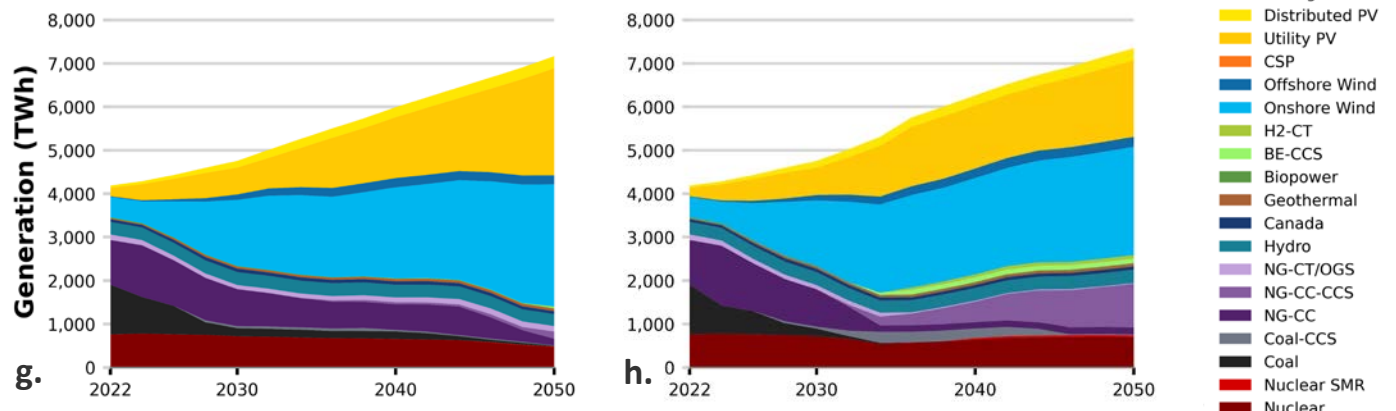
Decarbonization Cases:

- g. 95% by 2050
- h. 100% by 2035

Six “Business-As-Usual” Style Projections



Two National Decarbonization Projections



What Is Cambium?

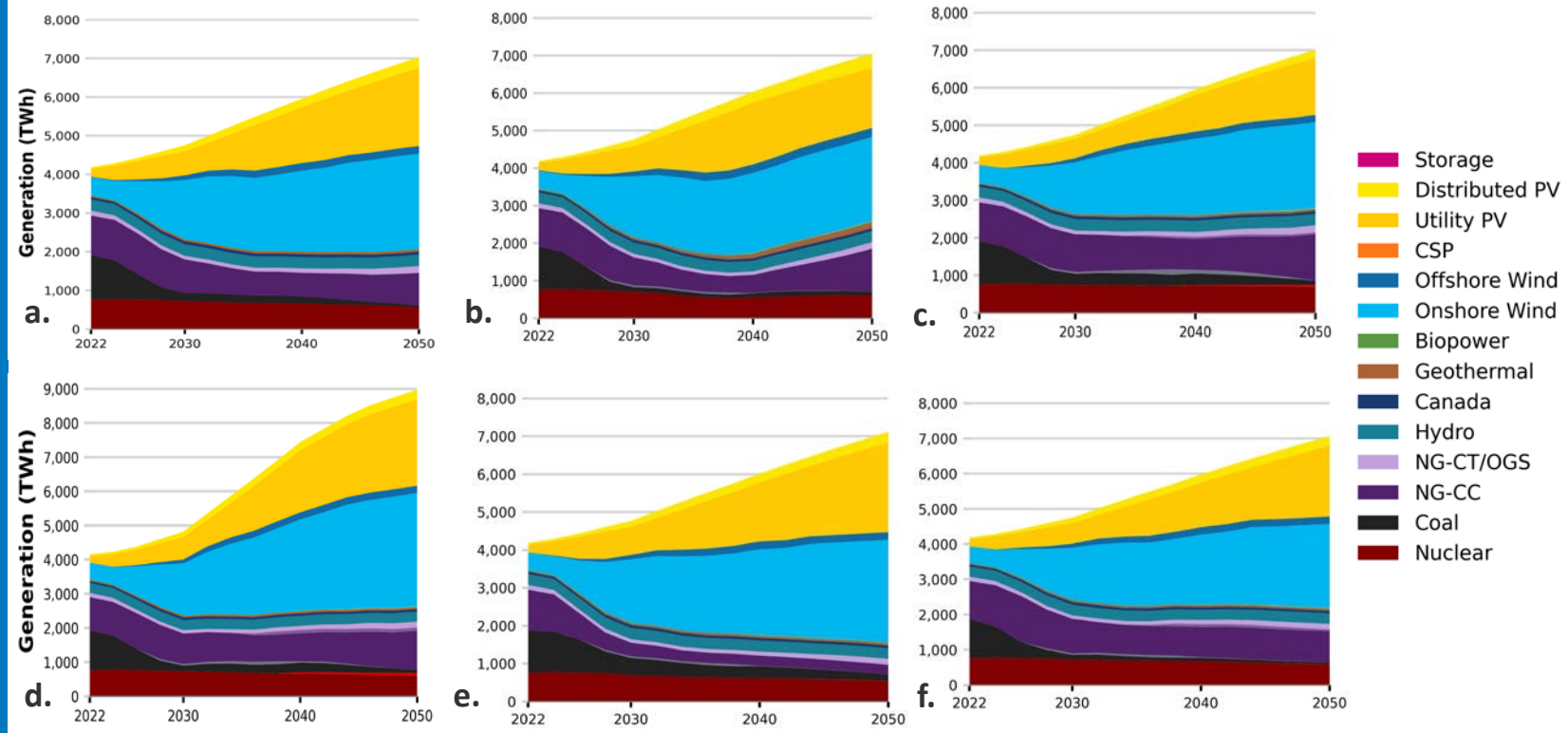
- Annually-updated database
- 5th edition upcoming
- Six business-as-usual-style scenarios, two decarbonization projections
- Data designed to support other analyses
- Primary model is NREL's ReEDS

What Is ReEDS?

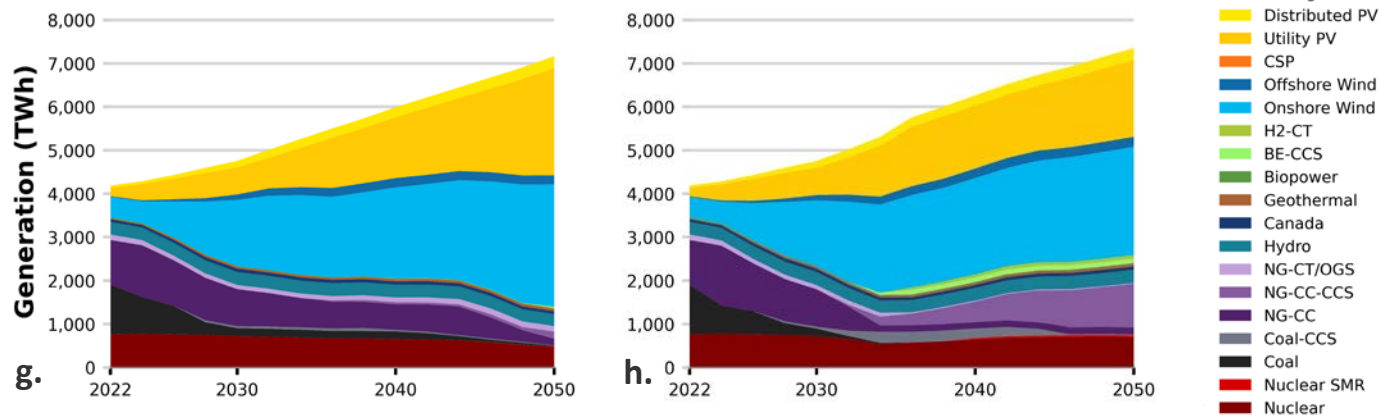
- Projects evolution of electric grid
- Least-cost, subject to reliability, operating, and policy constraints



Six "Business-As-Usual" Style Projections



Two National Decarbonization Projections



What Metrics Are Available?

Operational

Generation

- Hourly generation by technology

Capacity

- Nameplate capacity by technology
- MWh of storage

Portfolio

- Renewable portfolio standards (RPS) and clean energy standards (CES) shadow prices
- RPS and CES fractions

Load

- Busbar load
- Busbar load for end-use
- End-use load
- Direct air capture load
- Load from storage charging
- Transmission losses
- Net load

Transmission

- Imports
- Exports

Operations

- Average distribution loss rate
- Marginal distribution loss rate
- Operating reserve demand
- Operating reserve shadow price
- Planning reserve margin
- Planning capacity
- Capacity shadow price
- Marginal generator technology
- Marginal energy source technology
- CO₂ shadow price

Costs (Busbar and End-Use)

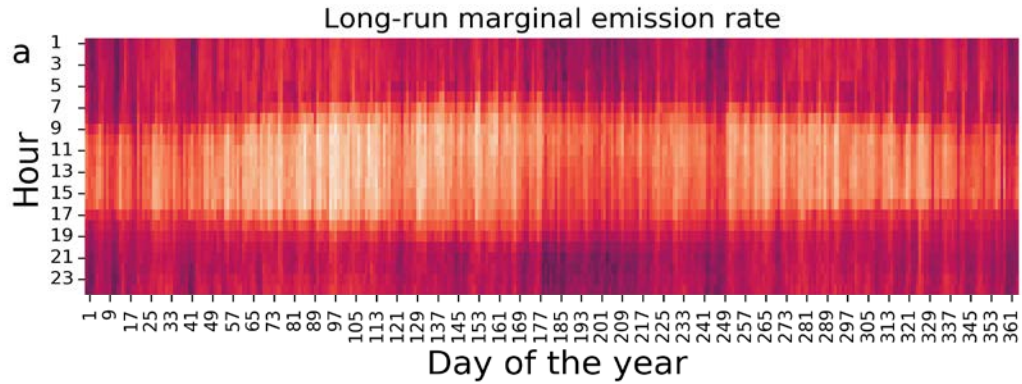
- Hourly marginal energy cost
- Hourly marginal capacity cost
- Hourly marginal portfolio cost

Greenhouse Gas Emissions

- Average from in-region generation
- Average induced by in-region load
- Short-run marginal emission rate
- Long-run marginal emission rate

Several Temporal Resolutions Available

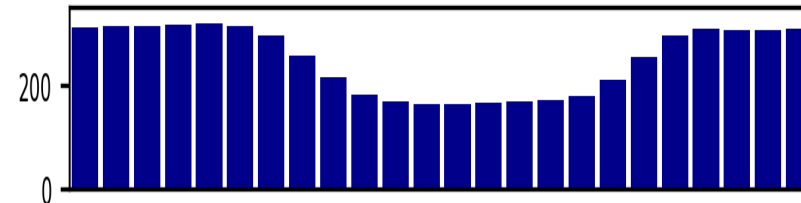
Hourly



Month-Hours

Month	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	314	317	320	322	322	318	316	316	280	221	194	181	177	177	179	189	234	284	307	308	305	307	309	
2	308	310	312	316	317	313	312	308	259	203	181	170	163	163	164	171	204	259	296	304	301	301	304	
3	268	269	269	272	274	273	270	243	184	146	131	126	124	125	126	127	132	160	214	266	278	270	266	266
4	253	251	251	253	256	256	242	189	141	118	111	109	108	110	111	114	120	141	188	248	270	260	251	251
5	283	280	281	282	282	277	241	184	154	136	132	131	131	134	138	141	146	164	201	259	291	286	281	283
6	312	310	311	312	312	303	253	197	171	156	152	151	153	157	159	164	168	184	215	267	306	309	312	313
7	353	352	356	358	360	353	304	242	215	198	193	195	198	201	203	207	212	229	259	306	340	340	345	352
8	359	359	364	368	369	365	331	265	230	210	202	201	203	206	208	212	217	236	273	324	345	346	350	355
9	334	333	337	340	341	337	320	260	210	190	180	177	178	181	183	187	194	225	278	321	327	322	325	328
10	298	300	301	303	306	302	296	257	195	165	154	148	149	151	152	156	169	214	274	297	296	288	290	294
11	310	314	317	319	319	315	312	297	238	189	173	169	168	169	170	173	191	246	295	309	304	302	301	307
12	325	326	330	332	333	331	324	320	285	228	206	197	194	194	194	197	214	260	306	320	317	314	317	321

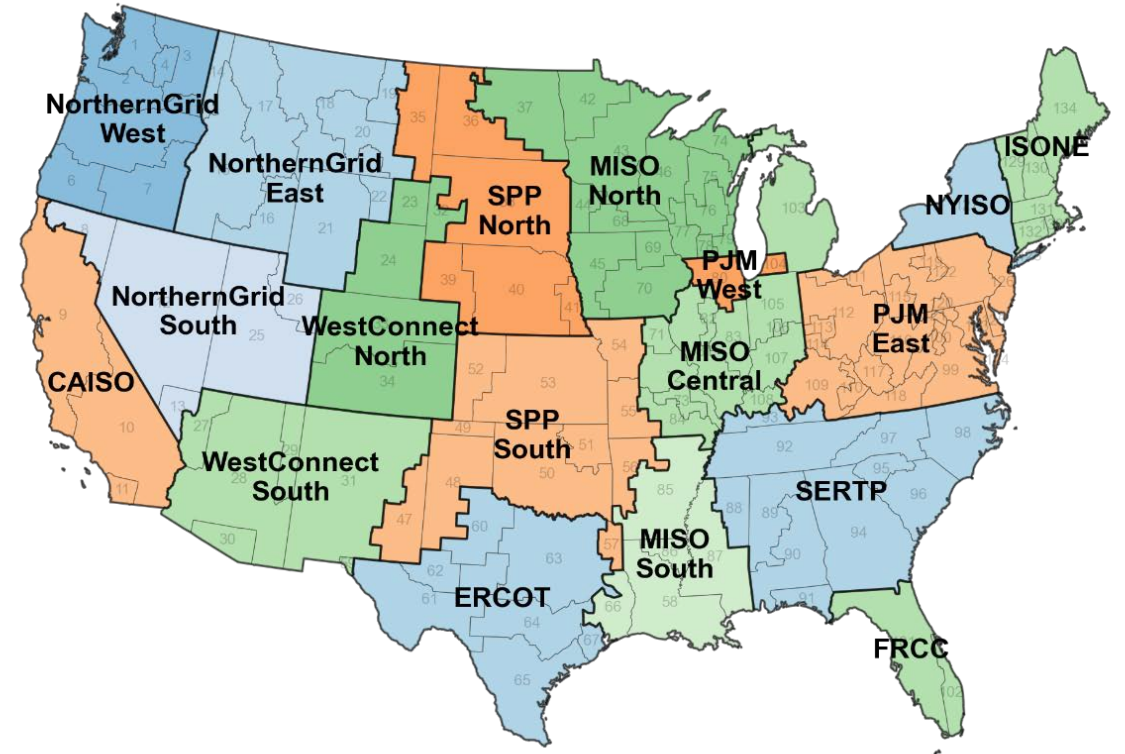
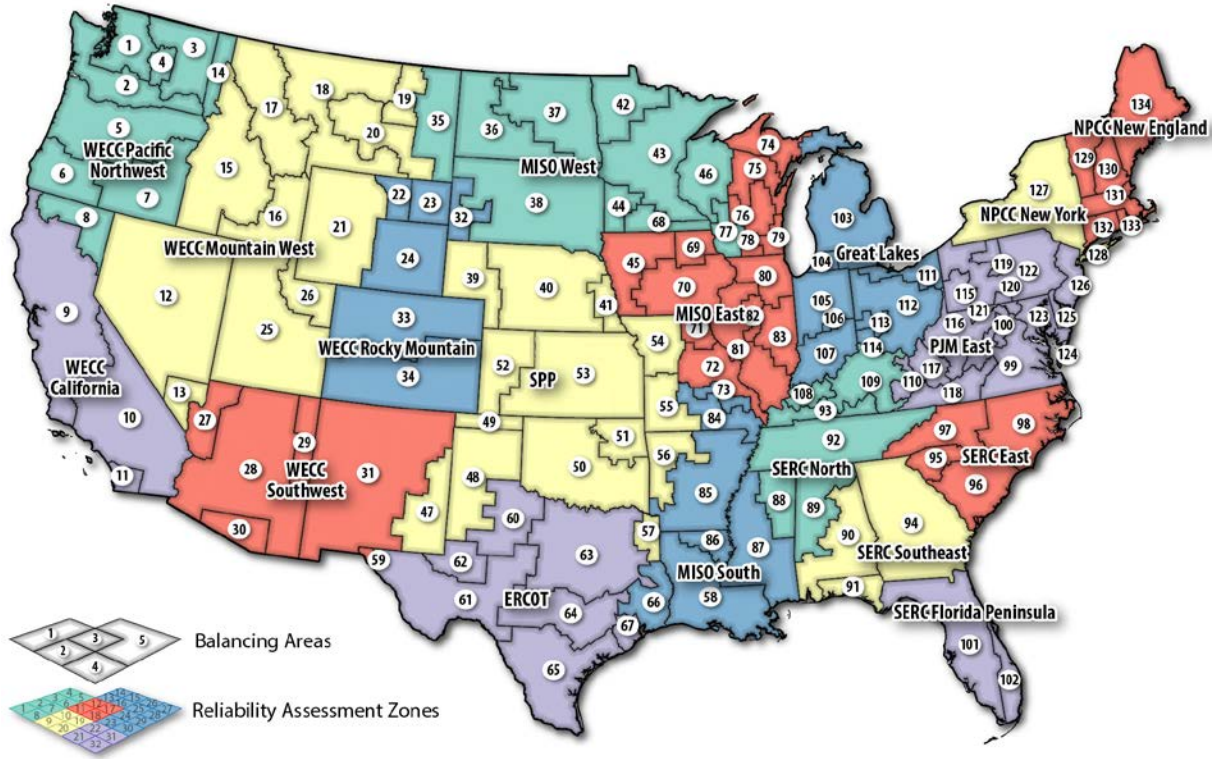
Time-of-Day



Annual

220 kg/MWh

Several Geographic Resolutions Available



How Is Cambium Data Being Used?

In Research:

The screenshot shows a Google Scholar search results page for the query 'Cambium'. The search bar at the top contains the text 'Cambium' and shows 'About 28 results (0.02 sec)'. The results are sorted by relevance. The first result is 'Cambium 2022 scenario descriptions and documentation' with a checkbox for 'Search within citing articles'. The second result is '[HTML] Considerations for estimating operational greenhouse gas emissions in whole building life-cycle assessments' by F Greer, P Raftery, and A Horvath, published in Building and Environment, 2024 - Elsevier. The third result is 'Heat pumps for all? Distributions of the costs and benefits of residential air-source heat pumps in the United States' by E J H Wilson, P Munankarmi, B D Less, and J L Reyna, published in Joule, 2024 - cell.com. The fourth result is '[HTML] An evaluation of the demand response potential of integrated dynamic window and HVAC systems' by C Gehbauer, E S Lee, and T Wang, published in Energy and Buildings, 2023 - Elsevier. The fifth result is '[HTML] FGEM: Flexible Geothermal Economics Modeling tool' by M J Aljubran and R N Horne, published in Applied Energy, 2024 - Elsevier. The sixth result is 'Decarbonization of the Electric Power Sector and Implications for Low-Cost Hydrogen Production from Water Electrolysis' by A Badgett, J Brauch, and P Saha, published in Advanced Sustainable ..., 2023 - Wiley Online Library.

Google Scholar

Articles About 28 results (0.02 sec)

Any time
Since 2024
Since 2023
Since 2020
Custom range...

Sort by relevance
Sort by date

Create alert

Search within citing articles

[\[HTML\] Considerations for estimating operational greenhouse gas emissions in whole building life-cycle assessments](#)
F Greer, P Raftery, A Horvath - Building and Environment, 2024 - Elsevier
Building operations, which include the energy from electricity and natural gas account for about 28% of global greenhouse gas (GHG) emissions. Stakeholders need accurate ...
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[Heat pumps for all? Distributions of the costs and benefits of residential air-source heat pumps in the United States](#)
E J H Wilson, P Munankarmi, B D Less, J L Reyna... - Joule, 2024 - cell.com
Electrification of fossil-fuel combustion in buildings is a key component of achieving global greenhouse gas emissions targets. We use physics simulations of 550,000 statistically ...
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[\[HTML\] An evaluation of the demand response potential of integrated dynamic window and HVAC systems](#)
C Gehbauer, E S Lee, T Wang - Energy and Buildings, 2023 - Elsevier
Demand response (DR) increases the flexibility and reliability of the electricity grid as use of intermittent renewable energy sources increases. HVAC and envelope DR measures ...
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[\[HTML\] FGEM: Flexible Geothermal Economics Modeling tool](#)
M J Aljubran, R N Horne - Applied Energy, 2024 - Elsevier
Flexible energy resources are key for a reliable power supply in a decarbonized grid with a significant fraction of variable power sources. Whereas the development of fossil fuel ...
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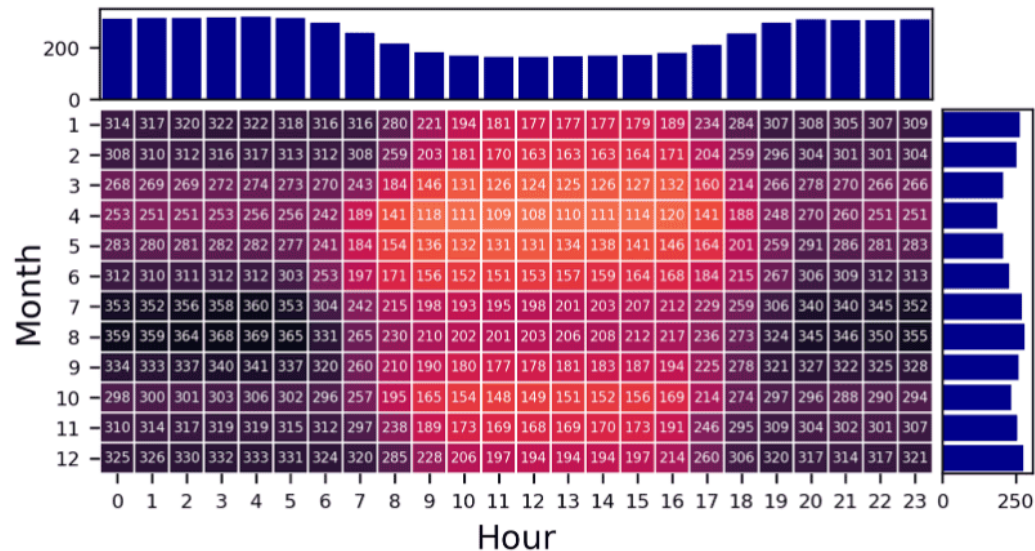
[Decarbonization of the Electric Power Sector and Implications for Low-Cost Hydrogen Production from Water Electrolysis](#)
A Badgett, J Brauch, P Saha... - Advanced Sustainable ..., 2023 - Wiley Online Library
Increasing development of wind and solar generation in the power sector can create economic opportunities for the deployment of water electrolyzers that produce hydrogen ...
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How Is Cambium Data Being Used?

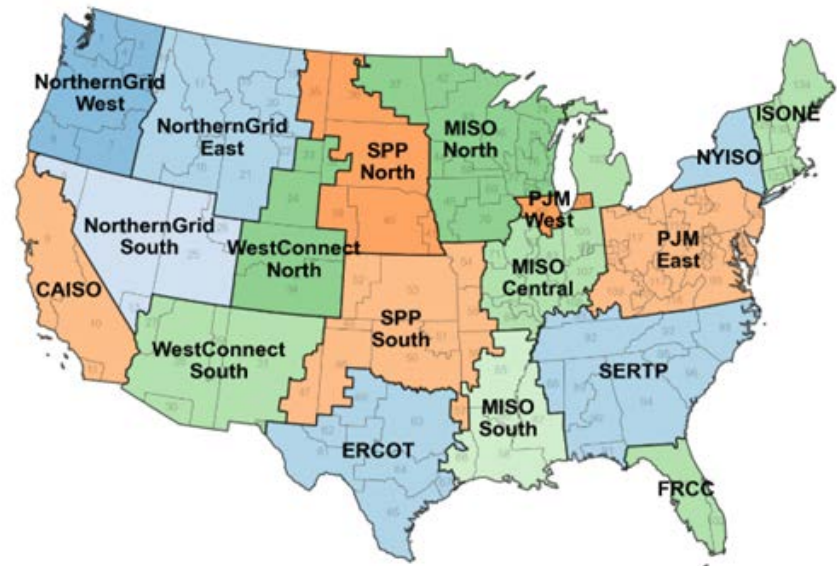
In Standards:

ASHRAE 189.1
RESNET 301

Month-Hour Levelized Long-Run
Marginal Emissions Rates



18 Regions for the United States

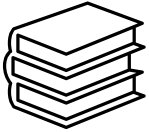


How Is Cambium Data Being Used?

In Decision Making:



State and Local Governments



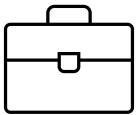
Academic Institutions



Utilities and Regulators



Global Clean Energy
Organizations



Consulting and Commercial
Sector

NREL and Amazon Aim To Create Guidebook for Emissions Impact Analysis

Improved Modeling Will Help Clean Energy Buyers Better Estimate Their Greenhouse Gas Emissions

Dec. 12, 2023 | By Connor O'Neil | Contact [media relations](#)

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How To Access the Data

Online Viewer

scenarioviewer.nrel.gov



CSV Download

scenarioviewer.nrel.gov

	A	B	C	D	E	F	G	H	I
1	Project	Scenario	Dollar_ye	Weather_	Start_day	country			
2	Cambium	MidCase	2022\$	2012	Sunday	usa			
3	Metric definitions and scenario descriptions: 2023 Cambium Documentation (https://www.nrel.gov/docs/fy23osti/81422.pdf)								
4	Geograph	Time	Load	Load	Load	Load	Load	Load	Load
5	unitless	unitless	MWh	MWh	MWh	MWh	MWh	MWh	MWh
6	gea	t	busbar_lo	battery_ch	phs_charg	trans_loss	busbar_lo	enduse_lc	net_load
7	CAISO	2025	3.02E+08	13712291	9519449	3140698	3.28E+08	2.91E+08	2.1E+08
8	CAISO	2030	3.39E+08	13784752	23312132	3172645	3.79E+08	3.27E+08	2.39E+08
9	CAISO	2035	4.03E+08	13270438	41995036	3235847	4.62E+08	3.89E+08	2.76E+08
10	CAISO	2040	4.59E+08	16334725	58168840	3447979	5.37E+08	4.43E+08	3.11E+08

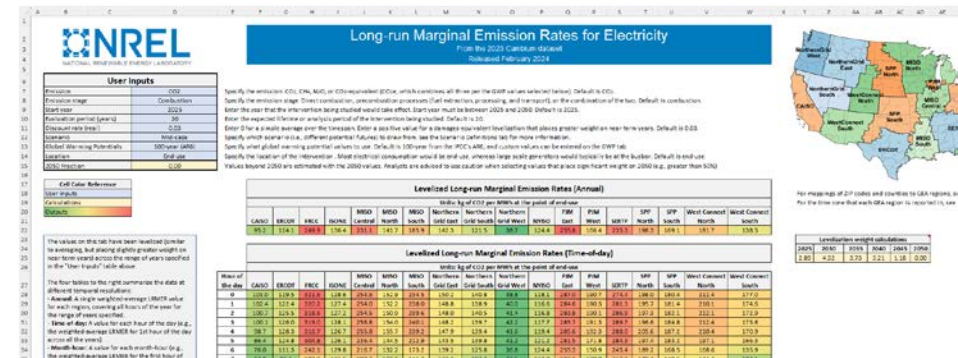
Documentation

Cambium 2023 Scenario Descriptions and Documentation, Gagnon et al. 2024



Emissions Workbooks

Long-run Marginal Emissions Rates for Electricity Workbooks for 2023 Cambium Data



Questions?

www.nrel.gov

NREL/PR-6A40-90906

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PRAS

PRAS: Probabilistic Resource Adequacy Suite



Gord Stephen

NREL Grid Systems Research
Engineer

Sept. 10 | 10 a.m. MT | 12 p.m. ET



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