Electricity Report Cards for the Fifty States

Agenda

- Critical Issues: Why GridClue Matters
- Evaluation Methodology
  - Resilience, Carbon Intensity, Reliability, and Cost
  - Evaluation of Top 10 and Bottom 10 States
- Case Studies
  - Washington
  - California
  - Texas
- Policy Scenarios
  - Wyoming as an Example of Modeling an Energy Transition
- Conclusions and Next Steps

Critical Issues: Why GridClue Matters

- U.S. electricity generation faces an acute, three-pronged challenge:
  - Electricity demand is rapidly growing
  - As aging fossil fuel fired plants retire, generation capacity is increasingly insufficient
  - Environmental concerns because of carbon dioxide emissions
- GridClue users can evaluate a state's generation resources with these tools:
  - **Electricity Report Card** shows a state's ability to support current customers
  - **Policy Scenario** feature lets users adjust a state's options to enhance electricity generation
- Whom will GridClue help? Policymakers, analysts, and concerned citizens
- How can users benefit? Improved regulation of electricity generation
  - Gain critical insights
  - Make informed decisions
  - Identify priorities

Evaluation Methodology

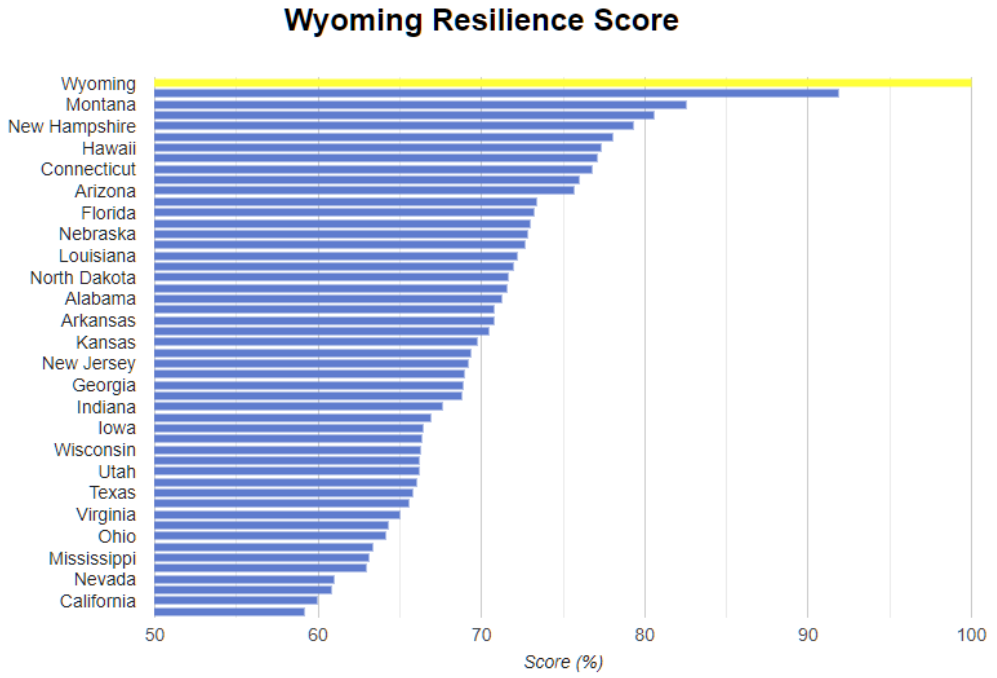
- Data sources – Public information from:
  - U.S. Energy Information Administration (EIA)
  - Environmental Protection Agency (EPA)
  - U.S. Department of Transportation (DOT)
  - Federal Energy Regulatory Commission (FERC)
  - U.S. Census Bureau
- "State Report Card" is primary evaluation tool. Grades states on:
  - Resilience: Dispatchable plants with on-site energy to protect against long-term outages
  - Carbon Intensity: Based on carbon dioxide emissions of in-state generation plants
  - Reliability: Based on average duration of customer outages experienced
  - Cost: Based on average price/kilowatt-hour billed to consumers
- Standard model for academic grading (i.e., "A" through "F")

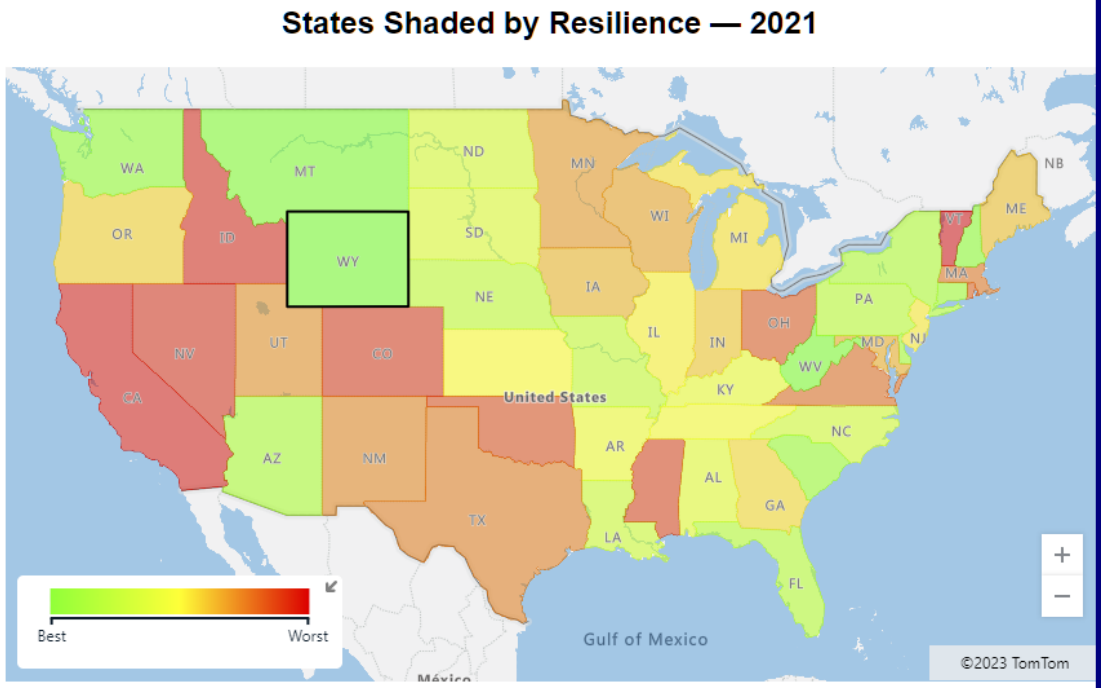
REPORT CARD GRADES

Resilience Grade

- Reflects a state's ability to promptly recover from a wide-area blackout
- Sufficient generation capacity to supply customer load of blacked-out areas
- Energy sources that are stored on-site and or redundant
- These generation resources are considered "resilient":
  1. Natural gas-fired plants that can switch to fuel oil backup (dual-fuel)
  2. Natural gas-fired plants connected to more than one pipeline
  3. Nuclear power plants
  4. Hydroelectric and pumped storage plants
  5. Geothermal plants
  6. Petroleum-fired plants
  7. Coal-fired plants

Resilience Scores



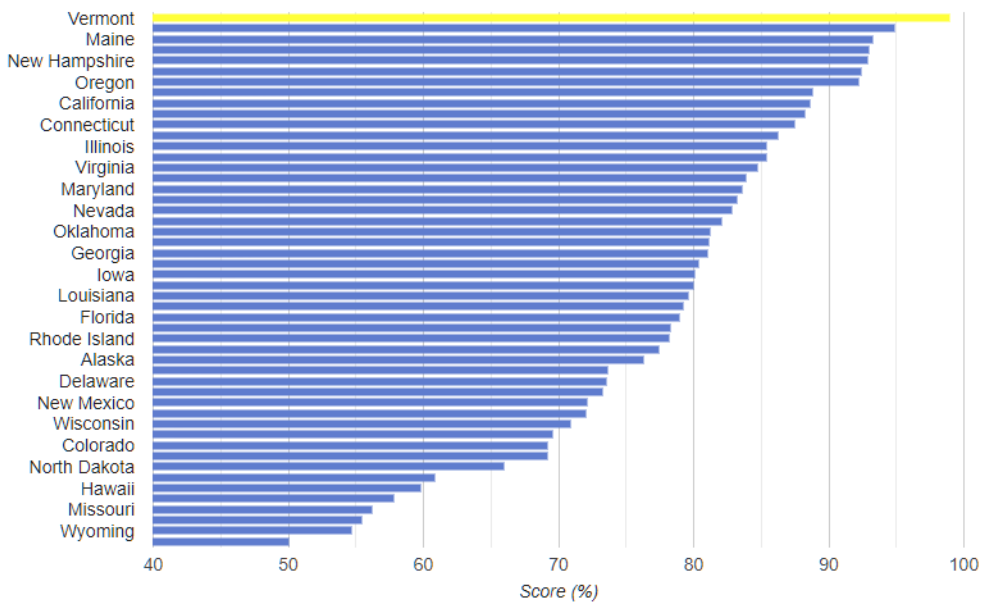


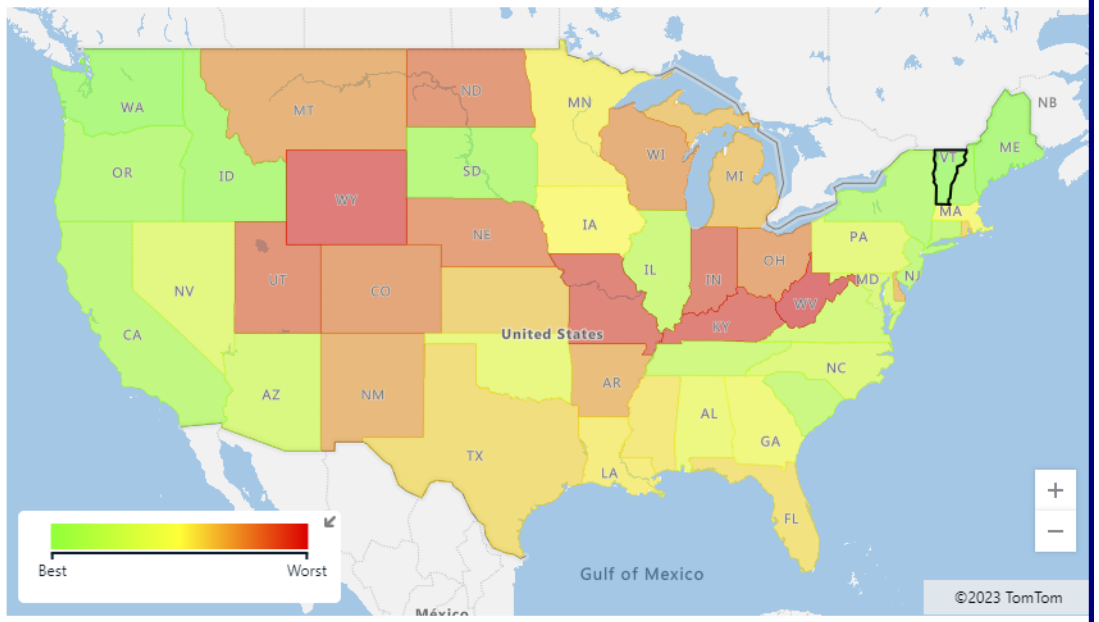
- #1: Wyoming with resilience ratio of 4.42
- #50: Vermont with resilience ratio of 0.81

Carbon Intensity Grade

- Measures carbon/kilowatt-hour that in-state generation produces
  - — A state earning a 100% generates all electricity without emissions
  - — A state earning a 50% emits the most, compared to all other states
- Carbon emissions resulting from imported electricity are not included because of insufficient publicly-available data
- Top performers received high marks for two reasons:
  - — They import substantial portions of their electricity
  - — Generation almost solely based on renewables or carbon-neutral sources

Carbon Intensity Scores



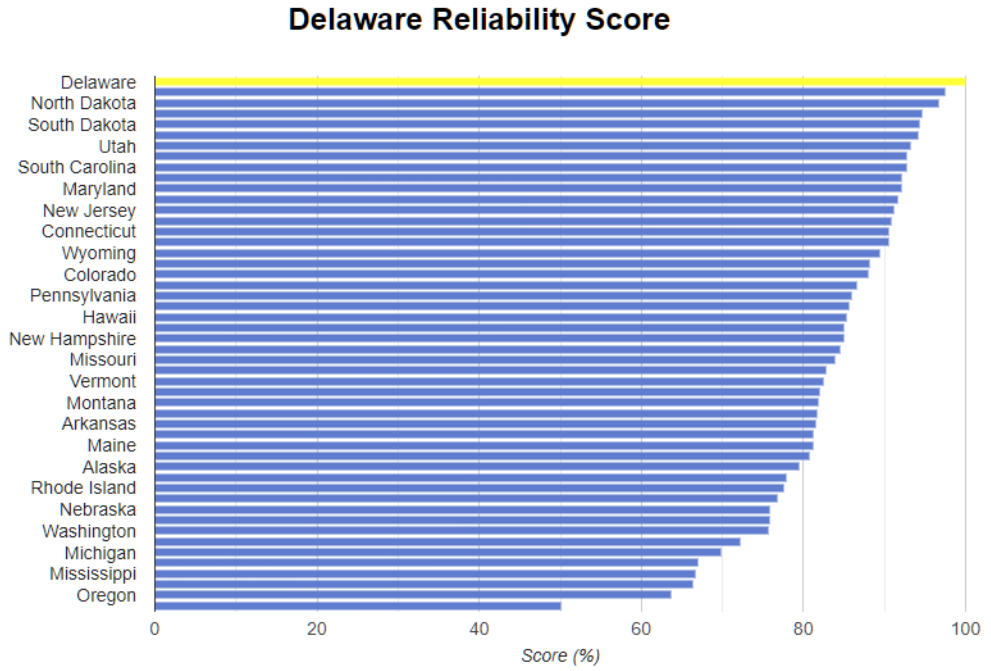


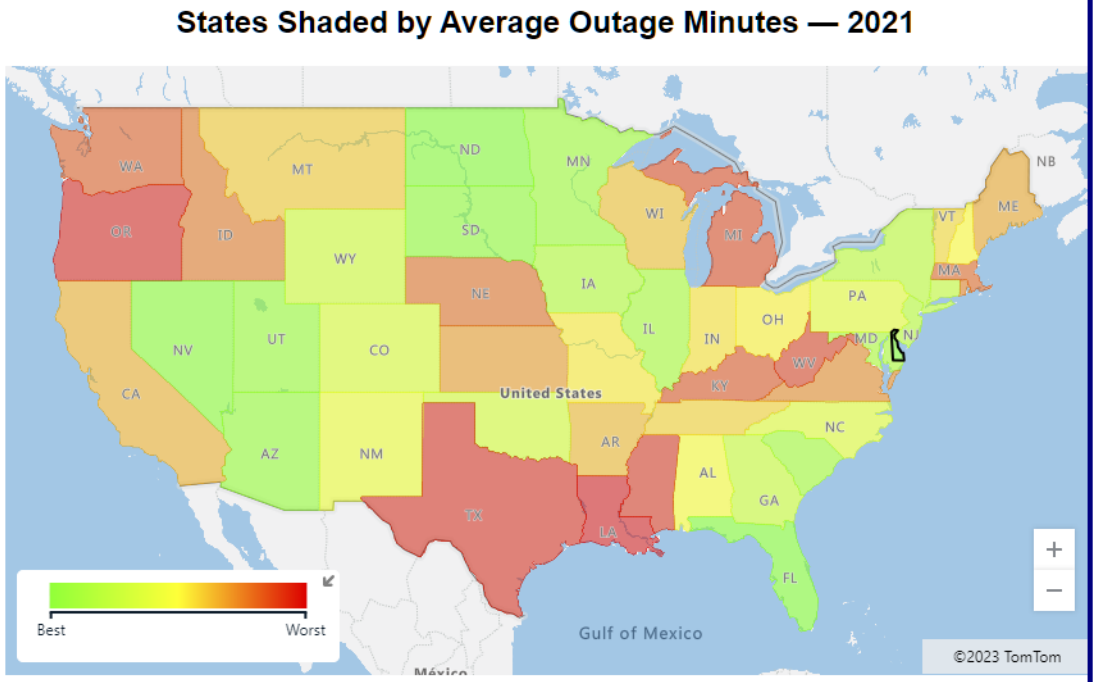
- #1: Vermont with a Carbon Intensity of 0.04 Lbs/kWh
- #50: West Virginia with a Carbon Intensity of 1.94 Lbs/kWh

Reliability Grade

- Uses the System Average Interruption Duration Index (SAIDI)
- Measures average duration of customer outages in the state for that year
  - A state earning a 100% has zero minutes of outages over the entire year
  - A state earning a 50% has the highest cumulative duration of outages
- Metric includes Major Event Days (MEDs) such as hurricanes and ice storms
  - Areas with severe weather in a single year can be penalized under SAIDI

Reliability Scores



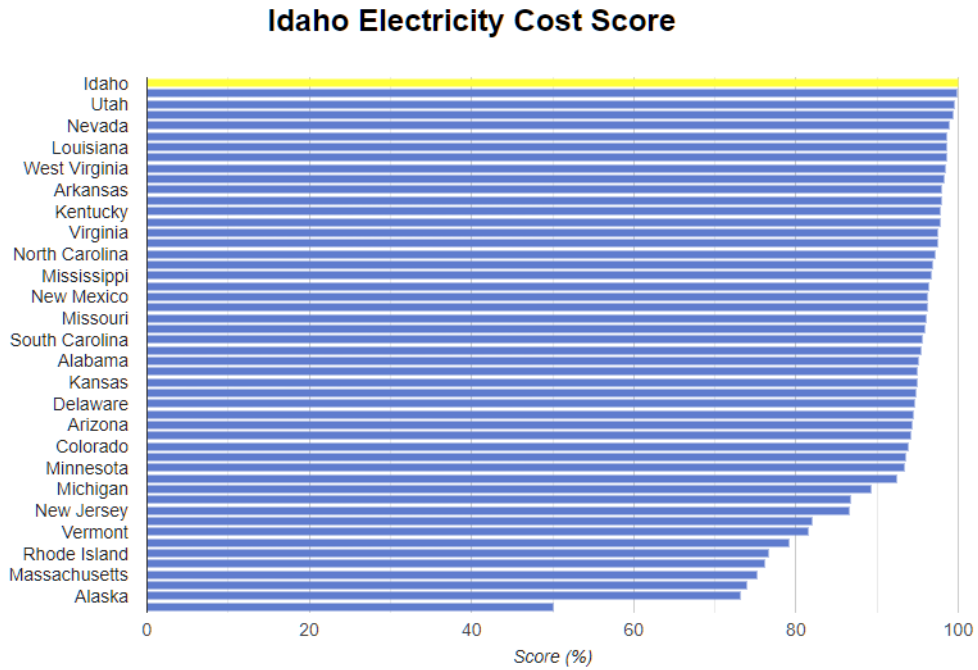


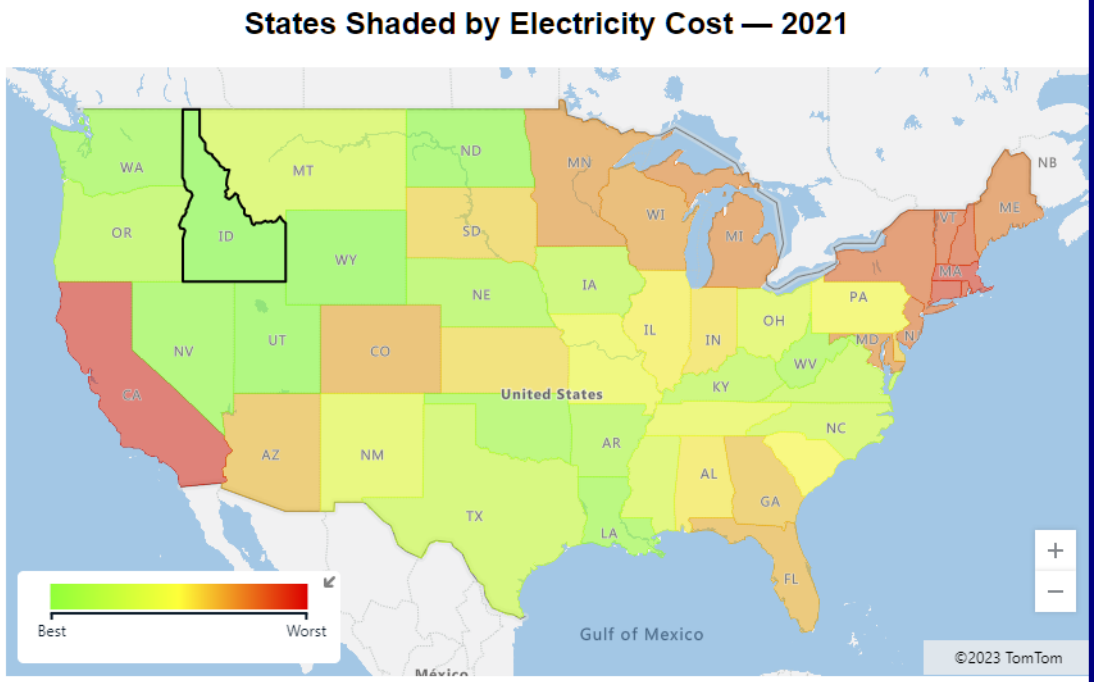
- #1: Delaware with a SAIDI of 64 minutes
- #50: Louisiana with a SAIDI of 4,811 minutes after Hurricane Ida

Cost Grade

- This metric uses the weighted average cost of electricity/kWh
- Average ratepayer cost is calculated using the weighted consumption for residential, commercial, and industrial sectors
- Many states have abundant natural resources (e.g., hydroelectric, coal, or natural gas), allowing inexpensive generation and, therefore, low electricity cost
- Electricity imported and then sold within a state is included in this calculation

Cost Scores





- #1: Idaho with a price of 8.17 cents/kWh
- #50: Hawaii with a price of 30.35 cents/kWh—using expensive imported fuel

States With Excellent Grades

Top ten performers for 2021:

- All of top performing states achieved high grades for reliability and cost
- Aside from Wyoming, all of these states offset a mediocre grade for Resilience with a contrasting high grade for Carbon Intensity (low carbon dioxide emitted)

	State	Overall GPA ▼	Overall Grade	Resilience	Low Carbon Intensity	Reliability	Low-Cost Electricity
1	South Dakota	3.35	**B+**	C-	A-	A	A
2	South Carolina	3.25	**B**	C+	B	A-	A
3	Arizona	3.25	**B**	C	B	A	A
4	Washington	3.15	**B**	C+	A	C	A+
5	Florida	3.15	**B**	C	C+	A+	A
6	Delaware	3.08	**B**	C	C	A+	A
7	Illinois	3.00	**B**	D+	B	A-	A
8	North Carolina	3.00	**B**	C-	B	B	A+
9	Wyoming	2.97	**B-**	A+	F	B+	A+
10	Nevada	2.92	**B-**	D-	B-	A	A+

States Needing Improvement

- Ten states below earned the lowest overall grades for 2021
- Hawaii relies on imported fossil fuels and intermittent renewables
- Rhode Island has a small in-state generation fleet and relies on imports
- Kentucky has large coal-fired generators
- Massachusetts generators depend on expensive natural gas from pipelines

	State	Overall GPA ▲	Overall Grade	Resilience	Low Carbon Intensity	Reliability	Low-Cost Electricity
1	Hawaii	1.32	**D+**	C+	F	B	F
2	Rhode Island	1.90	**C-**	D	C+	C+	C
3	Kentucky	1.92	**C-**	C-	F	C-	A+
4	Massachusetts	1.93	**C-**	D	B-	C	C
5	Michigan	1.97	**C-**	D+	C	D+	B+
6	California	2.00	**C**	F	B+	B-	C
7	Indiana	2.00	**C**	D+	F	B-	A
8	Mississippi	2.08	**C**	D	C+	D	A
9	Louisiana	2.08	**C**	C-	C+	F	A+
10	Texas	2.15	**C**	D	C+	D	A+

CASE STUDIES

Washington State: #1 in Class of Fifty States

- Ranks #6 in Resilience and #2 in Carbon Intensity
- Hydropower provides 21GW of capacity and 65% of generation
- Low-cost electricity results from availability of hydropower and inexpensive import of natural gas from Canada
- While ranking #43 in Reliability, Washington receives a “C” when compared to unreliable outlier states like Louisiana

State Report Card for 2021: Washington

Overall Grade	Resilience ⓘ	Carbon Intensity ⓘ	Reliability ⓘ	Electricity Cost ⓘ
B (3.15/4)	C+ (6th)	A (2nd)	C (43rd)	A+ (6th)

Washington State (#1)

State Report Card

Year: 2021

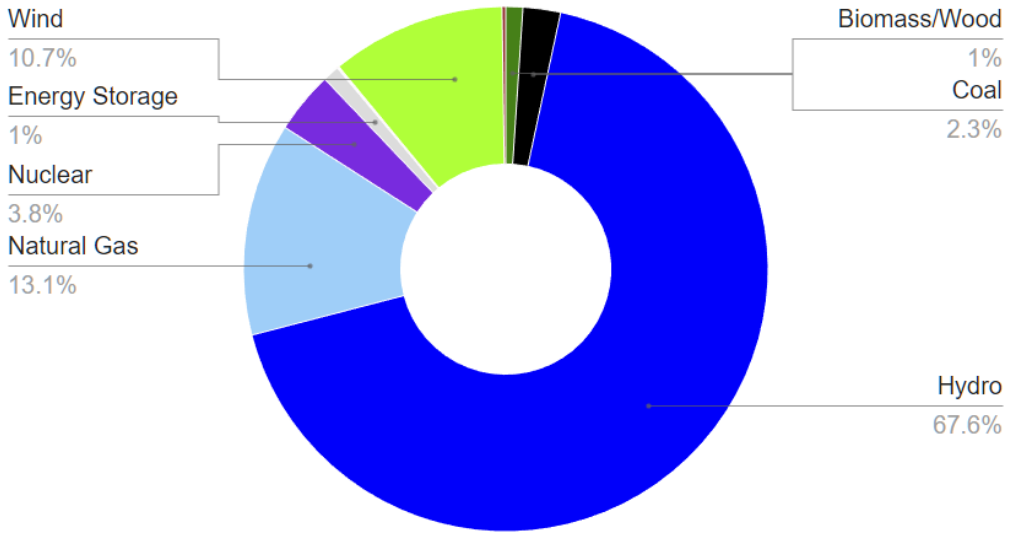
State: Washington

Display Statistic: Capacity in Megawatts (MW)

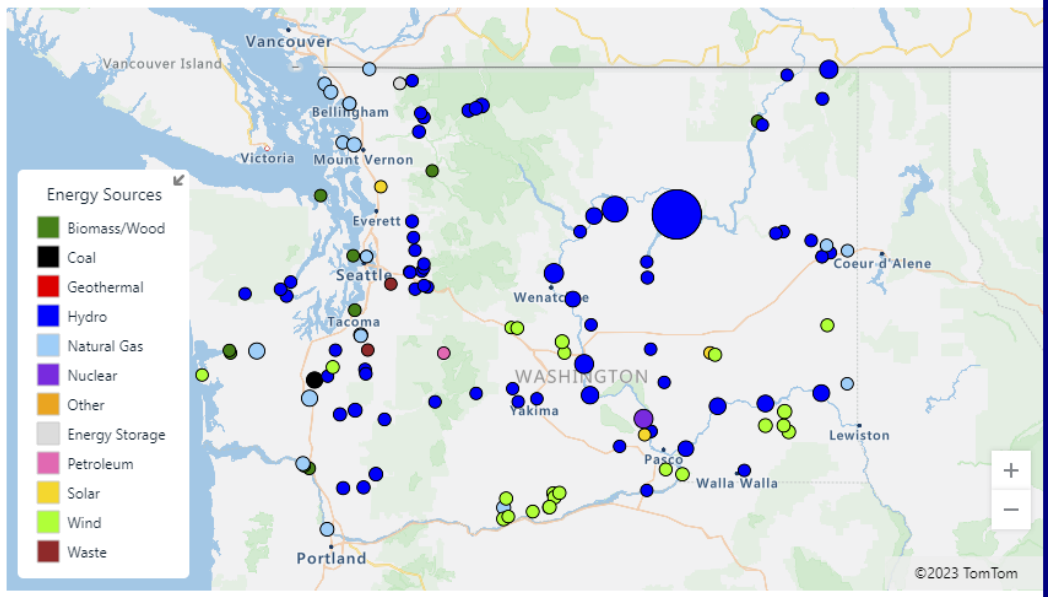
State Report Card for 2021: Washington

Overall Grade	Resilience	Carbon Intensity	Reliability	Electricity Cost
B (3.15/4)	C+ (6th)	A (2nd)	C (43rd)	A+ (6th)

Washington Capacity By Energy Source
31,512 MW in 2021



Washington Plants Scaled by Capacity — 2021



California: #48 in Class of Fifty States

- "F" in Resilience due to low dispatchable capacity
  - — California imports 20% of its electricity
  - — Only 28.3% of in-state capacity is resilient
- B+ in Carbon Intensity results from a large share of renewables (30.9% of energy supply) and no significant coal generation
- High electricity cost results from expensive natural gas, "bidding up" of in-state generation resources, and intermittent (and expensive) renewables

State Report Card for 2021: California

Overall Grade	Resilience ⓘ	Carbon Intensity ⓘ	Reliability ⓘ	Electricity Cost ⓘ
C (2.00/4)	F (49th)	B+ (9th)	B- (34th)	C (48th)

California (#48)

State Report Card

Year: 2021

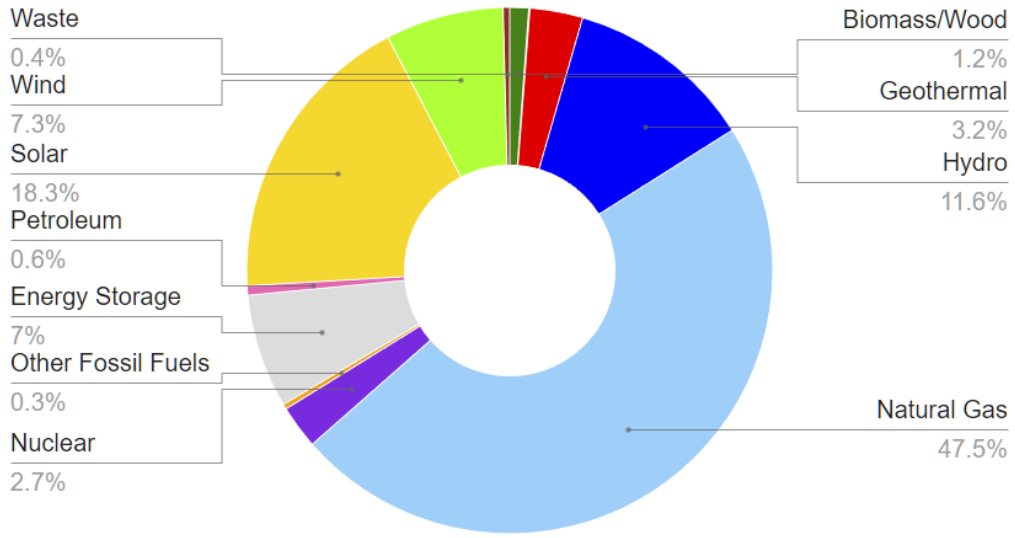
State: California

Display Statistic:
Capacity in Megawatts (MW)

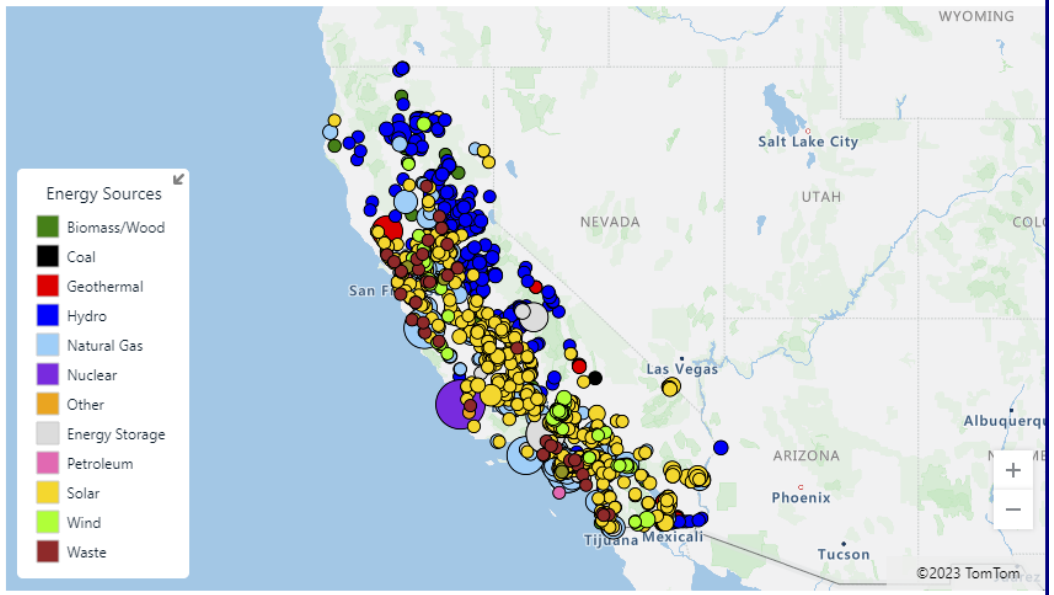
State Report Card for 2021: California

Overall Grade	Resilience	Carbon Intensity	Reliability	Electricity Cost
C (2.00/4)	F (49th)	B+ (9th)	B- (34th)	C (48th)

California Capacity By Energy Source
87,152 MW in 2021



California Plants Scaled by Capacity — 2021



Texas: #35 in Class of Fifty States

- "D" in Resilience due to a lack of resilient natural gas for generation
  - — 47% of natural gas is unresilient, lacking either pipeline redundancy or a secondary fuel backup
- Moderate Carbon Intensity with coal and natural gas supplying 66.9% of electricity generation
- #48 in Reliability because of Winter Storm Uri and ensuing blackouts
- Low electricity cost results from the ERCOT market structure, but at the expense of Resilience and Reliability

State Report Card for 2021: Texas

Overall Grade	Resilience ⓘ	Carbon Intensity ⓘ	Reliability ⓘ	Electricity Cost ⓘ
C (2.15/4)	D (39th)	C+ (30th)	D (48th)	A+ (16th)

Texas (#35)

State Report Card

Year: 2021

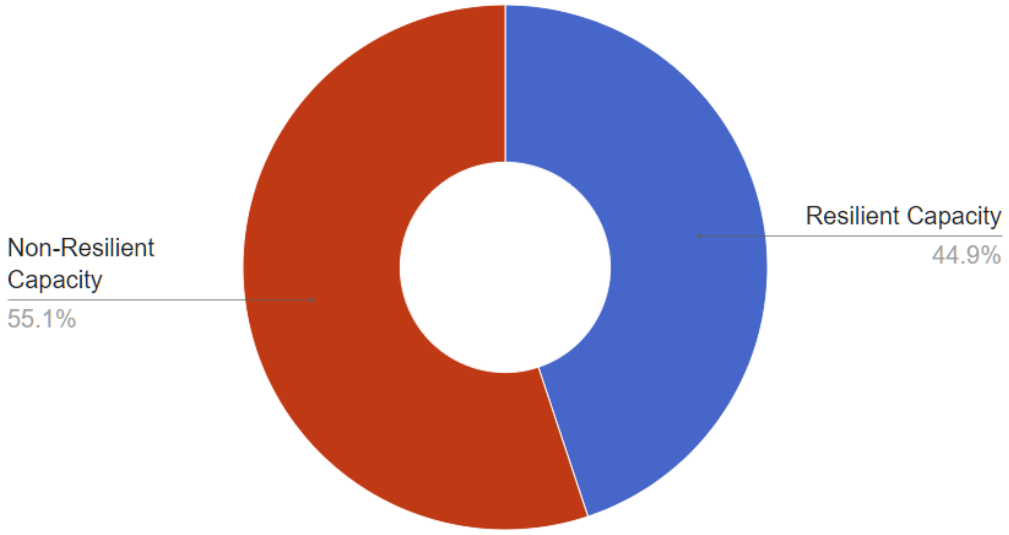
State: Texas

Display Statistic: ⓘ
Resilient vs. Non-Resilient Capacity

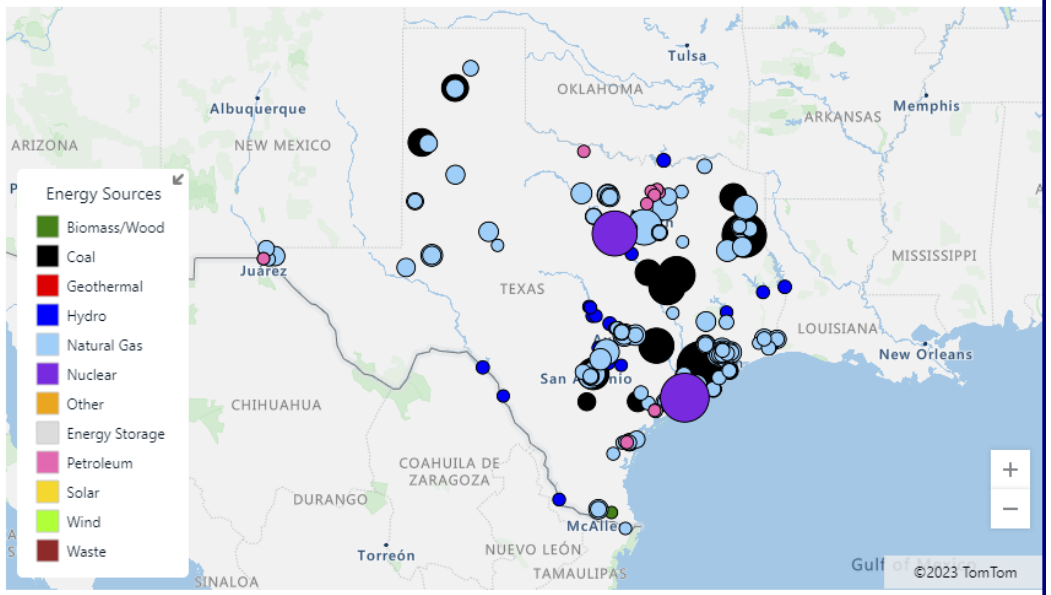
State Report Card for 2021: Texas

Overall Grade	Resilience ⓘ	Carbon Intensity ⓘ	Reliability ⓘ	Electricity Cost ⓘ
C (2.15/4)	D (39th)	C+ (30th)	D (48th)	A+ (16th)

Texas Resilient vs. Non-Resilient Capacity
151,092 MW in 2021



Texas Plants Scaled by Resilient Capacity — 2021



POLICY SCENARIOS

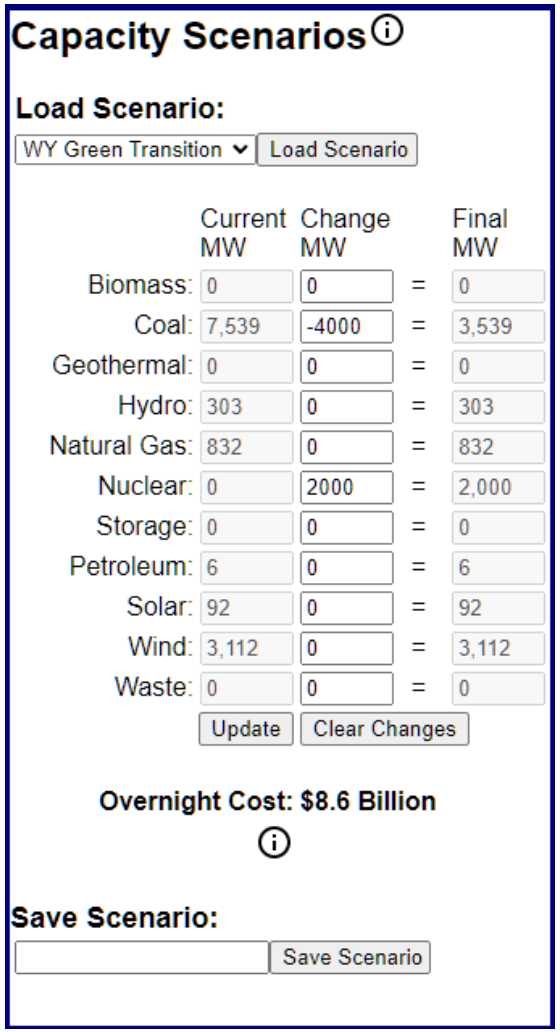
Policy Scenario Feature

- A data-driven, analytical tool built on the foundation of the Electricity Report Card
- Users can determine how a state might generate cleaner, more reliable energy by:
  - Adding, reducing, or deleting elements of a state's energy generating capacity
- Change in any resource will affect the Carbon Intensity score
- Changes in resilient energy sources will affect the Resilience score

Policy Scenario: Capacity Changes

The Capacity Scenarios page includes controls to change the capacity of each electricity resource in a state

- Currently listed capacities provide context on what can be adjusted and what can be reasonably added
- The “Change MW” fields can either be typed or adjusted using arrows within the text box
- When logged into GridClue, users have the option to load and save scenarios for future use
- Overnight Cost is calculated using the EIA and IPCC cost estimates for construction per megawatt



Policy Scenario Use Case: Wyoming

- Wyoming scores high for Resilience and low for Carbon Intensity
- Some coal generation might be retired to transition to cleaner energy sources
- Using the previous slide's selection of -4 GW of coal and +2 GW of nuclear:
  - Resilience drops 1 rank and from an "A+" to an "A"
  - Carbon Intensity increases 17 places from an "F" to a "C+"
  - Construction of a 2-GW nuclear plant is estimated to cost $8.6B
  - **Wyoming's overall grade changes from #6 to #2**

Electricity Report Card for 2021: Wyoming

Overall Grade (GPA)	Resilience	Carbon Intensity	Reliability	Electricity Cost
B- (2.98/4)	A+ (1st)	F (49th)	B+ (17th)	A+ (2nd)

Modified Electricity Report Card for 2021: Wyoming

Overall Grade (GPA)	Resilience	Carbon Intensity	Reliability	Electricity Cost
B+ (3.48/4)	A (2nd)	C+ (32nd)	B+ (17th)	A+ (2nd)

CONCLUDING ISSUES AND NEXT STEPS

Questions To Be Addressed in Grading Policies

- Resilience: How can we reward states with a diverse set of generators over states that rely on a single energy source (e.g., coal or hydro)?
- Carbon Intensity: How can we better score states that rely largely on imports generated with an unknown carbon intensity?
- Reliability: Should this grade reflect natural disasters and other major events? Or should Major Event Days (MED) be eliminated from the scores?
- Cost: Can cost-of-living be included in score calculations? If so, can this also be done for the commercial and industrial sectors?

Caveats to Grading Scheme for Electricity Report Cards

- Reliability grading curve can be “broken” some years by a handful of high outage states experiencing hurricanes, ice storms, or other extreme weather
- Wyoming and West Virginia affect Resilience grades of other 48 states by their extensive use of coal-fired plants with fuel stored on-site
- Grades for Cost are similarly affected by outlier Hawaii which must import fuel, resulting in twice the cost per kilowatt-hour of the national average
- Resilience and Carbon Intensity grades are usually a trade-off
  - Coal-fired plants are resilient but carbon-emitting
  - Nuclear, hydroelectric, and geothermal plants are both clean and resilient
  - Solar and wind generation contribute to lowering Carbon Intensity with no effect on Resilience due to their intermittent nature

How GridClue Can Contribute to Policymaking

- Prompt informed discussions by policy makers, analysts, and concerned citizens
- Enable users to examine each state's performance:
  - Current generation fleet and its resilience to extreme weather, disasters, and attacks—"Resilience"
  - Ability to provide clean and affordable electricity—"Carbon Intensity" and "Cost"
  - Experience in promptly restoring grid outages—"Reliability"
- Formulate policies that balance:
  - Low-cost electricity
  - Protecting the environment
  - Meeting electricity demands … current and projected … from the norm to the extreme