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ERCOT's Generator Outage/Derate Visualization App (EGOVA)

EGOVA can be used to examine the spatiotemporal distribution of outage/derate events during ERCOT's 2021 energy crisis. The online version allows the user to access the information of all events registers in EGOVA's database and visualize the timeline of events using user-defined time spans and one-hour time steps.

Access EGOVA Online: https://bit.ly/EGOVA
Download EGOVA's Database (Excel version): https://bit.ly/EGOVADatabase

A visualization showing the progression of events from February 10th to 20th, using a one-minute time span and a one-hour time step is available at https://bit.ly/EGOVAVideo.

The video includes additional features that summarize the following information for each type of fuel and battery energy storage (BES):

a) Number of generators or BES units reported out
b) Total capacity reduction (MW)
c) Capacity shortage (Seasonal Assessment of Resource Adequacy (SARA) expected capacity - observed capacity) (MW)

EGOVA Data Sources:

- Database describing the outage/derate events from ERCOT's public files released on March 12, 2021
- Spatial coordinates and power plant characteristics from EIA's 860-M Dec 2020 form released on Feb 24, 2021, and EPA's 2019 eGRID database released on February 23, 2020
- Expected capacities of electric generating units and battery storage from ERCOT's Winter 2020-21 Final Seasonal Assessment of Resource Adequacy (SARA) released on November 20, 2020

This document was prepared as a support for the online tool and describes the pre-processing of the information that is contained in EGOVA's database, introduces some of the characteristics of the data, and identifies the symbology and visualization elements used by EGOVA.

Disclosure about EGOVA's information:

Following the approval of Texas's PUC order, ERCOT disclosed an unredacted list of generation- and energy-storage- resources that self-reported at least one outage/derate event from February 10th to 20th, 2021.

As described in the file that ERCOT released "*details entered by ERCOT-registered Resource Entities into the ERCOT Outage Scheduler as of 12:00 p.m. on February 20, 2021. This data may not accurately reflect the operating state of each generator. The data may not include outages that are less than two hours in duration because Resource Entities are not required to enter those in the ERCOT Outage Scheduler.*"

Pre-processing ERCOT's database to produce EGOVA's database:

The database released by ERCOT, hereafter 'original database', contains 2,599 registers reporting outage/derate events. Each event is represented in the original database as a row that includes information about the station, unit, seasonal capacity, capacity during the event, capacity reduction during the event, fuel type, event start and end, resource entity, and county.

To facilitate its analysis and visualization, the original database was pre-processed (see Table 1). The first step was to remove 74 events that did not report any capacity loss (the 'MW Reduction from Outage/Derate' field was 0). From the 2,525 remaining registers, 644 represented continuous outage/derate events that were reported individually but could be unified into a single register. For example, Unit #1 of the Niels Bohr station reported a full capacity loss (197 MW) from 04:21 AM on February 12th until 09:00 pm, February 20th. This outage event was registered in the original database with nine different reports (e.g. 2/12 from 04:21 AM to 09:10 AM and 2/12 from 09:10 AM to 09:00 PM). As the unit reported the same capacity reduction during the entire time and the nine events were non-interrupted across time, they were merged into one single register in EGOVA's database.

Intending to facilitate traceability, EGOVA's Excel database lists each of the events in the original database and indicates if they were discarded (no capacity loss or unified under other registers) or modified (modifying the end date to reflect multiple events that were unified under one register). Registers classified into the latter include a note indicating the number of original records unified under a single event.

After pre-processing the original information, EGOVA's database contains 2,142 registers from which 261 were modified (by unifying multiple registers into one) and 1,881 had no modification. The database contains registers associated with 252 of the 549 power plants (45.9%) registered under ERCOT's overview in official databases like EIA-860 or EPA eGRID.

Table 1. Registers included in EGOVA's database.

Initial events included in the original database	2,599	
Events excluded because of no reported capacity loss	74	2.85%
Events unified with other registers in the database	383	14.74%
Events included in the final database	**2,142**	**82.42%**

Events included in EGOVA's database	2,142	100%
Number of events modified from the original database	261	12.18%
Number of events with no modification	1,881	87.82%

Information about the spatial coordinates and power plant characteristics was linked to each register based on EIA's 860-M form and EPA's eGRID 2019 database. New fields calculating the capacity reduction and event duration were added to each register. A capacity reduction field (%) was calculated as the quotient of the 'MW Reduction from Outage/Derate' field and the seasonal capacity (ranging from 0 to 100% where 100% represents a total capacity loss).

Table 2. Number of events included in EGOVA's database (after pre-processing), classified by fuel type and a seven-group category based on the observed capacity reduction.

Capacity Reduction (MW)		Category	Number of Events								
Lower	High		Coal	Natural Gas	Nuclear	Batteries	Solar	Wind	Hydro	Total	%
0	50	1	7	288	-	16	29	343	2	**685**	**32.0%**
50	100	2	10	212	-	-	28	401	-	**651**	**30.4%**
100	200	3	6	214	-	-	21	388	-	**629**	**29.4%**
200	350	4	7	85	-	-	-	29	-	**121**	**5.6%**
350	500	5	8	29	-	-	-	-	-	**37**	**1.7%**
500	750	6	6	5	-	-	-	-	-	**11**	**0.5%**
750	1,373	7	7	-	1	-	-	-	-	**8**	**0.4%**
		Total	**51**	**833**	**1**	**16**	**78**	**1161**	**2**	**2,142**	
		%	**2.4%**	**38.9%**	**0.0%**	**0.7%**	**3.6%**	**54.2%**	**0.1%**		

Table 3. Average capacity reduction during each event, classified by fuel type and a seven-group category based on the observed capacity reduction.

Capacity Reduction (MW)		Category	Average Capacity Reduction During Event (MW)						
Lower	High		Coal	Natural Gas	Nuclear	Batteries	Solar	Wind	Hydro
0	50	1	20	25	-	7	29	24	34
50	100	2	73	72	-	-	72	80	-
100	200	3	162	153	-	-	121	137	-
200	350	4	284	255	-	-	-	215	-
350	500	5	421	398	-	-	-	-	-
500	750	6	604	579	-	-	-	-	-
750	1,373	7	869	-	1,353	-	-	-	-

Based on the distribution of the events, registers were categorized under seven different categories of capacity reductions. The number of events categorized under each capacity reduction category and fuel type (including BES) is presented in Table 2. Table 3 presents the average capacity reduction for each category and fuel type (including BES).

When examining the end dates of the registers, as shown in Table 4, most of the registers reported ending in February (98.51%), with a minor number of events reporting end dates in March (1.07%), April (0.33%), or after. Using the events that reported an end date in February, Table 5 reports the average duration of events as the capacity reduction (%) for all registers included in EGOVA's database.

Table 4. Distribution of the end date for the events included in EGOVA's database.

Number of events with an end date before March	2,110	98.51%
Number of events with an end date before April	2,133	99.58%
Number of events with an end date before May	2,140	99.91%
Number of events with an end date after May	2	0.09%

Table 5. Average duration of events[a] and derate (capacity reduction) for all registers included into EGOVA's database classified by fuel type (including battery energy storage).

Fuel	**Event Duration[a] (hours)**	**Derate (%)**
Coal	32.7	47.2%
Batter Energy Storage (BES)	70.1	86.9%
Hydro	79.7	100.0%
Natural Gas	32.0	66.1%
Nuclear	63.7	100.0%
Solar	30.6	64.4%
Wind	37.6	71.8%

a. Events with an end date in February (98.51% of the reported events) in EGOVA's database.

Additional fields representing the expected capacity contributions during winter were included based on ERCOT's Winter 2020-21 Final Seasonal Assessment of Resource Adequacy (SARA). As described in ERCOT's SARA report, contributions by biomass, coal, gas, or nuclear generators were considered as fully expected (100%), while contributions from hydroelectric generators (78%), solar (7%), and wind (varying depending on location but range from 19-43%) were only partially expected. No capacity was expected from BES (0% contribution).

Using the seasonal capacity and the expected contributions, two fields calculating the surplus (observed capacity exceeds expected capacity) or shortage (expected capacity exceeds observed capacity) were added to each register. For example, the first unit of Rambler Solar has a winter capacity of 200 MW. This unit reported a derate, reducing by 11 MW its capacity for 1.5 days. The expected capacity for this unit was 14 MW (multiplying the expected capacity contribution of 7% by the seasonal capacity), which means that during the event the unit had a surplus of 175 MW. In contrast, the second coal unit of the Oak Grove plant was expected to contribute 100% of its capacity (855 MW) but reported a total capacity loss during the period from 2/15 09:07 pm to 2/17 12:12 Am. During this time the unit had a capacity shortage of 855 MW. Based on these metrics, Table 6 presents the distribution of events for each fuel type (including BES) and the total surplus or shortage.

Table 6. Surplus or shortage for each of the events included in EGOVA's database. The seasonal capacity is included based on ERCOT's Winter 2020-21 Final Seasonal Assessment of Resource Adequacy (SARA). Surplus represents an observed capacity that exceeds the expected capacity. Shortage an expected capacity that exceeds the observed capacity.

	Events with SARA Capacity Surplus (Observed - Expected)			**Events with SARA Capacity Shortage (Expected - Observed)**		
Fuel	**# of Events[a]**	**Total Surplus (MW)**	**Average Surplus per Event (MW)**	**# of Events[a]**	**Total Shortage (MW)**	**Average Shortage per Event (MW)**
Coal	-	-	-	51	16,908.0	331.5
BES	3	31	10	-	-	-
Hydro	-	-	-	2	63	32
Natural Gas	-	-	-	833	91,196	109
Nuclear	-	-	-	1	1,353	1,353
Solar	49	3,081	63	29	201	7
Wind	421	14,999	36	740	20,298	27
Total	**473**	**18,111**		**1,656**	**130,019**	

a. Considering the 2,129 events (99.4% of all events in EGOVA's database) that reported an expected capacity different from the one observed.

To facilitate the analysis of the events associated with the energy crisis, EGOVA's database includes a minute-by-minute timeline with values for the main metrics of the database (total capacity reported out as shown in Figure 1 and capacity surplus and shortage as shown in Figure 2). Table 7 summarizes the surplus and shortage when aggregating the timeline into hourly blocks.

The visualization platform allows the user to display all this information (see Figure 3). Each event is symbolized based on the capacity reduction using the symbology presented in Table 2, in which the symbol size is determined by the capacity reduction for each event. The color code depends on the fuel type. Events reporting outage/derate of batteries are depicted yellow, coal using black, hydroelectric using blue, natural gas using red, nuclear using gray, solar using orange, and wind using green. The timer in the top left menu, allows the user to select a time span (period in time where the events are displayed on the screen) and mobilize the time slider to see the progression of the events. Additionally, it offers the option of automatically playing the progression of the events using one-hour time steps.

Table 7. Hourly surplus or shortage from 2/10 to 2/20. The seasonal capacity is included based on ERCOT's Winter 2020-21 Final Seasonal Assessment of Resource Adequacy (SARA). Surplus represents an observed capacity that exceeds the expected capacity. Shortage an expected capacity that exceeds the observed capacity.

	SARA Capacity Hourly Surplus (Observed - Expected) (MW)		SARA Capacity Hourly Shortage (Expected - Observed) (MW)		SARA Hourly Net Capacity (Expected - Observed) (MW)	
Fuel	**Total[a]**	**Average**	**Total[a]**	**Average**	**Total[a]**	**Average**
Coal	-	-	29,246,847	2,031	-29,246,847	-2,031
BES	138,720	10	-	-	138,720	10
Hydro	-	-	358,405	25	-358,405	-25
Natural Gas	-	-	133,398,918	9,263	-133,398,918	-9,263
Nuclear	-	-	5,168,460	359	-5,168,460	-359
Solar	5,429,297	377	123,658	9	5,305,639	368
Wind	26,719,644	1,855	49,892,437	3,465	-23,172,793	-1,609
Total	**32,287,661**		**218,188,725**		**-185,901,064**	

a. Total surplus or shortage adding the hourly values registered between 2/10 and 2/20 (240 hours).

Table 8. Symbology used to represent each type of event.

Capacity Reduction (MW)		Category	Symbol Size (points)
Lower	**High**		
0	50	1	4
50	100	2	6
100	200	3	8
200	350	4	10
350	500	5	12
500	750	6	15
750	1,373	7	18

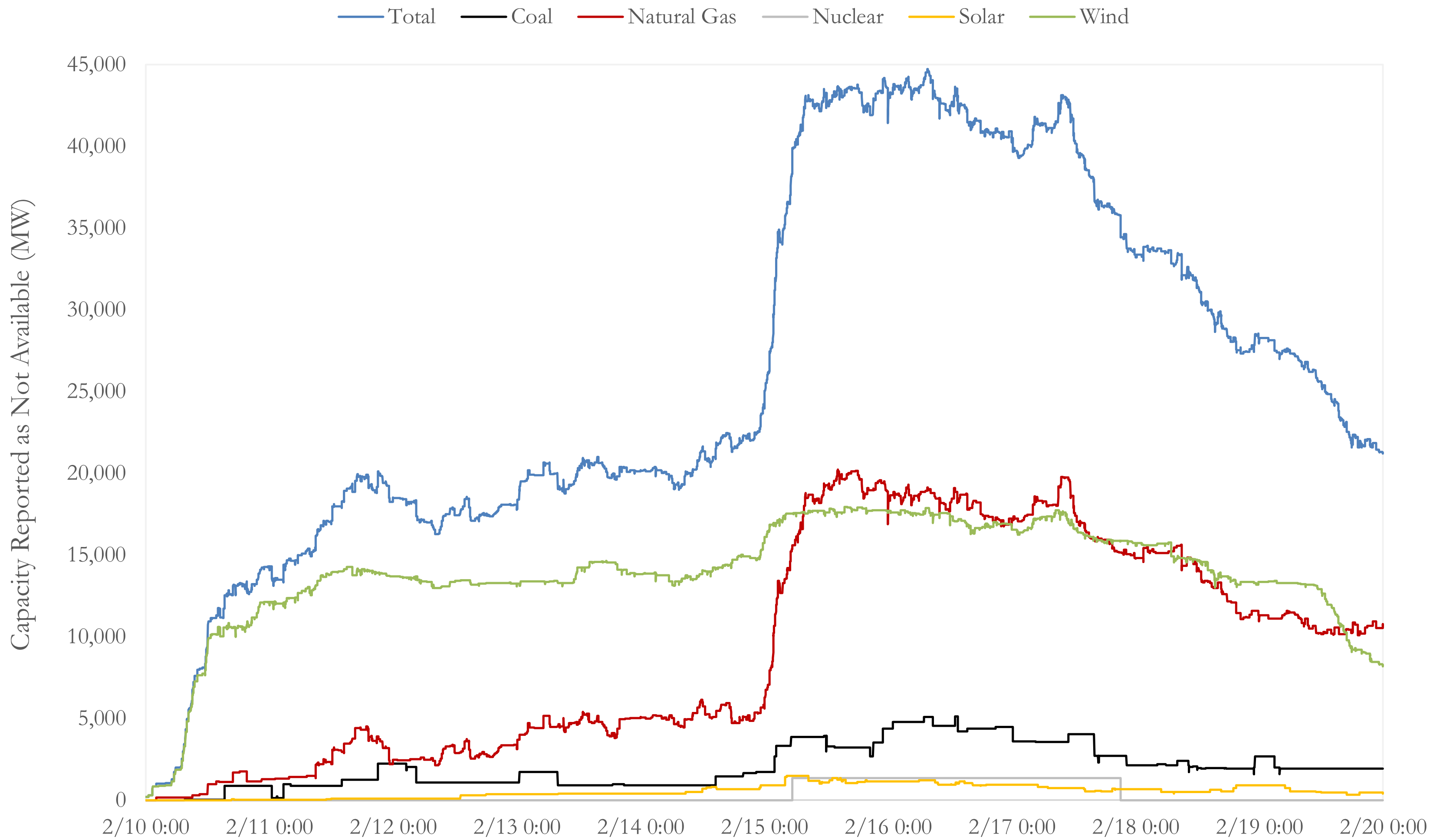

Figure 1. Capacity reported as not available for generation during the period of 2/10 to 2/20 based on ERCOT's public report released on March 12th, 2021. Only generators or BES that were included in ERCOT's outage report are depicted in the figure. The black series represents coal, the red natural gas, the gray nuclear, the orange solar, and the green wind. Neither battery energy storage nor hydroelectric generators are presented in the figure.

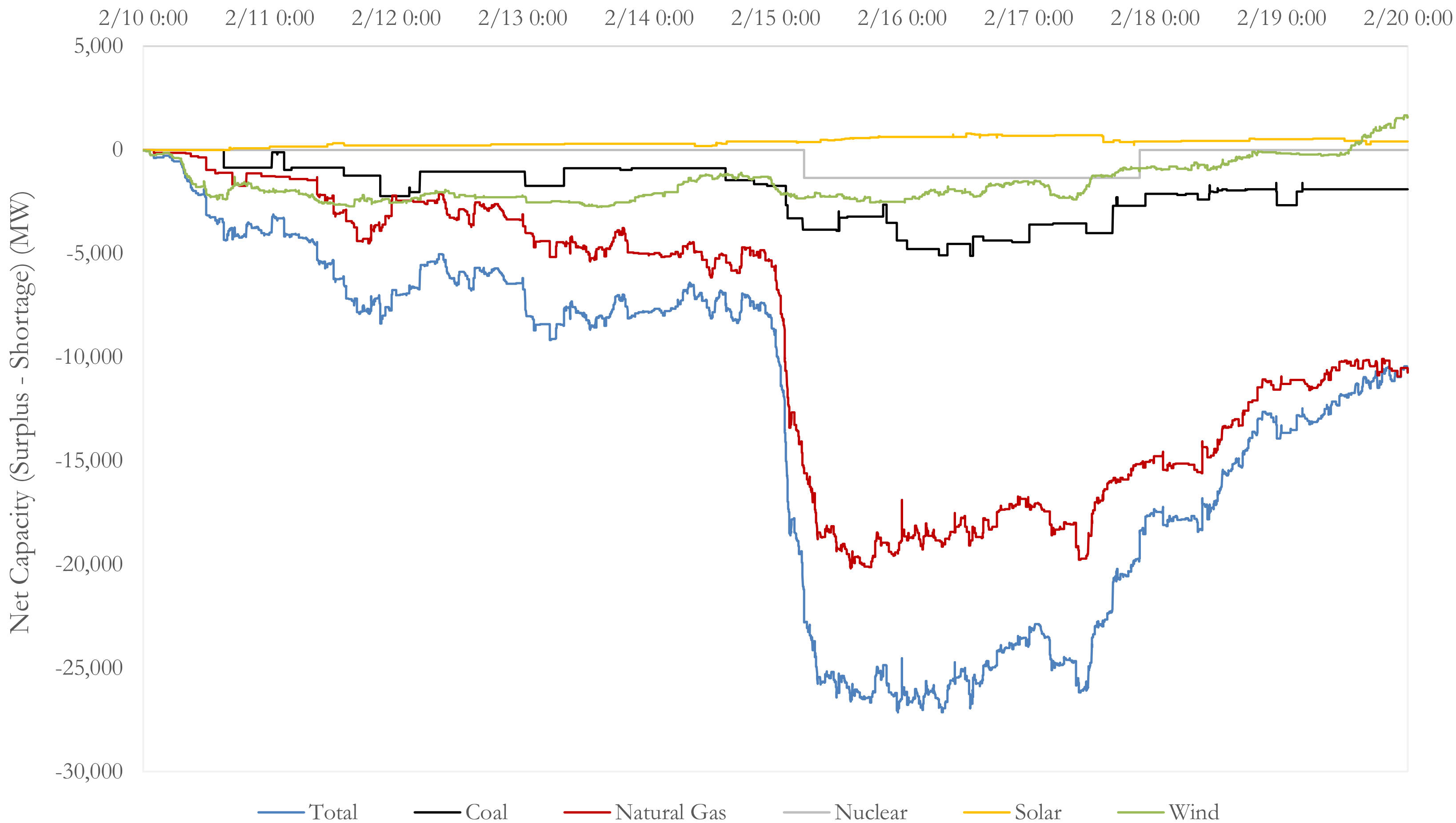

Figure 2. Net capacity not available for generation, calculated by comparing the expected and observed capacity of generators that reported an outage/derate. The expected capacity is based on ERCOT's winter Seasonal Assessment of Resource Adequacy (SARA) report released on November 20th, 2020. The observed capacity is based on the reported capacity for each of the generators. Only generators that were included in ERCOT's outage report are depicted in the figure. The black series represents coal, the red natural gas, the gray nuclear, the orange solar, and the green wind. Neither battery energy storage nor hydroelectric generators are presented in the figure.

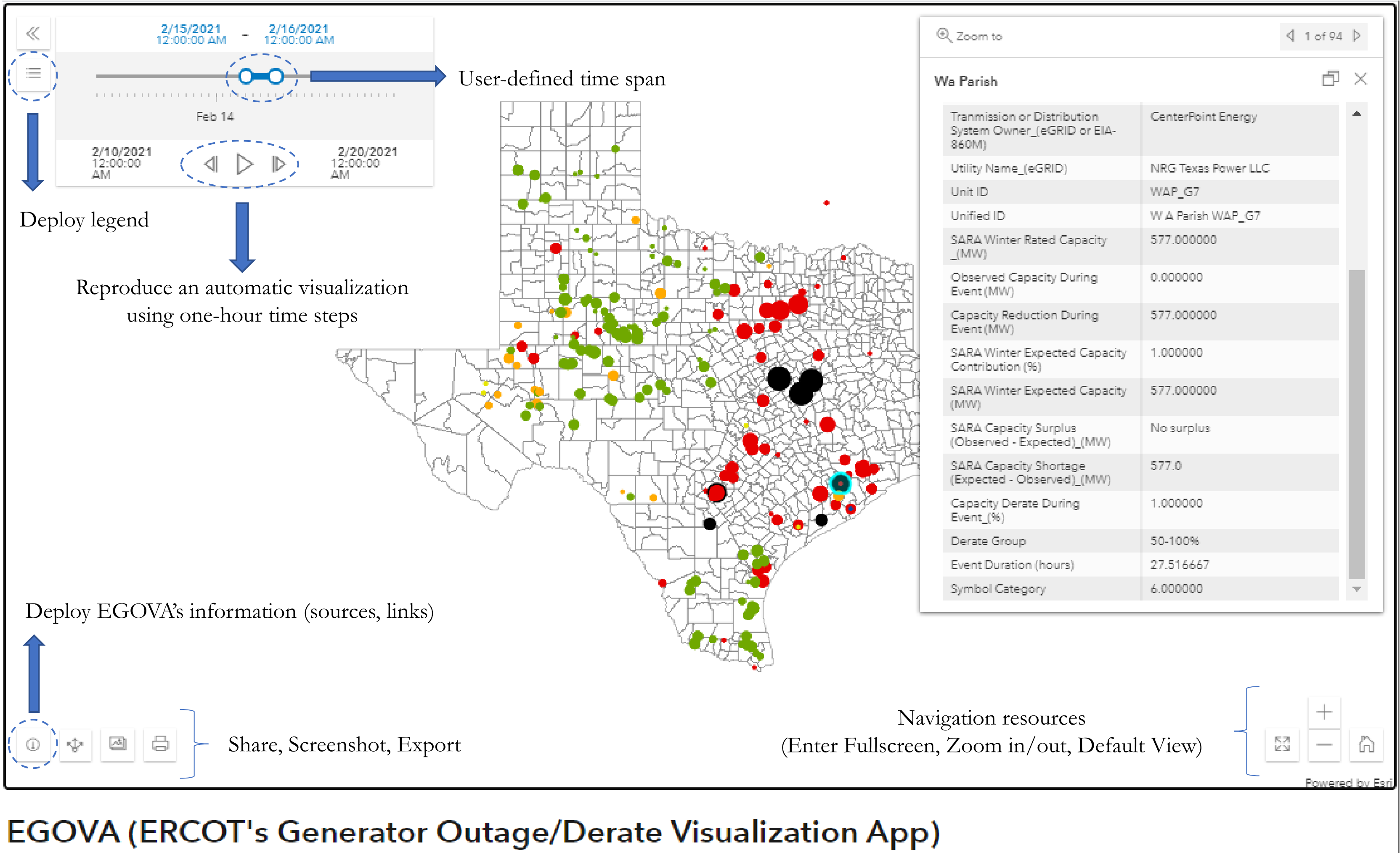

Figure 3. EGOVA allows the user to visualize the information for each of the events including the capacity reduction, the duration of the event, and comparisons between the observed and expected capacity contribution for the generators that reported one outage/derate events from February 10th to 20th, 2021. The app includes a time slider option that allows the user to choose a time span (period of time where the events are visualized) and observe the evolution of events using one-hour time steps. The app can be accessed at: https://bit.ly/EGOVA.