SAE INTERNATIONAL

FORMULA SAE

ENERGY METER STUDENT MANUEL

Updated June 13, 2025

Introduction

Formula SAE Electric requires the installation of the competition provided energy meter in every vehicle. The energy meter will monitor energy usage and peak power, voltage and battery temperature. This information is used to check for power, voltage and temperature violations during the competition as well as computing the efficiency score.

The energy meter is designed in two components, a receptacle and the energy meter. Teams will need to purchase the receptacle from SAE and install it in the vehicle prior to competition. The energy meter itself will not be available for purchase. At competition, the energy meter will be provided and installed in the receptacle. The receptacle must not be inside any tractive system enclosure and must be easily accessible without significant disassembly. Removal of body panels is allowed to access the energy meter. The provided energy meter will need to be returned at the end of competition.

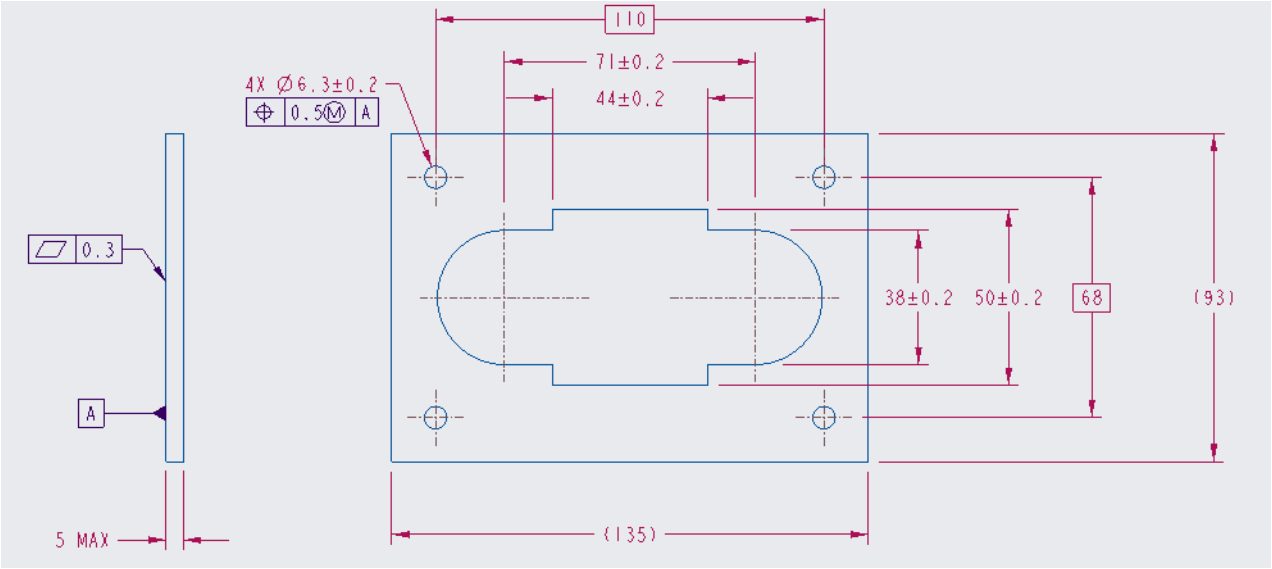
The energy meter is based the Amphenol MSDXLF000F / MSDXLM000 manual service disconnect. The energy meter cannot be used as the FSAE Manual Service Disconnect (EV.5.5.2) and should remain installed in the receptacle for the entire duration of the competition. This includes when downloading the energy meter. Teams must plan for appropriate access to the download connector while the energy meter is installed in the vehicle. Extending the download connector is not allowed.

Teams should plan to purchase an Amphenol MSDXLM000 from the supplier of their choice to use when running not at competition. This will make the required TS and interlock connections in the receptacle to allow TS operation. The modified receptacle used for the energy meter is compatible with the unmodified service disconnect which can be used to complete the TS connection when not at competition.

Contents

Mechanical

The receptacle cut-out is based off the Amphenol MSDXLF000F recommendations. Additional clearance will be required to account for the TS and GLV connectors. Below provides a summary. Modification may be required to fit to teams' specific applications.

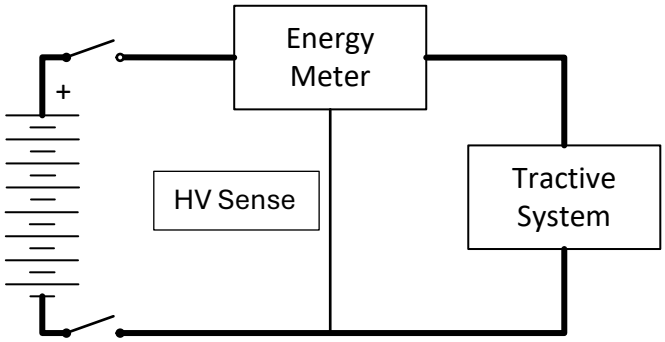


Receptacle mounting screws are M6 x 1.0, torque limit is 8 Nm. The bolted connections for the series high current TS connections are M8 x 1.25, torque limit is 13.4 Nm.

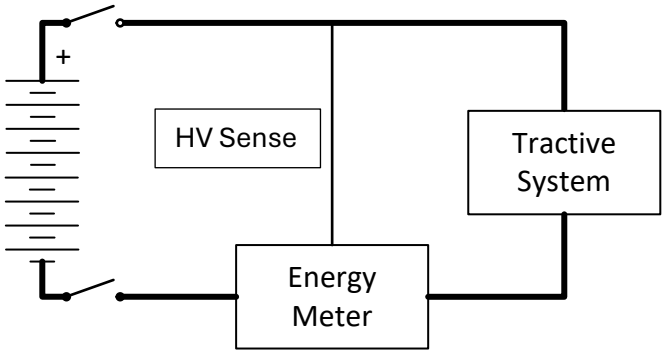
The receptacle is based on the front mount (MSDXLF000F) receptacle from Amphenol and is designed to be mounted on the outside side of an exterior panel of a TS enclosure. Rear mount receptacles are not available.

TS Wiring

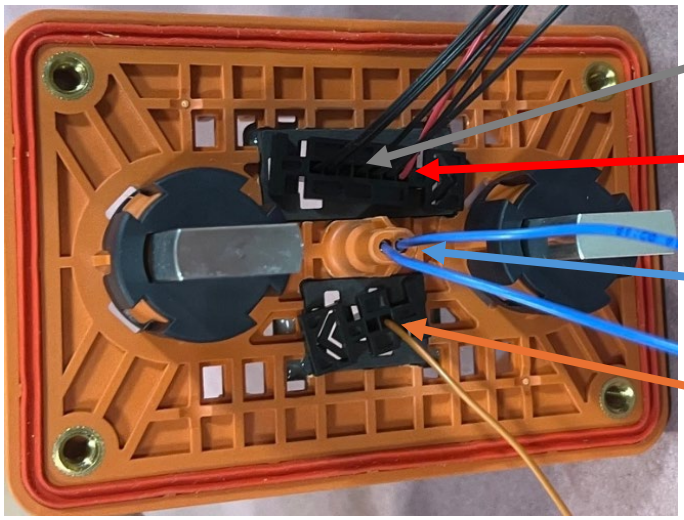
The energy meter has 3 TS connections. The first two connections must be wired in series with the high current path of the TS such that all TS power runs through the energy meter. This series connection must be in either the most positive or most negative side of the TS. The energy meter cannot be wired midpack. The third connection must be wired to the other pole of the TS for sensing voltage – connect to the wire lead in the #1 socket of the 2 pin connector. The energy meter must be connected on the tractive system (not always energized) side of the isolation relays.



Option A: Energy Meter in HV+ Path



Option B: Energy Meter in HV- Path

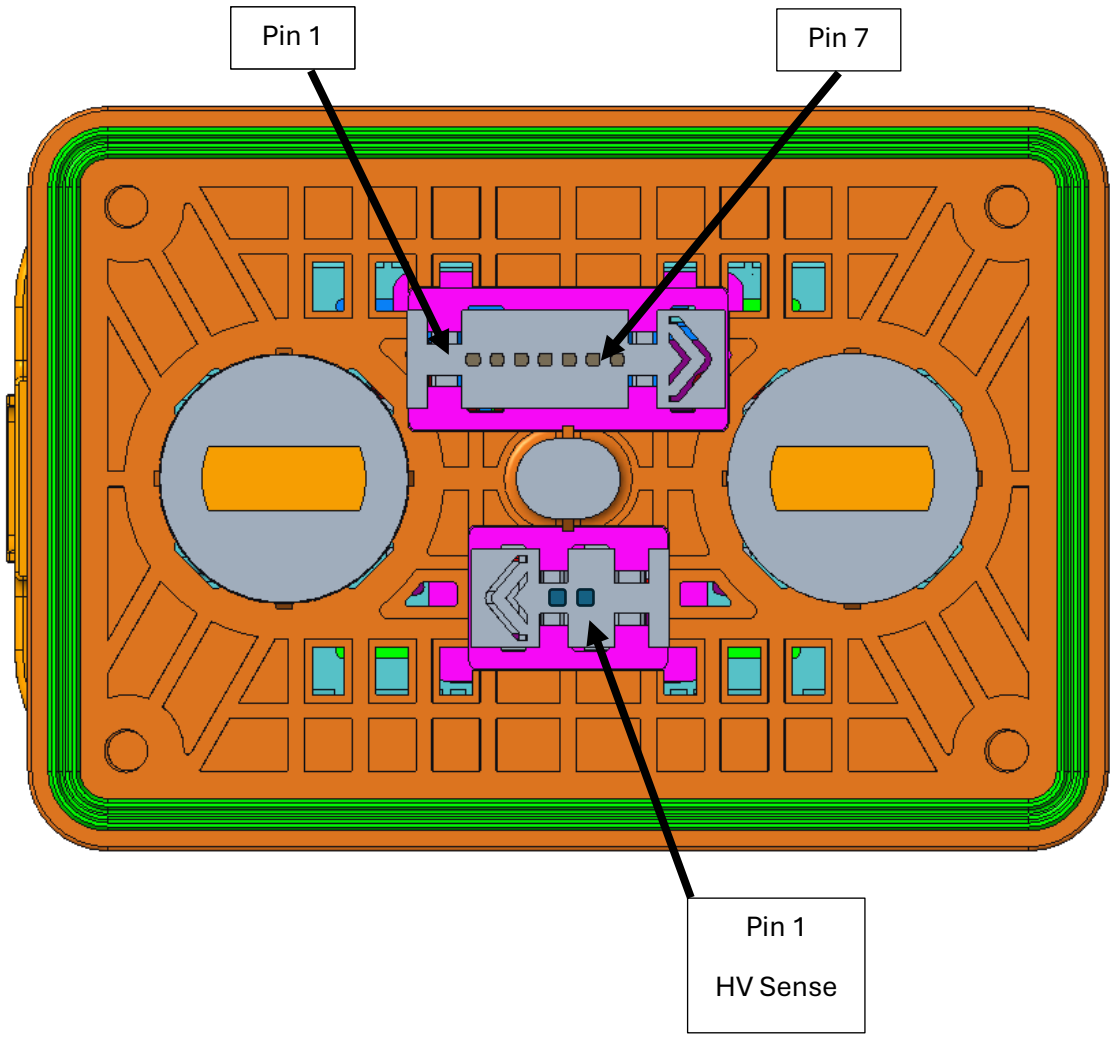


The energy meter receptacle is provided with 300mm long leads terminated and installed in all low current connections of the energy meter. The other end of the leads is left unterminated and should be terminated as needed by the teams.

GLV Wiring

The energy meter must be provided with GLV power from the vehicle.

Pin	Function
1	Temp Sense Ground
2	Temp Sense One Wire
3	No Connection
4	CAN Low
5	CAN High
6	GLV Negative
7	GLV Positive



GLV Specifications

Voltage Input: 6 – 40V
Current Draw: ~125mA
CAN Baud Rate: 500k

CAN Messaging

The energy meter provides a CAN bus connection which will allow access to the real time data within the energy meter. The CAN bus also allows the addition of team signals to the energy meter data log. These team signals are not required and are provided for the convenience of the team. Use of the CAN bus connection of the energy meter is not required and is completely optional.

All signals are big endian (Motorola).

Measurement Message
Message Id: 0x10d (11 bit ID)
Transmitted by energy meter
Rate: 20ms

Data Byte	0	1	2	3	4	5	6	7
Signals	Current [A] float				Voltage [V] float			

Status Message
Message Id: 0x40d (11 bit ID)
Transmitted by energy meter
Rate: 100ms

Data Byte	0	0	1	2	3	4	5	6	7
Data Bit	0	1							
Signals	Violation	Logging	Energy [Whr] float						

Temperature Message
Message Id: 0x60d (11 bit ID)
Transmitted by energy meter
Rate: 250ms

The temperature message includes a multiplexor signal. The first bits of the first byte of the message (the multiplexor) are used to determine the meaning of bytes 3-7.

All temperatures are sent as an unsigned byte with the following scaling. degC = raw * 0.5

Data Byte	0	0	1	2	3	4	5	6	7
Data Bit	0-2	3-7							
Signal	0	Num Sensors	Min Temp	Max Temp	Temp 0	Temp 1	Temp 2	Temp 3	Temp 4
	1				Temp 5	Temp 6	Temp 7	Temp 8	Temp 9
	2				Temp 10	Temp 11	Temp 12	Temp 13	Temp 14
	3				Temp 15	Temp 16	Temp 17	Temp 18	Temp 19
	4				Temp 20	Temp 21	Temp 22	Temp 23	Temp 24
	5				Temp 25	Temp 26	Temp 27	Temp 28	Temp 29
	6				Temp 30	Temp 31			

Team Data 1 Message
Message Id: 0x30d (11 bit ID)
Received by energy meter

Data Byte	0	1	2	3	4	5	6	7
Signals	Team Signal 1 sint32				Team Signal 2 sint32			

Team Data 2 Message
Message Id: 0x30e (11 bit ID)
Received by energy meter

Data Byte	0	1	2	3	4	5	6	7
Signals	Team Signal 3 sint32				Team Signal 4 sint32			

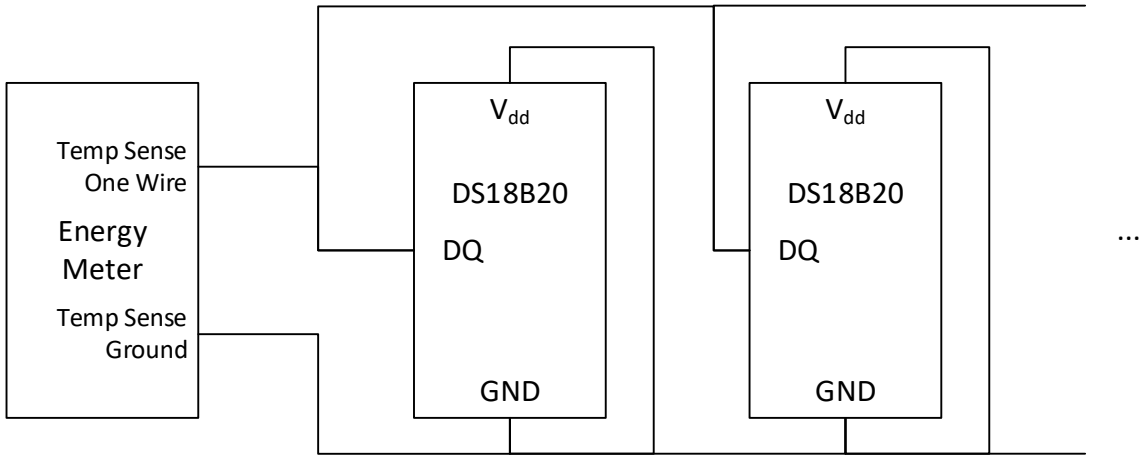
Temperature Sensors

For the 2025 seasons teams are required to have at least 1 energy meter temperature sensor in the accumulator. The exact location is not specified, and it can be located anywhere the team prefers within the accumulator.

Starting in the 2026 season, teams will be required to have at least 1 energy meter temperature sensor per accumulator segment. The temperature sensors must be in the hottest region of each segment and meet EV.7.5.4. The sensors must also have appropriate levels of electrical isolation between the sensor and cell. It is recommended to use a thermally conductive, electrically insulating thermal interface material.

The sensors used must be an Analog Devices DS18B20 (any package) wired for parasite power Vdd connector to Gnd. Multiple sensors should be connected in parallel.

There are many counterfeit sensors on the market. Counterfeit sensors will not be accepted. Teams are encouraged to only purchase from trusted suppliers to ensure they are receiving genuine parts.



Download Connector

The download connector is located on top of the energy meter and must be accessible without removing the energy meter from the vehicle. Teams are not allowed to extend or relocate the download connector. Cabling to connect to the energy meter will be provided at the download stations at competition.

Operation

The energy meter requires GLV power to log data. Once GLV power is applied and the energy meter has booted, it will begin logging into a new file when the TS voltage is detected to be > 60V. The energy meter will stop logging when the TS voltage is detected to be < 60V.

The energy meter has a status LED visible through the translucent cover near the download connector. The LED has the following indications:

Condition	Pattern	Description
Booting Up		solid red
Idle		orange single flash
Idle with Fault		red single flash
Logging		Orange single flash off
Logging with Fault		Red single flash off
Server Operation		orange flashing
Server Operation with Fault		red flashing

Downloading

Downloading data from the energy meter will be the responsibility of the teams.

Download stations will be available at the competition near dynamic events, the practice track, and EV tech. The download station will provide a cable that must be plugged into the download connector on the energy meter. During the download process the energy meter will be powered by the download cable and GLV power is not required.

The status of the download process will be available through the FSAE website and the status LED on the energy meter. Teams may use this to monitor the download progress.

Data will be publicly available to download from the FSAE website.

After data has been transferred to the FSAE site teams will be required to associate their dynamic event runs to the data files. It is the responsibility of the team to ensure that data is downloaded from the energy meter and associated to their dynamic event runs prior to the deadline. Teams do not have to be connected to the download station to associate their dynamic runs to the data files.

Teams will be required to login into their FSAEonline accounts before associating any of their dynamic event runs.

Teams will associate the data on the website: results.fsaeonline.com

How to Download & Associate Team Energy Meter Data to Dynamic Event Runs

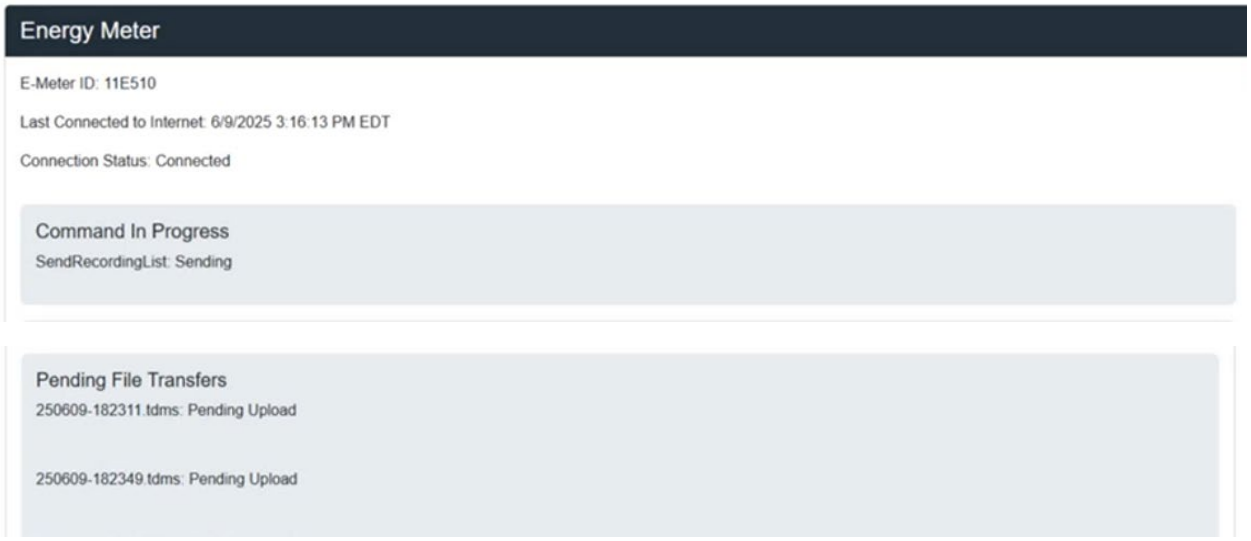
Downloading

Once you connect green download cable to the energy meter, the energy meter will be powered by the download station and GLV power is not required.
The status of the download process will be visible by the status LED on the energy meter.

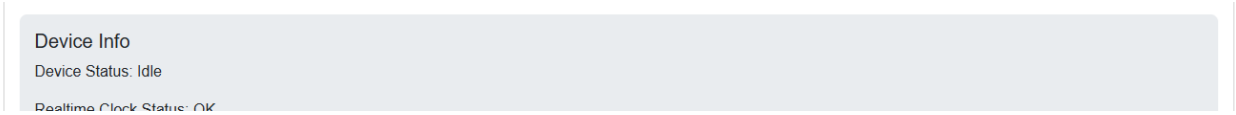
Teams may view the data transfer and monitor the transfer process online.

1. Navigate to result.fsaeonline.com portal OR via the FSAE Mobile App select Live Results
2. Select My Team's Result
3. Enter car number and click GO
4. Select E-Meter Data

It will take approximately 10 – 15 seconds for the energy meter to make connection to download station to begin data transfer. You do not need to refresh your webpage; it will do that when Connection Status changes like image below showing that and the Command in Progress.



Data upload is complete when there is no Command In Progress and the Device Status is Idle.



All recordings that are uploaded throughout duration of the competition will be visible under Recordings like shown in image below:

Additional information on the buttons under Actions:

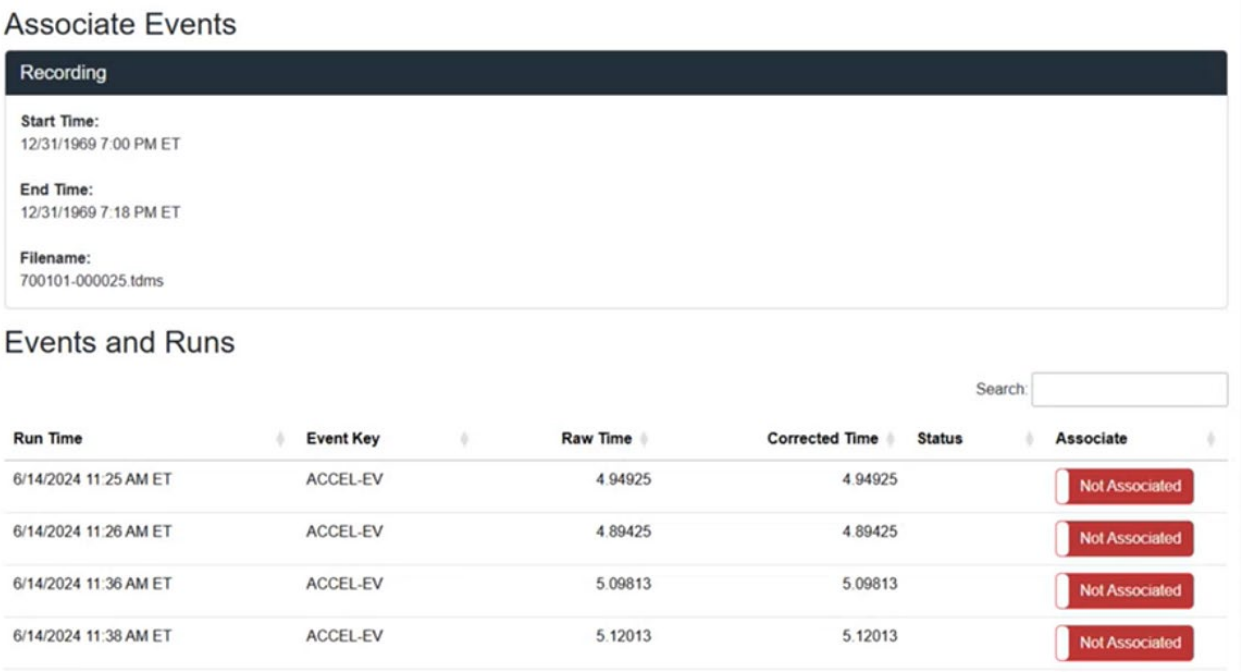
TDMS – this will give you raw data and can be downloaded
PLOT – gives you a quick glance of data via plot. This plot graph can be zoomed in/out as needed
***ASSOCIATE EVENTS** – will use to associate data to dynamic runs.
***EDIT NOTE** – this is only visible to the team data associated with or the EV Tech/Scoring volunteers
**These two buttons require you to log into your account on fsaeonline.com to associate data or edit any notes.*

REMINDER:
Teams only need to be connected to the download station to download data from energy meter. Once files are downloaded, teams can disconnect from the download station to free up for other teams.

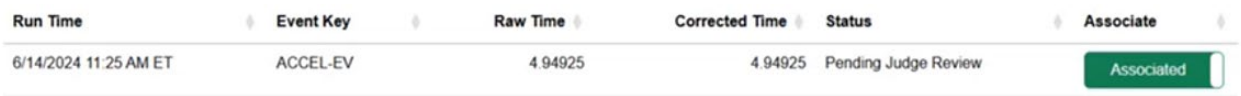
Associating Data

Recordings must be associated to event runs. This allows the scoring system to understand which recordings have data for the dynamic event runs.

To associate data to events, select the Associate Events button of a recording which has data from an event. If you are not already logged into your fsaeonline.com account, you will be required to do. Then, you will be directed to a page like this:



Toggle the Not Associated / Associated button in the Associate column for each event run contained in this data file to the Associated state. The associate state will change to a green Associated, and the association will be reviewed by a judge and approved. Teams may associate and unassociate data from a run if they make a mistake but ONLY before a Judge Reviews and accepts it.



Multiple runs can be contained in and associated to a single recording file. Multiple recordings can be associated to the same event in the case that TS power was cycled during a run producing multiple data files.

After associating data to dynamic event runs, you will notice on the Team Data page that your data has been associated to the event like the example below shows:

Please Note:

A recording can contain multiple runs, and a run could contain multiple recordings.

REMINDER:

- Teams should have all energy meter data associated to Dynamic Runs by or before 6PM on Friday Dynamic Event Day.