

2007 Formula ELECTRIC & HYBRID ITALY RULES

Preliminary issue

1. Formula ELECTRIC & HYBRID ITALY overview

1.1. The Objectives

The 2007 Formula ELECTRIC & HYBRID ITALY addresses the same scope and overall objectives of the previous Formula TECH.

The Formula ELECTRIC & HYBRID ITALY (EHI) addresses the development and competitive demonstration of advanced electric & hybrid vehicles integrating powertrains based on advanced technologies. The development and the demonstration shall be performed by university students.

A main objective is to show outcomes of research in the field of new technologies, which can contribute to reach the target of a sustainable ecological and energy effective mobility.

A part of the goal is to address the industry attention to new solutions in this field, suitable to be transferred to the engineering and industrial development process.

Another scope is to stimulate and activate exchange of information and contacts among Academic Institutions and relevant supportive industries about these new and socially beneficial technologies.

A final aim is to promote and contribute to the diffusion of the culture of electric and hybrid vehicles and to encourage industries and users to the development and the acceptance of these environment and energy conscious vehicles.

The attention of the Formula ELECTRIC & HYBRID ITALY and the evaluation of the merits of the research products demonstrated by the participants are addressed to the following aspects:

- Energy effectiveness
- Operational response
- Environmental impact
- Innovation level
- Industrial and utilisation aspects

To create synergies with other competitions addressing the same technical areas, the SAE 2007 Formula Hybrid Rules has been assumed as reference for some basic concepts and test procedures.

1.1. Eligibility

1.1.1. Society Membership

Students, Team Leaders and Faculty Advisors must be **MEMBERS** of their national referent Association or of **ATA**. For example, Italian Teams must be associated to ATA, English to MechE, etc,

Proof of membership, such as membership card, is requested while registering.

1.1.2. Registration

Teams may enter a vehicle as many years as they like, provided they can show evidence of substantial development since the last time the vehicle was entered.

1.2. Admitted Categories

Formula EHI welcomes the following research product categories:

Category 1: Four wheel car, single seat, formula style body (as for SAE 2007 Formula Hybrid), equipped with the following types of powertrain:

- Hybrid electric, with Internal Combustion Engine, including plug-in (externally chargeable) hybrids.
- Battery electric, rechargeable from external grid and/or from on board solar panels
- Fuel Cell, fuelled with Hydrogen, including plug-in (with battery externally chargeable).

Vehicles built with chassis commercially available are admitted

Category 2: Two or Three or Four wheel vehicles, equipped with the following types of powertrain

- Hybrid electric, with Internal Combustion Engine, including plug-in (externally chargeable) hybrids.
- Battery electric, rechargeable from external network and/or from on board solar panels
- Fuel Cell, fuelled with Hydrogen, including plug-in (with battery externally chargeable).

Category 3: Systems, Components and Projects, concerning electric and hybrid technologies.

- Static demonstrators
- Posters

2. Rules for Category 1

For the vehicle requirements the provisions of SAE 2007 Formula Hybrid Rules are to be met. .

These rules are linked to Formula SAE rules, which are available for download from:
<http://students.sae.org/competitions/formulaseries/rules/rules.pdf>

Static events and dynamic events will be performed:

2.1 Static Events

The following steps and relevant maximum possible scores are established:

- Technical inspection

The inspection of the vehicle, to be performed by the Technical Committee, aims to verify the consistency with the basic requirements and the adequacy of the vehicle to perform the dynamic events.

The Team might be requested to demonstrate the compliance of the powertrain with the prescribed power limits through appropriate documentation.

- Presentation

Room presentation of the vehicle characteristics.

The elements should be put in evidence, which are related to the main objectives (par 1.1.):

- Operational performance
- Energy consumption, refuelling and battery charging procedures
- Environmental aspects
- Prototype realisation program and cost report

Maximum possible score: 100 points

- Engineering Design

The concept and architecture of the powertrain and its integration in the vehicle structure should be presented in the room or in the box, with particular respect to the following objectives:

- Industrial aspects, including cost estimation for potential industrial production
- Utilisation aspects, including mission analysis, infrastructure interfacing requirements and operational cost estimation in the practical use of a potential industrial product.
- Elements of innovation with respect to the state of the art of technology.

A design report should be presented including drawings (see point 4.5.2.1 of SAE 2007 Formula Hybrid Rules Revision 1 dated 1/15/2007).

Maximum possible score: 200 points.

The Static Events include the technical analysis of the vehicle in the box.

2.2 Dynamic Events

The dynamic events are established to demonstrate the practical behaviour of the vehicle and to complement the evaluation resulting from the static events. Vehicle systems shall have the same hardware configuration for all events.

Acceleration Event

The acceleration event evaluates the car acceleration in a straight track on flat pavement.

Acceleration procedure

The car will accelerate from a standing start over a distance of 75 m (82 yards) on a flat surface.

The foremost part of the car will be staged at 0.30 m (11.8 inches) behind the starting line.

There will be a minimum of 2 acceleration runs. One must be run electric-only, with the engine shut off. The second run may be done in any configuration the team chooses. Teams have the option of making up to two additional runs in each mode (electric-only and unrestricted) for a total up to 6 runs. The fastest run in each mode will be the recorded acceleration time.

It is permissible for one driver to make all the acceleration runs.

The two acceleration modes will be scored separately for 75 points each.

The acceleration score is based upon the corrected elapsed time. Elapsed time will be measured from the time the car crosses the starting line until it crosses the finish line.

A two (2) second penalty will be added for each Cone Down Or Out (DOO), including entry and exit gate cones, that occurred on particular run, to give the corrected elapsed time.

Maximum score for acceleration event: 150 points (75 for each mode)

Battery electric and fuel cell cars will run in electric only, with maximum score 150 points

Acceleration scoring formula:

$$\text{ACCELERATION SCORE} = 75 \times \frac{(\text{Tmax}/\text{Tyour}) - 1}{(\text{Tmax}/\text{Tmin}) - 1}$$

Where:

T_{your} is the best corrected elapsed time for the team including penalties

T_{min} is the elapsed time of the fastest car

T_{max} is the maximum acceptable acceleration time, corresponding to an acceleration time 0 – 50 km/h in 7 s at constant acceleration.

- Skid Pad Event

There is no Skid Pad Event in the 2007 Formula Electric and Hybrid Italy.

-Autocross Event

The objective of the autocross event is to evaluate the car behaviour in terms of manoeuvrability and handling quality. The autocross course combines the performance features of acceleration, braking and cornering in one event.

Autocross course specification and scoring is the same as for Formula SAE (chapter 5.6.3 to 5.6.8) with possible adaptation to the specific characteristics of the proving ground.

Maximum score for Autocross Event: 100 points.

$$\text{AUTOCROSS SCORE} = 100 \times \frac{(\text{Tmax}/\text{Tyour}) - 1}{(\text{Tmax}/\text{Tmin}) - 1}$$

- Endurance and Energy Economy Event

The Endurance and Energy Economy Event is designed to evaluate in a single demonstration test the overall performance, the reliability and the energy efficiency of the car.

The test will take place on a track of total length 33 km, consisting on straights segments, constant turns, hairpin turns.

Battery electric cars

The consumption will be measured in kWh as the amount of electric energy supplied by the grid to bring the batteries at the end of the test to the same state of charge as at the beginning (typically full charge).

Hybrid electric cars

For externally chargeable (or "plug-in") cars, the electric energy consumption will be measured as previously described for battery electric car. The fuel consumption will be measured in kg by refilling the tank up to the same level as at the beginning of the run.

For one source of energy cars the fuel consumption will be measured in kg by refilling the tank at the end of test to the initial level, measuring the difference of the state of

charge of storage unit from the beginning to the end of the test. The measurement will be done by means of an Ah meter which will be provided by the Technical Committee. In the case of storage made with a supercapacitor, initial voltage will be measured. The energy will be computed on the basis of the nominal characteristics of the storage system (battery voltage, supercapacitor capacitance). The energy unbalance will be conventionally converted in fuel consumption according to following conversion formula: 0.35 gasoline kg/kWh.

Fuel Cell electric cars

The evaluation will be done by measuring the hydrogen consumption (ref. Standard ISO CD 23828-1) at the end of test in gram of hydrogen, verifying that the powertrain storage unit (if any) is at the same State Of Charge at the end as at the beginning of the test.

Fuel Cell electric cars will be subject to a separate score procedure.

Maximum score for Energy Economy/evaluation	350 points
Maximum score for Endurance evaluation:	100 points

Endurance and Energy Economy Course Specification and Speeds

Description is according to Formula SAE paragraph 5,7,4.

The event will be run as a single 33 km heat. A driver change can be made during a three-minute period at the mid point of the heat.

Mode of operation is unrestricted.

The energy consumption referred to the payload is evaluated in terms of CO2 emission at the primary energy source.

If considered opportune, the vehicle could be loaded with an extra weight, provided that the maximum allowable vehicle weight limits are not exceeded.

The driver weight is considered 70 kg.

Energy Economy Score Formula

$$\text{ENERGY ECONOMY SCORE} = 350 \times \frac{(C_{\max}/C_{\text{your}}) - 1}{(C_{\max}/C_{\min}) - 1}$$

Where:

C_{\max} is the maximum of the CO2 emission, referred to the payload, among the participants for the complete heat.

C_{\min} is the lowest CO2 emission, referred to the payload, by any competitor in the heat.

C_{your} is the CO2 emission, referred to the payload, by the Team being scored.

The following prospect should be used to calculate the CO2 produced starting from the primary energy source to make available electricity at the grid and the CO2 produced to make available fuel at the refuelling infrastructure.

3. Category 2 Rules

The rules for Category 2 vehicles (two, three or four wheel vehicles) are basically the same as for Category 1 cars. Specifically:

3.1 Static Events

Same as paragraph 2.1.

Total maximum score for static events 300 points

3.2 Dynamic Events

-Acceleration Event

Same procedure as for Category 1, except the following difference:

The acceleration test in the two modes, for hybrid vehicles, will be scored separately for 100 points each.

Maximum score for acceleration event: 200 points.

Battery electric and fuel cell vehicles will run in electric only with maximum score 200 points.

-Endurance and Energy Economy Event

Same procedure as for Category 1

Maximum score for Energy Economy evaluation: 400 points

Maximum score for Endurance evaluation: 100 points

Total maximum score for Energy Economy and Endurance: 500 points

4. Category 3 Rules

The systems and components will be object of room presentation and demonstration in the box.

The demonstration should address the energy efficiency and the performance with procedure based on relevant standards and system features.

The evaluation will take into account the merits related to the aspects listed in the chapter 1.1.

The maximum score will be 50 points, to be assigned to the extent of maximum 10 point for each of the items.

Projects will be object of room presentation and poster exhibition in the box.

The evaluation will be performed with the same criteria as for systems and components.