Shell Eco-marathon

Official Rules 2009

CHAPTER I

FOREWORD

The Shell Eco-marathon: challenging young people to design, build and drive energy-efficient vehicles

The Shell Eco-marathon is an educational platform that encourages innovation, reinforces conservation and fosters the development of leading technology for greater energy efficiency.

The Shell Eco-marathon encourages integration of vehicle design, finance and construction into the curriculum, as well as demonstrating the value of multi-disciplinary Teams, working together with industry towards a common goal.

Shell[1] organises energy-economy competitions on a real motor racing circuit in both the Americas and Europe. Known as the Shell Eco-marathon, this competition is governed by the Official Rules presented herein.

Participants can design vehicles for the 'Prototype' or the 'UrbanConcept' Group.
The **Prototype Group** encourages a maximum of technical creativity, imposing only minimal restriction on critical automotive design aspect.
The **UrbanConcept Group** is intended to be closer to road going vehicles in appearance and technology, addressing current transportation aspects.

These Official Rules are designed to enable safe, technically sound and fair competitions. They intentionally leave various design parameters, technologies and tactics unspecified in order to stimulate creativity and allow for the competition of novel ideas and solutions.

The vehicles may use one of the following fuel or energy types:

- Shell Unleaded 95 (EU) / Shell Plus 89 (US) Petrol/Gasoline
- Shell Diesel
- Liquefied Petroleum Gas (LPG)
- Shell Gas To Liquid (100% GTL)
- Fatty Acid Methyl Ester (100% FAME)
- Ethanol E100 (100% Ethanol)
- Hydrogen
- Solar

[1] The name "Shell" is used for the sake of simplicity when referring to one or more companies of Royal Dutch Shell plc.

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1 - ORGANISATION

Article 1: Acceptance

The entry forms must be sent completed, with all necessary documents, to the Organisers who will accept Teams based on the quality of the proposed entry packet. All decisions by the Organisers regarding the acceptance of Teams are final.

By the simple fact of their entry, participants accept all the provisions of the present Official Rules and agree to abide by all decisions made by the Shell Eco-marathon Organisers. The Organisers reserve the right to modify, delete or add any article of the present Official Rules. In such an event, the Teams will be notified. The Organisers are solely empowered to pronounce on cases not provided for in the present Official Rules.

The Organisers reserve the right to modify, delay or even cancel the competition in the event of unforeseen circumstances, notably rain and high winds. No claims for compensation will be accepted.

By entering the Shell Eco-marathon, all participants recognise the right of the Organisers, Shell, and more generally the companies of the Shell Group to use, if necessary, their images for publicity or materials promoting this project

Article 2: Entries

For each entry, a Team Manager, a Driver and a Reserve Driver must be designated.

The Team Manager can only be responsible for one vehicle. He/she may also be a Driver for that vehicle, but only for that vehicle.

The Team Manager is the Team's sole official liaison with the Organisers. All information will be addressed to him/her. For the purposes of the project, he/she will be responsible for the Team, must speak on behalf of the Team and must be able to understand and speak English.

The eligibility criteria for Drivers are detailed in the relevant section of Chapter II. The Driver for one vehicle cannot be the Driver or Reserve Driver for another vehicle. The main and reserve drivers must be affiliated with the educational organisation for which he / she is driving.

A Reserve Driver may be assigned to two vehicles. However, once he/she has driven one of those vehicles (during practice or in competition), he/she may no longer drive the other vehicle.

Each interested Team must apply to compete in the regional Shell Eco-marathon event closest to their home country. The attendance at another Shell Eco-marathon event outside its home region is subject to decision of the relevant regional organising committee.

Article 3: Track Access Conditions

During both the practice runs and the competition, all vehicles must comply with the technical and safety rules of the event. Whenever the track is entered, the vehicle body must be in place and bear all the competition numbers, partner streamers and Shell logos required by the Official Rules. Organisers will supply these numbers and logos upon entry confirmation.

Article 4: Identification

Logos, official partner streamers and racing numbers must be fixed to the vehicle body in accordance with the diagram provided (see Chapter II) such that they can be clearly read during any public presentation, in promotional films and on all photographs for team use, school use, press or promotional material.
Under no circumstances may the Shell logos, the partner streamers or racing numbers be modified, either on the vehicle or on any other documentation. It is prohibited to cut the stickers supplied by the Organisers. Their dimensions are as follow:

- For each side and for the front of the vehicle: a Shell logo, 20 x 20cm.
- For each side and for the front of the vehicle: racing numbers (stickers), with a different colour for each energy class, 20 x 26cm.
- For each side, on the lower part of the body: a partner streamer, 90 x 6cm.

A mandatory 10cm space must be left free on all four sides of the Shell logo.

Any other sponsor names / logos must be smaller than the Shell logo. The sponsor stickers must fit within a surface of 400 cm^2 (empty space included)

In the event of a breach of this rule, the Organisers reserve the right to remove any sponsor logos.
Furthermore, the trademarks or logos of other energy companies, direct competitors of event partners, tobacco companies and alcoholic drinks producers are prohibited.

All vehicles are subject to the Organisers' approval concerning these provisions.

Article 5: Compliance

Only those vehicles that comply with the present Official Rules are allowed to participate. No vehicle will be allowed on the track for practice or competition until the Organisers have approved it. The decisions of the Organisers are final in all matters concerning the compliance of vehicle design and construction with the present Official Rules.
The Organisers reserve the right to rescind vehicle approval upon further or more detailed checks. The Organisers must be notified of any modifications to the vehicle after inspection. Non-compliance with this rule will lead to vehicle disqualification.

Article 6: Timekeeping

All vehicles will be supplied with an electromagnetic transponder at the circuit that must be fitted after vehicle inspection using adhesive tape or bolts and nuts, inside or outside the vehicle according to the vehicle's characteristics. A security deposit may be required for this transponder. The security deposit will be returned upon presentation of the transponder at the end of the competition.

---------- PROTESTS AND DISPUTES ----------

Article 7: Protests

The Team Manager is the only person authorised to lodge protests. Protests must be addressed in writing to the Competition Director. Depending on their nature, said protests must be lodged within the following times:

- Vehicles: before the end of the competition.
- Team and Driver behaviour: within 10 minutes following the end of the attempt.
- Results: within 15 minutes after the results of an attempt have been posted.

Article 8: Disputes

In the event of any disputes, all decisions made by the Competition Director are binding and final.

Article 9: Penalties

Non-compliance with the driving rules will result in a warning, invalidation of the attempt or disqualification of the Team, depending on the severity of the breach.

The Organisers will exclude, disqualify or otherwise penalise any competitor who, in the judgement of the Competition Director, has gained an unfair advantage as a result of any breach of these Official Rules, hindrance of other participants, departure from the normal course, or any act or omission capable of misrepresenting performance, especially with regard to fuel consumption or method of propulsion.

During the competition, the Driver or the Team Manager must report to the Organisers any movement made or attempted by means other than the vehicle's own motive power. In such an event, the attempt in question will not be taken into account. If this type of incident is not reported, all the Team's attempts will be invalidated.

The Organisers will apply the following penalties for the following infractions:

- Non-use of the horn prior to overtaking.
- Non-compliance with safety or driving rules (unsafe or unwise behaviour).

1st infraction: Formal warning
2nd infraction: Best overall attempt invalidated at the end of the competition
3rd infraction: Immediate Team disqualification.

2 - SAFETY

Article 10: Safety Rules

As with any activity there should be an understanding that certain inherent risks will be present. Recognising and controlling the risks are vital for the well being of people and local surroundings. Safety is an essential consideration for the event Organisers. These Rules are to protect all individuals and surrounding area and are in no way intended to curtail the spirit of the competition. Any activity deemed unsafe or outside of the spirit of the event will be met with appropriate action by the event Organisers.

Therefore, compliance with safe driving and sporting rules will be mandatory for everyone. All Team members will comply with the safety measures and must notify Organisers about any anomalies or incidents; and in the event that dangerous conditions are present leave areas immediately. During the event the Pit areas will be monitored by the Organisers to assist Teams to comply with safe practices.

Non-compliance with any of the Official Rules may lead to disqualification from the competition at the sole and absolute discretion of the Organisers.

---------- DRIVING RULES----------

Article 11: Driving Knowledge and Test

Only the registered Driver and the Reserve Driver will be authorised to drive the vehicle.
During vehicle inspection, Drivers may be questioned to test their knowledge of the driving regulations.

Driving on-track: In the interest of safety it is important that Drivers learn and apply smooth and predictable driving techniques, e.g. thinking well ahead, avoiding sudden directional changes, and being fully aware of other competitors around them.

Article 12: Driving under the Influence of Alcohol / Illegal Substances

Driving under the influence of any alcohol and or illegal substance(s) is forbidden. This applies to all Drivers, Reserve Drivers and cyclists entering the track.

Procedures for alcohol or substance testing are detailed in Chapter II.

Any breach will be penalized in line with Article 9 and the following additional penalties:

- Any alcohol and substance related breach of the rules will be treated at least as '2nd infraction' of the Team, even if no prior violation has occurred.
- In addition, the affected Driver (or cyclist) is immediately banned from access to the track as long as he /she is under the Influence. The Reserve Driver may substitute the Driver if he/she is eligible to drive.
- Any second alcohol related infraction will lead to the immediate disqualification of the entire Team.

Article 13: Briefing

The attendance of any briefing sessions by Race Control is mandatory for Team Managers and Drivers. Scheduled briefings will be posted at the track.

Article 14: Access to the Track and Test Lap

Vehicles must pass a safety inspection prior to accessing the track for practice runs. A safety sticker will be clearly affixed once the vehicle has passed the inspection.

For practice runs, only vehicles with a safety sticker will be allowed on the track. For the competition, only vehicles with safety and technical inspection stickers will be allowed to compete.

Each Team may have a single bicycle on the track, but only during the practice runs. The cyclist must wear a badge bearing the Team's number and must ride in the racing direction, taking care not to disturb any of the other Teams; bicycles only will be permitted. Each cyclist must wear a cycling helmet and appropriate footwear, i.e. no sandals, flip-flops, etc.

Team Managers and Drivers may request a familiarisation lap aboard a Race Control vehicle. The dates and times for these test laps must be arranged at the Reception Desk and will be posted in the track area.

Article 15: Pushing the Vehicle

During the competition, the Driver will not be allowed to push his/her vehicle or to have it pushed, including to start the run or to cross the finish line. Non-compliance with this rule may lead to disqualification of that run.

Article 16: Competition Direction

It is forbidden to drive in reverse gear or to drive against the normal race direction; any breach of this rule will lead to disqualification of the vehicle and of the Team.

Article 17: Radio Communication

The use of hand-held communications is forbidden in the vehicle. However, the use of a “hands-free” kit is allowed.

Article 18: Overtaking

Drivers are required to give clear passage for other competitors wishing to overtake.

- The Driver in the overtaking vehicle must sound their horn and pass with caution. Attention: The Driver of the overtaking vehicle is responsible for the safety of the manoeuvre.
- The Driver of the vehicle being overtaken will use his/her rear – and side-view mirrors and must not change course suddenly.

Reminder: On the track, overtaking is authorised on both the right and the left, as long as the above-mentioned safety rules are followed

Article 19: Breakdowns and Other Incidents

Intentional stopping on the track is forbidden.

If a vehicle breaks down or is involved in an accident on the track, the Driver will immediately make every attempt to drive the vehicle to the shoulder of the track.

The Driver is allowed 30 seconds to attempt to re-start the vehicle from within its driving position.

If unsuccessful, the Driver must get out of the car and wait in a safe place off the track for the Track Marshals to arrive and recover the vehicle.

It is forbidden to carry out repairs on the track. In the event of a flat tyre, even when near the starting line, a new start will not be granted for the attempt in question.

Article 20: Off-track vehicle movements

All vehicles must be parked inside the designated paddock area or directly in front of it. When off the track, vehicles must be moved without the use of the engine. They must be pushed or pulled. Test-driving in the paddock area is forbidden.

Race Marshals will notify Race Control of any breaches and any unsafe or unfair behaviour.

---------- DRIVER EQUIPMENT ----------

Article 21: Driver Weight

Drivers should weigh at least 50 kg in full driving gear.
Ballast must be fitted to the vehicle in the event the minimum weight requirement is not met. This ballast must be provided by the Team, and must be effectively tied down and secured to the vehicle to ensure no danger for the Driver in the event of collision or roll-over. The Driver (in full driving gear) may be weighed before each official attempt

Article 22: Helmets

For practice and competition, Drivers must wear protective helmets (Motorcycle style is recommended) that comply with the safety standards specified in Chapter II of the Official Rules of each Shell Eco-marathon event. The helmet labels must be clearly attached to the exterior of the helmet. Helmets worn by both the Driver and Reserve Driver will be subject to Inspector's approval.
Several styles of helmets are permitted, for example full-face or three quarter. Generally the full-face and three quarter style helmets can be affixed with face shields and are highly recommended. If a face shield is not utilised, safety goggles will be required. The helmets must correctly fit the Drivers; otherwise they will not be approved for the event.

Article 23: Driver Clothing

All Drivers must wear a racing suit as the outermost layer of clothing (fire retardant highly recommended). Casual clothing and street wear are not permitted. Chapter II provides further guidelines regarding the racing suit specifications and availability. Wearing synthetic outer clothes or underwear is strictly forbidden for Drivers when seated in their vehicle.
Gloves and shoes are required; bare feet or socks only are prohibited.

---------- TEAM SAFETY EQUIPMENT ----------

Article 24: Equipment and Materials

Teams are required to provide and use the following at the event:

- Gloves for general work: leather or canvas material.
- Gloves for fuel or motor oil handling: Chemical resistant.
- Safety glasses for all Team members. (Disposable types are permitted).
- Hearing protection for all Team members. (Approved Earplugs or muffs).
- Duct tape to secure any cords or cables lying on the pit floor.

- Lift stands or appropriate raised platform for vehicle tuning and repairs.
- Each Team must provide an operational 6 kg dry-chemical (powder) (10 lb. Unit for US application) extinguisher suitable for “ABC” class of fires. The extinguisher must be accessible in the Team’s specific pit area in the garage. The extinguisher must be full, and have a certificate of validity bearing the manufacturer's number, the date of manufacture, and the expiry date.

---------- ATTENTION ----------

Please review all sections of the Official Rules as they may contain additional safety matters specific to the topic.

3 – VEHICLE DESIGN

3A – Prototype Group

Article 25: Vehicle Design

During vehicle design, construction and competition planning, participating Teams must pay particular attention to all aspects of safety, i.e. Driver safety, the safety of other Team members and spectator safety.
Vehicles must have three or four running wheels, which under normal running conditions must be all in continuous contact with the road. Aerodynamic appendages, which adjust or are prone to changing shape due to wind whilst the vehicle is in motion, are forbidden (e.g. no shrink wrap allowed).

Vehicle bodies must not include any external appendages that might be dangerous to other Team members. The vehicle interior must not contain any objects that might injure the Driver during a collision.

Article 26: Dimensions

- The maximum height must be less than 100 cm
- The maximum height measured at the top of the Driver's compartment must be less than 1.25 times the maximum track width between the two outermost wheels.
- The track width must be at least 50cm, measured between the midpoints where the tyres touch the ground.
- The wheelbase must be at least 100cm.
- The maximum total vehicle width must not exceed 130cm.
- The maximum total length must not exceed350cm.
- The maximum vehicle weight, without the Driver, is 140kg.

Article 27: Body / Chassis Solidity

Team members must ensure that the vehicle shell and/or chassis are solid. The cockpit must be equipped with an effective roll bar that extends in width beyond the shoulders of both authorised Drivers. The roll bar must be included in the chassis and also extend 5 cm above the top of the Driver's helmet in the normal driving position with the safety belt properly fastened. This roll bar must be capable of withstanding a 70kg static load applied to its centre without bending. The vehicle cockpit must be wide enough in order to ensure that the Driver would not be directly exposed in the event of a lateral collision.
A 5cm-thick layer of polyurethane foam with a minimum density of 28kg/m^3 must be placed on the inside wall of the front of the vehicle body in order to protect the Driver's feet in the event of a frontal collision.

Article 28: Visibility

The Driver must have *access to a* direct *arc of* visibility (*ahead, and to*) 90° on each side of the longitudinal axis of the vehicle. This field of vision must be achieved without aid of any optical *(or electronic)* devices such as mirrors, prisms, periscopes, etc. *Movement of the Driver's head within the confines of the vehicle body to achieve a complete arc of vision is allowed.*

The vehicle must be equipped with a rear-view mirror on each side of the vehicle, each with a minimum surface area of 25cm^2. The visibility provided by these mirrors, and their proper attachment, will be subject to inspection. An electronic device must not replace rear-view mirror

An Inspector will check visibility in each of the vehicles in order to assess on-track safety. This Inspector will check good visibility with seven 60cm high blocks spread out every 30° in a half-circle, with a 5m radius in front of the vehicle.

Article 29: Safety Belts

The Driver's seat must be fitted with an effective safety belt having at least five mounting points to maintain the Driver in his/her seat. The fifth point must be designed and fitted to prevent the Driver from slipping forward in case of a frontal accident. The 5 independent belts must be firmly attached to the vehicle's main structure and be fitted into a single buckle, specifically designed for this purpose. Safety belt buckles and attachments must be made of metal. The safety belt must be worn and fastened at all times when the vehicle is in motion. The fitness for purpose of the belt and its fitting will be evaluated during technical inspection by raising the vehicle with the Driver on board using the safety harness for suspension. The safety belt must withstand a force of at least 1.5 times the Driver's weight.

Article 30: Vehicle Access

It is imperative for Drivers to be able to vacate their vehicles at any time without assistance in less than 10 seconds. Vehicles with closed bodywork must be equipped with a sufficiently large opening for the cockpit. The driving position must be designed so that emergency services can easily extract the Driver from his/her vehicle, if necessary.

Said opening may be enclosed wholly or partly by means of hinged, detachable and/or folding doors, provided that a release mechanism is easily operable from inside and that the method of opening from the outside is clearly marked by a red arrow and does not require any tools.

It is forbidden to attach or to reinforce the closing mechanism or cockpit with adhesive tape.

Article 31: Driving Position

For safety reasons, the head-first driving position is prohibited.

Article 32: Cockpit - Ventilation

Participating Teams should note that high temperatures could be attained inside the vehicle, thus negatively affecting Driver comfort. The cockpit should therefore be properly ventilated to provide fresh air to the Driver and be equipped with a sunscreen. It is recommended that Drivers consume sufficient amounts of water to avoid dehydration.

Article 33: Engine and Fuel System Isolation from the Driver

A permanent, rigid, fire resistant bulkhead must be mounted between the engine compartment and the cockpit, thus preventing any manual access to the engine compartment by the Driver.

The whole fuel system, from the tank to the engine, must be placed behind this bulkhead or in a compartment completely separated from the cockpit.

Article 34: Horn

Each vehicle must be equipped with the authorised horn that can be purchased on the Shell Eco-marathon Website's e-shop centre.

Article 35: Fire Extinguisher

Each vehicle must be fitted with a fire extinguisher (ABC or BC type). All Drivers must be trained in the use of said fire extinguisher. This extinguisher must have a minimum capacity of 1kg (2lb unit for US application), be full and

must have a certificate of validity bearing the manufacturer's number, the date of manufacture, and the expiry date.

Plumbed-in extinguishers may be located in the engine compartment and must discharge into the engine compartment. Triggering systems must be located within the cockpit and be operable by the Driver in his/her normal driving position.

Hand held extinguishers must be located within the cockpit and be accessible to the Driver once they have vacated the vehicle. In the event of a fire, Drivers should first exit the vehicle and then if possible, remove the extinguisher and attempt to extinguish the fire if safe to do so.

Article 36: Clutch and Transmission

Vehicles with internal combustion engines must be equipped with a clutch system, so that they can be immobilised on the starting line without any outside assistance.
The fitting of chain guard(s) is mandatory.

Article 37: Wheels, Axles and Wheel Hubs

All types of wheels are allowed.
Any type of wheel rim may be used. Rims must be compatible with the dimensions of the selected tyres in order to satisfy safety standards.
Teams must take into account the fact that bicycle and motorcycle wheels are not generally designed to support substantial lateral cornering forces, such as may be found in Shell Eco-marathon vehicles at certain speeds.
The wheel axles must be of a size more appropriate for loads distributed on both sides and not in a cantilever fashion. Care should be taken to distribute loads so as to avoid any deformation of wheels or their axles.
The wheels located inside the vehicle body must be isolated from the Driver by a bulkhead. Any handling or manipulation of the wheels is forbidden from the moment the vehicle is at the starting line until it crosses the finish line.

Article 38: Turning Radius

The turning radius must be sufficient to enable safe overtaking as well as negotiating the curvature of the track. If Race Marshals observe that the turning radius of a vehicle is insufficient, the vehicle will be removed from the track for technical inspection.

Article 39: Vehicle Handling and Driver Position

A vehicle handling course may be set up in order to verify the following when the vehicle is in motion: turning radius, steering precision and the Driver's position inside the vehicle. In particular, Inspectors will verify that steering is precise, with no extra play,

Article 40: Braking

Vehicles must be equipped with two independently activated brakes or braking systems; each system comprising of a **single command control** (lever or foot pedal), **command transmission** (cables or hoses) and **activators** (callipers or shoes).
One system has to act on the front wheel(s), the other on the rear wheel(s). When breaking on two wheels at the front or the rear of the vehicles, two activators (callipers or shoes) have to be used (one on each wheel) commanded by only one command control. In addition, the right and left brakes must be properly balanced.
It must be possible to activate the two systems at the same time without taking either hand of the steering system. Foot control is recommended.

The effectiveness of the two braking devices will be tested during vehicle inspection. The vehicle will be placed on an incline with a 20 percent slope. The brakes will be activated each in turn. Each system alone must keep the vehicle immobile.
The use of a hydraulically controlled braking system is recommended. Cable operated systems are allowed, and if a bicycle-type brake shoe system is used, only the V-Brake system is authorised.

Article 41: Exhaust System

The exhaust gases must be evacuated outside the vehicle body.
Exhaust pipes must not extend beyond the rear of the vehicle body.

Article 42: Sound Level

The sound level for a Prototype vehicle must not exceed 90dB when measured 4 metres away from the vehicle.

Article 43: Emergency Shut-down mechanism

An emergency shutdown mechanism, accessible from the exterior, must be installed on all vehicles. A red arrow at least 10cm long and 3cm wide at the widest point must be positioned on the vehicle body to indicate clearly the position of this emergency shutdown mechanism from the exterior. This system must stop the engine and isolate the battery.

Article 44: Additional Inspections

After passing the technical inspection, the replacement of major engine or vehicle part will be subject to re-approval from Race Inspectors.
After any significant incident on the track the vehicle will be subject to a re-inspection.

At any time, the Organisers may perform unannounced inspections on the vehicles.

3B - UrbanConcept Group

Article 45: Definition

Under the name “UrbanConcept”, Shell offers an opportunity to design and build fuel-economy vehicles that are closer in appearance to road-going cars than prototypes. UrbanConcept vehicles must comply with the specific rule of the Shell Eco-marathon for this group. One particular feature of this group is that vehicles competing in this group will require “stop & go” driving.

Article 46: Energies

All authorised types of energy for prototypes are also permitted for UrbanConcept vehicles.
In addition, the use of hybrid technology is also allowed for the UrbanConcept Group. Hybrid technology means the combined use of internal combustion engine and electric motors in vehicles supported by an electric power accumulation system. Solar panels are not allowed for hybrid vehicles. Regenerative energy braking systems are allowed in this group.

It is not permitted to preheat the engine after commencement of the fuelling operations for the attempt.

Article 47: Vehicle Design

During vehicle design/construction and competition planning, competitors must pay particular attention to all aspects of safety, i.e. Driver safety and the safety of other participants and spectators.

UrbanConcept vehicles must have four wheels, which under normal running conditions must be all in continuous contact with the road. Aerodynamic appendages, which adjust or are prone to changing shape due to wind whilst the vehicle is in motion, are forbidden (e.g. no shrink wrap allowed).

Vehicle bodies must not include any external appendages that might be dangerous to other participants. The vehicle interior must not contain any objects that might injure the Driver during a collision.

Article 48: Dimensions

- The total vehicle height must be between 100cm and 130cm.
- The total vehicle width must be between 120cm and 130 cm.
- The total vehicle length must be between 220cm and 350cm.
- The track width must be at least 100cm for the front axle and 80cm for the rear axle.
- The wheelbase must be at least 120cm.
- The Driver's compartment must have a minimum height of 88cm and a minimum width of 70cm at the Driver's shoulders.
- The ground clearance must be at least 10cm.
- The maximum vehicle weight (excluding the Driver) must be 160kg.

Article 49: Vehicle Body

The body must cover all mechanical parts, whether the vehicle is viewed from the front, the rear, the sides or from above. When seen from above, the body must cover the wheels. When seen from front, the body must cover the wheels down to the ground clearance of the vehicle. Wings/fenders must be an integral part of the body and not only attached to the wheel axle.

- It is prohibited to use a commercial vehicle body (e.g. mini-car).
- The vehicle must be equipped with a side door enabling easy access. This door must be easy to open from both the inside and the outside of the vehicle. The side door opening must extend from a maximum height of 10cm above ground clearance to a minimum height of 10cm below the total vehicle height
- The vehicle must have a roof covering the Driver's compartment.
- A windscreen is mandatory.
- Luggage space must be available for a suitcase-like object with dimensions of 50 x 40 x 20cm (LxHxW). This space must be easily accessible from the outside and must include a floor and sidewalls to hold the luggage in place when the vehicle is moving.
- The vehicle must not have any sharp edges on its exterior.
- A towing hook or ring is mandatory on the front of the vehicle, so that it can be towed with a cable by another vehicle. This hook or ring must resist a traction force of 2000N.

Article 50: Body/Chassis Solidity

Teams must ensure that the vehicle shell and/or chassis are solid. The cockpit must be equipped with an effective roll bar that extends in width beyond the shoulders of both authorised Drivers. The roll bar must be included in the body / chassis and also extend 5 cm above the top of the Driver's helmet in the normal driving position with the safety belt properly fastened. This roll bar must be capable of withstanding a 70kg static load applied to its centre without bending.

Moreover, all sides of the compartment must be sufficient to protect the Driver from possible lateral and frontal shocks. Any vehicle not equipped with the above safety features will be subject to disqualification.
A 5cm-thick layer of polyurethane foam with a minimum density of 28kg/m^3 must be placed on the inside wall of the front of the vehicle body in order to protect the Driver's feet in the event of a frontal collision.

Article 51: Engine and Fuel System Isolation from the Driver

A permanent, rigid, fire resistant bulkhead must be mounted between the engine compartment and the cockpit, thus preventing any manual access to the engine compartment by the Driver.
The whole fuel system, from the tank to the engine, must be placed behind this bulkhead or in a compartment completely separated from the cockpit.

Article 52: Fire Extinguisher

Each vehicle must be fitted with a fire extinguisher (ABC or BC type). All Drivers must be trained in the use of said fire extinguisher. This extinguisher must have a minimum capacity of 1kg (2lb unit for US application), be full and must have a certificate of validity bearing the manufacturer's number, the date of manufacture, and the expiry date.

Plumbed-in extinguishers may be located in the engine compartment and must discharge into the engine compartment. Triggering systems must be located within the cockpit and be operable by the Driver in his normal driving position.

Hand held extinguishers must be located within the cockpit and be accessible to the Driver once they have vacated the vehicle. In the event of a fire, Drivers should first exit the vehicle and then if possible, remove the extinguisher and attempt to extinguish the fire if safe to do so.

Article 53: Visibility

The Driver must have *access to a* direct *arc of* visibility (*ahead, and to*) 90° on each side of the longitudinal axis of the vehicle. This field of vision must be achieved without aid of any optical *(or electronic)* devices such as mirrors, prisms, periscopes, etc. *Movement of the Driver's head within the confines of the vehicle body to achieve a complete arc of vision is allowed.*

The vehicle must be equipped with a rear-view mirror on each side of the vehicle, each with a minimum surface area of 25cm^2. The visibility provided by these mirrors, and their proper attachment, will be subject to inspection. An electronic device must not replace rear-view mirror.

An Inspector will check visibility in each of the vehicles in order to assess on-track safety. This Inspector will check good visibility with seven 60cm high blocks spread out every 30° in a half-circle, with a 5m radius in front of the vehicle.

Article 54: Safety Belts

The Driver's seat must be fitted with an effective safety belt having at least five mounting points to maintain the Driver in his/her seat. **The fifth point must be designed and fitted to prevent the Driver to from slipping** forward in case of frontal accident. The 5 independent belts must be firmly attached to the vehicle's main structure and be fitted into a single buckle, specifically designed for this purpose. Safety belt buckles and attachments must be made of metal. The safety belt must be worn and fastened at all times when the vehicle is in motion. The fitness for purpose of **the belt and its fitting will be evaluated during technical inspection by raising the vehicle with the Driver on board**

using the safety harness for suspension. The safety belt must withstand a force of at least 1.5 times the Driver's weight.

Article 55: Vehicle Access

It is imperative for Drivers to be able to vacate their vehicles at any time without assistance in less than 10 seconds.
The door opening must be covered by means of a hinged or sliding doors. The release mechanism must be easily operable from the inside. The method of opening from the outside must be clearly marked by a red arrow and must not require any tools.
It is forbidden to attach or to reinforce the door with adhesive tape.

Article 56: Steering

Vehicle steering must be achieved by means of a steering wheel. It must be precise, with no extra play. The turning diameter must be less than 12m.

Article 57: Wheels

The rims must be 16 or 17 inches in diameter.
The wheels located inside the vehicle body must be made inaccessible to the Driver by a bulkhead. Any handling or manipulation of the wheels is forbidden from the moment the vehicle arrives at the starting line until it crosses the finish line.
Teams must take into account the fact that bicycle and motorcycle wheels are not generally designed to support substantial lateral cornering forces, such as may be found in Shell Eco-marathon vehicles at certain speeds. Furthermore, such axles are usually not appropriate for cantilever type load distribution.
Therefore, bicycle wheels are not permitted and all wheels and axles must be of a size appropriate for the application.

Article 58: Tyres

All tyre types are allowed as long as they are fitted on the type and size of rims recommended by their manufacturers. The tyre / rim assembly must have a minimum width of 90mm, measured from sidewall to sidewall. The width is measured with the tyre fitted on its rim at its rated pressure. Caution: the manufacturer's size indications should not be taken as measure, as the width of the rim directly impacts the width of the rim/tyre assembly.

Article 59: Lighting

The vehicle must have a lighting system in proper working order for on- road use, including:

- Two front headlights
- Two front turn indicators
- Two amber rear turn indicators
- Two red brake indicators lights in the rear
- Two red rear lights (may be combined with the brake lights)
- The centre of each headlight beam must be located at least 30cm to each side of the longitudinal axis of the vehicle.
- The mandatory red indicator light for the self starter operation must be separate from any of the above (Article 78)

Article 60: Horn

Each vehicle must be equipped with the authorised horn that can be purchased on the Shell Eco-marathon Website's e-shop centre.

Article 61: Vehicle Handling and Driver Position

A vehicle handling course may be set up in order to verify the following when the vehicle is in motion: turning radius, steering precision and the Driver's position inside the vehicle. In particular, Inspectors will verify that steering is precise, with no extra play,

Article 62: Braking

The vehicle must be equipped with a four-disc hydraulic brake system, with a brake pedal, which has a minimum surface area of 5 x 5cm.

The brakes must operate independently on the front and rear axles or in an X pattern (i.e. right front wheel with left rear wheel, and left front wheel with right rear wheel).

A single master cylinder may be used, provided that it has a dual circuit (two pistons and dual tank).

The effectiveness of the braking system will be tested during vehicle inspection for both Drivers. The vehicle must remain immobile when it is placed on a 20 percent incline with the main brake in place. Moreover, a dynamic inspection may be performed on the vehicle-handling course.

Race Inspectors may check the brakes again just prior to the start.

Article 63: Clutch and Transmission

Vehicles with internal combustion engines must be equipped with a clutch system, so that they can be immobilised on the starting line without any outside assistance.

The fitting of chain guard(s) is mandatory.

Article 64: Exhaust System

The exhaust gases must be evacuated outside the vehicle body

Exhaust pipes must not extend beyond the rear of the vehicle body

Article 65: Sound Level

The sound level for an Urban Concept vehicle must not exceed 90dB when measured 4 metres away from the vehicle.

Article 66: Emergency Shut-down mechanism

An emergency shutdown mechanism, accessible from the exterior, must be installed on all vehicles. A red arrow at least 10cm long and 3cm wide at the widest point must be positioned on the vehicle body to indicate clearly the position of this emergency shutdown mechanism from the exterior. This system must stop the engine and isolate the battery.

Article 67: Additional Inspections

After passing the technical inspection, the replacement of major engine or vehicle part will be subject to re-approval from Race Inspectors.

After any significant incident on the track the vehicle will be subject to a re-inspection.

At any time, the Organisers may perform unannounced inspections on the vehicles.

4 – ENERGY SOURCES

Article 68: General

The vehicles may only use the following fuels:

- Shell Unleaded 95 (EU) / Shell Plus 89 (US) Petrol/Gasoline.
- Shell Diesel.
- Liquefied Petroleum Gas (LPG).
- Shell Gas to Liquid (100% GTL).
- Fatty Acid Methyl Ester (100% FAME).
- Ethanol E100 (100% Ethanol).
- Hydrogen.
- Solar

Results will be expressed in kilometres per litre (i.e. theoretical distance covered using energy of Shell Unleaded 95 (EU) / Shell Plus 89 (US) Petrol/Gasoline equivalent) corrected to a temperature of 15°C.

Regardless of the fuel used, the ranking will be determined from this equivalent consumption of Shell Unleaded 95 (EU) / Shell Plus 89 (US) Petrol/Gasoline. This calculation will be performed using the net calorific value (NCV), which represents the quantity of energy released per unit mass or volume of fuel during complete combustion yielding steam and carbon dioxide.

Typical NCV values (mass basis) for different fuels are given in the table below. The NCV values (vol.) at 15ºC are calculated on the day of competition by multiplying the actual mass-based NCV by the fuel density at 15ºC.

For example, if a distance of 1,000km is covered with one litre of Shell Diesel, whose corresponding energy is 35,663kJ (if we assume a fuel density of 0.83716kg/l at 15ºC), this represents 0.0280km covered per kJ. Since the energy from one litre of Shell Unleaded 95 (EU) / Shell Plus 89 (US) Petrol/Gasoline is 32,010kJ (if we assume a fuel density of 0.74616kg/l at 15ºC), this corresponds to a corrected distance of 896km (rounded to the nearest unit). The final result for a vehicle having covered 1,000km with one litre of diesel fuel (at the reference temperature of 15ºC) will thus be 896km for the equivalent of 1 litre of Shell Unleaded 95 (EU) / Shell Plus 89 (US) Petrol/Gasoline (also at the reference temperature of 15ºC).

Fuel	NCV by mass (kJ/kg)
Shell Unleaded 95 (EU)	42,900
LPG	46,000
Shell Diesel	42,600
Fatty Acid Methyl Ester	37,700
Gas to Liquid	44,000
Ethanol E100	26,900
Hydrogen	119,930

Article 69: Authorised Fuels

Only the fuels listed in Article 68, as provided to the participants by the Organisers during the event, are authorised for use during practice and competition.

Supplies adequate for practice and competition will be available by the officials in charge of measuring fuel consumption (Fuel Marshals).

No additives may be added to the fuel. Only the power derived from the combustion of the fuel in the presence of air alone within the engine system may be used for forward propulsion. No other material that could serve as engine fuel may be used at any time during the event.

Any participant handling fuel must wear safety glasses and chemically resistant gloves.

Article 70: Engine Lubricants

The Organisers will provide the engine oils for use by the competitors.

Article 71: On-Board Battery

For safety reasons, the maximum voltage on board of any vehicle must not exceed 48 Volts.

It is mandatory to have one battery for the operation of the on board safety devices (e.g. horn, hydrogen sensor) and the starter. Only one battery is allowed. All other additional sources of electricity are forbidden. Competitors must provide the Organisers with a precise description and technical drawing of the vehicle's electrical circuitry.

Competitors are required to provide the main characteristics of the battery in their technical documentation: maximum voltage that can be supplied, capacity in ampere-hours (i.e. the quantity of electricity that the battery can theoretically provide when new), dimensions and weight.

On the basis of the statistical results obtained from all entrants, the Organisers reserve the right to request additional information from Teams using high-capacity batteries. The Organisers also reserve the right to verify the information provided in the technical documentation.

The Organisers reserve the right to request Teams to install one joulemeter, intended to measure the quantity of electricity provided by the battery. This electricity consumption will be then converted into an equivalent consumption of Shell Gasoline and added to the engine consumption. This calculation will be performed using the net calorific value for this fuel, i.e. 42,900 kJ/kg.

4A – Internal Combustion Engines

Article 72: Propulsion

The type or design of the internal combustion engines is not restricted.

The use of Hybrid Technology (= combined use of internal combustion engine and electric motor) is only allowed for Urban Concept vehicles and not permitted for Prototype vehicles.

Event Organisers reserve the right to verify the compliance of the propulsion system with the rules during the event. If a Team decides to change any part of their propulsion system after inspection, the Team must notify the Inspectors,

who will perform a new inspection. Unannounced inspections may be performed during the competition.

Article 73: Other on-board energy sources

For all type of fuel, stored electrical or pneumatic energy not replaced during the competition by the engine may be used only for the self-starter, the ignition, the injector, the instrumentation, the horn and electronic management systems.

Fuel pumps are permitted for all fuels provided they are mechanically driven by the engine only.

Electric fuel pumps are only permitted for LPG fuelled vehicles, provided they don't raise the pressure by more than 5 bar. The pumps must be detachable from the vehicle as part of the fuel system for measurement purposes.

It is permitted to pressurise the liquid fuel tanks, in order to feed the engine, only under the following conditions:
Pressurisation is done by means of a translucent compressed air bottle fitted with a safety valve set to 5 bars maximum. It must include a standard valve as used for car tyres in order to enable verification/control of the pressure setting for the safety valve. Said pressurisation is done in the starting area by means of an air pump. The Driver must not modify the pressure during the competition
Auxiliary energy sources (chemical, latent energy from phase changes, etc.) are not permitted.

If the engine temperature is regulated, said regulation should be limited to the use of pure, un-pressurised water as coolant. The external regulation temperature of the engine (for engines thus equipped) is limited to 100°C.
It is forbidden to use a battery-powered electrical pump to ensure oil or water circulation in the engine, except in cases where this pump is only used when the engine is being started.

Article 74: Fuel Tanks (with the exception of LPG/Hydrogen)

The fuel tank must remain visible at all times from the outside of the vehicle. The vehicle must be equipped with only one of the following Shell supplied and approved fuel tanks:

Tank capacities: Prototype group: 30, 100 or 250cc
UrbanConcept group: 30, 100, 250 or 350cc

Only tanks bearing a clearly visible stamp proving its "APAVE"* certification compliance can be used for pressurised systems.

* *APAVE*: This organisation tests fuel tanks and certifies their ability to withstand a pressure of 5 bar (72.4 psi).

The fuel tank cap, whether it is leak proof or not (drilled), must be in place at all times during official attempts.

All hoses of the fuel supply system must be made of semi-rigid and translucent materials of the Rilsan / Nylon type.

Hoses from pressurised bottles to tank caps should be flexible (do not need to be Rilsan / Nylon type) to allow easy connection and in order to prevent side loading to the tank necks.

Article 75: Fuel System

The participants must provide a description and a precise technical drawing of the fuel supply system from the tank to engine.
This system must be translucent and designed in such a way that it can be completely drained and refilled before the competition.

The fuel line between the tank and the engine must not include any additional elements, apart from a filter (transparent) or, in the case of a diesel engine, a cut-off solenoid valve. For LPG fuelled vehicles a fuel pump, pressure gauge and valves are permitted as per Article 73.

Any fuel system including a float chamber (carburettor) must be fitted with a valve enabling Inspectors to partially drain the chamber and to ensure that the fuel level goes down in the tank.

Similarly, the air intake manifolds must not contain any fuel or blowby gas* when the vehicle is on the starting line prior to departure. Blowby gas must not be recycled during the competition.
* *Blowby* gas: gas inside the engine (in particular, oil vapours, unburnt gas or gas in the combustion chamber that has not been evacuated in the exhaust). This gas is usually recovered at the intake manifold. This is known as blowby gas re-circulation.

The entire fuel system must be made inaccessible to the Driver by means of a bulkhead. The fuel system must be easily accessible for inspection and measurements.

It must be possible to set the fuel supply system to atmospheric pressure for measurement of the fuel level. This system must be equipped with a pressure gauge. Normal running pressure must be clearly marked on the gauge.

Attention: fuel is a volatile product. Therefore, it is not allowed to artificially increase the fuel system temperature, which would lead to the formation of vapour locks. Conversely, cooling or refrigeration of the fuel below ambient temperature is also prohibited.

Article 76: LPG Cartridge

An LPG fuel system comprises of:

- A cartridge.
- A standard valve to select use of LPG in the liquid or gas phase.
- A safety valve set to 1,500 kPa (15 bar) that discharges LPG outside the vehicle and towards the ground.
- An automatic (solenoid) valve. This solenoid valve must enable isolation of the cartridge from the fuel system. This valve must be closed when the engine stalls, even if the ignition is still on. A timer is allowed.

The LPG cartridge must be visible at all times from the outside of the vehicle.

A standard LPG cartridge containing approximately 230g of LPG (plus fittings) is supplied by the Organisers and must not be modified.

Liquid LPG injection systems must only be re-filled under the supervision of the Fuel Marshals.

The electric installation associated with the LPG fuel circuit must be protected by a fuse. The components of this installation must not be exposed to friction or to shocks, particularly the cartridge.

For safety reasons, the cartridges must not exceed a temperature of 50°C at any time. The layout of the exhaust system as well as the choice of cartridge placement must take this into account.

The entire fuel system must be made inaccessible to the Driver by means of a bulkhead. The fuel system must be easily accessible for inspection and measurements.

It is forbidden to pressurise the LPG cartridge.

Hoses transporting LPG must be LPG-compatible (proof of compatibility is required).

Hoses carrying gaseous LPG at a pressure greater than 120 kPa (1.2 bar) must resist a pressure twice the maximum operating pressure (proof is required). They must be equipped with threaded fittings.

Hoses carrying liquid LPG must resist a pressure of 3,000 kPa (30 bar).

For Liquid Injection Systems:
A fuel tank (built in accordance with good manufacturing practices) may be used with an integrated or external pump.

The entire system must be tested and certified at a pressure of 3,000 kPa (30 bar) prior to the event. The competitor must present official documentation, no older than 6 months, as proof to the Inspectors. The total system volume is limited to 500 millilitres and must not be filled past 80%. A standard filling connection must be provided.

Note: For liquid injection systems, a safety valve set to 1,800 kPa (18 bar) is allowed, instead of 1,500 kPa (15 bar).

Article 77: Urban Concept vehicles using hybrid technology

The use of a Super-Capacitor to store recovered electricity is mandatory. This capacitor must be the only source of energy for the electric motor driving the vehicle. Two connectors must be installed outside the vehicle to allow the voltage measurement on the starting line.
The state of charge of the super-capacitor will be checked before and after each run by measuring the super-capacitor voltage. The voltage registered after the run must be at least equal to the voltage registered before the run. In the event of the contrary, the super-capacitor must be re-charged by running the engine until their voltage is equal to the voltage registered before the run.
As per Article 71, a single battery can be used to power the self-starter, the ignition, the injector, the instrumentation, the horn and electronic management systems.

Article 78: Starter

An electric self-starter may be used during the competition, provided that it can operate only when the ignition and fuel systems are activated. It must be clearly established that the starter is never capable of providing any forward propulsive force to the vehicle. A **red indicator light equivalent in luminosity to a car brake light** must be installed on the rear of the vehicle and be clearly visible from both sides of the track in order to signal any restarting of the vehicle (electrical interlock).
In the event that Track Marshals report the repeated or intensive use of the self-starter by a Team, the Organisers reserve the right to order an immediate

inspection of the vehicle. If any non-compliance is observed, the Team will be penalised in accordance with Article 9.

At the start, the starter and hence red light must be extinguished by the time the rear wheel of the vehicle crosses the start line. Failing to comply will invalidate the run and count towards the maximum number of attempts.

4B – Electric Motors

Article 79: Fuel Cell powered Motors

Fuel system
The competitors must provide a description and a precise technical drawing of the fuel supply system.

The entire fuel system must be made inaccessible to the Driver by means of a bulkhead. The fuel system must be easily accessible for inspection and measurements.

Hydrogen cartridge, cylinder, filling
The technical documentation provided in the entry packet of a FC-powered vehicle must specify whether the vehicle uses a metal hydride cartridge, known hereafter as a cartridge, or a compressed hydrogen cylinder, referred to hereafter as a cylinder.

- Cartridge

Competitors must provide their own cartridges.

Only one cartridge may be fitted to each vehicle.

For prototypes, the cartridge capacity must not exceed 70 Nl of hydrogen.

For Urban Concept vehicles, the cartridge capacity must not exceed 160 Nl of hydrogen.

A label specifying the refilling pressure and time must be placed on the cartridge. (Nl is normal litre of gas at 0 °C and 1013.25 hPa.)

- Cylinder

Competitors must use the cylinders provided by the Organisers during the event. Only one cylinder may be fitted to each vehicle.

For prototypes, the maximum size allowed for hydrogen cylinder is:
EU: B04. A full B04 cylinder contains 0.4 litre of hydrogen at 200 bar.
Americas: Exchange cylinder 7” X 16” (18 X 41 cm) weighing 15 lbs. (7 kg) at ~ 140 bar.

For UrbanConcept vehicles, the maximum size allowed for hydrogen cylinder is:
EU: B1. A full B1 cylinder contains 1 litre of hydrogen at 200 bar.
Americas: Exchange cylinder 7” X 16” (18 X 41 cm) weighing 15 lbs. (7 kg) at ~ 140 bar.

Cylinders and cartridges are filled by a Fuel Marshal. They must be installed on the vehicle under the supervision of a Fuel Marshal. Participants are not

allowed to keep any cylinders or cartridges in their possession over night. Upon arrival at the circuit, Team Managers must contact the Fuel Marshal, who will organise the storage and filling of cylinders and cartridges.

Ventilation
The vehicle body must allow for ventilation at the highest point of the fuel cell compartment, providing an orifice with a minimum opening of 5 cm^2. If the shape of the vehicle body enables hydrogen accumulation at or near the top of the cockpit, another 5 cm^2 openings must be included in these areas.

Hydrogen detector
A hydrogen sensor must be installed in the fuel cell compartment, near the main ventilation orifice mentioned above. This hydrogen sensor must drive the emergency shutdown valve and relay mentioned below. The trip level of the hydrogen sensor must be tuned to 25% of the LEL (Lower Explosive Limit) of hydrogen, i.e. 1% of hydrogen in air. A test will be carried out during the technical inspection.

The reset of the hydrogen detector, i.e., the hydrogen sensor and its electronics, must be done manually via a switch located in the fuel cell compartment. This switch must not be accessible by the pilot from the cockpit.

Emergency shutdown valve and relay
The hydrogen supply circuit must be equipped with a solenoid emergency shutdown valve. This valve must be normally closed in the absence of electricity. This valve must be located immediately after the pressure regulator.
The power supply to the motor must be automatically cut off at the same time as the above emergency shut down valve is activated. This is to be achieved by a suitable fail-safe relay.

This valve and relay must be activated by any of the following three scenarios:
- Through hydrogen detection as explained above
- Through an emergency push-button located beside the cockpit, on the outside of the vehicle. A red arrow at least 10 cm long and 3 cm wide must be positioned on the vehicle body to clearly indicate the place of this emergency push-button.
- Through another emergency push-button, accessible by the pilot in driving position.

In case of activation by one of these three scenarios, the valve and relay must act simultaneously.

These three scenarios will be tested during the technical inspection and before each attempt.

Pipes and connections of the hydrogen circuit
Non-rigid and unscrewed connectors are only allowed if the hydrogen pressure is below 1.5 bar absolute. These pipes and connections must be designed for hydrogen use. The Team Manager must be able to deliver, during the technical inspection, the technical sheets of the manufacturer of these pipes and connections to show that they comply with hydrogen use.
For higher hydrogen pressure, only steel pipes and screwed connectors are allowed.

Purge pipe
If a purge pipe is needed, its end must be located outside the vehicle.

Measurements and Equivalencies
The consumption of hydrogen is be measured by an embedded flowmeter. The flowmeter has to be purchased on the Shell Eco-marathon website's e-shop centre. The volume of hydrogen consumed is posted in normal litres. The display of the flowmeter must be easy to read from outside the vehicle, when the vehicle body is closed. It must be inaccessible by the pilot in normal driving position.

Oxygen and air reserves
The use of non-replaced oxygen or compressed air reserves is forbidden.

Super capacitors
If an embedded electric storage device is part of the powertrain, it must be of capacitor type, referred to hereafter as super-capacitors. Other types of embedded electric storage device (Pb, NiMh, etc. batteries) are forbidden. The state of charge of the super-capacitor will be checked before and after each run by measuring the super-capacitor voltage. Two connectors must be installed outside the vehicle to allow the voltage measurement of the super-capacitors on the starting line.

The voltage registered after the run must be at least equal to the voltage registered before the run. In the event of the contrary, the super-capacitor must be re-charged by running the fuel cell until the voltage is equal to the voltage registered before the run. The figure displayed by the flowmeter will then be picked up.

External starter battery
An external battery can be used on the starting line to start the fuel cell system. As soon as the vehicle starts to move, this battery must be unplugged.
If an external battery is used, two connectors must be installed outside the vehicle to allow a quick connection and fuel cell system start on the starting line.

Only stand-alone external battery can be used to start the fuel cell system.

As mentioned in Article 71 (sec 4, batteries) it is mandatory to supply the hydrogen detector and the horn by one on board battery. This battery may also supply the emergency shut down valve, relay and lighting system for UrbanConcept.

Electrical circuit / Electronics
All electrical / electronic cases must be made of transparent material or at least have a transparent top.

A fuse must be installed on the positive terminal of the fuel cell stack. Its melting current (expressed in Amps) must be less than0.5 times the active area (expressed in square centimetres) of one cell of the stack. For instance, if the active surface of one cell of a 20 cell stack is 60 cm^2, the melting current of the fuse must not exceed 30 A.

On the super-capacitor, a fuse must be installed on the positive terminal of the super-capacitors pack. Its melting current must be less than the electric current that corresponds to an electric power of 300 W for prototypes and 1000 W for Urban Concept vehicles, assuming that the super-capacitors are completely charged. For instance, on a prototype, if the super-capacitor pack has a maximum voltage of 15 V, the fuse set point must not exceed 300W/15V = 20 A.

Article 80: Solar-Powered Motors

Competition:

- All vehicles must be equipped with two joulemeters, one to measure the electric motor energy consumption, the other one the solar panel energy production. Stickers, "SOLAR PANEL" and "MOTOR" must identify the two joulemeters.
- The Organisers provide these joulemeters for the duration of the event. A security deposit may be required for the joulemeters.
- The joulemeters must be positioned so that their display can be easily read from outside the vehicle.
- The joulemeters must be inaccessible to the Driver in his or her normal driving position.
- In line with the technical specification of the joulemeters, the electric currents must not exceed 50 amperes permanent and 150 amperes peak.
- Any types of batteries are permitted, subject to the maximum voltage of 48 Volts. However, super capacitors will not be allowed.
- The vehicles will go to the starting line with their batteries charged.
- On the starting line, Fuel Marshals will reset to zero the two joulemeters, then the vehicles will have access to the track to start their attempt under the same distance and time conditions as specified for their respective vehicle class.
- At the finish line, Fuel Marshals will read the two joulemeter displays.
- Only vehicles for which the energy production is higher than energy consumption will be classified.
- The classification of valid runs will be determined by the energy consumption measured by "MOTOR" joulemeter (from the lower to the higher result).