Shell Eco-marathon

Official Rules 2011

CHAPTER I

FOREWORD

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

The Shell Eco-marathon has been challenging students from around the world to design and build energy efficient vehicle for many years, with the ultimate goal to drive them at the annual events in the Americas, Europe and as of 2010, in Asia.

In line with our long standing tradition of keeping the Shell Eco-marathon competition challenging and relevant to current automotive and energy trends, the Organisers will allow '**Battery Only'** powered vehicles to participate in both the Prototype and the UrbanConcept category from the 2011 season onwards. This 'Battery Only' energy option, commonly referred to as 'Plug-In' will complement the already existing Electric Mobility categories of 'Solar' and 'H2 Fuel Cell'. Further details on this latest addition can be found in Article 81.

We strongly encourage all competitors to read these Official Rules thoroughly and completely. Although we have made every effort to highlight significant changes to last year's rules in Blue, some of the existing regulations are often overlooked, causing disappointment during the events.

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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 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, high winds or excessive heat. 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 their images for publicity or other promotional material.

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.

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.
Vehicles complying with all safety rules but not with some of the other technical rules will not qualify for the competition, however may be allowed on the track for practice or demonstration.

Article 6: Timekeeping

For details see Chapter II of the 'Official Rules' for the relevant Region (i.e. Americas, Europe, Asia)

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

Article 7: Protests

The Team Manager is the only person authorised to lodge protests. Protests must be brought to the attention of the Technical Manager via the results desk. Depending on the nature protests must be lodged within the following times:

- Vehicles: before track closure on the current day
- Team and Driver behaviour: within 30 minutes following the end of the attempt.
- Results: within 1 hour after the result of an attempt has been posted.

Article 8: Disputes

In the event of any disputes, all decisions made by the Race 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 Race 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 Motorsport activity there should be an understanding that certain inherent risks will be present. Recognising and controlling these 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 areas 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, as well as any instructions given by Track Marshals is mandatory for everyone. All Team members must comply with the safety measures and must notify Organisers about any anomalies or incidents. In the event that dangerous conditions are present leave the area 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. The Organisers reserve the right to deny track access to a driver with insufficient knowledge of the Official Rules.
- 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 and Reserve Drivers 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 / or 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 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 and / or substance related infraction will lead to the immediate disqualification of the entire Team.

Article 13: Briefing

The attendance of any briefing sessions by the Organiser 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.

The Organisers will allow sufficient time for Team Managers and Drivers to inspect the track on foot or by bicycle, i.e. before any vehicles are allowed on the track. Each cyclist must wear a cycling helmet and appropriate footwear, i.e. no sandals, flip-flops, etc.

Article 15: Pushing the Vehicle

At no time on the race track, drivers are allowed to push their vehicle or have it pushed, including to start the run or to cross the finish line

Article 16: Competition Direction

It is forbidden to drive in reverse gear or to drive against the race direction.

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 as long as both hands of the driver remain on the steering system.

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.
- 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 unless it is required by the competition, e.g. for Urban Concept vehicles or for driver changes in Asia.

If a vehicle breaks down or is involved in a disabling accident on the track, the Driver must 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 him/her and 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 the Race Director of any breaches and any unsafe or unfair behaviour.

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

Article 21: Driver Weight

- Drivers of Prototype vehicles must weigh at least 50 kg in full driving gear, including communication devices. 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. It must be readily detachable for weighing.
- Drivers of Urban Concept vehicles must weigh at least **70 kg** in full driving gear, including communication devices and luggage item. Ballast must be fitted in the luggage compartment of 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. It must be easily detachable for weighing.
- The Driver (in full driving gear, including communication devices) and the ballast may be weighed before or after each official attempt.

Article 22: Helmets

For practice and competition, Drivers must wear Motorcycle or Motorsport style helmets that comply with the safety standards specified in Chapter II of the Official Rules of each Shell Eco-marathon event (bicycle/riding/skating type helmets are not permitted). The helmet labels must be clearly readable. Helmets worn by both the Driver and Reserve Driver will be subject to inspection.

Only full-face or three quarter helmets are permitted. Generally, the full-face and three quarter style helmets can be affixed with face shields which are highly recommended. If a face shield is not utilised, safety goggles are 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 and must be provided by the team; bare feet or socks only are prohibited.

Article 23A: Driver Comfort

Please note that in the event of hot weather conditions high temperatures could be attained inside the vehicle, potentially affecting Driver comfort and / or causing heat stress.

- It is recommended to properly ventilate the inside of the vehicle to provide cooling to the Driver.
- It is recommended to provide sufficient drinking liquids to the driver for the duration of an attempt. If fluid containers are provided to the driver(s), these containers must be hands free, e.g. camel-back style or bottles secured inside drivers compartment with flexible feed straw.
- It is recommended to equip the vehicle with an effective sunscreen.
- The Organisers reserve the right to restrict individual driving time by any means at their sole discretion, e.g. shortening the distance, requesting driver change (pit stop), limit maximum number of attempts per driver per day, etc.

---------- 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.
- Own tools and materials.
- 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 ----------

Review *all* sections of the Official Rules as they may contain further 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.
- Vehicle bodies must not include any external appendages that might be dangerous to other Team members; e.g. sharp points must have a radius of 5cm or greater, alternatively they should be made of foam or similar deformable material.
- The vehicle interior must not contain any objects that might injure the Driver during a collision.
- Windows must not be made of any material which may shatter into sharp shards. Recommended material: Polycarbonate (e.g. Lexan)

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 exceed 350cm.
- The maximum vehicle weight, without the Driver, is 140kg.

Article 27: Chassis / Monocoque Solidity

- Teams must ensure that the vehicle chassis or monocoque is solid.

  A monocoque is a construction that supports structural load by using an object's external skin as opposed to using a frame.
- The vehicle chassis must be equipped with an effective roll bar that extends 5cm around the driver's helmet when seated in normal driving position with the safety belts fastened.
- This roll bar must extend in width beyond the driver's shoulders when seated in normal driving position with the safety belts fastened.

  It is permissible to either use a tubular or panel type roll bar. If a 'tubular roll bar' is used, it must be made of metal. A panel roll bar is the rigid partition separating the cockpit from the engine compartment. Such a panel roll bar must be an integral part of the vehicle chassis or integrated in a monocoque.
- Any roll bar must be capable of withstanding a static load of 700N (~ 70 kg) applied in a vertical, horizontal or perpendicular direction, without deforming (i.e.in any direction).
- The vehicle chassis or monocoque must be wide and long enough to protect the driver's body in case of a frontal or lateral 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 $25cm^2$ (e.g. 5cm x 5cm). The visibility provided by these mirrors, and their proper attachment, will be subject to inspection. An electronic device must not replace a 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 harness having at least five mounting points to maintain the Driver in his/her seat.

- The mounting point(s) for the crotch strap(s) must be below the Driver's torso to prevent the Driver from slipping forward.
- 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.
- The safety harness must be worn and fastened at all times when the vehicle is in motion.
- The fitness for purpose of the harness 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 harness must withstand a force of at least 1.5 times the Driver's weight.
- The safety harness must be worn and fastened at all times when the vehicle is in motion.

Article 30: Vehicle Access

It is imperative for Drivers, fully harnessed, 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.

The 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 use adhesive tape to securely close the Driver's opening from the outside.

Article 31: Driver Position

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

Article 32: Cockpit - Ventilation

No specification – please review considerations in *Article 23A*

Article 33: Engine and Fuel System Isolation from the Driver

- **A permanent Bulkhead must completely separate the vehicle's propulsion and energy storage systems from the driver's compartment**.

  *This means engines, fuel cells, fuel tanks, batteries, hydrogen cylinders, super capacitors, etc. must be placed outside the driver's compartment behind the bulk head. The purpose of this bulkhead is that in the event of a fuel leak or fire, it prevents liquids and / or flames and / or smoke reaching the driver. Therefore, it is necessary to pay particular attention to avoid **any** gaps and holes between the body and the bulk head. It is recommend to seal gaps with materials such as metal / aluminium sheeting or aluminium tape.*
- This bulkhead must be of fire retardant material and construction.
- In closed-top vehicles the bulkhead must effectively seal the driver's compartment from the propulsion and fuel system.
- In open vehicles the bulkhead must extend at least 5cm above the highest point of the propulsion and fuel system or the driver's shoulders – whichever is the highest.
- The bulkhead must prevent manual access to the engine / energy compartment by the driver.

Article 34: Horn

Each vehicle must be equipped with the authorised horn that can be purchased from the organiser.

Article 35: On-board 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 extinguishant capacity of 1kg (2lb for US application), equivalent size extinguishers are not permitted. It must be full and 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. These should be securely mounted to prevent movement while driving/braking. 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.
- The on-board fire extinguisher does not replace the need for an adequate fire extinguisher for the teams garage area.

Article 36: Clutch and Transmission

- Vehicles with internal combustion engines must be equipped with a clutch system, so that during inspection and fuelling operations the vehicle remains stationary with the engine running.

  All Clutch systems used prior to 2011 must be reviewed with respect to whether the clutch system remains not engaged at engine start up. (This means: The vehicle wheels must NOT turn when the engine is started with brakes not applied)
- **The starter motor speed must always be below the engagement speed of the clutch.**
- **The installation of an effective transmission chain or belt guard(s) is mandatory.**

This is required to protect driver or technician when working on the car in the event of the chain or belt breaking. It must be made of metal or composite material rigid enough to withstand a break.

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 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 designed for cantilever loads (like in wheel chairs) rather than for load distributed equally on both sides (like in bicycles).
- Wheels located inside the vehicle body must be isolated from the Driver by a bulkhead.
- Any handling or manipulation of wheels by the Driver 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 Steering and Handling

A vehicle handling course may be set up in order to verify the following when the vehicle is in motion: driver skills, sufficient turning radius and steering precision. In particular, Inspectors will verify that steering is precise, with no excessive play or undue delay.

Indirect steering is permitted as long as adequate fail safe and backup measures are in place.

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).
- **Indirect and / or electronic braking systems are not permitted.**
- One system has to act on the front wheel(s), the other on the rear wheel(s). When braking 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. Foot control operation is recommended.
- It must be possible to activate the two braking systems at the same time without taking either hand of the steering system. For single handed steering systems incorporating one braking system, the second system must be foot operated.
- 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 highly recommended.

  Cable operated systems are allowed as long as they are effective and pass the brake test.

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.
- All vehicles are expected to comply with reasonable environmental standards, e.g. amount of smoke and odour emitted.

Article 42: Sound Level

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

Maximum sound levels will be measured and recorded at the start line and teams exceeding the permissible level will be notified with a request for correction within a reasonable timeframe.

Article 43: Emergency Shut-down mechanism

An emergency shutdown mechanism, accessible from the exterior, must be permanently installed on all vehicles (not part of the detachable bodywork used to allow driver access). 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 and / or alteration of engine or vehicle part must be re-approved by the Technical Inspectors.
- After any significant incident on the track the vehicle will be subject to a re-inspection as well
- 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 close in appearance to today's production type passenger cars. 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: deleted

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 **exactly four wheels**, which under normal running conditions must be all in continuous contact with the road. A fifth wheel for any purpose is forbidden.
- 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; e.g. sharp points must have a radius of

5cm or greater, alternatively they should be made of foam or similar deformable material.

This means for example exposed corners of solar panels, pointed parts of the vehicle body, etc.

- The vehicle interior must not contain any objects that might injure the Driver during a collision.
- Windows must not be made of any material which may shatter into sharp shards. Recommended material: Polycarbonate (e.g. Lexan)

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, measured between the midpoints where the tyres touch the ground.
- 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 **205**kg.

Article 49: Vehicle Body

Teams are requested to submit technical drawings, photographs or animations of their entire vehicle design to the organisers for approval at their earliest opportunity.

This is strongly recommended to avoid upsets by failing the technical inspection at the event on grounds of design non-compliance.

- **The body must cover all mechanical parts excluding wheels and suspension, whether the vehicle is viewed from the front, the rear, the sides or from above.**
- **The wheels and suspension must be fully covered by the body when seen from above and up to the axle centre line when seen from front or rear.**
- It is prohibited to use any commercially available vehicle body parts (e.g. mini-car).
- **Access to the vehicle by the Driver must be as easy and practical as typically found in production type passenger cars.**
- Any access opening mechanisms (e.g. doors) must be firmly attached to the vehicle body (e.g. by means of hinges, sliding rails, etc.) Adhesive tape, Velcro, etc. are not permitted for this purpose.
- 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. A competitor supplied suitcase-like object must be placed in this space during any competition. For drivers requiring ballast this suitcase-like object must contain the ballast.
- Vehicle bodies must not include any external appendages that might be dangerous to other Team members; e.g. sharp points must have a radius of 5cm or greater, alternatively they should be made of foam or similar deformable material.

- 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 (~200 kg).

Article 50: Chassis / Monocoque Solidity

- Teams must ensure that the vehicle chassis or monocoque is solid.

  A monocoque is a construction that supports structural load by using an object's external skin as opposed to using a frame.
- The vehicle must be equipped with an effective roll bar that extends 5cm around the driver's helmet when seated in normal driving position with the safety belts fastened.
- This roll bar must extend in width beyond the driver's shoulders when seated in normal driving position with the safety belts fastened.

  It is permissible to either use a tubular or panel type roll bar. If a 'tubular roll bar' is used, it must be made of metal. A panel roll bar is the rigid partition separating the cockpit from the engine compartment. Such a panel roll bar must be an integral part of the vehicle chassis or integrated in a monocoque.
- Any roll bar must be capable of withstanding a static load of 700N (~ 70 kg) applied in a vertical, horizontal or perpendicular direction, without deforming (i.e.in any direction).
- The vehicle chassis or monocoque must be wide and long enough to protect the drivers body in case of a frontal or lateral collision.

Article 51: Engine and Fuel System Isolation from the Driver

- **A permanent Bulkhead must completely separate the vehicle's propulsion and energy storage systems from the driver's compartment**.

  *This means engines, fuel cells, fuel tanks, batteries, hydrogen cylinders, super capacitors, etc. must be placed outside the driver's compartment behind the bulk head. The purpose of this bulkhead is that in the event of a fuel leak or fire, it prevents liquids and / or flames and / or smoke reaching the driver. Therefore, it is necessary to pay particular attention to avoid **any** gaps and holes between the body and the bulk head. It is recommend to seal gaps with materials such as metal/aluminium sheeting or aluminium tape.*
- This bulkhead must be of fire retardant material and construction.
- In closed-top vehicles the bulkhead must effectively seal the driver's compartment from the propulsion and fuel system.
- In open vehicles the bulkhead must extend at least 5cm above the highest point of the propulsion and fuel system or the driver's shoulders – whichever is the highest.
- The bulkhead must prevent manual access to the engine / energy compartment by the driver.

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 extinguishant capacity of 1kg (2lb for US application), equivalent size extinguishers are not permitted. It must be full and 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. These should be securely mounted to prevent movement while driving/braking. 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 (e.g. 5cm x 5cm). 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 harness having at least five mounting points to maintain the Driver in his/her seat.

- The mounting point(s) for the crotch strap(s) must be below the Driver's torso to prevent the Driver from slipping forward.
- 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.
- The safety belt must be worn and fastened at all times when the vehicle is in motion.
- The fitness for purpose of the harness and its fitting will be evaluated during technical inspection.
- The harness must be propriety.

  This means the safety harness must be specifically manufactured for motorsport use. (e.g. certified or compliant with FIA standards)
- The safety harness must be worn and fastened at all times when the vehicle is in motion.

Article 55: Vehicle Access

It is imperative for Drivers, fully harnessed, to be able to vacate their vehicles at any time without assistance in less than 10 seconds.
The opening 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 use adhesive tape to securely close the Driver's opening from the outside.

Article 56: Vehicle Steering / Handling and Turning Radius

- Vehicle steering must be achieved by one system operated with both hands using a turning motion. It must be precise, with no excessive play.
- Steering must be achieved using a steering wheel or sections of a wheel.
- Steering bars, tillers, joysticks, indirect or electric systems are not permitted.
- The turning radius must be less than 6m.

- A vehicle handling course may be set up in order to verify the following when the vehicle is in motion: driver skills, turning radius and steering precision. In particular, Inspectors will verify that steering is precise, with no excessive play.

Article 57: Wheels

- The rims must be between **13 to** 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.

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 80mm, 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 functional external lighting system, including:

- Two front headlights
- Two front turn indicators
- Two rear turn indicators
- Two red brake lights in the rear
- Two red rear lights (may be combined with the brake lights)
- The centre of each headlight unit must be located at an equal distance and at least 30cm from 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 from the Organisers.

Article 61: Driver Position

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

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 $25cm^2$.
- 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 during inspection and fuelling operations the vehicle remains stationary with the engine running.

  All Clutch systems used prior to 2011 must be reviewed with respect to whether the clutch system remains not engaged at engine start up. (This means: The vehicle wheels must NOT turn when the engine is started with brakes not applied)
- **The starter motor speed must always be below the engagement speed of the clutch.**
- **The installation of an effective transmission chain or belt guard(s) is mandatory.**

  This is required to protect driver or technician when working on the car in the event of the chain or belt breaking. It must be made of metal or composite material rigid enough to withstand a break.

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.
- All vehicles are expected to comply with reasonable environmental standards, e.g. amount of smoke and odour emitted.

Article 65: Sound Level

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

Maximum sound levels will be measured and recorded at the pit stop locations during a race and teams exceeding the permissible level will be notified with a request for correction within a reasonable timeframe.

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 and / or alteration of engine or vehicle part must be re-approved by the Technical Inspectors.
- After any significant incident on the track the vehicle will be subject to a re-inspection as well
- 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:

Internal Combustion:

- Shell FuelSave Unleaded 95 (Europe and Asia) / Shell Regular 87 (US) Petrol / Gasoline. **
- Shell FuelSave Diesel (Europe) / Shell Diesel (Asia and US). **
- Shell Gas to Liquid (100% GTL).
- Fatty Acid Methyl Ester (100% FAME).
- Ethanol E100 (100% Ethanol).

*** The gasoline and diesel provided by the Organisers are the Shell fuels prevalent in the local markets where the events take place. For testing and tuning purposes in the team's home countries where Shell FuelSave Unleaded 95 and Shell FuelSave Diesel are not available it is recommended to use the locally available Shell Unleaded 95 or Shell Diesel instead.*

Electric Mobility:

- Hydrogen.
- Solar.
- 'Plug-In' Electricity.

Results for the Internal Combustion Category will be expressed in kilometres per litre (km/l) (i.e. theoretical distance covered using energy of Shell FuelSave Unleaded 95 (Europe and Asia) / Shell Regular 87 (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 FuelSave Unleaded 95 (Europe and Asia) / Shell Regular 87 (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 FuelSave Unleaded 95 (Europe and Asia) / Shell Regular 87 (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 FuelSave Unleaded 95 (Europe and Asia) / Shell Regular 87 (US) Petrol / Gasoline (also at the reference temperature of 15ºC).

Results for the Electric Mobility Category (hydrogen fuel cell, solar, 'Plug-In'-electricity) will be expressed in kilometres per kilowatt hour (km/kWh).

Fuel Cell vehicles will use a flow meter to measure the H2 consumed. The result will be calculated using the NCV of H2 listed below

The results of Solar and 'Battery-Only' vehicles will be determined by using joulemeters which are supplier by the Organisers.

The results for hybrid vehicles will be expressed based on the primary energy used.

No additives, catalysts, water injection, or fuel treatment devices are allowed.

Internal Combustion Fuel	**NCV by mass (kJ/kg)**
Shell FuelSave Unleaded 95 (Europe and Asia) Shell Regular 87 (US) Petrol / Gasoline	42,900
Shell FuelSave Diesel (Europe) Shell Diesel (Asia and US)	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.
- 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.**
- Weather conditions will vary throughout the event and solar competitors need to take this effect into account during the competition.

Article 70: Engine Lubricants

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

Article 71: On-Board Electrical Energy

- **For safety reasons, the maximum voltage on board of any vehicle must not exceed 48 Volts (this includes on-board batteries, external batteries, super capacitors, fuel cell stack, etc).**
- **Only one battery per vehicle is allowed.**

  A 'battery' is defined as a source of electrical energy, which has exactly two connectors and comes as a single unit. This single unit may contain more than one sub-unit.
- This on-board battery must operate all safety devices (e.g. horn, hydrogen sensor) for the duration of the competition may also operate the starter motor, the ignition, the instrumentation and electronic management systems. All other additional sources of electricity are forbidden.

- 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. The on-board battery is not allowed to power compressors, blowers, engine cooling systems, motors, etc. It may however be used to power a ventilation/cooling fan for the driver.
- Competitors must provide the Organisers with a precise description and technical drawing of the vehicle's electrical circuitry.

  The Organisers reserve the right to request additional information from Teams using high-capacity batteries.
- The Organisers reserve the right to request Teams to install one joulemeter, intended to measure the quantity of energy provided by the battery. If this amount of energy exceeds the power typically required to operate the starter motor, horn and safety devices the competitor will be disqualified.
- Batteries must be installed outside of the driver's compartment behind a bulk head.
- The following devices may be powered by additional batteries provided they use built-in batteries: radio communication system, GPS system, data loggers excluding engine management units, driver ventilators.
- If a Lithium Polymer battery is used, a Battery Monitoring System (BMS) must be installed to control and protect the battery against risk of fire.

4A – Internal Combustion Engines

Article 72: Propulsion

The type or design of the internal combustion engines is not restricted, however they must run only on the fuel provided by the Organisers and must not consume any engine oil.

Article 73: Other on-board energy sources

- For all fuel categories, stored electrical or pneumatic energy not replaced during the competition by the engine may only be used 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.
- 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. The 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, the 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.

Comment: *For 2012 the use of electric fuel pumps creating higher injection pressures is under consideration. They will only be allowed if the entire system (tank, fuel lines, pump, injector) can be easily and safely removed from the vehicle for weighing purposes.*

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

- The vehicle must be equipped with only one of the following approved fuel tanks supplied by the Organisers:

  Tank capacities: Prototype: 30, 100 or 250cc
  UrbanConcept: 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 has to be mounted in an accessible and zero degree vertical position which allows in-situ filling with a burette of approx 1 metre height.
- The fuel tank must be mounted in a way that its top is at least 5cm below the roll bar.
- The fuel tank cap, whether it is leak proof or not (drilled), must be in place at all times during the competition.

  Note that for gravity fed systems a small (<3mm) hole should be drilled in the centre of the cap to allow air to enter the tank, hence allow fuel out!

Fuel return lines must be fed into the fuel feed line below the fuel tank.

- Competitors must only use hoses for the fuel system as supplied by the Organisers.

  It is permissible for each team to provide and install suitable connectors for these fuel lines.
- For pressurised fuel systems the hoses connecting the pressure bottle with the fuel tank cap must 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 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 (no additional filters or valves).
- For diesel engines, a cut-off solenoid valve is required.
- Any fuel system including a float chamber (carburettor) must be fitted with a drain valve at the bottom of the carburettor enabling Inspectors to partially drain the chamber and to ensure that the fuel level goes down in the tank.
- 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 but needs to be collected in a specific canister for environmental protection.

  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 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. The pressurisation system must be equipped with a pressure gauge and normal running pressure must be clearly marked on the gauge.
- The standard fuel consumption measurement method for liquid fuels is by volumetric replacement of the fuel consumed and temperature corrected fuel (including temperature correction).
- The fuel consumption of gasoline and ethanol powered vehicles capable of achieving 1500km/l (3528 mpg) or more will be measured gravimetrically. At the Start a Technical Inspector will fill the fuel system and then the entire fuel system (including tank, injector, pipes, carburettor) will be weighed on a precision balance. All these components must be compact and easily detachable for weighing purposes. After completion of a successful run, the entire fuel system will be deinstalled and weighed again on the same balance. This handling of the fuel system, including mounting to and dismounting from the vehicle and transporting it to the weighing room must be performed by a competent team member with has the a valid garage access pass. The entire process of handling the fuel system will be supervised by a Technical Inspector. The weighing will also be performed by a Technical Inspector and needs to be witnessed by a Team Member.
- 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: **deleted**

Article 77: ***Vehicles using hybrid technology***

- The use of a Super Capacitor to store recovered electric energy 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 its 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. The time required to recharge the super capacitor by running the engine after the competition is added to the recorded time of the relevant run.
- As per Article 71, a battery can be used to power the self-starter, the ignition, the injector, the instrumentation, the horn and electronic management systems.
- The entire electric circuitry must be correctly fused to prevent overloading any of its parts. This fuse needs to be clearly identified in the technical drawings and easily visible and accessible for technical inspection.

Article 78: ***Starter***

- An electric 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 propulsion to the vehicle. (see also Article 36 and 63 respectively)
- **Starter light: A clearly visible red indicator light, equivalent in its luminescence to a 21W light bulb, must be installed** on the rear of the vehicle and must be clearly visible from both sides of the track in order to signal any operation of the started motor.
- In the event that Track Marshals report the repeated or intensive use of the electric 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 accordingly.

At the start, the starter and hence the starter 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 Vehicles

Fuel system

- The competitors must provide a description and a precise technical drawing of the fuel supply system.
- **The fuel system must be easily accessible for inspection and measurements**.

Hydrogen cylinders

FC-powered vehicle must use a compressed hydrogen cylinder, referred to hereafter as a cylinder, as provided by the Organisers during the entire event. Only one cylinder may be fitted to a vehicle at any time.

Cartridges and any other means of H2 storage are not permitted.

For Prototypes vehicles, the following cylinders will be provided:

- Europe: B04 cylinder, 0.4 litre of hydrogen at 200 bar. (7cm / 33cm) 1.4kg
- Americas: Exchange cylinder 7" X 16" (18cm x 41 cm) weighing 15 lbs. (7 kg) at ~ 140 bar.
- Asia: Catalina MD cylinder, 2.9 litre of hydrogen@139bar, (11.1cm x 42.4cm), 2.4kg

For UrbanConcept vehicles, the following cylinders will be provided:

- Europe: B1 cylinder, 1 litre of hydrogen at 200 bar. (10cm x 35cm), 2.57kg
- Americas: Exchange cylinder, 7" X 16" (18cm x 41 cm) weighing 15 lbs. (7 kg) at ~ 140 bar.
- Asia: Catalina MD cylinder, 2.9 litre of hydrogen@139bar, (11.1cm x 42.4cm), 2.4kg

Cylinders must be installed on the vehicle under the supervision of a Fuel Marshal. Participants are not allowed to keep any cylinders in their possession over night. Upon arrival at the circuit, Team Managers must contact the Fuel Marshal, who will organise all relevant logistics.

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. Another 5 cm^2 opening must be provided at the highest point of the driver compartment.

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.

For commercial Fuel Cells with integrated H2 detector it is still required to fit a H2 sensor as described above.

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 pressure regulator must be connected directly to the H2 cylinder.

The power supply to the motor must be automatically cut off at the same time as the above emergency shutdown 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 the emergency push-button located 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. (Note: It must not be part of the detachable bodywork used to allow driver access)
- 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
In all cases, piping and connectors of the hydrogen circuit must be designed for hydrogen use. The Team Manager must be able to present during the technical inspection the technical data sheets from the manufacturer of these piping and connectors to show that they are suitable for hydrogen use.
If the pressure in the hydrogen circuit is higher than 1.5 bar absolute (=0.5 bar above atmospheric pressure) piping must be made of steel and connectors must be screw type.
If the pressure in the hydrogen circuit is lower than 1.5 bar absolute (=0.5 bar above atmospheric pressure) flexible piping and unscrewed connectors are accepted.
PTFE (Teflon) sealing tape must not be used.

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

Measurements and Equivalencies
The consumption of hydrogen is measured by an embedded flow meter. The flow meter will be checked / calibrated by the Organisers before technical inspections.

The flow meter has to be purchased from the Organisers.
The volume of hydrogen consumed is posted in normal litres. The display of the flow meter 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 power-train, it must be of capacitor type, referred to hereafter as 'Super Capacitor'. 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.
- 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 their voltage is equal to the voltage registered before the run. The additional time required to recharge the super capacitor by running the fuel cell after the competition is added to the recorded time of the relevant run
- The maximum super capacitor voltage must not exceed 48V.

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.
- As mentioned in Article 71 (bullet 4, batteries) it is mandatory to power the hydrogen detector and the horn using the on board battery. This battery must also power the emergency shutdown valve, relay and lighting system for UrbanConcept vehicles.

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 than 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 cm², the melting current of the fuse must not exceed 60A.
- 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.

Other equipment
Compressors, fans and coolers for the fuel cell system must be powered by the fuel cell or super capacitor (**not** by the onboard battery).

Article 80: Solar Powered Vehicles

- 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 or Super Capacitor are permitted, subject to the maximum voltage of 48 Volts.
- If a Lithium Polymer battery is used, the vehicle must be equipped with a Battery Monitoring System (BMS) to control and protect the battery against risk of fire.
- Batteries or Super Capacitor must be placed outside the drivers compartment behind the bulkhead.
- 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, and 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.
- All Solar vehicles which complete a successful run will be classified. Teams with a positive energy balance (i.e. more produced than consumed) will be classified first, in order of ascending energy consumption, followed by all vehicles with a negative energy consumption (i.e. more consumed than produced), again in order of ascending energy consumption.
- An additional on-board battery as defined in Article 71 is permitted. It must not be connected to the electric circuit(s) involving any power train components and must only be used to power safety related components and those mentioned specifically in Article 71.

Article 81: 'Battery Only' Powered Vehicles ('Plug-In's')

- The 'Battery Only' energy category is a new addition for the 2011 season.
- Competitors will be able to participate with both Prototype and UrbanConcept vehicles in the new category.
- The drive train in the 'Battery Only' category is restricted to a maximum of one electric storage device, electric motor(s), one control unit and the required connections.
- Only Super Capacitors and Lithium Polymer batteries are permitted as electric storage devices.
- If a Lithium Polymer battery is used, the vehicle must be equipped with a Battery Monitoring System (BMS) to control and protect the battery against risk of fire.
- Any type of electric storage device and on-board system is subject to the maximum voltage of 48 Volts.
- The competitors must provide a description and a precise technical drawing of their electrical drive train with the application.
- The entire drive train must be easily accessible for inspection and measurements.
- Batteries or Super Capacitor must be placed outside the drivers compartment behind the bulkhead.
- All electrical / electronic cases must be made of transparent material or at least have a transparent top.

- All vehicles must be equipped with one joulemeter to measure the electric motor energy consumption.
- The Organisers will provide this joulemeter for the duration of the event. A security deposit may be required for the joulemeter.
- The joulemeter must be positioned so that its display can be easily read from outside the vehicle.
- The joulemeter must be inaccessible to the Driver in his or her normal driving position.
- In line with the technical specification of the joulemeter, the electric current must not exceed 50 amperes permanent and 150 amperes peak.
- The entire installation must be adequately fused.
- The vehicles will go to the starting line with their batteries charged.
- On the starting line, Fuel Marshals will reset the joulemeter to zero, and 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 joulemeter display.
- All 'Battery Only' powered vehicles which complete a successful run will be classified in ascending order of energy consumed, expressed in km/kWh.
- An additional on-board battery as defined in Article 71 is permitted. It must not be connected to the electric circuit(s) involving any power train components and must only be used to power safety related components and those mentioned specifically in Article 71.