

Shell Eco-marathon®

Official Rules 2013

CHAPTER I

FOREWORD

Dear Shell Eco-marathon Competitors, Friends and Enthusiasts

Over the decades, the Shell Eco-marathon has seen an outstanding increase in vehicle fuel economy from 'a few miles per gallon' some 70 years ago to 'a few thousand kilometres per litre' to date. As impressive as this trends is, I am equally impressed with the over 400 Shell Eco-marathon teams worldwide today who continuously improve their personal performance year on year.

It is noticeable that these improvements do not relate to fuel economy alone, but also to vehicle reliability, safety, ergonomics, selection of materials, driving strategy, electronics and last but not least vehicle design. Every season, I look forward to seeing the new and creative designs, genuine ideas and immaculate fabrications of vehicle bodies. While some of these designs may not be the most energy efficient ones, this trend shows that the motivations for our competitors to participate in this programme are multi-fold, and the much coveted off-track awards like the *Shell Eco-marathon Design Award* provide a big incentive for many teams.

As many areas have seen continuous improvement year on year, unfortunately the quality of the technical documentation in general, especially mechanical and electrical drawings and schematics as required by these rules does not seem to receive an equal amount of attention and enthusiasm for perfection. Please be reminded that these documents, prepared to international standards, are not only a pre-requisite to a successful application, but they can also help to avoid potential upsets at the event. If the documentation is prepared comprehensively and to a high standard my colleagues and I will be more likely to spot potential problems or non-compliances *prior* to you shipping your vehicle to an event, giving you more time and opportunities to correct problems.

As already announced last year, in 2013 we are integrating the previously separate Solar and Battery Electric energy classes into one existing energy class, which brings new opportunities for this very popular competition by allowing the integration of Solar Cells in the vehicle body. While (in the spirit of the event) this will increase the technical challenges for the Battery Electric teams, it comes with the benefit that any solar energy 'harvested' will be deducted from the total energy used for propulsion – a strong incentive for applying this exciting technology.

I look forward to seeing you at one of our events in Houston, Rotterdam or Sepang and wish all competitors a safe and successful Shell Eco-marathon 2013.

Norman Koch

Global Technical Manager

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1- ORGANISATION

Article 1: Acceptance

- a) 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.
- b) 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.
- c) 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.
- d) 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

- a) For each entry, a Team Manager, a Driver and a Reserve Driver must be designated.
- b) 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.
- c) 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.
- d) 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.
- e) 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.
- f) 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

- a) 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.
- b) 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:
 - i) For each side and for the front of the vehicle: a Shell logo, 20 x 20 cm.
 - ii) For each side and for the front of the vehicle: racing numbers, 20 x 26 cm.
 - iii) For each side, on the lower part of the body: a partner streamer, 90 x 6 cm.
- c) A mandatory 10 cm space must be left free on all four sides of the Shell logo
- d) Any other sponsor names / logos must be smaller than the Shell logo. The sponsor stickers must fit within a surface of 400 cm² (empty space included)
- e) In the event of a breach of this rule, the Organisers reserve the right to remove any sponsor logos.
- f) Furthermore, the trademarks or logos of other energy companies, direct competitors of event partners, tobacco companies and alcoholic drinks producers are prohibited.
- g) All vehicles are subject to the Organisers' approval concerning these provisions.

Article 5: Compliance

- a) 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.
- b) **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.
- c) 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: 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:

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

Article 7: Disputes

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

Article 8: Penalties

- a) Non-compliance with the driving rules will result in a formal warning, invalidation of the best overall attempt or disqualification of the Team, depending on the severity of the breach.
- b) 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.
- c) 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.
- d) The Organisers will apply the following penalties:
 - 1st infraction: Formal warning
 - 2nd infraction: Best overall attempt invalidated at the end of the competition
 - 3rd infraction: Immediate Team disqualification.

2- SAFETY

Article 9: Safety Rules

- a) 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.
- b) 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 paddock area will be monitored by the Organisers to assist Teams to comply with safe practices.
- c) The Race Director is responsible for and has the final authority in determining the safe conditions for track operations in regards to weather.
- d) 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 10: Driving Knowledge and Test

- a) Only the registered Driver and the Reserve Driver will be authorised to drive the vehicle.
- b) 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.
- c) 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 11: Driving under the Influence of Alcohol / Illegal Substances

- a) 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.
- b) Procedures for alcohol or substance testing are detailed in Chapter II.
- c) Any breach will be penalized in line with Article 8: and the following additional penalties:

- i) 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.
- ii) 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.
- iii) Any second alcohol and / or substance related infraction will lead to the immediate disqualification of the entire Team.

Article 12: Briefing

The attendance of any briefing sessions by the Organiser is mandatory for Team Managers and Drivers. Please refer to Chapter II for further details on these briefings. Scheduled briefings will be posted at the track.

Article 13: Access to the Track and Test Lap

- a) 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.
- b) For practice runs, only vehicles with a safety sticker will be allowed on the track.
- c) For the competition, only vehicles with safety and technical inspection stickers will be allowed to compete.
- d) The Organisers will allow opportunity for Team Managers and Drivers to inspect the track, i.e. before any vehicles are allowed on the track. For further details please refer to Chapter II.
- e) After pre-start measurements have been completed, teams must be ready to start their attempt within two minutes or return to the paddock.

Article 14: 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 15: Competition Direction

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

Article 16: 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 17: Overtaking

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

- a) 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.

- b) The Driver of the vehicle being overtaken will use his/her rear – and side-view mirrors and must not change course suddenly.
- c) On the track, overtaking is authorised on both the right and the left, as long as the above-mentioned safety rules are followed

Article 18: Breakdowns and Other Incidents

- a) Intentional stopping on the track is forbidden unless it is required by the competition, e.g. for UrbanConcept vehicles.
- b) The Driver is allowed 30 seconds to attempt to re-start the vehicle from within its driving position.
- c) If a vehicle breaks down or is involved in a minor disabling accident on the track, the Driver must immediately make every attempt to drive the vehicle to the side of the track and wait in the vehicle for the Marshalls to arrive.
- d) In an emergency, the Driver must get out of the car and wait in a safe place off the track for the Track Marshalls to arrive and recover him/her and the vehicle.
- e) 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 19: Off-track vehicle movements

- a) 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.
- b) Race Marshalls will notify the Race Director of any breaches and any unsafe or unfair behaviour.**

Driver & Equipment

Article 20: Driver Weight

- a) Drivers of Prototype vehicles must weigh at least 50 kg in full driving gear, including communication devices, prior to an attempt. 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 easily detachable for weighing.
- b) Drivers of UrbanConcept vehicles must weigh at least 70 kg in full driving gear, including communication devices and luggage item, prior to an attempt. 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. (Refer to Article 46:h))

- c) The Driver (in full driving gear, including communication devices) and the ballast may be weighed before or after each official attempt. A weight loss of up to 1 kg during an attempt will be tolerated.

Article 21: Helmets

- a) 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.
- b) 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 22: Driver Clothing

- a) 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.
- b) Gloves and shoes are required and must be provided by the team; bare feet or socks only are prohibited.

Article 23: 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.

- a) It is recommended to properly ventilate the inside of the vehicle to provide cooling to the Driver.
- b) 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 the driver's compartment with flexible feed straw.
- c) It is recommended to equip the vehicle with an effective sunscreen.
- d) 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:

- a) Gloves for general work: leather or canvas material.
- b) Gloves for fuel or motor oil handling: Chemical resistant.
- c) Safety glasses for all Team members. (Disposable types are permitted).
- d) Hearing protection for all Team members. (Approved Earplugs or muffs).
- e) Duct tape to secure any cords or cables lying on the pit floor.
- f) Lift stands or appropriate raised platform for vehicle tuning and repairs.
- g) Own tools and materials.
- h) Each Team must provide an extinguisher for their paddock area with a minimum extinguishing capacity of 1 kg in addition to the vehicle's 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 contain further safety matters specific to the topic.

3- VEHICLE DESIGN

3A - General

Article 25: Vehicle Design

- a) 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.
 - i) Prototype vehicles must have three or four running wheels, which under normal running conditions must be all in continuous contact with the road.
 - ii) 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.
- b) Aerodynamic appendages, which adjust or are prone to changing shape due to wind whilst the vehicle is in motion, are forbidden.
- c) Vehicle bodies must not be prone to changing shape due to wind and must not include any external appendages that might be dangerous to other Team members; e.g. pointed part of the vehicle body. Any sharp points must have a radius of 5 cm or greater, alternatively they should be made of foam or similar deformable material.
- d) The vehicle interior must not contain any objects that might injure the Driver during a collision.
- e) Windows must not be made of any material which may shatter into sharp shards. Recommended material: Polycarbonate (e.g. Lexan)
- f) Any cover of the energy compartment (engine / motor / transmission / battery, etc.) should be easy to open for quick inspection access.
- g) All parts of the drive train, including fuel tank, hydrogen system components, etc. must be within the confines of the body cover.
- h) All objects in the vehicle must be securely mounted, e.g. bungee cords or other elastic material are not permitted for securing heavy objects like batteries.

Article 26: Chassis / Monocoque Solidity

- a) 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.

- b) The vehicle chassis must be equipped with an effective roll bar that extends 5 cm around the driver's helmet when seated in normal driving position with the safety belts fastened.

- c) 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.

- d) Any roll bar must be capable of withstanding a static load of 700 N (~ 70 kg) applied in a vertical, horizontal or perpendicular direction, without deforming (i.e. in any direction).
- e) 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 27: Propulsion and Energy Storage System Isolation

- a) 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 (both propulsion and auxiliary), 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 recommended to seal gaps with materials such as metal / aluminium sheeting or aluminium tape.

- b) This bulkhead must be of fire retardant material and construction.
- c) In closed-top Prototype vehicles and in all UrbanConcept vehicles, the bulkhead must effectively seal the driver's compartment from the propulsion and fuel system.
- d) In open Prototype vehicles the bulkhead must extend at least 5 cm above the highest point of the propulsion and fuel system or the driver's shoulders – whichever is the highest.
- e) The bulkhead must prevent manual access to the engine / energy compartment by the driver.

Article 28: Visibility

- a) 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.
- b) The vehicle must be equipped with a rear-view mirror on each side of the vehicle, each with a minimum surface area of 25 cm² (e.g. 5 cm x 5 cm). 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.

- c) An Inspector will check visibility in each of the vehicles in order to assess on-track safety. This Inspector will check good visibility with 60 cm high blocks spread out every 30° in a half-circle, with a 4 m radius in front of the vehicle.
- d) For UrbanConcept vehicles wet weather visibility is also mandatory (Article 52:)

Article 29: Safety Belts

- a) 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.
- b) The mounting point(s) for the crotch strap(s) must be below the Driver's torso to prevent the Driver from slipping forward.
- c) 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.
- d) The safety harness must be worn and fastened at all times when the vehicle is in motion.
- e) The fitness for purpose of the harness and its fitting will be evaluated during technical inspection. For Prototype cars this will be done by raising the vehicle with the Driver on board using the safety harness for suspension.
- f) The safety harness for prototype vehicles must withstand a force of at least 1.5 times the Driver's weight.
- g) The UrbanConcept vehicle safety harness must be specifically manufactured for motorsport use. (e.g. certified or compliant with FIA standards)

Article 30: Vehicle Access

- a) It is imperative for Drivers, fully harnessed, to be able to vacate their vehicles at any time without assistance in less than 10 seconds.
- b) For Prototype 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.
- c) For Prototype vehicles, 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.
- d) For UrbanConcept vehicles, the opening release mechanism must be easily and intuitively operable from the inside and the outside of the vehicle. The method of opening from the outside must be clearly marked by a red arrow and must not require any tools.
- e) It is forbidden to use adhesive tape to securely close the Driver's opening from the outside.

Article 31: Horn

- a) Each vehicle must be equipped with an electric horn mounted towards the front of the vehicle, in such a manner that is effectively audible to other vehicles and track marshals. With the vehicle in normal running condition, it must emit a sound greater than 85 dBA when measured 4 meters horizontally from the vehicle.
- b) The horn must have a high tone (pitch) of equal or greater than 420 Hz.
- c) The horn must have a noise capacity/volume greater than 110 decibels (dBA).

Article 32: On-board Fire Extinguisher

- a) 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 1 kg (2 lb for US application); equivalent size extinguishers are not permitted. It must be full and have a certificate of validity bearing the manufacturer's number and the date of manufacture or expiry.
- b) 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.
- c) 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.
- d) The on-board fire extinguisher does not replace the need for an adequate fire extinguisher for the team's garage area.

Article 33: Driver Position

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

Article 34: Clutch and Transmission

- a) All vehicles with internal combustion engines must be equipped with a clutch system.
- b) For centrifugal / automatic clutches the starter motor speed must always be below the engagement speed of the clutch.
- c) **For UrbanConcept only:** The vehicle must have 'idling capabilities', i.e. the vehicle must remain stationary with the engine running.
- d) For manual clutches the starter motor must not be operable with the clutch engaged. An interlock is required to facilitate this functionality.
- e) Please refer to Article 64: regarding starter motor requirements.
- f) The installation of 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 35: Exhaust System

- a) The exhaust gases must be evacuated outside the vehicle body.
- b) Exhaust pipes must not extend beyond the rear of the vehicle body.
- c) All vehicles are expected to comply with reasonable environmental standards, e.g. amount of smoke and odour emitted.
- d) All exhaust components must be made of metal.

Article 36: Sound Level

The sound level of the vehicle must not exceed 90 dB 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 37: Emergency Shut-down

- a) An emergency shutdown system, **operable from both, the exterior of the vehicle and the interior driver position**, must be permanently installed on all vehicles (not part of the detachable bodywork used to allow driver access). A red arrow (on a white background) at least 10 cm long and 3 cm wide at the widest point must be positioned on the vehicle body to indicate clearly the exterior position of the emergency shutdown actuator. This system must stop the engine / motor.
- b) For Battery Electric vehicles the emergency shutdown mechanism must provide a **physical isolation** of the propulsion battery from the vehicle electrical system. If relays are used, the relays must be a normally open contact type. The use of a power controller or other logic systems to drive an isolation device is not permitted. *It is suggested, but not required that the accessory battery be isolated as part of an emergency stop action.*
- c) For Hydrogen vehicles see Article 65:e) .

Article 38: Additional Inspections

- a) After passing the technical inspection, the replacement and / or alteration of the engine, any vehicle wiring, or any other vehicle part must be re-approved by the Technical Inspectors.
- b) *After any significant incident to the vehicle, it must be re-inspected.*
- c) At any time, the Organisers may perform unannounced inspections on the vehicles.

3B - Prototype Group

Article 39: Dimensions

- a) The maximum height must be less than 100 cm.
- b) 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.
- c) The track width must be at least 50 cm, measured between the midpoints where the tyres touch the ground.
- d) The wheelbase must be at least 100 cm.
- e) The maximum total vehicle width must not exceed 130 cm.
- f) The maximum total length must not exceed 350 cm.
- g) The maximum vehicle weight, without the Driver is 140 kg.

Article 40: Cockpit - Ventilation

No specification – please review considerations in Article 23:

Article 41: Tires, Wheels, Axles and Wheel Hubs

- a) All types of tires and wheels are allowed.
- b) Any type of wheel rim may be used. Rims must be compatible with the dimensions of the selected tires 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).

- c) Wheels located inside the vehicle body must be isolated from the Driver by a bulkhead.
- d) 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.
- e) All installations must be carried out in a way that there is no likelihood of the wheels coming into contact with other parts of the vehicle (i.e. cables, wires, hoses, and engine compartment components like batteries, etc.). These must be safely mounted / secured so that they cannot interfere with the turning wheel during driving and cause accidents.

Article 42: Turning Radius and Steering

- a) Front wheel or rear wheels steering is permitted. If rear wheel steering is used then it should be easy for the driver to locate the straight ahead position. If the

Organisers are not satisfied with the effectiveness and/or control of a vehicles steering system, this vehicle will be removed from the competition.

As Shell Eco-marathon events move to narrower city tracks with more corners, efficient and stable steering systems are required. Rear wheel steering is less intuitive than front wheel steering due to the lack of inherent self-centring. Therefore, careful consideration should be taken when selecting and engineering this method, which needs to be tested and confirmed to be safe before arriving at the event.

- b) The turning radius must be sufficient to enable safe overtaking as well as negotiating the turns of the track. If the Organisers suspect that the turning radius of a vehicle is insufficient for the track, the vehicle will be required to negotiate a slalom course.
- c) The slalom course in Asia and the Americas will require a turning radius of 6 m, in Europe it will require a turning radius of 10 m. It will also aim to verify driver skills and steering precision, i.e. that it has excessive play or undue delay.

For Europe only: Please note that the minimum turning radius will be reduced further in the coming years to be harmonised with Asia and the Americas. It is strongly recommended to design any new vehicle with a minimum turning radius of 6 m.

- d) **Electrically operated indirect steering systems are permitted providing they are operated by a steering wheel or similar (rotary potentiometer), joystick operation is not permitted. When electronic steering systems are used, then in event of release of the steering wheel by the driver or electrical failure, the vehicle should revert to the straight ahead position.**

Article 43: Braking

- a) Vehicles must be equipped with two independently activated brakes or braking systems; each system comprising of a **single command control** (lever(s) working together or foot pedal), **command transmission** (cables or hoses) and **activators** (callipers or shoes).
- b) One system has to act on **all** front wheel(s), the other on **all** rear wheel(s). When braking on two steering wheels at the front, 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.
- c) The rear system must work on each wheel, unless they are connected by a common shaft in which case they can have a single system.
- d) 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.
- e) The effectiveness of the breaking systems 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.
- f) 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.

3C - UrbanConcept Group

Article 44: Definition

Under the name “UrbanConcept”, Shell offers an opportunity to design and build fuel efficient 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 45: Dimensions

- a) The total vehicle height must be between 100 cm and 130 cm.
- b) The total body width, excluding rear view mirrors, must be between 120 cm and 130 cm.
- c) The total vehicle length must be between 220 cm and 350 cm.
- d) The track width must be at least 100 cm for the front axle and 80 cm for the rear axle, measured between the midpoints where the tyres touch the ground.
- e) The wheelbase must be at least 120 cm.
- f) The Driver’s compartment must have a minimum height of 88 cm and a minimum width of 70 cm at the Driver’s shoulders.
- g) The ground clearance must be at least 10 cm.
- h) The maximum vehicle weight (excluding the Driver) is 205 kg.

Article 46: Vehicle Body

- a) 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.

- b) The body must cover all mechanical parts whether the vehicle is viewed from the front, the rear, the sides or from above. However, 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. The covering for the wheels and suspension must be a rigid integral part of the vehicle body.
- c) It is prohibited to use any commercially available vehicle body parts.
- d) Access to the vehicle by the Driver must be as easy and practical as typically found in production type passenger cars. The “door” opening must have a **minimum** dimension of 500 x 800 mm.

This means the door opening will be verified with a rectangular template of 500 x 800 mm.

- e) 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.
- f) The vehicle must have a roof covering the Driver's compartment.
- g) A windscreen with effective wiper(s) is mandatory. Please refer to Article 52:.
- h) Luggage space must be available for a rectangular solid box with dimensions of 500 x 400 x 200 mm (L x H x W). 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. This box must be supplied by the competitor and must be placed in this space during the competition. For drivers requiring ballast this box must contain the ballast in a safe and secure manner.
- i) 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 5 cm or greater, alternatively they should be made of foam or similar deformable material.
- j) A towing hook or ring is mandatory on the front of the vehicle, under the body and easily accessible, so that it can be towed with a cable by another vehicle. This hook or ring must resist a traction force of 2,000 N (~200 kg).

Article 47: Turning Radius and Steering

- a) Vehicle steering must be achieved by one system operated with both hands using a turning motion. It must be precise, with no excessive play.
- b) Steering must be achieved using a steering wheel or sections of a wheel.
- c) Steering bars, tillers, joysticks, indirect or electric systems are not permitted.
- d) The turning radius must be less than 6 m.
- e) 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 48: Wheels

- a) The rims must be between 13 to 17 inches in diameter.
- b) 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 49: Tyres

The choice of tyres is free as long as they are fitted on the type and size of rims recommended by their manufacturers and have a minimum tread of 1.6 mm. The tyre / rim assembly must have a minimum width of 80 mm, 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 50: Lighting

The vehicle must have a functional external lighting system, including:

- a) Two front headlights
- b) Two front turn indicators
- c) Two rear turn indicators
- d) Two red brake lights in the rear
- e) Two red rear lights (may be combined with the brake lights)
- f) The centre of each headlight unit must be located at an equal distance and at least 30 cm from the longitudinal axis of the vehicle.
- g) The mandatory red indicator light for the self starter operation must be separate from any of the above (Article 64:c))

Article 51: Braking

- a) The vehicle must be equipped with a four-disc hydraulic brake system, with a brake pedal, which has a minimum surface area of 25 cm².
- b) 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).
- c) A single master cylinder may be used, provided that it has a dual circuit (two pistons and dual tank).
- d) 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.
- e) Wet weather capability is mandatory (see Article 52:)

Article 52: Wet Weather Running

- a) During weather conditions of light rain/drizzle, the UrbanConcept vehicles (**only**) may be required to drive on the track during competition with approval from the Race Director. Therefore, all UrbanConcept vehicles must be adequate for running under such conditions.
- b) The vehicle must be equipped with an effective electric windscreen wiper(s).
- c) The operation of the wiper assembly must be activated by an independent switch easily accessible to the driver.
- d) The wiper operation must provide the driver a clear view.

This means the wiper unit must function as designed, and remain on the vehicle during competition.
- e) The vehicle must be adequately ventilated to prevent driver's compartment from fogging.

- f) The vehicle's electrical system must be suitable for wet weather conditions (e.g. will not malfunction during wet conditions).
- g) Tyres must have a minimum tread of 1.6 mm (refer to Article 49:).
- h) The vehicle's brake effectiveness may be re-inspected before and/or after any run.
- i) The effectiveness of the vehicle to run in wet conditions will be evaluated during the initial inspection phase.

4- ENERGY SOURCES

4A - General

Article 53: Energy Types

Vehicles may only use the following energies:

a) Internal Combustion:

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

b) Electric Mobility:

- i) Hydrogen.
- ii) Battery Electric.

Weather conditions will vary throughout the event and teams using solar cells need to take this effect into account during the competition.

Article 54: Results Calculations

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

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

- d) For example, if a distance of 1,000 km is covered with one litre of Shell Diesel, whose corresponding energy is 35,660 kJ (if we assume a fuel density of 0.83716 kg/l at 15 °C), this represents 0.0280 km covered per kJ. Since the energy from one litre of Shell FuelSave Unleaded 95 (Europe and Asia) / Shell Regular 87 (US) Petrol / Gasoline is 32,010 kJ (if we assume a fuel density of 0.74616 kg/l at 15 °C), this corresponds to a corrected distance of 896 km (rounded to the nearest unit). The final result for a vehicle having covered 1,000 km with one litre of diesel fuel (at the reference temperature of 15 °C) will thus be 896 km 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 15 °C).
- e) Results for Hydrogen Fuel Cell and Battery Electric vehicles will be expressed in kilometres per kilowatt hour (km/kWh).
- f) Fuel Cell vehicles will use a flow meter to measure the H₂ consumed. The result will be calculated using the NCV of H₂ listed above.
- g) The results of Battery Electric vehicles will be determined by using joulemeters which are supplied by the Organisers.
- h) The results for hybrid vehicles will be expressed based on the primary energy used.

Article 55: Fuels Supply & Handling

- a) Only the fuels listed in Article 53:, as provided to the participants by the Organisers during the event, are authorised for use during practice and competition.
- b) Supplies adequate for practice and competition will be available by the officials in charge of measuring fuel consumption.
- c) 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.
- d) Any participant handling fuel must wear safety glasses and chemically resistant gloves.
- e) No additives, catalysts, water injection, or fuel treatment devices are allowed.

Article 56: Engine Lubricants

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

Article 57: Vehicle Electrical Systems

- a) For safety reasons, the maximum voltage on board of any vehicle at any point must **not exceed 48 Volts nominal and 60 Volts max** (this includes on-board batteries, external batteries, super capacitors, fuel cell stack, solar cells, etc).

Battery definition: 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.

- b) If Lithium-Ion based batteries are used, **Battery Management Systems (BMS)** tailored to this chemistry must be installed to control and protect the battery against risk of fire. The BMS must provide cell balancing and overvoltage protection during off-track charging. For e-mobility vehicles, the additional requirement of overdischarge, over-current and over-temperature must be provided as part of the on-vehicle system. **The BMS must AUTOMATICALLY isolate the battery, without operator intervention**, if a limit or out of range condition is reached on any of the above parameters. For Li-Ion based accessory batteries, the BMS cell balancing and overvoltage protection may be contained as part of the off-board charger.
- c) All batteries and super capacitors must be short circuit protected. Protection may be in the form of a fuse, fusible link, or a current interrupting device (circuit breaker). Automatic reclosing current interrupting devices are not allowed. Short circuit protection devices must be located on the positive conductor and as close as possible to the battery or super capacitor itself. The rating of the short circuit protection device must be such that the battery or super capacitor will be able to supply enough short circuit current at all times to open the device.
- d) All vehicle electrical circuits must be protected against electrical overload. Overload protection may be in the form of fixed current limits within electric controllers or by the insertion of individual circuit fuses.
- e) The accessory battery (refer Article 57:h)) must maintain a negative ground.
- f) For safety reasons, the propulsion battery or super capacitors, both positive and negative circuits must be electrically isolated from the vehicle frame and the accessory battery circuit.

This only applies to Hybrid and e-mobility vehicles which have a propulsion battery.

- g) Only one propulsion battery (for e-mobility vehicles only) and one **accessory battery** per vehicle are allowed.
- h) The **accessory battery** must operate all safety devices (e.g. horn, hydrogen sensor) for the duration of the competition and may also operate, only for internal combustion engine, the starter motor, the ignition, the instrumentation and electronic management systems. All other additional sources of electricity are forbidden.

- i) The **accessory 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.
- j) The Organisers reserve the right to request Teams to install one joulemeter, intended to measure the quantity of energy provided by the accessory 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.
- k) Both propulsion and accessory batteries must be installed outside of the driver's compartment behind a bulk head. (See Article 27:)
- l) The following devices may be powered by batteries other than the propulsion or accessory battery provided they use built-in batteries: radio communication system, GPS system, data loggers excluding engine management units, driver ventilators.
- m) All electrical / electronic enclosures built and populated by the teams must be made of transparent material or at least have a transparent cover to allow the technical inspectors to view the contents.

Article 58: Technical Documentation

- a) Competitors must provide the Organisers with a precise technical description of the vehicle's fuel system and electrical circuitry. This documentation serves only to verify that the teams have an understanding of the Rules. Admission to the competition in no way constitutes a pre-approval for the Technical Inspection phase. Final technical approval is only granted at the event.
- b) Technical Documentation – **prior to event.**
 - i) Competitors must provide, through the online submittal process, documentation on the fuel and vehicle electrical system.
 - ii) For internal combustion vehicles, the documentation must include a description and a precise technical drawing of the fuel supply system from the tank to engine. This should contain the following:
 1. Major fuel system components such as pressurised air bottle, pressure relief valves, air pressure gauges, fuel tank, filters, valves, carburetors, fuel injectors, float chambers, pumps, starter motor , engine, etc.
 2. A description on how the vehicle clutch works (showing that use of the starter motor will not engage the clutch)
 - iii) For all vehicles, the electrical systems documentation may be in form of one or more block diagrams / electrical circuit diagram containing the following:
 1. Point to point vehicle wiring diagram showing the location of all major relevant electrical components of the system, such as batteries, super capacitors, fuses/circuit protectors, lights, alternators, horn, starter motor (for **e-mobility vehicles** this should also include drive train components such as fuel cells, motors, controllers, solar cells, MPPTs, joulemeters), etc.
 2. Component voltage, current, and power ratings of major components.
 3. Locations and ratings of all circuit protection devices.

4. Illustration of how the emergency stop system works, and presence of both external and internal emergency switches in the electrical circuit. A separate sheet may be used to illustrate this if necessary.
 5. A description of any battery(s) or ultra (super) capacitors being used in the system, including type, rated voltage, max charge voltage and capacity in amp-hours or capacitance.
 6. Starter motor, starter light connections (for vehicles with starter motor).
- c) Technical Documentation – **at event** (to be reviewed during Technical Inspection)
- i) Competitors must have available for inspection with the vehicle, a **printed copy** of the **latest version** of the documents submitted above (Article 58:b)) and the additional documentation as defined below.
 - ii) For all vehicles, if a Lithium-Ion battery is used as accessory battery, printed / written documentation on the BMS operation must be provided. (Note, the requirement for BMS system operation data is independent of whether the BMS is integrated into a purchased battery, part of the charger or special built.) The BMS data **MUST** include:
 1. Cell over-voltage protection limits.
 2. Operation of cell balancing (how and when).
 3. Battery operation when over-voltage, limits are reached. (that is, what will the BMS/Battery do when these limits are reached)
 - iii) For all E-mobility vehicles printed/written documentation on the BMS operation must be provided. (Note, the requirement for BMS system operation data is independent of whether the BMS is integrated into a purchased battery or special built.) The BMS data **MUST** include:
 1. Cell over-voltage and under-voltage protection limits.
 2. Battery over-current limit.
 3. Operation of cell balancing (how and when).
 4. Battery over-temperature limit.
 5. How the BMS will protect the battery when an over-voltage, under-voltage, over-current or over-temperature condition is reached. (That is, how will the BMS isolate the battery when these limits are reached?)
 - iv) For E-mobility vehicles the additional printed technical documentation must include:
 1. Any additional information not submitted prior to the event on the battery type, energy capacity and nominal voltage ratings (both propulsion and accessory if used).
 2. Any additional information not submitted prior to the event on the motor(s) and motor controller(s) power and voltage ratings.
 3. PV data sheet power and voltage ratings (P_{mpp} , I_{sc} , V_{oc} , V_{mpp}) (if used).
 4. PV controller (MPPT), power and voltage ratings (if used).

4B - Internal Combustion Engines

Article 59: 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 (2 stroke engines are forbidden).

Article 60: Other on-board energy sources

- a) 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.
- b) Fuel pumps are permitted for all fuels provided they are mechanically driven by the engine only.
- c) 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 – or the lower operation pressure of the vehicle system. It must include a standard valve as used for car tires 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.

- d) Auxiliary energy sources (chemical, latent energy from phase changes, etc.) are not permitted.
- e) 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.
- f) 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 2014 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 61: Fuel Tanks (with the exception of Hydrogen)

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

Tank capacities: Prototype: 30, 100 or 250 cc

UrbanConcept: 30, 100, 250 or 350 cc

- b) 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).*

- c) 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.
- d) The fuel tank must be mounted in a way that its top is at least 5 cm below the roll bar.
- e) 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 (<3 mm) hole should be drilled in the centre of the cap to allow air to enter the tank, hence allow fuel out!

- f) Fuel return lines must be fed into the fuel feed line below the fuel tank. However, the return line can only be fitted to the fuel cap if the engine was originally equipped with a manual priming pump and this return line and the pump have not been modified.
- g) Competitors must equip their vehicle with clear fuel lines which are not prone to expansion when pressurised (max. internal diameter 8 mm). At technical inspection the Organisers will supply a suitable line if required
- h) 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 62: Fuel System

- a) The participants must provide a description and a precise technical drawing of the fuel supply system from the tank to engine.
- b) This system must be designed in such a way that it can be completely drained and refilled before the competition.
- c) The fuel line between the tank and the engine must not include any additional elements (no additional filters or valves).
- d) For diesel engines, a cut-off solenoid valve is required.
- e) 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.
- f) The air intake manifolds must not contain any fuel (or be able to accumulate 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.

- g) The fuel system must be easily accessible for inspection and measurements.

- h) 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.
- i) The standard fuel consumption measurement method for liquid fuels is by volumetric replacement of the fuel consumed and temperature corrected fuel (including temperature correction).
- j) The fuel consumption of gasoline and ethanol powered vehicles which have achieved more than 1500 km/l (3528 mpg) in the past 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 de-installed and weighed again on the same balance. This handling of the fuel system, including mounting to and dismantling from the vehicle and transporting it to the weighing room must be performed by a competent team member who has 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.
- k) 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 63: Vehicles using hybrid technology

- a) A Super Capacitor is the only allowed energy storage device for hybrid vehicles. The use of any battery for the hybrid propulsion system is forbidden.
- b) This capacitor must be the only source of stored energy for the electric motor driving the vehicle. It must be electrically isolated from the vehicle accessory battery (see Article 57:f)).
- c) Two connectors must be installed safely outside the vehicle to allow the voltage measurement on the starting line.
- d) 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 its 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.
- e) As per Article 57:, an accessory battery can be used to power the self-starter, the ignition, the injector, the instrumentation, the horn and electronic management systems.
- f) 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. (See Article 57:)

Article 64: Starter

- a) An electric starter may be used during the competition, provided that it can operate only when the ignition and fuel systems are activated.
- b) It must be clearly established that the starter is **never** capable of providing any forward propulsion to the vehicle. (see also Article 34: Article 34:d)
- c) **Starter light: A clearly visible red indicator light, equivalent in its luminescence to a 21 W 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.
- d) 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 and to install a joulemeter to measure starter energy used. If any non-compliance is observed, the Team will be penalised accordingly.
- e) 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.

4C - Electric Propulsion

Article 65: Fuel Cell Powered Vehicles

- a) Fuel system
 - i) The competitors must provide a description and a precise technical drawing of the fuel supply system.
 - ii) The fuel system must be easily accessible for inspection and measurements.
 - iii) The fuel cell must run by itself. The electricity needed for temperature regulation, fan, compressor, electronic management system for the fuel cell and the electric motor must be supplied by the fuel cell and not by the onboard battery.
 - iv) The hydrogen system must be designed as follows:

*H₂ cylinder → Pressure regulator directly attached to the cylinder →
Emergency shutdown valve directly attached to the outlet of the
pressure regulator → Flow meter → Fuel Cell*
 - v) The flow meter must be fixed at the inlet of the fuel cell. Both must be at the same pressure.
- b) Hydrogen cylinders
 - i) 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.
 - ii) Cartridges and any other means of hydrogen storage are not permitted.

- iii) For Prototypes vehicles, the following cylinders will be provided:
- Europe: B04 cylinder, 0.4 litre of hydrogen at 200 bar.
(7 cm / 33cm) 1.4 kg
 - Americas: Exchange cylinder ~ 140 bar
7" X 16" (18 cm x 41 cm), 15 lbs. (7 kg)
 - Asia: Catalina MD cylinder, 2.9 litre of hydrogen @139 bar
(11.1 cm x 42.4 cm), 2.4 kg

- iv) For UrbanConcept vehicles, the following cylinders will be provided:

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

- v) 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.

c) 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 cm². Another 5 cm² opening must be provided at the highest point of the driver compartment.

d) Hydrogen detector

- i) 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.

- ii) **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.

e) Emergency shutdown valve and relay

- i) The hydrogen supply circuit must be equipped with a solenoid emergency shutdown valve. This valve must be normally closed in the absence of electricity.
- ii) 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.
- iii) This valve and relay must be activated by any of the following three scenarios:
1. Through hydrogen detection as explained above

2. Through the emergency push-button located on the outside of the vehicle. A red arrow (on a white background) 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)
 3. Through another emergency push-button, accessible by the pilot in driving position.
- iv) In case of activation by one of these three scenarios, the valve and relay must act simultaneously.
 - v) These three scenarios will be tested during the technical inspection and before each attempt.
- f) Pipes and connections of the hydrogen circuit
- i) 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.

The use of PTFE pipes is recommended. PU tubing should not be used as this tends to leak.
 - ii) 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 / compression type.
 - iii) 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.
 - iv) PTFE (Teflon) sealing tape must not be used because it can damage the flow meter. In any case competitors are responsible for damage to the flow meter due to wrong connections.
- g) Purge pipe
- If a purge pipe is needed, its end must be located outside the vehicle.
- h) Measurements and Equivalencies
- i) The consumption of hydrogen is measured by an embedded flow meter. The flow meter will be checked / calibrated by the Organisers before technical inspections.
 - ii) The flow meter has to be purchased from the Organisers.
 - iii) 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.
 - iv) The serial number on the hydrogen flow meter must not be covered or removed .
- i) Oxygen and air reserves
- The use of non-replaced oxygen or compressed air reserves is forbidden.

j) Super Capacitors

- i) 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.
- ii) The state of charge of the super-capacitor will be checked before and after each run by measuring the super-capacitor voltage. **Two measurement points (super-capacitor voltage + and -) must be installed outside the vehicle to allow the voltage measurement on the starting line.**
- iii) 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
- iv) The maximum super capacitor voltage must not exceed that referenced in Article 57:a) .

k) External starter battery

- i) 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.
- ii) 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. **These external connectors must be securely fastened to the vehicle.**
- iii) As mentioned in Article 57:h) it is mandatory to power the hydrogen detector and the horn using the accessory battery. This battery must also power the emergency shutdown valve, relay and lighting system for UrbanConcept vehicles.

l) Electrical circuit / Electronics

- i) All wiring associated with the accessory battery circuit must only be in two colours, positive in orange and negative in purple. All other wiring used must be in any other colour except orange or purple.
- ii) 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 60 A.
- iii) "If a super-capacitor is used in the circuit, a fuse must be installed on the positive terminal of the super-capacitor pack. The fuse rating must be less than or equal to the maximum usable power divided by the rated voltage."

m) Other equipment

Compressors, fans and coolers for the fuel cell system must be powered by the fuel cell or super capacitor (**not** by the accessory battery). (Refer Article 57:i))

Article 66: Not Used

Article 67: Battery Electric Vehicles

- a) This category is open to both Prototype and UrbanConcept entries.
- b) The drive train in the 'Battery Electric' category is restricted to a maximum of one electric storage device, and up to two electric motors, with associated control units.
- c) Only Lithium-Ion batteries are permitted as electric storage devices.
- d) The vehicle must be equipped with a Battery Management System (BMS) to control and protect the battery against risk of fire as defined in Article 57:.

Please do note that as of 2013 any BMS for propulsion Batteries must provide an AUTOMATIC isolation of this battery in the event of any measured parameters getting out of their designed range.

- e) The Lithium-Ion battery and any accessory circuits are subject to the maximum voltage defined in Article 57:a)
- f) An accessory battery as defined in Article 57:h) is permitted. If one is used, all accessory circuits must not be connected to any of the electric circuit(s) involving any power train components and must only be used to power safety related components and only those systems mentioned specifically in Article 57:.
- g) Solar cells **MAY** be integrated into the vehicle electrical circuit. If solar cells are included they must meet the following requirements:
 - 1. The solar cells must be fully integrated into the bodywork of the vehicle. They must NOT form an independent structure or be part of any other structures protruding from the vehicle.
 - 2. The maximum voltage present at any point in any circuit, whether before or after the maximum power production (MPP) controller, must not be greater than that defined in Article 57:a).
 - 3. For a Prototype vehicle, the total combined surface area of the solar cells shall be less than 0.17 m² (e.g. 10 cells of 5x5 inches or 7 cells of 6x6 inches).
 - 4. For an UrbanConcept vehicle, the total combined surface of the solar cells shall be less than 0.65 m² (e.g. 40 cells of 5x5 inches or 27 cells of 6x6 inches).
 - 5. The output of the solar cells will be measured through a joulemeter. The joulemeter will be connected in the vehicle electrical circuit before the motor joulemeter and after the solar cell MPP controller, if equipped.
 - 6. The calculation of the race result (expressed in km/kWh) will be based on the Net propulsion energy supplied by the battery only, excluding the energy contributed by the solar cells, i.e. Net propulsion energy = motor propulsion energy – solar energy. The motor propulsion energy includes both, the energy consumed by the motor and the motor controller.

- h) The competitors will be required to present electrical schematics at the competition technical inspection. (See Article 58:)
- i) All Batteries must be placed outside the driver's compartment behind the bulkhead and securely mounted. Bunge cords or other elastic material are not permitted for securing the battery. (see Article 27:)
- j) All vehicles must be equipped with one joulemeter located between the battery and the motor controller(s), and, if equipped with solar cells, a second joulemeter for the solar output as described in Article 67:g)5 above, to measure the vehicle propulsion energy consumption.
- k) The Organisers will provide the joulemeter(s) for the duration of the event. A security deposit may be required for the joulemeter.
- l) The joulemeter(s) must be positioned so that its display can be easily read from outside the vehicle.
- m) The joulemeter(s) must be inaccessible to the Driver in his or her normal driving position.
- n) All electrical circuits must be protected as defined in Article 57:d).
- o) On the starting line, Fuel Marshals will reset the joulemeter(s) 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.
- p) At the finish line, Fuel Marshals will read the joulemeter(s) display.
- q) All 'Battery Electric' vehicles which complete a successful run will be classified in descending order of fuel economy, expressed in km/kWh.