



# **SHELL ECO-MARATHON**

## OFFICIAL RULES 2014

### CHAPTER 1





## FOREWORD

### DEAR SHELL ECO-MARATHON COMPETITORS, FRIENDS AND ENTHUSIASTS



More than 9 billion people are expected to live on our planet by 2050, up from 7 billion today. The demand for energy is likely to double by then. With these challenges on our hands, we need to find innovative answers to the question of how to deliver energy in a sustainable way. Shell Eco-marathon inspires young people to find creative ways of achieving extreme energy efficiency in transport. With events in the Americas, Europe and Asia, the competition challenges students from around the world to design, build and compete in the ultimate energy-efficient

car. It offers engineers of the future a unique, hands-on experience in testing alternative fuels and advanced technologies.

Over the decades, Shell Eco-marathon Participants have been making outstanding contributions to this challenge. In order to continue this legacy successfully, the 2014 Rules have been updated with the intention to increase the technical challenge and the learning opportunity. One example is the Battery Electric vehicle class which now requires teams to build their own motor controller. In future years, we may continue to 'raise the bar' further by asking teams to build own Maximum Power Production (MPP) controllers, Li-Ion batteries and associated battery management systems.

As safety is our top priority in Shell, we aim to continuously increase the safety standards for all Shell Eco-marathon Participants. Therefore, several articles in these Rules contain new or improved requirements to protect the vehicle drivers. For example, in 2014 all vehicles must have a solid floor that prevents any part of the driver's body from contacting the ground. From 2015 onwards all Prototype vehicles must be fully covered. Open body vehicles will no longer be allowed.

But any safety standard is only as effective as it is complied with. Most teams follow the requirements set out in these Rules, but some are not as compliant. This is particularly noticeable when it comes to proper documentation. Unless teams provide the required set of vehicle documents my team and I are unable to anticipate potential safety problems and carry out effective inspections. Therefore, in 2014 we will strictly enforce the Rules about documentation pre-event and at the event; or to put it simply: NO DOCUMENTS = NO INSPECTION.

I would like to thank all Participants who continue to provide my team and me with useful feedback, ideas and suggestions. Your input is very valuable as it helps us to keep this competition interesting, challenging and relevant. As a direct result of what we heard and learnt during the 2013 season, we are limiting the allowable amount of solar energy used for the propulsion of Battery Electric vehicles to 20% of the total propulsion energy consumed. This change will allow top teams to continue to strive for victory, especially during the not so popular morning and evening hours, while less advanced teams can invest their efforts in improving their vehicle's overall efficiency without the need to invest significant amounts of time and money into solar cells in order to remain competitive.

I wish you a safe and successful season and look forward to seeing you at one of the next Shell Eco-marathon events in 2014.

*Norman Koch*

Shell Eco-marathon Technology Manager & Student Liaison

## **TABLE OF CONTENTS**

<b>1. ORGANISATION.....</b>	<b>5</b>
ABOUT THE RULES .....	5
ARTICLE 1:    ACCEPTANCE.....	6
ARTICLE 2:    ENTRIES .....	6
ARTICLE 3:    TRACK ACCESS CONDITIONS.....	6
ARTICLE 4:    IDENTIFICATION.....	7
ARTICLE 5:    COMPLIANCE .....	7
ARTICLE 6:    PROTESTS .....	7
ARTICLE 7:    DISPUTES .....	8
ARTICLE 8:    PENALTIES .....	8
<b>2. SAFETY.....</b>	<b>9</b>
ARTICLE 9:    SAFETY RULES.....	9
<b>DRIVING RULES .....</b>	<b>9</b>
ARTICLE 10:   DRIVING KNOWLEDGE AND TEST .....	9
ARTICLE 11:   DRIVING UNDER THE INFLUENCE OF ALCOHOL/ILLEGAL SUBSTANCES .....	9
ARTICLE 12:   BRIEFING.....	10
ARTICLE 13:   ACCESS TO THE TRACK AND TEST LAP .....	10
ARTICLE 14:   PUSHING THE VEHICLE .....	10
ARTICLE 15:   RACE DIRECTION .....	10
ARTICLE 16:   RADIO COMMUNICATION .....	10
ARTICLE 17:   OVERTAKING.....	10
ARTICLE 18:   BREAKDOWNS AND OTHER INCIDENTS.....	10
ARTICLE 19:   OFF-TRACK VEHICLE MOVEMENTS.....	11
<b>DRIVER &amp; EQUIPMENT .....</b>	<b>11</b>
ARTICLE 20:   DRIVER WEIGHT .....	11
ARTICLE 21:   HELMETS .....	11
ARTICLE 22:   DRIVER CLOTHING.....	12
ARTICLE 23:   DRIVER COMFORT .....	12
<b>TEAM SAFETY EQUIPMENT.....</b>	<b>12</b>
ARTICLE 24:   EQUIPMENT AND MATERIALS.....	12

**3. VEHICLE DESIGN..... 13**

**3A – GENERAL..... 13**

ARTICLE 25: VEHICLE DESIGN ..... 13

ARTICLE 26: CHASSIS/MONOCOQUE SOLIDITY ..... 14

ARTICLE 27: PROPULSION AND ENERGY STORAGE SYSTEM ISOLATION ..... 14

ARTICLE 28: VISIBILITY..... 15

ARTICLE 29: SAFETY BELTS ..... 15

ARTICLE 30: VEHICLE ACCESS..... 16

ARTICLE 31: HORN..... 16

ARTICLE 32: ON-BOARD FIRE EXTINGUISHER..... 16

ARTICLE 33: DRIVER POSITION ..... 16

ARTICLE 34: CLUTCH AND TRANSMISSION..... 17

ARTICLE 35: EXHAUST SYSTEM..... 17

ARTICLE 36: SOUND LEVEL ..... 17

ARTICLE 37: EMERGENCY SHUT-DOWN..... 17

ARTICLE 38: ADDITIONAL INSPECTIONS ..... 18

**3B – PROTOTYPE GROUP ..... 19**

ARTICLE 39: DIMENSIONS ..... 19

ARTICLE 40: NOT USED ..... 19

ARTICLE 41: TIRES, WHEELS, AXLES AND WHEEL HUBS ..... 19

ARTICLE 42: TURNING RADIUS AND STEERING ..... 19

ARTICLE 43: BRAKING..... 20

**3C – URBANCONCEPT GROUP ..... 21**

ARTICLE 44: DEFINITION ..... 21

ARTICLE 45: DIMENSIONS ..... 21

ARTICLE 46: VEHICLE BODY ..... 21

ARTICLE 47: TURNING RADIUS AND STEERING ..... 22

ARTICLE 48: WHEELS ..... 22

ARTICLE 49: TYRES..... 22

ARTICLE 50: LIGHTING..... 23

ARTICLE 51: BRAKING..... 23

ARTICLE 52: WET WEATHER RUNNING ..... 23

<b>4. ENERGY SOURCES .....</b>	<b>25</b>
<b>4A – GENERAL .....</b>	<b>25</b>
ARTICLE 53: ENERGY TYPES .....	25
ARTICLE 54: RESULTS CALCULATIONS .....	25
ARTICLE 55: FUELS SUPPLY & HANDLING .....	26
ARTICLE 56: ENGINE LUBRICANTS .....	27
ARTICLE 57: VEHICLE ELECTRICAL SYSTEMS .....	27
ARTICLE 58: TECHNICAL DOCUMENTATION .....	28
<b>4B – INTERNAL COMBUSTION ENGINES .....</b>	<b>31</b>
ARTICLE 59: PROPULSION .....	31
ARTICLE 60: OTHER ON-BOARD ENERGY SOURCES .....	31
ARTICLE 61: FUEL TANKS (WITH THE EXCEPTION OF HYDROGEN) .....	31
ARTICLE 62: FUEL SYSTEM .....	32
ARTICLE 63: VEHICLES USING HYBRID TECHNOLOGY .....	33
ARTICLE 64: STARTER .....	33
<b>4C – ELECTRIC PROPULSION .....</b>	<b>35</b>
ARTICLE 65: FUEL CELL POWERED VEHICLES .....	35
ARTICLE 66: NOT USED .....	38
ARTICLE 67: BATTERY ELECTRIC VEHICLES .....	38
ARTICLE 68: NOT USED .....	40
ARTICLE 69: NOT USED .....	40
<b>5. AWARDS AND PRIZES .....</b>	<b>41</b>
<b>5A – ON TRACK AWARDS .....</b>	<b>41</b>
ARTICLE 70: AWARD OVERVIEW AND PRIZES .....	41
<b>5B – OFF TRACK AWARDS .....</b>	<b>42</b>
ARTICLE 71: AWARD OVERVIEW AND PRIZES .....	42
ARTICLE 72: COMMUNICATIONS AWARD .....	42
ARTICLE 73: SHELL HELIX TRIBOLOGY AWARD .....	43
ARTICLE 74: VEHICLE DESIGN AWARD .....	44
ARTICLE 75: TECHNICAL INNOVATION AWARD .....	44
ARTICLE 76: SAFETY AWARD .....	45
ARTICLE 77: PERSEVERANCE IN THE FACE OF ADVERSITY AWARD .....	45

# 1. ORGANISATION

## ABOUT THE RULES

- a) The full Rules for Shell Eco-marathon 2014 events in Europe and the Americas are comprised of the Shell Eco-marathon Official Rules 2014 Chapter I, hereinafter referred to as “Official Rules” (this document) and the specific Chapter II of the region where the Shell Eco-marathon takes place, which can be downloaded from the ‘For Participants’ section of the Shell Eco-marathon website once available.
- b) It is the responsibility of every participating team to ensure the full Rules are read and understood. In order to highlight rule changes and aid the understanding of frequently misunderstood rules several tools have been used in this document:
- i. **Text set in red** indicates a change / addition / amendment compared to the previous year’s Rules.
  - ii. *Text set in italic indicates* a note or explanation of the rule above to aid its understanding. The text set in italic itself does not form part of the Rules itself.
  - iii. Links are used throughout this document to improve navigation.
  - iv. Hyperlinks to videos and drawings are used throughout this document to explain certain rules and illustrate acceptable and non-acceptable solutions.
- c) **In this document functions and roles are defined as follows:**
- i. **‘Organisers’** – the specific Shell company that organises the Shell Eco marathon event in a particular region as named in Chapter II, and all persons acting on its behalf.
  - ii. **‘Team’** – group of individuals with a team name and one vehicle that has been accepted for entry to the Shell Eco-marathon competition.
  - iii. **‘Participant’** – member of a Team.
  - iv. **‘Team Manager’** – a Participant that has been appointed on the event registration document as single focal point for his/her team towards the Organisers.
  - v. **‘Race Director’** – person appointed by the Organisers, who is responsible to manage and sanction all on-track activities.
  - vi. **‘Track Marshall’** – person appointed by the Race Director to act on his / her behalf, in particular to ensure on track safety and observe on-track rule compliance.
  - vii. **‘Fuel Marshall’** – person appointed by the Organisers, works as member of the technical team and supervises fuelling activities in line with the requirements of these rules.
  - viii. **‘Technical Director’** – person appointed by the Organisers, who is responsible to ensure the technical standards and integrity of the Shell Eco-marathon competition.



**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, postpone or cancel the competition for any reason including for reasons of force majeure due to, including but not limited to, adverse or extreme weather conditions, the occurrence of a natural disaster, acts of terrorism or safety concerns. No claims for compensation will be accepted.
- d) The Participant is aware that photo, audio and video recordings will be made of the event. By entering the Shell Eco-marathon, the Participant permanently relinquishes all rights in respect of these photos, audio and video recordings, which are made by third parties, the Organisers and its affiliates. Shell companies may use said photo, audio and video material for internal and external communications and own presentations (including but not limited to promotions, advertising, internet presence, TV and radio reports and press reports).

**Article 2: ENTRIES**

- a) For each entry, a Team Manager and a Driver must be designated. **A Reserve Driver may also 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 **and the Reserve Driver** for one vehicle cannot be the Driver or Reserve Driver for another vehicle.
- e) Each interested Team must apply to compete in the regional Shell Eco-marathon event closest to their home country. 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 follows:
  - 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 total area of 400 cm<sup>2</sup> (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 at the discretion of the Technical Director.

**Article 6: PROTESTS**

The Team Manager is the only person authorised to lodge protests. Protests must be brought to the attention of the Technical Director 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 Participant 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 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 Participants 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 these 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) Drivers may be questioned about their knowledge of the driving rules during inspection. The Organisers reserve the right to deny track access to Drivers with insufficient knowledge of the 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 vehicles 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 track access as long as he/she is under the Influence. A 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 the daily Drivers' Briefing is mandatory for the Team Manager and all registered Drivers every day. Failure in attending these Briefings by the Team Managers and Drivers will disqualify the team from practicing and / or competing that day.

**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 are drivers allowed to push their vehicle or have it pushed, including to start the run or to cross the finish line

**Article 15: RACE 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 vehicles wishing to overtake.

- a) Drivers in overtaking vehicles must sound their horn and pass with caution. The Driver of the overtaking vehicle is responsible for the safety of the manoeuvre.
- b) Drivers of the vehicles being overtaken must use their 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) Track Marshalls will notify the Race Director of any breaches and any unsafe or unfair behaviour.

### **DRIVER & EQUIPMENT**

#### **Article 20: DRIVER WEIGHT**

- a) The minimum Driver Weight is:  
Prototype vehicles - 50 kg  
UrbanConcept vehicles - 70 kg
- b) **The Driver Weight is defined as the weight of the person driving the vehicle including full driving gear and communication devices. If the Driver Weight does not meet the minimum weight requirement ballast needs to be fitted to the vehicle. 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, and also must be easily detachable for weighing. For UrbanConcept vehicles, the ballast must be placed in the luggage. Any ballast provided must not serve any other purpose than adding weight to the vehicle. It must not be of any use to the vehicle or the driver during the competition.**

*Tools, sharp objects and liquids cannot be used as ballast. Adjustable ankle/wrist weights are acceptable but must not be worn by the driver*

- c) Drivers (in full driving gear, including communication devices) and their ballast may be weighed before or after each 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). Helmet labels must be clearly readable. Helmets worn by 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 (**covering all fingers fully**) 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 pit 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. The extinguisher must be full, 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.
- i) **All vehicles must have a solid floor and frame that prevents any part of the driver's body from contacting the ground.**

*From 2015 onwards, all vehicles must be fully covered. Open top vehicles will no longer be allowed. Vehicles that look like bicycles, tricycles or wheelchairs are not acceptable.*



**Article 26: CHASSIS/MONOCOQUE SOLIDITY**



- a) Teams must ensure that the vehicle chassis or monocoque is designed **wide and long enough to effectively protect the driver's body in the case of collisions or rollovers. The Organizers will exclude any vehicle whose construction is deemed to be dangerous.**

*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.

*If this position impairs the driver visibility it will be deemed that the roll bar is not adequate. The effectiveness of the roll bar and driver's visibility will be validated simultaneously, i.e. the driver must not be in such position that he or she must raise their head or torso above the roll bar to pass the visibility test.*

- 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).

**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. 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.

- f) If holes are made in the bulkhead to pass through wires, cables, etc. it is essential that the wires/cables are protected by a grommet or similar protective material to prevent chafing or damage. All gaps/holes must also be filled.

**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.

*The driver's helmet must be 5 cm below the roll bar at all times.*

- 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 cm<sup>2</sup> (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) In technical inspection visibility will be checked in order to assess on-track safety by using 60 cm high poles 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 (see 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 securely in his/her seat. The five 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 mounting points should be fitted so that the belts will self align with the direction of the load.
- b) The safety harness must prevent any upward or forward motion of the driver's torso. Any slack in the harness must be adjusted by using the seat belt length adjuster. The adjuster must be located as close as possible to the connection point. The crotch strap mounting point should be behind the chest line and the topmost straps should be at an angle of at least 10° below the shoulder line.
- c) The safety harness must be worn and fastened at all times to prevent the driver from having any free movement when the vehicle is in motion.
- d) 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 buckle as the lifting point, this must be capable of withstanding 1.5 times the Driver's weight.
- e) The Urban Concept 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) 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.

**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. **The driver position should be such that the helmet is 5 cm below the roll bar AND that the visibility for the driver is unimpaired at the same**

time.

#### **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 dBA 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**

The purpose of the emergency shutdown system is to disable the propulsion system of the vehicle. Different types of propulsion systems require different measures to accomplish this:

- a) Spark ignition engines (gasoline, ethanol) will require the emergency shutdown mechanism to shutdown the ignition. It is not necessary to isolate the accessory battery.
- b) Compression ignition engines (diesel, GTL) will require the emergency shutdown mechanism to shut off the fuel or air flow. It is not necessary to isolate the accessory battery.
- c) 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 not necessary to isolate the accessory battery.**

- d) For Hydrogen vehicles see Article 65:e).
- e) **There must be both an internal and an external shutdown mechanism.**
  - i. **The internal emergency shutdown mechanism is for driver operation and can be designed in any effective way.**
  - ii. **The external emergency shutdown mechanism must be at the rear of the vehicle and permanently installed on a non-detachable part of the bodywork.**
  - iii. **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.**
- f) **The following external emergency shutdown mechanisms should be used for the following propulsion types:**
  - i. **Spark ignition engines (gasoline, ethanol) – latching red push button**
  - ii. **Compression ignition engines (diesel, GTL) – latching red push button or push/pull red lever**
  - iii. **Battery electric – latching red push button**
  - iv. **Hydrogen fuel cell vehicles - latching red push button**

#### **Article 38: ADDITIONAL INSPECTIONS**

- a) After passing technical inspection, the replacement and/or alteration of the engine, any vehicle wiring, or any other vehicle part must be re-approved by the Organisers.
- 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 vehicle maximum height must be less than 100 cm.
- b) The vehicle track width must be at least 50 cm, measured between the midpoints where the tyres of the outermost wheels touch the ground.
- c) The ratio of maximum height divided by track width must be less than 1.25 .
- d) The vehicle 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: NOT USED****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 wheel 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.

*The increasing popularity of rear wheel steered vehicles has led to increased numbers of on-track roll-overs globally. This is a direct result of the complexity to accurately design and operate such systems. In the interest of increasing*

*Participants' safety, teams are encouraged to review their steering system and utilise front wheel steering.*

*Only front wheel steering systems will be allowed from the 2015 season onwards.*

- 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 8 m, in Europe it will require a turning radius of 10 m. This is to verify driver skills and steering precision, i.e. that it has no excessive play or undue delay.**

*The turning radius is the distance between the centre of circle and the external wheel of the vehicle. The external wheel of the vehicle must be able to follow a half circle of 8 m / 10 m radius in both directions*

*For Europe only: Please note that the minimum turning radius will be harmonised with the other regions and be reduced to 8 m from the 2015 season onwards.*

- 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 off the steering system. Foot control is recommended.
- e) The effectiveness of the braking systems will be tested during vehicle inspection. The vehicle will be placed on an incline with a 20 percent slope **with the driver inside**. 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 **with the driver (and necessary ballast) in the vehicle.**
- 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 **common** production type passenger cars. The “door” opening must have a minimum dimension of 500 x 800 mm. **This means a rectangular template of this dimension must be able to pass through the door opening in the vertical plane.**
- 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. The luggage must be supplied by the Participant and must be placed in this space during the competition. **The luggage compartment and luggage must be able to safely contain the ballast without moving around or coming loose during competition.**
- 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 **with a minimum opening of 6 cm** 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. **The turning radius is the distance between the centre of the circle and the external wheel of the vehicle. The external wheel of the vehicle must be able to follow a 90° arc of 6 m radius in both directions.**
- 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 (see 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 cm<sup>2</sup>.
- 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 with the Driver inside 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) **A parking brake function is required in order to keep the car stationary during technical inspections and fuel measurements. It must provide a brake force of at least 50 N.**
- f) 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 arm assembly typically found in a production car.**
- 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.
- 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 (see 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 any one of 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. Ethanol E100 (100% Ethanol)\*\*
  - iv. Shell Gas to Liquid (100% GtL)\*\*

*\* The gasoline and diesel provided by the Organisers during the competition are the Shell fuels prevalent in the local market where the event takes place. For testing and tuning purposes in the team's home countries where Shell fuels may not be available it is recommended to use the locally available Unleaded 95 (87 US) or Diesel instead.*

*\*\* Ethanol E100 and Shell Gas to Liquid will be ranked jointly in one prize category called 'Alternative Fuels' on an energy content corrected basis.*

- b) Electric Mobility:
  - i. Hydrogen.
  - ii. Battery Electric.

*In order to allow teams to plan ahead when building new vehicles or redesigning drive trains the following changes to Article 53 are intended to be put in place for the next two seasons:*

- 1. 2015 – CNG will be added as a fuel option for internal combustion engines*
- 2. 2016 - Due to their insignificance for real-world mobility applications solar cells will no longer be allowed in Battery Electric vehicles.*

#### Article 54: RESULTS CALCULATIONS

- a) **All live results displayed at on-site monitors as well as the internet during the competition are provisional until verified and published by the Organisers after the completion of the event, usually within 3 days after the event.**
- b) 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 **on a tank-to-wheel basis.**

- 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.
- d) 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

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
Ethanol E100	26,900
Gas to Liquid	44,000
Hydrogen	119,930

*For example, if a distance of 1,000 km is covered with one litre of Shell FuelSave 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 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 (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 H<sub>2</sub> consumed. The results will be calculated using the NCV of H<sub>2</sub> 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 made available to all teams at the event.
- c) No additives may be added to the fuel. Only the energy 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) Participants 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 engine oil for use by the Participants.

**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) **For all vehicles only one on-board battery is allowed. For ICE and hydrogen fuel cell vehicles this is the accessory battery (see Article 57:h). For battery electric vehicles this is known as the propulsion battery. For battery electric vehicles only there is the option of having a propulsion battery and an accessory battery.**



- c) 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 **cell level** 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.



- d) 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.
- e) 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.
- f) The accessory battery (see Article 57:h) must maintain a negative ground.
- g) 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 or Super Capacitors.*



- h) The accessory battery provides for all allowed electrical needs such as safety devices (horn, windscreen wipers, lights, hydrogen sensors, hydrogen relays and hydrogen shutdown valve), ignition, fuel injection control, starter motor, and ventilation/cooling fan for the driver. For Internal Combustion vehicles only the accessory battery may also be used for engine management systems.  
The capacity of the accessory battery must be sufficient to power all the accessory loads with sufficient safety margin which will be verified during inspection. The accessory battery is not allowed to power compressors, blowers, engine cooling systems, motors, Battery Management Systems or propulsion related controllers in E-mobility vehicles.
- i) 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.
- j) Both propulsion and accessory batteries must be installed outside of the driver's compartment behind a bulk head (see Article 27:).
- k) 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.
- l) 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 contain the following:**
    1. A description and a precise drawing of the fuel system from tank to engine, including all components such as pressurised air bottle, pressure relief valves, air pressure gauges, fuel tank, valves, carburettors, fuel injectors, float chambers, mechanical pumps, 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 batteries or 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 and the additional documentation as defined below. **Accessing the information on-line via the internet during inspection is not allowed.**  
***No documentation = No inspection***
  - ii. For all vehicles, if a Lithium-Ion battery is used as accessory battery, printed/written documentation on the BMS operation must be provided. **Accessing the information on-line via the internet during technical inspection is not allowed.** 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. (i.e. 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. **Accessing the information on-line via the internet during technical inspection is not allowed.** (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, i.e. 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 and design of the internal combustion engines are 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 not allowed).

**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:
  - i. 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.
  - ii. The system must include a standard valve as used for car tires in order to enable verification/control of the pressure setting for the safety valve.
  - iii. The said pressurisation is done in the starting area by means of an air pump.
  - iv. 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.

**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. **For gravity fed systems a small (<3 mm) hole must 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) Participants must provide a description and a precise technical drawing of the fuel supply system from 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 to partially drain the chamber during Technical Inspection 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 has 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 Fuel Marshal 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 dismounting 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 Fuel Marshal who will also perform the weighing which 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. **Mechanical or hydraulic energy storage is not permitted.** 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:g).
- c) Two connectors must be installed safely outside the vehicle to allow the voltage measurement on the starting line. **These must be labelled "Super Capacitor Voltage".**
- 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: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. Participants 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 accessory battery.
  - iv. The hydrogen system must be designed as follows:
 

*H<sub>2</sub> 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  
**and**  
**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
  - 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 cm<sup>2</sup>. Another 5 cm<sup>2</sup> 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 H<sub>2</sub> detector it is still required to fit a H<sub>2</sub> 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 Driver 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 Driver 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 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 Participants 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 Inspection.
  - 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 Driver 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 - labelled "Super Capacitor voltage"**) 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 be clearly distinguishable from the propulsion system using** 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 cm<sup>2</sup>, 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 (see Article 57:h).

Article 66: **NOT USED**

Article 67: **BATTERY ELECTRIC VEHICLES**

- a)  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. **The electric motors may be purchased, purchased-and-modified, or purpose-built. The motor controller MUST be purpose-built for the Shell Eco-marathon. Modifications to purchased motor controllers are not acceptable. Motor controllers built from sub-components such as single-board computers, power stages, etc. are encouraged. If a unit is developed incorporating the motor controller into one or more single printed circuit boards (PCB) the text "SEM" needs to be included in the mask of the PCB etching.**
- b) Only Lithium-Ion batteries are permitted as electric storage devices.
- c) 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:
  - 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.*
- d) The Lithium-Ion battery and any accessory circuits are subject to the maximum voltage defined in Article 57:a) .
- e) 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:.

- f) Solar cells MAY be integrated into the vehicle electrical circuit. If solar cells are included they must meet the following requirements:
- i. The solar cells must be fully integrated into **the natural contour of the vehicle's body**. They must NOT form an independent structure or be part of any other structures protruding from the vehicle. This will be checked during Technical Inspection at the event. **It is highly recommended that prior to the vehicle build / modification you send pictures / drawings / sketches to the Shell Eco-marathon e-mail address to ensure compliance.**
  - ii. The maximum voltage present at any point in any circuit, before or after the maximum power production (MPP) controller, must not be greater than defined in Article 57:a).
  - iii. For a Prototype vehicle, the total combined surface area of the solar cells shall be less than 0.17 m<sup>2</sup> (e.g. 10 cells of 5x5 inches or 7 cells of 6x6 inches).
  - iv. For an UrbanConcept vehicle, the total combined surface of the solar cells shall be less than 0.65 m<sup>2</sup> (e.g. 40 cells of 5x5 inches or 27 cells of 6x6 inches).
  - v. 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.
  - vi. 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 amount of solar energy used in this calculation will be limited to no more than 20% of the motor propulsion energy used during the run.** The motor propulsion energy includes both, the energy consumed by the motor and the motor controller.
- g) Participants are required to present electrical schematics at Technical Inspection (see Article 58:).
- h) All batteries must be placed outside the Driver's compartment behind the bulkhead and securely mounted. Bunge cords or other elastic materials are not permitted for securing the battery (see Article 27:).
- i) 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:f)v above, to measure the vehicle propulsion energy consumption.
- j) The Organisers will provide the joulemeter(s) for the duration of the event. A security deposit may be required for the joulemeter.
- k) Joulemeter(s) must be positioned so that the display can be easily read from outside the vehicle.
- l) The joulemeter(s) must be inaccessible to the Driver in his or her normal driving position.
- m) All electrical circuits must be protected as defined in Article 57:e).
- n) 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.
- o) At the finish line, Fuel Marshals will read the joulemeter(s) display.

- p) All 'Battery Electric' vehicles which complete a successful run will be classified in descending order of fuel economy, expressed in km/kWh.

Article 68: **NOT USED**

Article 69: **NOT USED**

## 5. AWARDS AND PRIZES

### 5A – ON TRACK AWARDS

#### Article 70: AWARD OVERVIEW AND PRIZES

All on-track prizes and trophies below are awarded twice, once for Prototype and once for UrbanConcept vehicles.

	Americas Asia	Europe	Comment
<b>Shell FuelSave Gasoline Winner</b>	<b>\$ 2,000</b>	<b>€ 1,500</b>	<b>Prize Money, Trophy, on-stage Winners Ceremony</b>
Shell FuelSave Gasoline Runner-up	\$ 1,000	€ 750	Prize Money, Certificate-in-mail
Shell FuelSave Gasoline 3rd place	\$ 500	€ 375	Prize Money, Certificate-in-mail
<b>Shell FuelSave Diesel Winner</b>	<b>\$ 2,000</b>	<b>€ 1,500</b>	<b>Prize Money, Trophy, on-stage Winners Ceremony</b>
Shell FuelSave Diesel Runner-up	\$ 1,000	€ 750	Prize Money, Certificate-in-mail
Shell FuelSave Diesel 3rd place	\$ 500	€ 375	Prize Money, Certificate-in-mail
<b>Alternative Fuel Winner (E100+GtL)</b>	<b>\$ 2,000</b>	<b>€ 1,500</b>	<b>Prize Money, Trophy, on-stage Winners Ceremony</b>
Alternative Fuel Runner-up	\$ 1,000	€ 750	E100 or GtL ; Prize Money, Certificate-in-mail
Alternative Fuel 3rd place	\$ 500	€ 375	E100 or GtL ; Prize Money, Certificate-in-mail
<b>Battery-electric Winner</b>	<b>\$ 2,000</b>	<b>€ 1,500</b>	<b>Prize Money, Trophy, on-stage Winners Ceremony</b>
Battery-electric Runner-up	\$ 1,000	€ 750	Prize Money, Certificate-in-mail
Battery-electric 3rd place	\$ 500	€ 375	Prize Money, Certificate-in-mail
<b>Hydrogen Fuel Cell Winner</b>	<b>\$ 2,000</b>	<b>€ 1,500</b>	<b>Prize Money, Trophy, on-stage Winners Ceremony</b>
Hydrogen Fuel Cell Runner-up	\$ 1,000	€ 750	Prize Money, Certificate-in-mail
Hydrogen Fuel Cell 3rd place	\$ 500	€ 375	Prize Money, Certificate-in-mail

## 5B – OFF TRACK AWARDS

Participating teams may choose to apply for a maximum of two off-track awards; or for three if one application is for the Safety Award.

Applications for off-track awards must be relevant for and related to the work carried out for the Shell Eco-marathon project. Previous award winners cannot re-apply on the basis of the same vehicle design, innovation, tribology concept, communications or safety campaign. Their submission must be clearly different from their previous winning submission.

Please refer to the specific Chapter II of the Shell Eco-marathon Rules of your region for further application requirements, such as submission deadlines, submission standards, specific forms to be used, Terms and Conditions and other relevant information.

For all awards the juries will make their first selection based on the submission received prior to an event. All teams shortlisted for an award may then receive a visit by the judges at the event and are required to make a team member available to them at their request. The judges may ask further questions, wish to see particular evidence or discuss the submission in more detail to test knowledge.

Teams cannot apply for the 'Perseverance & Spirit of the Event' Award.

### Article 71: AWARD OVERVIEW AND PRIZES

Winner	Americas Asia	Europe
Communications Award	\$ 2,000	€ 1,500
Shell Helix Tribology Award	\$ 2,000	€ 1,500
Vehicle Design Award	\$ 2,000	€ 1,500
Technical Innovation Award	\$ 2,000	€ 1,500
Safety Award	\$ 2,000	€ 1,500
Perseverance & Spirit of the Event Award	\$ 2,000	€ 1,500

### Article 72: COMMUNICATIONS AWARD

a) Objective

To run the most impactful communications campaign for the benefit of the team, in which teams demonstrate their understanding of the energy future, the role the Shell Eco-marathon plays within this, and how students are the innovators of future energy and mobility solutions.

b) Overview

Participating teams are required to develop, run and evaluate a creative communications campaign under the headline "The Shell Eco-marathon and its relevance for future energy and mobility solutions".

Team are encouraged to consider all available media channels for their campaign and chose the most effective one(s), such as press, radio, TV, YouTube, social media, events, blogs, etc.



The Winner will be judged to equal shares by the quality of the campaign content, by the creativity of the campaign and by the impact (reach) of their communication campaign (i.e. Media impressions, YouTube views, Facebook likes, event attendance, etc).

The communication campaign must be launched, run and completed prior to the submission deadline for this award. Please refer to Chapter II of these Rules for further information and requirements.

In order to be eligible for this Award the winning team must have successfully passed technical inspection.

c) **How to participate**

Participation in this competition is voluntary. Teams interested in winning the Communications Award must submit an application. This application shall consist of three parts submitted to the Organisers by the deadline, containing:

- i. Communications Plan – A .pdf document containing no more than 500 words explaining the idea, objectives, strategy and timeline of the Communications Campaign.
- ii. Implementation Summary – A .pdf document containing no more than 1500 words explaining all content elements of the Communications Campaign, the methods and techniques employed and the media used for activation.
- iii. Impact Analysis – A .pdf document containing no more than 250 words evaluating the success of the Communications Campaign compared with the objectives plus copies of any campaign activity, such as:
  1. Radio and TV clips
  2. YouTube videos
  3. Newspaper cuttings & relevant circulation numbers
  4. Event photographs, footage, posters, etc.
  5. Facebook activity report and likes
  6. Websites, blog threads, social media activities

**Article 73: SHELL HELIX TRIBOLOGY AWARD**

a) **Objective**

This award aims to encourage competing teams to study possible fuel efficiency gains through the use of lubricants as part of their Shell Eco-marathon vehicle. It is a platform for students to apply a tribology lens to manage friction in all parts of their vehicle and to further improve their on-track performance.

b) **Overview**

Teams will be required to describe and demonstrate which actions, experiments or simulations were performed to improve the fuel efficiency of their vehicle by using lubrication principles. Teams shortlisted for the Award will be required to present their submission to the Jury at the event and be interviewed to further clarify their report's findings.

In order to be eligible for this Award the winning team must have at least one valid competition attempt, i.e. the team must have a result on the score board.

The judging criteria for this award are as follows:

- i. Quantifying the impact of lubrication on vehicle performance
  - ii. Modification of engineering designs as result of understanding tribological impacts
  - iii. Application of computer modelling and/or calculations to determine engine/vehicle friction
  - iv. Maximising fuel economy credit for all potentially lubricated components
  - v. Consideration of lubricant selection and design
  - vi. Demonstration of understanding of concept design limits
  - vii. Consideration of Health Safety and Environment (HSE) implications of lubricant choice
- c) How to participate

Application for this award is voluntary. Teams interested in winning the Shell Helix Tribology Award must submit an application in .pdf format which is not to exceed 1500 words with diagrams & appendices as appropriate. Please refer to Chapter II of these Rules for further information and requirements.

#### Article 74: **VEHICLE DESIGN AWARD**

a) **Objective**

This prize recognises innovative design research and execution and will be awarded to the team, which presents the most original and coherent vehicle in terms of ergonomics, aesthetics, choice of materials, technical feasibility and eco-friendliness. Each of these five criteria will be weighted equally in the Jury's decision.

b) **Overview**

Teams are required to describe their design approach, the basis for their research, factors which make this design special and issues and solutions encountered during the vehicle production process. Photographs, drawings and / or animations must be included to illustrate the process. Teams shortlisted for the Award will be visited by the Jury during the event to answer further question and present their vehicle.

In order to be eligible for this Award the winning team must have at least one valid competition attempt, i.e. the team must have a result on the score board.

c) **How to participate**

Application for this award is voluntary. Teams interested in winning the Vehicle Design Award must submit an application in .pdf format which is not to exceed 1,500 words plus photographs, drawings or animations. Please refer to Chapter II of these Rules for further information and requirements.

#### Article 75: **TECHNICAL INNOVATION AWARD**

a) **Objective**

This award is presented to the Team which demonstrates outstanding technical ingenuity along

with optimal use of new materials, components and inventions in their drive train, chassis, body, instrumentation and tyres.

b) **Overview**

Teams will be required to explain their innovative concept, it's features, it's benefits, how it relates to the Shell Eco-marathon competition and the potential it has for 'real world' application. Teams are strongly encouraged to consider all intellectual property developed in conjunction with the Shell Eco-marathon programme as valuable assets and seek professional advice about its protections through patents or trademarks before publishing.

In order to be eligible for this Award the winning team must have at least one valid competition attempt, i.e. the team must have a result on the score board.

c) **How to participate**

Application for this award is voluntary. Teams interested in winning the Technical Innovation Award must submit an application in .pdf format which is not to exceed 1,500 words plus photographs, drawings or animations as applicable. Please refer to Chapter II of these Rules for further information and requirements.

## Article 76: **SAFETY AWARD**

a) **Objective**

This award aims to highlight the importance of structural, process and behavioural safety in the Shell eco-marathon programme and encourages all participating teams to actively consider and implement safe practices in their daily work. It challenges all team to review established practices, inspect tools and equipment as well review their procedures in order to implement changes which lead to higher safety standards.

b) **Overview**

In order to win the award, the team must demonstrate excellent understanding of safe design concepts and the application to their car and the manufacturing process. Furthermore, the winning team must be able to demonstrate safe working practices as well as an overall proactive approach to their own and other people's safety at the event. In their submission the team will also explain which changes they have implemented to achieve higher standards of safety.

In order to be eligible for this Award the winning team must have successfully passed technical inspection.

c) **How to participate**

Application for this award is voluntary. Teams interested in winning the Safety Award must submit an application in .pdf format which is not to exceed 1,500 words plus supporting photographs, documents, drawings or animations as applicable. Please refer to Chapter II of these Rules for further information and requirements.

## Article 77: **PERSEVERANCE AND SPIRIT OF THE EVENT AWARD**

This Award is presented to the Team which, in the opinion of the Organisers, symbolises best the spirit and values of this event through their actions, which can involve, but are not restricted to:

- Overcoming great obstacles in order to attend the Shell Eco-marathon,

- Mastering exceptional challenges while participating in the Shell Eco-marathon,
- Supporting other participants to help them overcoming significant challenges or obstacles,
- Keeping high spirits, showing outstanding resilience, resolve and resourcefulness.

Teams cannot apply for this award.