




# SHELL ECO-MARATHON

## 2020 OFFICIAL RULES

## CHAPTER I

Shell Eco-marathon

# FOREWORD

Dear Shell Eco-marathon Participants,

Welcome to the 2020 competition season! This year we are celebrating the 35th anniversary of Shell Eco-marathon as a formal competition! For those of you who are new, Shell Eco-marathon is a unique global programme where students design, build, and drive ultra-energy-efficient cars. As students around the world collaborate to find innovative solutions to improve energy efficiency, this reflects Shell's broader purpose and commitment to power progress together with more and cleaner energy solutions.

Within Shell Eco-marathon, there are two vehicle classes: Prototype and Urban Concept, and three energy categories: internal combustion engine, battery-electric, and hydrogen fuel cell. Each team competes for an on-track award by their vehicle class and category, and we also encourage each team to apply for multiple off-track awards. In addition to the traditional Shell Eco-marathon competitions, we are working with Southwest Research Institute to develop a new Autonomous competition.

In 2020, Shell Eco-marathon Asia will remain in Malaysia, Shell Eco-marathon Americas will remain in California, and Shell Eco-marathon Europe will remain in London. The Drivers' World Championship will once again provide an opportunity for Urban Concept teams, who achieve maximum energy efficiency with their cars, to match this with the speed, skill and strategy of the driver in a race. There will also be at least three Shell Eco-marathon Challenger events, including events in Brazil, South Africa, and China.

Safety is our top priority at Shell and within the Shell Eco-marathon programme. Please read the Shell Eco-marathon Official Rules carefully and arrive with your vehicle fully built and ready for the competition. If you need help understanding the rules, please watch the Shell Eco-marathon Tech Tips videos, comment on the Shell Eco-marathon Facebook page, participate in our regional webcasts, or send us an email. We want to hear your feedback. I look forward to celebrating the 2020 season with you!

Kind regards,

Shanna Simmons
Shell Eco-marathon Global Technical Director

TECH TIPS TEAM PREPARATION

# TABLE OF CONTENTS

# 1. ORGANISATION

## ABOUT THE RULES

### TECH TIPS OVERVIEW

a) The rules for Shell Eco-marathon 2020 events can be downloaded from the Shell Eco-marathon website. They comprise of:

   i. Chapter I – the Shell Eco-marathon 2020 Official Rules (referred to as "Official Rules" in this document).

   ii. Chapter II – Rules of the specific location where Shell Eco-marathon takes place.

   iii. Chapter III – Specific rules for the Shell Eco-marathon Drivers' World Championship, which is for Urban Concept cars only.

   iv. Chapter IV – Rules for the Autonomous competition.

b) It is the responsibility of participating teams to read and understand the Official Rules. To highlight rule changes and aid the understanding of frequently misunderstood rules:

   i. **Red text** indicates a change, addition, or amendment to the previous year's Official Rules.

   ii. *Italic text* is explanation of a rule for better understanding.

c) Links are used throughout this document for navigation.

d) Tech Tips videos have been developed to explain specific rules and illustrate acceptable solutions. Links to these videos will be available from the Shell Eco-marathon participant's webpage.

e) 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 region stated 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 a single focal point for his/her team for the Organisers.

   v. 'Faculty Advisor' – a professional staff member of the educational institute which the Team represents.

   vi. 'Race Director' – person appointed by the Organisers, who is responsible for managing and sanctioning all on-track activities.

   vii. 'Track Marshal' – person appointed by the Race Director to act on his/her behalf, to ensure on-track safety and observe on-track rule compliance.

   viii. 'Technical Director' – person appointed by the Organisers, who is responsible for managing and ensuring the technical standards and integrity of the Shell Eco-marathon competition.

f) Any decision by the Organisers is final, independent of whether it is explicitly identified in Chapter I or not.

## ARTICLE 1: ACCEPTANCE

a) Applications to enter the competition must be made via online registration on the Shell Eco-marathon website. The Organisers will review all applications and will select Teams based on the quality of their proposed entry and historical successes from previous Shell Eco-marathon events. The criteria for the historical successes will include achieving valid runs, completing technical inspection, and demonstrating a readiness to compete upon arrival to the event. In addition, the Organisers reserve the right to invite Teams who represent the spirit of this competition.

b) By fact of their entry, Participants accept all provisions of the Official Rules and agree to abide by all decisions made by the Organisers. The Organisers reserve the right to add, modify or delete any article of the Official Rules. In such an event, the Teams will be notified. The Organisers are solely empowered to pronounce in cases not provided for in the 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 throughout the event. By entering 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 photos, 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) Shell Eco-marathon is an academic educational programme. All Teams wishing to enter must be affiliated with an educational institution and their participation must be endorsed by it. Educational Institutions eligible for Shell Eco-marathon participation are universities, colleges and secondary schools preparing students for higher education degrees, vocational training certificates, professional certificates or official second-level school-leaving examinations. **Participants must be at least 16 years of age on the first day of the competition, however 14 and 15-year olds may be allowed if appropriate safety and supervision plans are agreed with the Organiser.**

b) For each entry, a Team Manager, a Driver and a Faculty Advisor must be designated. A Reserve Driver may also be designated.

c) The Team Manager must be a student member of the team currently enrolled at the institution. In case all Participants are legal minors, the Faculty Advisor must act as Team Manager.

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

e) 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.

f) The eligibility criteria for Drivers are detailed in the relevant section of Chapter II. The Driver and Reserve Driver must be students of the educational institution in question. The Driver and the Reserve Driver for one vehicle cannot be the Driver or Reserve Driver for another vehicle. Both must be able to speak and understand English. Both the Driver and the Reserve Driver must be at least 16 years old.

g) 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.

h) Teams are permitted to select names that are appropriate to their research, their school, and Shell Eco-marathon. Names that are offensive or disrespectful to others who may be participating will not be allowed. The Organisers reserve the right to require teams to change their name.


## TEAM PREPARATION

### 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 a vehicle enters the track, the vehicle body must be in place and bear all the competition numbers, sponsor stickers and Shell logos required by the Official Rules. Organisers will supply these numbers and logos.

### ARTICLE 4: IDENTIFICATION

a) Logos, official sponsor stickers and racing numbers must be fixed to the vehicle body in accordance with the diagram provided (see Appendix 1: such that they can be clearly read during any public presentation, in promotional films and on all photographs.

b) Under no circumstances may the Shell logos, the sponsor stickers 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, 200 x 215 mm.

   ii. For each side and for the front of the vehicle: racing numbers, 200 x 260 mm.

   iii. For each side, on the lower part of the body: a sponsor sticker, 770 x 800 mm.

c) A mandatory 100 mm space must be left free on all four sides of the Shell logo, and it should be placed with the base parallel to the ground (not at an angle).

d) Any other sponsor names/logos must be smaller than the Shell logo. Each sponsor sticker must fit within a maximum area of 400 $cm^2$ (empty space included).

e) The trademarks or logos of tobacco companies and alcoholic drinks producers are prohibited. Trademarks and logos of other energy companies and direct competitors to event sponsors require the prior written approval of the Organisers. This rule applies to all vehicles and all Participants' apparel.

f) In the event of a breach of this rule, the Organisers reserve the right to remove any sponsor logos.

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

### ARTICLE 5: COMPLIANCE

a) Only vehicles that comply with the present Official Rules can 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 Official Rules.

b) The Organisers reserve the right to rescind vehicle approval upon further or more detailed evaluation. 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 all technical rules will not be allowed to compete. However, they 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. 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 and safety rules will result in the penalties in Article 109:d). Notwithstanding this, the Organisers reserve the right to make decisions on a case by case basis depending on the severity of the breach.

b) The Organisers may exclude, disqualify or penalise any Participant who has cheated, gained an unfair advantage due to any breach of the Official Rules, hindrance of other Participants, departure from the normal course, or any act or omission capable of misrepresenting performance, especially regarding energy consumption or method of propulsion.

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

d) The following general penalties apply:

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 case of dangerous conditions, 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 regarding 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.

e) Electrical safety in the paddocks is an especially important topic in Shell Eco-marathon events. Teams must read and comply with the safety concerns in Article 24: and Article 57: and their regional Chapter II Rules.

# 2A – 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: Drivers must **use** smooth, safe driving techniques **for example** thinking ahead, avoiding sudden directional changes, and being fully aware of vehicles around them.

d) Drivers must have a minimum of two hours of driving experience with their vehicle. Drivers will be asked various questions to verify their skill level:

1. **Do you have prior experience driving in a Shell Eco-marathon competition?**
2. **Do you have prior experience driving in a similar mileage competition?**
3. **Do you have a minimum of 2 hours driving experience in your team vehicle?**
4. **Have both drivers driven the current vehicle?**

***Drivers may be required, in the discretion of the Technical Director, to verify their skill level on a test track as part of passing Technical Inspection.***

## ARTICLE 11: DRIVING UNDER THE INFLUENCE OF ALCOHOL/ILLEGAL SUBSTANCES

a) Driving under the influence of alcohol or illegal substances is forbidden. This applies to all Drivers, Reserve Drivers, and Participants.

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

c) Any breach will be penalised in line with Article 8: and the following additional penalties:

   i. Any alcohol or substance related breach of the rules will be treated at least as a '2nd infraction' of the Team, even if no prior violation has occurred.

   ii. In addition, the affected Driver is immediately banned from track access if 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 and Reserve 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

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 on both, the test track and the competition track, 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 survey the track 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 if 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, provided 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 Urban Concept vehicles, or is needed to prevent a safety incident.

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 Track Marshals 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 Marshals 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) Any breaches and any unsafe or unfair behaviour brought to the attention of the Organisers could result in a penalty.

## 2B – DRIVER AND EQUIPMENT

### ARTICLE 20: DRIVER WEIGHT

a) The minimum Driver Weight is:

- Prototype vehicles – 50.0 kg
- Urban Concept vehicles – 70.0 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, in form of weightlifting discs or rectangular metal plates. No other form of ballast is permitted. The ballast must be effectively secured to the vehicle **outside the driver compartment** to ensure Driver safety in the event of collision or roll-over. A seal will be installed around the ballast by a technical inspector and must remain in place during the event. If the seal has been tampered with or removed the vehicle will no longer be valid to compete.

c) If a team has two drivers and one or both drivers are underweight, the ballast weight will be based on the lightest driver.

d) 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 full-face or three-quarter helmets suitable for motorsport activities. Helmet certification labels must be clearly readable. Helmets worn by all Drivers will be subject to inspection. Helmets should not have any indentations or cracks and should be in proper working condition as intended by the helmet manufacturer.

b) All helmets must be affixed with a face shield (or visor). The face shield (or visor) must cover from the top of the face down to below the driver's nose. Tinted face shields or sunglasses to be worn under the face shield are permitted. The helmets must correctly fit the Driver and be secured by a chin strap. Visors should be free from major scratches and have clear visibility.

### ARTICLE 22: DRIVER CLOTHING

a) All Drivers must wear a one-piece racing suit as the outermost layer of clothing, and the racing suit must be classified as Flame Retardant Clothing (FRC) **according to a recognised standard**. Drivers are not allowed to wear synthetic clothing underneath the race suit because synthetic material may melt if exposed to flames.

*Cotton shirt and underwear are recommended.*

b) Socks (made from cotton or FRC material) and shoes are required.

c) Fire retardant gloves are required and must completely cover all fingers.

d) **If Drivers wear balaclavas, they are required to be made from FRC material.**

e) No bare skin should be visible when the Driver is wearing the racing suit, gloves, socks, shoes and helmet.

### ARTICLE 23: DRIVER COMFORT

Please note that in the event of hot weather conditions, high temperatures may affect Driver comfort and potentially cause 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.

*Camel-back style or bottles secured inside the driver's compartment with flexible feed straw are recommended.*

c) It is recommended to equip the vehicle with an effective shield from the sun.

d) For driver comfort, teams can install fans or air-cooling type systems that are not included in the electrical measurement of the vehicle. **Any fans or air-cooling systems must be self-powered by internal batteries.**

## 2C – GENERAL SAFETY

### ARTICLE 24: EQUIPMENT AND MATERIALS

Teams are required to provide and use at the event:

a) Leather or canvas gloves for general work

b) Chemical resistant gloves for fuel or motor oil handling

c) Safety glasses for all Participants

d) Hearing protection for all Participants

e) Duct tape to secure cords or cables lying on the pit floor

f) Lift stands or appropriate raised platform for vehicle tuning and repairs

g) Tools and materials

h) Effective equipment suitable to mitigate and/or control Lithium-based battery fires must be used during battery charging. The equipment must prevent or contain the spread of fire or battery even during charging. Equipment that may be used includes:

   i. A battery charging bag that is designed specifically for containment of a Lithium battery fire, or

   ii. A fireproof blanket that can be placed over AND under the lithium battery being charged. The blanket must be **big enough** to fully cover and contain any potential **battery fire**.

i) Vehicle Crates and Transportation


SHIPPING

   i. Participants are required to seek early guidance regarding shipment of any Dangerous Goods material from a commercial freight company to obtain the latest shipping legislation.

      *Dangerous Goods include, but are not limited to: flammable liquids, batteries, and pressurized containers (e.g. fire extinguishers).*

      *Commercial transportation regulations have increased significantly in recent years. Teams need to understand the ramifications for non-compliance.* ***Individual teams are responsible for commercial shipments****.*

      *Shipments made by air freight are the most stringent compared to road freight.*

   ii. Dangerous Goods shipping and packing information is available on the Shell Eco-marathon website, including mandatory declaration form(s), and Shipper contact information for each region.

j) Electrical safety

   i. All electrical equipment used must be properly fused.

   ii. Electrical cables must be in good condition and appropriate for the equipment it is intended for.

   iii. **Teams are only allowed to use a single multi-plug strip with internal overcurrent protection.**

## 2D – ATTENTION

Review all sections of the Official Rules as they contain further safety matters specific to each topic.

# 3. VEHICLE DESIGN

TECH TIPS VEHICLE DESIGN

## 3A – GENERAL

### ARTICLE 25: VEHICLE DESIGN

a) During vehicle design, construction and competition planning, participating teams must pay attention to all aspects of safety, including the safety of the driver, participants, volunteers and spectators.

   i. Prototype vehicles must have three or four running wheels that are in constant contact with the road.

   ii. Prototype vehicles must have a minimum crumple zone of 100 mm between the front of the vehicle body and the driver's feet.

   iii. Urban Concept vehicles must have exactly four wheels that are in constant contact with the road.

b) Aerodynamic appendages, which adjust or are prone to changing shape due to wind, are not allowed.

c) Vehicle bodies must not include any external appendages that might be dangerous to participants; this includes pointed parts of the vehicle body. Sharp points must have a radius of 50 mm or greater or covered with foam or a deformable material.

d) Vehicle body panels and windows must be rigid and may not change shape due to wind.

e) The vehicle interior must not contain any objects that might injure the Driver in the event of a collision.

   Windows must not shatter into sharp shards. Protective film covering the windows is allowed but must not distort the driver's visibility.

f) The energy compartment (engine/motor/transmission/battery, etc.) should be easy to access for quick inspection.

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. Bungee cords or other elastic material are not permitted for securing heavy objects.

i) All vehicles must have a solid floor and frame that prevent any part of the driver's body from contacting the ground.

j) All vehicles must be fully covered. Open top vehicles are not allowed. Vehicles that look like bicycles, tricycles or wheelchairs are not acceptable.

k) The Organisers will provide all Urban Concept vehicles with a telemetry System and require them to install in their vehicle for competition monitoring and result calculation (see Section 5).

l) **The use of asbestos and asbestos-containing materials is forbidden.**

### ARTICLE 26: CHASSIS/MONOCOQUE SOLIDITY

a) Teams must ensure that the vehicle chassis or monocoque will safely protect the driver's body, including crumple space in the event of a front, side, or rollover collision.

*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 50 mm 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.*


### ROLL BAR & SAFETY BELTS

c) The roll bar must extend in width beyond the driver's shoulders when seated in normal driving position with the safety belts fastened.

*Teams may use a tubular or panel roll bar. If a tubular roll bar is used, it must be metal. A panel roll bar is the rigid partition separating the cockpit from the energy compartment, and it must be integrated into the vehicle chassis or monocoque.*

d) The roll bar must be able to withstand a static load of 700 N (~ 70 kg) applied in a vertical, horizontal, and/or perpendicular direction, without deforming in any direction.

e) If the vehicle must be lifted at a specific place on its body, it should be clearly marked with a rectangular box stating, "LIFT HERE".

## ARTICLE 27: PROPULSION AND ENERGY STORAGE SYSTEM ISOLATION

a) A rigid Bulkhead must safely isolate and seal the vehicle's propulsion and energy storage systems from the driver's compartment.

*A bulkhead is an upright partition separating the driver's compartment from the energy compartment. This means engines, fuel cells, fuel tanks, batteries (propulsion or accessary), hydrogen cylinders, supercapacitors, etc. must be placed outside the driver's compartment behind the bulkhead. The purpose of this bulkhead is that in the event of a fuel leak, fire or battery release incident, it prevents liquids and/or flames from reaching the driver. Avoid having any gaps or holes between the body and the bulkhead. It is recommended to seal gaps with materials such as metal/aluminium sheeting or aluminium tape.*

b) The bulkhead must be able to protect the driver from an open flame in the energy compartment.

c) The bulkhead must prevent manual access to the energy compartment by the Driver.

d) If holes are made in the bulkhead to pass through wires or cables it is essential that the wires and cables are protected by a grommet or similar protective material to prevent chafing or damage. All gaps and holes must 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. The Driver's field of vision must be achieved without aid of any optical or electronic devices. Movement of the Driver's head within the confines of the vehicle body to achieve a complete arc of vision is allowed, but the driver's helmet must always be 50 mm below the roll bar. **The side windows tinting must be light enough to allow the driver to be seen from outside the vehicle.**

b) The vehicle must be equipped with a rear-view mirror on each side of the vehicle, each with a minimum surface area of 2500 $mm^2$ (e.g. 50 mm x 50 mm). An electronic device may not replace a rear-view mirror.

c) For Urban Concept vehicles wet weather visibility is also mandatory (see Article 52:).

## ARTICLE 29: SAFETY BELTS

### TECH TIPS ROLL BAR & SAFETY BELTS

a) The Driver's seat must be fitted with an effective safety harness with 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.

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 adjustor must be located as close as possible to the connection point. The crotch strap mounting point must be underneath the body, and the topmost straps should be mounted 0° to 10° below the top of the Driver's shoulder.

c) The safety harness must always be worn tight and fastened to prevent the Driver from having free movement when the vehicle is in motion.

d) Each safety harness mounting point must able to withstand a 200 N force in any direction.

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 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) **The driver compartment must have a single opening mechanism, which must be easily and intuitively operable from both inside and outside the vehicle.** The method of opening from the outside must be clearly marked by a red arrow and must not require any tools.

d) It is forbidden to use adhesive tape to close the Driver's opening from the outside.

## ARTICLE 31: HORN

a) Each vehicle must be equipped with an electrically powered horn typically used in current automobiles. Bike or cycling horns are no longer permitted.

b) The horn must be mounted at the front of the vehicle without obstruction.

c) The horn must emit sound greater than 85 dBA when measured 4 meters in front of the operating vehicle. The horn must produce a continuous single tone sound when activated – chirping or siren-like tones are not permitted.

d) The horn must be powered by the vehicle battery. However, the power consumed by the horn does not need to be measured by the Joulemeter (See Article 56:iv).

## ARTICLE 32: NOT USED

## ARTICLE 33: DRIVER POSITION

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

## ARTICLE 34: CLUTCH AND TRANSMISSION

a) All vehicle propulsion must be achieved only through the friction between the wheels and the road.

b) All vehicles with internal combustion engines must be equipped with a clutch system.

c) For centrifugal/automatic clutches the starter motor speed must always be below the engagement speed of the clutch.

d) Only Urban Concept ICE vehicles are required to have 'idling capabilities. This means the vehicle must be able to remain stationary while the engine is running.

e) For manual clutches the starter motor must not be operable with the clutch engaged. An interlock is required to facilitate this functionality.

f) Please refer to Article 109:b) regarding starter motor requirements.

g) Guards for transmission chains and/or belts are 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 or the side of the vehicle body.

c) Exhaust pipes must be solid with no signs of fatigue or leaks.

d) Exhaust pipes must be appropriate for high temperatures.

## ARTICLE 36: ENVIRONMENTAL CONSIDERATIONS

All vehicles are expected to comply with reasonable environmental conditions including smoke, odour, and sound level emitted.

## ARTICLE 37: EMERGENCY SHUT-DOWN


EMERGENCY SHUTDOWN

a) 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.

b) Spark ignition engines (gasoline, ethanol) will require the emergency shutdown mechanism to shut down the ignition. It is not necessary to isolate the accessory battery.

c) Compression ignition engines (diesel) will require the emergency shutdown mechanism to shut off the fuel or air flow. It is not necessary to isolate the accessory battery.

d) For Battery Electric vehicles the emergency shutdown mechanism must provide a physical isolation of the propulsion battery from the vehicle electrical system. The use of a power controller or other logic systems to drive an isolation device is not permitted. **If relays are used, the relays must be a normally open contact type**.

*Care should be taken to ensure that the relay coil power is also removed when the relay coil is open. This may be achieved by **using** a latching circuit*

e) For Hydrogen vehicles see Article 109:e).

f) There must be both an internal and an external shutdown mechanism.

   i. The internal emergency shutdown mechanism is for driver operation and may 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 standard sticker (Blue triangle with red electrical arc) provided by the Organiser must be positioned on the vehicle body to indicate clearly the exterior position of the emergency shutdown actuator.

g) The external emergency shutdown mechanism must be achieved by means of a latching red push button, which can only be re-activated by rotating it. Push/pull levers are not accepted.

h) In addition to the above devices, all vehicles must be equipped with a "dead man's safety device" or sometimes referred to as "operator presence control." The purpose for this device is to ensure that in case the driver becomes incapacitated the vehicle's propulsion power is automatically disengaged (returns to an idle condition). This device may consist of a spring-loaded hand operated accelerator or foot pedal lever. An electric dead man switch is permissible if the switch is located on the steering wheel. If an electric dead-man switch is used the driver must directly (for example by thumb or index finger) engage the switch continuously while driving.

   i. This device is a separate switch from the required "emergency shut-down" mechanisms identified in 37.

   ii. If an ICE Prototype vehicle is designed with a WOT (wide open throttle) operation of the dead-man switch must switch off the ignition system.

### ARTICLE 38: ADDITIONAL INSPECTIONS

a) After passing technical inspection, any alternation 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 CLASS

### ARTICLE 39: DIMENSIONS

a) The vehicle maximum height must be less than 1000 mm.

b) The vehicle track width must be at least 500 mm, measured between the midpoints where the tyres of the outermost wheels touch the ground.

c) The ratio of height divided by track width must be less than 1.25.

d) The vehicle wheelbase must be at least 1000 mm.

e) The maximum total vehicle width must not exceed 1300 mm.

f) The maximum total length must not exceed 3500 mm.

g) The maximum vehicle weight, without the Driver is 140 kg.

h) None of the body dimensions above must be achieved by design singularities such as 'stuck-on' appendages or cut-outs.

## ARTICLE 40: NOT USED

## ARTICLE 41: TYRES, WHEELS, AXLES AND WHEEL HUBS

a) All types of tyres and wheels are allowed.

b) Any type of wheel rim may be used. Rims must be compatible with the dimensions of the selected tires to satisfy safety standards.

*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 wheelchairs) 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 and must not **touch** the chassis or body.

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 the wheels will **touch** other parts of the vehicle (i.e. cables, wires, hoses, and energy 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) Only front wheel steering is permitted. 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.

b) The turning radius must be 8 m or less. 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 8 m radius in both directions. The steering system must be designed to prevent any contact between tyre and body or chassis.

c) Electrically operated indirect steering systems are permitted providing they are operated by a steering wheel or similar (rotary potentiometer), joystick operation is not permitted. If electronic steering systems are used, in the event of system failure, the vehicle must be equipped with manual steering override.

d) The Organisers reserve the right to set up a vehicle handling course to verify the following when the vehicle is in motion: driver skills, turning radius and steering precision. For example, the Organisers will verify that steering is precise, with no play.

## ARTICLE 43: BRAKING

BRAKING

a) **Vehicles must have two hydraulic braking systems, one per axle. Brakes that act on the tyres are not permitted.**

i. **The front brake(s) must have a single foot operated pedal controlling front wheel(s).**

ii. **The rear brake(s) must have a single lever action attached to the steering wheel or a single pedal.**

iii. **For each axle, a maximum of two master cylinders is allowed, but they must act on single hydraulic circuit to ensure a proper balance between right and left wheel. One master cylinder per wheel is not allowed.**

iv. It must be possible to activate the two brake systems at the same time without taking either hand off the steering system.

b) The effectiveness of the braking systems will be tested during vehicle inspection. The vehicle will be placed on a 20 percent incline with the driver inside. Each brake system will be activated separately, and each individual brake system must keep the vehicle immobile.

c) During practice or competition runs, the brakes must be protected against any adjustments made by the driver. The effectiveness of the protection will be evaluated during technical inspection and rechecked before entering the track. In addition, vehicles will be checked at the start and/or finish area. Any system that has been compromised will invalidate that run and a penalty may be issued by the Organisers.

## 3C – URBAN CONCEPT CLASS

### ARTICLE 44: DEFINITION

The Urban Concept class offers an opportunity to design and build energy efficient vehicles that are closer in appearance to modern passenger cars. Urban Concept vehicles must comply with the specific Shell Eco-marathon rules for this vehicle class. Vehicles competing in this class will focus on "stop and go" driving.

During practice and competition driving at Shell Eco-marathon events, only the Driver is allowed inside Urban Concept vehicles, regardless of the number of seats installed.

### ARTICLE 45: DIMENSIONS

a) The total vehicle height must be between 1000 mm and 1300 mm.

b) The total vehicle width, excluding rear view mirrors, must be between 1200 mm and 1300 mm.

c) The total vehicle length must be between 2200 mm and 3500 mm.

d) The track width must be at least 1000 mm for the front axle and 800 mm for the rear axle, measured between the midpoints where the tyres touch the ground.

e) The wheelbase must be at least 1200 mm.

f) The Driver's compartment must have a minimum height of 880 mm and a minimum width of 700 mm at the Driver's shoulders.

g) The **vehicle body and chassis** ground clearance must be at least 100 mm with the driver (and necessary ballast) in the vehicle.

h) The maximum vehicle weight (excluding the Driver) is 225 kg.

i) All vehicle dimensions must not be achieved by body extensions such as 'stuck-on' appendages or cut-outs.

### ARTICLE 46: VEHICLE BODY

a) Teams must submit technical drawings, photographs or animations of their entire vehicle design to the Organisers for approval at their earliest opportunity.

b) The vehicle body must cover all mechanical parts when viewed from all sides. The wheels and suspension must be fully covered by the body when seen from above, and the wheels must be covered 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) Teams may NOT use commercially available vehicle body parts.

d) Driver access must be easy and practical, as found in common passenger cars. All Urban Concept vehicles must have two side doors. Each door opening must have a minimum dimension of 500 x 800 mm.

*This will be verified with a rectangular template of 500 x 800 mm with 50 mm radius corners*

e) Any access opening mechanisms must be firmly attached to the vehicle body by means of hinges or sliding rails. Adhesive tape, Velcro, or similar materials are not permitted for this purpose.

f) The vehicle must have a fixed roof covering the Driver's compartment.

g) A windscreen with effective wiper(s) is mandatory. Please refer to Article 109:b).

h) Space must be available for a rectangular rigid luggage 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 inspection and 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 50 mm or greater, alternatively they should be made of foam or similar deformable material.

j) A towing hook or ring is mandatory at the front of the vehicle. It can be rigid or flexible (cable or strap). If it is rigid, it must be placed fully under the body for safety reasons. Alternatively, it may be retractable or removable as in a regular car but should be easily accessible. It must be used to tow the vehicle in case of breakdown on the track. It must have a traction resistance equivalent to the weight of the vehicle and have an opening width of at least 30 mm.

## 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 play or delay. Steering must be operated predominately through the front wheels.

b) Steering must be achieved using a steering wheel or sections of a wheel with a minimum diameter of 250 mm.

c) Steering bars, tillers, joysticks, indirect or electric systems are not permitted.

d) The turning radius must be 6 m or less. 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. The steering system must be designed to prevent any contact between tyre and body or chassis.

e) The Organisers reserve the right to set up a vehicle handling course to verify the following when the vehicle is in motion: driver skills, turning radius and steering precision.

## ARTICLE 48: WHEELS

a) The rims must be between 15 to 17 inches in diameter.

b) The wheels located inside the vehicle body must be made inaccessible to the Driver by a bulkhead and must not come in contact with the chassis or body. 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

**It is mandatory to use flat profile tyres designed for small passenger cars or light trailers, not round or triangular profile tyres used for mopeds or motorbikes.** Tyres must fit the rims recommended by the manufacturer and have a minimum tread of 1.6 mm. The tyre/rim assembly must have a width **equal or greater than 80 mm**, measured from tire sidewall to tire 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.
- Tires that measure less than 80 mm will not be approved.

## 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 running lights

f) The centre of each headlight unit must be located at an equal distance and at least 300 mm from the centre-line of the vehicle.

g) The mandatory red indicator light for the self-starter operation must be separate from any of the above (see Article 109:c).

h) A Hazard light function must be included in the vehicle system.

## ARTICLE 51: BRAKING

BRAKING

a) The vehicle must be equipped with a four-disc hydraulic brake system, with a single brake pedal, which has a minimum surface area of 2500 mm². The brake pedal must operate the master cylinders either directly or through a rigid mechanical link. Wires/cables are not allowed. Commercially available brake systems (discs and callipers) with a minimum disc thickness of 3 mm are mandatory. Manufacturer's documentation is required to demonstrate authenticity. Bicycle brakes are not allowed.

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 it has a dual circuit. A maximum of two master cylinders is allowed.

d) The effectiveness of the brake system will be tested during vehicle inspection. 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 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 109:a).

## ARTICLE 52: WET WEATHER RUNNING

a) During weather conditions of light rain/drizzle, the Urban Concept vehicles (only) may be required to drive on the track during competition with approval from the Race Director. Therefore, all Urban Concept 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) It is required that the vehicle's electrical system be suitable for wet weather conditions to prevent malfunction.

g) The effectiveness of the vehicle to run in wet conditions will be evaluated during the initial inspection phase.

h) Tyres must have a minimum tread of 1.6 mm (see Article 49:).

i) The vehicle's brake effectiveness may be re-inspected before and/or after any run.

# 4. ENERGY SOURCES

## 4A – GENERAL

### ARTICLE 53: ENERGY TYPES

Vehicles may only use one of three energy categories listed below, which each have individual prize categories. (See Article 100.)

a) Internal Combustion Engine:

   i. Shell FuelSave Unleaded 95 (Europe and Asia)/Shell Nitrogen Enriched (US) Gasoline*

   ii. Shell FuelSave Diesel (Europe)/Shell Diesel (Asia and US)

   iii. Ethanol E100 (Denatured)

   ** 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.*

b) Battery-Electric

c) Hydrogen Fuel Cell

### ARTICLE 54: RESULTS CALCULATIONS

a) All live results displayed during the competition are provisional until verified and published by the Organisers after the completion of the event, usually within three days after the event.

b) For Prototype vehicles, the results will be calculated based on the propulsion energy consumed.

c) For Urban Concept vehicles, the results will be calculated based on the propulsion energy consumed PLUS the electrical energy consumed by the vehicle as measured by a joulemeter.

d) Results for the Internal Combustion Category will be expressed in kilometres per litre (km/l) or miles per gallon (mpg) depending on region (i.e. theoretical distance covered using energy of gasoline equivalent) corrected to a temperature of 15°C on a tank-to-wheel basis.

   i. Regardless of the fuel used, for the internal combustion category, the measurement will be determined from this equivalent consumption of 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, and the energy consumed from the battery as measured by the joulemeter, corrected to allow for the efficiency of the electricity production process. The inclusion of electrical energy consumed is only applicable for Urban Concept vehicles only. (See Article 109:b).

   ii. 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.

| ENERGY TYPE | NCV BY MASS (kJ/kg) |
|---|---|
| Shell FuelSave Unleaded 95 (Europe and Asia), Shell Nitrogen Enriched (US) Gasoline | 42,900 |
| Shell FuelSave Diesel (Europe), Shell Diesel (Asia and US) | 42,600 |
| Ethanol E100 | 26,900 |
| Hydrogen | 119,930 |

iii. Example: 1,000 km is covered with one litre of Shell FuelSave Diesel and the total electrical energy consumed is 200 kJ. Given that the general density values of diesel and gasoline are 0.83716 and 0.7646 kg/l @ 15°C respectively, and NCVs as per the table above, then the corresponding gasoline equivalent volumes consumed are:

*Diesel: 1 x 0.83716 x 42600 / (42900 x 0.7646) = 1.09 litres gasoline*
*Electricity: 200 / 0.25 / 0.75 / (42900 x 0.7646) = 0.03 litres gasoline*
*Nett = 1.09 + 0.03 = 1.12 litres gasoline*

*Where*

*0.25 = efficiency of the engine conversion process*

*0.75 = the efficiency of engine driven alternator generated electricity*

*The final fuel consumption result is thus:*
*Fuel consumption (km/L) -= 1000 / 1.12 = 892.9 km/litre gasoline equivalent at a reference temperature of 15°C*

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

e) Results for Battery Electric vehicles will be expressed in kilometres per kilowatt hour (km/kWh), or miles/kWh depending on region, and will be determined by using a joulemeter supplied by the Organisers.

f) Hydrogen Fuel Cell vehicles will use a flow meter to measure the $H_2$ consumed, and for Urban Concept vehicles, the energy consumed from the starter or accessory battery will be measured by the joulemeter. The results will be calculated using the NCV of $H_2$ listed above and expressed in km/$m^3$ hydrogen.

## ARTICLE 55: FUELS SUPPLY AND HANDLING

a) Only the fuels listed in Article 53: will be provided to the Participants by the Organisers during the event.

b) 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.

c) Participants handling fuel must wear safety glasses and chemically resistant gloves.

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

## ARTICLE 56: JOULEMETERS

a) Joulemeters will be installed on all Urban Concept, prototype battery electric, and selected Prototype ICE and hydrogen vehicles.

b) The Organisers will provide a joulemeter to selected teams at the event.

c) Joulemeters must be installed inside the engine compartment. Joulemeters mounted outside the vehicle are not allowed.

   i. For internal combustion vehicles, the joulemeter must be easy to read and reset.

      *Easy to read means someone standing outside the vehicle can easily read the screen of the joulemeter and have access to the on-off switch at the side of the of the joulemeter.*

   ii. For battery electric and hydrogen vehicles, the joulemeter must be positioned so that the display can be easily read and reset from outside the vehicle without the removal of any vehicle body components. It is acceptable to access the joulemeter from outside the vehicle though a hinged door.

d) Joulemeter placement in vehicle electrical circuit:

   i. For Urban Concept and non-battery electric Prototypes vehicles, the joulemeter must be installed between the battery and the vehicle electrical system.

      *For ICE vehicles, the starter motor cable must be connected after the joulemeter but before the main vehicle fuse. This placement is to insure the joulemeter measures the starter energy. The starter motor is not required to be fused.*

   ii. For Prototype battery electric vehicles, the joulemeter should be located between the vehicle electrical system and the motor controller.

   iii. For Urban Concept hydrogen vehicles without an accessory battery, the joulemeter must be installed between the external starter battery and the vehicle electrical system. (See Article 65:ii.)

   iv. The horn circuit may be powered by a separate circuit connected directly to the battery. (See d).)

      *This means the horn circuit does not need to pass through the joulemeter (if installed) and the horn energy will not be measured by the joulemeter*

e) The location and placement of the joulemeter will be verified during technical inspection.

## 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 or 60 Volts max. (This includes on-board batteries, external batteries, supercapacitors, fuel cell stack, etc.)

### TECH TIPS BATTERY SAFETY

b) For all energy types, only one vehicle battery is allowed.

   i. For ICE and hydrogen fuel cell vehicles this is called the accessory battery (see Article 109:h)

   ii. For battery electric vehicles this is called the propulsion battery, which means that an accessory battery is not allowed.

      *Battery definition: A 'battery' is defined as a source of electrical energy, which has exactly two connectors and* ***can be described as a unit. This unit may contain more than one sub-unit. If more than one sub-units are used they should be packaged together in a single physical package. The package may be made of any material provided it contains the entire battery.***

c) The battery must be installed outside of the Driver's compartment behind the bulkhead. (See Article 27:) Batteries mounted directly under the driver's seat are not allowed.

d) If Lithium-based batteries are used,

i. Battery Management Systems (BMS) must be tailored to the lithium chemistry to control and protect the battery against risk of fire.

1. The BMS must provide cell balancing and overvoltage protection during off-track charging.

2. For battery electric vehicles, the additional requirement of cell level over-discharge, cell level overcurrent and **battery 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.

**3. For battery electric vehicles, the on-vehicle BMS must be located in the physical battery package (See Article 57:b,ii above.)**

ii. For all self-built batteries, the following applies (note: a battery with a separately purchased BMS is also considered a self-built battery).

1. If there are one or more cells or modules, the overcurrent protection value for cells in parallel must be selected such that under normal operating or expected failure conditions, no single cell will be exposed to current beyond its rating.

2. All cells or modules must be identical in configuration. (i.e. a battery constructed from cells of different capacities is not allowed).

*If the BMS is purchased separate from the battery, ensure it is compatible with battery chemistry. Example: Li-Polymer (LiPo) batteries require a BMS designed for LiPo batteries.*

iii. Charging of batteries must be done with the battery charger purchased together with the battery or a purpose-built charger specifically suited to the given battery chemistry. For self-built batteries, teams must demonstrate that the charger is suitable and is integrated with the BMS system.

iv. The maximum capacity of any Lithium-based battery used is 1,000 Wh. For batteries not rated in Wh, the Wh rating is calculated by multiplying the amp-hour rating of the battery by its nominal voltage.

v. Protection for Lithium-based battery charging, whether in or out of the vehicle must be provided, see Article 109:h).

vi. Any Lithium based battery must be equipped with a **solid metal containment tray under the battery** OR the battery must be enclosed in a battery charging bag. Either the tray or bag must be suitable to prevent the battery, in the event of a battery fire, from burning through the battery mounting or the vehicle body and dropping to the ground **or in the engine compartment in the event of a vehicle rollover**. Lightweight aluminium, other semi-metallic materials, or non-solid trays are not acceptable as metal containment.

vii. Power tool or hand-held equipment batteries are not permitted as a battery electric propulsion battery.

viii. Printed manufacturer's documentation for lithium-based batteries and the associated battery management system must be available for review during technical inspection (see c).

e) All batteries and Supercapacitors 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, or a maximum 300 mm from the positive terminal of the battery or Supercapacitor. The rating of the short circuit protection device must enable the battery or Supercapacitor to always supply enough

short circuit current to open the device. For vehicles with a starter motor, the starter motor cable is NOT required to be protected.

f) For safety reasons, both the positive and negative circuits of the propulsion battery (for battery-electric vehicles) and Supercapacitors must be electrically isolated from the vehicle body, frame, and metal components.

g) 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.

h) Accessory battery

i. The accessory battery provides all allowed electrical needs such as safety devices (windscreen wipers, lights, hydrogen sensors, hydrogen relays and hydrogen shutdown valve), ignition, fuel injection control, and starter motor.

ii. The accessory battery may also power electrically driven engine components such as engine oil and cooling pumps, electric turbo compounding, electromechanical variable valve timing, compressors/ blowers, etc. The use of electric fuel pumps is not allowed.

**Only Urban Concept vehicles** can utilize electrically driven engine components.

i) The following devices may be powered by batteries other than the vehicle battery provided they use built-in batteries: radio communication system and driver ventilation.

j) All electrical/electronic enclosures purchased or built 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.

k) Electrical wiring must be in good condition, neat, secured and not close to moving parts. All wiring connections and terminations must be visible and easily accessible. Splices are not allowed.

## ARTICLE 58: TECHNICAL DOCUMENTATION

### TECH TIPS TECHNICAL DOCUMENTS

a) Competitors need to provide technical documentation in 2 stages:

i. Prior to the event during the online submittal process (see Article 109:b)
This documentation serves only to verify that the teams understand the Rules. Online approval in no way constitutes a pre-approval for the Technical Inspection phase.

ii. At the event (see Article 109:c))
This should be a precise technical description of the vehicle. During technical inspection, the documentation will be compared against the vehicle. Deviations between the technical documentation and the vehicle will be required to be reconciled prior to passing technical inspection.

b) Technical Documentation – prior to event.

i. Competitors must provide, through the online submittal process, documentation on the vehicle energy supply and propulsion system. It is not necessary to submit detailed component specifications or electrical schematics as part of the online submittal process.

ii. Energy supply block diagram

The online submitted energy supply block diagram and associated text description must contain information describing the energy flow and component function for the vehicle energy systems. Specific items to be included in the block diagram for each energy category are listed below:

- ICE: engine, fuel tank, fuel line, injector, pressure relief valves, pressure regulators, pressure gauge, compressed air bottle, vehicle cut-off mechanism
- H2: Fuel cell, cylinder, solenoid valve, pressure regulator, flow meter, motor controller, motor, supercapacitor, vehicle cut-off mechanism
- BE: Motor, battery/BMS, fuse, wiring, e-stop switches, motor controller, vehicle cut-off mechanism

iii. Propulsion system block diagram

The online submitted propulsion system block diagram and associated text description must contain information describing the propulsion mechanism for each energy category below:

- ICE: Engine/Motor to road (engine, transmission, clutch, wheel, motor, supercapacitor, motor controller)
- H2: Motor to road
- BE: Motor to road

c) Technical Documentation – at event (to be reviewed during Technical Inspection)

i. Competitors must have available for inspection with the vehicle printed documentation describing selective technical aspects of the vehicle. The printed documentation must be bound and divided into the following sections. The specific required sections for each energy category are defined below.

**ICE energy category**

- Energy Supply Diagram
- Propulsion System Diagram
- Electrical Schematic
- Hybrid System +
- Battery/BMS ++

**Battery Electric energy category**

- Energy Supply Diagram (Electrical Schematic)
- Propulsion System Diagram
- Battery/BMS
- Motor/Motor Controller

**Hydrogen category**

- Energy Supply Diagram
- Propulsion System Diagram
- Fuel Cell
- Electrical Schematic
- Motor/Motor Controller
- Supercapacitor +
- Battery/BMS ++

+ If included in the vehicle

++ If a Lithium-based accessory battery is included in the vehicle

ii. The minimal contents of each of the above required sections are defined below.

- Energy Supply Diagram: include updated diagrams and associated descriptive text as defined in Article 109:b) above.
- Electrical Schematic: provide a vehicle level schematic showing all vehicle wiring and associated components and connections. The schematic should include component values such as voltage levels and fuse ratings. Schematics of components such as the engine management system or fuel cell controller are not required in this section.
- Hybrid System: include manufacturers' component specifications at the lowest level of purchased components. Include diagrams describing the power flow into and out of the hybrid system. Include supercapacitor documentation (see the **supercapacitor** section below).
- Battery/BMS: (For Lithium-based batteries only) Provide battery/BMS manufacturer component specifications at the lowest level of purchased components. At minimum, the battery documentation should include cell chemistry, cell electrical characteristics, cell series or parallel configurations, battery voltage, and current ratings. The BMS data MUST include:
  1. Cell over-voltage and under-voltage protection limits
  2. Battery over-current limit (not required for accessory battery)
  3. Operation of cell balancing (how and when)
  4. Battery over-temperature limit (not required for accessory battery)
  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 protect or isolate the battery, in the case of Battery Electric Vehicles, when these limits are reached?
- Motor/Motor Controller: Provide motor/motor controller manufacturers component specifications at the lowest level of purchased components. For Battery Electric Vehicles, include design documentation on the purpose-built motor controller. The documentation may contain control flow diagrams, motor controller and sub-component schematics and PC board layouts if PC boards were used. Also, include software documentation if software was written as part of the motor controller development.
- Fuel Cell: Provide fuel cell manufacturers component specifications at the lowest level of purchased components. This should also include the surface area of the fuel cells, rated power and voltage.
- Supercapacitors: Provide supercapacitor manufacturers component specifications at the lowest level of purchased components. At a minimum, include supercapacitor system rated voltage and maximum current.

## 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 pneumatic energy not replaced during the competition by the engine may only be used for the fuel injection system. Fuel pumps are permitted for all fuels provided they are mechanically driven by the engine only.

*Electric fuel pumps are prohibited.*

b) It is permitted to pressurise the liquid fuel tanks, 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. This safety valve must be located between the pressure regulator and the **pressurised air bottle**.

ii. The pressurisation is done in the starting area by means of an air pump.

iii. The Driver must not modify the pressure during the competition.

c) Auxiliary energy sources (chemical, latent energy from phase changes, etc.) are not permitted.

d) For Urban Concept vehicles engine temperature can be regulated with a pressurized pure water or commercially available coolant in a cooling system powered by an electrical pump.

e) For Prototype vehicles, if the engine temperature is regulated with water, the said regulation should be limited to the use of pure, un-pressurised water as coolant and a mechanical water pump.

f) The external regulation temperature of the engine by external heating devices is limited to 100°C.

g) **The use of vacuum from air intake cannot be used for auxiliary equipment such as clutches.**

## ARTICLE 61: FUEL TANKS (ICE VEHICLES)

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

Urban Concept: 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 tests fuel tanks and certifies their ability to withstand a pressure of five bar.*

c) The fuel tank must be mounted in an accessible and zero-degree vertical position which allows in-situ filling with a burette of approximately 1 metre height.

d) The fuel tank must be mounted in a way that its top is at least 50 mm below the roll bar and far from any moving parts, batteries, heat and ignition sources.

e) The fuel tank cap, whether it is leak proof or not (drilled), must be in place during the competition. For diesel engines, 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. For diesel engines, the return line can be fitted to the fuel cap only if the engine was originally equipped with a manual priming pump and this return line and the pump have not been modified.

g) Teams must equip their vehicle with clear fuel lines which are not prone to expansion when pressurised (max. internal diameter 8 mm).

h) For all pressurised fuel systems, the hoses connecting the pressure bottle to the fuel tank cap must be flexible (do not need to be Rilsan/Nylon type) to allow easy connection and 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 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 components, for example filters. A second valve directly at the bottom of the fuel tank is tolerated.

d) For diesel engines, a cut-off solenoid valve is required. (See c)

e) Engines with carburettors are prohibited (Fuel injection is mandatory).

f) The air intake manifolds must not contain any fuel (or be able to accumulate any fuel) or blow-by gas when the vehicle is on the starting line prior to departure. Air filters are not allowed in the intake system. Blow-by gas must not be recycled during the competition but must be collected in a specific canister for environmental protection.

*Blow-by gas: gas inside the engine (oil vapours, unburnt fuel, 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 blow-by 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 with a temperature corrected volume of the fuel.

j) The fuel consumption of all ICE vehicles that have achieved more than 1500 km/l (3,528 mpg) will be measured gravimetrically. At the start, the Technical Team will fill the fuel system, and the entire fuel system (including tank, injector, pipes, injector) will be weighed on a precision balance. All the components must be compact and easily detachable for weighing purposes. After completion of a successful run, the entire fuel system will be removed and weighed again on the same balance. This handling of the fuel system and transportation to the weighing room must be performed by a competent team member who has a valid access pass. The handling of the fuel system will be supervised by a Technical Team member who will also perform the weighing, which must **be witnessed** by a Participant.

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 Supercapacitor is the only allowed energy storage device for hybrid vehicles. Mechanical or hydraulic energy storage is not permitted. The use of any battery in the hybrid propulsion system is forbidden.

b) This capacitor must be the only source of stored energy for the electric motor driving the vehicle.

c) Two connectors must be installed safely outside the vehicle to allow the voltage measurement on the starting line. These must be labelled "Supercapacitor Voltage".

d) The state of charge of the Supercapacitor 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 Supercapacitor 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 Supercapacitor by running the engine after the competition is added to the recorded time of the relevant run.

e) The electric circuitry must be correctly fused to prevent overloading any of its parts. The fuse needs to be clearly labelled in the technical drawings and easily accessible for Technical Inspection (see Article 109:g).

### ARTICLE 64: STARTER

a) An electric starter must be used during the competition. Manual hand starting is prohibited.

b) It must be clearly established that the starter is never capable of providing any forward propulsion to the vehicle.

c) **For Prototype vehicles only** a clearly visible red indicator light called the starter 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 to signal any operation of the starter motor.

d) If Track Marshals report the repeated or intensive use of the electric starter by a Team, the Organisers reserve the right to order an immediate inspection of the vehicle. If any non-compliance is observed, the Team will be penalised accordingly.

e) At the start, the starter and 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

TECH TIPS HYDROGEN SAFETY

a) Fuel system

i. Participants must provide a description and a process flow diagram 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:

*$H_2$ 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. Fuel cell -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.

ii. Cartridges and 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 (60 mm/320 mm) 1.4 kg

Americas: Exchange cylinder ~ 152 bar
5.3" X 17.1" (135 mm x 434 mm), 8.6 lbs. (3.9 kg)

Asia: Catalina MD cylinder, 2.9 litre of hydrogen @139 bar
(111 mm x 424 mm), 2.4 kg

iv. For Urban Concept vehicles, the following cylinders will be provided:

Europe: B1 cylinder, 1 litre of hydrogen at 200 bar
(100 mm x 350 mm) 2.57 kg
and
B04 cylinder, 0.4 litre of hydrogen at 200 bar
(60 mm/320 mm) 1.4 kg

Americas: Exchange cylinder ~ 152 bar
5.3" X 17.1" (135 mm x 434 mm), 8.6 lbs. (3.9 kg)

Asia: Catalina MD cylinder, 2.9 litre of hydrogen @139 bar
(111 mm x 424 mm), 2.4 kg

v. All cylinders must be installed on the vehicle under the supervision of the Technical Team. Participants are not allowed to keep any cylinders in their possession overnight. Upon arrival at the circuit, Team Managers must contact the Technical Team, who will organise all relevant logistics.

vi. The cylinder must be installed securely in the vehicle to minimise movement and stress on pipework when the vehicle is moving.

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 500 mm². Another 500 mm² 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 $H_2$ detector it is still required to fit a $H_2$ 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. The emergency shutdown sticker provided by the Organisers must be positioned on the vehicle body to clearly indicate the place of this emergency push-button. (See Article 109:f)
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.

v. **H2 piping and equipment must be protected from overpressure at 90% or lower of their maximum pressure rating.**

***In case of the use of pressure relief valves, they must be vented outside through the top section of the vehicle. The exhaust tubing must be well secured to the vehicle.***

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. Only flow meters specified by the Organisers are permitted. For Urban Concept cars at regional events, refer to Article 82:

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

Oxygen for the fuel cell's operation must be from the surrounding air, not from oxygen tanks or compressed air reserves.

j) Supercapacitors

i. If an embedded electric storage device is part of the power-train, it must be of capacitor type, referred to hereafter as 'Supercapacitor'. Other types of embedded electric storage device (Pb, NiMh, etc. batteries) are forbidden.

ii. The state of charge of the Supercapacitor will be checked before and after each run by measuring the Supercapacitor voltage. Two measurement points (Supercapacitor voltage + and – a labelled "Supercapacitor 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 Supercapacitor 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 Supercapacitor by running the fuel cell after the competition is added to the recorded time of the relevant run

iv. The maximum Supercapacitor voltage must not exceed that referenced in Article 109:a).

k) Fuel cell starter battery

i. Accessory battery
If the accessory battery can be electrically isolated from the fuel cell output, the accessory battery can be used to start the fuel cell. The battery is considered electrically isolated when energy from the accessory battery cannot contribute to vehicle propulsion.

ii. External battery
If the accessory battery cannot be isolated from the fuel cell output, an external battery must be used on the starting line to start the fuel cell system.

1. As soon as the vehicle starts to move, this battery must be unplugged.

2. 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:i, it is mandatory to power the hydrogen detector using the accessory battery. This battery must also power the emergency shutdown valve, relay and lighting system for Urban Concept vehicles.

l) Electrical circuit/Electronics

i. All wiring associated with the accessory battery circuit must be clearly distinguishable from the propulsion system by physical isolation or the use of different wire colours.

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 $cm^2$, the melting current of the fuse must not exceed 60 A.

iii. If a Supercapacitor is used in the circuit, a fuse must be installed on the positive terminal of the Supercapacitor 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 Supercapacitor, not by the accessory battery.

## 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 or the use of purchased motor controller evaluation kits are not acceptable. Motor controllers built from sub-components such as single-board computers, power stages, etc. are encouraged. If a motor controller is built incorporating one or more single printed circuit boards (PCBs), the text "SEM" must be included in the mask of the PCB etching. If the motor controller includes controlling software, the software must be developed or integrated for the Shell Eco-marathon.

### TECH TIPS MOTOR CONTROLLER

b) Only Lithium-based batteries are permitted as electric storage devices.

c) The vehicle must be equipped with an onboard Battery Management System (BMS) to control and protect the battery against risk of fire as defined in Article 109:d).

*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-based battery and any accessory circuits are subject to the maximum voltage defined in Article 109:a).

e) Participants are required to present a printed copy of their electrical schematics at Technical Inspection. (See c)

f) The vehicle battery must be placed outside the Driver's compartment behind the bulkhead and securely mounted. Bungee cords or other elastic materials are not permitted for securing the battery. See Article 109:h)

g) All electrical circuits must be protected as defined in Article 109:g).

h) All 'Battery Electric' vehicles which complete a successful run will be classified in descending order of fuel economy, expressed in distance/kWh, where distance is either miles or km depending on the region.

# 5. ON-VEHICLE TELEMETRY EQUIPMENT

## ARTICLE 80: GENERAL

TECH TIPS TELEMETRY

a) For Regional events, all Urban Concept vehicles must install the telemetry system provided by the Organiser for the duration of the event. **This telemetry system is composed of an onboard computer (consisting of an antenna pod and a backbone),** a dedicated battery system and cables, and one or more energy measurement sensors, dependent on the vehicle's energy type.

b) The use of telemetry equipment is limited to Regional events.

c) Teams are responsible for ensuring their vehicle electrical system is compatible with on-vehicle telemetry equipment. While there is no direct electrical connection between the telemetry equipment and vehicle electrical system, vehicle electrical noise may interfere with the operation of the telemetry equipment. Organisers will work with teams to mitigate vehicle electrical system noise impacting the operation of the telemetry equipment, but if not resolved, teams may not be allowed to compete in the Shell Eco-marathon Drivers' World Championship.

## ARTICLE 81: ONBOARD COMPUTER

a) Mounting location **must be approved by the Organiser** and instructions will be provided.

b) The onboard computer will be powered by a dedicated battery system provided by the Organisers. The dedicated battery system must remain isolated from the vehicle electrical system. **Teams are responsible for charging the telemetry battery provided.**

c) The external antenna pod must be mounted on the outside of vehicles that has an unobstructed view of the sky and its LED's must be visible from the side of the vehicle. The mounting of this antenna requires a 32 mm diameter hole in the body of the vehicle.

## ARTICLE 82: NOT USED

## ARTICLE 83: HYDROGEN FLOW METER

a) All Urban Concept Hydrogen vehicles must be fitted with the hydrogen flowmeter which is provided by the event Organisers. The onboard computer will be connected to the flowmeter via a one-meter cable.

b) The hydrogen flowmeter is a Vögtlin Red-y smart series Hi performance GSM-B9TA-BN00 calibrated for Shell Eco-marathon.

## ARTICLE 84: LIQUID FLOWMETER

a) All Urban Concept Internal Combustion Engine vehicles must be fitted with the liquid flowmeter, which is provided by the event Organiser. The liquid flowmeter will be connected to the onboard computer backbone via a one-meter cable.

b) The liquid flowmeter is a Max Machinery Model P001 specially modified for the Shell Eco-marathon. The liquid flowmeter must be installed **below the fuel injector** by the teams prior to Technical Inspection.

## ARTICLE 85: JOULEMETERS

a) Joulemeters will be used to measure the vehicle electrical energy and will be installed in all Urban Concept vehicles, see Article 56:. In Urban Concept vehicles, the Joulemeter will be connected to the onboard computer backbone via a 1meter cable.

# 6. AWARDS AND PRIZES

## 6A – ON-TRACK AWARDS

### ARTICLE 100: ON-TRACK AWARD OVERVIEW AND PRIZES

For Regional events, all on-track prizes are awarded separately for both Prototype and Urban Concept.

| SHELL ECO-MARATHON ON-TRACK AWARD | ASIA AMERICAS | EUROPE | COMMENT |
|---|---|---|---|
| Internal Combustion Winner | US$ 3,000 | € 2,500 | Prize Money, Trophy, on-stage Winners Ceremony |
| Internal Combustion Runner-up | US$ 2,000 | € 1,700 | Prize Money only |
| Internal Combustion 3rd place | US$ 1,500 | € 1,250 | Prize Money only |
| Internal Combustion 4th place | US$ 1,000 | € 800 | Prize Money only |
| Internal Combustion 5th place | US$ 750 | € 600 | Prize Money only |
| Internal Combustion 6th place | US$ 500 | € 400 | Prize Money only |
| Battery Electric Winner | US$ 3,000 | € 2,500 | Prize Money, Trophy, on-stage Winners Ceremony |
| Battery Electric Runner-up | US$ 2,000 | € 1,700 | Prize Money only |
| Battery Electric 3rd place | US$ 1,500 | € 1,250 | Prize Money only |
| Battery Electric 4th place | US$ 1,000 | € 800 | Prize Money only |
| Battery Electric 5th place | US$ 750 | € 600 | Prize Money only |
| Battery Electric 6th place | US$ 500 | € 400 | Prize Money only |
| Hydrogen Fuel Cell Winner | US$ 3,000 | € 2,500 | Prize Money, Trophy, on-stage Winners Ceremony |
| Hydrogen Fuel Cell Runner-up | US$ 2,000 | € 1,700 | Prize Money only |
| Hydrogen Fuel Cell 3rd place | US$ 1,500 | € 1,250 | Prize Money only |
| Hydrogen Fuel Cell 4th place | US$ 1,000 | € 800 | Prize Money only |
| Hydrogen Fuel Cell 5th place | US$ 750 | € 600 | Prize Money only |
| Hydrogen Fuel Cell 6th place | US$ 500 | € 400 | Prize Money only |

# 6B – OFF-TRACK AWARDS

Applications for Off-track Awards must be related to the Shell Eco-marathon project. Previous award winners cannot re-apply using the same vehicle design, innovation, communications or safety campaign. Submission must be clearly different from previous winning applications. Applications must include the team race number on the cover.

Applications for all Off-track Awards must be made in the English language.

For Shell Eco-marathon Off-track Awards, the required documents must be uploaded using the online team registration system. Please refer to Chapter II of the Shell Eco-marathon 2020 Rules of your regional event for the applicable submission deadline.

For all awards, the juries will make their first selection based on the submission received prior to the competition. All teams shortlisted for an award may then receive a visit by the judges during 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 evidence, or discuss the team's submission in more detail. **There might also be public voting elements to any judging.**

By submitting an Off-track Award entry, the Team agrees for the Organisers to publish their entry as deemed necessary to recognise the achievement and provide coaching to other Teams.

Teams cannot apply for the "Perseverance & Spirit of the Event" award, as this award is nominated and chosen by the Organisers.

## ARTICLE 101: OFF-TRACK AWARD OVERVIEW AND PRIZES

For Regional events, all off-track prizes and trophies below are awarded once. Winners will receive the respective prize money, as well as a trophy on-stage during the Awards Ceremony.

| SHELL ECO-MARATHON OFF-TRACK AWARD | ASIA AMERICAS | EUROPE |
|---|---|---|
| Communications Award | $3,000 | €2,500 |
| Vehicle Design Award Prototype | $3,000 | €2,500 |
| Vehicle Design Award Urban Concept | $3,000 | €2,500 |
| Technical Innovation Award | $3,000 | €2,500 |
| Safety Award | $3,000 | €2,500 |
| Perseverance & Spirit of the Event Award | $3,000 | €2,500 |
| **Circular Economy Award** | **$3,000** | **€2,500** |

## ARTICLE 102: COMMUNICATIONS AWARD

a) Objective

To run the most impactful and successful integrated Communications campaign showing the efforts to promote the team ahead of the Shell Eco-marathon competition in 2020. The winner will be the team that demonstrates best the continuous communicational and promotional activities of the team on the road to

Shell Eco-marathon (SEM) competition.

b) Overview

An integrated Communications campaign, using different media channels and engagement activities, is integral for students to promote their teams ahead of Shell Eco-marathon. Participating teams are required to create, run and evaluate a communications plan with various activities to show the team's trajectory ahead of the competition.

When preparing the campaign, teams are encouraged to use a wide range of media channels, from traditional media (press, radio and TV), to online tools (websites, blogs) or social media networks (Facebook, Twitter, YouTube, Instagram etc.).

The winner will be judged on the quality and creativity of the content, the volume of activity as well as the impact (potential reach) of the campaign (i.e. media impressions; website visits; YouTube video views; Facebook likes; event attendance, etc.).

As we evaluate the team's trajectory before Shell Eco-marathon, the application should indicate when the campaign is launched and run and should include planned activities after the submission deadline.

Remember that engaging with the Shell Eco-marathon online and social media channels are also an important part of the campaign. Teams applying to the Communications Award are invited and expected to join the regional SEM Facebook groups, follow SEM on Twitter, and use the **#ShellEcoMarathon** hashtag whenever possible.

Teams must note that the effectiveness of the Communications campaign will be judged in activities related to Shell Eco-marathon only. This includes, for instance, the unveiling of the vehicle, press conferences, photos or videos of the team and the car, or any social media activity. Participation in other competitions without a clear reference to Shell Eco-marathon will not be taken into consideration.

To be eligible for the Shell Eco-marathon Off-Track Communications Award, the team must have successfully passed Technical Inspection.

c) How to participate

Participation in this competition is voluntary. Teams interested in applying to the Off-Track Communications Award must apply via the online Team Registration web site. This application must consist of one (01) document (.pdf format) that should be simple and straightforward, and should contain:

i. Communications Plan: A short summary (no more than 500 words) indicating the main idea, objectives, strategy and timeline of the Communications Campaign.

ii. Impact Analysis: A summary report (no more than 500 words) evaluating the success of the Communications Campaign compared with its objectives. Teams should also submit the main results (numbers) gathered throughout the campaign (e.g. event attendees, media impressions; video views; social media likes and shares; re-Tweets; etc.).

iii. Campaign portfolio: Teams should collate and share all (or the best) examples of their campaign. This includes, for instance: press clips; event photos and footage; posters and brochures; creative infographics; websites links; social media channels (Facebook, Twitter, Instagram, Google+, YouTube, Tumblr, Vimeo, Vine etc.); blog posts; screen shots of social media posts; links to YouTube, Vimeo or Vine videos, etc.

## ARTICLE 103: 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 aesthetics, ergonomics, technical feasibility, choice

of materials and eco-friendliness. Each of these five criteria **will be considered in a final decision**. Due to their non-comparable designs there will be one award each for the Prototype and Urban Concept categories.

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.

To be eligible for the Vehicle Design 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 a summary in .pdf format which does not exceed 1,500 words plus photographs, drawings or animations. This document must contain as a minimum the following information:

i. Description of the original design idea the team wanted to develop and why

ii. Seven images of the vehicle (photographs or drawings) which represent the car, such as:

- 3/4 front perspective view
- 3/4 rear perspective view
- Direct Front view
- Direct Rear view
- Side view
- Top view
- Cockpit view

iii. A brief project timeline and overview of the team structure and work allocation

iv. When was this vehicle registered for the first time for Shell Eco-marathon?

v. What are the new developments this year (if registered before)?

vi. Details about research and tests done to prove the vehicle's energy-efficiency

vii. Details about vehicle safety and driver ergonomics aspects

viii. Details about the eco-friendly materials used and how well they can be recycled

ix. The weight of the car and details on how the team managed weight reduction

## ARTICLE 104: 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, its features and its 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.

To be eligible for the Technical Innovation 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 apply in .pdf format which is not to exceed 1,500 words plus photographs, drawings or animations as applicable.

## ARTICLE 105: SAFETY AWARD

a) Objective

This award aims to highlight the importance of road and behavioural safety in the Shell Eco-marathon programme and encourages all participating teams to actively implement safe practices in their daily activities. It challenges all teams to review travel practices, inspect tools and equipment, and review their procedures to implement changes which lead to higher safety standards.

b) Overview

To be eligible for the award, the team must demonstrate excellent understanding of safe design concepts, road safety, and safe manufacturing process. Furthermore, the 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, both in the paddocks and on the track. In their submission, the team will also explain changes they have implemented to achieve higher standards of safety both on and off the track.

To be eligible for the Safety Award the team must successfully pass technical inspection.

c) How to participate

Application for this award is voluntary. Teams interested in winning the Safety Award must apply in .pdf format which is not to exceed 1,500 words plus supporting videos, photographs, documents, and drawings, which are encouraged.

## ARTICLE 106: 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 Shell Eco-marathon through their actions, which can involve but are not restricted to:

- Overcoming great obstacles 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.

## ARTICLE 107: CIRCULAR ECONOMY AWARD

a) **Objective**

**This award is presented to the Team which demonstrates circular economy thinking in the concept, design, and execution of their vehicle production and disassembly process. The objective is to**

motivate students to think how they can integrate the concept of circular economy in engineering of materials, products and services for real life industrial and consumer solutions.

b) Overview

Teams are required to explain their innovative concept, its features and its benefits, how it relates to the Shell Eco-marathon competition and the potential it has for 'real world' application. Innovations may include but are not limited to: re-manufacturable materials; minimizing natural resource use, whilst maximizing material reuse; recycled car batteries; bio-degradable products; accessories or parts regenerated from waste; repurposing of disassembled parts; circular solutions for fuel wastage and emissions etc. They should be able to describe and demonstrate how circular economy is integrated into the design, production, functioning, and disassembly of their vehicle. This could be through photographs, drawings or animations to illustrate the process. Teams shortlisted for the Circular Economy Award may be visited by the Jury during the event to answer further questions and present their vehicle.

To be eligible for the Circular Economy 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 Circular Economy Award must apply in .pdf format which is not to exceed 1,500 words plus photographs, drawings or animations as applicable. This document must contain as a minimum the following information:

i. Description of the circular design idea the team developed
ii. Images, photographs, illustrations, or animations of the circular concept in practice
iii. Details about research and tests done to prove the circular concept works
iv. How the solution can be scaled to address real life challenges

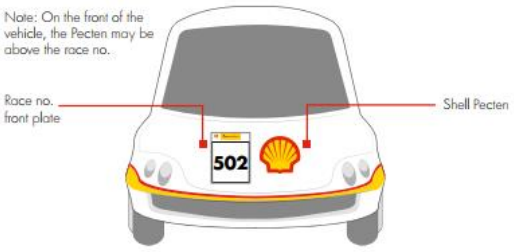
## ARTICLE 108: INTELLECTUAL PROPERTY

Any work performed in the preparation of vehicles for use in the Shell Eco-marathon programme may result in the creation of intellectual property. Teams are encouraged to consider all intellectual property created during the Shell Eco-marathon programme as valuable assets, and to seek professional advice.

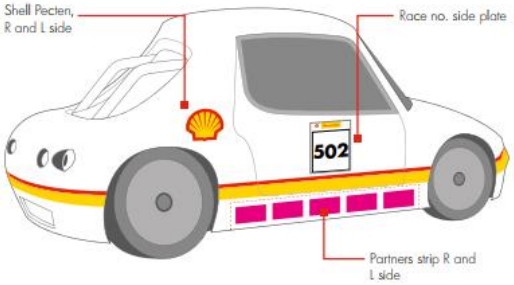
## APPENDIX 1: IDENTIFICATION OF VEHICLES

### URBANCONCEPT

**FRONT View**

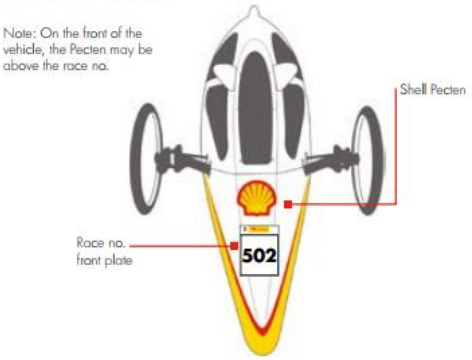



**SIDE View**

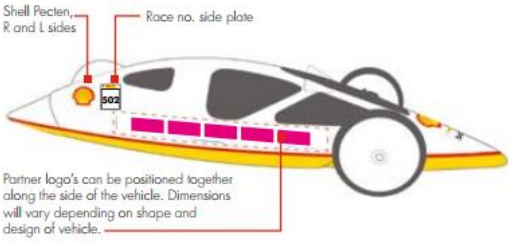



### PROTOTYPE

**FRONT View**




**SIDE View**




| IDENTIFICATION | POSITION | FORMAT | NUMBER | NOTES |
|---|---|---|---|---|
| Shell Pecten | ■ Right side<br>■ Left side<br>■ Front of vehicle | 215mm x 200mm | 3 | Mandatory |
| Race number plate<br>502 | ■ Right side<br>■ Left side<br>■ Front of vehicle | 200mm x 260mm | 3 | Mandatory |
| Partner strip | ■ Right side<br>■ Left side | 770mm x 80mm | 2 | Mandatory |
| Helmet stickers<br>Shell Eco-marathon | ■ Right side<br>■ Left side | 130mm x 20mm | 2 | Optional |
| Emergency sticker | On exterior position of the shutdown actuator | 120mm x 105mm | 2 | Mandatory: provided by the Organisers |