The regulations for 2012 are very similar to the 2011 regulations.

The only technical change for this year is a change to the drag plate requirements: the area of the drag plate has been reduced to 150 square cm and it must be in aluminium at least 1.2 mm thick.

Interpreting the requirements of technical specifications is always difficult. As an aid to understanding, the Technical Section of the car specifications have been copied below, together with comment and interpretations of the requirements given in blue after each section. For any regulation whose meaning is simple and obvious a comment has not been provided.

Do remember that the purpose of specifications is to either mandate or prohibit nominated features. For you and your car design this really means that anything not mentioned specifically in the regulations is an available option in your design and build project.

8. CAR SPECIFICATION

8.1 Test criteria: Unless otherwise specified all references to car behaviour and measurements will assume that the car is on a flat, straight section of the track, and in full racing configuration.

8.2 No commercially built cars: Cars must not use any part of the chassis or body of any commercially available model car. This only refers to the structural frame and body, not to the drive train components such as gears, shafts, wheels, tyres, or to suspension and steering components.

This regulation is to ensure the cars are designed and built by the students – viz Victorian or other kit car bodies are precluded.

8.3 Size limit: Maximum car size allowed is 550mm long, 180mm high and 320mm wide, at no time may any part of the car extend sideways more than 190mm from the centre of the guide rail.

This is to ensure a car will not encroach on the other cars running lane or collide with the timing equipment or the track edge in the case of the NSW track. It will be tested during scrutineering by placing the car on a flat surface which has a section of guide and the limiting dimensions marked. To test for the maximum distance possible the car
can move away from the centre line of the guide the car will be pushed both ways till the
guide system (presumably rollers) engages with the guide rail.

8.4 Source of power: Only commercially available silicon photovoltaic cells are allowed.

This primarily ensures that competitors are all using panels that are readily available to
everyone at low cost. It also ensures the use of cells which respond well to the spectrum
produced by our light box allowing us to accurately determine power output and hence
ballasting requirements.

8.5 Solar array and support structure: The solar cells connected together to provide the
power which drives the car will be referred to as the array. The complete unit on which the
photovoltaic cells (the array) are mounted is the array support structure. The thickness of the
array and its support structure must not exceed 30 mm. The structure must be robust enough
to enable handling by the scrutineers and officials. The organizers will accept no
responsibility for any damage to the solar cells or the solar array.

The 30 mm thickness limit is to delineate the solar array and support structure from the
body in order to allow its weighing for ballast calculation.

8.6 Array structure removal: The array and its support structure must be easily and quickly
(less than 2 minutes) removable from the car for testing and ballasting purposes. And when
removed the car must be capable of free and stable movement.

Free and stable movement is specified to ensure the car does not rely on the solar panel
and its support structure to perform the function of a chassis. This prevents the fitting
of wheels to a solar panel and calling it a car.

8.7 Non planar arrays: Curved, stepped or multi-planed arrays must be able to be re-
configured such that when placed on the flat light box measuring surface no part of any cell is
more than 30 mm away from that surface. The scrutineers will calculate a maximum power
value for non conforming panels.

The 30 mm is in effect a flatness tolerance, it is included to ensure accurate power
measurements of panels that are not a single flat plane. As an example of application to
measuring a curved panel, consider a curved panel placed on the light box measuring
surface. If the curve was convex compared to the light box surface it would be touching
in the centre but could be 30 mm above the light box surface at each end. For a concave
curve it would be touching at each outer edge and the centre could be 30 mm above the
light box surface.

8.8 Solar array wiring: All wiring on the solar array must be visible. All panels must be
presented for scrutineering with a pair of connections marked +ve and –ve for connection to
the alligator clips on the power measuring equipment. Teams using panels of their own construction or modified commercial panels must provide a wiring diagram. Where the panel has multiple individual sections to allow for series and parallel connection, teams must supply pairs of connections as described above for each section of the panel. The power of each section will be measured and the values obtained added together. All wiring must be carried out with standard copper or tinned copper conductors.

8.9 No devices on the array: All mechanical, electrical or electronic devices including the ON/OFF switch and any devices for changing the panel voltage must be separate from the array. A plug, socket or terminal block to allow connection of the panel wiring to the car wiring is allowed.

8.10 Power measurement
The power delivered by the solar array will be assessed by the scrutineers using a light box. Solar panels presented for testing must produce no more than 25 volts open circuit or 2.0 amps short circuit when tested at 1 Sun (nominal AM 1.5), otherwise they will be assigned the value:

\[
\text{Power} = (\text{open circuit voltage}) \times (\text{short circuit amps}) \times 0.8 \text{ watts.}
\]

Scrutineers will measure the power output of all panels at a Sun level expected to be the average over the duration of the event. The power figure obtained will be used to ratio up to the power expected at full Sun. This full Sun figure will then be used for all further calculations. Artificial manipulation of Fill Factor is prohibited and will result in disqualification of the team involved.

Use of the average Sun level expected over the duration of the event has now been included in an attempt to make the competition more a measure of car design and build rather than a measure of solar panel characteristics. Confused ??? let me explain. Solar panels have both series and parallel resistance internally within the silicon and externally in the interconnecting wires between the cells, the ratio of these resistances control power output variation with varying light intensity. For a “good” commercial panel such as Solarex SX 10, series resistance is in the order of 3 Ohms while parallel resistance is in the order of 30,000 Ohms. This panel exhibits only a small power variation between the 50% Sun level power multiplied by 2 and the power actually produced at 100% Sun, meaning it has only a small advantage or disadvantage in the form of ballast being carried compared to its actual power output as Sun levels change.

However, panels exist with characteristics that will give them either an advantage or a disadvantage. The variation can in the extreme be large. I have an 8 Watt panel with characteristics that give it a 180 gm ballast advantage at full Sun conditions when its ballasting power is determined by the 50% Sun power multiplied by 2 method. The
same magnitude of ballast variation can and does occur in the opposite direction ie. the panel carries ballast for which it has no actual power. All this is controlled by “the luck of the draw” depending on the actual ratio of resistances of the panel in question.

Measuring panel power for ballasting purposes closer to the Sun level under which the competition is conducted reduces the magnitude of any ballasting variations.

**Definition of terms.**

Two terms have been used in these regulations which may not be familiar to competitors. These are air mass AM1.5 which is commonly used by manufacturers to test panel output under **Standard Test Conditions** and Fill Factor.

**Standard test conditions (STC):** The testing conditions to measure photovoltaic cells or modules nominal output power. Irradiance level is 1,000 W/m², with the reference air mass 1.5 solar spectral irradiance distribution and cell or module junction temperature of 25°C. ([http://www.iea-pvps.org/pv/glossary.htm](http://www.iea-pvps.org/pv/glossary.htm))

**Fill Factor** is the ratio of area under the Voltage vs Current curve as a fraction of the area under the rectangle bounded by the extrapolated lines for Short Circuit Current and Open Circuit Voltage. Viz.

\[
\text{Voltage} \quad \text{Current} \quad V_{oc} \quad I_{sc}
\]

**8.11 Temperature correction:** As the power output of a silicon solar cell is affected by temperature, the scrutineers will scan all panels with a non-contact thermometer immediately after power testing. The maximum panel temperature recorded will then be used to standardise the power output to the power expected at a temperature of 25°C using the following formula.

\[
P_{\text{standardised}} = P_{\text{measured}} + P_{\text{measured}} \times 0.004 \times (T - 25)
\]

Where \(P = \) power in watts and \(T = \) maximum panel temperature in degrees Celsius.

Any ballast required will then be calculated using this standardised power rating.
8.12 **Power limit**: Panels must register a total power of less than 10 watts. Any panel recording a power above 10 watts will have tape applied by the scrutineers covering portion of each cell in the array. Tape will be applied in integral widths of $19 \pm 1$ mm until the power is below 10 watts. Fine tuning of final power will not be allowed. Removal of this tape except by the scrutineers is prohibited. Racing without the appropriate tape in place will result in forfeiture of the race and depending on circumstances disqualification.

Maximum allowed panel power has been reduced to 10 watts. This aims to move towards minimising cost to competitors and vehicle weight, hence reducing any possible injury to spectators or other cars if the car comes off the track. So as not to penalise any competitors with older panels producing more than 10 Watts any panel over 10 Watts will have tape applied by the scrutineers covering approximately the same % of area on each cell in the array. Tape used will be standard 19 mm wide opaque tape. The scrutineers will attempt to place tape in such a way that the power is reasonably close to the 10 Watts allowed, however once a value less than 10 Watts is attained no fine tuning will be undertaken. Digital photographs will be taken of the masked panel as a guide to the officials. Scrutineers will retest panel power if any doubt exists.

8.13 **Array and array support structure weight**: The minimum required combined weight of the solar array its support structure and ballast for cars using electronics systems will be calculated using the formula:

$$ W (\text{solar array and ballast}) \ [\text{grams}] = 250 \times (\text{Standardised Panel Power} \ [\text{watts}]) - 900 $$

The minimum required combined weight of the solar array its support structure and ballast for cars not using electronics systems will be calculated using the formula:

$$ W (\text{solar array and ballast}) \ [\text{grams}] = 150 \times (\text{Standardised Panel Power}) - 650 $$

The Committee will provide scales to determine array and support structure and ballast weights, measured accurate to $\pm 5$gm.

The use of ballast places the emphasis on car design and build quality rather than solar panel power and weight. Please note use of the formula above can give a minus weight for low powered panels. Obviously negative weight is impossible, but depending on the panel chosen and its power output a very lightweight panel and consequently a very lightweight car is possible.

It is possible under this ballasting formula to build a good car that will have high Sun performance at a level that guarantees instability and crashing. Do consider this in your design and car set up.
8.14 Use of electronic devices: Teams may elect to use electronic circuitry for such purposes as solar panel regulation or motor control. During the time trials (usually held on Saturday) they may decide before each individual race whether to use such devices or not. However they must decide before each round of knockout races whether they will run with or without electronic devices for all races to be held in that particular round. During the final where the best of 5 races determines the winner the teams may change to electronics or not as the case may be after the second heat, but must then stick with this configuration for all remaining races.

At scrutineering teams will be required to indicate their intention to run either exclusively with or without electronics or their intention to select between electronics or not during the course of the competition.

The scrutineers will record the appropriate weight on the car and all cars may be check weighed before or after each race. It is the teams responsibility to ensure their car is correctly ballasted at all times. Any car found to be incorrectly ballasted will forfeit that race. A repeated offence will result in exclusion.

The generous reduction in weight of ballast plus panel is to encourage teams to operate without electronics and thus increase their knowledge and understanding of the interactions between solar panel, motor and chosen gear ratios. This reduction is generous and the operation without electronics will be rewarding for teams who understand their car, particularly if solar conditions are reasonably constant as they were in 2010 in Perth for the National competition.

NOTE: the new ballast formula will make some cars so fast at high Sun levels that instability will be more of an issue. Teams will need to limit the speed of their cars in order to safely negotiate the track.

Teams can decide before each round of knockout races whether they will run with or without electronic devices for all races to be held in that particular round. During the final where the best of 5 races determines the winner the teams may change to electronics or not as the case may be after the second heat, but must then stick with this configuration for all remaining races.

Any teams considering running without electronics must have undertaken extensive testing and trialling of their car to ensure they can quickly reconfigure the car to suit changing sun conditions. If they intend to run both with and without electronics it is strongly recommended they run at least one heat of the time trials without electronics to test their ability to correctly configure their car.

With the generous reduction in ballast for non electronic cars we expect many more teams to avail themselves of this option. This regulation change makes it easier for the officials to keep track of which cars are or are not running with electronics and more importantly ensure cars are correctly ballasted.
8.15 Ballast: Any additional weight required by 8.13 to bring the weight of the solar array and its support structure up to the required minimum is defined as ballast, and must be carried on board the car whenever the car is on the track. Teams should have the correct amount of ballast when presenting for scrutineering. Ballast will not be provided by the scrutineers. Ballast must be suitably contained to prevent possible spillage onto the track. Note, any item or material used as ballast must not perform any function on the car when racing other than acting as the ballast.

8.16 No energy storage systems: No energy storage system, whether electrical, mechanical or chemical, which assists in the performance of the car, will be permitted. Capacitors of less than 0.2F and inductors less than 1mH are allowed as part of the electrical system. Capacitors above 0.047F must be discharged immediately before the race.

8.17 ON/OFF switch: Each car must be fitted with a commercial ‘ON/OFF’ switch, the ON and OFF positions must be clearly marked and the switch must be in a location easily visible by the official starter when the car is on the start line. Note: the starter is on the left hand side, so typically the switch would be mounted on the left hand side or on the top.

8.18 Car wiring: Where possible all electrical wiring and electronic modules in the car must be reasonably visible. Teams will be required to explain any wiring going into sealed body areas. A simple block wiring diagram will be required if this condition is not met.

8.19 Motors: There is no restriction to the type, size, or number of motors that may be fitted to the car. However, the motor manufacturer and/or part number must be made available to the scrutineer for data base information.

8.20 Wheels: There is no limit as to the number, location, or the diameter of wheels. To reduce damage to the track, knife-edge wheels are not allowed. Each wheel must be at least 1mm wide or have a radius of 0.6mm on the running surface.

8.21 Steering: Each car must incorporate a means of steering around the track. The guide rails as described in 4.3 are approximately 16mm wide and 13mm high. The steering mechanism must be designed to operate on the outside of the guide rail.
The diagram above shows the guide channel and a typical guide layout, the photographs below depict actual guides installed on cars.

The photographs below may be of help in describing what is normally done. Do note however that the guides are usually ball bearings or rollers to reduce friction. It is typical to have 2 sets of guides one at the front and another at the rear.
This photograph of a different car shows how close to the ground guides are normally positioned.

8.22 Removable Drag Plate: The car must include a ??????

Detail to be inserted when available.

The inclusion of a drag plate introduces significant aerodynamic drag. New contestants can easily construct a simple car with external drag plate. Such a car could have quite acceptable performance, but by enclosing the drag plate within an aerodynamic body even better performance could be obtained. However the use of bodywork complicates the design and build requiring a trade off between aerodynamics, weight and complexity of build.

Note that this year there is no requirement for the 150 square cm. drag plate to be rectangular or have no holes or cut outs in it. The only requirement is that there is a minimum 150 square cm of aluminium in the drag plate. It may have cut outs and holes but these will not count towards the required area. Aluminium plate of minimum thickness 1.2 mm has been specified as the scrutineers intend to use the plate weight as an approximate quick check of area. Using a balance with 0.1 g resolution will allow determination of area to within about 1/3 square cm. For plates thicker than the minimum 1.2 mm scrutineers will adjust the required weight by using the ratio of thicknesses.

As additional encouragement to design an aerodynamic body the plate may be in two pieces to facilitate its removal from the car. It must however be in a single plane (this means no overlap) when in place in the car, and of course vertical and transverse.

8.23 Body/ Chassis: A car body is completely optional. Any bodywork must not form part of the solar array or array support structure. The body may however form all or part of the chassis. The car must have a chassis or frame with sufficient structural integrity to allow free and stable movement with the ballast and solar array removed.
Again reiterated here, the bodywork if any must not form part of the solar array or array support structure, as before this is to enable delineation between solar array its support structure and bodywork (if any) for the purposes of ballast determination.

Free and stable movement without the solar panel and ballast is a check to prove the solar array and ballast do not form part of the car chassis or frame. They almost certainly will though add to the overall strength and stiffness of the car when fully assembled. This is good design and is acceptable.

8.24 Side Panels: The car must have two side panels capable of retaining their shape at all times for attaching numbers and sponsors logos. These must be easily seen by spectators while the car is racing. They will be located one on each side of the car. Each side panel must be capable of supporting a sticker 100mm long and 50 mm high. Allowed curvature of the side panels is 20 mm vertically and 15 mm horizontally.

8.25 Solar panel cover: All teams should provide a suitable opaque cover which will completely shade the active area of their solar array for use at the starting position. The use of the cover is to assist the officials detect and eliminate any hidden illegal energy storage devices. The cover must be a flat sheet of rigid material capable of supporting sponsors logos. The use of flexible items such as clothing, towels or similar will not be accepted. If teams do not provide a suitable cover, the organizers will provide a cover of their choosing. The organizers will not be responsible for any problems created by the use of this cover.

8.26 School and Car Name: Each entry must have its school name (possibly abbreviated) and car name shown on the car in letters at least 10mm high and visible when racing. These can be attached to any part of the car, other than the side panels.