

## Making of an ‘all reason’ electric Vehicle

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### Abstract

Mahindra Reva (Earlier Reva Electric Car Company) has been pioneering the development of electric vehicles in India. The ‘decade long’ experience of putting over 4500 Reva cars on the road in 24 different countries has given Reva a unique ‘insider view’ into the changing context of mobility around the world. The evolving new mobility context uniquely places electric vehicles to signify disruptive changes in the automotive DNA. This also necessitates taking a fresh look at the philosophies of designing new generation electric vehicles.

The very reason for Electric vehicles to exist goes beyond the well articulated environmental advantages. These include making changes in every aspect, starting with the very way mobility is perceived to the way solutions are designed, manufactured and used. At Mahindra Reva, practice of these philosophies has been distilled into simple articulations of the 5Cs.

This paper presents the implementation of these philosophies in a new electric car developed for ‘all reasons’. The car is named e2O (E- To – Oh) and will be referred to as such in the rest of the paper.

*Keywords: E2O, Mahindra Reva, Electric Vehicle, Clean, Convenient, Connected, Clever, Cost effective.*

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## 1 Introduction

The philosophy of the new electric car is derived from several factors which include advances in technology, changing user requirements, increasing environment consciousness and an overall felt need for taking a radical new look at the future of mobility.



Fig 1: The 5Cs

This encompasses changes in several areas spanning vehicle usage patterns, user interactions with the car, eco system integration as also cost and convenience expectations.

Understanding of these changes has resulted in the visualisation and articulation of 5Cs for new electric vehicles. The 5Cs are : Clean, Convenient, Connected, Clever and Cost effective.

The following discussion covers the implementation of these philosophies

## 2 Clean

The philosophy of ‘clean’ is, quite obviously, interred into the very philosophy of EVs. The e2O extends beyond the product usage environment into the plant and processes used to make the vehicle.

The car is made in a newly built manufacturing plant specially designed with the ‘clean’ objective in mind. The plant has been accorded the ‘platinum rating’ which represents the ‘highest level’ by the Indian Green Building Council.

The manufacturing process is also designed to be ‘clean’ by use of lean processes use very little energy.

. Some of the other clean features of the manufacturing plant are:

- Use of natural lighting and ventilation
- Only LED lights wherever needed.
- Captive solar PV based electricity generation.
- Rain water harvesting and
- A solar EV parking lot.



Fig 2: The Platinum rated manufacturing plant

Every car coming out of this plant also receives it's first charge from 'renewable' energy sources (solar) which makes each car 'born green'.

Another important manifestation of the 'clean' philosophy is in the sun2car feature.

The E2O includes a solar charging option whereby the car can be directly charged using solar energy.



Fig 3: Sun2Car

Options for routing the solar energy to the AC charging port or directly to the batteries' DC terminals allow users to choose the best solution for their requirements.

The 'clean' philosophy is also carried to the process of manufacture. Some of the salient implementations of this philosophy are represented by

- Lean production processes requiring very little energy.
- Use of pre impregnated panels which eliminate the need for painting.

### 3 Convenient

Convenience of usage and 'hassle free ownership experience' are some of the guiding principles of the EV design. The E2O is designed to be 'convenient to drive', 'convenient to charge' and 'convenient to own & use'.

Convenience of access and entry are ensured by several innovative features that include

- A feature rich keyless entry supplemented by remote and 'telematic' lock/ unlock' features.
- No gearshifts - An easy to use PRNDL that directly links to the traction control system.
- A small turning radius that ensures ease of parking and manoeuvring
- A hill hold feature.
- Simple charge plug for home charging.

While these are some of the 'convenience features' available on the EV, the idea convenience extends to the whole experience of owning and using the car.

The powerful telematics capabilities of the car are used to enable 'remote service' and 'service at home' for car users. Continuous monitoring of car data over a telematics link enables the service centre to precisely assess the state of car's subsystems and estimate specific service needs. This helps adapt a 'minimally invasive' philosophy

to vehicle service and adds greatly to the convenience of ownership.



Fig 4: Quick2Charge

The convenience factor is also enhanced by the 'fast charge feature' which allows a direct DC charging of the car through a dedicated port.

## 4 Connected

One of the most important technology elements of the car is the 'connectivity'. Connectivity encompasses all interacting elements like the car, the owner, other cars and the larger social circle.

All cars are connected to a central server for data and command exchange.

This facilitates a host of functions that enable all the other Cs.

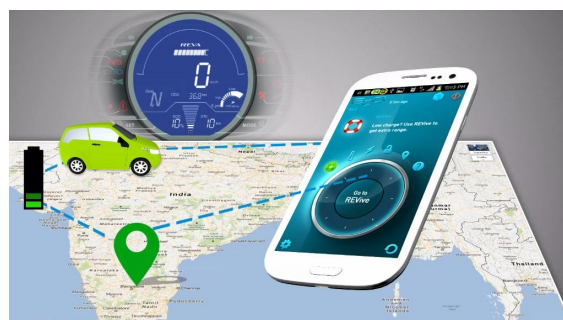


Fig 5: Connected

Some of the functions enabled by this connectivity include:

- Sending of 'specific commands' to the car. Eg; Door lock / unlock, Climate control ON/OFF.

- Generation of specific 'alerts' and transmission of the same from the car to the service station.
- Remote initiation of certain test / diagnostic sequences.
- Download of 'live' data to ascertain current condition of the car.
- Download of historical data stored 'on board'.

The connectivity is further manifest in connectivity to the energy eco system.

An important feature of the connectivity is a direct connection between the user and his car by means of a smartphone interface.

A user of the car can query and command the car through a smart phone.

The cars also effectively form a 'connected network' which enhances 'cumulative knowledge' of both the user community and the design community.

A further dimension of the connected car paradigm is the connectivity of the car's on board energy system to the immediate energy environment.

This means that the car can intelligently exchange energy with the local grid through custom designed 'external energy' converters.

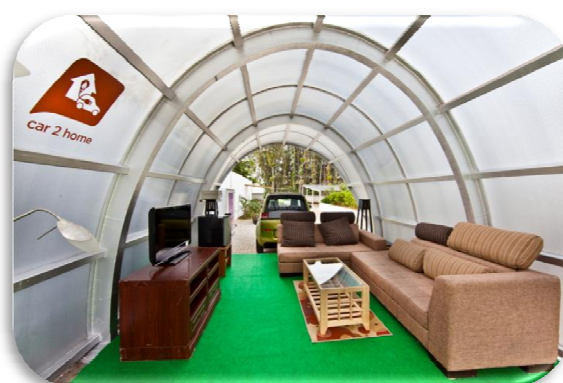


Fig 6: Car2Home

This features effectively transforms the car into a 'home power' back system which is useful in environments where the grid supply is not reliable.



Also, the Car2Home is a precursor to a ‘full grid connectivity’ which will be demanded when smartgrids become commonplace.

## 5 Clever

As can be seen by the above discussion ‘Clever’ is what the car is. The car and eco system are built with several layers of intelligence that constitute the ‘cleverness’ picture.

Each car is equipped with a high level of ‘on board

“intelligence” that handles all the functions of energy management and data transactions. This ‘embedded electronics’ also generates user information by analysing the data.

Some of the clever functions of the user interface include

- Display of drive efficiency
- Display of Distance to empty and Time to charge and
- A ‘message centre’

on an LCD IP cluster.



Fig 7: LCD Instrument Cluster

The ‘feature rich’ infotainment system also adds to the clever user experience by providing actual drive analysis and a host of car information displays, in addition to the conventional functions of standard infotainment systems.

The overall design philosophy uses flexible technology platforms that are future upgradeable and enable use of vehicles as sources of energy for home power as also grid stabilisation.

## 6 Cost Effective

One of the most important attributes of the design philosophies is to make electric vehicles

cost effective. This is a philosophy that runs through the whole area of work encompassing

- Product design
- Manufacturing process and
- Sales and service processes

This is reflected in the ‘right sizing’ of design, innovative processes that lead to ‘lowered acquisition costs’ as also maintenance costs.

## Authors

Chetan Maini founded Reva Electric Car company in India and currently serves as the Chief Executive of Mahindra Reva Electric Vehicles. Chetan Maini is recognised as one of the global pioneers of electric mobility and is the recipient of many international honours.. Chetan holds a bachelors degree in mechanical engineering from University of Michigan, USA and masters from Stanford University, USA.



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