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TOWARD A SUSTAINABLE MOBILITY: A SOLAR VEHICLE FOR A NEW QUALITY OF LIFE

Abstract: *The vehicular mobility causes 15% of greenhouse gases emission: one million tons of carbon anhydrite per hour. In addition, it produces CO, NOx, fine powders, carcinogenic and mutagenic elements: these substances will disappear in the presence of solar vehicles. And solar mobility would also mitigate indirect effects: fuel used to transport fuel, energy for the distillation of hydrocarbons, gas leaks, even fracking, explosions, rivers and oceans. In contrast, electric and hybrid vehicles do not allow this improvement in the quality of life. In almost all modern countries, the energy mix is strongly unbalanced towards fossil fuels: massive electrification would not make mobility sustainable, but rather risks worsening its effect on the environment by shifting the problem of emissions from cities to power plants. The Sun, indeed, can guarantee long-term sustainable mobility: for every circulating solar vehicle CO2 production is really zero. From July to today, our solar racing car has travelled 3000 km, avoiding to emit half a ton of CO2: reporting these data to a conventional use, each solar vehicle would avoid the release of 1.5 tons of CO2 per year: like planting 10 large trees for each month in our garden. This study describes how to transform a solar super-car into an ordinary vehicle for urban and everyday mobility.*

Keywords: *Solar Vehicles, Sustainable Mobility, Quadricycles, Low Emission, Green Houses Gasses*

1. Introduction

The expression "quality of life" has been used since 1980 with reference to signs indicative of urban decay and criminality, and therefore of diminishing quality of life.
In the years after 2000 the concept of quality of life was often compared to the concept of sustainable development, especially in relation to the growing awareness of the limited nature of energy reserves related to oil and coal and to the negative effects of many modern technologies on the natural environment and resources.
Public opinion is beginning to wonder if all technological advances are always convenient, or if, on the other hand, long-term damage will nullify its immediate advantages, and even threaten the quality of life of future generations.
In these terms, another interesting expression more and more related to the modern idea of quality of life is the “Seventh Generation Standard”. It proposes that the government should take into consideration the effect its decisions will have in the long term, up to

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the seventh generation, that is about a century later.

In the United States, for instance, the Seventh Generation Amendment was proposed to be included in the United States Constitution. In Canada, a similar amendment was proposed, called the Canada Well-Being Measurement Act. This strategy seems very difficult to put into practice because predicting the future is never easy. At the same, often these laws have significant impacts in social, economic and industrial terms. But the essence of these legislative proposals lies in the importance they give to sustainable development and to forecasts of damage to the environment, an irreplaceable heritage of all peoples.

A strategic sector in which an intervention in such direction would be necessary for sure and, maybe, not-postponable, is represented by the personal mobility.

According to the European Environmental Agency (EEA), the vehicular mobility causes 15% of greenhouse gases emission in Europe, roughly equivalent, in proportion, to 10^6 t/h of CO_2 worldwide. In addition, the fuel combustion produces further elements as CO, NOx, fine powders and other carcinogenic or mutagenic elements.

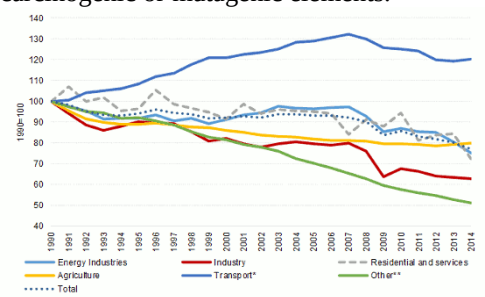

Figure 1. Greenhouse gases emission trends in Europe since 1990 (sources: EEA).

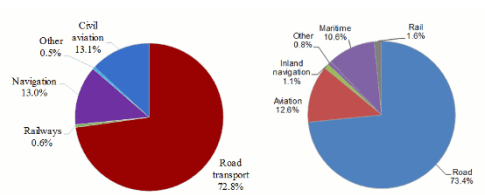

Figure 2. Greenhouse gas emissions (left) from transport by mode, compared with the transport energy demand (right) (sources: EEA, year 2014).

Finally, the vehicular transport is the main cause of air pollution in cities and it has not seen the same gradual decline in emissions as other sectors (Figs. 1 and 2).

At the same time, referring to the most common indicators used by national and international agencies in assessing the quality of life, the mobility surely represents a distinctive element, beyond the air pollution and environmental protection themselves, able to influence fundamental aspects as:

- Car ownership rate
- Urban congestion rate
- Accessibility to a parking lot
- Noise pollution
- Road accidents
- Subjective perception of security
- Injury rate outside work
- Quality of urban cleaning

together with a wide range of economic factors, since the relevance of the automotive industrial sectors and market segments in wealth creation and technology development.

In accordance with the EU strategy for a low-emission mobility, by *midcentury greenhouse gas emissions from transport will need to be at least 60% lower than in1990 and be firmly on the path towards zero*.

This is only a part of the overall strategy aiming to assure long terms benefits for European citizens and consumers *by delivering improvements in air quality, reductions in noise levels, lower congestion levels and improved safety*. Practically speaking, both national and supranational authorities are now looking for solutions able to guarantee less energy consumption and/or the use of alternative fuels, as a way for a long-term sustainable mobility.

It also means that the general interests are deeply focused on the developing technical

answers aiming at:

- Increasing the efficiency of the transport system;
- Encouraging the shift to lower emission transport modes;
- Speeding up the deployment of low-emission alternative energy for transport;
- Investigating the potentialities of advanced biofuels, electricity, hydrogen and renewable synthetic fuels;
- Removing obstacles to the electrification of transport.

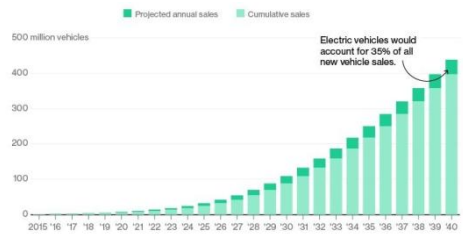

Figure 3. Expansion trend of electric vehicles (sources: Bloomber New Energiy Finance)

But, a strategy moving towards zero-emission vehicles may turn out to be a chimera, if not properly defined, as repeatedly emphasized.

Hydrogen used as a fuel represents, i.e., an interesting solution, but still technologically not ready and full of risks. Furthermore, the production of hydrogen, usually through water electrolysis, is a process that requires a lot of water and a lot of energy, representing an option only combined with nuclear energy. Otherwise, planned benefits will miss on the environment or the economy.

The same contest can be assumed for the electrical vehicles, a market segment in quick expansion. Electric powetrain is an effective and modern mobility solution and all the major car manufacturers are directed in that direction. Toyota, for instance, has made hybrid engines the main development line, while Tesla is all about powerful electric motors. Compared to traditional vehicles, electric vehicles offer greater energy efficiency with increasingly competitive performances (as speed and acceleration).

On the contrary, many people think through the electric mobility nothing more than an alibi respect to a real sustainable mobility.

Undoubtedly this technology reduces to zero the gas emissions into the environment in our cities. But it also acts moving the emissions to our suburbs, where the thermal and coal power plants are usually located. Then, the powertrain electrification can certainly characterize the future mobility in our planet, but it is far from demonstrating, globally, a zero impact at the moment.

2. Solar vehicles

A restricted, but emerging technology is represented by the solar vehicles. A solar car consists of an electrical powertrain supplied by photovoltaic panels: the vehicle is able to extract all the energy it needs from the Sun and this energy is directly used through electric motors that transform it into motion, without passing by a combustion.

Therefore, all emissions characterizing combustion engine vehicles will disappear in the presence of solar vehicles. And this exclusivity remains true regardless of the particular fuel with which the comparison is proposed: petrol, diesel, methane, alcohol and so on, but only solar vehicles are able to guarantee a real zero-emission policy, for real, both at local and global levels.

Thus, the solar mobility seems to represent the only strategy able to mitigate the indirect effects: fuel used to transport fuel, energy for the distillation of hydrocarbons, gas leaks, even fracking, explosions, rivers and oceans. It also acts reducing the need of a massive electrification and the risk related to the fact that currently all countries present an energy mix strongly unbalanced towards fossil

fuels.

Unfortunately the attention of carmakers for solar mobility seems quite far away in terms of large investment and production. Thus, at the moment, the largest part of solar vehicles crossing the roads were or are prototypes. Several hundreads of them are represented by racing single-seaters, designed with the sole purpose of racing at maximum speed possible in typical solar racing environments.

Figure 4. Single-seat solar car, made by the University of Bochum.

Made inside the top universities of the world (as Delft, Michigan, Tokyo, Sydney between others), these advanced prototypes represent an important step in demonstrating the future perspectives of the solar mobility.

The real leap in their quality is offered by the recent development of another category of solar vehicles: the multi-occupants. In short, these vehicles intend to represent a middle ground from the light racing single-seaters and electric minicars, already available on the market.

At the same time, they also present technical features, such as energy efficiency and battery autonomy, capable of making them particularly attractive for a future potential commercialization.

For instance, the solar car, recently designed and developed by the University of Bologna for the American Solar Challenge 2018, won this 2700 km competition travelling with four occupans at an average speed over 60 km/h. It is characterized by advanced design, light materials and efficient energy solutions.

Figure 5. Multi-occupant solar car, made by the University of Bologna.

3. Sustainable vehicles

Next step in the direction of a sustainable mobility would be the transformation of a performing prototype like this in an attractive car, suitable for the modern transport needs.

This goal must involve the design and implementation of a different and new:

- vehicle profile, able to reduce the overall dimensions;
- location for batteries increasing space and habitability;
- mechanics, more suited for a conventional driving;
- luggage compartment for the transport of goods;
- cabin interior for a better driving experience.

With very light carbon fiber reinforced structures, high-performance monocrystalline silicon panels, ultra-modern lithium batteries, motors incorporated directly in the wheels, this new vehicle will have all the design and construction features to ensure the highest performance in terms of efficiency and use of energy (as for the race prototype).

In addition, an aluminum roll cage, anti-intrusion systems, numerical crash tests and many other expedients will ensure the best target in terms of personal protection, a very critical aspect for the citycars.

At the same time, the design changes will permit to largely improve the vehicle

features toward a better drivability, usability and livability.

4. Conclusion

Only the Sun is able to guarantee a long-term sustainable mobility: for every circulating solar vehicle CO_2 production is really zero. Never benefits are not limited to this, involving multiple aspects of the quality of life: elimination of carcinogenic substances, noise reduction, economic savings and so on.

Consequently, the development of solutions capable of making solar mobility increasingly valid and efficient should represent a goal of primary interest. At this time, solar vehicles are mainly seen as a curious attraction, but their performances should attract much more than this. Our solar racing car, for instance, has travelled 3000 km with without emission. Reporting these data to a conventional mobility, each solar vehicle would avoid the release of 1.5 tons of CO_2 per year.

This results can be obtaind, according to the authors' opinion, transforming the solar extra-efficient prototypes, currently used inside solar races, in something more similar to the ordinary light vehicles, suitable for the urban and everyday mobility.

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