

## SOME ENERGY PROBLEMS OF VEHICLES; REALITY AND FICTION

Cezary Szczepaniak

*Instytut Pojazdów, Politechnika Łódzka, 90-924 Łódź, ul. S. Żeromskiego 116  
tel.: +46 42) 631-23-93, fax: +46 42 631-23-98, e-mail: instpoj@p.lodz.pl*

### **Abstract**

*The present paper presents different sources of energy. Energy of source, converted in vehicle engine, is transferred to the vehicle. Energy conversion, carried out in the engine, determines the kind of engine to be used in planetary and cosmic vehicles. All energy sources available on Earth are presented, supplying different forms of energy, used in planetary and cosmic vehicles. Energy of solar radiation is divided into two groups, used in land and cosmic vehicles. A method of using energy of solar radiation in planetary and cosmic vehicles, using solar batteries composed of photovoltaic cells, in which electric current is generated. Attention is drawn on hydrogen as source of chemical energy. Attention is drawn on the possibility of using nuclear energy in on-board reactor of rocket motor, using heat for heating working medium. It is emphasized that there are other energy sources in the Universe, the use of which is still subject to theoretical concepts. These are: energy of magnetic and electric fields and gravitational energy.*

**Keywords:** *transport, cosmic vehicles, energy sources, fuel cells*

Vehicles created by man can be divided into different categories, namely those moving on planets of the solar system: Earth, Moon, Mars, and those moving in cosmic space, within gravitational field of Earth, and also cosmic probes, moving beyond the field of terrestrial gravity. The first of them will be referred to as planetary vehicles, whereas the remaining ones will be referred to as cosmic vehicles [1].

Each of these vehicles can be considered as a kind of energy system, in which different forms of energy, as a result of conversion taking place most of the time in vehicle engine, are transformed into mechanical energy, appearing in form of kinetic energy of the vehicle, moving in universe space with velocity  $V$ .

This general statement is true, since one of the facts concerning the Universe is that within its observable part the same physics laws are in force.

All energy sources available on Earth, supplying different forms of energy used in planetary and cosmic vehicles, are shown in Fig. 1. As it is known, all sources available on Earth are derived from the energy of the Sun.

The energy of natural resources is understood as coal, petrol and gas beds that exist on Earth.

The theory of relativity has modified laws concerning kinetic energy, and has connected this energy with another kind of energy, namely energy of body mass. This energy does not depend on the nature of the body in question. „If we cause two bodies to disappear, then we will obtain certain amount of energy, according do Einstein’s formula:  $E = m C^2$ ” [2].

The energy of agricultural products is the source of energy produced from plants being grown, e.g. rape, sugar cane or others. This energy is successfully used in terrestrial vehicles.

The energy of solar radiation is divided into two groups. One group comprises the energy that can be obtained using radiation (light) pressure effect. The pressure exerted by solar radiation at the distance Earth – Sun is comprised within  $(4.7 - 9.4) \cdot 10^{-6} \text{ N/m}^2$ . In case of incidence of solar radiation on perfectly reflective surfaces, pressure value is approximately twice bigger than in case of totally absorbing (non-reflective) surface. Despite so small forces produced by light pressure,

solar sails could find practical application in cosmic vehicles, since resistance to motion in cosmic space close to Earth orbits are considerably smaller than forces produced by light pressure.

The other method of using the energy solar radiation in cosmic and planetary vehicles relates to solar batteries composed of photovoltaic cells, in which electric current is generated. This kind of energy use is well known, and solar batteries are commonly used as energy sources in cosmic vehicles. As far as terrestrial vehicles are concerned, attempts are known and made to use solar energy in vehicle drive systems. Figure 2 shows panels of solar cells of a vehicles supplied with energy produced in photovoltaic cells. Figure 3 shows MIR space station, and deployed panels of solar cells.

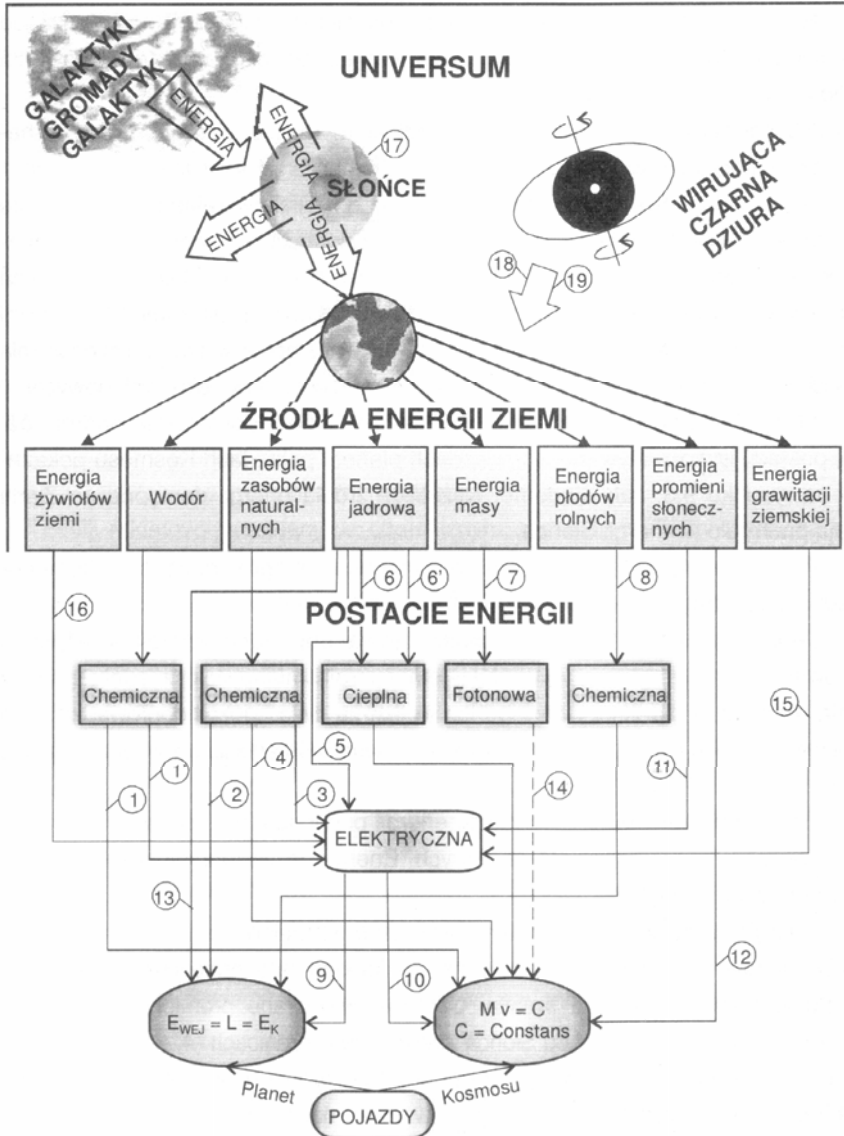


Fig. 1. Energy sources available on Earth, and sources of cosmic energy, still unavailable to vehicles of men and goods

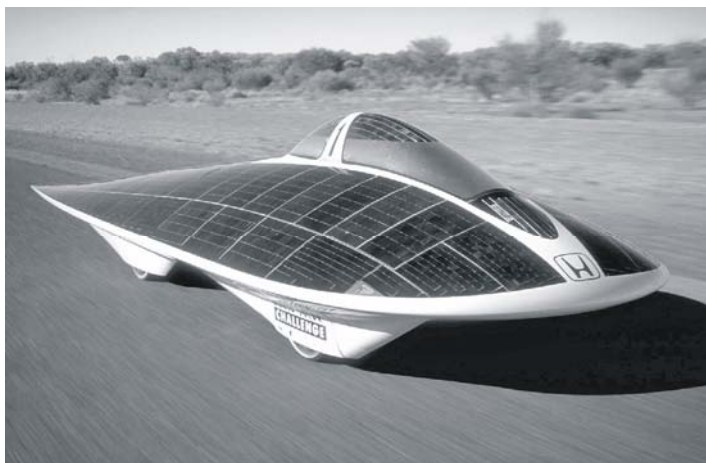
1. Transformation of chemical energy of hydrogen into kinetic energy in rocket motor
2. Transformation of hydrogen energy into electric energy in fuel cell
3. Transformation of chemical energy of natural resources of Earth: petrol, natural gas into kinetic energy in internal combustion engines of terrestrial vehicles
4. Transformation of chemical energy of natural resources of Earth: petrol, natural gas into electric energy in coal power plants
5. Other, besides hydrogen, fuels for rocket motors: e.g. lithium + boron
6. Nuclear energy transformed into electric energy in atomic power station
7. Nuclear energy transformed into heat in on-board nuclear reactor
8. Energy of radioactive isotopes transformed into heat in on-board motor
9. Energy of mass transformed into radiation energy in annihilation process
10. Chemical energy contained in agricultural products of Earth, e.g. in rape, beets, sugar cane and others, released in engines of terrestrial vehicles
11. Electric energy supplied to propulsion means of planetary vehicles. This energy comes from mains (terrestrial vehicles), batteries, generators of electric energy such as photovoltaic cells, fuel cells
12. Electric energy for supplying plasma rocket motors of cosmic vehicles
13. Solar energy transformed into electric energy in photovoltaic cells
14. Energy obtained as a result of pressure exerted by solar radiation. Solar sails
15. Nuclear energy produced in on-board nuclear reactors, e.g. of submarines
16. Photon energy used in cosmic vehicles
17. Energy of Earth gravitation transformed in electric energy, e.g. in water-power plant
18. Energy of Earth elements
19. Energy of Sun transferred to Earth
20. Gravitational energy of rotating fields and stationary black holes
21. Energy of electromagnetic fields of space

Hydrogen as source of chemical energy is well known and often used in vehicles, especially in cosmic ones, as fuel for main propulsion engines.

Hydrogen is also used as working medium in fuel cells, supplying electric energy used for propulsion of terrestrial vehicles - automobiles. In Japan there is produced a passenger car supplied with energy from hydrogen fuel cell, known as FCEV.

Nuclear energy in on-board nuclear reactor of rocket motor is converted into heat, heating a working medium, e.g. hydrogen to a temperature of 3000° C. This makes it possible to obtain three times bigger outlet velocity of working medium.

Energy produced as a result of radioactive decay of isotopes is used to increase the temperature of working medium. Appropriate selection of isotope material, located in special container – heater, allows to use the whole energy of ionizing radiation for heating of working medium e.g. hydrogen.



*Fig.2 Panels of solar cells of Honda automobile*

Photon energy can be obtained through matter annihilation. Annihilation is the conversion process of mass into conversion radiation energy by combination of matter and antimatter. Such a method of releasing energy is not only hypothetic. Elementary particles of antimatter have been obtained yet. The problem is, how to use the energy of radiation resulting from annihilation.

Energy forms: chemical and electric are energy forms supplied mainly to planetary vehicles and cosmic vehicle. Both energy forms are converted into mechanical – kinetic energy in vehicle engines.

In case of transformation of electric energy into mechanical energy, electric motors are also used. In terrestrial vehicles, the principle of functioning of electric motors supplied with energy from e.g. mains, batteries, energy generators such as fuel cells is commonly known. In electric rocket propulsion, methods of transformation of electric energy into mechanical energy can be generally divided into thermal, electrostatic and electromagnetic processes. Said processes have given names to electric motors of rockets: electro-thermal, ionic, plasma [1].

Energy of Earth elements is the energy of sea and ocean waves, and of winds. The problem of using the energy of sea waves has occupied human thoughts for many years. However, there is still no clear concept of possible conversion of this energy into a form transformable into effective work. Energy of winds is actually used in wind power plants. One can expect that acquiring electric energy from wind energy, and its storage and use for propulsion of terrestrial vehicles – automobiles – will become the future goal of quest for new energy sources. The solution of this problem is a matter of organization and technology, since the theoretical conversion scheme of wind energy into kinetic energy is known.

All the above discussion about energy sources concerns those sources only, that can be considered as existing and available on Earth. In space, one can expect other sources of energy. Although solar energy comes from the universe, it is the primordial source of all sources of energy existing on Earth. Because of that, solar energy will not be taken into consideration as energy of cosmic source. There are other energy sources in the universe, not available up to now, and their possible use is the subject of different theoretical concepts. These are: energy of magnetic and electric fields, and gravity energy.

When analyzing the motion in space of vehicles having a mass  $m_0$ , and velocity  $V$ , close to even a small fraction of order of magnitude to the velocity of light  $C$ , the relativistic mass  $m$  and kinetic energy of that mass  $E_K$  are equal to:

$$m = \frac{m_0}{\sqrt{1 - \left(\frac{V}{C}\right)^2}} \quad E_K = m_0 C^2 \left( \frac{1}{\sqrt{1 - (V/C)^2}} - 1 \right), \quad (1)$$

where:  $m_0$  – rest mass.

It has to be noted that when  $V \rightarrow 0$  then  $m \rightarrow m_0$  and  $E_K \rightarrow 0$ , and when  $V \rightarrow C$ , then  $m \rightarrow \infty$  and  $E_K \rightarrow \infty$ . From the above formulae it can be clearly seen that there is an increase of mass and energy resulting from increase of velocity  $V$ .

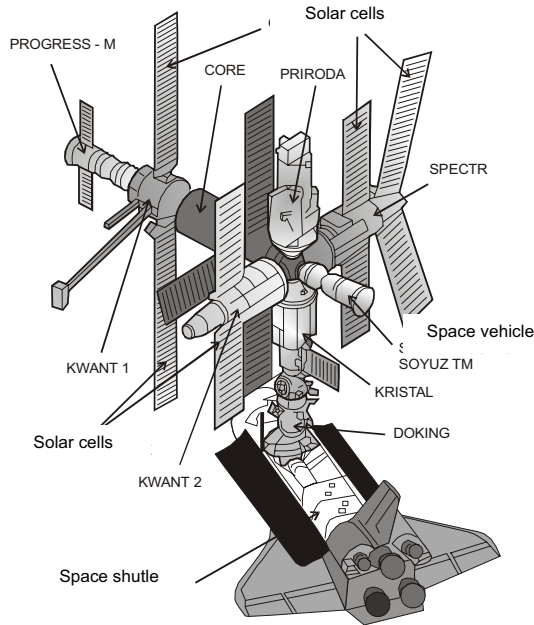
Since on Earth we meet up to now only velocities  $V \ll C$  (with the exception of accelerators of elementary particles), so there is only the question of kinetic rest energy -  $E = \frac{m_0 V^2}{2}$ .

Below are given some examples of energy consumption on a world scale.

In 1990, world consumption of energy was 361,16 Exa Joules, of which 40% were produced from petrol. In the same year, total energy consumption in the USA was 85,96 Exa Joules, of which 27% was consumed by transport. The above data are quoted after [3].

The rocket motor of a vehicle having initial mass of 2000 kg, carrying a mass of approximately 150 kg on an orbit 164 km from Earth surface, consumes approximately 0,22 TJ using 1850 kg of fuel – hydrogen – having 120 MJ/kg calorific value.

The above numbers have been quoted in order to demonstrate, how different can be the values of energy on Earth and in cosmic conditions.



*Fig.3. Space station "MIR" with all modules and space shuttle attached.*

Development of civilization results in increasing demand for energy. The present state of creation of information civilization indicates very clearly the intensive development of transport, including means of transport and motorization. These tasks of civilization development require not only a very stringent policy concerning natural environment preservation, but also new sources and new forms of energy. We will have to look for new energy sources also beyond our planet. Striving for energy sources existing in the universe seems to be an important path of quest for new energy sources.

Many cosmological studies deals with black holes and energy connected with these celestial bodies.

A black hole is a star contracted to minimum dimensions. Contraction – collapse of a star is the result of action of gravitational forces that are greater than forces resulting from internal pressure caused by nuclear reactions.

In certain phase of collapse of a star, matter concentration causes so strong gravitational effects, that the escape of light photons from star surface becomes impossible. The star then becomes invisible. On the other hand, the gravitation is still so small that it is unable to draw photons into the black hole. We could imagine that photons, created on star surface, swarm in thin,

spherical, membrane-like layer wrapping the black hole. Such a border of black hole, retaining all photons, is called horizon of events.

Black holes are the result of evolution of stars. It has to be noted that black holes created from non-rotating bodies now also do not rotate about any axis, whereas rotating black holes result from collapse of rotating bodies. Rotation of black holes has a strong impact on its gravitational field, and besides the mass and electric charge is one of its characteristic parameters. Fig. 4 shows a rotating black hole and describes its characteristic elements. Fig. 4 and description of black holes are given after Katty Ferguson study, see [4].

Ergosfera: obszar w którym nic nie może pozostać w spoczynku, wszystko wewnątrz wskazanego obszaru zostanie wprowadzone w ruch obrotowy w tym samym kierunku, w którym wiruje czarna dziura

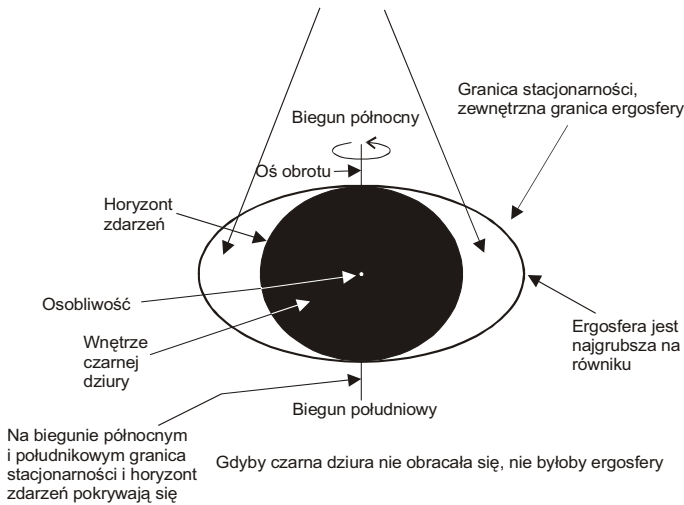


Fig. 4. Rotating black holes

As can be seen from descriptions in e.g. [4], [5] concerning black holes, two possibilities of using the energy of black holes are discussed. One example is given below.

Let's imagine that a vehicle (rocket) with engines switched off gets into the ergosphere of a rotating black hole. It moves inside it in the direction in conformity with its rotation. In the vicinity of the black hole engines are switched on again. It is possible to direct the motion of the rocket in such a manner, that combustion gases fall into the black hole. Then the rocket will accelerate and will be expelled off the ergosphere with enormous velocity, as fired from a catapult which is a gravitational vortex. This increase of velocity cannot be explained by engine run. The energy of the rocket would come from the vortex, i.e. from rotational energy of black hole. The rocket would receive the maximum energy from the black hole if its engines were switched on exactly on horizon surface. This extraordinary possibility of using the energy of black holes was predicted by Roger Penrose. If we had a map showing the location of rotating black holes in the whole Universe, we could use their energy on our "itinerary" for propulsion of our vehicle on that given stage of our voyage.

Another concept of obtaining energy from black holes consists in using the effect of super-radiation of electromagnetic waves. This phenomenon consists in an increase of intensity of beam of radiation passing through black hole vortex. The mechanism of this phenomenon resembles the phenomenon of increasing the energy of a body expelled off the ergosphere. Amplification factor of beam intensity depends on radiation nature, and is equal to 4,4% for electromagnetic waves, and 138% for gravitation waves.

Let's imagine the following device. A black hole is surrounded by a sphere reflecting electromagnetic waves. Inside this sphere there is a small amount of radiation meeting the condition required in super-radiation phenomenon. These waves fall on the black hole, are amplified and move away from it. After having reached the mirror sphere they are reflected again, and redirected to the black hole. They are amplified again. Amplification process is repeated several times and the energy of radiation increases dramatically.

If there is a hole in the sphere, amplified radiation partially gets to the outside. We have then a generator of electromagnetic radiation, transforming directly the energy of black holes.

If there is no hole in the sphere, radiation pressure will finally destroy the sphere. The system will explode. The explosion of such a device was called "small gravitation bomb", see [5]

We have to note that using this device is difficult, since up to now we cannot create black holes on Earth by strong constriction of matter.

"If I am allowed to dream (of course, I mean strictly scientific dreams), I can imagine that in a very distant future we will be able to master the production of very small black holes in space. They would store the energy used for their production, and then would irradiate it at a desired rate in form of particles with energy determined by the mass of the black hole. Then a black hole with a mass of  $10^{+15}$  g (i.e. the mass of an average mountain) would emit  $10^{+17}$  ergs per second for approximately 10 billion years", see [5]

Will these dreams about production of black holes, as almost unlimited sources of energy, become reality?

Positive answer this question will be given by future generations, and the pace of scientific discoveries allows to be optimist.

## **Bibliography**

- [1] Szczepaniak, C., Dychto, R., *Pojazdy w Kosmosie*, Wydawnictwo Naukowe Politechniki Łódzkiej, 2003.
- [2] Feynman Richard F., *Feynmana Wykłady z Fizyki* .t. 1Część 1. PWN, Warszawa 1968.
- [3] Riley, R. Q. *Alternative Cars in 21st Century*. Published by SAE Inc 400 Commonwealth Drive Warrendale PA 15096-001. USA.
- [4] Ferguson, K., *Czarne Dziury czyli Uwięzione Światło*. Wydawnictwo Prószyński i S-ka, 1999.
- [5] Nowikow, J., *Czarne Dziury - Wszechświat*. Wydawnictwo Prószyński i S-ka, 1995.

