

NOVE PARADIGME U KORIŠTENJU ALTERNATIVNIH GORIVA

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Undergraduate thesis / Završni rad

2017

Degree Grantor / Ustanova koja je dodijelila akademski / stručni stupanj: **Polytechnic of Šibenik / Veleučilište u Šibeniku**

Permanent link / Trajna poveznica: <https://urn.nsk.hr/urn:nbn:hr:143:075501>

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Download date / Datum preuzimanja: **2025-03-11**

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VELEUČILIŠTE U ŠIBENIKU
PROMETNI ODJEL
PREDDIPLOMSKI STRUČNI STUDIJ PROMET

Petar Tanfara

NEW PARADIGMS IN THE USAGE OF ALTERNATIIVE FUELS

Završni rad

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Šibenik, veljača 2017.

TEMLJNA DOKUMENTACIJSKA KARTICA
Veleučilište u Šibeniku
Odjel Promet
Preddiplomski stručni studij prometa

Završni rad

NOVE PARADIGME U KORIŠTENJU ALTERNATIVNIH GORIVA

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Sažetak rada:

Alternativna goriva su neophodna za poboljšanje kvalitete zraka, te u smanjenju ovisnosti o fosilnim gorivima. Oni pomažu smanjiti emisiju stakleničkih plinova, ali kao što svi znamo, financijske prepreke sprječavaju globalno širenje takve tehnologije. Zato vlade diljem svijeta sufinanciraju velike projekte, pa čak i jednostavne u domaćinstvima, u stvaranju energije iz obnovljivih izvora, iz energije vjetra, solarne energije, itd. Potaknut nestabilnim cijenama nafte, potrošnjom i klimatskim promjenama kao posljedicom visokih emisija stakleničkih plinova, sektor prijevoza je pokazao veliki interes za prevladavanje tih prepreka. Biogoriva imaju potencijal da zamijene naftu na globalnoj razini. Prva generacija biogoriva se proizvodi od šećera, druga generacija od poljoprivrednih otpadaka, a ne od usjeva koji ujedno mogu biti hrana, što znači da su takva goriva puno više održiva i imaju manji utjecaj na proizvodnju hrane. Biodizel je alternativa konvencionalnom dizelu, izrađen od obnovljivih izvora, kao što su nejestivo biljno ulje, a male preinake motora ili nikakve su potrebne za njegovu primjenu. Postoje dvije tvrtke u Hrvatskoj koje proizvode električna vozila, a obje se nalaze na području Zagreba. Jedna od tvrtki je Rimac, koji je stvorio remek djelo među vozilima, Concept one. No prosječni potrošač si ne može priuštiti takvo vozilo. Glavni cilj ovog rada je ukazati na posljedice prekomjernog korištenja fosilnih goriva, te na pozitivne i negativne strane alternativnih goriva.

(34 stranice / 12 slika / 4 tablice / 103 literaturna navoda / jezik izvornika: Engleski)

Rad je pohranjen u: Knjižnici Veleučilišta u Šibeniku

Ključne riječi: alternativna goriva, obnovljiva energija, solarna, biomasa, valovi, Rimac

Mentor: mr.sc. Ivana Kardum Goleš, pred.

Rad je prihvaćen za obranu:

BASIC DOCUMENTATION CARD

Polytechnic of Šibenik
Department of Traffic
Professional Undergraduate Studies of Traffic

Final paper

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Abstract:

Alternate fuels are essential in improving air quality, and in decreasing dependence on fossil fuels. They help reduce emission of the greenhouse gases, but as we all know, financial barriers are preventing the global spread of such technology. That is why governments all over the world are co-financing large-scale projects, and even the simple domestic projects in creating renewable energy, from wind power, solar energy, etc. Driven by unstable oil prices, consumption, and climate changes as result of high emissions of greenhouse gases, the sector of transportation has shown a great interest in overcoming these barriers. Biofuels have a potential to replace petroleum fuels on a global scale. The first generation biofuels are produced from sugar, the second generation is produced from agricultural wastes, and not from food crops, meaning it is much more sustainable and has a lower impact on food production. Biodiesel is an alternative to conventional diesel, made from renewable resources such as non edible vegetable oils, and small engine modifications or none are required for the usage of biodiesel. There are two companies in Croatia that manufacture electric vehicles and both are located in the area of Zagreb. One of the companies is Rimac, which created state of the art vehicle, Concept one. But the average consumer can not afford such vehicles. Therefore, the aim of this thesis is to point out the consequences of excessive use of fossil fuels, and the pros and cons of alternative fuels.

(34 pages / 12 Figures / 4 tables / 103 references / original language English)

Paper deposited in: Polytechnic of Sibenik' library

Key words: alternate fuels, renewable energy, solar, biomass, wave, rimac,

Supervisor: mr.sc. Ivana Kardum Goleš, lecturer

Paper accepted:

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1. FOREWORD

Since the beginning of time, we, the humans have been trying to come up with different ways of making our lives easier. With many obstacles that nature created, humans had to find a way to conquer them, thus improvising floating objects, wheels, etc. First ever means of transport were, of course, our own feet, but we soon learned how to use animals to transport objects, goods and ourselves. Then came in the internal combustion engine, and with it the need of extracting oil from the depths of the earth. Of course with the term of extracting oil, there were various interest groups, that exist till this very day, and even more conspiracy theories, but I do not want to alienate from the subject. Environmentalists say that everything we extract from the earth has its own unique purpose, and that we do not know what the consequences are, nor will be, in overusing fossil fuels.

It takes thousands of years for animal remains to fall into the depths of the ocean, mix with mud, sand and other molecules, to finally create oil. How much oil do we have left remains a mystery, but on that issue, scientists have found ways to replace the oil with other energy sources, and in this work I will elaborate various types of alternate fuels, their usage and their environmental impact.

2. RENEWABLE ENERGY

Renewable energy is the energy that comes from natural sources like the wind, sunlight, rain and waves. In general terms renewable energy is used in the high scale projects, but that does not exclude the usage of it for small villages or even in domestic use. When the house or a farm is far away from the energy network, it's only option is to have windmills or solar panels to power the certain appliances. Renewable energy is named as it is named because it is environment friendly and everlasting, meaning it can not diminish.

2.1. Wind power

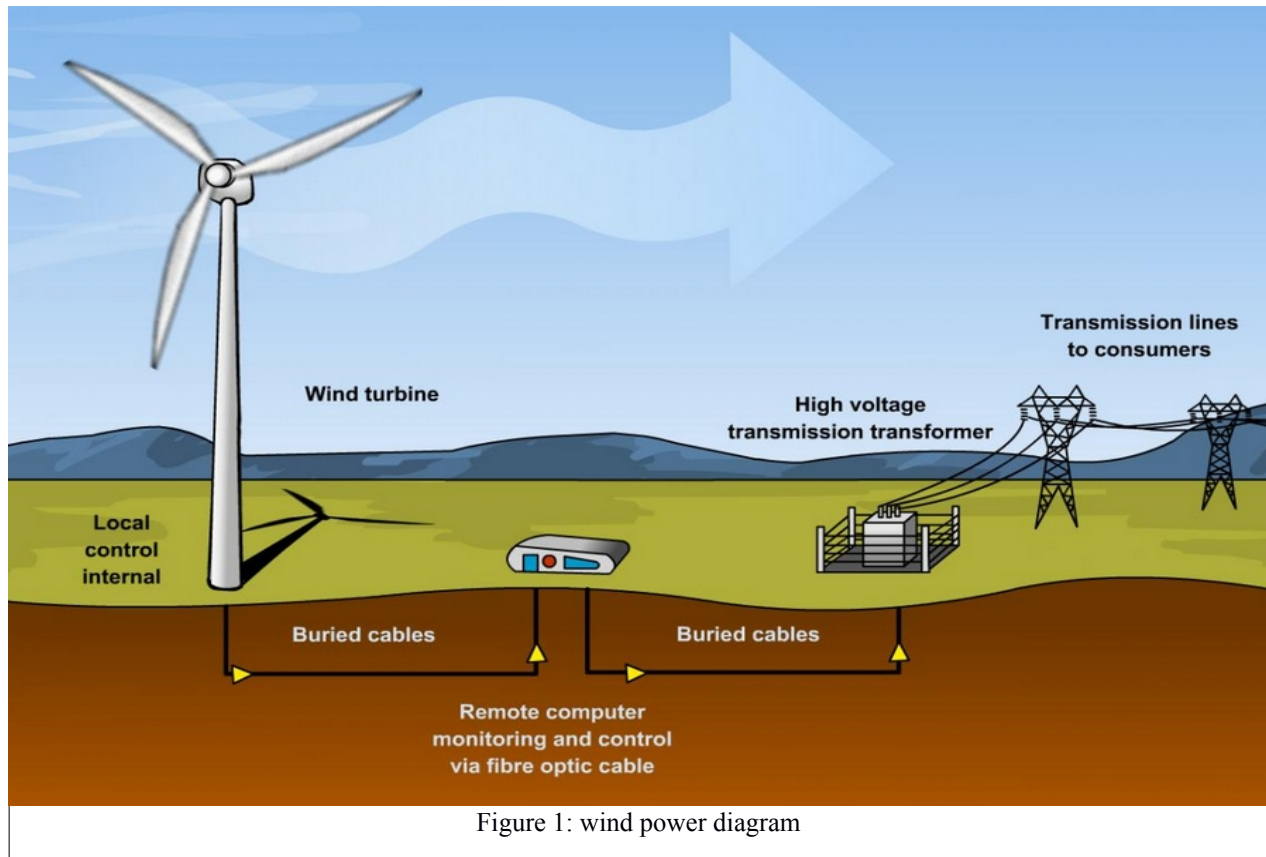
The wind has been an energy source for a very long time now. It is said that it has propelled boats along the Nile River since 5000 B.C. and by 200 B.C. windmills were pumping water for the crops¹. The energy in the wind can be used by making a tower that stands high above the sea level, with a large propeller, that goes round and round as the wind blows, and a turbine that converts wind's kinetic energy into electrical power. By building more of these windmills, we can produce more power. The most suitable areas for building these wind turbines are tops of the hills, open fields, and various places where the wind is strong and continuous. There are also some disadvantages regarding wind power, as the turbines can be harmful to birds and other creatures, therefore they are a threat to wildlife. According to the current literature somewhere between 140,000 and 328,000 birds die each year from collisions with wind turbines². And they need to be dug deep into the earth, thus having negative effects on the underground habitats. Another disadvantages is that the wind cannot be predicted, and that is why companies study the area before building. Wind turbines also create a lot of noise, that is why they are not built near residential areas. According to a 2009 study, a network of land-based, 2.5-megawatt wind turbines in rural areas operating at just 20% of their rated capacity could supply 40 times the current worldwide consumption of energy³. But Dr Robert Lyman says “To meet 8% of the U.K.’s energy needs, one would have to build 44,000 offshore wind turbines; these would have an area of 13,000 square miles, which would fill the entire 3000 km coastline of the U.K. with a strip 4 km

1<http://windenergyfoundation.org/about-wind-energy/history/> 12.09.2016.

2<http://www.smithsonianmag.com/smart-news/how-many-birds-do-wind-turbines-really-kill-180948154/> 12.09.2016

3<http://www.epa.gov/greenpower/gpmarket/index.htm>. 23.11. 2016.

wide²⁴.



Source: <http://www.hydro.com.au/system/files/images/Flash/windfarm-static.jpg>

2.2 Hydro power

Hydropower plants capture the energy of falling water to generate electricity. The power is then used for direct mechanical purposes or, more frequently, for generating electricity. Other sources of water power are waves and tides. Hydropower is by far the most established and widely used renewable resource for electricity generation and commercial investment. Hydropower provided about 16.6% (3,940 TWh) of total global electricity generation in 2015 (70% of renewable generation)⁵. The UK generated in the 2011. about 1.5% of its electricity from hydroelectric schemes⁶. The main disadvantages of hydro-power are associated with effects other than the generating equipment,

⁴ <https://friendsofsciencecalgary.wordpress.com/page/8/> 23.11.2016.

⁵ <https://www.wiseinternational.org/nuclear.../825/renewables-2016-global-status-report> 05.10.2016.

⁶ <https://www.gov.uk/guidance/harnessing-hydroelectric-power> 05.10.2016.

particularly for large systems⁷. These include possible adverse environmental impact, effect on fish, silting of dams, corrosion of turbines in certain water conditions, social impact of displacement of people from the reservoir site, loss of potentially productive land, and relatively large capital costs compared with those of fossil power stations. Although the ideal turbine efficiency is 100%, in practice values range from 50% for small units to 90% for accurately machined large commercial systems.

2.2.1. Wave energy

The history of wave energy is old. It is said that in the 1799 when Girard and his son presented a proposal for the first time, to have patent rights to use this power⁸. Then in 1910 in Paris again Bochaux Praceique asked government to use this power to light his house⁹. Scientist realized its importance but it was in 1973 when the growing oil crises arouse the desire to find alternative sources of power. Many research scientists from renowned universities started working on this project, however this development fell drastically in 1980's when the problem of oil was resolved.¹⁰

The ocean's waves harvest great amounts of raw energy and represent the single largest unexploited source of renewable energy today. Converted into electricity, wave energy could potentially satisfy up to one tenth of current global power demands. Waves are created when the wind glides on the oceans surface. Even the small ripples on the surface push waves, making it to grow and travel thousands of miles, until the energy scatters on the shore. The best part is, the states of the sea can be predicted up to 48 hours in advance¹¹, and the waves have high power density, making them attractive for electricity generation. Basically the energy from the wind is transferred into the sea, creating waves, which travel to the collection of the machines in the same location, that flex and bend as the waves pass, generating the wave power electricity¹². That collection of machines is called a wave farm. The biggest disadvantage of this type of energy harvest is that it's suitable only to certain locations. The movement of the large machines creates a lot of noise, and it disturbs the sea life, with a possibility to spill various chemicals that are used on wave energy¹³. Wave farms have to be placed near the coastline, near the cities, thus disturbing vessels. The performance drops significantly during rough weather.

7 Mervyn Richardson: Risk reduction: Chemicals and energy into the 21st Century, 2002, page 207

8<http://renewable-solarenergy.com/wave-power-energy.html> 03.03.2016

9<http://www.agreenroadjournal.com/2014/04/wave-powered-kinetic-energy-production.html> 03,03.2016.

10<http://renewable-solarenergy.com/wave-power-energy.html> 03.03.2016.

11<http://theconversation.com/why-ocean-energy-needs-a-cyberinfrastructure-to-thrive-37087> 20.04.2016.

12<http://www.alternative-energy-news.info/technology/hydro/wave-power/> 20.04.2016.

13http://www.conserve-energy-future.com/advantages_disadvantages_waveenergy.php 20.04.2016.

2.2.2. Tidal range power

The level of water in the large oceans of the Earth rises and falls according to predictable patterns. Sites of large range give the greatest potential for tidal power, but other vital factors are the need for the power, such as costs and benefits from the construction¹⁴. Tidal current is likely to be attractive for power generation only where it is enhanced in speed by water movement in straights between islands and mainland, or between relatively large islands. The harnessing of tidal range power has been used for small mechanical power devices, such as in medieval England and in China. The best known large-scale electricity generating system is the 240MWe ‘La Rance’ system at an estuary into the Gulf of St Malo in Brittany, France, which has operated reliably since 1967¹⁵. The major disadvantages are, there are very few ideal locations for construction of plant and they too are localized to coastal regions only, and may be distant from the locations that demand for power. This technology is still not cost effective and more technological advancements are required to make it commercially viable.

2.3. Solar energy

We all have used magnifying glass, that was invented in 1250, to burn ants, so I am sure most kids back then did the same, meaning we do not actually know when was the first time someone transformed Sun beams into energy. The Greek scientist, Archimedes, which we all know for his famous law that comes in handy as an excuse during holidays, when we all stuff ourselves, saying we are not as heavy in water; when a body is inserted into liquid, it is relatively lighter by the amount of liquid it forces out, used the reflectiveness of bronze shields to focus sunlight towards wooden ships, thus setting them on fire. Although, there is no proof of this accomplishment, the Greek navy recreated this experiment in the 1973, and successfully set the fire to a wooden boat that was distanced 50 meters¹⁶.

In the 1760s Swiss naturalist Horace de Saussure, said “It is a known fact, and a fact that has probably been known for a long time, that a room, a carriage, or any other place is hotter when the rays of the sun pass through glass¹⁷”. Later on he built a rectangular box, with a glass covered top, and placed two smaller boxes inside¹⁸. When it was exposed to light, the bottom box heated to 9 degrees Celsius above

14John Twidell, Tony Weir: Renewable energy resources, Second edition 2005, page 448

15 ibid, page 430

16http://www.unmuseum.org/burning_mirror.html 20.11.2016.

17<http://heliotactic.github.io/articles/dessaussure/> 20.11.2016.

18<http://solarcooking.org/saussure.htm> 23.11.2016.

the boiling point of water. Meaning it heated up to 109 degrees Celsius. Sunshine penetrated the glass covers. The black inner lining absorbed the sunlight and converted it into heat. Though clear glass allows the rays of the sun to easily enter through it, it prevents heat from doing the same. As the glass trapped the solar heat in the box, it heated up. Its inventor realized that someday the hot box might have important practical applications, as “it is quite small, inexpensive and easy to make.” Indeed, the hot box has become the prototype for the solar collectors that have provided sun-heated water to millions since 1892¹⁹.

During 19th century, inventors and entrepreneurs in Europe and the U.S. developed solar energy technologies that would form the basis of modern designs. In 1839, nineteen-year-old Edmund Becquerel, a French experimental physicist, discovered the photovoltaic effect while experimenting with an electrolytic cell made up of two metal electrodes. Becquerel found that certain materials would produce small amounts of electric current when exposed to light²⁰. According to well-established measurements, the average power density of solar radiation just outside the atmosphere of the Earth is 1366 W/m², widely known as the solar constant. Not all solar radiation falls on Earth’s atmosphere reaches the ground. About 30% of solar radiation is reflected into space. About 20% of solar radiation is absorbed by clouds and molecules in the air. About three quarters of the surface of Earth is water. However, even if only 10% of total solar radiation is utilizable, 0.1% of it can power the entire world. The total power of solar radiation reaching Earth is 5,460,000 EJ/year. The current annual consumption of fossil fuel energy is approximately 300 EJ²¹.

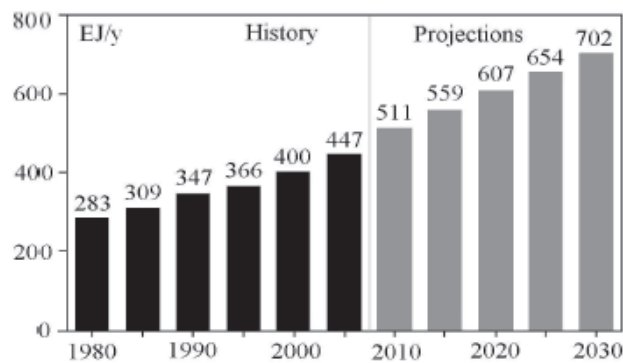


Figure 2: World marketed energy consumption, 1980–2030.

Source: Energy Information Administration (EIA), official energy statistics from U.S. government

¹⁹http://www.californiasolarcenter.org/history_solarthermal.html

²⁰W.W. Anderson and Y.G. Chai, “Becquerel effect solar cell”, Energy Conversion, vol.15, Issues 3-4, 1976, page 85

²¹C. Julian Chen: Physics of Solar Energy, 2011, page 2

Total proved reserves of fossil fuel is approximately 1.4% of the solar energy that reaches the surface of Earth each year.

| Item | Quantity | Unit Energy | Energy (EJ) |
|-------------------|--------------------------------------|------------------------------------|-------------|
| Crude oil | 1.65×10^{11} tons | 4.2×10^{10} J/ton | 6,930 |
| Natural gas | 1.81×10^{14} m ³ | 3.6×10^7 J/m ³ | 6,500 |
| High-quality coal | 4.9×10^{11} tons | 3.1×10^{10} J/ton | 15,000 |
| Low-quality coal | 4.3×10^{11} tons | 1.9×10^{10} J/ton | 8,200 |
| Total | | | 36,600 |

Figure 3: Proved Resources of Various Fossil Fuels

Source: BP Statistical Review of World Energy, June 2007, British Petroleum.

Using photovoltaic cells, energy from the sun can be converted into electricity that we can use every day²². Silicon is one of many materials that can be used in a photovoltaic cell to convert the sun's energy into electricity. As sunlight strikes a silicon solar cell the electricity generated can be used to power a motor. A lens can be used to collect a large amount of light and concentrate it to hit a smaller solar cell. The sun is a great natural resource of energy. On a sunny day, the sun provides approximately 1000 watts of power per square meter (W/m²)²³. This energy from the sun can be used in many ways—from passive solar heating to day-lighting; from heating water for steam turbines to directly generating electricity through photovoltaic devices. The more light that touches the device, the more power will be generated. The power provided by the solar cell depends both on this current that is generated and the voltage that is produced on the device from the light hitting it. Solar energy has the edge over all renewable energy sources²⁴. Other renewable sources have many constraints. Wind is either weather specific or its limited to coastal regions. Waves are naturally limited to regions near the sea or the ocean, etc. But the sun is everywhere, its free, and it cannot be stopped from traveling to earth. It can also be used in any country in the world, developed or underdeveloped. There are no constraints in using it. Solar energy is considered the most environmental friendly power source²⁵. The biggest disadvantage of solar power is it cannot be created during the night²⁶. The power is reduced during the cloudy days, but it is still produced. When the sun is not on the optimal angle, it also reduces

22<http://www.nwwindandsolar.com/solar-power-in-seattle-and-the-northwest/how-do-solar-systems-produce-energy/> 05.10.2016

23<https://ag.tennessee.edu/solar/Pages/What%20Is%20Solar%20Energy/Sun%27s%20Energy.aspx> 05.01.2017

24<http://news.energysage.com/solar-energy-news-renewable-energys-edge-over-natural-gas/> 13.01.2017

25<http://alternativeenergy.procon.org/view.answers.php?questionID=001274> 26.01.2017

26<https://cleantechnica.com/2013/10/08/advantages-disadvantages-solar-power/> 26.01.2017.

energy production, meaning the solar panels should face directly at the sun. Most efficient solar cells convert from 15 up to 20% of the sun's rays²⁷, but after installing them, they create free energy.

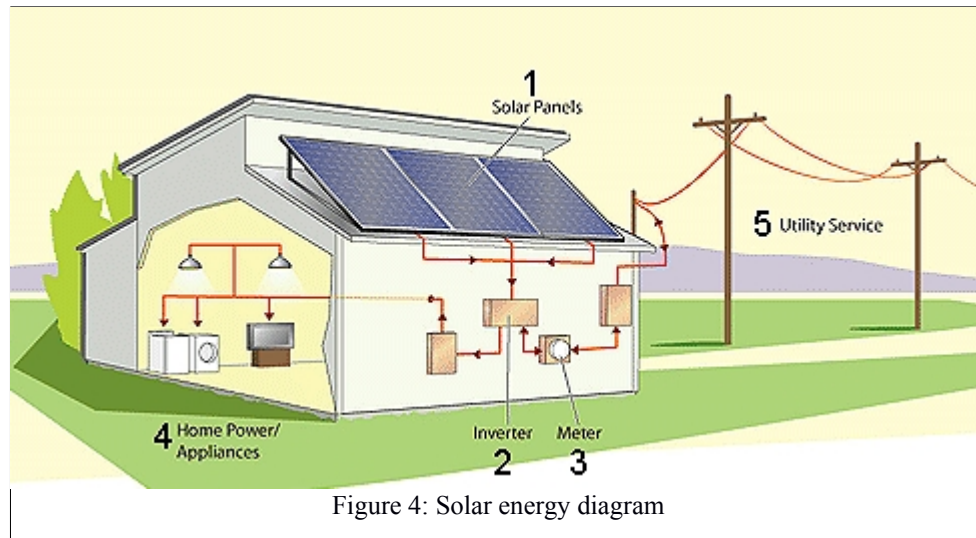


Figure 4: Solar energy diagram

Source: http://sroeco.com/solar/wp-content/uploads/2009/05/how_solar_works_en.png

2.4. Waste to energy

We first saw this concept back in the 1995, where we laughed at Dr. Emmet Brown, a fictional character, from the Back to the future trilogy, where he powered his time traveling De Lorean, filling it with banana peels and trash can ingredients, but now we are not laughing anymore. We humans need energy to perform our every day activities, thus needing food, water, oxygen. After we consume these resources, there is a lot of waste material, that can be harmful if it is not disposed properly. With the everlasting grow of population, the waste not only needs to be disposed properly, but also has some advantages in waste renewable energy²⁸. The concept of recycling is almost the same as photosynthesis. After the plants give away their final breath, they are used as a compost to feed the remaining living plants, so the ingredients which we first utilized as an energy source after becoming waste can be renewed to use it profitably. The concept of extracting energy from waste is quite attractive, but burning waste is never safe, as it produces great amounts of carbon dioxide, which is bad for the environment. One of the methods of waste conversion into energy source is Thermo-chemical

²⁷<http://news.mit.edu/2016/new-solar-cell-more-efficient-costs-less-its-counterparts-0829> 26.01.2017.

²⁸<http://renewable-solarenergy.com/waste-renewable-energy.html> 26.01.2017

method²⁹, where the waste material is burned in the confined area to store heat which is later used as a source of energy. The other method is known as Biochemical method, where the waste produces bio gas, that is later used as heat and electricity³⁰. The third method is called pellet, known as the physicochemical method, where the waste is buried and then burned underground, after what the waste is turned into fuel pallets, which are better than coal. This technology is continually under development. However there is always a debate about the effects on health of incineration and its by-products. The United Kingdom and European Union have strict controls on emissions and all emissions and residues are monitored closely in the UK by the government's environment agency.

2.4.1. Plasma gasification

Plasma is an ionized gas that is formed when an electrical discharge passes through a gas. The resultant flash from lightning is an example of plasma found in nature. Plasma torches and arcs convert electrical energy into intense thermal (heat) energy. Plasma torches and arcs can generate temperatures up to 5,500 degrees Celsius. Plasma technologies have been used for over 30 years in a variety of industries, including the chemical and metals industries. Historically, the primary use of this technology has been to safely decompose and destroy hazardous wastes, as well as to melt ash from mass-burn incinerators into a safe, non-leachable slag.³¹

2.5. Pedal renewable energy

Pedal renewable energy means indirectly taking power away from human beings.³² It is the transfer of energy from a human source through the usage of a foot pedal and a crank system. This system has been used in over hundreds of years to propel bicycles. The power box is a pedal generator that generates electricity while pedaling. Perhaps no one, besides Lance Armstrong, probably will not produce enough energy, to power the entire house, the pedal powered generators can play a very useful role in homes. Pedal power energy is renewable as well as sustainable³³. As it is needed as long there is human existence on this planet and the ultimate source is the human himself. It is cost effective, and emission

29<http://www.alternative-energy-news.info/waste-renewable-energy-source/> 26.01.2017.

30<https://www.google.com/patents/US3755156> 30.01.2017.

31<http://www.gasification-syngas.org/technology/plasma-gasification/> 30.01.2017.

32<http://renewable-solarenergy.com/pedal-renewable-energy.html> 30.01.2017.

33<http://renewable-solarenergy.com/pedal-renewable-energy.html> 30.01.2017.

of carbon is zero, it also creates a healthy workout routine.

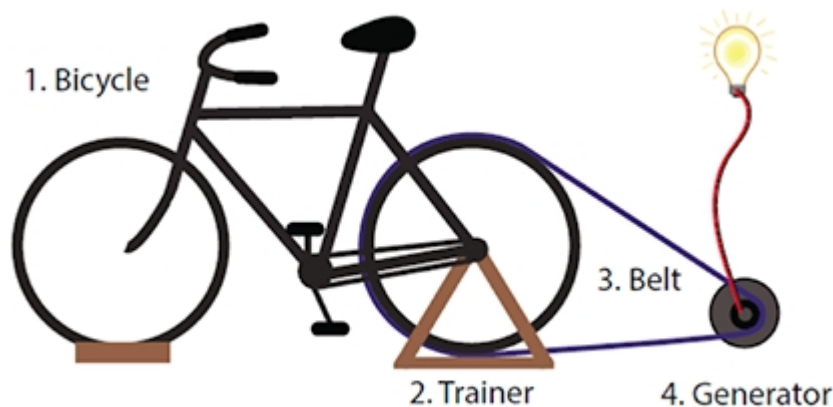


Figure 5: Pedal renewable energy

Source: http://nau.edu/uploadedImages/Academic/CEFNS/Centers-Institutes/Folder_Templates/_Media/bike-diagram-470.png

2.6 Chemical energy

The energy that results during a chemical reaction is called chemical energy³⁴. Chemical Energy is energy stored in the bonds of chemical compounds (atoms and molecules)³⁵. When chemical energy is released, the substance from which the energy came is often changed into an entirely different substance³⁶. Many objects store and release chemical energy, such as: batteries, wood, food, air bags.

2.7. Nuclear energy

Since the beginning of the industrial revolution, the energy demand has been increasing rapidly every year. Most of these demands are satisfied with the combustion of fossil fuels, but some of the not so recent accidents, like the one in Fukushima nuclear plants, as well as others, like the one in the Three

³⁴http://www.softschools.com/facts/energy/chemical_energy_facts/391/ 28.12.2016

³⁵<http://www.eschooltoday.com/energy/kinds-of-energy/what-is-chemical-energy.html> 28.12.2016.

³⁶<http://examples.yourdictionary.com/examples-of-chemical-energy.html> 28.12.2016.

Mile Island³⁷, has made nuclear power lose its eagerness that it once had. Because of the unstable prices, as well as the harmful effects on the environment, caused by fossil fuels, scientist, an others are looking for ways to replace our need for fossil fuels. While some pre mentioned renewables, such as solar, and wind energy, have proven to be relatively worthy replacements, they are still miles away from completely meeting our needs. Nuclear power plants usually run uranium, that is found in the earth's crust, at a depth round 550 – 600 meters³⁸, and we have all heard about it in the movies. Uranium was also used in the atomic bombs that went off in the World War two³⁹. Uranium is mined, then formed into pellets that are placed in the reactor, then the atoms of the reactor undergo a control chain reaction which emits heat. Pressurized water around the reactor vessel is heated and circulated through pipes in steam generator which produces water vapor that spins turbine attached to a generator⁴⁰. After leaving the turbine, steam is condensed so that the cycle can continue. There are number of benefits of using nuclear energy, such as lack of carbon emissions, the ability to create he amount of energy. Because there are no fossil fuels used in the consumption of uranium, direct carbon emissions are non existent, and indirect emissions are limited to the construction of facilities. The main concerns are safety, waste disposal and cost. It is considered to be the safest of all energy sources, because there were no direct deaths reported in either Fukishima meltdown or Three Mile Island. But it can also force the people out of their homes and change the soil around them for a very long time, thus making it unstable for the animals and their natural habitats. A single uranium fuel pellet, that is the size of a fingertip, which is shown on the Figure 6, contains as much energy as 500 cubic meters of natural gas, 800 kilograms of coal or 560 liters of oil⁴¹.

37<http://www.world-nuclear.org/information-library/safety-and-security/safety-of-plants/safety-of-nuclear-power-reactors.aspx> 08.08.2016

38<http://www.world-nuclear.org/information-library/nuclear-fuel-cycle/mining-of-uranium/uranium-mining-overview.aspx> 08.08. 2016.

39<http://www.livescience.com/45509-hiroshima-nagasaki-atomic-bomb.html> 09.08.2016.

40www.tayloredge.com/periodic/trivia/ReactorConcepts.pdf 21.11. 2016.

41<https://www.nei.org/Knowledge-Center/Nuclear-Fuel-Processes> 21.11.2016.



Figure 6: Uranium pallet

Source: https://planetforwardgw.files.wordpress.com/2011/10/carbon_smart_1.jpg

2.8. Electric energy

Electric energy can be either renewable or non-renewable, depending on the resource that creates it. Electricity is not a naturally occurring energy phenomenon like oil from the ground, but it must be created and refined at electrical power plants using other energy sources. The natural resources that create electric energy are usually non-renewable, with some exceptions. Electricity is usually produced by burning fossil fuels in processing plants, which produce electricity in exchange for the fuel burned. The coal, oil or gasoline that powers the electricity-producing turbines is derived from non-renewable, limited energy sources. However, sources such as solar, wind or geothermal power can also create electricity. These perpetual forces are always renewable. In the year 2014, electricity for transportation purposes was mainly used in the rail sector (76% of the final energy use in transport) where 54% of the European railway lines are electrified⁴². Electric vehicles not only have zero-tailpipe emissions, but they can also make a significant contribution to removing greenhouse gas emissions from transport even when emissions from the power stations are taken into consideration. With the average carbon intensity of the power sector, electric vehicles emit less greenhouse gas than their internal combustion equivalents.

⁴² http://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2014_en.htm 11.10.2016.

3. ENERGY STORAGE AND DISTRIBUTION

Energy is useful only if it is available exactly when and where it is wanted. Distribution or transmission means carrying energy where it is wanted, and storage means keeping that same energy available until when it is wanted⁴³. In the terms of natural ecology, biomass is an energy storage unit for parasites and animals, where the seeds become form of distribution, but in the terms of society and technology, energy storage and long distance transmissions are not new concepts. As the renewable energy supplies increase, there is a need to build other methods to improve distribution and transmission, especially for electricity. There is a slight problem in matching the rate at which energy is used. It varies with time, on scales of months for house heating, of days with artificial lightning, and even seconds with starting engines. We have a choice or either storing the energy for future use, or matching the load for available supply.

3.1. Energy storage and distribution in Croatia

Technical requirements for the operation, management and development of the storage system, connection with other parts of the gas system, the connection to the transmission system and measurement rules for gas storage are regulated by the Rules of the gas storage system usage⁴⁴. The amount of compensation for the distribution of gas and concession for building of distribution systems is determined by the Regulation on amount and method of payment of fees for the concession for gas distribution and concession for building of distribution systems⁴⁵.

3.2. Energy storage and distribution in the UK

There are currently 27 installed energy storage projects in the UK, with a total capacity of around 33GWh. Energy storage can bring benefits to transmission and distribution networks, greatly reducing the need to invest in reinforcements for the grid.

43 John Twidell, Tony Weir: Renewable energy resources; Second edition, 2005, page 489

44 „Narodne novine“, broj 50/2009

45 „Narodne novine“, br. 27/2010

4. ALTERNATE FUELS

Even if there was an endless supply of fossil fuel, the environmental damage that its use causes to the earth could not be sustained for long period of time without serious consequences. Fossil fuels are burned to release their stored energy for a variety of uses including electricity, space heating and transportation. In doing so, many different pollutants are released into the atmosphere.

4.1. Biofuels

Biomass is the material of plants and animals, including their wastes and remains, that reacts with oxygen and releases heat, which may be used to generate electricity and other forms of work. The initial material is usually transformed by chemical and biological processes into biofuel. Some of the biofuels are gases and liquids that can be used in internal combustion engines, and are important to replace petroleum fuels, especially for vehicles. They are designed to replace gasoline, diesel fuel and coal, which are called “fossil fuels” because they are residues from animals and plants that died millions of years ago, as I have already explained in the Introduction. Biofuels are made mostly from plants that have just been harvested. The usage of industrial biofuels is non polluting and sustainable. Biomass provides about 10% of total mankind energy consumption.⁴⁶ Firewood consumption and forest clearing is faster than tree growth in all the areas of the world. Energy from biomass is carbon neutral because the carbon in biomass is obtained from CO₂ in the atmosphere via photosynthesis, and not from fossil sources. When biomass is burnt or digested, the emitted CO₂ is recycled into the atmosphere. The use of sustainable biofuels in place of fossil fuels lowers the emission of fossil CO₂ and so reduces the forcing of climate change. Bionergy is a term that is used to cover both biomass and biofuels, such as methane gas, solid charcoal, ethanol, methyl esters⁴⁷.

Biofuels are considered renewable because they can be replenished as quickly as they are used⁴⁸. That means we will not run out of energy derived from biofuels. Some scientists say the biofuels are better for the environment because the carbon dioxide goes into circle. When its produced it is used again when the new crops for biofuels are grown, meaning there is no increase in carbon dioxide. Energy

⁴⁶<https://www.iea.org/topics/renewables/subtopics/bioenergy/> 16.09.2016.

⁴⁷John Twidell, Tony Weir: Renewable energy resources; Second edition, 2005 , page 352

⁴⁸<http://biofuel.org.uk/biofuels-for-kids.html> 16.09. 2016.

needs to be invested for growing biofuels⁴⁹. The main concern is that the land will be cleared too much to produce biofuels, thus threatening natural habitats. But the other side of the story is that biofuel production requires the use of fossil fuels in many phases, starting from fertilizers, and even transportation of raw material. Depending on biomass used, processing biofuels require a great amount of fossil fuel. If the biofuel production systems are not carefully designed, fossil fuel use for biofuels production is more likely to result in green deserts and social damages than to become a renewable energy source to society⁵⁰. Technology improves constantly, and maybe someday we will get more energy from biofuels than we spend to make them, but the future will always remain blurry, meaning the biofuels have become the unerenewable renewables.

4.1.1. First generation biofuels

First generation biofuels are made directly from the food crops, being derived from sugar, animal fats, vegetable oils that these crops provide. The structure of biofuels does not change between generations, but the source from which the fuel is derived does.

4.1.1.1. Corn

Corn is one of the primary sources of the globes fuel ethanol. Disadvantages of ethanol may include high requirements for pesticide and fertilizers. It is not just expensive, but it leads to contamination of soil and water. Corn is also a food, and usage in biofuel may increase food prices. It also takes a lot of energy from methane, oil, and coal to produce corn, and even more fossil energy to convert the corn feedstock into ethanol.

⁴⁹<http://biofuel.org.uk/> 16.09.2016.

⁵⁰http://www.globalbioenergy.org/uploads/media/0710_Ortega_et_al_-_Are_biofuels_renewable_energy_sources.pdf 05.01.2017.

4.1.1.2. Sugarcane

Sugar cane is not far behind in terms of overall ethanol production. Majority of world sugar cane is produced in Brazil. They have produced 588 million tons of sugarcane in 2012/13⁵¹. Unlike corn, sugarcane provides sugar rather than starch, which is more easily converted to alcohol. Where the corn requires heating and then fermentation, sugarcane requires only fermentation. The biggest disadvantage of sugar cane is it can only be farmed in some regions of South and Central America⁵².

4.1.1.3. Soybean

Soybeans are grown throughout much of North America, South America, and Asia⁵³, meaning they are a global food crop. Despite its high price as a food crop, soybean is still a major feedstock for the biofuel production. Soybean faces weather related challenges and it is considered the worst feedstock for biofuel production, as it faces number of diseases.

4.1.1.4. Vegetable oil

Vegetable oil can be derived from any number of vegetables. It can fit into both first and second generation of biofuels. If it is used as fresh vegetable oil, it fits in the frames of first generation, but if it is used after it is no longer fit for cooking, then it becomes a second generation biofuel⁵⁴.

4.1.2. Second generation biofuels

Second generation biofuels are also known as advanced biofuels⁵⁵. They have been developed to overcome the limitations of first generation biofuels. The fact that feedstock used in producing second generation biofuels are not food crops, separates them from the first generation⁵⁶. The only time the food crops can act as second generation biofuels is if they have already fulfilled their food purpose, like

51<http://english.unica.com.br/faq/> 05.01. 2017.

52<http://biofuel.org.uk/first-generation-biofuel.html> 05.01.2017.

53<http://cropwatch.unl.edu/bioenergy/soybeans> 06,01,2017.

54<http://biofuel.org.uk/first-generation-biofuel.html> 06,01,2017.

55<http://biomassmagazine.com/articles/2070/sustainability-of-biofuels-future-generations> 06,01,2017.

56<http://biofuel.org.uk/second-generation-biofuels.html> 07.01. 2017.

in the pre mentioned vegetable oil⁵⁷. For a biofuel to be a second generation feedstock, the source should not be fitting for the human consumption. And also you can grow feed stock anywhere, but it should be grown on a marginal land. Marginal land is land of poor quality with regard to agricultural use, and unsuitable for housing and other uses⁵⁸. The production of second generation biofuels is non-commercial at this moment, although there are some facilities being developed⁵⁹. Second generation biofuels are produced from biomass in a more sustainable fashion, which is truly carbon neutral or even carbon negative in terms of its impact on CO₂ concentrations⁶⁰.

4.1.3. Third generation biofuels

The term third generation fuel is associated with algae⁶¹. But not so long ago algae was considered a second generation biofuel, but when it became obvious that algae are capable of much higher yields with lower resource inputs than other feedstock, they were moved to their own category. A minor drawback regarding algae is that biofuel produced from them tends to be less stable than biodiesel produced from other sources⁶². This is because the oil found in algae tends to be highly unsaturated. Unsaturated oils are more volatile, particularly at high temperatures, and thus more prone to degradation⁶³.

4.2. Algae

Algae are a interesting new biomass source for the production of renewable energy. Some of the main characteristics that separate algae from other biomass sources are that most algae have a high biomass yield per unit of light and area, they do not require agricultural land, and any nutrients can be supplied by wastewater and CO₂ by combustion gas. There are two different types of algae, macroalgae, which is mostly known as seaweed, and microalgae. Microalgae small size makes the harvesting more complicated⁶⁴. For microalgae, the development of dedicated culture systems only started in the 1950s

57<http://consistentoil.blogspot.hr/2015/12/what-is-bio-fuel-and-its-types.html> 07.01. 2017.

58<https://stats.oecd.org/glossary/detail.asp?ID=1591> 07. 01. 2017.

59S.N. Naik: Production of first and second generation biofuels: A comprehensive review, 2010, page 579

60 ibid. page 587

61<http://biofuel.org.uk/third-generation-biofuels.html> 09.01. 2017.

62www.shsu.edu/dotAsset/44e6dda6-53f2-4e0f-8fad-981299000280.pptx 09.01.2017

63<http://onlinelibrary.wiley.com/doi/10.1111/1541-4337.12006/full> 09.01.2017.

64<ftp://ftp.fao.org/docrep/fao/012/i1199e/i1199e02.pdf> 11.01.2017.

when algae were investigated as an alternative protein source for the increasing world population⁶⁵. Later, algae were researched for the interesting compounds they produce, to convert CO₂ to O₂ during space travel and for remediation of wastewater⁶⁶.

4.2.1. Cultivation system

There are different kinds of systems which use artificial light, and they demand far more energy in lighting than what is gained as algal energy feedstock, so I will only consider the ones that use the light from the sun. Seaweed has historically been harvested from natural populations or collected after washing up on shore, but this practice is unlikely to sustain strong growth.

4.2.2. Open cultivation system

The main large-scale algae cultivation system is the so-called raceway pond⁶⁷. The name is given because it is shaped like a small race track. These are simple closed-loop channels in which the water is kept in motion by a paddle wheel. Raceway channels are usually 20 cm deep and are typically built in concrete or compacted earth, and are often lined with white plastic. During daylight, the microalgal culture is fed continuously in front of the paddlewheel where the flow begins⁶⁸. It is designed for optimal light capture and low construction costs. The main land requirement is that the land should be flat. The open system makes it possible for algae predators to infiltrate the system and compete with the algae species intended to be cultivated, meaning this monoculture can only be maintained under extreme conditions⁶⁹, thus generally limiting optimal growth and operate at a low algae concentration, making harvesting more difficult.

⁶⁵<https://scienceflora.org/journals/index.php/jes/article/viewFile/3027/3018> 11.01.2017.

⁶⁶www.fao.org/3/a-ak333e.pdf 11.01.2017.

⁶⁷Chunyang Su: Sustainable Cultivation of Microalgae for Biofuels: Supplying Organic Carbon and Other Nutrients from Low-cost Biomass, 2014, page 7

⁶⁸www.fao.org/docrep/012/i1704e/i1704e.pdf 14.01.2017.

⁶⁹www.fao.org/docrep/012/i1704e/i1704e01.pdf 14.01.2017.

4.2.3. Closed cultivation system

Many of the problems of open systems can be softened by building a closed system which is less influenced by the environment. Many configurations exist but all of them rely on the use of transparent plastic containers through which the algae flow and in which are exposed to light⁷⁰. Closed system allows more species to be grown, it allows the species that are being grown to stay dominant, and it extends the growing season, only slightly if unheated, and if heated it can produce year round⁷¹. These systems also suffer from high energy expenditures for cooling and mixing, and are more difficult to maintain and build.

4.2.4. Sea based cultivation system

Algae cultivation in the sea is the domain of seaweed. Seaweed should be produced in floating cultivation systems spanning hundreds of hectares. Most seaweeds require a substrate to hook to; which in practice means that the cultivation system must contain a network of ropes.

4.2.5. Algal products

Since there are so many different algal species, algae as a group can produce a wide variety of products. A large number of different commercial products have been derived from microalgae and cyanobacteria. These include products for human and animal nutrition, poly-unsaturated fatty acids, anti-oxidants, coloring substances, fertilizers and soil conditioners, and a variety of specialty products such as biofloculants, biodegradable polymers, cosmetics, pharmaceuticals, polysaccharides, and stable isotopes for research purposes. The consumption of microalgal biomass as a human healthfood supplement is currently restricted to only a few species⁷².

70Chunyang Su: Sustainable Cultivation of Microalgae for Biofuels: Supplying Organic Carbon and Other Nutrients from Low-cost Biomass, 2014 page 8

71<http://www.oilgae.com/algae/cult/cp/cp.html> 15.01.2017.

72National Algal Biofuels Technology Review, Bioenergy Technologies Office, 2016

4.3. Bioalcohols

The use of alcohol as a fuel is not a new concept. Henry Ford originally planned for his cars to run on ethanol, but the value of alcohol for drinking made it more expensive for use as a fuel than the newly discovered petroleum⁷³.

4.3.1. Ethanol

Ethanol is a colorless, flammable liquid, that is inconstant and evaporative, known to most as alcohol. Its creation is probably one of the earliest known chemical processes in history, as it is found in most alcoholic beverages. Prior to 1962, ethanol was commonly used in lamps⁷⁴. When it was released in 1908, the Model T could run on either gasoline or ethanol or a combination of both⁷⁵. As the market embraced petroleum, mostly because Prohibition outlawed alcohol use in the 1920, Ford stopped producing vehicles that could run on either fuel and focused on gasoline engines.

Nowdays, when the gasoline prices are unstable, ethanol is coming back as a gasoline substitute. Ethanol melts at -114.1°C , boils at 78.5°C ⁷⁶. Its low freezing point has made it useful as the fluid in thermometers for temperatures below -40°C , which is the freezing point of mercury, and for other low temperature purposes, such as for antifreeze in automobile radiators. For higher ethanol concentration blends, ones with up to 85% ethanol, minor engine modifications are needed to avoid the corrosive effects of alcohol, but these changes are easy to implement and are inexpensive, so to speak. when making new vehicles. Despite its many advantages, there are also many disadvantages and potential problems regarding ethanol, such as: large amounts of arable land are required to produce the crops required to obtain ethanol, major environmental problems would arise out of the disposal of its waste, current engines would require modification to use high concentrations of ethanol. In a 2005 study, Cornell University researcher David Pimental factored in the energy needed to grow crops and convert them to biofuels and concluded that producing ethanol from corn required 29 percent more energy than ethanol is capable of generating⁷⁷.

⁷³<http://biofuel.org.uk/bioalcohols.html> 19.01.2017.

⁷⁴<http://www.ethanolhistory.com/> 19.01.2017.

⁷⁵<http://www.mtfca.com/discus/messages/29/15018.html?1149263899> 19.01.2017.

⁷⁶Thomas Nordegren: The A-Z Encyclopedia of Alcohol and Drug Abuse, 2002, page 33

⁷⁷http://environment.about.com/od/ethanolfaq/f/ethanol_benefit.htm 19.01.2017.

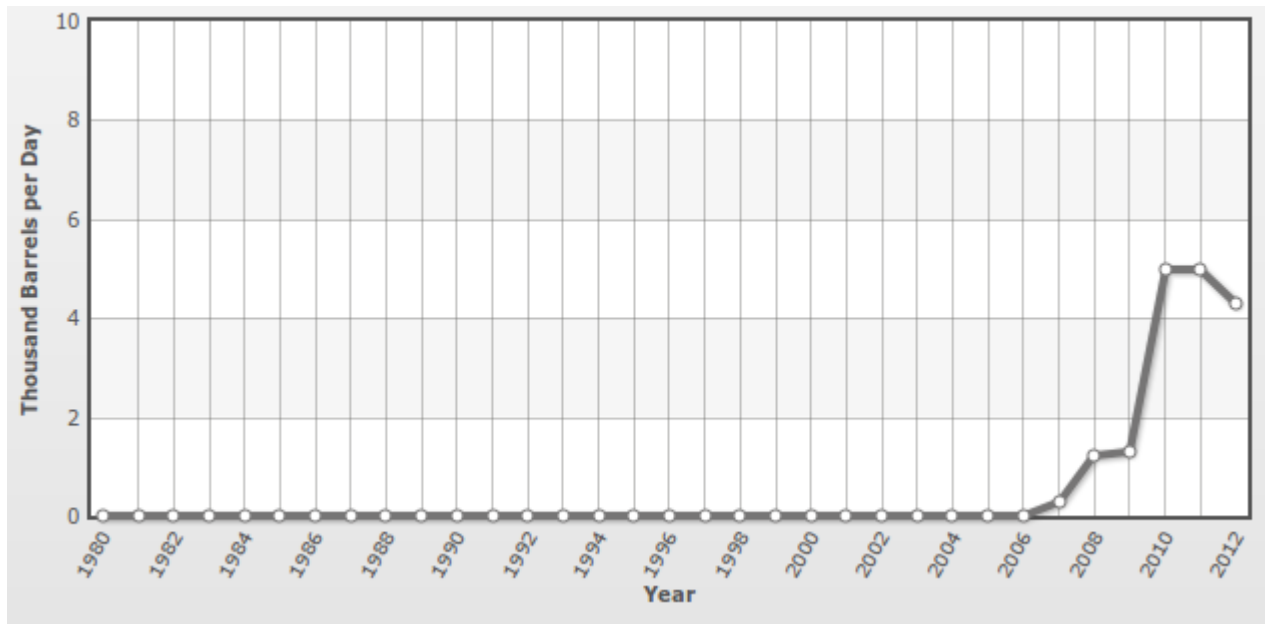


Figure 7: United Kingdom ethanol production per year

Source: <http://www.indexmundi.com/energy/?country=gb&product=ethanol&graph=production>

4.3.1.1. Bioethanol

Bioethanol is fuel used as a petrol substitute for road transport vehicles. It can be combined with gasoline in any concentration up to pure ethanol, and the most vehicles with spark igniting engines will operate with mixtures of 10% ethanol⁷⁸. The main sources of sugar required to produce ethanol come from fuel or energy crops⁷⁹. According to the EU Cereal Balance 2% of the grain grown in the EU is used to produce fuel ethanol, which means that 98% of European grain production is used for other purposes. Production of renewable ethanol in Europe only uses around 0.7% of agricultural land⁸⁰.

Bioethanol can be produced from a variety of biological materials, or feedstocks. The process used depends mostly on the type of feedstock. The three main feedstocks for ethanol production are sugar

⁷⁸http://www.biofuels.ru/bioethanol/What_bioethanol/ 20.01.2017.

⁷⁹http://www.esru.strath.ac.uk/EandE/Web_sites/02-03/biofuels/what_bioethanol.htm 20.01.2017.

⁸⁰ epure.org/media/1137/state-of-the-industry-report-2014.pdf 20.01.2017.

crops, starch crops, and cellulosic material. The feedstock is the most important factor in determining the feasibility of large-scale ethanol implementation and its prospects for reducing greenhouse gas emissions. Ethanol is produced by fermenting and distilling sugar. This sugar can be obtained directly from plants, such as sugarcane or sugar beets, or the sugar can be produced from other substances derived from plants, such as starch or cellulose. Sugar from sugar crops such as sugarcane or sugar beets can be directly fermented into ethanol. The process is simple and already practiced on an industrial scale, especially in Brazil, where ethanol provides a substantial amount transportation fuel. If ethanol is to reduce carbon dioxide emissions then the amount of energy that can be derived from the ethanol must be greater than the amount of energy used to produce it. But some studies find that ethanol production requires more energy than it can produce. Other energy sources must be used to produce ethanol as well, and these sources might be non renewables such as coal, natural gas, or petroleum products. If this is the case, then ethanol will fail to address the original environmental concern. It is almost impossible to estimate the environmental effects of land use change. It is safe to say that corn ethanol alone is not a practical substitute for gasoline. The concept of using vegetable oil as an engine fuel likely goes back to the time when Rudolf Diesel developed the first engine to run on peanut oil, as he demonstrated at the World Exhibition in Paris in 1900⁸¹. Rudolf Diesel firmly believed the utilization of a biomass fuel to be the real future of his engine⁸². He wanted to provide farmers, small industries and those in isolated communities the opportunity to produce their own fuel and to compete with the large monopolies that controlled all energy production at that time⁸³.

4.3. Diesel

On February 27, 1892, the engineer Rudolf Diesel filed a patent with the Imperial Patent Office in Berlin for a “new rational heat engine”⁸⁴. On February 23, 1893, he was granted the patent and the rest is history. Despite its huge success in Europe, the Diesel engine is largely unaccepted by passenger vehicles buyers in the United States. It makes up for half of the sales in Europe⁸⁵. The leaders of four major global cities: Paris, Mexico City, Madrid and Athens say they will stop the use of all diesel-

81<http://www.biodieseloflasvegas.com/biodiesel-history.aspx> 20.01.2017.

82<http://pellets-wood.com/positive-features-of-biofuels-0660.html> 20.01.2017.

83Brian H. Berret: Energy Abundance Now, 2007, page 63

84Klaus Mollenhauer, Helmut Tschoeke: Handbook of Diesel Engines, 2010, page 3

85Robert, Bosch. "History of the diesel engine." Diesel-Engine Management Systems and Components 2006, page 15

powered cars and trucks by the 2025⁸⁶. Diesels produce 15% less CO₂ than petrol, but emit four times more nitrogen dioxide pollution (NO₂) and 22 times more particulates, the tiny particles that penetrate the lungs, brain and heart⁸⁷. However, Britain’s car industry says that diesel is being wrongly attacked and has helped to reduce pollution, with the fuel proving more efficient than petrol, meaning CO₂ emissions are lower⁸⁸. In 2012, consumption of road transport fuels in the United Kingdom was 33,339 kilo tonnes of fuel⁸⁹.

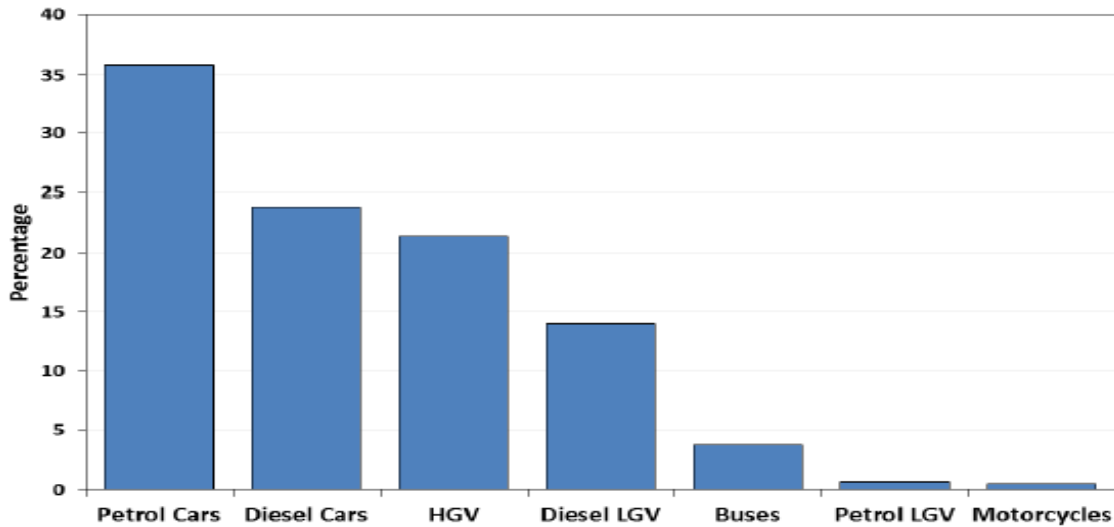


Figure 8: Road transport fuel consumption in the UK by vehicle type, 2012

Source:https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/322458/sub_national_road_transport_consumption_factsheet_2012.pdf

4.3.1. Biodiesel

In the mid 1970’s, fuel shortages spurred interest in diversifying fuel resources and then the biodiesel was developed as an alternative⁹⁰ to his petroleum cousin. Biodiesel is a liquid fuel derived from vegetable oils and fats, which has similar combustion properties to regular petroleum diesel fuel. It can be produced from straight vegetable oil, animal oil and fats, and even from cooking oil. It is

86<http://www.bbc.com/news/science-environment-38170794> 28.01.2017.

87<https://www.theguardian.com/environment/2015/sep/22/the-rise-diesel-in-europe-impact-on-health-pollution> 28.01.2017.

88<http://www.telegraph.co.uk/finance/newsbysector/transport/11463519/Car-industry-fumes-about-the-demonisation-of-diesel-engines.html> 28.01.2017.

89https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/322458/sub_national_road_transport_consumption_factsheet_2012.pdf 28.01.2017.

90<http://www.cyberlipid.org/glycer/biodiesel.htm> 29.01.2017.

biodegradable, nontoxic, and has fewer emissions than petroleumdiesel when burned. Biodiesel can be used in pure form (B100) or may be blended with petroleum diesel at any concentration in most modern diesel engines⁹¹. Biodiesel is a better solvent than petroleum diesel and has been known to break down deposits of residue in the fuel lines of vehicles that have previously been run on petroleum diesel⁹². Some of the disadvantages of biodiesel include its price, as it is more expensive than petroleum diesel fuel. It also can harm rubber hoses in most older vehicles, that are produced around 1992. While it cleans dirt, that same dirt may enter the filters, that have to be changed after the first several hours of biodiesel use.

4.4. Aviation biofuel

Fuels like methanol and ethanol are not practical for aviation as they have very low energy densities. Planes would be severely limited in their range or would not even take off thanks to the weight of the fuel they would need to carry. Water in aviation fuel can freeze and cause lines to clog at higher altitudes. This is one of the reasons that alcohols, which tend to attract water, are not useful as aviation fuels.

4.5. Hydrogen

Humans have harnessed hydrogen for a variety of applications, from blasting rockets into space to making common household products like toothpaste⁹³. Hydrogen is the fuel of the future. It is an energy carrier that can be used in internal combustion engines or fuel cells producing almost no greenhouse gas emissions when combined and burnt with oxygen, as water vapor being its only emission. Hydrogen can be produced from several different methods, with only a couple being environmentally beneficial. It can be produced from natural gas with different chemical processes, from coal, by process of water electrolysis. In Germany, the government has plans to install 100 hydrogen stations by 2018, which is sufficient to set up an initial network, and there will be up to 400 additional stations by 2023⁹⁴. High concentrations of it in the air cause a lack of oxygen with the risk of

91http://www.conserve-energy-future.com/advantages_disadvantages_biodiesel.php 29.01.2017.

92http://www.poel-tec.com/english/biodiesel_.php 29.01.2017.

93<https://www.scientificamerican.com/article/hydrogen-may-prove-fuel-of-the-future/> 29.01.2017.

94<http://www.digitaltrends.com/cars/bmw-is-preparing-for-a-hydrogen-future/> 31.01.2017.

unconsciousness or death⁹⁵.

4.6. Natural gas

Natural gas is widely used for heating and cooking, electric power production, and industrial use. Being a gas, it must be stored inside a vehicle in either a compressed gaseous or liquefied state. Compressed natural gas is typically stored in a tank at a pressure round 200 bar. Liquefied natural gas is super-cooled and stored in its liquid form at -125°C in protected tanks⁹⁶. Liquid is more dense than gas, so it means more energy can be stored by volume. Fuel tanks for natural gas vehicles are strong and extremely resistant, and they undergo testings according to strict standards. Once in use, they must be inspected in a qualified service facility every three years or every 60 000 km, whatever comes first⁹⁷. It is estimated that new drilling techniques could have increased the available resources, by up to a factor three in recent years. In 2013 the total gas consumption for the EU was 472 billion m³ , while considering that over 300 billion m³ (55%) were sourced from within European borders.⁹⁸ Natural gas powers about 150,000 vehicles in the United States and roughly 15.2 million vehicles worldwide⁹⁹. Some of the disadvantages of natural gas include: more expensive vehicles then those powered on gasoline, limited number of fueling stations, and most of all, Natural Gas is a non renewable fuel.

⁹⁵<http://www.lenntech.com/periodic/elements/h.htm> 31.01.2017.

⁹⁶http://www.afdc.energy.gov/fuels/natural_gas_distribution.html 31.01.2017.

⁹⁷<https://www.gpo.gov/fdsys/pkg/CFR-2011-title49-vol6/xml/CFR-2011-title49-vol6-sec571-304.xml> 31.01.2017.

⁹⁸www.eurogas.org/uploads/media/Eurogas_Statistical_Report_2014.pdf 31.01.2017.

⁹⁹http://www.afdc.energy.gov/vehicles/natural_gas.html 31.01.2017.

Table 1: Compressed natural gas and Natural Gas Vehicle stations in EU

| Country | Last Changed | Number of stations | Price per kg |
|----------------------|---------------------|--------------------|--------------|
| Austria | January 2015 | 177 | 1.02 |
| Croatia* | October 2016 | 2 | 1.24 |
| Great Britain | July 2015 | 16 | 1.06 |
| Germany | January 2015 | 921 | 1.11 |
| Macedonia | December 2012 | 1 | 0.52 |

Source: <http://cngeurope.com/>

* According to <http://www.ina.hr/default.aspx?id=474>, Croatia has over 77 Gas stations that provide Liquid or Compressed Natural Gas.

5. CROATIA 2020 PLAN

By entering in the European Union, in July 1st 2013., Croatia has gained full partnership, and with it accepted the *Directive*^{100*} regarding the usage of energy from the alternate sources, and the usage would have to be at least 20% of total energy consumption until 2020. To fulfill this objective, every member of the Union is bound to have the national plan based on the production of electric energy, energy for heating and cooling, and transportation from renewable sources. Republic of Croatia has created a similar program even before becoming equal member, because it was a part of the negotiations for entering the Union fund for environmental protection and energy efficiency is co financing the project up to 1.5 million Croatian kuna per project for companies and with 30.000 Croatian kuna per home¹⁰¹. As the time goes by, I am sure this co financing would even be greater, because otherwise Croatia would pay penalties for not fulfilling the directive. In the system of co financing, on the 30.09.2013., there were 458 power plants, with production power of 294 MW, wind powered with total production of 254 MW, biomass 14 MW. The total number of solar system power plants were 423 with the approximately power of 10 MW. It is expected that there will be an increase of 16,3%. in the capacity of power plants by the year 2020. The total amount of renewable energy in the transportation will be 162 ktoe. Croatia shall fulfill the responsibilities according to the EU Directive on the promotion of the use of biofuels for transport, on a share of biofuels, in final energy consumption of 10% until 2020. Croatia has good natural possibilities for the use of renewable energy sources. Renewable energy sources are local energy sources and their utilization is a mean of enhancing the security of energy supply, stimulation to the development of local production of energy equipment and services, and also a manner for accomplishing the environmental protection goals. Croatia shall stimulate renewable energy sources to the utmost, along with acceptable social costs of their usage. Croatia shall fulfill the commitments according to the EU Directive on the promotion of the use of energy from renewable sources on the share of renewable energy sources, including large hydropower plants, in final energy consumption of 20%. Croatia sets up a goal to maintain the level of 35% of a share of electricity generation from renewable energy sources, including large hydropower plants, in overall electricity consumption until 2020. The road traffic on Croatian territory uses about 97% liquid fuel, the share of gas fuel is about 3%, and renewable sources participate with a share less than 0.1%¹⁰².

100DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009

101Ministarstvo Gospodarstva: Nacionalni akcijski plan za obnovljive izvore energije do 2020. Godine, 2013, page 27

102 Mr. sc. Ivo Brozović, Veleučilište u Rijeci i građevinarski fakultet u Rijeci, 7. poglavlje Promet i okoliš 2013. page 14

Table 2: Estimation of total contribution (final energy consumption) that is expected of each technology for the production of renewable energy in Croatia to meet the binding targets by 2020 for the share of energy from renewable sources in energy production for heating and cooling for the period 2010 – 2020 in ktoe

| | 2005 | 2010 | 2016 | 2017 | 2018 | 2019 | 2020 |
|--------------|--------------|--------------|--------------|------------|--------------|--------------|--------------|
| Geothermal | 0 | 4,9 | 12,1 | 13 | 13,9 | 14,8 | 15,7 |
| Sun | 0 | 3,9 | 34,0 | 49,8 | 65,6 | 81,5 | 97,3 |
| Biomass | 351,8 | 325,2 | 388,1 | 390,3 | 392,5 | 394,6 | 396,8 |
| Heat pumps | 0 | 16,5 | 52,1 | 63 | 73,8 | 84,7 | 95,6 |
| TOTAL | 351,8 | 350,4 | 486,2 | 516 | 545,8 | 576,6 | 605,4 |

Source: Ministarstvo Gospodarstva: Nacionalni akcijski plan za obnovljive izvore energije do 2020. Godine, 2013

Table 3: Estimation of total contribution expected of each renewable energy technology in the Republic of Croatia to meet the binding targets by 2020 for the share of energy from renewable energy sources in the transport sector for the period 2010 – 2020 in ktoe

| | 2005 | 2010 | 2016 | 2017 | 2018 | 2019 | 2020 |
|----------------------|------------|-------------|--------------|--------------|--------------|--------------|--------------|
| Bioethanol | 0 | 0 | 16,2 | 16,3 | 23,2 | 16,3 | 16,3 |
| Biodiesel | 0 | 2,6 | 68,8 | 82,0 | 95,2 | 108,4 | 121,6 |
| Hydrogen | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Electric | 8,4 | 8,9 | 13,0 | 14,4 | 15,8 | 17,2 | 18,5 |
| Diverse (oil, gas..) | 0 | 0 | 1 | 2,1 | 3,1 | 4,1 | 5,1 |
| TOTAL | 8,7 | 11,6 | 101,1 | 116,2 | 137,3 | 146,5 | 161,6 |

Source: Ministarstvo Gospodarstva: Nacionalni akcijski plan za obnovljive izvore energije do 2020. Godine, 2013

Table 4: Cost assessment measures to encourage the application of renewable energy in electricity production (HRK)

| Technology | 2013. | 2014. | 2015. | 2016. | 2017. | 2018. | 2019. | 2020. |
|----------------------------|-------------|-------------|---------------|---------------|---------------|---------------|---------------|----------------|
| Wind power plants | 338.664.480 | 448.620.480 | 653.704.128 | 666.778.211 | 680.113.775 | 693.716.050 | 707.590.371 | 721.742.179 |
| Biomass | 25.777.440 | 26.292.989 | 422.148.542 | 540.012.415 | 633.486.234 | 729.428.913 | 828.955.904 | 932.172.204 |
| Biogas | 69.276.870 | 70.662.407 | 135.253.082 | 183.339.112 | 232.368.710 | 284.230.444 | 337.110.526 | 392.974.556 |
| Solar plants | 19.143.360 | 31.730.119 | 107.882.405 | 110.040.053 | 112.240.854 | 114.485.672 | 116.775.385 | 119.110.893 |
| Hydro plants | 134.150.400 | 166.464.000 | 200.356.070 | 232.766.212 | 266.392.616 | 301.270.970 | 337.437.902 | 374.931.002 |
| Geothermal | 0 | 0 | 50.937.984 | 62.348.092 | 74.194.230 | 86.489.274 | 99.246.442 | 112.479.301 |
| Total | 587.012.550 | 743.769.995 | 1.570.282.212 | 1.795.284.095 | 1.998.796.420 | 2.209.621.323 | 2.427.116.530 | 2.653.410.134 |
| Total 2013 2020 | | | | | | | | 13.985.293.259 |

Source: Ministarstvo Gospodarstva: Nacionalni akcijski plan za obnovljive izvore energije do 2020. Godine, 2013

The Government stimulates the changes in the structure of energy use. The Strategy sets as a goal for electricity used for heating and domestic hot water to be replaced by other energy sources: solar energy, biomass, natural gas and liquefied petroleum gas (in the areas remote from natural gas network). This goal does not refer to the use of electricity for heating and domestic hot water from heat pumps. In transport, the forms decreasing the energy intensity shall be stimulated.

| Year | Average price (kn/kWh) | Average price (EUR/MWh) |
|-------|------------------------|-------------------------|
| 2007. | 0,91 | 121,67 |
| 2008. | 1,04 | 138,56 |
| 2009. | 1,21 | 161,13 |
| 2010. | 1,27 | 169,40 |
| 2011. | 1,24 | 165,59 |
| 2012. | 1,35 | 180,32 |
| 2013. | 1,37 | 182,76 |
| 2014. | 1,46 | 194,60 |
| 2015. | 1,51 | 201,75 |
| 2016. | 1,58 | 210,14 |
| 2017. | 1,63 | 217,43 |
| 2018. | 1,69 | 224,80 |
| 2019. | 1,73 | 230,42 |
| 2020. | 1,77 | 235,69 |

Figure 9: The average price of electricity produced from renewable energy sources in Croatia in the period until 2020

Source: Ministarstvo Gospodarstva: Nacionalni akcijski plan za obnovljive izvore energije do 2020. Godine, 2013

There were 458 power plants in Croatia that deliver renewable energy to the grid in the year 2013, with the installed capacity of 294 MW.

| Privileged producers | Number of powerplants | Power (kW) | Total funds needed annually to pay privileged producers |
|------------------------------|-----------------------|-------------------|---|
| Vjetroelektrane | 14 | 254.250,00 | 511.705.920,20 |
| Elektrane na biomasu | 3 | 6.690,00 | 61.905.391,00 |
| Elektrane na bioplin | 9 | 8.135,00 | 92.668.641,87 |
| Sunčane elektrane | 423 | 9.781,69 | 35.755.230,99 |
| Hidroelektrane | 4 | 1.340,00 | 8.067.595,01 |
| Kogeneracijska postrojenja | 4 | 11.493,00 | 5.266.610,60 |
| Elektrane na deponijski plin | 1 | 2.500,00 | 51.271,00 |
| UKUPNO | 458 | 294.189,69 | 715.420.660,68 |

Figure 10: List of powerplants and funds needed for privileged producers.

Source: Ministarstvo Gospodarstva: Nacionalni akcijski plan za obnovljive izvore energije do 2020. Godine, 2013

5.1. Oil demand

Liquid fuels are the main energy source in the Republic of Croatia. Along with the existing oil consumption of around 1 t per person, Croatia is close to the developed European economies in total energy consumption¹⁰³. Despite all measures of energy efficiency and the replacement of liquid fuel an increase in the consumption of liquid fuel is foreseen in final consumption from 0.9% per annum until 2020, from 3.1 millions tons in 2006 to 3.5 millions tons in 2020. It is assumed that total consumption of liquid fuels in 2020 will be around 4.3 millions tons.

5.2. Natural gas

Natural gas has been imported from Russia since the 1978, so it can meet all the demands of expenditure, which cover about one third of total consumption. In order to balance the seasonal production and consumption of natural gas, some of the depleted gas deposits are transformed into underground storages, where the extra gas was produced in the warm periods of the year, and is being used during the winter months¹⁰⁴. Croatia has around 25% share of natural gas in total energy consumption. Over the past twenty years, the consumption is in a constant growth due to the contacts for the energy development in the European Union.

5.3. Coal

After 1999, coal in Croatia has not been exploited¹⁰⁵ and Croatia does not have any domestic coal reserves that it can utilize commercially. However, import of the coal of good quality has been provided by the maritime transport. Total coal consumed in the Republic of Croatia is provided from import. Brown coal is mostly imported from Bosnia and Herzegovina and some small quantities from the Czech Republic and Slovenia¹⁰⁶. The main advantage of coal is its big reserves worldwide, and its more available comparing to oil and gas reserves. The second advantage of coal is its price stability in comparing with other fossil energy forms. Mining and burning coal releases harmful pollutants into the

103Ministarstvo gospodarstva, rada i poduzetništva: Energetska strategija Republike Hrvatske, 2009. page 53

104<http://www.enciklopedija.hr/Natuknica.aspx?ID=50450> 01.02.2017.

105 <http://www.enciklopedija.hr/natuknica.aspx?id=62991> 01.02.2017.

106www.mingo.hr/userdocsimages/energetika/Energija2010_cd.pdf 01.02.2017.

air¹⁰⁷.

5.5. Electric cars in Croatia

Croatia is one of the countries that produces electric vehicles. There are two companies that manufacture these vehicles and both are located in the area of Zagreb. Rimac company has created the Concept One vehicle, which is on the Figure 10, and that car is also the first Croatian electric car. The vehicle resembles to high class sport cars, and its performance is not far behind. It reaches 100 kilometers per hour in 2.6 seconds and its top speed is 355 km/h. The Concept One¹⁰⁸ features the M2M system that sends more than 500 information including the state of all of the systems, telemetry data and location to a cloud via 4G network. That data can be seen in real time or analysed later via mobile application or desktop computer application. This vehicle can reach up to 600km with one charge. The biggest downside of it, its the price, which is around 700 000 euro.



Figure 11: Rimac Concept one

Source: https://www.netcarshow.com/rimac/2016-concept_one/1024x768/wallpaper_03.htm

107<http://www.greenpeace.org/international/en/campaigns/climate-change/coal/> 01.02.2017.

108<http://www.rimac-automobili.com> 08.09.2016.

The other company is called DOK-ING, also located in Zagreb, created the model Loox. Their concept of the electric vehicle was originally red colored, but it also comes in different colors. It is a two or three seats economic vehicle, small dimensions, thus being easy to park. It is ideal for driving in the urban parts. It reaches 100 km/h in 7.5 seconds, with a max speed of 140km/h. Its range is 200 km with a single charge. and its price range is between 30 – 50 000Euro.



Figure 12: DOK-ing Loox

Source: http://insideevs.com/wp-content/uploads/2015/12/Doking-XD_front.jpg

6. CONCLUSION

Fossil fuels have been in use for the past 150 years, that's less than two life times, and in that time we have dug into earth's core and successfully sucked them out. Once the accessible way of extracting oil was no longer an option, we have went miles of shore and started digging the depths of the ocean, thus polluting oceans and seas. With the industrialization, came over consumption, and soon we had more products than we needed. Then the economists invented sport and movie idols and commercials in which those idols are in the symbioses with the product they do not even use in the real life, just so that an average consumer continues to buy. Then we found that the cheapest labor is in China, that uses 50% of the entire world's coal. But what will happen when we run out of coal, and oil?

We have to learn how to live without fossil fuels, but that is going to be a long and hard process, as we have built our energy storage and distribution system, as well as the transportation to suit gas and oils, and if we want to change that we would have to redesign the entire world.

No matter if we use petrol, diesel or whatever type of fuel, there are always going to be environmentalists with researches that say the combustion of those fuels exhaust toxic fumes that are bad for the environment, animals, humans, etc., and there will always be major companies with the same research, but with the opposite result, that says no diseases, poisonings, deaths of living creatures, nor the pollution of air and soil is directly linked to the fumes or liquids their products discharge.

Alternate fuels need various types of work to be produced. Meaning we have to spend energy to plant the crops from which the oil will be extracted, we have to spend energy to harvest the same crops, we have to spend energy to transport the product to its final storage destination, thus spending a lot of fossil fuels, to begin with. We also need large areas of land that could be used for food production. But the amount of the released carbon dioxide from combustion is the same as the Carbon dioxide captured by the plants.

We have to adapt and somehow manage to live with the nature's renewable resources, and use them in the natural pace, so that the nature has enough time to reconstruct itself, otherwise we are looking at the empty and polluted future.

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