WHAT IS SOLUTION FOR THE ENERGY FUTURE?

Momir Đurović[1]

ABSTRACT:
The review of the problems concerning energy supply, energy sources and technologies is given. The analysis of the possible solution and representation of different scenarios of the energy future is given. A special attention is paid to renewable energy sources.

Key words: renewable, energy scenarios.

1. INTRODUCTION

Never before the world community was faced with such a big challenge: how to get the carbon inhalants under control by changing the global energy supply system, now made up of frightening 75% of fissile fuel and 14% biomass, together producing 8 billion tons of CO_2 yearly. Many options are opened today with the aim to preserve natural resources of the Earth, or to provide sustainable future. There is no much time left for experimenting.

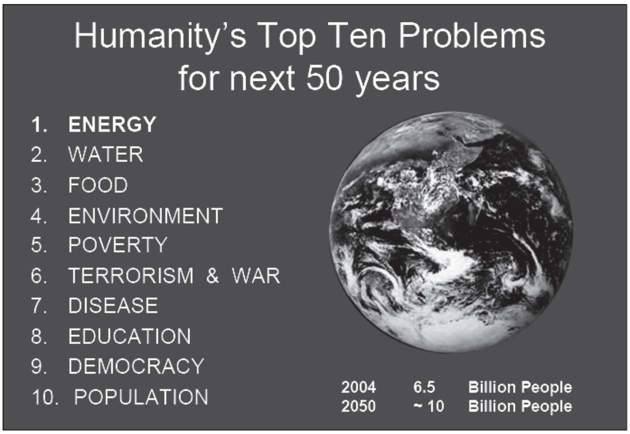

Fig. 1 Humanity's Top Ten Problems for Next 50 Years

Many studies, related to the most important

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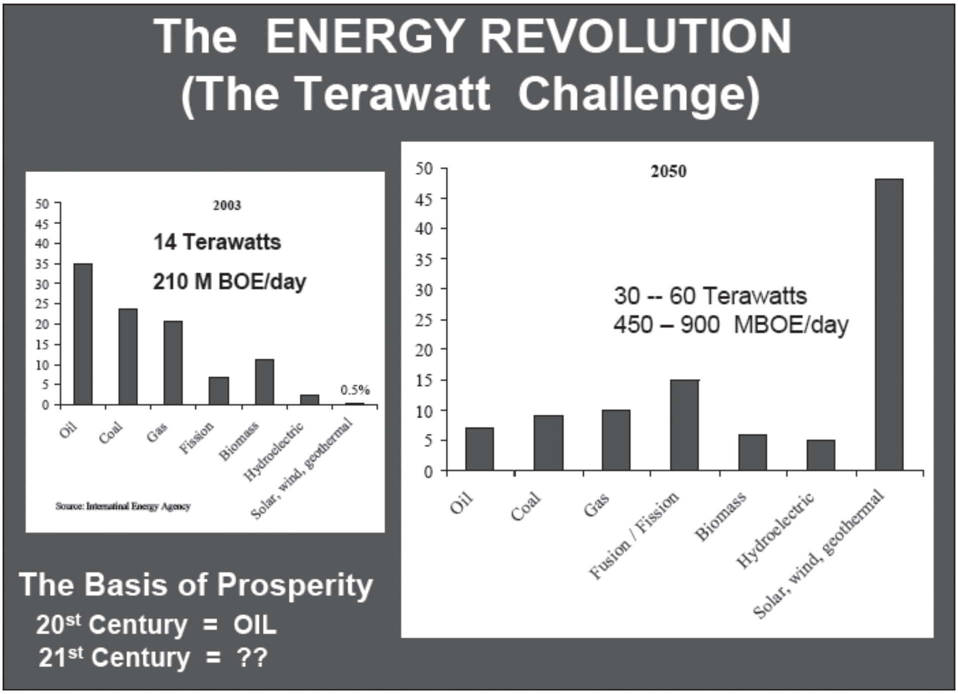

Fig. 2. Transition from 2003 to 2050

problems the world is going to face, grade in different ways various topics, but they all agree that the most important issue that lies ahead of us, and which we have to solve is energy. This civilization and the one which will emerge in the future are both energy biased. Energy is needed for all out activities. In fact, we cannot solve many other problems without solving energy problems first. This refers to food, health, water supply and many others. The present world population is of 6.5 billion, and is expected to rich 10 – 12 billion by 2100 year. Feeding this increased number of people presents one of the major problems, too. Food and energy are to some extent linked. Our minimum energy requirement, expressed in food supply, is 1/6 t. c. e. per year per capita. In practice this figure is much bigger since there is need to grow, process, package, transport and cook foodstuffs. For this purpose more resources will be necessary, among them energy being the most important one. This increased energy use will bring about additional difficulties. The same analogy applies to many other problems. Energy is the most crucial component in the majority of activities of all economies. It is needed to process and fabricate materials, to heat industrial premises and homes, to provide transport of people and goods, and to power communications.

In connection with the extensive use of energy, numerous environmental hazards, including climate change, loss of soil and water, air pollution, new diseases, have been recorded. These environmental risks, caused by a more extended use of energy, are the major concern of today's energy sector. Never before was the world faced with such problems: how to provide enough energy and how to preserve the environment safe, at the same time.

The problem might be looked at in the right way if we realize that an energy revolution is just in front of us. Today we use 14 TWh or 210 M BOE/day which is forecast to reach in 2050 year 30-60 TWh or 450-900 MBOE/day. This means that by 2020 year we would need, at least, a minimum of new 10 Terawatts (150 M BOE/day) from some new clean energy sources. On top of that, energy should provide worldwide peace and prosperity, if it happens to be cheap. It is obvious that this cannot be done with the current technology.

2. ENERGY AND FUTURE

Energy, like food, water and shelter, is a basic need of people throughout the world. And today we all stand together at the crossroads. If six and a half billion people already inhabiting this Planet, plus the next generations, are to have access to affordable energy options, then we must choose the path which leads to a sustainable energy future.

Currently the world average per capita consumption of commercial (largely non-renewable) energy is around 2 t. c. e. per year. The figure of 5 t. c. e. is typical for developed countries, while less than 0.5 t. c. e. for developing countries. This energy comes primarily from fissile fuels, coal, oil and natural gas, with a small contribution from hydro-power and nuclear. In most developing countries there is a significant consumption of biomass (wood, charcoal), too. Those fuels are naturally limited and the share of its resources is given in Fig 3.

Today, with nearly 80% of the world's population, the developing nations account for only a third of all energy use.

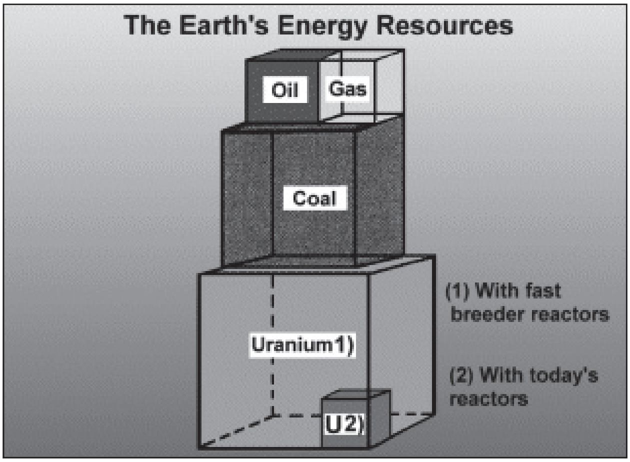

Fig. 3. The Earth's energy resources

But, their electricity growth rate is seven times that of the industrialized countries. And if this trend continues, the developing nations will become world's primary energy consumers within two or three decades. Total world energy use is expected to double by the year 2025, and quadruple by 2100 year. One of the

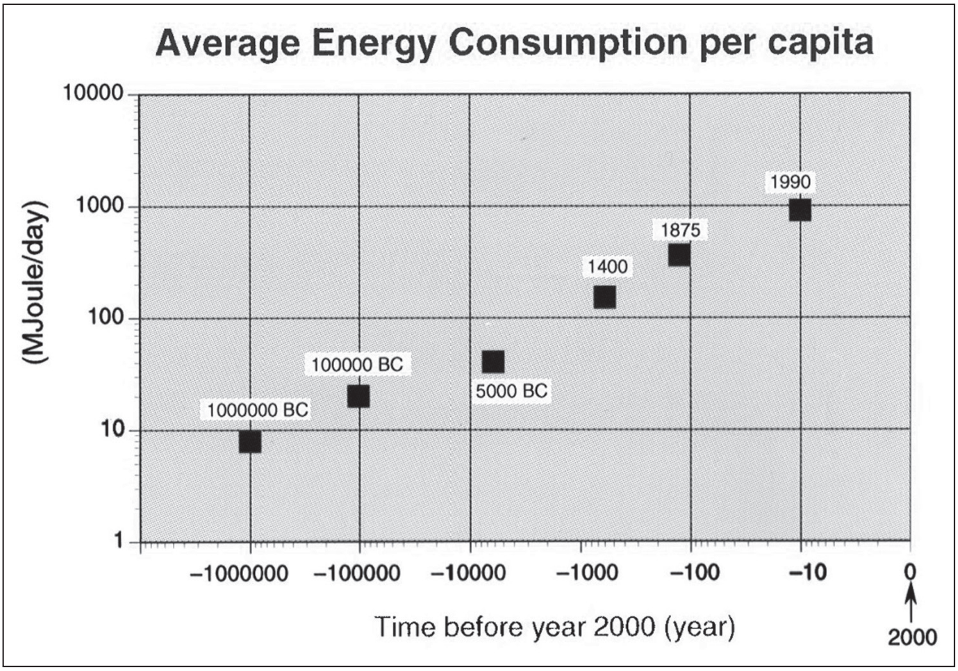

Fig. 4. Average energy consumption per capita in time scale

problems is the distribution of energy consumption per capita, as well as world primary energy mix. It has been estimated that 10 toe/ capita was used in Canada in 2003 year, while India has only less than 0.3 teo/capita. At the same time 22,4% of coal was used, 34% of oil, 19.8% of gas, nuclear 6.4%, hydro 6.5%, CRWs 10.3% and new renewable 0.3% (wind/tide/solare-0.2% and geothermal 01%) of the total TREP in 2004 year, as reported by theWEC.

The average consumption per capita has been rising in the past, with two big jumps: one being when agriculture started to be organized, and another when industrial revolution happened. This is shown in Fig. 4.

All this energy was generated using natural primary resources. To understand the process one has to know that in order to generate 1 GW of electricity the following is required:

3 million tons of coal per year
20 km^2 of solar cells
200 km^2 of windmills
2000 km^2 of fast growing trees
700 kg per year of thorium in Energy amplifiers
25 tons per year of Helium to supply the USA and theEU

It is indicated that during next two decades we might need between 200 and 300 GWe of the new generating capacity. Having in mind that the existing energy park has to be replaced, then this amount could be almost doubled. This will happen due to an increase in two main factors:

– Energy consumption per capita grows with economic development, inevitably closing off the gap in per capita consumption between developed and developing countries, and

– The spectacular way of growing of the world population, mainly in developing countries, where economic growth is great, too.

Thus, for example, if the developing countries were to reach per capita energy consumption of the USA, the increase would be enormous. Assuming they only reach the European level (45% of the USA) by year 2100, then the energy consumption would have to increase by factor 6 from the present 13 TWatt-year. Anotherr example is the estimate of the Chinese government that China electricity production needs to increase by factor 6 to 7 in the next 30 years. The problem is somewhat worse in India. Both of the countries represent about a half of the world population. Certainly, a firm prediction is very difficult to make.

In large, if we were to provide for all 10 billion of the people in 2050 year or later, living on the planet Earth, the level of energy consumption used in the developed world, a couple of kilowatt – hours per person, we would need to generate 60 terawatts around the planet – the equivalent of 900 million of barrels of oil per day. The crucial question is: how can we do it? If

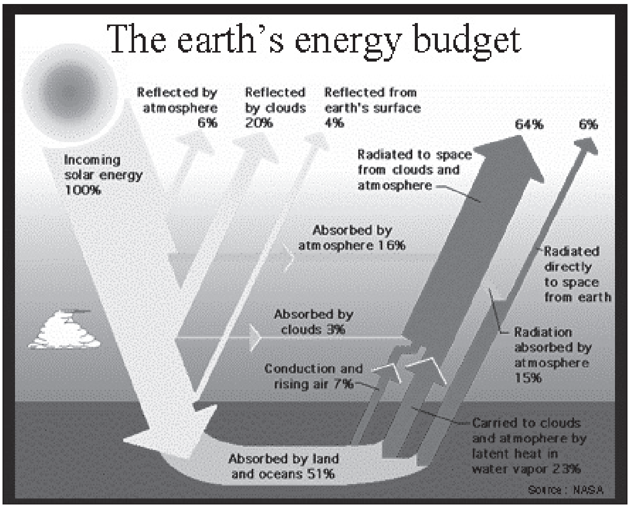

Fig. 5 The Earth's energy budget

nothing is done to change the present trend („Business as usual”) the total energy mix is going to be dominated by fossil fuels, e. g. in Europe in 2030 year: 38% oil, 29% gas, 19% solid fuels, 8% renewables and barely 6% nuclear.

The problems can be solved only on the basis of the “Earth’s energy budget”.

Approximately, from the Earth´s energy budget 100.000 TW of the energy is received from the sun, 70.6 % from water surfaces and 29% from soil. Using the existing technology of photovoltaic 13 TW of today’s world consumption can be provided by only 0.23% of the area, while using the existing technologies in biomass 4.6% of earth’s area is required. It looks from this point of view that there is

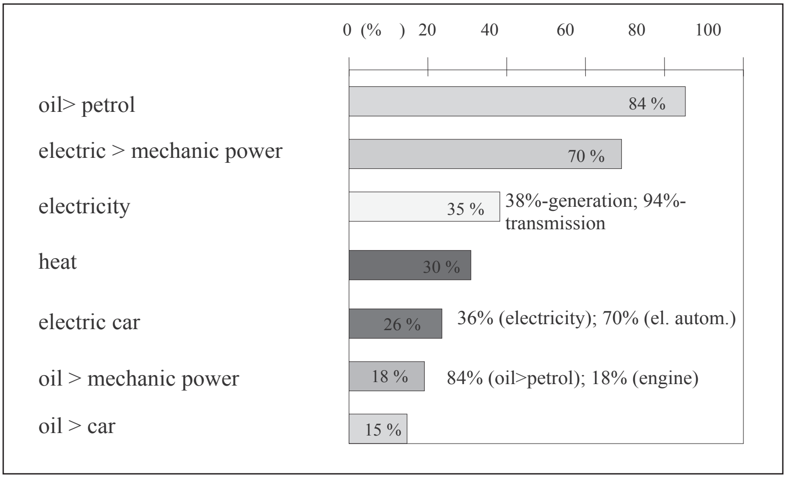

Fig. 6. Efficiency of energy transformation

no problem at all. But, knowing that we use useful energy in energy services, but not the primary energy, then the major problem occurs. It is the way of transforming primary energy in useful. This process is illustrated by Fig. 6 and it shows that the transformation of primary energy into a useful one, such as mechanical, electrical, chemical, a significant amount of energy is wasted. This waste of energy has become a major concern of us.

The wasted energy in this process is wasted in losses, mainly manifested in heat. The consequence being production of green house gases (GHG), CO_2 dominating and NO_x, CH_4, SO_x and other present. The consequence of these being, among others, global warming of the Earth. This process has attracted all the necessary attention and is recognized as the major treat to this civilization at the moment.

Thus, it is not only a question how to find new natural resources, but even more how to transform them so as to eliminate in this process GHG or, at least, to control their ppm concentration in the atmosphere. It has been reported that we are emitting about twice the amount of CO_2 that the atmosphere can integrate. In fact, even forty years ago the *Club of Rome* report stated that we have been using even 20% more of the resources than the Earth's system can integrate. It is now out of doubt that, if the current practices continue, the pollution of the Earth will be dramatic, with very unpleasant consequences, even catastrophic. The property losses and population displacement, effect on productivity of farms, forests and

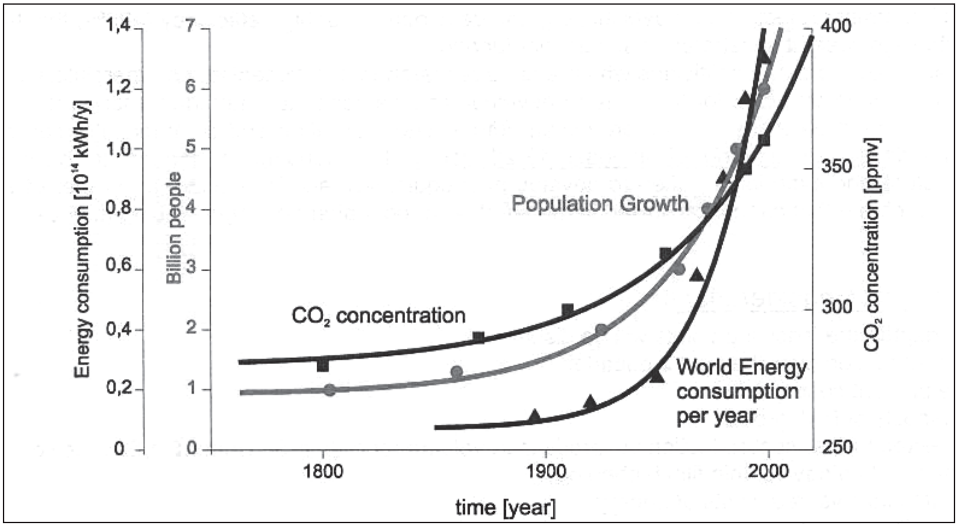

Fig. 7. Population, global energy consumption and CO_2 concentration since 1700 year

fisheries, heat induced deaths, distribution and abundance if species, temperature rise, enlargement of ozone hole, ice melting, ocean chemistry of dissents have been, already, recorded as the consequence of global warming, i. e. an extended use and conversion of energy with treat to enlarge these phenomenon. The concentration of CO_2 in atmosphere has reached 382 ppm (2007 measurements), being higher than it has been recorded in the last 100.000 years. These effects are closely related to the energy consumption and a rise of world population, as shown in Fig. 7

What can be done to bring the CO_2 emission to the value which can be absorbed by the biosystem and the seas? The only sensible answer to this question is:

– To bring fissile fuel emission to a level which can be absorbed by the biosystem of this Planet,

– To increase carbon absorbed plants to a level that can reduce the excess carbon content in the atmosphere in order to restore a sustainable climate and bio balance,

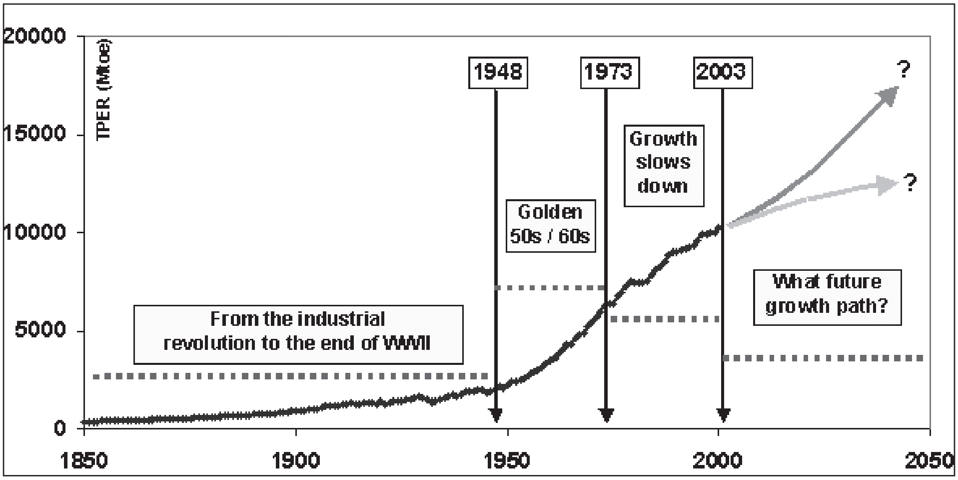

Fig. 8. The energy path to the future

– To introduce new technologies which tend to zero-emission of CO_2.

In order to solve this problem enough energy has to be provided for the world population and for all its needs, making it available, affordable and accessible, as stated in the WEC documents. „Availability" means that the energy supply will be reliable and of good quality, providing right energy mix of domestic and imported sources. „Accessible" presupposes efficiency of both transformation and use of energy; whereas „acceptability" implies environmental issues to be put in focus, as well as consumer preference and economic impact of price fluctuation. A mix of energy sources is required to provide sufficient power for the future, and each of these energy sources requires further research, development and new technology. In that sense comprehensive energy policy must enable the development of economically and environmentally sustainable resources- both fossil and renewable.

Thus, many paths are open for the future of energy sector. Two of them can be recognized as crucial, as shown in Fig. 8.

3. ENERGY SCENARIOS

Many scenarios concerning energy future of the Planet have been published, among which the most known are: WEC (*A, B, C*), IEA, Wupertall, Club of Rome, IIASA, EREC, DPS, latest WEC: Elephant, Lion, Leopard and Giraffe and many others. All they rely on very elaborate models out of which the Asian Pacific Integrated, Atmospheric Stabilization Framework Model, Integrated model to Assess the Greenhouse Effect, Multiregional Approach for Resource and Industry

Allocation, Model for Energy Supply Strategy Alternatives and their General Environmental Impact, The Mini Climate Assessment Model, and POLES are the most used. All those models produce results which show the possible ways of the energy future. The development of a clean, efficient and renewable energy technology has become one of the most important tasks assigned to modern science and engineering.

One result, all the scenarios have brought out, is a higher participation of renewables in further energy solutions. Thus, the IEA accounts for 7.5% to 8.5% increase per year in commercial use of new energy sources till 2010 year. WEC ²Business as usual scenario² forecasts growth of 18% to 21% in TREP till 2020 year; ecologically based scenarios even (18-31)% of TREP till 2020 year. The UN forecasts growth of 30% of renewables in TREP, and 45% till 2050 year. IEA alternative policy scenarios predict even 40% of TREP from renewables in OECD countries. DPS scenario quotes 27% of RES till 2040 year, but 57% by AIP scenario. There are some scenarios (Clean energy) which claim that 100% of TREP will be in renewables till 2100 year.

The most common WEC scenarios are divided in *A, B, C* categories. *A*-scenarios are based on high economic and technological growth and favourable geopolitical conditions and a free market economy. Further, *A1* relies on high figures

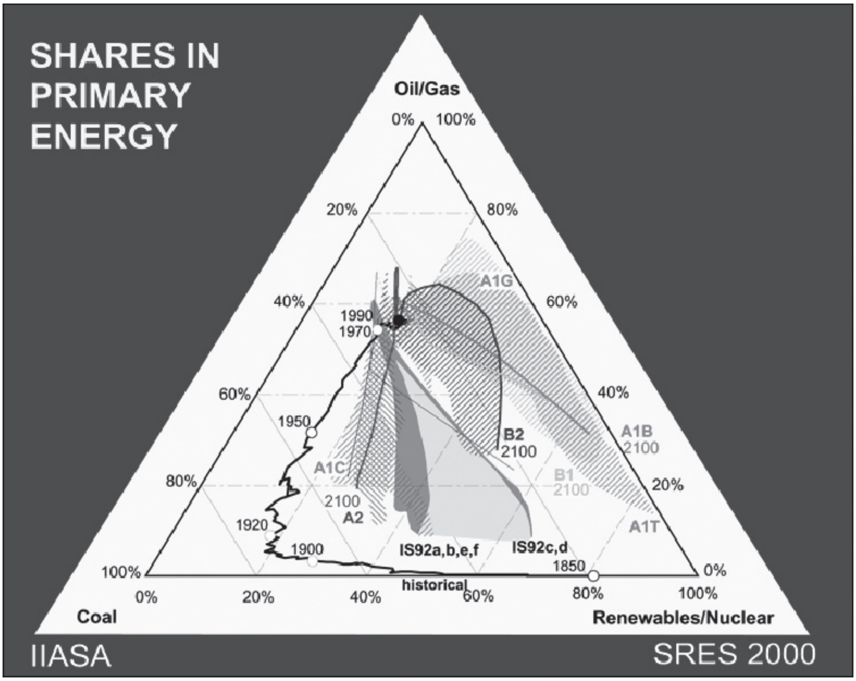

Fig. 9. Shares in primary energy

availability of oil and gas resources, *A2* scarces resources of oil and gas, and a return to coal; whereas *A3* phase out of the fossil fuels for economic reasons.

B-scenarios are based on a more modest economic and technological growth, more modest energy demand and transition to non-fossils sources due to financial and environmental reasons, not for geology. *C*-scenarios are optimistic about

	2001	2010	2020	2030	2040
World Primary Energy Consumption (Mtoe)	10038,3	11752	13553	15547	17690
Biomass	1080	1291	1653	2221	2843
Large Hydro	222,7	255	281	296	308
Small Hydro	9,5	16	34	62	91
Wind	4,7	35	167	395	584
PV	0,2	1	15	110	445
Solar Thermal	4,1	11	41	127	274
Solar Thermal Power	0,1	0,4	2	9	29
Geothermal	43,2	73	131	194	261
Marine (tidal/wave/ocean)	0,05	0,1	0,4	2	9
TOTAL RES	1364,5	1682,5	2324,4	3416	4844
RES Contribution	13,6%	14,3%	17,1%	22,0%	27,4%

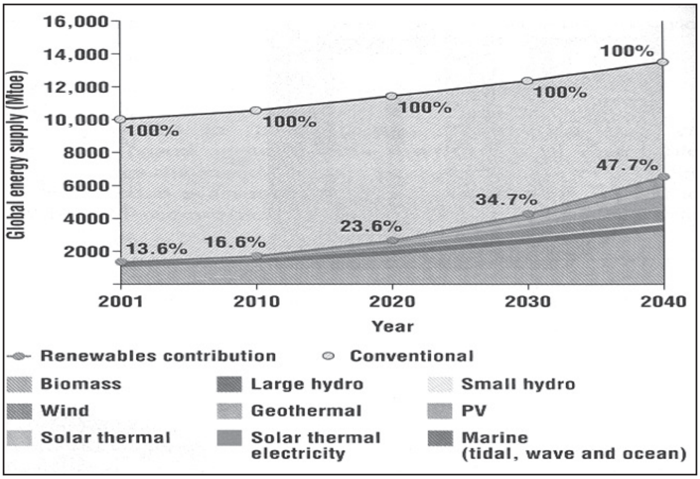

Fig. 10. AIP and DPS scenarios

technology and politics and international cooperation and focuse on the environmental protection. There are two paths for nuclear energy: *C1* (a transient technology, phased out at the end of the 21st century) and *C2* (a new technology for small, safe power plants). These, the so called SRES, scenarios have produced the share of energy, as shown in Fig. 9.

Centralized Electricity production:

Coal conventional	Conventional coal power plants with DESOX and DENOX
IGCC	Integrated coal Gasification Combined cycle
Coal fuel cell	Coal based high temperature fuel cell
Oil	New standard oil power plant, existing crude oil and light oil engine-plants, light oil combined cycle power plants
Gas standard	Standard gas power plant
NGCC	Natural gas-fired Combined Cycle power plant with DENOX
NGFC	Natural Gas-power high temperature Fuel Cell, cogeneration possibilities
Bio	New biomass-fired power plant, advanced biomass power plants
Nuclear	Conventional, existing nuclear power plants
Advanced nuclear	Nuclear high temperature reactors for electricity and hydrogen co production, further inherently safe nuclear reactors designs, and other future zero-carbon electricity-generating technologies for base load
Hydro	Hydropower plants (low and high cost)
Wind	Wind power plants
Other renewables	Geothermal power plant, grid connected solar PV power plants (no storage), solar thermal power plant for hydrogen production

Decentralized electricity generation:

Hydrogen fuel cell	Decentralised stationary and mobile hydrogen fuel cells
Photo-voltaic	On-site solar photo-voltaic power plant in the residential and/or commercial sectors, and in the industry sector
Synfuels:	Coal synliquid Light oil and methanol production from coal
Biomass synliquids	Ethanol production from biomass
Gas synliquids	Methanol production from natural gas
Syngases	Syngases from various sources, including biomass and coal gasification
Hydrogen H_2 (1)	Hydrogen production from fossil fuels
Hydrogen, H_2 (2), (3)	Non-fossil hydrogen production: H_2 (2) fro biomass and electricity, H_3 (3) from nuclear and solar

Some other scenarios, such as Factor 4 (Wupertall), claim that our energy demand has to be reduced four times till 2045 year so that climate could be stabilized. AIP (EREC) scenario is very much concerned with renewables; the same being true for Dynamic policy scenario (DPS)

Whatever happens with the share of primary sources, all do agree that the main medium for using energy will be electricity. It would be transported and distributed by the Centralized and Decentralized electricity generation and from the point of today's knowledge in the following manner:

Definitely, the aim is to reduce the use of non renewable energy sources. The means for reducing the per capita non renewable energy consumption should comprise:

– more energy efficient life style,
– increased conversion efficiency,
– conservation of energy,
– recycling,
– use of wastes for energy production,
– increased use of renewable sources.

This should be possible without loss of quality of life.

4. STATE OF THE ART AND TRENDS IN NEW AND EXISTING TECHNOLOGIES

The main concern about the use of nuclear energy for power production lies in safety issues, treat and disposal of radioactive waste products from nuclear-energy plants, design of inherently safe and proliferation-resistant reactors that minimize waste and development of fusion energy sources. Today's world's nuclear power stations consume around 67.000 tons of uranium per year. At this rate the high grade material will be depleted within 28 years, and the energy costs of nuclear power will begin to rise steeply. Within 60 years, nuclear power stations will be consuming more energy than they produce. Assuming that the world nuclear generating capacity remains at 2005 year level, after about 2016 year the mean grade of uranium ore will fall significantly from today's levels, and even more so after 2034 year. After about 60 years the world nuclear power system will fall of the ²Energy cliff² meaning that the nuclear system will consume as much as can be generated from the uranium ore. Very similar is with thorium, needed for fusion. Fortunately there are very significant resources of it on the Moon.

The problem we are faced with using fossil fuel for energy generation is how to solve technologies and catalysts for cleaner use of coal as fuel and its conversion to other fuels, how to invent new technologies for improved use of conventional fossil fuels and inconvenient sources, such as oil share, oil sands and deep sea methane hydrates. Undoubtedly, one of the major challenges are practical and environmentally responsible methods to compare and sequester carbon dioxide. Since the reserves of coal are significant, the use of coal for energy production might be expected to be favoured.

It the field of renewables a breakthrough in many technologies is expected. The hydro power has been, mainly, exploited in many parts of the world. Thus, the high cost hydro plants can be expected. Production of the energy from hydro, large and small plants, is going to be more and more an integral process innterconnecting the use of water for generation of KW with its use for irrigation, drinking and commercial use. Thus, its use is going to be very much favoured.

The use of new renewables, such as wind, solar thermal, geothermal, photovoltaic, tide and waves and others is in progress.

Wind generated electricity has been one of the big renewable energy successes of the past 30 years. Total wind world capacity, technologically recoverable, is 53.000 TWh/year. The wind has become the most booming energy industry around the world. But, stil, l there are many problems to be solved, such as reinstallation of more efficient on – shore plants and installation of new off-shore plants, control of active and reactive power such that windmills can operate under grid fault conditions. There are new technologies in propeller construction, as well as new materials used. The double fed induction generator has become the major type of

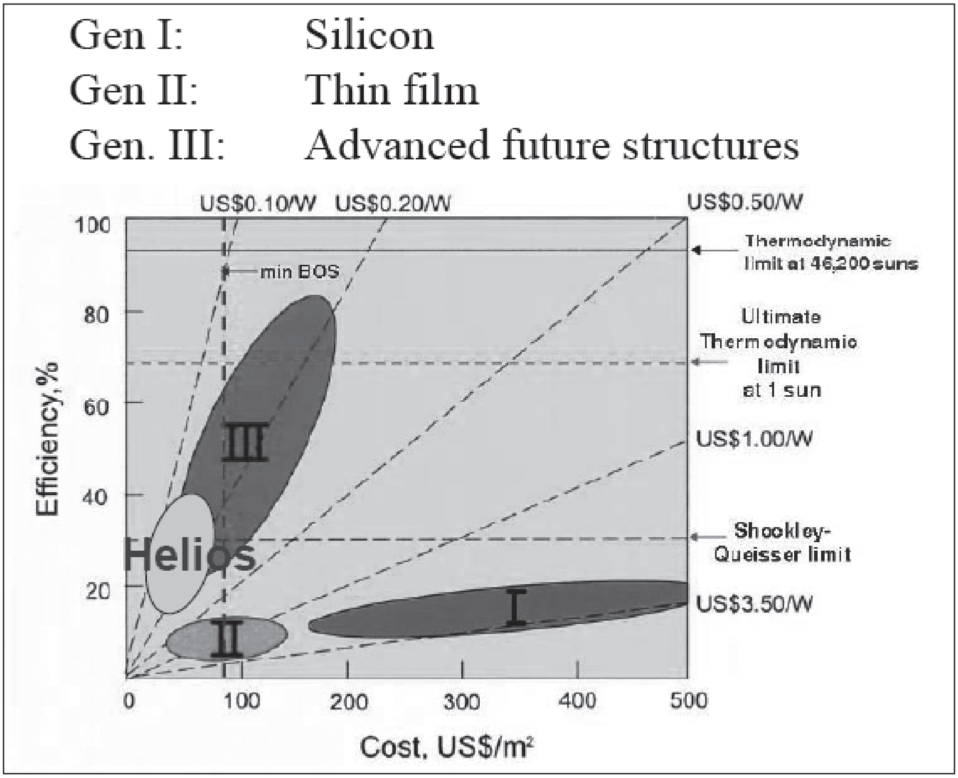

Fig. 11. History of PV development

generator. The ambition in wind power installation is very prestigeous. The plans, for example for European target for 2020 year have been revised several times up to now reaching figure of 180.000 MW, 110 on – shore and 70 off-shores.

Photovoltaic is still an expensive and low efficient technology. From the initial monocristal structure it has been advancing in development aiming to advanced future structures (tandem) with very high efficiency, even higher than 90%. A breakthrough is expected only in the middle of this century.

Biomass is a very promising fuel. Still many problems remain to be solved, such as: sunlight to fuel by biomass conversion (improved conversion of biomass to fuels, improved biomass production, novel biofuel synthesis from organisms), microbial synthesis of biofuels using photosynthesis, direct photochemical of photo electrochemical solar to fuel conversion and sunlight to electricity to fuel conversion. Both broad and narrow biomass, defined by the EU, have found a very significant share in many energy scenarios for the future.

Many other technologies, such as solar thermal, are booming, but still with low efficiency and high cost. Fuel cells need still some time to get into market, too. Problems which concern their stability and degradation are still to be resolved. Wave technology is giving the first results. Some solutions in theUK (worms), Denmark and Australia, although still under development, are very promising. Geothermal energy is specifically distributed and has been used successfully.

In other words, major problems in renewables are to make more stable those sources, using less expensive materials and methods to capture solar energy and to convert it into electricity or other useful products, to take opportunities to use biomass as renewable fuel source, as well as feedstock for industrial applications, and to design new technologies for economical conversion of cellulose waste and energy crops.

Special attention is paid to hydrogen. It is not a primary energy source, rather it is a medium for storing and transporting energy. When hydrogen comes from sunlight and water it represents a perfect fuel. Produced in this way hydrogen generates neither emissions nor pollutants. It can be used for the production of energy we want, and in the form we need. It can be used in fuel cells to supply electricity and heat to run cars and for our houses. Used in this way it produces only energy and pure water vapour – nothing else. Still many questions have to be solved, such as: new materials and processes for hydrogen generation from renewable sources, new material for hydrogen storage with capacity for achieving economically viable hydrogen density and the development of an infrastructure for distribution and delivery of hydrogen.

Another two concerns related to energy future are: transport of energy and storage of energy. Oil is not only a great primary energy source; it is also the best form for transport of energy over continental distances and across oceans. However, it is much less efficient to transport natural gas in this way. Natural gas has to be cooled, liquefied to LNG before it goes into a tank. The LNG tankers are more expensive.

The best answer would be to transport energy as energy, not as the mass. Instead of storing energy in some chemical form it is more efficient to keep it as energy. Electricity is the most essential way to do it. There are essentially two ways to transport electricity in bulk. We could microwave energy up to a satellite and bounce it down, or we could run it along wires on the earth surface. We could do both, but still merely we will use wires.

Possibility for storing large quantities scale of energy producing gigawats of power are very limited. Water can be pumped uphill and run back down again or the air can be compressed. Large scale energy storing technologies exist, but, except in special cases, they lack practicality and desirability of small scale storage

Already in 1998 at WEC conference in Huston the following statement was issued: "Increase of energy efficiency at end users would provide the most direct, the biggest and more efficient opportunity to reduce energy consumption and protection of environment." Rising efficiency of energy use is also of assistance in reducing exposure to supply disruption, overexploitation of resources, and in achieving richer societies and important entry point for encouraging conservation – an ethics that has a far broader use in promoting sustainable development. Although many schemes exist around the world for promoting energy efficiency, especially in the areas of electric appliances and lightning, many barriers persist related to the lack of knowledge, uncertain performances and returns, high initial product and transportation costs, and lack of finance. The existing attitudes and behaviour are not the least of them. Here, improved labelling and testing, tighter standards and their effective application, together with the accompanying regulation, are all required. Incentives for early retirement of inefficient energy – using devices and purchase of more energy efficient ones -can help. Carbon taxes may help to raise efficiency as well as de-carbonization of the fuel mix. However, it is important that policies be applied consistently and persued rigorously – preferential tax treatment of domestic fuel and power bills

Energy efficiency has to provide inexpensive, high energy density, and quickly rechargeable energy storage devices that make electric vehicle practical, less expensive; more stable fuel cells; photocatalitic systems with efficiencies great enough to use for chemical processing on a significant scale, superconducting materials for energy distribution over long distances; lower cost, lighter weight, more durable, more resilient, and recyclable materials for the construction of safer lighter-weight vehicles, and improved materials for buildings. Still the energy efficiency can only significantly contribute, but not solve, energy problems awaiting us in coming decades.

5. WHAT TO DO?

If worldwide energy use continues to rise at around 2% per year (Business as usual), energy supply investments of US$ 35-50 trillion will be needed from 2000 to 2050 year – two to four times the level of investment in energy production and conversion worldwide during the 1990's. If by 2050 year we have solved the problem, the world's energy breakdown will probably look like a reverse of what it is today. Oil, hydroelectric, coal and gas would supply the least amount of energy, with fusion/ fission and biomass processes being somewhat larger players, and solar/wind/ geothermal resources providing the majority of the world's energy. This breakdown will represent a revolution in the largest enterprise of humankind, an energy industry that currently runs about 3 trillion USA$ per year. The solution for these problems has to be looked in dual strategy i. e. to solve:

1. Conservation: maximize energy efficiency and minimize energy use, while insuring economic prosperity, and
2. To find new sources of clean energy.

In that sense the WEC has a set number of rules, as follows:

– Keep all energy options open,
– Ensure the necessary investment in energy infrastructure,
– Adopt a pragmatic approach to market reform,
– Place priority on the measures needed to ensure reliability of supply,
– Promote regional integration of energy supply systems,
– Exploit the "win-win" opportunities of emerging climate change response,
– Ensure technical innovation,
– Foster and sustain public understanding and trust.

Among many values for related to energy future in the new millennium, there are some that have emerged as imperatives. The first being drastic reduction, if not elimination, of the coupling of energy consumption, on the one hand, and economic growth (GDP), material use and emissions, on the other. It has become obvious that re-examining of the assumption that energy problems can be solved without changes in life – styles in industrialized countries has to be done. Reduction of poverty, especially in developing countries, and in that sense a universal access to affordable modern energy sources is urgent. The trend of increase scope for the people's participation with decentralised systems should be kept In that sense all efforts should be made to turn the 21st century into a century of sustainable development.

To achieve sustainability the first objective is to stabilize emission of CO_2 at least to 550 ppm or lower. This is a rather difficult problem in many ways. It requires new knowledge and technologies, better energy efficiency, lower increase in population and a lot more, as discussed earlier. But the largest constraint is the cost of stabilization of CO_2, as shown in Fig. 12.

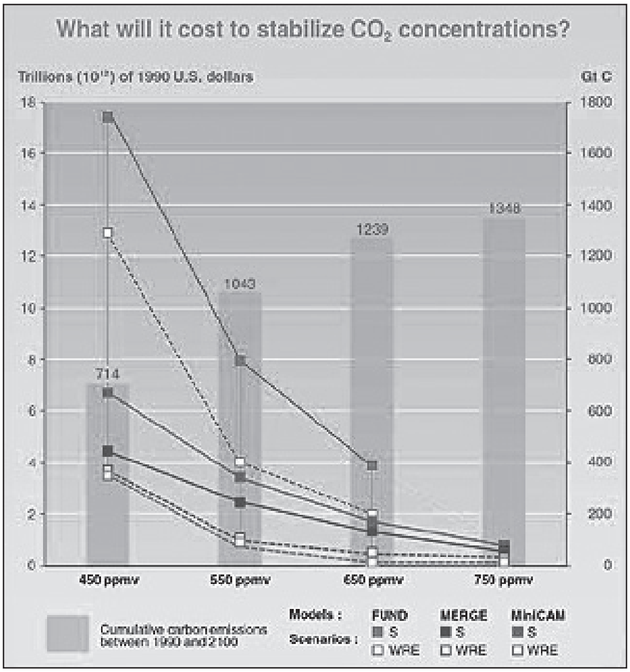

Fig. 12. What will cost to stabilize CO_2 concentration in atmosphere?

To solve energy problems the following options exist: either to continue "Business as usual" or to impose new scenarios. Only new knowledge and new technologies will provide stabilization at the needed level of GHG. As exciting as the future can sound be with these new technologies, history tells us it takes time to change energy mix. This is so because it requires, often a considerable, time, to:

– Create a new technology;
– Demonstrate and commercialize the new technology ;
– Develop self- sustaining businesses, and
– Develop consumer confidence and self sustaining markets.

Thus, at present, the major concern is the development and demonstration of new technologies for an economical, clean, effective, and sustainable preservation, recovery, renovation and construction.

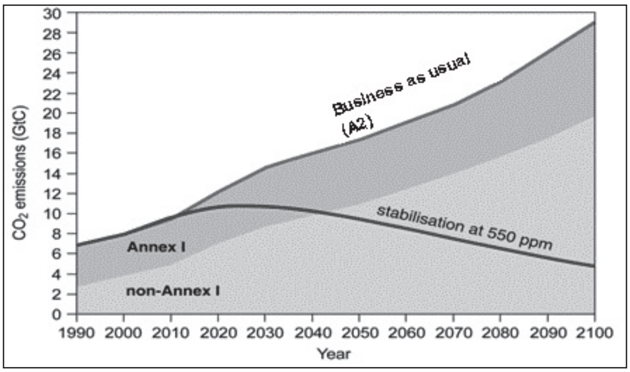

Fig. 13. The path to 550 ppm

We know that this new energy– where we get it, how we use it –

will be different in the coming decades. Many diverse solutions will be required in terms of:

– Fuel
– New knowledge
– Technologies
– Sizes
– Ownership
– Distributed units vs. central stations, and
– Environmental requirements.

6. LITERATURE

[1] Energy for tomorrows World, WEC
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SAŽETAK:
Pregled stanja u energetskim izvorima, raspoloživosti i tehnologija, kao i potrebe za energijom su analizirane. Različiti scenariji energetske budućnosti su dati. Posebna pažnja posvećena je obnovljivim izvorima energije.