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ENERGY EFFICIENCY, RENEWABLES AND ECONOMY

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Abstract: The paper gives results of the investigation of the impact of energy efficiency and the use of renewable energy sources on the economy in the world. In relation to this, it is also noted that energy efficiency and the use of renewable energy sources play a vital role in meeting the needs for energy and global climate changes worldwide. Furthermore, a survey is presented of the measures that are being taken in promoting the use of renewable energy sources and the increase of the energy efficiency in Europe and other countries in the world.
Keywords: energy efficiency, renewable energy sources, economy

1. INTRODUCTION

Being energy efficient means doing the same work while using less energy. By energy efficiency one finds ways to reduce energy consumption while achieving the necessary results. Energy efficiency results in many benefits. Greater effects such as lowering energy costs, reducing local air pollutants in energy efficiency can be achieved by improving equipment, better energy management and better operational practices. Energy efficiency results in less need to develop additional energy resources, and in reduction of energy costs. Thus, one can say that energy efficiency optimizes the energy system as a whole. This is achieved by eradicating wastages through necessary behavior change and improving efficiency through the implementation of energy-efficient technologies [1,2].

Energy efficiency plays an important role in global climate change, too. The International Energy Agency estimates that to fight global warming using less energy is the first and best step; this should come from the improved energy efficiency.

Benefits from energy efficiency are universal, equally important in big and small countries. Sustainable Energy for All, an initiative launched by the UN Secretary-General and co-led by World Bank President sets an objective for 2030 to double the rate of improvement of the energy efficiency globally. This objective was articulated earlier in the report of an expert panel organized by the UN Foundation in 2007 "Realizing the Potential of the Energy Efficiency", supporting the launch of the Global Energy Efficiency. More than 100 banks and a group of Investors, managing close to US$ 4 trillion in assets, have committed to a major increase in the energy efficiency [3]. Led by the European Bank for Reconstruction and the Development and UNEP Finance Initiative, this represents a major undertaking of the energy efficiency potential for the climate change. To achieve those goals, a significant number of countries have set targets and policies to improve the efficiency of the buildings, appliances, transport, vehicles and industry.

From a state's perspective, encouraging energy efficiency should promote economic growth, affect energy costs and supply and minimize its environmental footprint. Thus, the energy efficiency includes: environmental, economic, utility system benefits, and benefits in risk management. In that way, results are achieved in lowering household energy bills, improving business competitiveness, increasing energy available for export, increasing comfort and reducing local air pollutants [4]. Also, the energy efficiency is a key tool in the fight against climate change as it can reduce greenhouse gas emissions from the fossil fuels [5−8].

2. ENERGY EFFICIENCY, RENEWABLES AND GENERATION

Energy conversion efficiency describes an efficiency of converting energy from one form to another in a device, and is the ratio of value of the useful energy output that results from a given energy input. The value of the energy conversion efficiency ratio is generally expressed as a percentage from

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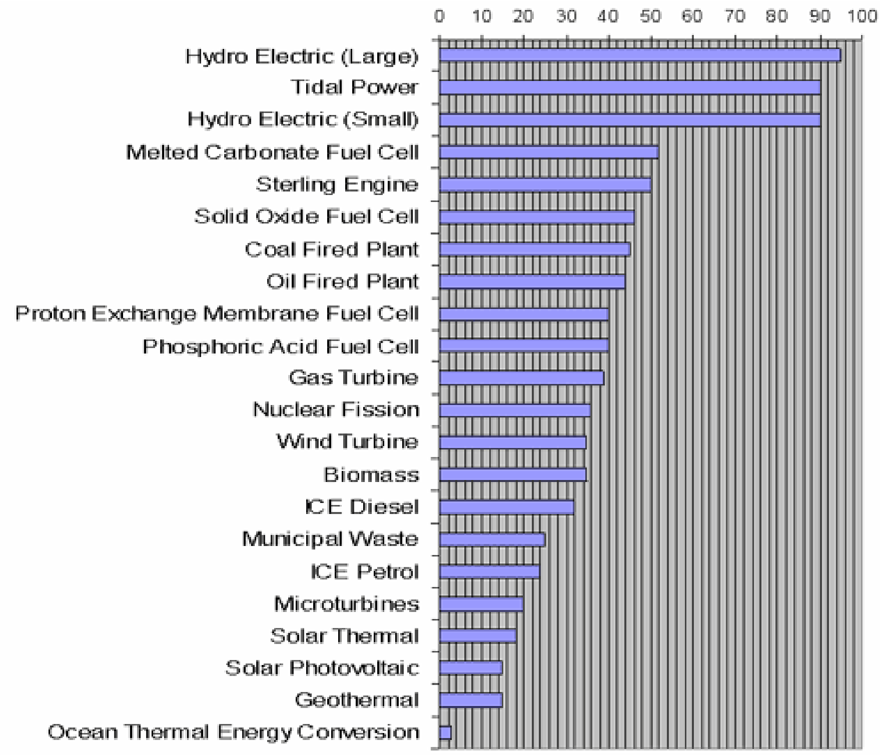
zero to 100 percent, or as a number from zero to one. A conversion device can lose efficiency through a variety of means. Numerous environmental factors can negatively impact the overall efficiency, too.

For example, for the electricity generation based on steam turbines, 65% of all prime energy is wasted as heat. For modern practical systems it is less and amounts to 40%. The efficiency falls still further if fuels with lower energy content, i.e. biomass are used to supply the plant, or with renewables. In domestic electric lighting, less than 1% of the energy consumed is converted into the light energy.

Graph 1. shows the theoretical efficiency of converting various energy sources by a variety of methods into the useful electrical energy [9].



Graph 1. Energy generation efficiency in % (Source – Eurelectric)

In practice, electricity generation installations rarely deliver theoretical capacity. The following factors are used to indicate the effectiveness of a generating utility:

− *The capacity factor* is a measure of the ability to deliver full capacity. It is simply the generator's actual energy output for a given period divided by the theoretical energy output of the machine. For example, *the capacity factor* of a conventional nuclear or coal-fired power plant may be over 80%, whereas *the capacity factor* of wind generators or solar power plants is typically less than 40%, with 25% not being unusual.

− *The load factor* is the ratio of the average load to peak load during a specified time interval. *Poor load factor* means inefficient use of a plant.

− High efficiency plants are normally scheduled to deliver *the base load* of the grid and are consequently operated at a very high load factor.

− Generating plants supplying *peak loads* will normally have a very poor load factor.

− *The plant margin* is an indicator of the security of supply. It is the amount expressed as a percentage by which the installed generation capacity exceeds the forecast peak demand. A *plant margin* of at least 20% is considered to be necessary. A high *plant margin* thus results in a low load factor.

The energy is also wasted due to the transmission and distribution processes. The resistance of the cables results in efficiency losses. *The Distribution Loss Factors* is the main characteristic of grid energy efficiency. These losses are typically 5% for supplies to urban locations close to the power source, but as high as 10% to 20% for remote rural locations. In many developed countries the average loss is 7% to 8%. With high voltage transmission systems there are also additional, though minor, copper and iron losses in the transformers.

The energy efficiency of transmission can be improved by using as low current as possible associated with the higher transmission voltages. The level of voltage is limited by the breakdown of the air insulation between the power cables and the earth, or by reactive load. To reduce further losses at high transmission voltages, transmission with direct current is preferable [11].

Sun is the source of all energies. The primary forms of solar energy are heat and light. Sunlight and heat are transformed and absorbed by the environment in various ways. Some of these transformations result in renewable energy flows such as biomass and wind energy. There has not been much systematic linking of the energy efficiency and renewables in the policy arena, although a small, but growing number of policies have begun to address efficiency and renewable energy in concert, particularly through building-related incentives and economy-wide targets and regulations [12,13].

Special synergies exist between energy efficiency and renewable energy sources in both technical and policy contexts. This applies across numerous sectors from buildings and electrical services to transportation and industry. Energy efficiency and renewable energy are two energy options that promise significant savings on energy, costs and CO_2 emissions. They each have their own unique benefits; they require different kinds of investments and resources. Renewable energy and energy efficiency are twin pillars of a sustainable energy future. As energy services are delivered more efficiently, renewables can more quickly become an effective and significant contributor to the primary energy supply.

Renewable energy is a clean and in many cases easy affordable source of energy. It offers many far-reaching benefits. It is crucial not to rush into the implementation of renewables for a particular site. Once the system has undergone all possible changes in energy conservation and improved efficiency, only then should renewable energy be explored as an option for isolated loads, to supplement other sources, or sometimes totally account for the remaining load. Adopting renewable energy solutions when a system is not fully efficient carries a number of substantial risks. The essential feature of renewables is that they are products of manufacturing and, as such, are limited only by the build-up of the manufacturing capacity and the resources needed to feed that capacity.

Renewable energy continued to grow in 2014 and 2015 against the backdrop of increasing global energy consumption, as well as a dramatic decline in oil prices in 2014 and 2015, and global financial crises. Renewable energy provided an estimated 19.1% of the global final energy consumption and growth in capacity and generation continued to expand. Heating capacity grew at a steady pace, and the production of biofuels for transport increased for the second consecutive year, following a slowdown in 2011–2012. Renewables represented approximately 58.5% of net additions to global power capacity in 2014, with significant growth in all regions. Wind, solar PV and hydro power dominated the market. By the year's end, renewables comprised an estimated 27.7% of the world's power generating capacity, enough to supply an estimated 22.8% of the global electricity.

Over the period 2007–2012, renewable power generation grew at an average rate of 5.9% per year. In contrast, global electricity consumption increased by an annual average rate of 2.7% in the same period, with the electricity consumption in non-OECD countries growing twice as rapidly. In 2014 the renewables growth occurred on the power capacity reaching an estimated 1,712 GW at the year's end, an increase of 8.5% over 2013. Hydropower capacity rose by 3.6% (1,055 GW), while other renewables grew nearly 18% to an estimated total approaching 660 GW. Globally, wind and solar PV each saw record capacity additions, and together they accounted for more than 90% of non-hydro installations in 2014 [14].

In 2014, the energy use for heat accounted for about a half of the total world final energy consumption. Renewable energy, of which over two-thirds was traditional biomass accounted for more than 25% of the final energy use in the heating sector. Modern renewable energy supplied the remaining third—or approximately 8% of the total heat.

In 2014, about half of the modern renewable heat is consumed by industry, representing 10% of the total heat demand and is produced almost entirely from biomass. The other half of the renewable heat consumption occurs in buildings for space heating, water heating and cooking, and is derived primarily from biomass, with solar and geothermal contributing with much smaller shares. Renewable energy is also used for cooling. In recent years, the global solar cooling market has grown at an annual rate exceeding 40%.

The use of renewables in transportation is still small. Renewable energy accounted for an estimated 3.5% of the global energy demand for road transport in 2013, up from 2% in 2007. In the transport sector the renewables are present by the use of 100% liquid biofuels or blended biofuels with conventional fuels, with a growing role of natural gas, and the increasing electrification of transportation. The use of hydrogen is still negligible, although promising.

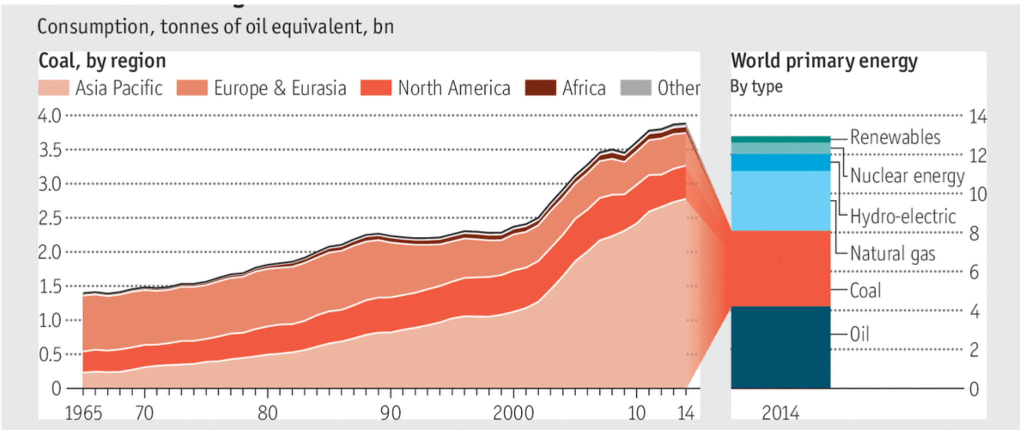


Figure 1. World primary energy share (Coal is still 40% of primary energy) (Source: BP Statistical Review of World Energy 2015)

An estimated 37 GW of hydropower capacity was commissioned in 2014, increasing the total global capacity by 3.6% to approximately 1,055 GW.

Geothermal resources provide energy in the form of electricity and direct heating and cooling, totaling an estimated 528 PJ (147 TWh) in 2014. Approximately 640 MW of the new geothermal power generating capacity was completed in 2014, bringing the total global capacity close to 12.8 GW.

Ocean energy refers to any energy harnessed from the ocean by means of: ocean waves, tidal range (rise and fall), tidal streams, ocean (permanent) currents, temperature gradients, and salinity gradients. At the end of 2014, global ocean energy capacity remained at about 530 MW, with most of this coming under the category of the tidal power.

The concentrating solar thermal power (CSP) market in 2014 continued its strong growth. New projects totaling over 0.9 GW increased the total global capacity by 27% to nearly 4.4 GW. In 2013, global solar thermal market growth slowed largely due to the decline of the markets in Europe and China. The world installed 55 GWth (789.6 million m2) of solar heat capacity in 2012. Cumulative capacity of all collector types in operation rose by a net 44 GWth for a year-end total of 374.7 GWth.

Over 51 GW of wind power was added in 2014, representing a 44% increase over the 2013 market and bringing the global total to around 370 GW. By the end of 2014, at least 85 countries had seen commercial wind activity, while at least 74 had more than 10 MW of capacity in operation, and 24 had more than 1 GW. There are dynamic and emerging markets in most regions.

Global investment in renewable energy was USD 50.2 billion in the first quarter (Q1) of 2015. This total was down 10% compared to Q1 in 2014 mostly due to a slowdown in the big markets such as Brazil, China, and in Europe. Buildings account for about 40% of the total global energy consumption. It is estimated that the energy savings in buildings could be between 20 and 40%.

Some policymakers are using regulations to advance the efficiency and renewables in combination. Three main approaches in policy have been taken: encouraging renewables and energy efficiency in parallel on an economy-wide basis; integrating renewables and energy efficiency under the same economy-wide basis; and requiring the joint implementation of the renewables and energy efficiency.

Energy efficiency measures and renewable energy options can work together to reduce system-wide environmental and economic costs. The two pillars support each other to enable applications that otherwise might not be technically or economically practical.

Energy efficiency and therefore renewables are a key tool in the fight against the climate change as it can reduce greenhouse gas emissions from the fossil fuels. The Huffington Post has reported that energy efficiency just may be a solution, with the International Energy Agency (IEA) claiming that „energy efficiency can deliver 38% of what is needed to keep our planet within the two degree scenario“. The COP21 acted in the same line [8,13].

3. ENERGY EFFICIENCY AND ECONOMY

A significant body of literature has been devoted to the economics of energy efficiency, renewables and conservation. The energy efficiency of a sector or of the economy as a whole can be measured „as the level of a gross domestic product per unit of energy consumed in its production“. In contrast, energy conservation is defined as a reduction in the total amount of the energy consumed. Furthermore, one must distinguish between the energy efficiency and economic efficiency. The energy should be treated as an input into the production of energy services rather than as a final product [15].

Improving energy efficiency is one of the most constructive and cost–effective ways to address the challenges of high energy prices, energy security and independence, air pollution, and global climate change. Maximizing economic efficiency is generally not going to imply maximizing energy efficiency. From an economic perspective, energy efficiency involves investment that trade off the initial capital costs and uncertain future energy operating costs, thus energy-efficient investment requires weighing the initial capital cost against the expected future savings. The consumer decisions regarding investing in more energy-efficient products and equipments are affected by the energy markets and market prices. Thus, an energy price increase is more likely to significantly affect the energy efficiency adoption.

The *energy efficiency gap* presents „a significant difference between the observed levels of energy efficiency and some notion of the optimal energy use". Often, the efficiency gap is illustrated by a comparison of the market discount rate and the relatively high *implicit discount rates* that are implied by the consumer choices over appliances with different costs and energy efficiencies [16].

The common theme regarding economics of energy efficiency is energy market failures i.e. the fact that energy prices do not reflect the true marginal social cost of energy consumption. Furthermore, information problems and programs are consistently raised in the energy efficiency literature and "along with behavioral failures, are often given as the primary explanation for the energy efficiency gap". In addition, asymmetric information may lead to adverse selection. The lack of purchasers of the less energy-efficient product owing to the lack of access to credit, results in underinvestment in energy efficiency. Other parameters are mentioned in literature such as: innovation market failures, behavioral failures, information programs and financial incentives [17].

There are a few critical issues common to energy efficiency policies. One important is evaluating product standards, not less important is examining the historical effectiveness and the cost of energy efficiency and conservation policies in order to improve future policy making. A very important issue is *Product Standards* which are set as a minimum level of the energy efficiency that all covered products on the market must meet. The literature on product standards focuses for the most part on the appliance standards. These range from the energy management system standard ISO 50001 that can be used by any organization in any sector, to standards specific to certain sectors, such as building or transportation [18].

One of the most common indicators used to illustrate the rate of improvement in economics of the energy efficiency is energy intensity. However, the effectiveness of this indicator is limited because changes in energy intensity can be caused by factors other than energy efficiency, such as structural changes in the economy.

Greater use of renewable energy is seen as a key component to combat climate change, and is being aggressively promoted as such by many governments. Yet, there is a scarce economic analysis of the renewable energy [19]. Many renewables are characterized by their intermittency and this has not been adequately factored into the discussions of their potential. Though power from solar and wind is intermittent, nature often cancels out the fluctuations: sunny days tend not to be windy, and vice versa. But if the intermittent energy can be stored, its economics is dramatically improved: the cost of installing capacity remains the same but the cost per kilowatt hour shrinks. Without new storage technologies, much of the decarbonization of the economy will still have to come from nuclear, carbon capture and storage (CCS) and energy efficiency. Although the storage business is booming (in 2014 alone projects amounting to 363MW were announced), there is no significant improvement in storage technology currently in sight [20]. New energy storage technologies could greatly increase the role of renewables.

Whether or not it represents a good value for money, renewable energy has become a serious part of the energy mix. Thus, in 2013 the clearest sign of health in the renewables market was China whose investment in 2013 included 16GW of wind power and 13GW of solar. The renewable-power capacity China installed in that year was bigger than its new fossil-fuel and nuclear capacity put together. On top, Denmark's wind turbines provided a third of the country's energy supply and Spain's a fifth.

The biggest boost to solar, both in the rich and the emerging world, is its plummeting cost. In a recent report the IEA noted that the cost of solar panels had come down by a factor of five in the past six years and the cost of the full PV systems by three. The cost of electricity from new solar systems can vary from $80 to $300 per MWh. In Japan the cost of power produced by the residential photovoltaic systems fell by 21% in 2013. In the European Union, renewables, despite a 44% fall in investment, made up the largest portion (72%) of the new electric generating capacity for the sixth year running. It has been recorded that the *levelised cost* of electricity from decentralized (small-scale) solar PV systems in some markets is „approaching or falling below the variable portion of the retail electricity prices“. The IEA expects the cost of solar panels to half in the next 20 years. By 2050, it predicts, solar will provide 16% of the world's electric power, well over 11% in 2010.

Many renewable technologies are becoming cheaper and more practical and in some countries their application are boosted by generous subsidies [21]. Germany rebates 30% on the cost of a solar-plus-battery household system, offering low-interest credit, too. California has legislation under which a third of its energy must come from renewable resources by 2020. Three large utilities have to provide 1.3GW of the storage capacity. Around 85MW of this is likely to be used by small providers with solar panels.

The main reason for the growth of investments in solar energy is innovations. The smaller is in thermal storage, in which sunlight is concentrated as heat. Investment in the second, more widespread form of solar energy, electricity produced by photovoltaic (PV) cells, fell back in 2013 after ten years when the average annual growth was around 50%. Yet, solar energy received 53% investments worldwide in the renewable power in 2013 with the same trend in 2014. It still provides only a small portion of the world's energy, and even by 2020 it will make up just 2% of the global electricity supply [22].

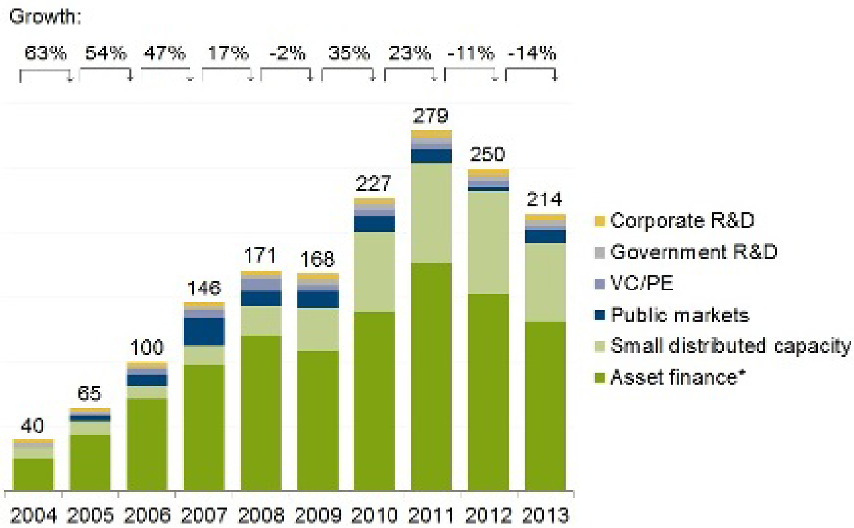


Figure 2. Global New Investment in Renewable Energy by asset class, 2004-2014 ($BN)
(Source: UNEP, Bloomberg New Energy Finance)

Thus, for example, at a site with average wind speeds of 7 m/s, a typical turbine will produce about 1,100 kWh per square meter of area per year. For turbine's blades 35 meters in diameter, for a total swept area of 1,000 square meters, the power output will be about 1.1 million kWh/year. Furthermore, the power output from a wind turbine is a function of the cube of the average wind speed. Finally, the power in the wind varies with height, temperature and altitude, which all affects the air density. An important parameter in the cost of the wind power is the turbines' distance from transmission lines. It is not unusual for remote areas (for example, northern Canada or Siberia) to have high average wind speeds, but be too far from the grid for the wind power to be used economically. For offshore wind projects, the economics depends on the distance from the shore because turbine foundation costs increase rapidly with increasing water depth.

Wind energy costs are now lower than the costs of most new conventional sources and are close to cost-competitive with the new natural gas generation. Thus, the price of the American wind power has declined more than 90% since 1980; in 2011 and 2012, the price of wind in the United States averaged just 4 cents per kilowatt hour, which is 50% lower than in 2009. The cost of energy from the wind is mostly a function of the wind resource. The more the wind blows, the more power will be produced. The term used to describe this is „an average capacity“, which is simply the percentage of power a turbine produces compared to what it could produce if it were steadily running. A more precise measure of the output is the „specific yield“. This measures the annual energy output per square meter of area swept by the turbine blades as they rotate. In general, wind turbines capture between 20% and 40% of the energy in the wind.

4. EU AND ENERGY EFFICIENCY

Under the Directive, all EU countries are required to use energy more efficiently at all stages of the energy chain from its production to its final consumption. According to the Energy Efficiency Communication of July 2014, the EU is expected to achieve energy savings of 18%−19% by 2020 – missing the 20% target by 1%−2%. However, if EU countries implement all of the existing legislation on energy efficiency, the 20% target can be reached [23].

The EU has adopted a number of measures to improve energy efficiency in Europe [24]. They include:

− an annual reduction of 1.5% in national energy sales,

− EU countries making energy efficient renovations to at least 3% of the buildings owned and occupied by central governments per year,

− mandatory energy efficiency certificates accompanying the sale and rental of buildings,

− minimum energy efficiency standards and labelling for a variety of products such as boilers, household appliances, lighting and televisions (Eco Design),

− the preparation of National Energy Efficiency Action Plans every three years by EU countries,

− the planned rollout of close to 200 million smart meters for electricity and 45 million for gas by 2020,

− large companies conducting energy audits at least every four years,

− protecting the rights of consumers to receive easy and free access to data on real-time and historical energy consumption.

The EU's drive towards a more energy efficient future has already produced substantial benefits for the Europeans, for instance:

− new buildings consume half the energy they did in the 1980s,

− energy intensity in the EU industry decreased by almost 19% between 2001 and 2011,

− more efficient appliances are expected to save consumers €100 billion annually – about €465 per household – on their energy bills by 2020,

− the share of refrigerators meeting the highest energy efficiency labelling classes (A and above) increased from less than 5% in 1995 to more than 90% in 2010.

Further benefits are expected in the future which will include improvements of technology as well as management in private sector, commercial sector, industry and transportation sector. One of the major criticisms of the energy efficiency and conservation policy evaluation literature is that “free riders” are not always properly accounted for.

All EU countries have adopted national renewable energy action plans showing what actions they intend to take to meet their renewables targets. These plans include sectorial targets for electricity, heating and cooling, and transport; planned policy measures; the different mix of renewables technologies they expect to employ and the planned use of cooperation mechanisms [25].

Renewables will continue to play a key role in helping the EU meet its energy needs beyond 2020. EU countries have already agreed on a new renewable energy target, under EU's energy and climate goals for 2030, of at least 27% of final energy consumption. It is important to note that by using more renewables to meet its energy needs, the EU lowers its dependence on the imported fossil fuels and makes its energy production more sustainable. The renewable energy industry also drives technological innovation and employment across Europe [26].

5. CONCLUSIONS

One of the greatest uncertainties in the energy future is whether greenhouse warming due to the technological activities will prove to be both real and significant. Energy efficiency can lower energy costs, reduce local air pollutants such as small particulate matter, and make our homes and buildings more comfortable. In any case technology will be called on initially to deal with the goal of massive energy conservation. The improvement in structures, buildings, design, and insulation with regard to the efficient electricity flow, and the development of the new, more efficient engines will all move ahead rapidly and simultaneously. The re-engineering of the global energy infrastructure is inevitable, although it might not be enough since greenhouse-based warming has been proved. In the future, our global energy infrastructure is likely to be structured around two primary sources of the noncarbonated fuels. One is nuclear power, with uniformity of design, economy of scale, and interchangeable parts and staff. The other is solar energy, whose primary contribution will be photovoltaics for direct generation of electricity and passive solar for the production of hot water. Another likely source is wind: great improvements in that technology have developed over the past five years.

Effective energy management systems increase energy efficiency by at least 5% irrespective of size, technology or process. At the same time, there are things we must do to tackle the climate change that go beyond being more energy-efficient.

Cost-effectiveness of the technical solutions: profitability of investing in energy efficiency technologies is often unknown or questioned. Financing energy efficiency requires a long-term commitment, and the financing framework should take this into account. The loan terms should be covering the entire lifetime of the solution. To agree on the short-term solutions, impact assessment should be based on a full life-cycle analysis, and also be realistic and achievable.

Toward that end, *the UN Foundation* supported the launch of a *Global Energy Efficiency Accelerator Platform* at the *UN Climate Summit in September 2014*, and *COP21* has done in the same line.

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ЕНЕРГЕТСКА ЕФИКАСНОСТ, ОБНОВЉИВИ ИЗВОРИ ЕНЕРГИЈЕ И ЕКОНОМИЈА

Сажетак: У раду су дати резултати проучавања утицаја енергетске ефикасности и коришћења обновљивих извора енергије на економска кретања у савременом свету. У вези са тим је истакнуто да енергетска ефикасност и коришћење обновљивих извора енергије играју веома важну улогу у задовољавању енергетских потреба и глобалним климатским променама у свету. Поред овога, дат је преглед мера које се предузимају у вези коришћења обновљивих извора енергије и повећања енергетске ефикасности у Европи и осталим земљама у свету.

Кључне речи: енергетска ефикасност, обновљиви извори енергије, економија.