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Sustainable energy system with zero emissions of GHG for cities and countries

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ABSTRACT

Many documents in EU and other countries in the world are dealing with changes in energy system, with final goal of attaining greenhouse gases (GHG) emissions reduction. Vision of the new Sustainable Energy System (SES) is based on the carbon recycling using solar and planetary energy. SES is based on the existing infrastructure and known chemical reactions. With regards to available renewable energy resources (RES) it is unrestricted in comparison to present fossil fuels use.

The proposed SES consists of the three main energy carriers, needed in any settlement: electricity from RES, synthetic methane (CH_4) and synthetic methanol (CH_3OH). The last two are the only energy carriers in nature with one carbon (in our case from biomass) with four hydrogen's (coming in the future from electrolysis of water or other solar processes). To these two, we can add transitional hybrid fuels dimethylether (CH_3OCH_3 – consisting of one oxygen and two methyl groups – two carbons and six hydrogen atoms) and synthetic diesel, produced from cities' organic waste and biomass. All these energy carriers can be used in the existing energy transformation equipment in industry, transportation and buildings. SES has no GHG emissions, because CO_2 and water are recycled in nature.

1. Introduction

Cities and villages are the main energy consumers. More and more people are living in urban areas, which are sometimes becoming extremely large, their size approaching to megacities. From [1] we quote:

> "In 1800, only 3% of the world's population lived in cities, a figure that rose to 47% by the end of the twentieth century. In 1950, there were 83 cities with populations exceeding one million; by 2007, this number had risen to 468. If the trend continues, the world's populations as a whole will double every 45 years. The UN forecasts that today's urban population of 3.2 billion will rise to nearly 5 billion by 2030, when three out of five people will live in cities. . . . . By 2025, according to the Far Eastern Economic Review, Asia alone will have at least 10 megacities, including Mumbai, India (33 million), Shanghai, China (27 million), Karachi, Pakistan (26.5 million), Dhaka, Bangladesh (26 million) and Jakarta, Indonesia (24.9 million people). Lagos, Nigeria has grown from 300,000 in 1950 to an estimated 12.5 million today, and the Nigerian government estimates that the city will have expanded to 25 million residents by 2015."

Growth is very fast: Shanghai has growing to 35 million inhabitants up to date.

Energy transformation in cities caused serious environmental problems such as air pollution and in some cases waste and water pollution.

We can read [1] further: "Many urban areas have significant problems with smog, a type of air pollution derived from vehicle emissions from internal combustion engines and industrial fumes that react in the atmosphere with sunlight to form secondary pollutants that also combine with the primary emissions to form photochemical smog.

Smog is also caused by large amounts of coal burning, which creates a mixture of smoke and sulfur dioxide. World coal consumption (updating from author according [2]) was about 5.595 billion tons in 2012 (with world reserves of 860.938 billion tons, for ~106 years) and is expected to increase to 9.053 billion tons by 2030. China produced 2.738 billion tons (~47.5% of total) in 2012. India produced about 343.2 million tons in 2012 (6.0% of total). USA consumed in 2012 about 11.7% of the world total, and is using 90% of it for generation of electricity."

In Principles of Intelligent Urbanism [3] **principle one is a *balance with nature.*** We quote:

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"According to proponents of Intelligent Urbanism, balance with nature emphasizes the distinction between utilizing resources and exploiting them. It focuses on the thresholds beyond which deforestation, soil erosion, aquifer depletion, siltation and flooding reinforce one another in urban development, saving or destroying life support systems. The principle promotes environmental assessments to identify fragile zones, threatened ecosystems and habitats that can be enhanced through conservation, density control, land use planning and open space design. This principle promotes **life cycle building energy use and pollutant emission analysis**."

Clean air and emission free traffic are two of the most important issues for the future quality of life in the cities.

Not only the low energy and healthy buildings, but clean renewable energy supply is needed for the cities and metropolitan areas all over the world. Regardless of how long the fossil fuels will be available in the world or local markets, they have finite life time and we have to prepare the society for a new sustainable energy system with zero GHG emission. The system should enable a smooth transition from the present system to a new one, using existing infrastructure and must be available everywhere on the planet.

There are two basic long term solutions: **solar energy** or/and **planetary energy conversion** (geothermal, tide) to useful energy carriers. According to some scientist we can use fusion, the third, and find no sustainable solution.

Our choice is **solar and planetary energy conversion** and we will explain how to build a new system and what technologies are needed to realize such a **sustainable energy system** (SES).

2. What do we need to replace?

World total primary energy supply (TPES) in 2012 [2,4] was approaching 12.500 Mtoe with conversion efficiency (FE/TPES) of only 68%. Amount of RE energy in TPES in 2012 was 8.6%, consisting of hydro power 6.7% (831.1 Mtoe/y) and other RE 1.9% (237.4 Mtoe). World electricity consumption was 21,431 TWh with 16.3% coming from HE. The electricity from other RES is less than 3.7%, together 20%. This means that new system should replace 80% of fossil fuels for electricity generation with renewable electricity. We must replace, in the first phase (all data from 2012 [2]), 3730.1 Mtoe coal and 560.4 Mtoe nuclear fuels. In the second phase we have to replace the rest of the fossil fuels used for the conversion to electricity, mostly oil ~ 4130.5 Mtoe. In the first and second phases we have to replace a total of ~8421 Mtoe of present fossil fuel consumption for electricity generation.

If we accept that natural gas – methane – will be one of the future energy carriers, we have to replace it with the synthetic methane in the third phase in equivalent of 3 033.54 Mtoe.

Different world scenarios (IEA, BP, Shell, etc.) forecast the TPES growth from 17% to 33% up to year 2035. This means that required replacement will increase for this amount.

3. Environmental issues

Present emissions of GHG from fuel combustion are over 31,342 Mt/y $CO_{2ekv.}$ (2011). From the IPCC 5th report [5] we can take the following information:

"Annual CO_2 emissions from fossil fuel combustion and cement production were 8.3 [7.6 to 9.0] GtC/y averaged over 2002–2011 (high confidence) and were 9.5 [8.7 to 10.3] GtC/y in 2011, 54% above the 1990 level. Annual net CO_2 emissions from anthropogenic land use change were 0.9 [0.1 to 1.7] GtC/y on average during 2002 to 2011 (medium confidence). From 1750 to 2011, CO_2 emissions from fossil fuel combustion and cement production have released 375 [345 to 405] GtC to the atmosphere, while deforestation and other land use change are estimated to have released 180 [100 to 260] GtC. Cumulative anthropogenic emissions are **555 [470 to 640] GtC**. Of these cumulative anthropogenic CO_2 emissions, **240 [230 to 250] GtC** have accumulated in the atmosphere, 155 [125 to 185] GtC have been taken up by the ocean and 160 [70 to 250] GtC have accumulated in natural terrestrial ecosystems (i.e., the cumulative residual land sink)".

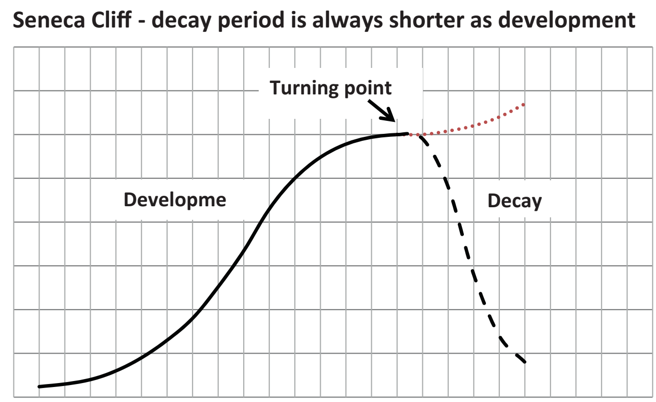

Fig. 1. "S"-development curve as part of Seneca cliff with possible new development after turning point [6].

We are facing two challenges if we would like to solve the problem:

- the growth of world population and
- growing energy need for development in developing countries.

The first challenge, growth of world population, will be, as expected from world OUN statistics, solved by the nature itself, with aging of present population in developed (EU, Japan, USA) and in some developing countries (China). Using theory of S-shaped development curve of natural processes for population growth and energy needs we can expect the saturation of population growth near the end of this century [1] at 10 billion of population. If this S-curve is part of "Seneca cliff" [6] (Fig. 1) than we can expect the limit of the energy growth also near the end of this century. Turning point can be prolonged using new technologies or can be reversed in new development, changing the energy system. Looking back to 1972, the MIT researcher for Club of Rome predicted similar development in [7] with turning point in 2030 (Fig. 2). Real development of population growth and energy supply of the world is shown in Fig. 3. Original figure is from year 1992 and all predictions at that time are in accordance to present development.

After 42 years of first the UN conference on environment (Only one Earth, 1972) and 22 years after RIO, we have not been able to change the basic direction of the development. Business as usual prevail all scientific warnings from that time. Climate changes and needs for adaptations are the result of such behavior.

The second challenge, energy growth needed for development, has to be solved through development and stepwise equalization of energy use per capita in the world. If we look at the present situation it becomes clear that energy needs in the world are very different. Great differences are between developed countries (and even between them) and countries in development. In (Table 1), data of energy use [4] and GDP for selected countries is presented. From this data we can conclude that quality of life doesn't depend

[1] See the prediction of the population change in Japan and EU [14,15].