Assessing Our Civilization's Future Energy Needs

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1.0 Introduction

This article attempts give us a glimpse into the future energy needs of our civilization by examining the predictions and recommendation of recently published studies by the three of the world's most prestigious energy organizations: the World Energy Council (WEC) in cooperation with the Paul Scherrer Institute (PSI), the U.S. Energy Information Administration (EIA) and the International Energy Agency (IEA). Each organization has provided quantifiable predictions about the future energy needs of society by mid-century and how these predictions will be fulfilled. This article concludes, with a projection about the potential size and value of the energy market in the same time period.

Please note that when reporting about energy production and consumption, each of these organizations and their reports discuss energy values using different measurements such as: BTU – British thermal units, EJ – Exajoules, MTOE – Million tons of oil equivalent and BOE - barrels of oil equivalent. As this can be confusing for the non-specialist and as it makes these reports difficult to compare, for the purposes of this article we have attempted to convert and harmonize their published energy values and measurements so that they can be compared with each other. This should help us to arrive at an accurate energy assessment.

In order that the reader can validate and crosscheck our assumptions and conclusions, all of the values mentioned in this article are derived from the specific reports and/or are referenced. Our conversion methods are described in the text and are referenced at the end of this article where we provide links to several web sites that offer online forms for making the conversions.

2.0 IPCC Intergovernmental Panel on Climate Change

For additional background and context on the topic of energy we find it necessary to reference the recent assessment *Climate Change 2013: The Physical Science Basis* [1] by the Intergovernmental Panel on Climate Change (IPCC) which has reinforced the dire predictions of its earlier assessments about the impact and influence of human activities which they assert is leading to a change in the climate of the Earth specifically called: Anthropogenic Global Warming (AGW) or Catastrophic Anthropogenic Global Warming (CAGW). They predict that a warmer planet will lead to a rise in sea levels, ocean acidification, a shift in food productions regions and more migration pressures. They also report that a large consensus – some 97% - of the scientific community support this view.

One of the new key findings of their 2013 report was that humanity needs to emit no more than one trillion tons of carbon in order to stand a good chance of limiting global warming to 2 °C. They also point out that CO_2 stays in the atmosphere for centuries with the result that its build-up is cumulative.

"What's new here is that we show the carbon we emit will largely stay in the atmosphere for centuries. So every ton we emit creates a long-term impact," says Reto Knutti of the Institute of

Atmospheric and Climate Science in Zurich, Switzerland, who was the lead author of the relevant section of the IPCC report on the science of climate change. "The climate change it causes will be essentially irreversible," he adds, without geo-engineering (large-scale deliberate manipulation of the earth's climate. [2]

As of December 2013, the world has now emitted over 575 billion tons since the beginning of the industrial age and, based on current trends, the trillionth ton is expected to be reached in October, 2040. If humanity goes beyond this trillion ton threshold, the climate will warm correspondingly. A web site set up by climate researchers at Oxford University, England, is counting the tons of CO_2 emissions in real time: www.trillionthtonne.org. According to the web site, to prevent the trillionth ton ever being emitted, our emissions have to fall by 2.48 percent a year, and to keep on falling at that rate until they eventually reach zero. [3]

As reported in The Guardian newspaper:
"Scientists calculate that nearly half of all the carbon dioxide that can be safely emitted without raising temperatures above a dangerous 2°C has already been emitted. This, says the IPCC, means governments must act quickly to have a reasonable change of avoiding 2°C. It is also very likely that more than 20% of emitted CO_2 will remain in the atmosphere longer than 1,000 years after man-made missions have stopped. According to the IPCC, a large fraction of climate change is thus "irreversible on a human time-scale", except if man-made CO_2 emissions are sucked out of the atmosphere over a long period." [4]

Put quite simply, the IPCC believes these trends could compromise the sustainability or our civilization if human activities lead to passing the trillion ton CO_2threshold in the year 2040. It should also be noted that measures and investments which will be necessary to remove or reduce levels of CO2 in the atmosphere such as carbon capture storage and sequestration (CCS) technologies will add significantly to the overall costs of energy in the future.

As we will see in the reports by the energy organizations, meeting the world's energy needs in the years 2040-2050 with sufficient energy levels and at the same time meeting the specific goal of limiting CO_2 emissions to the trillion ton cap poses a major challenge for our global society. This situation is already exerting much influence on governmental and industrial policies as well as on the actions and aspirations of every human being alive today.

3.0 World Economic Council / Paul Scherrer Institute

In January 2012 the Paul Scherrer Institute (PSI) of Switzerland and the World Energy Council (WEC) established a partnership aiming to elaborate comprehensible scenarios for global energy supply in the year 2050, and to examine the implications of these scenarios. Their goal was to answer the question: *"How will the world secure its energy supply in 2050 and what are the possible economic, ecological and social, implications of different pathways and choices?"*

Their report: *"World Energy Scenarios: Composing energy futures to 2050"* published in October this year states that the global population in the year 2050 will be between 8.7 and 9.4 billion people and global economic production will be at a minimum twice as high as it is today. By the year 2050, China and India are likely to replace Europe and North America as the largest economic spheres, while the population will grow fastest in Africa. Long-term projections for global economic growth will average about 3% per year in the developed countries and will be more in the developing and emerging economies. They discuss what this means for the world between now and the year 2050 in the areas of energy resources and energy supply as well as for CO_2 emissions.

In this context, the WEC/PSI report indicates that our primary energy source in year 2050 will still be mostly derived from fossil fuels – mainly from oil, natural gas and coal. They developed two societal energy scenarios and used musical metaphors to name the scenarios *Jazz* and *Symphony*. In short, the market driven *Jazz* scenario produces more energy and more prosperity with less government intervention, yet at the expense of higher CO_2 emissions. The *Symphony* scenario results in a drop in CO_2 emissions at the expense of prosperity, higher costs and more government intervention.

In the Jazz scenario the individual stakeholders and free market forces play the lead role in decisions about energy carriers and technologies. Key elements in this scenario include higher income and affordable access to energy. From an ecological perspective, the strategy anticipates different levels of environmental protection emerging in different parts of the world at different times, along with adjustments and adaptation to environmental damage instead of avoiding damage altogether. In this scenario the global economy grows rapidly, while by contrast the global population increases moderately. Greater economic growth leads to higher energy needs despite steady improvements in energy efficiency. Fossil fuels continue to cover a large share of these energy needs, meaning that CO_2 emissions increase by around 50 percent compared to today.

In the "Symphony" scenario there is a stronger involvement of governments and international cooperation with a focus on energy security and avoiding environmental damage. In this scenario renewable energies are promoted to a greater degree. State support also helps to mitigate the financial and other risks of new large-scale hydropower and nuclear power plants. In addition, deployment breakthroughs are realized for carbon capture, utilization and storage (CC(U)S) technologies thanks in part to state initiatives. In this scenario the economy grows at a slightly slower rate while the global population increases more than in the Jazz scenario. Despite greater improvements to energy efficiency in the Symphony scenario, energy consumption still increases compared to today. Per capita energy requirements, however, fall slightly compared to today and CO_2 emissions are reduced by 40 percent despite increases in population and economic output. The power production sector undergoes an important transformation, driven by state support for renewable energies, hydropower, nuclear power and the deployment of CO_2 capture and storage in fossil fuel power stations. This transformation supports reduced CO_2 emissions and climate protection policy, but requires a third more investment in electricity generation than in the Jazz scenario, although the Jazz scenario produces around 10 percent more electricity.

The number of people without access to electricity by 2050 will be noticeably reduced. In the market driven Jazz scenario this reduction is stronger – about 300 million. This is above all thanks to the quicker increase in prosperity and the increasing urbanization. In the "Symphony" scenario more than 500 million people still remain without electricity in 2050.

The WEC/PSI report estimates that total primary energy supply (TPES) (equal to consumption) will increase globally from 546 EJ (152 PWh) in 2010 to 879 EJ (144 PWh) in the Jazz scenario and 696 EJ (193 PWh) in the Symphony scenario in 2050. This corresponds to an increase of 61% in Jazz scenario and 27% in Symphony scenario in 2050. [5]

(*Note: EJ = Exajoule and PWh = Petrawatthour. We will compare these energy designations to other energy measures below.)

Global electricity generation will increase between now and 2050: In 2010, global electricity production was 21.5 billion MWh globally. In Jazz, this is expected to increase by 150% to 53.6 billion MWh by 2050. In Symphony, the increase is about 123% to 47.9 billion MWh by 2050. Simply due to the sheer increase in electricity production that is needed to meet future demand, the future electricity generation mix will be subject to tremendous changes up to 2050. [5]

A very interesting item in the report mentions that in order to cater to the rising electricity needs generated by economic development to 2050, the WEC estimates that the world will need to invest from US$19 trillion in Jazz to over US$26 trillion in Symphony for electricity generation alone, with the majority of investments required being directed towards solar PV, hydro and wind. [5, 6, 7]

(Please keep these figures in mind when we discuss the size of the future energy market later in this article.)

It should be noted that the anticipated 33% rise in the cost of energy production outlined in the Symphony scenario could perhaps be tolerated in the developed countries but it would be very painful for the developing economies of the world. This will surely pose a political and economic dilemma in the decades ahead. Indeed, the results of the recent UN Framework Convention on Climate Change in Warsaw which was supposed to lead to a new global deal to cut CO_2 emissions, ended on November 16, 2013 in a deadlock. Richer countries were not willing to take the blame for the impacts of climate change on poorer nations that have a lot more to lose. More specifically, the developed countries won't let any statements slip into any UN climate document that could be used against them in the future. [8]

In an article posted on their website on November 10, 2013 titled: *"What are the energy realities? Challenging the myths, defining the future"*, the WEC has called on policy makers and industry leaders to get "real" about defining our energy future and warned that several prevailing myths are severely hampering the efforts of governments, industry and civil society to create a sustainable energy future. [9]

> ***Myth 1: Global energy demand will flatten out***
> *The Reality: Energy demand will continue to increase and double by 2050, primarily driven by economic growth in non-OECD countries.*
>
> ***Myth 2: Peak Oil – there is an imminent shortage of fossil fuel resources***
> *The Reality: There is no shortage in sight. The continued discovery of new resources and the emergence of new technologies that both enable the release of unconventional oil and gas and improve the recovery rates from existing fields have already multiplied the available fossil fuel reserves by a factor of four, and this trend will continue.*
>
> ***Myth 3: Demand growth will be fully met by the new clean energy sources***
> *The Reality: WEC analysis in the World Energy Scenarios shows that despite significant growth in the relative contribution of renewables from 15% today to a figure between 20% and 30% in 2050, in absolute terms the volume of fossil fuels used to meet global energy demand will be 16,000 MTOE in the Jazz (the more consumer-driven scenario) and 10,000 MTOE in Symphony (the more voter-driven scenario), compared to 10,400 MTOE in 2010. This represents a 5% decrease in the absolute amount of fossil fuels in Symphony but a 55% increase in Jazz.*
>
> ***Myth 4: We can reduce global greenhouse gas (GHG) emissions by 50% by 2050***
> *The Reality: According to the WEC's World Energy Scenarios, even in the best case we will see a near doubling of GHG emissions by 2050, compared to where we should be in 2050 to meet the 450 parts per million CO_2 reference adopted by many. At worst GHG emissions could increase by over four-fold.*

Myth 5: Current business models and markets are delivering
The Reality: WEC analysis shows that energy markets are become increasingly complex, driven by accelerated change in energy policy, technological innovation, and consumer expectations. Current market designs and business models are unable to cope with the increasing renewable shares, decentralized systems, or growing information architecture.

Myth 6: Current programs will deliver universal access to energy within the next 10 to 15 years
The Reality: Universal access is far from becoming a reality. While acknowledging recent progress and current programs to reduce energy poverty, the WEC's analysis shows that on current paths, between 730 million and 880 million people for Jazz and Symphony respectively will still be without access to electricity in 2030 and between 320 million and 530 million people in 2050 globally.

Myth 7: On a global scale capital is cheap and abundant
The Reality: Capital is extremely sensitive to perceived political and regulatory risks. Moreover, due to the growing pressures on public finances in most countries, public funds will not be available to substitute or augment the private financing of energy initiatives.

4.0 U.S. Energy Information Administration (EIA) International Energy Outlook 2013 (*IEO2013*)

In July this year, the U.S. Energy Information Administration (EIA) released its *International Energy Outlook 2013* (*IEO2013*) which projects that world energy consumption will grow by 56 percent between 2010 and 2040. Total world energy use rises from 524 quadrillion British thermal units (Btu) in 2010 to 630 quadrillion Btu in 2020 and to 820 quadrillion Btu in 2040. [10]

(*Note: We will convert and compare these Btu measures below.)

Much of the growth in energy consumption occurs in countries outside the Organization for Economic Cooperation and Development (OECD), known as non-OECD, where demand is driven by strong, long-term economic growth. Energy use in non-OECD countries increases by 90 percent; in OECD countries, the increase is 17 percent. The IEO2013 Reference case does not incorporate prospective legislation or policies that might affect energy markets.

Renewable energy and nuclear power are the world's fastest-growing energy sources, each increasing by 2.5 percent per year. ***However, fossil fuels continue to supply almost 80 percent of world energy use through 2040.*** *Natural gas is the fastest-growing fossil fuel in the outlook. Global natural gas consumption increases by 1.7 percent per year. Increasing supplies of tight gas, shale gas, and coalbed methane support growth in projected worldwide natural gas use. Coal use grows faster than petroleum and other liquid fuel use until after 2030, mostly because of increases in China's consumption of coal and tepid growth in liquids demand attributed to slow growth in the OECD regions and high sustained oil prices.*

The industrial sector continues to account for the largest share of delivered energy consumption; the world industrial sector still consumes over half of global delivered energy in 2040. Given current policies and regulations limiting fossil fuel use, worldwide energy-related carbon dioxide *emissions rise from about 31 billion metric tons in 2010 to 36 billion metric tons in 2020 and then to 45 billion metric tons in 2040, a 46-percent increase.*

(*Note: with an average of 37 billion metric tons of CO_2 per year x 30 years = 1.1 trillion cumulative metric tons of CO_2 by year 2040 – see IPCC reference above.)

The EIA report then continues with a discussion of the economic outlook:

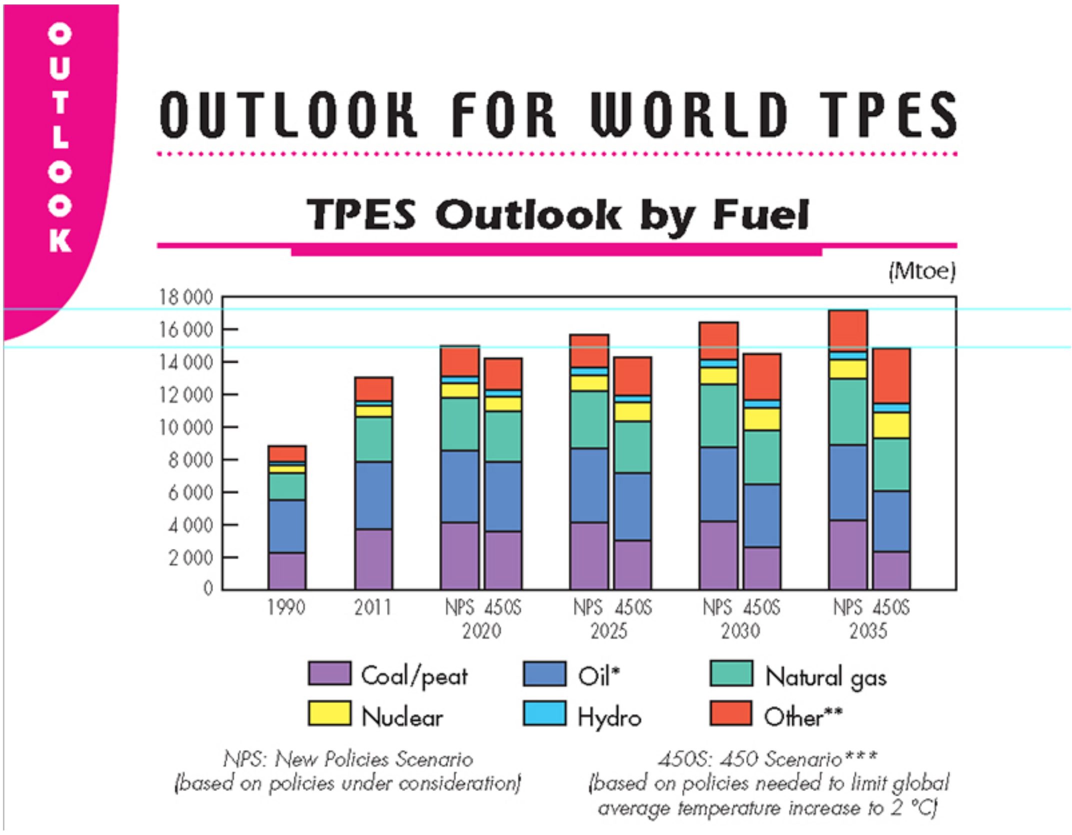
The world's real gross domestic product (GDP, expressed in purchasing power parity terms) rises by an average of 3.6 percent per year from 2010 to 2040. The fastest rates of growth are projected for the emerging, non-OECD regions, where combined GDP increases by 4.7 percent per year. In the OECD regions, GDP grows at a much slower rate of 2.1 percent per year over the projection, owing to more mature economies and slow or declining population growth trends. The strong growth in non- OECD GDP drives the fast-paced growth in future energy consumption projected for these nations.

With the Brent crude oil spot price averaging $112 per barrel in 2012, and EIA's July 2013 Short-Term Energy Outlook projects averages of $105 per barrel in 2013 and $100 per barrel in 2014. With prices expected to increase in the long term, due to demand from the developing countries and increasing world population, the world oil price in real 2011 dollars reaches $106 per barrel in 2020 and $163 per barrel in 2040 in the IEO2013 Reference case. [10, pp.14]

With 80% of world energy consumption coming from some form of fossil fuel these estimated cost projections mentioned above are extremely interesting. We will use these numbers to estimate the value of the global energy market value in Section 6 below.

5.0 International Energy Agency (IEA) : World Energy Outlook 2013

The *IEA World Energy Outlook 2013* only looks into the future as far as year 2035. In their 2013 Key World Energy Statistics we find the following graphic which gives additional insight. [12, 13]



[13: IEA: Key World Energy Statistics, pp.46]

Here, too, we have two energy scenarios: the *New Policies Scenario* and the *450 Scenario* with the latter emphasizing governmental measures to limit and/or capture CO_2 emissions. Also we find yet another way to describe energy consumption - in this case Mtoe – Million tons of oil equivalent. Without being 100% accurate the above chart gives us the approximate projected values for the Total Primary Energy Source (TPES) for the year 2025 i.e. 14,200 Mtoe in the 450 scenario and 15,800 Mtoe in the NPS scenario. For the year 2035 we have 14,800 Mtoe for the 450 Scenario and 17,300 Mtoe in the NPS scenario.

(*Note: we will compare the above estimated energy quantities with the other reports below.)

Large differences in regional energy prices are set to affect industrial competitiveness, influencing investment decisions and company strategies. The extraordinary rise of light tight oil (fracking) in the United States will play a major role in meeting global demand growth over the next decade, but the Middle East – the only large source of low-cost oil – will remain at the centre of the longer-term oil outlook. India is set to overtake China in the 2020s as the principal source of growth in global energy demand.

Their report presents a central scenario in which global energy demand rises by one-third in the period to 2035. The shift in global energy demand to Asia gathers speed, but China moves towards a back seat in the 2020s as India and countries in Southeast Asia take the lead in driving consumption higher. The Middle East also moves to centre stage as an energy consumer, becoming the world's second-largest gas consumer by 2020 and third-largest oil consumer by 2030, redefining its role in global energy markets.

"Major changes are emerging in the energy world in response to shifts in economic growth, efforts at de-carbonization and technological breakthroughs," said IEA Executive Director Maria van der Hoeven. "We have the tools to deal with such profound market change. Those that anticipate global energy developments successfully can derive an advantage, while those that do not risk taking poor policy and investment decisions." [14]

From the IEA *Special Report Redrawing the Energy-Climate Map* released 10 June we learn:

Governments have decided collectively that the world needs to limit the average global temperature increase to no more than 2oC and international negotiations are engaged to that end. Yet any resulting agreement will not emerge before 2015 and new legal obligations will not begin before 2020. Meanwhile, despite many countries taking new actions, the world is drifting further and further from the track it needs to follow. The energy sector is the single largest source of climate-changing greenhouse-gas emissions and limiting these is an essential focus of action. The World Energy Outlook has published detailed analysis of the energy contribution to climate change for many years. But, amid major international economic preoccupations, there are worrying signs that the issue of climate change has slipped down the policy agenda. [15]

Thus, it is quite clear that these world energy organizations take the IPCC conclusions very seriously and have tried to create future energy scenarios that take their recommendations into account.

6.0 Making Some Comparisons.

In this section we will attempt to compare the predictions of the three reports by converting all of the energy measurements into a comprehensible table. As the price of a barrel of oil is something most people can relate to and, not to favor a particular organization, we will introduce a common way of discussing energy which has been used for years which is the term: Barrels of Oil Equivalent or BOE.

Roughly speaking one Barrel of Oil = 42 U.S. gallons = 5,800,000 Btus. As the energy value of a BOE may vary depending on the actual quality of the oil we will use the online energy converter *Unit Juggler* instead. [17]

The online calculator gives us the following output: 1 BOE = 5,551,365 Btus

The U.S. Energy Information Administration (EIA) International Energy Outlook 2013 (*IEO2013*) report mentioned in Section 4 above projects that total world energy use will rise from 524 quadrillion British thermal units (Btu) in 2010 to 630 quadrillion Btu in 2020 and to 820 quadrillion Btu in 2040.

In order to convert this amount of Btus into equivalent BOEs we need to divide *524 quadrillion British thermal units (Btu)* by the Btu value of BOE to arrive at the number of barrels of oil equivalent or BOE.

Again, using the online calculator Unit Juggler (see link below) we arrive at the following values:

- 2010: 524 quadrillion Btu = approx. 94,4 billion BOE
- 2020: 630 quadrillion Btu = approx. 113.4 billion BOE
- 2040: 820 quadrillion Btu = approx. 147.7 billion BOE

To compare the above with the WEC/PSI figures found in Section 2, we need to make two conversions. First, we convert EJ – Exajoules to Btus and then we must convert Btus to BOE. As Unit Juggler cannot convert EJ to BOE we will use another online calculator *Convert Units* [18] to make this calculation and then Unit Juggler to obtain the BOE value.

- 879 EJ = 833,131,211,341,371,000 Btu = 833 quadrillion Btu = 150 billion BOE
- 696 EJ = 659,680,686,113,304,000 Btu = 660 quadrillion Btu = 119 billion BOE

- 2050: Jazz scenario : 833 quadrillion Btu = approx. 150 billion BOE
- 2050: Symphony scenario: 660 quadrillion Btu = approx. 119 billion BOE

Now we will look at the 2025 and the 2035 projections contained in the IEA World Energy Outlook 2013 report mentioned in Section 5. In this report energy values are expressed in terms of Mtoe or Million Tons of Oil Equivalent. The Total Primary Energy Source (TPES) for the year 2025 is 14,200 Mtoe in the 450 scenario and 15,800 Mtoe in the NPS scenario. For the year 2035 we find 14,800 Mtoe in the 450 Scenario and 17,300 Mtoe in the NPS scenario.

Using Unit Juggler we arrive at the following conversions:

- 2025: 11,750 Mtoe = approx. 101.4 billion BOE
- 2025: 15,800 Mtoe = approx. 113 billion BOE
- 2035: 14,800 Mtoe = approx. 106 billion BOE
- 2035: 17,300 Mtoe = approx. 123.6 billion BOE

Now we can compare all of the reports by year in terms of BOE:

- 2010: (US-EIA) = approx. 94,4 billion BOE
- 2020: (US-EIA) = approx. 113.4 billion BOE
- 2025: (IEA 450) = approx. 101.4 billion BOE
- 2025: (IEA NPS) = approx. 113 billion BOE
- 2035: (IEA 450) = approx. 106 billion BOE
- 2035: (IEA NPS) = approx. 123.6 billion BOE
- 2040: (US-EIA) = approx. 147.7 billion BOE
- 2050: (WEC/PSI Symphony) = approx. 119 billion BOE
- 2050: (WEC/PSI Jazz) = approx. 150 billion BOE

Even though we do not have exact year-by-year comparisons, we find that the projected energy trends are relatively consistent with some expected variations among the different approaches and philosophies of the various energy organizations.

Now we will look at the estimated value of the energy market in the years 2020, 2035, 2040 and 2050 using the price per barrel of oil estimates contained in the EIA 2013 report in Section 4.

> *"With prices expected to increase in the long term, due to demand from the developing countries and increasing world population, the world oil price in real 2011 dollars reaches $106 per barrel in 2020 and $163 per barrel in 2040 in the IEO2013 Reference case."*

(Please note we have used the EIA pegged US $ value 2011 to calculate the table below.)

To arrive at a realistic estimate of the price of energy in the future years we will use the following prices per barrel of oil: $80 for year 2010, $106 for year 2020, $120 for year 2025, $150 for year 2035, $163 for year 2040 and $170 for year 2050.

Projected Energy Market 2012-2050

- 2010:(US-EIA) 94,4 billion BOE x $80 = approx. $ 7.6 trillion
- 2020:(US-EIA) 113.4 billion BOE x $106 = approx. $ 12.0 trillion
- 2025: (IEA 450) 101.4 billion BOE x $120 = approx. $ 12.2 trillion
- 2025: (IEA NPS) 113 billion BOE x $120 = approx. $13.6 trillion
- 2035: (IEA 450) 106 billion BOE x $150 = approx. $15.9 trillion
- 2035: (IEA NPS) 123.6 billion BOE x $150 = approx. $18.5 trillion
- 2040: (US-EIA) 147.7 billion BOE x $163 = approx. $24.1 trillion
- 2050:(WEC/PSI Symphony) 119 billion BOE x $170 = approx. $20.2 trillion
- 2050: (WEC/PSI Jazz) 150 billion BOE x $170 = approx. $25.5 trillion

Please recall that we mentioned in Section 3, the WEC/PSI report estimates that the world will need to invest from US$19 trillion in the Jazz to scenario and over US$25 trillion in Symphony scenario for electricity generation alone. This is in addition to the actual costs of consumed energy which are listed in the table above. This additional cost will be averaged over the years but it does add to the overall cost of energy to the consumer.

7.0 Energy and Prosperity

So far we have been looking at projected future demand for energy and the associated end user price. All the reports assume the developing countries will develop faster than today while the already developed countries will develop at a slower pace. This makes sense, however the reports do not state that the developing countries will attain the same level of energy affluence found in the developed countries. Let's look at the world's per capita energy use. In 2010 the world's population was approximately 6.9 billion people. If will divide 94.4 billion BOE used in that year by 6.9 billion people we arrive at 13.68 per capita BOE for the world in the year 2010.

The US EIA International Energy Statistics [19] gives us the per capita energy consumption per region and per country expressed in Btus. To compare with the number above we find that the per capita Total Primary Energy Consumption is 74.386 million Btus in the year 2010.

Using the Unit Juggler converter once again we can make the following calculations:

74,386,000 Btus = approx. 13.4 per capita BOE which is very close to our own calculation above.

Now let's look at some other regions and then some countries.

North America:	259,706,000 Btus	= approx. 46.8 per capita BOE
Europe:	138,169,000 Btus	= approx. 24.9 per capita BOE
Central & S. America	56,840,000 Btus	= approx. 10.2 per capita BOE
Asia and Ocenia	50,925,000 Btus	= approx. 9.2 per capita BOE
Africa:	15,926,000 Btus	= approx. 2.9 per capita BOE
World:	74,386,000 Btus	= approx. 13.4 per capita BOE

Using the standard of living found in Europe and its associated per capita of 24.9 BOE as an ideal for the world we find that economic disparity will persist in the projected energy consumption figures.

Considering that in the next decades the emerging and developing countries will aspire to a similar use of energy as the people in Europe in order to raise their standard of living to similar level, we can use a per capita 25 BOE as an ideal goal for global energy consumption and call it the Energy and Prosperity for Everyone goal or (EPE).

Assuming world population stabilizes at 9 billion in the year 2050 and the emerging economies have had sufficient development to actually reach this goal we can now calculate how much energy would be necessary to reach the EPE standard worldwide. In this case we will multiply 9 billion people by per capita 25 BOE to reach the EPE level of 225 billion BOE. Now we will compare the most optimistic scenarios in terms of prosperity of the previous mentioned projections by the WEC/PSI report.

2050 Jazz:	150 billion BOE divided by 9 Billion people = 16.7 per capita BOE
2050 Symphony:	119 billion BOE divided by 9 Billion people = 13.2 per capita BOE
EPE:	225 billion BOE divided by 9 Billion people = 25 per capita BOE

The above shows us that there will still be substantial discrepancy in the year 2050 with either of the Jazz or the Symphony scenarios: i.e. the developing countries will never reach the standard of living of today's European societies and the developed countries will most likely have to lower their standard of living and energy use to comply with the world energy estimates especially while trying to comply with the IPCC $C0_2$ goals that are already influencing governmental and industrial policies.

Now we need to make one more calculation to discover the potential size of the energy market in the year 2050 in our EPE scenario. Using the anticipated price per barrel of oil of US $170 that we used above we arrive at a projected world energy market of $38.25 trillion (which does not include any investment in energy optimization technologies such as CC(U)S, etc.)

225 billion BOE x $170 = approx. $ 38.25 trillion

Thus, at this moment there exists an energy and environmental dilemma that obviously needs to be solved. However, there also exists a gigantic market for supplying energy at the projected levels and prices. As the studies point out, absence of any viable alternative energy resource, the primary source of energy in the near term will continue to be based on fossil fuels as these are less expensive but their use results in higher CO_2 emissions. Not only is this predicted by the IPCC 5th assessment report to have serious consequences for the climate but perhaps even more importantly, such increases in the use of fossil fuels between now and the year 2050 may be even worse for the environment in terms of pollution. The reports also predict that the current energy boom in the US, i.e. fracking for shale oil and gas or tight oil, will not be duplicated elsewhere in the world and that this boom will taper off and begin declining in 2020 and, that by 2030, the world's major fossil fuel production will again come from the Middle East.

As before, we can anticipate that the supply of fossil fuels will be accompanied by geopolitical competition and conflicts over the remaining resources. For example, the political temperature in the Arctic rose on December 10, 2013 when Vladimir Putin vowed to step up Russia's military presence in the region in response to a claim by Canada to the North Pole. Not only Russia and Canada, but also the US, Greenland, and Danish have heightened interests in claiming the Artic territory which, according to the US geological survey, contains 30% of the world's undiscovered natural gas and 15% of its oil. [16]

Alternative terrestrial renewable energy sources such as hydropower, geothermal, photovoltaic and wind, though desirable and important additions to the world's energy mix, apparently cannot scale to meet these future energy demands. The WEC/PSI report asserts that energy production from these sources will remain a modest fraction of the total energy picture as these technologies are unlikely to provide the huge amounts of new and sustainable energy that will be needed in the coming decades. Likewise, use of nuclear energy will increase at about the same pace, however it is also not a viable option because of its unsolved political and environmental issues as well as the high start-up costs. It has been estimated that we would need to build 11,000 to 12,000 nuclear power plants by year 2050 to meet this predicted energy demand or possibly more because the average age of a nuclear plant is around only around 21 years. [17]

9.0 Conclusion

A key element of **The Space Option** concept has been the utilization of extraterrestrial resources for meeting the needs of humanity on Earth. Plentiful and environmentally friendly energy is perhaps the most important resource for the future sustainability of our civilization. Energy from space in the form of solar power which is often referred to as Space Based Solar Power (SBSP) has been looked at for several decades. We believe it has the potential to meet much - if not all - of civilization's future energy needs and, as it is environmentally benign, meaning that it is CO_2 neutral and does not produce harmful pollutants, it can help society realistic address the coming environmental and energy challenges. Astonishingly, this attractive alternative energy resource is not included nor referenced in today's energy debates, predictions and policies.

Development and population increases will stimulate a burgeoning energy market of enormous proportions. In order for the global economy to increase by incorporating the less developed regions of the world, it will need substantially more energy than is being produced and used today. The world's top energy organizations tend to agree that humanity will remain dependent on fossil fuels to meet its energy needs throughout mid-century and this will have a negative impact on meeting its CO_2 reduction goals. Government interventions to do so will significantly add to the cost of energy and restrict the pace of development in the emerging economies.

This is both a challenge and an opportunity for the energy sector, especially when this has to be achieved in the context of CO_2 reduction policies. If we strive for the EPE goal - *Energy and Prosperity of Everyone* - then our civilization will need almost twice as much energy as the energy organizations are predicting will be available in the year 2050.

Therefore, if there existed a viable environmentally clean energy option which was CO_2 neutral and one that has the potential to meet a substantial portion of our civilization's future energy needs and would avoid geopolitical conflicts over resources and territory, then this should be the obvious choice that humanity would *soon* want to make.

Fortunately, as **The Space Option** has pointed out in previous publications, the alternative to terrestrial energy resources is Space Based Solar Power (SBSP). Considering a potential energy market of $20-38 trillion in the year 2050 and beyond – even if it supplies just 10% of that future market - SBSP would appear to be an attractive opportunity. As such, it is one of those *Cosmic Choices* that our civilization needs to make to insure its sustainability and viability.

However we must also ask, *"If the case for SBSP, as a possible solution to meeting the energy and climate challenges of the future is so compelling, why it is not even mentioned by the world energy organizations when considering the future energy needs of our civilization?"*

This will be the subject of future articles.

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